Indian Institute of Technology Indore

Curriculum and
Courses of Study
for
Bachelor of Technology
and Minor Programs

June 2024
[After incorporating decisions of 44th meeting of the Senate held on 09 July 2024]

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Course Structure
of
B. Tech., B.Tech.+M.Tech. Program

Curriculum of 1st Year BTech (For AY 2009-10)

Semester I

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credits
CH 101	Chemistry	2-1-0	6
CS 101	Computer Programming & Utilization	2-0-2	6
MA 101	Calculus	3-1-0	8
PH 101	Physics –I	2-1-0	6
CH 151	Chemistry Lab	0-0-3	3
ME 151	Engineering Graphics & Drawing	0-1-3	5
NC 101#	National Cadet Crops (NCC)	0-0-0	P/NP
NO 101#	National Sports Organization (NSS)	0-0-0	P/NP
NS 101#	National Service Scheme (NSS)	0-0-0	P/NP
	Total	**9-4-7**	**34**

Semester II

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credits
PH 102	Physics – II	2-1-0	6
HS101/ HS 103/ HS 105	Introduction to Philosophy/ Economics/ Reading Literature	3-0-0	6
CS 102 EE 102 ME 102	Abstractions and Paradigms for Programming* Intro. to Elect. And Electronics Circuit* Engineering Mechanics*	3-0-2 2-1-0 2-1-0	8 6 6
MA 102	Linear Algebra and Ordinary Differential Equation – I	3-1-0	8
ME 152	Workshop Practice	0-1-3	5
PH 112	Physics Lab	0-0-3	3
NC 102#	National Cadet Crops (NCC)	0-0-0	P/NP
NO 102#	National Sports Organisation (NSS)	0-0-0	P/NP
NS 102#	National Service Scheme (NSS)	0-0-0	P/NP
	Total	**11/10-3/4-8/6**	**36/34**

Any one of these courses to be taken
* Department Introductory course, specific to the students of concerned Departments

2nd Year BTech (Computer Science and Engineering)

(For AY 2010-11)

Semester III

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
HS 111 / HS 113 / HS 115	Introduction to Philosophy / ***** Economics / Reading Literature	3-0-0 / 3-0-0 / 3-0-0	3 / 3 / 3
MA 201	Mathematics-III (Complex Analysis and Differential Equations-II)	3-1-0	4
EE 104	Basic Electrical and Electronics Engineering	2-1-0	3
CS 201	Discrete Mathematical Structures	2-1-0	3
CS 203	Data Structures and Algorithms	2-1-0	3
CS 253	Data Structures and Algorithms Lab	0-0-3	1.5
CS 261	Program Development and Software Design Lab-I	0-1-4	3
EE 154	Basic Electrical and Electronics Engineering Lab	0-0-2	1
IC 211	Experimental Engineering Lab	0-0-3	1.5
	Total	**12-5-12**	**23**

Semester IV

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
MA 204	Numerical Methods	3-1-0	4
CS 202	Automata Theory and Logic	2-1-0	3
CS 204	Design and Analysis of Algorithms	2-1-0	3
CS 206	Logic Design	2-1-0	3
CS 208	Software Engineering	2-1-0	3
CS 254	Design and Analysis of Algorithms Lab	0-0-3	1.5

CS 256	Logic Design Lab	0-0-3	1.5
CS 258	Software Engineering Lab	0-0-3	1.5
CS 262	Program Development and Software Design Lab-II	0-1-4	3
	Total	**11-6-13**	**23.5**

* Students have to choose an HSS course other than the one which they have taken in the 2nd Sem.

2nd Year BTech (Electrical Engineering)

(For AY 2010-11)

Semester III

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
HS 111 / HS 113 / HS 115	Introduction to Philosophy / * Economics / Reading Literature	3-0-0 / 3-0-0 / 3-0-0	3 / 3 / 3
MA 201	Mathematics-III (Complex Analysis and Differential Equations-II)	3-1-0	4
EE 201	Network Theory	2-1-0	3
EE 203	Electronic Devices	2-1-0	3
EE 205	Introduction to Electrical Systems	3-1-0	4
EE 253	Electronic Devices Lab	0-0-3	1.5
EE 154	Basic Electrical and Electronics Engineering Lab	0-0-2	1
IC 211	Experimental Engineering Lab	0-0-3	1.5
	Total	**13-4-8**	**21**

Semester IV

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
MA 204	Numerical Methods	3-1-0	4
EE 202	Signals and Systems	3-1-0	4
EE 204	Analog Circuits	3-0-0	3
EE 206	Electrical Machines and Power Electronics	3-0-0	3
EE 208	Digital Systems	2-1-0	3
EE 254	Analog Circuits Lab	0-0-3	1.5
EE 256	Electrical Machines Lab	0-0-4	2
EE 258	Digital Systems Lab	0-0-3	1.5
	Total	**14-3-10**	**22**

* Students have to choose an HSS course other than the one which they have taken in the 2nd Sem.

2nd Year B. Tech. (Mechanical Engineering)

(For AY 2010-11)

Semester III

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
HS 111 / HS 113 / HS 115	Introduction to Philosophy / * Economics / Reading Literature	3-0-0 / 3-0-0 / 3-0-0	3 /3 / 3
ME 201	Solid Mechanics	3-1-0	4
ME 203	Fluid Mechanics	3-1-0	4
ME 205	Materials Science	2-1-0	3
ME 257	Machine Drawing	1-0-3	2.5
EE 104	Basic Electrical and Electronics Engineering	2-1-0	3
EE 154	Basic Electrical and Electronics Engineering Lab	0-0-2	1
IC 211	Experimental Engineering Lab	0-0-3	1.5
	Total	**14-4-8**	**22**

Semester IV

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
MA 204	Numerical Methods	3-1-0	4
ME 202	Strength of Materials	3-1-0	4
ME 204	Fluid Machinery	3-0-0	3
ME 206	Thermodynamics	3-1-0	4
ME 208	Theory of Manufacturing Processes	3-0-0	3
ME 251	Solid Mechanics Lab	0-0-3	1.5
ME 254	Fluid Mechanics and Machinery Lab	0-0-3	1.5
ME 258	Manufacturing Processes Lab	0-0-3	1.5
	Total	**15-3-9**	**22.5**

* Students have to choose an HSS course other than the one which they have taken in the 2nd Sem.

Curriculum of 1st year BTech (common to all the Departments)

Semester I

Curriculum of 1st Year B. Tech. Program (From AY 2010-11 to AY 2013-14)			
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
CH 103	Chemistry	3-1-0	4
MA 103	Mathematics-I (Calculus)	3-1-0	4
PH 103	Physics-I (Modern Physics)	2-1-0	3
HS 107	English Language and Literature	2-0-0	2
CS 103	Computer Programming	2-0-0	2
CH 153	Chemistry Lab	0-0-3	1.5
HS 157	English Language Lab	0-0-2	1
CS 153	Computer Programming Lab	0-0-3	1.5
ME 153	Engineering Graphics	1-0-3	2.5
NC 101/ NO 101/ NS 101	National Cadet Corps (NCC) National Sports Organization (NSO) National Service Scheme (NSS)	0-0-0 0-0-0 0-0-0	P/NP P/NP P/NP
	Total	**13-3-11**	**21.5**

Curriculum of 1st Year B. Tech. Program (From AY 2014-15 to AY 2018-19)			
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
CH 103	Chemistry	3-1-0	4
MA 105	Calculus	3-1-0	4
PH 105	Physics-I	2-1-0	3
HS 159	English Language and Communication	0-3-0	3
CS 103	Computer Programming	2-0-0	2
CH 153	Chemistry Lab	0-0-3	1.5
CS 153 ***(upto AY 2017-18)*** IC 151 ***(from AY 2018-19 onwards)***	Computer Programming Lab	0-0-3	1.5
IC 153	Engineering Graphics	1-0-3	2.5
NC 101/ NO 101/ NS 101	National Cadet Corps (NCC) National Sports Organization (NSO) National Service Scheme (NSS)	0-0-0 0-0-0 0-0-0	P/NP P/NP P/NP
	Total	**11-6-9**	**21.5**

Semester II

Curriculum of 1st Year B. Tech. Program (From AY 2010-11 to AY 2013-14)			
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
MA 104	Mathematics-II(Linear Algebra and Ordinary Differential Equations-I)	3-1-0	4
PH 104	Physics-II (Electricity and Magnetism)	2-1-0	3
HS 108	Fundamentals of Economics	3-0-0	3
EE 104	Basic Electrical and Electronics Engineering	2-1-0	3
ME 104	Basic Mechanical Engineering	3-0-0	3
PH 154	Physics Lab	0-0-3	1.5
EE 154	Basic Electrical and Electronics Engineering Lab	0-0-2	1
ME 154	Basic Manufacturing Techniques	2-0-2	3
NC 102/ NO 102/ NS 102	National Cadet Corps (NCC) National Sports Organization (NSO) National Service Scheme (NSS)	0-0-0 0-0-0 0-0-0	P/NP P/NP P/NP
	Total	**15-3-7**	**21.5**

Curriculum of 1st Year B. Tech. Program (From AY 2014-15 to AY 2018-19)			
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
MA 106	Linear Algebra and Ordinary Differential Equations-I	3-1-0	4
PH 106	Physics-II	2-1-0	3
BSE 102	Bio-Sciences	2-1-0	3
HS 108	Fundamentals of Economics	3-0-0	3
EE 104	Basic Electrical and Electronics Engineering	2-1-0	3
ME 106	Basic Mechanical Engineering	2-1-0	3
PH 156	Physics Lab	0-0-3	1.5
EE 154	Basic Electrical and Electronics Engineering Lab	0-0-2	1
IC 156	Basic Manufacturing Techniques	0-0-3	1.5
NC 102 / NO 102 / NS 102	National Cadet Corps (NCC) National Sports Organization (NSO) National Service Scheme (NSS)	0-0-0 0-0-0 0-0-0	P/NP P/NP P/NP
	Total	**15-4-8**	**23**

Sections and Course structure of 1st year BTech (from AY 2019-20 to AY 2022-23)

Section-A (CSE + CE + MEMS) **Classroom No. 1B-201, Titanium POD**				**Section-B (EE + ME)** **Classroom No. 1D-105, Chromium POD**			
1st (i.e. Autumn) Semester							
Course Code	**Course Title**	**Teaching Hours (L-T-P)**	**Credits**	**Course Code**	**Course Title**	**Teaching Hours (L-T-P)**	**Credits**
CH 103	Chemistry	3-1-0	4	BSE 102	Bio-Sciences	2-1-0	3
MA 105	Calculus	3-1-0	4	MA 105	Calculus	3-1-0	4
PH 105	Physics-I	2-1-0	3	PH 106	Physics-II	2-1-0	3
CS 103	Computer Programming	2-0-0	2	EE 104	Basic Electrical and Electronics Engineering	2-1-0	3
				ME 106	Basic Mechanical Engineering	2-1-0	3
HS 159	English Language and Communication	0-3-0	3	HS 108	Fundamentals of Economics	3-0-0	3
CH 153	Chemistry Lab	0-0-3	1.5	PH 156	Physics Lab	0-0-3	1.5
IC 151	Computer Programming Lab	0-0-3	1.5	EE 154	Basic Electrical and Electronics Engineering Lab	0-0-2	1
IC 153	Engineering Graphics	1-0-3	2.5	IC 156	Basic Manufacturing Techniques	0-0-3	1.5
NO 101	National Sports Organization (NSO)	0-0-0	P/NP	NO 101	National Sports Organization (NSO)	0-0-0	P/NP
	Total	**11-6-9**	**21.5**		**Total**	**14-5-8**	**23**
2nd (i.e. Spring) Semester							
BSE 102	Bio-Sciences	2-1-0	3	CH 103	Chemistry	3-1-0	4
MA 106	Linear Algebra and Ordinary Differential Equations-I	3-1-0	4	MA 106	Linear Algebra and Ordinary Differential Equations-I	3-1-0	4
PH 106	Physics-II	2-1-0	3	PH 105	Physics-I	2-1-0	3
EE 104	Basic Electrical and Electronics Engineering	2-1-0	3	CS 103	Computer Programming	2-0-0	2

ME 106	Basic Mechanical Engineering	2-1-0	3				
HS 108	Fundamentals of Economics	3-0-0	3	HS 159	English Language and Communication	0-3-0	3
EE 154	Basic Electrical and Electronics Engineering Lab	0-0-2	1	IC 151	Computer Programming Lab	0-0-3	1.5
PH 156	Physics Lab	0-0-3	1.5	CH 153	Chemistry Lab	0-0-3	1.5
IC 156	Basic Manufacturing Techniques	0-0-3	1.5	IC 153	Engineering Graphics	1-0-3	2.5
NO 102	National Sports Organization (NSO)		P/NP	NO 102	National Sports Organization (NSO)		P/NP
	Total	**14-5-8**	**23**		**Total**	**11-6-9**	**21.5**

Sections and Course structure of 1st year BTech (from AY 2023-24 onwards)

Section-A (CSE+CE+MEMS+CH+EP)			
Semester-I	**Autumn Semester**		
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
EE 101	Basic Electrical Engineering	1-1-0	2
ME 101	Engineering Mechanics	2-0-0	2
PH 107	Basics of Physics	2-1-0	3
PH 157	Physics Lab- I	0-0-2	1
MA 101N	Calculus-I (half Semester)	3-1-0 (=4/2)	2
MA 103N	Calculus-II (half Semester)	3-1-0 (=4/2)	2
HS 109	Language and Composition	2-0-0	2
HS XXX	Flexible Elective (HSS)	1-0-0	1
IC 152	Makerspace	1-0-6	4
CS 103	Computer Programming	2-0-0	2
IC 151	Computer Programming Lab	0-0-3	1.5
NO 101	National Sports Organization (NSO)	0-0-0	P/NP
	Total	**14-3-11**	**22.5**

Section-B (EE+ME+MC+SSE)			
Semester-I	**Autumn Semester**		
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
EE 101	Basic Electrical Engineering	1-1-0	2
ME 101	Engineering Mechanics	2-0-0	2
CH 105	Chemistry	3-0-0	3
CH 155	Chemistry Lab	0-0-2	1
MA 101N	Calculus-I (half Semester)	3-1-0 (=4/2)	2
MA 103N	Calculus-II (half Semester)	3-1-0 (=4/2)	2
HS 109	Language and Composition	2-0-0	2
HS XXX	Flexible Elective (HSS)	1-0-0	1
CS 103	Computer Programming	2-0-0	2
IC 151	Computer Programming Lab	0-0-3	1.5
NO 101	National Sports Organization (NSO)	0-0-0	P/NP
	Total	**14-2-5**	**18.5**

Semester-II	Spring Semester		
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
BSE 102	Biosciences	2-1-0	3
MA 102N	Linear Algebra (half Semester)	2-1-0 (=3/2)	1.5
MA 104N	Differential Equations-I (half Semester)	2-1-0 (=3/2)	1.5
ES 102	Environmental Studies: Scientific and Engineering Aspects (half Semester)	2-1-0 (=3/2)	1.5
HS 102	Environmental Studies: Social Aspects (half Semester)	2-1-0 (=3/2)	1.5
HS 104	Fundamentals of Economics	2-0-0	2
CH 105	Chemistry	3-0-0	3
CH 155	Chemistry Lab	0-0-2	1
ZZ XXX	Flexible Elective	1-0-0	1
ZZ XXX	Flexible Elective	1-0-0	1
ZZ XXX	Flexible Elective (HSS)	1-0-0	1
NO 102	National Sports Organization (NSO)	0-0-0	P/NP
	Total	**14-3-2**	**18**

Semester-II	Spring Semester		
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
BSE 102	Biosciences	2-1-0	3
MA 102N	Linear Algebra (half Semester)	2-1-0 (=3/2)	1.5
MA 104N	Differential Equations-I (half Semester)	2-1-0 (=3/2)	1.5
ES 102	Environmental Studies: Scientific and Engineering Aspects (half Semester)	2-1-0 (=3/2)	1.5
HS 102	Environmental Studies: Social Aspects (half Semester)	2-1-0 (=3/2)	1.5
HS 104	Fundamentals of Economics	2-0-0	2
IC 152	Makerspace	1-0-6	4
PH 107	Basics of Physics	2-1-0	3
PH 157	Physics Lab- I	0-0-2	1
ZZ XXX	Flexible Elective	1-0-0	1
ZZ XXX	Flexible Elective	1-0-0	1
ZZ XXX	Flexible Elective (HSS)	1-0-0	1
NO 102	National Sports Organization (NSO)	0-0-0	P/NP
	Total	**14-4-8**	**22**

Curriculum for BTech (CSE)

Semester III

Curriculum of 2nd Year B. Tech. (CSE) (From AY 2011-12 to AY 2013-14)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
HS 201 / HS 203 / HS 205 HS 207	Understanding Philosophy / Psychology / Sociology / French Language – I	3-0-0 / 3-0-0 / 2-1-0 / 2-1-0	3 / 3 / 3 / 3
MA 201	Mathematics-III (Complex Analysis and Differential Equations-II)	3-1-0	4
CS 201	Discrete Mathematical Structures	2-1-0	3
CS 203	Data Structures and Algorithms	2-1-0	3
CS 205	Abstraction and Paradigms for Programming	2-1-0	3
CS 253	Data Structures and Algorithms Lab	0-0-3	1.5
CS 255	Abstraction and Paradigms for Programming Lab	0-0-3	1.5
IC 211	Experimental Engineering Lab	0-0-3	1.5
	Total	**12/11-4/5-9**	**20.5**

Curriculum of 2nd Year B. Tech. (CSE) (From AY 2014-15 onwards to AY 2023-24)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ZZ XXX	Course-I for Minor Program	X-X-X	3
MA 203	Complex Analysis and Differential Equations-II	3-1-0	4
CS 201	Discrete Mathematical Structures	2-1-0	3
CS 203	Data Structures and Algorithms	2-1-0	3
CS 207	**Data Base & Information Systems**	**3-0-0**	**3**
CS 253	Data Structures and Algorithms Lab	0-0-3	1.5
CS 257	**Data Base & Information Systems Lab**	**0-0-3**	**1.5**
IC 211	Experimental Engineering Lab	0-0-3	1.5
	Total	**10-3-9**	**17.5 / 20.5**

Curriculum of 2nd Year B. Tech. (CSE) (From AY 2024-25 onwards)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ZZ xxx	Course-I for Minor Program	x-x-x	3
MA 205	Complex Analysis	3-1-0 (1/2 Sem)	2
MA 207	Differential Equations-II	3-1-0 (1/2 Sem)	2
CS 201	Discrete Mathematical Structures	2-1-0	3
CS 203	Data Structures and Algorithms	2-1-0	3
CS 207N	Database and Information Systems	2-1-0	3
CS 209	Logic Design	2-0-2	3
CS 253	Data Structures and Algorithms Lab	0-0-3	1.5
CS 257	Database and Information Systems Lab	0-0-3	1.5
CS 2XX	Department Elective I	x-x-x	3
	Total	11-4-8 **	22/25

Semester IV

Curriculum of 2^{nd} Year B. Tech. (CSE) (From AY 2011-12 to AY 2013-14)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
HS 208	French Language – II +	2-1-0	3
MA 204	Numerical Methods	3-1-0	4
CS 202	Automata Theory and Logic	2-1-0	3
CS	Design and Analysis of Algorithms	2-1-0	3

Curriculum of 2^{nd} Year B. Tech. (CSE) (From AY 2014-15 onwards to AY 2023-24)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ZZ XXX	Course-II for Minor Program	X-X-X	3
MA 204	Numerical Methods	3-0-2	4
CS 202	Automata Theory and Logic	2-1-0	3
CS 204	Design and Analysis of	2-1-0	3

204						Algorithms		
CS 206	Logic Design	2-1-0	3		CS 206	Logic Design	2-1-0	3
CS 208	Software Engineering	2-1-0	3		CS 208	Software Engineering	2-1-0	3
CS 254	Design and Analysis of Algorithms Lab	0-0-3	1.5		CS 254	Design and Analysis of Algorithms Lab	0-0-3	1.5
CS 256	Logic Design Lab	0-0-3	1.5		CS 256	Logic Design Lab	0-0-3	1.5
CS 258	Software Engineering Lab	0-0-3	1.5		CS 258	Software Engineering Lab	0-0-3	1.5
	Total	**11/13-5/6-9**	**20.5 / 23.5**			**Total**	**11-5-9**	**20.5 / 23.5**

+ Additional course ONLY for those students who have taken and passed HS 207 in their 3rd Semester.

Curriculum of 2nd Year B. Tech. (CSE) (From AY 2024-25 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ZZ xxx	Course-II for Minor Program	x-x-x	3
MA 204N	Numerical Methods	2-0-2	3
CS 202	Automata Theory and Logic	2-1-0	3
CS 204	Design and Analysis of Algorithms	2-1-0	3
CS 210	Computer Architecture	2-1-0	3
CS 254	Design and Analysis of Algorithms Lab	0-0-3	1.5
CS 264	Computer Architecture Lab	0-0-3	1.5
CS 2XX	Department Elective II	x-x-x	3
ZZ 2XX	Institute Elective-I	x-x-x	3
	Total	**8-3-8**	**21/24**

Curriculum for BTech (CSE)

Semester V

Curriculum of 3rd Year B. Tech. (CSE) (From AY 2011-12 to AY 2014-15)					Curriculum of 3rd Year B. Tech. (CSE) (From AY 2015-16 to AY 2024-25)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**		**Course Code**	**Course Title**	**Weekly L-T-P**	**Credits**
HS xxx	HSS Course	3-0-0	3		ZZ XXX	Course-III for Minor Program	X-X-X	3
CS 301	Data Base & Information Systems	3-0-0	3		**CS 309**	**Parallel Computing**	**2-1-0**	**3**
CS 303	Operating Systems	2-1-0	3		CS 303	Operating Systems	2-1-0	3
CS 305	Computer Architecture	2-1-0	3		CS 305	Computer Architecture	2-1-0	3
CS 307	Optimization Algorithms and Techniques	3-0-0	3		CS 307	Optimization Algorithms and Techniques	2-1-0	3
CS 351	Data Base & Information Systems Lab	0-0-3	1.5		**CS 359**	**Parallel Computing Lab**	**0-0-3**	**1.5**
CS 353	Operating Systems Lab	0-0-3	1.5		CS 353	Operating Systems Lab	0-0-3	1.5
CS 355	Computer Architecture Lab	0-0-3	1.5		CS 355	Computer Architecture Lab	0-0-3	1.5
CS 357	Optimization Algorithms and Techniques Lab	0-0-3	1.5		CS 357	Optimization Algorithms and Techniques Lab	0-0-3	1.5
	Total	**13-2-12**	**21**			**Total**	**8-4-12**	**18 / 21**

Curriculum of 3rd Year B. Tech. (CSE) (From AY 2025-26 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ZZ xxx	Course III - Minor Program	x-x-x	3
CS 311	Parallel Computing	2-0-2	3
CS 303	Operating Systems	2-1-0	3
CS 307	Optimization Algorithms and Techniques	2-1-0	3
CS 313	Computer Networks	2-0-2	3
CS 353N	Operating Systems Lab	0-0-2	1
CS 357N	Optimization Algorithms and Techniques Lab	0-0-2	1
CS 3XX	Department Elective III	x-x-x	3
ZZ 3XX	Institute Elective II	x-x-x	3
	Total	**8-2-8**	**20/23**

Semester VI

Curriculum of 3rd Year B. Tech. (CSE) (From AY 2011-12 to AY 2014-15)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
HS 302 ES 302	Environmental Studies: Social Aspects (Half Semester course) Environmental Studies: Scientific and Engineering Aspects (Half Semester course)	3-0-0 3-0-0	1.5 1.5
CS 302	Computer Graphics and Visualization	3-0-0	3
CS 304	Artificial Intelligence	3-0-0	3
CS	Computer Networks	3-0-0	3

Curriculum of 3rd Year B. Tech. (CSE) (From AY 2015-16 to AY 2024-25)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
HS 302 ES 302	Environmental Studies: Social Aspects (Half Semester course) Environmental Studies: Scientific and Engineering Aspects (Half Semester course)	3-0-0 3-0-0	1.5 1.5
CS 302	Computer Graphics and Visualization	2-1-0	3
CS 304N	Computational Intelligence	2-1-0	3
CS 306	Computer Networks	2-1-0	3

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CS 308	Compiler Techniques	3-0-0	3		CS 308	Compiler Techniques	2-1-0	3
CS 352	Computer Graphics and Visualization Lab	0-0-3	1.5		CS 352	Computer Graphics and Visualization Lab	0-0-3	1.5
CS 354	Artificial Intelligence Lab	0-0-3	1.5		CS 354N	Computational Intelligence Lab	0-0-3	1.5
CS 356	Computer Networks Lab	0-0-3	1.5		CS 356	Computer Networks Lab	0-0-3	1.5
CS 358	Compiler Techniques Lab	0-0-3	1.5		CS 358	Compiler Techniques Lab	0-0-3	1.5
CS 391	Summer Internship (After the completion of the 6th semester)							
	Total	**15-0-12**	**21**			**Total**	**11-4-12**	**21**

Curriculum of 3rd Year B. Tech. (CSE) (From AY 2025-26 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ZZ xxx	Course IV - Minor Program	x-x-x	3
CS 302N	Computer Graphics and Visualization	2-0-2	3
CS 304N	Computational Intelligence	2-1-0	3
CS 310	Software Engineering	2-0-2	3
CS 308N	Compiler Techniques	2-0-2	3
CS 354N	Computational Intelligence Lab	0-0-3	1.5
CS 3XX	Department Elective IV	x-x-x	3
CS 3XX	Department Elective V	x-x-x	3
ZZ 3XX	Institute Elective III	x-x-x	3
	Total	**8-1-9**	**22.5/25.5**

Curriculum for BTech (CSE)

Semester VII

<table>
<tr><td colspan="4">Curriculum of 4th Year B. Tech. (CSE)
(From AY 2011-12 to AY 2013-14)</td><td></td><td colspan="4">Curriculum of 4th Year B. Tech. (CSE)
(From AY 2014-15 to AY 2025-26)</td></tr>
<tr><td>Course Code</td><td>Course Title</td><td>Weekly L-T-P</td><td>Credits</td><td></td><td>Course Code</td><td>Course Title</td><td>Weekly L-T-P</td><td>Credits</td></tr>
<tr><td>CS 401</td><td>Soft Computing</td><td>3-0-0</td><td>3</td><td rowspan="7"></td><td rowspan="7">CS 493</td><td rowspan="7">B Tech Project (BTP)
1. Student can do BTech project either outside the institute or within the institute under a supervision of an IIT Indore Faculty.
2. Summer Internship, if any, will be part of B Tech Project.
3. The choice is to be made latest by 30th April.
4. Duration: 6-7 months during 2nd week of May to Last week of Nov.
5. Last Date of Thesis submission: 1st week of Dec.
6. Last Date of Submission of Grades: 2nd week of Dec.</td><td rowspan="7">0-0-40</td><td rowspan="7">20</td></tr>
<tr><td>CS xxx</td><td>Department Elective – I</td><td>x-x-x</td><td>3</td></tr>
<tr><td>CS xxx</td><td>Department Elective – II</td><td>x-x-x</td><td>3</td></tr>
<tr><td>XX xxx</td><td>Institute Elective – I</td><td>x-x-x</td><td>3</td></tr>
<tr><td>CS 451</td><td>Soft Computing Lab</td><td>0-0-3</td><td>1.5</td></tr>
<tr><td>CS 491</td><td>B.Tech. Project (Stage 1)</td><td>0-0-12</td><td>6</td></tr>
<tr><td>CS 391</td><td>Evaluation of Summer Internship</td><td>0-2-0</td><td>2</td></tr>
<tr><td colspan="3">Total</td><td>21.5</td><td></td><td></td><td colspan="2">Total</td><td>20</td></tr>
</table>

Curriculum of 4th Year B. Tech. (CSE) (From AY 2026-27 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Course Code**	**Course Code**	**Credits**
ZZ xxx	Course-V for Minor Program	x-x-x	2
CS 493N	B Tech Project (BTP)	0-0-32	16
CS 495	Internship - I	x-x-x	1
CS 497	Internship - II	x-x-x	1
	Total	**0-0-32**	**18/20**

Semester VIII

Curriculum of 4th Year B. Tech. (CSE) (From AY 2011-12 to AY 2013-14)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
CS 402	Parallel Computing	3-0-0	3
CS 452	Parallel Computing Lab	0-0-3	1.5
CS xxx	Department Elective - III	x-x-x	3
CS xxx	Department Elective - IV	x-x-x	3
XX xxx	Institute Elective – II	x-x-x	3
CS 492	B. Tech. Project (Stage 2)	0-0-12	6
		Total	**19.5**

Curriculum of 4th Year B. Tech. (CSE) (From AY 2014-15 to AY 2015-16)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
CS 401 / CS 601	Soft Computing %	2-0-2	3
CS 402	Parallel Computing %	2-0-2	3
ZZ xxx	Elective-I	x-x-x	3
ZZ xxx	Elective-II	x-x-x	3
ZZ xxx	Elective-III	x-x-x	3
ZZ xxx	Elective-IV	x-x-x	3
		Total	**18**
From AY 2016-17 to AY 2019-20			
CS 419 / ICS 419	Computer Vision	2-1-0	3
ZZ xxx	Elective-I	x-x-x	3
ZZ xxx	Elective-II	x-x-x	3
ZZ xxx	Elective-III	x-x-x	3
ZZ xxx	Elective-IV (or Course-IV for Minor	x-x-x	3

			Program)		
		ZZ xxx	Elective-V (or Course-V for Minor Program)	x-x-x	3
				Total	18
		From AY 2020-21 to AY 2025-26			
		CS 419 / ICS 419	Computer Vision	2-1-0	3
		CS xxx	Department Elective-I	x-x-x	3
		CS xxx	Department Elective-II	x-x-x	3
		CS xxx	Department Elective-III	x-x-x	3
		ZZ xxx	Open Elective-I (or Course-IV for Minor Program)	x-x-x	3
		ZZ xxx	Open Elective-II (or Course-V for Minor Program)	x-x-x	3
				Total	**18**

Curriculum of 4th Year B. Tech. (CSE) (From AY 2026-27 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Course Code**	**Course Code**	**Credits**
CS 4XX	Department Elective VI	x-x-x	3
CS 4XX	Department Elective VII	x-x-x	3
ZZ 4XX	Institute Elective IV	x-x-x	3
ZZ 4XX	Institute Elective V	x-x-x	3
ZZ 4XX	Institute Elective VI	x-x-x	3
	Total	**X-X-X**	**15**

CSE courses available for the Elective Courses of BTech Program in CSE

CS 211 : UX/UI Design (2-0-2-3)
CS 213 : Matrix Factorization and Applications (2-1-0-3)
CS 215 : Mathematics for AI and ML (2-1-0-3)
CS 212 : Foundation of Algebraic Graph Theory (2-1-0-3)
CS 214: Foundations of Hardware Security (2-1-0-3)
CS 216 : Introduction to Blockchain (2-1-0-3) – ½ semester
CS 315 : Introduction to Complexity Theory (2-1-03)
CS 317 : Introduction to Internet of Things (2-1-0-3)
CS 319 : Foundations of Cryptography (2-1-0-3)
CS 321 : Introduction to Big Data Analysis (2-1-0-3)
CS 312 : Foundations of Secure Computation (2-1-0-3)
CS 314 : Computer and Network Security (2-1-0-3)
CS 401 / CS 601 : Soft Computing (2-0-2-3)
CS 403/ CS 603 : Machine Learning (2-0-2-3)
CS 404 / EE 304 : Digital Signal Processing (3-1-0-4)
CS 406 / CS 606 : Data Mining and Data Warehousing (2-0-2-3)
CS 407 : Peripherals and Interfaces (2-0-2-3)
CS 408 : Algorithms for Convex Programming (2-0-2-3)
CS 409 / CS 609 : Advanced Topics in Database Management Systems (2-1-0-3)
CS 410 : Genetic Algorithms (2-0-2-3)
CS 411/ CS 611 : Advanced Algorithms (2-0-2-3)
CS 412/ CS 612 : Pattern Recognition (2-0-2-3)
CS 413 : Topics in Artificial Intelligence Programming (2-1-0-3)
CS 414 / CS 614 : Cloud Computing and Applications (2-1-0-3)
CS 416 / CS 616 : Service Oriented Systems (2-1-0-3)
CS 417 / CS 617 : Cryptography and Network Security (2-0-2-3)
CS 418 / CS 618 : Systems and Usable Security (2-1-0-3)
CS 419 / ICS 419 / CS 619: Computer Vision (2-1-0-3) [From AY 2016-17 onward, it will be a compulsory course]
CS 420 / CS 620 : Embedded Systems (2-1-0-3)
CS 422 / CS 622 : Numerical Simulation (2-1-0-3)
CS 424 : Functional and Logic Programming (2-0-2-3)
CS 425 / CS 625 : Natural Language Processing (2-0-2-3)

CS 426/ CS 626 : Foundations of Cyber-Physical Systems (2-0-2-3)
CS 427/ CS 627 : Advanced Computer Networks (2-1-0-3)
CS 428/ CS 628 : Algorithmic Graph Theory (2-1-0-3)
CS 430/ CS 630 : Data Center Networking (2-1-0-3)
CS 432/ CS 632 : Reinforcement Learning (2-0-2-3)
CS 334/ CS 434/ CS 634: Wireless Networks and Applications (2-1-0-3)
CS 435/ CS 635 : Deep Learning (2-0-2-3)
CS 438/ CS 638 : Network Softwarization and Management (2-0-2-3)
CS 440/640 : Distributed Network Algorithms (2-1-0-3)
CS 442 : Generative AI (2-1-0-3)
CS 444 : Advanced Blockchain (2-1-0-3)
CS 446 : Blockchain for Responsible Computing (2-1-0-3)

Curriculum for BTech (Electrical Engineering)

Semester III

Curriculum of 2nd Year B. Tech. (EE) (From AY 2011-12 to AY 2013-14)					**Curriculum of 2nd Year B. Tech. (EE)** [From AY 2014-15 to AY 2023-24]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**		**Course Code**	**Course Title**	**Weekly L-T-P**	**Credits**
HS 201 / HS 203 / HS 205 HS 207	Understanding Philosophy / Psychology / Sociology / French Language – I	3-0-0 / 3-0-0 / 2-1-0 / 2-1-0	3 / 3 / 3 / 3		ZZ XXX	Course-I for Minor Program	X-X-X	3
MA 201	Mathematics-III (Complex Analysis and Differential Equations-II)	3-1-0	4		MA 203	Complex Analysis and Differential Equations-II	3-1-0	4
EE 201	Network Theory	2-1-0	3		EE 201	Network Theory	2-1-0	3
EE 203	Electronic Devices	2-1-0	3		EE 203	Electronic Devices	2-1-0	3
EE 205	Introduction to Electrical Systems	3-1-0	4		EE 205	Introduction to Electrical Systems	3-1-0	4
EE 253	Electronic Devices Lab	0-0-3	1.5		EE 253	Electronic Devices Lab	0-0-3	1.5
IC 211	Experimental Engineering Lab	0-0-3	1.5		IC 211	Experimental Engineering Lab	0-0-3	1.5
	Total	**13/12-4/5-6**	**20**			**Total**	**10-4-6**	**17 / 20**

Curriculum of 2nd Year B. Tech. (EE) (From AY 2024-25 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Course Code**	**Course Code**	**Credits**
ZZ 2XX	Course-I for Minor Program	X – X - X	3
MA 205	Complex Analysis	3 - 1- 0 (Half Semester)	2
MA 207	Differential Equations - II	3 - 1- 0 (Half Semester)	2
EE 201	Network Theory	2 - 1- 0	3
EE 203	Electronic Devices	2 – 1 - 0	3
EE 207	Electric Machines	2 – 1 - 0	3
EE 209	Digital Systems	2 – 1 - 0	3
EE 253N	Electronic Devices Lab	0 – 0 - 2	1
EE 259	Digital Systems Lab	0 – 0 - 2	1
EE 251	Electrical Networks Lab	0 – 0 - 2	1
EE 2XX	Department Elective I	x-x-x	3
	Total	**X-X-X**	**22/25**

Semester IV

Curriculum of 2nd Year B. Tech. (EE) (From AY 2011-12 to AY 2013-14)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
HS 208	French Language – II +	2-1-0	3
MA 204	Numerical Methods	3-1-0	4
EE 202	Signals and Systems	3-1-0	4
EE 204	Analog Circuits	3-0-0	3
EE 206	Electrical Machines and Power Electronics	3-0-0	3

Curriculum of 2nd Year B. Tech. (EE) [From AY 2014-15 i.e. 2013 BTech (EE) batch to AY 2023-24]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ZZ XXX	Course-II for Minor Program	X-X-X	3
MA 204	Numerical Methods	3-0-2	4
EE 202	Signals and Systems	3-1-0	4
EE 204	Analog Circuits	2-1-0	3
EE 206	Electrical Machines and Power Electronics	2-1-0	3

EE 208	Digital Systems	2-1-0	3		EE 208	Digital Systems	2-1-0	3
EE 254	Analog Circuits Lab	0-0-3	1.5		EE 254	Analog Circuits Lab	0-0-3	1.5
EE 256	Electrical Machines Lab	0-0-4	2		EE 256	Electrical Machines Lab	0-0-4	2
EE 258	Digital Systems Lab	0-0-3	1.5		EE 258	Digital Systems Lab	0-0-3	1.5
	Total	**14/16-3/4-10**	**22 / 25**			**Total**	**14-3-10**	**22 / 25**

+ Additional course ONLY for those students who have taken and passed HS 207 in their 3rd Semester.

Curriculum of 2nd Year B. Tech. (EE)
(From AY 2024-25 onwards) (Batch admitted in and after AY 2023-24)

Course Code	Course Code	Course Code	Credits
ZZ 2XX	Course-II for Minor Program	X – X - X	3
MA 204N	Numerical Methods	2 – 0 - 2	3
EE 202N	Signals and Systems	2 – 1 - 0	3
EE 204	Analog Circuits	2 – 1 - 0	3
EE 212	Power Electronics	2 – 1 - 0	3
EE 254	Analog Circuits Lab	0 – 0 - 3	1.5
EE 252	Electric Machines and Power Electronics Lab	0 – 0 - 3	1.5
EE 2XX	Department Elective II	x-x-x	3
ZZ 2XX	Institute Open Elective I	x-x-x	3
	TOTAL		21/24

Curriculum for BTech (Electrical Engineering)

Semester V

Curriculum of 3rd Year B. Tech. (EE) (From AY 2011-12 to AY 2013-14)			
Course Code	Course Title	Weekly L-T-P	Credits
HS xxx	HSS Course	3-0-0	3
EE 301	Microprocessors	3-0-0	3
EE 303	Probability and Random Processes	2-1-0	3
EE 305	Electromagnetic Waves	3-0-0	3
EE 307	Communication Systems	3-0-0	3
EE 309	Electrical Measurements and Instrumentation	3-0-0	3
EE 351	Microprocessors Lab	0-0-3	1.5
	Total	**17-1-3**	**19.5**

Curriculum of 3rd Year B. Tech. (EE) [From AY 2014-15 to AY 2024-25]			
Course Code	Course Title	Weekly L-T-P	Credits
ZZXXX HS XXX	Course-III for Minor Program * HSS Elective (for 2012 batch only)	X-X-X X-X-X	3 3
EE 301N	Microprocessors and Digital Systems Design	2-1-0	3
EE 303	Probability and Random Processes	2-1-0	3
EE 305	Electromagnetic Waves	2-1-0	3
EE 307	Communication Systems	2-1-0	3
EE 309	Electrical Measurements and Instrumentation	2-1-0	3
EE 311	VLSI Systems and Technology	2-1-0	3
EE 351N	Microprocessors and Digital Systems Design Lab	0-0-3	1.5
	Total	**14-1-3**	**22.5**

Curriculum of 3rd Year B. Tech. (EE) (From AY 2025-26 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	Course Code	Course Code	Credits
ZZ 3XX	Course – III for Minor Program	X – X - X	3
EE 301N	Microprocessors and Digital Systems Design	2 – 1 - 0	3
EE 313	Communication Systems Theory	2 – 1 - 0	3
EE 305	Electromagnetic Waves	2 – 1 - 0	3
EE 315	Power Systems	2 – 1 - 0	3

EE 317	Digital Signal Processing	2 – 1 - 0	3
EE 351N	Microprocessors and Digital Systems Design Lab	0 – 0 - 2	1
EE 3XX	Department Elective III	x-x-x	3
ZZ 3XX	Institute Open Elective II	x-x-x	3
	TOTAL		**22/ 25**

Semester VI

Curriculum of 3rd Year B. Tech. (EE) (From AY 2011-12 to AY 2013-14)					**Curriculum of 3rd Year B. Tech. (EE)** [From AY 2014-15 to AY 2024-25]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**		**Course Code**	**Course Title**	**Weekly L-T-P**	**Credits**
HS 302 ES 302	Environmental Studies: Social Aspects (Half Semester course) Environmental Studies: Scientific and Engineering Aspects (Half Semester course)	3-0-0 3-0-0	1.5 1.5		HS 302 ES 302	Environmental Studies: Social Aspects (Half Semester course) Environmental Studies: Scientific and Engineering Aspects (Half Semester course)	3-0-0 3-0-0	1.5 1.5
EE 302	Control Systems	2-1-0	3		EE 302	Control Systems	2-1-0	3
EE 304	Digital Signal Processing	3-1-0	4		EE 304 / CS 404	Digital Signal Processing	3-1-0	4
EE 306	Digital Communications	3-0-0	3		EE 306	Digital Communications	2-1-0	3
EE 308	Power Systems	2-1-0	3		EE 308	Power Systems	2-1-0	3
EE 352	Control Systems Lab	0-0-3	1.5		EE 352	Control Systems Lab	0-0-3	1.5
EE 356	Communications Lab	0-0-3	1.5		EE 356	Communications Lab	0-0-3	1.5
EE 391	Summer Internship (After the completion of the 6th semester)							
	Total	**13-3-6**	**19**			**Total**	**13-3-6**	**19**

*From 2013 BTech batch onwards

Curriculum of 3rd Year B. Tech. (EE) (From AY 2025-26 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Course Code**	**Course Code**	**Credits**
ZZ 3XX	Course – IV for Minor Program	x-x-x	3
EE 302	Control Systems	2 – 1 - 0	3
EE 306	Digital Communications	2 – 1 - 0	3
EE 310	VLSI Systems and Technology	2 – 0 - 2	3
EE 352N	Control Systems Lab	0 – 0 - 3	1.5
EE 356N	Communications Lab	0 – 0 - 2	1
EE 3XX	Department Elective IV	x-x-x	3
EE 3XX	Department Elective V	x-x-x	3
ZZ 3XX	Institute Open Elective III	x-x-x	3
	TOTAL		**20.5/23.5**

Curriculum for BTech (Electrical Engineering)

Semester VII

Curriculum of 4th Year B. Tech. (EE) (From AY 2011-12 to AY 2014-15)					Curriculum of 4th Year B. Tech. (EE) [From AY 2015-16 to AY 2025-26]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**		**Course Code**	**Course Title**	**Weekly L-T-P**	**Credits**
EE 401	VLSI Systems and Technology	3-0-0	3		EE 493	**B Tech Project (BTP)** 1. Student can do B Tech project either outside the institute or within the institute under a supervision of an IIT Indore Faculty. 2. Summer Internship, if any, will be part of B Tech Project. 3. The choice is to be made latest by 30th April. 4. Duration: 6-7 months during 2nd week of May to Last week of Nov. 5. Last Date of Thesis submission: 1st week of Dec. 6. Last Date of Submission of Grades: 2nd week of Dec.	0-0-40	20
EE 403	Digital Systems Design	3-0-0	3					
EE xxx	Department Elective-I	x-x-x	3					
XX xxx	Institute Elective-I	x-x-x	3					
EE 453	Digital Systems Design Lab	0-0-3	1.5					
EE 491	B.Tech. Project (Stage 1)	0-0-12	6					
EE 391	Evaluation of Summer Internship	0-2-0	2					
		Total	**21.5**				**Total**	**20**

Curriculum of 4th Year B. Tech. (EE) (From AY 2026-27 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Course Code**	**Course Code**	**Credits**
ZZ 4XX	**Course - V for Minor Program**	**X – X - X**	**2**
ZZ 4XX	**Internship I / II**	**X – X - X**	**2**
EE 493N	**B.Tech. Project (BTP)**	**0 – 0 - 32**	**16**
	TOTAL		**18/20**

Semester VIII

Curriculum of 4^{th} Year B. Tech. (EE)
(From AY 2011-12 to AY 2014-15)

Course Code	Course Title	Weekly L-T-P	Credits
EE xxx	Department Elective – II	x-x-x	3
EE xxx	Department Elective - III	x-x-x	3
EE xxx	Department Elective - IV	x-x-x	3
EE xxx	Department Elective - IV	x-x-x	3
XX xxx	Institute Elective – II	x-x-x	3
EE 492	B. Tech. Project (Stage 2)	0-0-12	6
		Total	**21**

Curriculum of 4^{th} Year B. Tech. (EE)
[From AY 2015-16 to AY 2019-20]

Course Code	Course Title	Weekly L-T-P	Credits
ZZ xxx	Elective-I	x-x-x	3
ZZ xxx	Elective-II	x-x-x	3
ZZ xxx	Elective-III	x-x-x	3
ZZ xxx	Elective-IV (or Course-IV for Minor Program *)	x-x-x	3
ZZ xxx	Elective-V (or Course-V for Minor Program *)	x-x-x	3
		Total	**15**

Curriculum of 4^{th} Year B. Tech. (EE)
[From AY 2019-20 to AY 2025-26]

EE xxx	Department Elective-I	x-x-x	3
EE xxx	Department Elective-II	x-x-x	3
EE xxx	Department Elective-III	x-x-x	3
ZZ xxx	Open Elective-I (or Course-IV for Minor Program *)	x-x-x	3
ZZ xxx	Open Elective-II (or Course-V for Minor Program *)	x-x-x	3
		Total	**15**

*Applicable for 2013 BTech batch onwards ONLY

Curriculum of 4th Year B. Tech. (EE) (From AY 2026-27 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Course Code**	**Course Code**	**Credits**
EE 4XX	Department Elective VI	X – X - X	3
EE 4XX	Department Elective VII	X – X - X	3
ZZ 4XX	Institute Elective IV	X – X - X	3
ZZ 4XX	Institute Elective V	X – X - X	3
ZZ 4XX	Institute Elective VI	X – X - X	3
	Total		**15**

Curriculum of **5-Year Degree Program with BTech (EE) and MTech (CSP) or BTech + PhD (from AY 2015-16 onwards)**

Semester VII

Course Code	Course Name	Weekly L-T-P	Credits
EE 603	Optimization Techniques	2-1-0	3
EE 641 / EE 441	Advanced Signal Processing	2-1-0	3
EE 643	Detection and Estimation Theory	2-1-0	3
EE 701	Time-Frequency Analysis	2-1-0	3
ZZ XXX	Elective-I	X-X-X	3
Total minimum credits earned during the semester			**15**

Semester VIII

Course Code	Course Name	Weekly L-T-P	Credits
CS 601 / CS 401	Soft Computing	2-0-2	3
EE 642	Wireless Communication	2-1-0	3
EE 644	Image Processing	2-1-0	3
EE 646 / EE 446	Information and Coding Theory	2-1-0	3
ZZ XXX	Elective-II	X-X-X	3
EE 698	PG seminar course	0-2-0	2
Total minimum credits earned during the semester			**17**

Semester IX

Course Code	Course Name	Weekly L-T-P	Credits (Grade)
EE 799 (ZZ 899 +)	M. Tech. Research Project (Stage-I) (**PhD Thesis)**	0-0-36	18 (SS/US)

Semester X

Course Code	Course Name	Weekly L-T-P	Credits (Grade)
EE 800 (ZZ 899)	M. Tech. Research Project (Stage-II) / (**PhD Thesis)**	0-0-36	18 (SS/US)

+ A student will have choice to convert his/her MTech program to the PhD program during its 2nd semester of MTech or 8th semester of BTech + MTech program.

Engineering Courses for Elective-I @			
Course Code	**Course Name**	**Contact hours (L-T-P)**	**Credits**
EE 625	VLSI Signal Processing	2-1-0	3
EE 645	Mathematical Methods for Signal Processing	2-1-0	3
CS 617 / CS 417	Cryptography & Network Security	2-1-0	3

Engineering Courses for Elective-II @			
Course Code	**Course Name**	**Contact hours (L-T-P)**	**Credits**
EE 622 / EE 422	Digital Circuit Design	2-1-0	3
EE 628 / EE 428	Advanced Memory Technology	2-1-0	3
EE 740	Speech Signal Processing	2-1-0	3
EE 742	MIMO Wireless Communications	2-1-0	3
ME 644 / ME 444	Robotics	2-1-0	3
CS 606 / CS 406	Data Mining and Data Warehousing	2-0-2	3
CS 618 / CS 418	Systems and Usable Security	2-1-0	3

@ In addition to this course list, a student can also opt from the PG courses being offered by the other Departments.

EE Courses available for the Elective Courses of BTech Programs in EE (From AY 2014-15 onwards)

EE 211 : Applied Probability for Communication Engineering (2-1-0-3)

EE 213 : Fundamentals of Optimization (2-1-0-3)

EE 214 : Electronic Instrumentation (2-1-0-3)

EE 216 : Machine Learning for Signal Processing (2-1-0-3)

EE 319 : Design and Analysis of Communication Networks (2-1-0-3)

EE 321 : Design of Photovoltaic Systems (2-1-0-3)

EE 312 : Microwave and Satellite Communication (2-1-0-3)

EE 314 : Restructured Power Systems (2-1-0-3)

EE 316 : RF Devices for Guided and Wireless Transmission (2-1-0-3)

EE 410 / EE 610 : Power Electronics Applications to Power Transmission (2-1-0-3)

EE 411 : Communication System Theory (2-1-0-3)

EE 412 / EE 612 : Digital Communication Systems (2-1-0-3)

EE 413 : Discrete Data and Digital Control (2-1-0-3)

EE 414 : Special Semiconductor Devices (2-1-0-3)

EE 415 : Electronic Instrumentation (2-1-0-3)

EE 416 : Industrial Instrumentation (2-1-0-3)

EE 417 : Analog Filters (2-1-0-3)

EE 418 : Control System Design (2-1-0-3)

EE 419 / EE 619 : Biomedical Optics (2-1-0-3)

EE 420 / EE 620 : IC Fabrication Technology (2-1-0-3)

EE 421 / EE 621 : MOS Devices and Modeling (2-1-0-3)

EE 422 / EE 622 : Digital Circuit Design (2-1-0-3)

EE 424 / EE 724 : Advanced Micro-processes and Nanotechnology (2-1-0-3)

EE 426 / EE 626 : MOSFET Reliability Issues (2-1-0-3)

EE 427 : Physics of Semiconductor Devices (2-1-0-3)

EE 428 / EE 628 : Advanced Memory Technology (2-1-0-3)

EE 429 / EE 629 : Nanotechnology and Nanoelectronics (2-1-0-3)

EE 430 / EE 630 : Analog CMOS IC Design (2-1-0-3)

EE 431 / IEE 431/ EE 631 : Organic Electronics (2-1-0-3)

EE 432 / EE 632 : Optoelectronics (2-1-0-3)

EE 434 / EE 634 : Semiconductor Based Devices (2-1-0-3)

EE 435 / EE 635 : VLSI Technology (2-1-0-3)

EE 436 : Microwave and Satellite Communication (2-1-0-3)

EE 438 : Computer Control and Automation of Power Systems (2-1-0-3)

EE 440 / EE 640 : Analog and Mixed Signal IC Design (2-1-0-3)

EE 441/ EE 641 : Advanced Signal Processing (2-1-0-3)

EE 446 / EE 646 : Information and Coding Theory (2-1-0-3)

EE 447/ EE 647 : Advanced Photonics (2-1-0-3)

EE 448/ EE 648 : Antennas and Propagation (2-1-0-3)

EE 450/ EE 650 : Internet of Things (IoT) Networks (2-1-0-3)

EE 450N/ EE 650N : IoT Communication Networks (2-1-0-3)

EE 455/ EE 655 : Optical Wireless Communications (2-1-0-3)

EE 483/ EE 683 : Error Correcting Codes (2-1-0-3)

EE 484/ EE 684 : Power System Protection (2-1-0-3)

Curriculum for BTech (Mechanical Engineering)

Semester III

Curriculum of 2nd Year B. Tech. (ME) (From AY 2011-12 to AY 2013-14)					Curriculum of 2nd Year B. Tech. (ME) [From AY 2014-15 to 2023-24]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**		**Course Code**	**Course Title**	**Weekly L-T-P**	**Credits**
HS 201 / HS 203 / HS 205 HS 207	Understanding Philosophy / Psychology / Sociology / French Language – I	3-0-0 / 3-0-0 / 2-1-0 / 2-1-0	3 / 3 / 3 / 3		ZZ XXX	Course-I for Minor Program *	X-X-X	3
ME 201	Solid Mechanics	3-1-0	4		ME 201	Solid Mechanics	3-1-0	4
ME 203	Fluid Mechanics	3-1-0	4		ME 203	Fluid Mechanics	3-1-0	4
ME 205	Materials Science	2-1-0	3		MM 205	Materials Science	2-1-0	3
ME 251	Solid Mechanics Lab	0-0-3	1.5		ME 251	Solid Mechanics Lab	0-0-3	1.5
ME 257	Machine Drawing	1-0-3	2.5		ME 257	Machine Drawing	1-0-3	2.5
IC 211	Experimental Engineering Lab	0-0-3	1.5		IC 211	Experimental Engineering Lab	0-0-3	1.5
	Total	**12/11-3/4-9**	**19.5**			**Total**	**9-3-9**	**16.5 / 19.5**

Curriculum of 2nd Year B. Tech. (ME) [From AY 2024-25 onwards] (Batch admitted in and after AY 2023-24)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ZZ XXX	Course-I for Minor Program	X-X-X	3
MA 205	Complex Analysis	3-1-0 (1/2 Sem)	2
MA 207	Differential Equations-II	3-1-0 (1/2 Sem)	2
ME 203N	Fluid Mechanics	2-1-0	3
ME 205N	Materials Science and Engineering	2-1-0 (1/2 Sem)	1.5
ME 207	Principles of Industrial Engineering	2-1-0	3

ME 201N	Solid Mechanics	2-1-0	3
ME 209	Thermodynamics	2-1-0	3
ME 251N	Solid Mechanics Lab	0-0-2	1
ME 2XX	Department Elective I	X-X-X	3
	Total		**21.5/23.5**

Semester IV

Curriculum of 2nd Year B. Tech. (ME) (From AY 2011-12 to AY 2013-14)					Curriculum of 2nd Year B. Tech. (ME) [From AY 2014-15 to 2023-24]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**		**Course Code**	**Course Title**	**Weekly L-T-P**	**Credits**
HS 208	French Language – II +	2-1-0	3		ZZ XXX	Course-II for Minor Program	X-X-X	3
MA 204	Numerical Methods	3-1-0	4		MA 204	Numerical Methods	3-0-2	4
ME 202	Strength of Materials	3-1-0	4		ME 202	Strength of Materials	3-1-0	4
ME 204	Fluid Machinery	3-0-0	3		ME 204	Fluid Machinery	2-1-0	3
ME 206	Thermodynamics	3-1-0	4		ME 206	Thermodynamics	3-1-0	4
ME 208	Theory of Manufacturing Processes	3-0-0	3		ME 208	Theory of Manufacturing Processes	2-1-0	3
ME 254	Fluid Mechanics and Machinery Lab	0-0-3	1.5		ME 254	Fluid Mechanics and Machinery Lab	0-0-3	1.5
ME 258	Manufacturing Processes Lab	0-0-3	1.5		ME 258	Manufacturing Processes Lab	0-0-3	1.5
	Total	**15/17-3/4-6**	**21 / 24**			**Total**	**15-3-6**	**21 / 24**

+ ONLY for those students who have taken and passed HS 207 in their 3rd Semester.

Curriculum of 2nd Year B. Tech. (ME) [From AY 2024-25 onwards] **(Batch admitted in and after AY 2023-24)**			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ZZ xxx	Course-II for Minor Program	x-x-x	3
MA 204N	Numerical Methods	2-0-2	3
ME 204N	Fluid Machinery	2-0-0	2
ME 202N	Strength of Materials	2-1-0	3
ME 208	Theory of Manufacturing Processes	2-1-0	3
ME 214	Introduction to Additive Manufacturing	2-1-0 (1/2 Sem)	1.5
ME 256	Computer Aided Machine Drawing	1-0-2	2
ME 254N	Fluid Mechanics and Machinery Lab	0-0-2	1
ME 258N	Manufacturing Processes Lab	0-0-2	1
ME 2XX	Department Elective II	x-x-x	3
ZZ 2XX	Institute Elective I	x-x-x	3
	Total		**22.5/25.5**

Curriculum for BTech (Mechanical Engineering)

Semester V

Curriculum of 3rd Year B. Tech. (ME) (From AY 2011-12 to AY 2013-14)					**Curriculum of 3rd Year B. Tech. (ME)** [From AY 2014-15 to 2024-25]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**		**Course Code**	**Course Title**	**Weekly L-T-P**	**Credits**
HS xxx	HSS Course	3-0-0	3		ZZ XXX HS XXX	Course-III for Minor Program * HSS Elective (for 2012 batch only)	X-X-X	3 3
ME 301	Heat Transfer	3-1-0	4		ME 301	Heat Transfer	3-1-0	4
ME 303	Kinematics and Dynamics of Machines	3-1-0	4		ME 303	Kinematics and Dynamics of Machines	3-1-0	4
ME	Machining Science and Metrology	3-0-0	3		ME	Machining Science and Metrology	2-1-0	3

305					305			
ME 307	Principles of Industrial Engineering	3-0-0	3		ME 307	Principles of Industrial Engineering	2-0-2	3
ME 351	Heat Transfer Lab	0-0-3	1.5		ME 351	Heat Transfer Lab	0-0-3	1.5
ME 353	Kinematics and Dynamics of Machines Lab	0-0-3	1.5		ME 353	Kinematics and Dynamics of Machines Lab	0-0-3	1.5
ME 355	Machining Science and Metrology Lab	0-0-2	1		ME 355	Machining Science and Metrology Lab	0-0-2	1
	Total	**15-2-8**	**21**			**Total**	**11-2-10**	**18 / 21**

Semester VI

Curriculum of 3rd Year B. Tech. (ME) (From AY 2011-12 to AY 2013-14)					**Curriculum of 3rd Year B. Tech. (ME)** [From AY 2014-15 to AY 2024-25]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**		**Course Code**	**Course Title**	**Weekly L-T-P**	**Credits**
HS 302 ES 302	Environmental Studies: Social Aspects (Half Semester course) Environmental Studies: Scientific and Engineering Aspects (Half Semester course)	3-0-0 3-0-0	1.5 1.5		HS 302 ES 302	Environmental Studies: Social Aspects (Half Semester course) Environmental Studies: Scientific and Engineering Aspects (Half Semester course)	3-0-0 3-0-0	1.5 1.5
ME 302	Applied Thermodynamics	3-0-0	3		ME 302	Applied Thermodynamics	2-1-0	3
ME 304	Instrumentation and Control Systems	3-0-0	3		ME 304	Instrumentation and Control Systems	2-1-0	3
ME 306	Machine Design-I	2-2-0	4		ME 306	Machine Design-I	2-2-0	4
ME 308	Quality Management	3-0-0	3		ME 308	Quality Management	2-1-0	3
ME 352	Applied Thermodynamics Lab	0-0-3	1.5		ME 352	Applied Thermodynamics Lab	0-0-3	1.5
ME 354	Instrumentation and Control Systems Lab	0-0-3	1.5		ME 354	Instrumentation and Control Systems Lab	0-0-3	1.5

ME 391	Summer Internship (After the completion of the 6th semester)							
	Total	**14-2-6**	**19**			**Total**	**14-2-6**	**19**

Curriculum for BTech (Mechanical Engineering)

Semester VII

Curriculum of 4th Year B. Tech. (ME) (From AY 2011-12 to AY 2013-14)					**Curriculum of 4th Year B. Tech. (ME)** [From AY 2014-15 onwards]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**		**Course Code**	**Course Title**	**Weekly L-T-P**	**Credits**
ME 401	Machine Design-II	2-2-0	4		ME 493	**B Tech Project (BTP)** 1. Student can do B Tech project either outside the institute or within the institute under a supervision of an IIT Indore Faculty. 2. Summer Internship, if any, will be part of B Tech Project. 3. The choice is to be made latest by 30th April. 4. Duration: 6-7 months during 2nd week of May to Last week of Nov. 5. Last Date of Thesis submission: 1st week of Dec 6. Last Date of Submission of Grades: 2nd week Dec.	0-0-40	20
ME xxx	Department Elective-I	3-0-0	3					
ME xxx	Department Elective-II	x-x-x	3					
XX xxx	Institute Elective-I	x-x-x	3					
ME 491	B.Tech. Project (Stage 1)	0-0-12	6					
ME 391	Evaluation of Summer Internship	0-2-0	2					
		Total	21			**Total**		**20**

Semester VIII

Curriculum of 4th Year B. Tech. (ME) (From AY 2011-12 to AY 2013-14)			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ME xxx	Department Elective – III	x-x-x	3
ME xxx	Department Elective – IV	x-x-x	3
ME xxx	Department Elective - V	x-x-x	3
ME xxx	Department Elective - VI	x-x-x	3
XX xxx	Institute Elective – II	x-x-x	3
ME 492	B. Tech. Project (Stage 2)	0-0-12	6
	Total		**21**

Curriculum of 4th Year B. Tech. (ME) [From AY 2014-15 to AY 2019-20]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ME 401	Machine Design-II	2-2-0	4
ZZ xxx	Elective-I	x-x-x	3
ZZ xxx	Elective-II	x-x-x	3
ZZ xxx	Elective-III	x-x-x	3
ZZ xxx	Elective-IV (or Course-IV for Minor Program*)	x-x-x	3
ZZ xxx	Elective-V (or Course-V for Minor Program*)	x-x-x	3
	Total		**19**

Curriculum of 4th Year B. Tech. (ME) [From AY 2020-21 to AY 2025-26]			
ME 401	Machine Design-II	2-2-0	4
ME xxx	Department Elective-I	x-x-x	3
ME xxx	Department Elective-II	x-x-x	3
ME xxx	Department Elective-III	x-x-x	3
ZZ xxx	Open Elective-I (or Course-IV for Minor Program*)	x-x-x	3
ZZ xxx	Open Elective-II (or Course-V for Minor Program*)	x-x-x	3
		Total	**19**

From the 2013 BTech batch onwards.

Curriculum of **5-Year Degree Program with BTech (ME) and MTech (PIE) and B Tech + PhD (from AY 2014-15 onwards)**
Semester VII

Course Code	Subject Name	Weekly L-T-P	Credits
ME 655	Advanced Manufacturing Processes	2-1-0	3
ME 657	Mechatronics and Metrology	3-0-2	4
ME 659 / ME 459	Micro and Precision Manufacturing	2-0-2	3
MM 661	Materials Science and Engineering	2-1-0	3
ME 675 / MA 675	Probability and Statistical Methods	2-0-2	3
ZZ XXX	Elective-I	X-X-X	3
		Total	**19**

Semester VIII

Course Code	Subject Name	Weekly L-T-P	Credits
ME 401	Machine Design II *	2-2-0	4
ME 672/ ME 472	Reliability Engineering	2-0-2	3
ME 650	Materials Characterization Techniques	2-0-2	3
ME 660/ ME 460	Technology of Surface Coatings	2-1-0	3
ME 698	PG seminar course	0-2-0	2
ZZ XXX	Elective-II	X-X-X	3
ZZ XXX	Elective-III	X-X-X	3
		Total	**21**

Semester IX

Course Code	Course Name	Weekly L-T-P	Credits (Grade)
ME 799 (ZZ 899^{+})	M. Tech. Research Project (Stage-I) (PhD Thesis)	0-0-36	18 (SS/US)

Semester X

Course Code	Course Name	Weekly L-T-P	Credits (Grade)
ME 800 (ZZ 899 +)	M. Tech. Research Project (Stage-II) (PhD Thesis)	0-0-36	18 (SS/US)
Total minimum credits to be earned during the program			**163.5/ 166.5**

*** Only** for BTech students of IITI admitted to this program**.**

+ A student will have choice to convert his/her MTech program to the PhD program during its 2nd semester of MTech or 8th semester of BTech + MTech program.

Mechanical Engineering Courses for Elective-I @

ME 653/ ME 453	Computer Aided Manufacturing	2-0-2	3
ME 663	Theory of Conventional Machining	2-1-0	3
ME 671/ ME 471 / MA 671	Operations Research	2-0-2	3
ME 751/ ME 451	Theory of Advanced Machining Processes	2-0-2	3

Mechanical Engineering Courses for Elective-II, III @

ME 640/ ME 440	Smart Materials and Structures	2-1-0	3
ME 644/ ME 444	Robotics	2-0-2	3
ME 646/ ME 446	Dynamics and Control Systems	2-1-0	3
ME 648/ ME 448	MEMS and Micro System Design	2-1-0	3
ME 654/ ME454	Rapid Product Manufacturing	2-0-2	3
ME 658/ ME 458	Laser based Measurements and Micro-Manufacturing	2-1-0	3
ME 730	Theory of Elasticity	2-1-0	3
ME 736/ ME 436	Finite Element Analysis	2-0-2	3
ME 738/ ME 438	Composite Materials	2-1-0	3
ME 756/ ME 456	Industrial Automation	2-0-2	3

@ In addition to this course list, a student can also opt from the PG courses being offered by any other Department.

Department Elective - I From AY 2024-25 onwards			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ME 217	Industrial Data Analytics	2-1-0	3
ME 219	Energy Storage Systems	2-1-0 (Half-Sem)	1.5
ME 221	Optical Measurement Techniques in Fluid Mechanics	2-1-0 (Half-Sem)	1.5
ME 223	Design Thinking	2-1-0 (Half-Sem)	1.5
ME 225	Fundamentals of Vibrations	2-1-0 (Half-Sem)	1.5
ME 227	Plastic Parts Manufacturing	2-0-2 (Half-Sem)	1.5

Department Elective - II From AY 2024-25 onwards			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**
ME 216	Thermal Systems and Applications	2-1-0 (Half-Sem)	1.5
ME 218	Quality Management	2-1-0 (Half-Sem)	1.5
ME 220	Fundamentals of Acoustics	2-1-0 (Half-Sem)	1.5
ME 222	Introduction to Experimental Aerodynamics	2-1-0 (Half-Sem)	1.5
ME 224	Fundamentals of Microscale Flows	2-1-0 (Half-Sem)	1.5
ME 228	High Strain rate Forming Process	2-1-0 (Half-Sem)	1.5

Curriculum of 5-Year Degree Program with B.Tech. (ME) and M.Tech. (MSD) and B.Tech. + Ph.D. (from AY 2021-22 onwards)

Semester VII

Course Code	**Subject Code**	**Weekly L-T-P**	**Credits**
ME 646/ ME 446	Dynamics and Control Systems	2-1-0	3
ME 647	Dynamics and Control Systems Lab	0-0-3	1.5
ME 730	Theory of Elasticity	2-1-0	3
ME 736/ ME 436	Finite Element Methods	2-0-2	3
ME 738/ ME 438	Composite Materials	2-1-0	3
ZZ XXX	Elective – I	X-X-X	3
Total minimum credits earned during the semester			**16.5**

Semester VIII

Course Code	Subject Code	Weekly L-T-P	Credits
ME 401	Machine Design II*	2-2-0	4
ME 632/ 432	Vibrations and Noise Control	2-1-0	3
ME 634/ 434	Principle of Product Design	2-1-0	3
ME 637/ 437	Fracture Mechanics	2-1-0	3
ME 656	Vibrations and Noise Control Lab	0-0-3	1.5
ZZ XXX	Elective – II	X-X-X	3
ZZ XXX	Elective – III	X-X-X	3
ME 698	PG seminar course	0-2-0	2
Total minimum credits earned during the semester			**22.5**

Semester IX

Course Code	Subject Code	Weekly L-T-P	Credits (Grades)
ME 799 (ZZ 899^{+})	M.Tech. Research Project (Stage-I) (PhD Thesis)	0-0-36	18 (SS/US)

Semester X

Course Code	Subject Code	Weekly L-T-P	Credits (Grades)
ME 800 (ZZ 899^{+})	M.Tech. Research Project (Stage-II) (PhD Thesis)	0-0-36	18 (SS/US)

Mechanical Engineering Courses for Elective I, II and III @			
Course Code	**Subject Code**	**Weekly L-T-P**	**Credits**
ME 607/ ME 407	Biofluid Mechanics	2-1-0	3
ME 608/ ME 408	Hybrid Electric Vehicles	2-1-0	3
ME 630	Robotic Control Systems	2-1-2	4
ME 639/ 439	Mechanical Behavior of Materials	2-1-0	3
ME 640/ ME 440	Smart Materials and Structures	2-1-0	3

ME 641/ 441	Design of Laminated Composite Structures	2-1-0	3
ME 643/ 443	Micromechanics and Nanomechanics	2-1-0	3
ME 644/ ME 444	Robotics	2-0-2	3
ME 648/ ME 448	MEM.S. and Micro-System Design	2-1-0	3
ME 756/ ME 456	Industrial Automation	2-0-2	3

@ In addition to this course list, a student can also opt from the PG courses being offered by the other Departments.
***Only for B.Tech. students of IITI admitted to this program.**
[+]A student will have choice to convert his/her M.Tech. program to the Ph.D. program during its 2nd semester of M.Tech. or 8th semester of B.Tech. + M.Tech. program.

ME Courses available for the Elective Course in the 8th Semester of BTech in ME (From AY 2014-15 onwards)

ME 406/ ME 606: Smart Materials based Energy Harvesters Design (2-1-0-3)	ME 412 : Energy Conversion (2-1-0-3)
ME 407 / ME 607 : Bio-fluid Mechanics (2-0-2-3 *from AY 2021-22*)	ME 414 : Power Plant Engineering (2-1-0-3)
ME 408/ 608 : Hybrid Electric Vehicles (2-1-0-3)	ME 416 / ME 616 : Non-conventional Energy Sources (2-1-0-3)
ME 411 / ME 611 : Refrigeration and Air Conditioning (2-1-0-3)	ME 418 / ME 618 : Computational Fluid Dynamics (CFD) (2-0-2-3 *from AY 2021-22*)
ME 413 / ME 613 : Internal Combustion (IC) Engines (2-1-0-3)	ME 420/ ME 620 : Alternative Cooling Technologies
ME 431 : Mechanical Vibrations (2-1-0-3)	ME 432/ ME 632 : Vibration and Noise Control (2-1-0-3)
ME 433 : Condition Monitoring and Diagnostics (2-1-0-3)	ME 434/ ME 634 : Principles of Product Design
ME 435 : Experimental Stress Analysis (2-1-0-3)	ME 436 / ME 736 : Finite Element Analysis (FEA) (2-0-2-3)
ME 437/ ME 637 : Fracture Mechanics	ME 438 / ME 738 : Composite Materials (2-1-0-3)
ME 439/ ME 639 : Mechanical Behavior of Materials	ME 440 / ME 640 : Smart Materials and Structures (2-1-0-3)
ME 441/ ME 641 : Design of Laminated Composite Structures	ME 442 : Design for Fatigue and Fracture (2-1-0-3)
ME 443/ ME 643 : Micromechanics and Nanomechanics	ME 444 / ME 644 : Robotics (2-0-2-3)
ME 459 / ME 659 : Micro and Precision Manufacturing (2-0-2-3)	ME 445/ ME 645 : Mobile Robotics (2-0-2-3)
ME 451 / ME 751 : Theory of Advanced Machining Processes (2-0-2-3)	ME 446 / ME 646 : Dynamics and Control Systems (2-1-0-3)
	ME 448 / ME 648 : MEMS and Micro-System Design (2-1-0-3)
ME 453 / ME 653 : Computer Aided Manufacturing (CAM) (2-0-2-3)	ME 454 / ME 654 : Rapid Product Manufacturing (2-0-2-3)
	ME 456 / ME 756 : Industrial Automation (2-0-2-3)
ME 471 / ME 671 : Operations Research (2-0-2-3)	ME 458 / ME 658 : Laser based Measurements and Micro-Manufacturing (2-1-0-3)
ME 473 : Engineering Optimization (2-0-2-3)	
ME 479/ ME 679 : Additive Manufacturing (2-0-2-3)	ME 460 / ME 660 : Technology of Surface Coatings (2-1-0-3)
ME 480/ ME 680 : Laser Material Processing and systems (2-0-2-3)	ME 464/ ME 764 : Microrobotics (2-1-0-3)
	ME 472 / ME 672 : Reliability Engineering (2-0-2-3)

	ME 474 : Non-traditional Optimization Techniques (2-0-2-3)

Curriculum for BTech (Civil Engineering)

2nd Year B. Tech. (Civil Engineering) from AY 2016-17 to AY 2023-24

Semester III

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credits
ZZ XXX	Course-I for Minor Program	X-X-X	3
MA 203	Complex Analysis and Differential Equations-II	3-1-0	4
CE 201	Solid Mechanics	3-1-0	4
CE 203	Fluid Mechanics-I	2-1-0	3
CE 251	Solid Mechanics Lab	0-0-3	1.5
CE 253	Fluid Mechanics Lab-I	0-0-2	1.0
CE 257	Civil Engineering Drawing	1-0-3	2.5
IC 211	Experimental Engineering Lab	0-0-3	1.5
	Total	**9-3-11= 23**	**17.5/20.5**

Curriculum of 2nd Year B. Tech. (CE) [From AY 2024-25 onwards] **(Batch admitted in and after AY 2023-24)**			
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
ZZ 2xx	Course-I for Minor Program	X-X-X	3
MA 205	Complex Analysis	3-1-0 (1/2 semester)	2
MA 207	Differential Equations-II	3-1-0 (1/2 semester)	2
CE 205	Strength of Materials	2- 1- 0	3
CE 203N	Fluid Mechanics	2- 1- 0	3
CE 253N	Fluid Mechanics Lab	0- 0- 3	1.5
CE 207	Building Materials	2- 0- 2	3
CE 209	Surveying	2- 1- 0	3
CE 255	Strength of Materials Lab	0- 0- 2	1
CE 259	Surveying Lab	0- 0- 2	1
CE 2XX	Department Elective I	x-x-x	3
	Total		**22.5/25.5**

Semester IV

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credits
ZZ XXX	Course-II for Minor Program	X-X-X	3
MA 204	Numerical Methods	3-0-2	4
CE 202	Structural Mechanics-I	2-1-0	3
CE 204	Fluid Mechanics-II	2-1-0	3
CE 206	Geodesy-I	2-1-0	3
CE 208	Water and Waste Water Engineering	2-1-0	3
CE 254	Fluid Mechanics Lab-II	0-0-2	1.0
CE 256	Geodesy Laboratory-I	0-0-3	1.5
Total		11-5-5 = 21	18.5 / 21.5

Curriculum of 2nd Year B. Tech. (CE) [From AY 2024-25 onwards] **(Batch admitted in and after AY 2023-24)**			
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
ZZ 2XX	Course-II for Minor Program	X-X-X	3
MA 204N	Numerical Methods	2-0-2	3
CE 210	Structural Analysis-I	2- 1- 0	3
CE 212	Soil Mechanics-I	2- 1- 0	3
CE 214	Engineering Geology	2- 0- 2	3
CE 252	Soil Mechanics Lab I	0- 0- 2	1
CE 218	Environmental Engineering	2- 1- 0	3
CE 258	Environmental Engineering Lab	0- 0- 2	1
CE 2XX	Department Elective II	x-x-x	3
ZZ 2XX	Institute Elective I	x-x-x	3
	Total		**23 /26**

3rd Year B. Tech. (Civil Engineering)

Semester V

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
ZZ XXX	Course-III for Minor Program	X-X-X	3
CE 301	Hydrology	2-1-0	3
CE 303	Soil Mechanics-I	2-1-0	3
CE 305	Structural Mechanics-II	2-1-0	3
CE 307	Design of Structures-I	2-1-0	3
CE 309	Engineering Geology	2-1-0	3
CE 353	Soil Mechanics Laboratory-I	0-0-2	1.0
CE 357	Design Laboratory-I	0-0-3	1.5
CE 359	Engineering Geology Laboratory	0-0-3	1.5
CE 361	Design of Open Channel Flow	1-0-2	2
	Total	**11-4-11 = 26**	**21/24**

Semester VI

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
HS 302 ES 302	Environmental Studies: Social Aspects (Half Semester course) Environmental Studies: Scientific and Engineering Aspects (Half Semester course)	3-0-0 3-0-0	1.5 1.5
CE 302	Geodesy-II	2-1-0	3
CE 304	Soil Mechanics-II	2-1-0	3
CE 306	Structural Mechanics-III	2-1-0	3
CE 308	Design of Structure-II	2-1-0	3
CE 310	Transportation Engineering-I	3-0-2	4
CE 352	Geodesy Lab-II	0-0-3	1.5
CE 354	Soil Mechanics Laboratory-II	0-0-2	1.0
CE 358	Design Laboratory II	0-0-3	1.5
	Total	**15-3-10 = 28**	**23**

4th Year B. Tech. (Civil Engineering)

Semester VII

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
CE 493	**B Tech Project (BTP)** 1. Student can do BTech project either outside the institute or within the institute under a supervision of an IIT Indore Faculty. 2. Summer Internship, if any, will be part of B Tech Project. 3. The choice is to be made latest by 30th April. 4. Duration: 6-7 months during 2nd week of May to Last week of Nov. 5. Last Date of Thesis submission: 1st week of Dec. 6. Last Date of Submission of Grades: 2nd week of Dec.	0-0-40	20
	Total	0-0-40	**20**

Semester VIII (from AY 2016-17 to AY 2019-20)

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
CE 402/ CE 602	Water Resources Engineering	2-1-0	3
CE 404	Design of Structures-III	2-1-0	3
CE 406	Transportation Engineering-II	2-1-0	3
CE 408	Foundation Engineering	2-0-2	3
ZZ xxx	Open Elective-I	x-x-x	3
ZZ xxx	Open Elective-II (or Course-IV for Minor Program)	x-x-x	3
ZZ xxx	Open Elective-III (or Course-V for Minor Program)	x-x-x	3
	Total		**21**

Semester VIII (from AY 2020-21 onwards)

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
CE 402/ CE 602	Water Resources Engineering	2-1-0	3
CE 404	Design of Structures-III	2-1-0	3
CE 406	Transportation Engineering-II	2-1-0	3
CE 408	Foundation Engineering	2-0-2	3
CE xxx	Department Elective-I	x-x-x	3
ZZ xxx	Open Elective-I (or Course-IV for Minor Program)	x-x-x	3
ZZ xxx	Open Elective-II (or Course-V for Minor Program)	x-x-x	3
	Total		**21**

CE Courses available for the Open Elective Courses of BTech in CE (From AY 2024-25 onwards)

CE 211 Smart Cities (2-1-0-3)

CE 213 Optimization Methods in Civil Engineering (2-1-0-3)

CE 220 Water Resources Planning and Management (2-1-0-3)

CE 222 Estimation and Costing (2-1-0-3)

CE 401/ CE 601 Mechanics of Advanced Composite Materials and Structures (2-1-0-3)

CE 410/ CE 610 Offshore Engineering (2-1-0-3)

CE 412/ CE 612 Sustainable Construction (2-1-0-3)

CE 414/ CE 614 Design of Short and Medium Span Bridges (2-1-0-3)

CE 418/ CE 618 Disaster Management (2-1-0-3)

CE 422 Hydraulic Structures (2-1-0-3)

CE 424 Ground Water Hydrology (2-1-0-3)

CE 426 Water Resources Systems (2-1-0-3)

CE 428/ CE 628 Theory of Plates and Shells (2-1-0-3)

CE 430/ CE 630 Elastic Stability (2-1-0-3)

CE 432/ CE 632 Plastic Analysis and Design (2-1-0-3)

CE 434/ 634 Numerical Methods in Civil Engineering (2-1-0-3)

CE 436 Finite Element Analysis (2-1-0-3)

CE 438 Probabilistic and Statistical Methods in Civil Engineering (2-1-0-3)

CE 442 Machine Foundations (2-1-0-3)

CE 444/ CE 644 Solid Waste Engineering and Management (2-0-2-3)

CE 448 Pre-stressed Concrete (2-1-0-3)

CE 462/ CE 662 Structural Dynamics (2-1-0-3)

CE 464/ CE 664 Advanced Solid Mechanics (2-1-0-3)

CE 470 Transportation Planning (2-1-0-3)

CE 472 Advanced Traffic Engineering (2-1-0-3)

CE 474/ CE 674 Road Safety (2-1-0-3)

CE 476 Geo-Informatics in Transportation Engineering (2-1-0-3)

CE 478 Advanced Pavement Material and Design (2-1-0-3)

CE 480 Computer Aided Design of Civil Engineering System (2-1-0-3)

CE 482 Construction Management (2-1-0-3)

CE 484/ CE 684 Advanced Concrete Technology (2-0-2-3)

CE 486 Rock Mechanics and Tunneling Technology (2-1-0-3)

CE 488 Environmental Geotechnics (2-1-0-3)

CE 490 Elements of Remote Sensing (2-1-0-3)

CE 494/ CE 694 Earthquake Engineering (2-1-0-3)

CE 496/ CE 696 Safety of Dams and Reservoirs (2-1-0-3)

CE 4XX/ CE XX Pre-stressed Concrete Design (2-1-0-3)

Curriculum of BTech Program

in

Metallurgy Engineering and Materials Science

(from AY 2016-17 to AY 2021-22)

(Approved in 10th meeting of Senate held on 4th May 2016)

Metallurgical Engineering and Materials Science

(Renamed from AY 2021-22 onwards)

2nd Year B. Tech. (Metallurgical Engineering and Materials Science)

Semester III

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
ZZ XXX	Course-I for Minor Program	X-X-X	3
MA 203	Complex Analysis and Differential Equations-II	3-1-0	4
MM 201	Mechanics of Materials	2-1-0	3
MM 203	Physical Metallurgy-I	2-1-0	3
MM 205	Materials Science	2-1-0	3
MM 207	Thermodynamics	2-1-0	3
MM 251	Mechanics of Materials Lab	0-0-3	1.5
IC 211	Experimental Engineering Lab	0-0-3	1.5
	Total		**19/ 22**

Curriculum of BTech Program in MEMS Semester III (From AY 2024-25 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Subject Name**	**Weekly Contact Hours (L-T-P)**	**Credits**
ZZ xxx	Course-I for Minor Program	x-x-x	3
MA 205	Complex Analysis	3-1-0-2 (1/2 semester)	2
MA 207	Differential Equations-II	3-1-0-2 (1/2 semester)	2
MM 209	Structure of Materials	2-1-0	1.5
MM 211	Physics of Materials	2-1-0	1.5
MM 215	Mechanical Behaviour of Materials	2-1-0	3
MM 217	Transport Phenomena	2-1-0	3
MM 219	Thermodynamics of Materials	2-1-0	3
MM 257	Metallography Lab	0-0-2	1
MM 255	Mechanical Behaviour of Materials Lab	0-0-2	1
MM 2XX	Department Electives	2-1-0	3
Total			21/24

Options for Electives I (III Semester) (From AY 2024-25 onwards) (Batch admitted in and after AY 2023-24)			
Course Code	**Subject Name**	**Weekly Contact Hours (L-T-P)**	**Credits**
MM 221	Finite Element Simulations in Materials	2-1-0	1.5
MM 223	Statistical Mechanics for Materials Science	2-1-0	1.5
MM 225	Materials Economics and Sustainability	2-1-0	1.5
MM 229	Nucleation and Crystal Growth	2-1-0	1.5

Semester IV (Till AY 2023-24)

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
ZZ XXX	Course-II for Minor Program	X-X-X	3
MA 204	Numerical Methods	3-0-2	4
MM 202	Extractive Metallurgy	2-1-0	3
MM 204	Physical Metallurgy–II	2-1-0	3
MM 206	Transport Phenomenon	2-1-0	3
MM 208	Theory of Metal Forming	2-1-0	3
MM 254	Physical Metallurgy Lab	0-0-3	1.5
MM 258	Metal Forming Lab	0-0-3	1.5
	Total		**19/ 22**

4th Curriculum of BTech Program in MEMS (IV Semester) (From AY 2024-25 onwards) (From Batch admitted in and after 2023)			
Course Code	**Subject Name**	**Weekly Contact Hours (L-T-P)**	**Credits**
ZZXXX	Course -II for minor program	X-X-X	3
MA 204N	Numerical Methods	2-0-2	3
MM 212	Casting and Welding Technology	2-1-0 (Half Semester)	1.5
MM 210	Powder Metallurgy and Additive Manufacturing	2-1-0 (Half Semester)	1.5
MM 208	Theory of Metal Forming	2-1-0	3
MM 216	Physical Metallurgy	2-1-0	3
MM 214	Materials Characterization	2-0-2	3
MM 252	Casting and Welding Technology Lab	0-0-2	1
MM 258N	Metal Forming Lab	0-0-2	1
MM 2XX	Department Elective II	2-1-0	3
ZZ XXX	Institute open elective I	2-1-0	3
Total		**14-5-8**	**23/26**

Elective Courses (IV Semester)			
Course Code	**Course Name**	**(L-T-P)**	**Credit**
MM 226	Materials Informatics	2-1-0	1.5
MM 228	Ceramic Science and Technology	2-1-0	1.5
MM 230	Diffusion in Solids	2-1-0	1.5
MM 232	Thin Film Technology	2-1-0	1.5

3rd Year B. Tech. (Metallurgical Engineering and Materials Science)

Semester V (Till Batch admitted 2022)

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
ZZ XXX	Course-III for Minor Program	X-X-X	3
MM 301	Polymer Technology	2-1-0	3
MM 303	Introduction to Electrochemistry	2-1-0	3
MM 305	Iron and Steel Making	2-1-0	3
MM 307	Composites	2-1-0	3
MM 309	Computational Methods for Materials	2-0-2	3
MM 351	Polymer Technology Lab	0-0-3	1.5
MM 357	Composites Development Lab	0-0-3	1.5
	Total		**18/ 21**

3RD Year Curriculum of BTech Program in MEMS – V Semester (From AY 2025-26 onwards) (From Batch admitted in and after 2023)			
Course Code	**Course Name**	**(L-T-P)**	**Credit**
ZZXXX	Course -III for minor program	X-X-X	3
MM 3XX	Computational Methods for Materials	2-1-0	3
MM 3XX	Iron and Steel Making	2-1-0	3
MM 3XX	Optical and Magnetic Properties of Materials	2-1-0 (Half Semester)	1.5
MM 3XX	Non-ferrous Extractive Metallurgy	2-0-2	3
MM 3XX	Polymer and Composites	2-1-0	3
MM 3XX	Computational Methods for Materials Lab	0-0-2	1
MM 3XX	Polymer and Composites Lab	0-0-2	1
MM 3XX	Department Elective - III	2-1-0	3
ZZ 3XX	Institute open elective - II	2-1-0	3
Total		**13-5.5-6**	**21.5/24.5**

Elective Courses (V Semester)			
Course Code	**Course Name**	**(L-T-P)**	**Credit**
MM 3XX	Lightweight Materials for Structural Applications	2-1-0	1.5
MM 3XX	High Temperature Structural Materials - Superalloys	2-1-0	1.5
MM 3XX	Graphene and its Derivatives	2-1-0	1.5
MM 3XX	Electrochemical Energy Storage	2-1-0	1.5
MM 416	Modeling and Simulation in Materials Engineering	2-1-0	3
MM4XX/6XX	Introduction to Crystal Plasticity	2-1-0	3
MM 4XX/6XX	Advanced Functional Materials	2-1-0	3
MM 4XX/6XX	Materials for Flexible Electronics	2-1-0	3

Semester VI (Till Batch admitted 2022)

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
HS 302	Environmental Studies: Social Aspects (Half Semester course)	3-0-0	1.5
ES 302	Environmental Studies: Scientific and Engineering Aspects (Half Semester course)	3-0-0	1.5
MM 302	Welding and Foundry Engineering	2-1-0	3
MM 304	Corrosion Engineering	2-1-0	3
MM 306	Powder Metallurgy	2-1-0	3
MM 308	Thin Films and Nanostructures	2-1-0	3
MM 310	Ceramics Technology	2-1-0	3
MM 352	Welding and Foundry Engineering Lab	0-0-3	1.5
MM 354	Corrosion Engineering Lab	0-0-3	1.5
	Total		**21**

3rd Year Curriculum of BTech Program in MEMS – VI Semester (From AY 2025-26 onwards) (From Batch admitted in and after 2023)			
Course Code	**Subject Name**	**Weekly Contact Hours (L-T-P)**	**Credits**
ZZXXX	Course -IV for minor program	X-X-X	3
MM 3XX	Electrochemistry and Corrosion Engineering	2-1-0	3
MM 3XX	Semiconductor Materials and Devices	2-1-0	3
MM 3XX	Microstructure Engineering	2-1-0	3
MM 3XX	Corrosion Engineering Lab	0-0-2	1
MM 3XX	Semiconductor and Thin Films Lab	0-0-2	1
MM 3XX	Department Elective - IV	2-1-0	3
MM 3XX	Department Elective - V	2-1-0	3
	Total	**12-6-4**	**20/23**

Elective Courses (VI Semester)			
Course Code	**Course Name**	**(L-T-P)**	**Credit**
MM 3XX	Advances in Sintering Technology	2-1-0	1.5
MM 3XX	Mechanical Behavior at Nanoscale	2-1-0	1.5
MM 3XX	Phase Transformation of Nano-Alloys	2-1-0	1.5
MM 3XX	Genetic Algorithms in Engineering Process Modeling	2-1-0	1.5
MM 3XX	Metallic Glass	2-1-0	1.5
MM 3XX	CO2 Capture and Utilisation	2-1-0	1.5
MM 3XX	Engineered Soft Materials	2-1-0	1.5
MM 3XX	High Entropy Materials	2-1-0	1.5
MM 3XX	Surface Engineering of Alloys	2-1-0	1.5
MM 3XX	Advanced Materials and Processes	2-1-0	3
MM 3XX	Fuels, Furnaces and Refractories	2-1-0	3
MM 3XX	Functional Coatings	2-1-0	3

4th Year B. Tech. (Metallurgical Engineering and Materials Science)

Semester VII

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
MM 493	**B Tech Project (BTP)** 1. Student can do BTech project either outside the institute or within the institute under a supervision of an IIT Indore Faculty. 2. Summer Internship, if any, will be part of B Tech Project. 3. The choice is to be made latest by 30th April. 4. Duration: 6-7 months during 2nd week of May to Last week of Nov. 5. Last Date of Thesis submission: 1st week of Dec. 6. Last Date of Submission of Grades: 2nd week of Dec.	0-0-40	20
	Total	0-0-40	**20**

4th Year Curriculum of BTech Program in MEMS – VII Semester (From AY 2026-27 onwards) (From Batch admitted in and after 2023)			
Course Code	**Subject Name**	**Weekly Contact Hours (L-T-P)**	**Credits**
ZZXXX	Project for Minor Program	0-0-4	2
MMXXX	B.Tech Project	0-0-32	16
	Internship -I	0-0-2	1
	Internship -II	0-0-2	1
	Total	0-0-36	**18/20**

Semester VIII (from AY 2016-17 to AY 2019-20)

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
MM 402/ MM 602	Design and Selection of Materials	2-1-0	3
ZZ xxx	Open Elective-I	x-x-x	3
ZZ xxx	Open Elective-II	x-x-x	3
ZZ xxx	Open Elective-III (or Course-IV for Minor	x-x-x	3

	Program)		
ZZ xxx	Open Elective-IV (or Course-V for Minor Program)	x-x-x	3
	Total		**15**

Semester VIII (from AY 2020-21 to AY 2026-27)

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
MM 402/ MM 602	Design and Selection of Materials	2-1-0	3
MM xxx	Department Elective-I	x-x-x	3
MM xxx	Department Elective-II	x-x-x	3
ZZ xxx	Open Elective-I (or Course-IV for Minor Program)	x-x-x	3
ZZ xxx	Open Elective-II (or Course-V for Minor Program)	x-x-x	3
	Total		**15**

Curriculum of BTech Program in MEMS – VII Semester (From AY 2026-27 onwards) (From Batch admitted in and after 2023)			
Course Code	**Subject Name**	**Weekly Contact Hours (L-T-P)**	**Credits**
MM 4XXX	Department Elective-VI	2-1-0	3
MM 4XXX	Department Elective-VII	2-1-0	3
ZZ 4XXX	Department Elective-II	2-1-0	3
ZZ 4XXX	Open Elective-I (or Course-IV for Minor Program)	2-1-0	3
ZZ 4XXX	Open Elective-II (or Course-V for Minor Program)	2-1-0	3
	Total	**10-5-0**	**15**

MEMS Courses available for the Open Elective Courses in the 8th Semester of BTech in MEMS

MM 404 Creep, Fatigue and Fracture Mechanics (2-1-0-3)

MM 405/ MM 605 Green Hydrogen: Materials and Technologies (2-1-0-3)

MM 406 Electronics Materials (2-1-0-3)

MM 408 Bio-Materials (2-1-0-3)

MM 410 Modern Materials (2-1-0-3)

MM 412 Surface Modification (2-1-0-3)

MM 414 Particulate Processing (2-1-0-3)

MM 416 Modeling and Simulation in Materials Engineering (2-0-2-3)

MM 418 Defects and Failures in Manufacturing and Services (2-1-0-3)

MM 420 Metallurgical Plant Design (2-1-0-3)

MM 422 Sintering Technology (2-1-0-3)

MM 424 Magnetic Materials (2-1-0-3)

MM 426 Advanced Materials Processing (2-1-0-3)

MM 428 Intelligent Materials (2-1-0-3)

MM 430/ 730 Two: Dimensional Materials and Electronic Devices (2-1-0-3)

ME 436/ ME 736 Finite Element Analysis (2-0-2-3)

MM 442/ MM 642: Quality Assurance in Metallurgy (2-0-2-3)

MM 647/ MM 447: Metallurgical Thermodynamics and Phase Transformations (2-1-0-3)

MM 448/ MM 648: Solidification and Phase Field Modeling (2-0-2-3)

MM 449/ MM 649: Advance Welding Technology (2-0-2-3)

MM 450/ MM 650: Ferrous and Non-Ferrous Alloys (2-1-0-3)

MM 451/ MM 651: Non-destructive Evaluation (2-0-2-3)

MM 452/ MM 652: Thermomechanical Processing (2-0-2-3)

MM 453/ MM 653: Non-equilibrium Processing of Materials (2-1-0-3)

MM 454/ MM 654: Advanced Foundry Technology (2-0-2-3)

MM 457/ MM 657: Advances in Energy Storage Materials (2-1-0-3)

MM 474/ MM 674: Fluorescence Phenomenon (2-1-2-4)

MM 475/ MM 675: Advanced Fracture Mechanics (2-1-0-3)

MM 477/ MM 677 High Temperature Deformation of Materials (2-1-0-3)

MM 479/ MM 679: Fundamentals and Engineering of Solar Energy Devices (2-1-0-3)

MM 481/ MM 681: High Pressure Materials Processing (2-1-0-3)

MM 483/ MM 683: Analysis and Modelling of Welding (2-0-2-3)

MM 485/ MM 685: Materials Degradation (2-0-2-3)

MM 486/ MM 686: Applied Photoelectrochemistry (2-1-0-3)

MM 487/ MM 687: Advanced Battery Technologies (2–1–0-3

MM 488/ MM 688: Electroceremics (2-1-0-3)

Elective Courses (VIII Semester)			
Course Code	**Course Name**	**(L-T-P)**	**Credit**
MM 3XX	High Strain Rate Deformation	2-1-0	1.5
MM 3XX	Dislocation Theory	2-1-0	1.5
MM 3XX	Mechanical Alloying	2-1-0	1.5
MM 3XX	High-Pressure Torsion for Alloy Development	2-1-0	1.5
MM 4XX/6XX	Non-Ferrous Alloys for Engineering Applications	2-1-0	3
MM4XX/6XX	Symmetry and Properties of Crystals	2-1-0	3
MM 4XX/6XX	Materials Manufacturing and Quality Assurance	2-0-2	3
MM 4XX/6XX	Defects in Materials	2-1-0	3
MM 6XX/4XX	Semiconductor Processing Technology	2-1-0	3
MM 4XX/6XX	Materials for Devices (Currently MSE 607: 2-1-2-4)	2-1-0	3
MM 4XX/6XX	Thin Film and Devices (Currently MSE 724: 2-1-2-4)	2-1-0	3
MM 4XX/6XX	Single Crystal Growth Techniques (Currently MSE 725: 2-1-2-4)	2-1-0	3

Curriculum of BTech Program

in

Chemical Engineering

(from AY 2023-24 onwards)

2nd Year B. Tech. (Chemical Engineering)
From AY 2024-25 onwards (Batch admitted in and after AY 2023-24)

Semester III

Course Code	Course title	Weekly contact hours (L-T-P)	Credits
ZZ 2XX	Course – I, Minor program	X-X-X	3
MA 205	Complex analysis and	3-1-0	2
MA 207	Differential equations	3-1-0	2
ChE 201	Chemical Engineering Thermodynamics	2-1-0	3
ChE 203	Transport Phenomena	2-1-0	3
ChE 205	Materials Science for Chemical Engineers	2-1-0	3
ChE 207	Chemical Process Calculations	2-1-0	3
ChE 2XX	Department Elective -1	2-1-0	3
ChE 251	Heat and Mass Transfer Lab	0-0-2	1
ChE 255	Materials Characterization lab	0-0-2	1
	Total	**13-6-4 (25)**	**21/24**

Semester IV
From AY 2024-25 onwards (Batch admitted in and after AY 2023-24)

Course Code	Course title	Weekly contact hours (L-T-P)	Credits
ZZ 2XX	Course – II, Minor program	X-X-X	3
MA 204N	Numerical Methods	2-1-0	3
ChE 202	Fluid Mechanics	2-1-0	3
ChE 204	Chemical Reaction Engineering	2-1-0	3
ChE 206	Separation processes	2-1-0	3
ChE 2XX	Department Elective II	x-x-x	3
ZZ 2XX	Institute elective I	x-x-x	3
ChE 256	Computational Chemical Engineering Lab -1	0-0-3	1.5
ChE 254	Reaction Engineering lab	0-0-2	1
ChE 252	Fluid Mechanics lab	0-0-2	1
Total		12-6-4 (22)	21.5/24.5

3rd Year B. Tech. (Chemical Engineering)
From AY 2025-26 onwards (Batch admitted in and after AY 2023-24)

Semester V

Course Code	Course title	Weekly contact hours (L-T-P)	Credits
ZZ 3XX	Course – III, Minor program	X-X-X	3
ChE 3XX	Process modeling	2-1-0	3
ChE 3XX	Fluid Particle Systems	2-1-0	3
ChE 3XX	Biochemical Engineering	2-1-0	3
ChE 3XX	Chemical Process synthesis and simulation	2-1-0	3
ChE 3XX	Department Elective - 3	2-1-0	3
ZZ 3XX	Institute open elective - 2	2-1-0	3
ChE 3XX	Bioprocessing lab	0-0-2	1
ChE 3XX	Unit operations Lab	0-0-2	1
	Total	**12-6-4 (22)**	**20/23**

3rd Year B. Tech. (Chemical Engineering) - Semester VI
From AY 2024-25 onwards (Batch admitted in and after AY 2023-24)

Course Code	Course title	Weekly contact hours (L-T-P)	Credits
ChE 3XX	Computer-Aided Process Equipment Design	2-1-0	3
ChE 3XX	Process Dynamics, Instrumentation & Control	2-1-0	3
ChE 3XX	Chemical Process Technology and Intensification	2-1-0	3
ChE 3XX	Plant Design and Economics	2-1-0	3
ChE 3XX	Department Elective – 4	2-1-0	3
ChE 3XX	Department Elective – 5	2-1-0	3
ZZ 3XX	Institute open elective -3	2-1-0	3
ChE 3XX	Process Control lab	0-0-2	1
ChE 3XX	Computer-aided chemical Engineering lab – 2	0-0-2	1
Total		14-6-4 (24)	23

4^{th} Year B. Tech. (Chemical Engineering)
From AY 2026-27 onwards (Batch admitted in and after AY 2023-24)

Semester VII

Course Code	Subject Name	Weekly contact hours (L-T-P)	Credits
CHE 493	**B Tech Project (BTP)** 1. Student can do BTech project either outside the institute or within the institute under a supervision of an IIT Indore Faculty. 2. The choice is to be made latest by 30^{th} April. 3. Last Date of Thesis submission: 1^{st} week of Dec. 4. Last Date of Submission of Grades: 2^{nd} week of Dec.	0-0-32	16
CHE 4XX	Internship-I		1
CHE 4XX	Internship-II		1
Total		0-0-32 (32)	18

Semester VIII

From AY 2026-27 onwards (Batch admitted in and after AY 2023-24)

Course Code	Course title	Weekly contact hours (L-T-P)	Credits
CHE 4XX	Department Elective – 6	2-1-0	3
CHE 4XX	Department Elective – 7	2-1-0	3
ZZ 4XX	Institute open Elective - 4	2-1-0	3
ZZ 4XX	Institute open Elective - 5	2-1-0	3
ZZ 4XX	Institute open Elective - 6	2-1-0	3
Total		10-5-0 (15)	15

List of the Elective Courses for BTech in Chemical Engineering

ChE 209 : Introduction to Soft Matter and Polymers (2-1-0-3)

ChE 211: Waste to Energy Conversion (2-1-0-3)

Curriculum of B.Tech. Program
in
Mathematics and Computing
(from AY 2023-24 onwards)

2nd Year B.Tech. (Mathematics and Computing)
From AY 2024-25 Onwards (Batch admitted in and after AY 2023-24)

Semester III

Course Code	Course Title	Weekly contact hours (L-T-P)	Credits
ZZ 2XX	Course-I for Minor Program	X-X-X	3
MA 205	Complex Analysis	3-1-0 (1/2 semester)	2
MA 207	Differential Equations-II	3-1-0 (1/2 semester)	2
MA 209	Foundations of Mathematical Analysis	2-1-0	3
MA 211/ CS 201	Discrete Mathematical Structures	2-1-0	3
MA 213/ CS 203	Data Structures and Algorithms	2-1-0	3
MA 215	Probability and Statistics	2-1-0	3
MA 253/ CS 253	Data Structures and Algorithms Lab	0-0-3	1.5
MA 2XX	**Department Elective I**	x-x-x	3
	Total	**13-5-5**	**20.5/23.5**

Semester IV
From AY 2024-25 Onwards (Batch admitted in and after AY 2023-24)

Course Code	Course Title	Weekly contact hours (L-T-P)	Credits
ZZ 2XX	Course-II for Minor Program	X-X-X	3
MA 204N	Numerical Methods	2-0-2	3
MA 202	Multivariate Calculus and Measure Theory	2-1-0	3
MA 206	Mathematical Logic and Theory of Computation	2-1-0	3
MA 208/ CS 204	Design and Analysis of Algorithms	2-1-0	3
MA 254/ CS 254	Design and Analysis of Algorithms **Laboratory**	0-0-3	1.5
MA 2XX	Department Elective II		3
ZZ 2XX	Institute Elective I	2-1-0	3
	Total	**12-5-5**	**19.5 / 22.5**

3rd Year B. Tech. (Mathematics and Computing)
From AY 2025-26 Onwards (Batch admitted in and after AY 2023-24)

Semester V

Course Code	Subject Name	Weekly contact hours (L-T-P)	Credits
ZZ 3XX	Course-III for Minor Program	X-X-X	3
MA 301	Matrix Computations	2-0-2	3
MA 305	Data Science	2-0-2	3
MA 307/ CS 307	Optimization Algorithms and Techniques	2-1-0	3
MA 303/ CS 303	Operating Systems	2-1-0	3
MA 313 / CS 313	Computer Networks#	2-0-2	3
MA 357/ CS 357	Optimization Algorithms and Techniques Lab	0-0-2	1
MA 353/ CS 353	Operating Systems Lab	0-0-2	1
MA 3XX	Department Elective III		3
ZZ 3XX	Institute Elective II	2-1-0	3
	Total	**13-4-10**	**23/26**

Semester VI
From AY 2025-26 Onwards (Batch admitted in and after AY 2023-24)

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
ZZ xxx	Course IV - Minor Program	x-x-x	3
MA 302	Statistical Inference	2-0-2	3
MA 306	Monte-Carlo Simulation	2-0-2	3
MA 308	Techniques in Parallel Computing	1-0-2	2
MA 304 /CS 304N	Computational Intelligence	2-1-0	3
MA 354 /CS 354N	Computational Intelligence Lab	0-0-3	1.5
MA xxx	Department Elective IV	x-x-x	3
MA xxx	Department Elective V	x-x-x	3
ZZ xxx	Institute Elective III	x-x-x	3
	Total		21.5/24.5

4th Year B. Tech. (Mathematics and Computing)
From AY 2026-27 Onwards (Batch admitted in and after AY 2023-24)

Semester VII

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
ZZ xxx	Course-V for Minor Program	x-x-x	2
MA 493	B Tech Project (BTP)	0-0-32	16
MA 495	Internship - I	x-x-x	1
MA 497	Internship - II	x-x-x	1
	Total		**18/20**

Semester VIII
From AY 2026-27 Onwards (Batch admitted in and after AY 2023-24)

Course Code	Subject Name	Weekly Contact Hours (L-T-P)	Credits
MA 4XX	Department Elective VI	x-x-x	3
MA 4XX	Department Elective VII	x-x-x	3
ZZ 4XX	Institute Elective IV	x-x-x	3
ZZ 4XX	Institute Elective V	x-x-x	3
ZZ 4XX	Institute Elective VI	x-x-x	3
Total		**x-x-x**	**15**

List of the Elective Courses for B.Tech. in Mathematics

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credits
MA 217	Linear Programming	2-1-0	3
MA 219	Introduction to Dynamical Systems	2-0-2	3
MA 210	Elementary Number Theory and Algebra	2-1-0	3
MA 212	Regression Analysis	2-1-0	3
MA 309	Numerical Methods for Partial Differential Equations	2-0-2	3
MA 311	Statistical Distribution Theory	2-1-0	3
MA 310	Algorithmic Techniques and Applications of Data Science	2-1-0	3
MA 314	Random Matrices	2-1-0	3
MA 452/ MA 652	Theory of Transforms	2-1-0	3
MA 407/ MA 607	Nonlinear Dynamics and Computations	2-0-2	3
MA 454/ MA 654	Mathematical Modeling and Simulations	2-0-2	3
MA 405/ MA 605	Differential Equations in Population Dynamics	2-0-2	3
MA 402	Industrial Statistics	2-0-2	3
MA 404	Foundation of Approximation Theory	2-1-0	3
MA 406	Graph Theory	2-1-0	3
MA 408	Mathematical Theory of Waves	2-1-0	3
MA 414	Time Series Analysis	2-1-0	3
MA 416	Integral Equations	2-1-0	3

Curriculum of B. Tech Program
in

Engineering Physics

(From AY 2023-24 onwards)

2nd Year B.Tech. in Engineering Physics
From AY 2024-25 onwards (Batch admitted in and after 2023-24)

Semester III

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credits
ZZ 2XX	Course -I for Minor Program	X-X-X	3
MA 205	Complex Analysis	3-1-0-2 (½ semester)	2
MA 207	Differential Equation-II	3-1-0-2 (½ semester)	2
PH 203/ AA 203	Classical Mechanics	2-1-0	3
PH 205/ AA 205	Electronic Devices and Circuits I	2-1-0	3
PH 207/ AA 207	Wave Phenomena and Optics	2-1-0	3
PH 209/ AA 209	Fundamental Concepts of Solid-State Engineering	2-1-0	3
PH 251/ AA 251	Engineering Physics Lab I	0-0-3	1.5
PH 255/ AA 255	Electronic Devices and Circuits Lab I	0-0-3	1.5
PH XXX	Department Elective I	x-x-x	3
	Total	**13-6-6**	**22/25**

Semester IV
From AY 2024-25 onwards (Batch admitted in and after 2023-24)

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credits
ZZ 2XX	Course II for Minor Program	X-X-X	3
MA 204	Numerical Methods	2-0-2	3
PH 206/ AA 206	Electronic Devices and Circuits II	2-1-0	3
PH 208/ AA 208	Electrodynamics	2-0-0	2
PH 210/ AA 210	Fundamentals of Quantum Mechanics	2-1-0	3
PH 212/ AA 212	Thermal Physics	2-1-0	3
PH 252/ AA 252	Scientific Computing Lab	0-0-2	1
PH 256/ AA 256	Electronic Devices and Circuits Lab II	0-0-3	1.5
PH 2XX	Department Elective II	x-x-x	3
ZZ 2XX	Institute Elective I	x-x-x	3
	Total		**22.5/ 25.5**

3rd Year BTech in Engineering Physics
From AY 2025-26 onwards (Batch admitted in and after 2023-24)

Semester V

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credits
ZZ 3XX	Course III Minor Program	X-X-X	3
PH 301	Nuclear Science and Engineering	2-1-0	3
PH 303	Quantum Mechanics	2-1-0	3
PH 305	Advanced Classical Mechanics	2-1-0 (1/2 semester)	1.5
PH 307	Topics in Mathematical Physics	2-1-0 (1/2 semester)	1.5
PH 309	Simulation Methods and Analysis	2-0-2	3
PH 351	Engineering Physics Lab II	0-0-3	1.5
PH 3XX	Department Elective III	x-x-x	3
ZZ 3XX	Institute Elective II	x-x-x	3
		Total	**19.5/ 22.5**

Semester VI
From AY 2025-26 onwards (Batch admitted in and after 2023-24)

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credits
ZZ 3XX	Course IV Minor Program	X-X-X	3
PH 302	Cooperative Phenomena in Solids	2-1-0	3
PH 304	Fundamentals of Statistical Mechanics	2-1-0	3
PH 306	Atomic and Molecular Spectroscopy	2-1-0	3
PH 398	UG Seminar	0-1-0	1
PH 352	Solid State Physics Lab	0-0-3	1.5
PH 356	Spectroscopy Lab	0-0-3	1.5
PH 3XX	Department Elective IV	x-x-x	3
PH 3XX	Department Elective V	x-x-x	3
ZZ 3XX	Institute Elective III	x-x-x	3
		Total	**22/ 25**

4th Year B Tech in Engineering Physics
From AY 2025-26 onwards (Batch admitted in and after 2023-24)

Semester VII

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credit s
PH 493	**B Tech Project (BTP)** 1. Students can do BTech project either outside the institute or within the institute under the supervision of an IIT Indore Faculty. 2. Summer Internship, if any, will be part of the B Tech Project. 3. The choice is to be made latest by 30 th April. 4. Duration: 6-7 months during 2 nd week of May to Last week of Nov. 5. Last Date of Thesis submission: 1 st week of Dec. 6. Last Date of Submission of Grades: 2 nd week of Dec.0-0-32 16	0-0-32	16
PH 4XX	Internship-I		1
PH 4XX	Internship-II		1
	Total	**0-0-32**	**18**

Semester VIII
From AY 2025-26 onwards (Batch admitted in and after 2023-24)

Course Code	Course Title	Weekly Contact Hours (L-T-P)	Credits
PH 4XX	Departmental elective VI	2-1-0	3
PH 4XX	Departmental elective VII	2-1-0	3
IE4XX	Open elective IV	2-1-0	3
IE4XX	Open elective V (or course IV for minor program)	2-1-0	3
IE4XX	Open elective VI (or course V for minor program)	2-1-0	3
	Total	**10-5-0**	**15**

List of the Elective Courses for BTech in Engineering Physics:

PH 211 : Fundamentals of Vacuum Science and Technology (2-1-0-3)

PH 213 : Detector Physics (1-12-3)

PH 214 : Classical Field Theory (2-1-0-3)

PH 215 : Geometrical Methods in Physics (2-1-03)

PH 216 : Accelerator Physics (2-1-0-3)

PH 218 : Introduction to General Relativity (2-1-0-3)

PH 311 : Physics of Semiconductor Devices (3-0-0-3)

PH 312 : Solar Photovoltaics: Fundamentals, Technologies and Applications (2-1-0-3)

PH 313 : Quantum Transport Theory and Simulations (2-0-2-3)

PH 314 : Solar Photovoltaics: Fundamentals, Technologies and Applications (2-1-0-3)

PH 315 : Advanced Quantum Mechanics (2-1-0-3)

PH 316 : Group Theory in Particle Physics (2-1-0-3)

PH 317 : Data Analysis in High Energy Physics (2-1-0-3)

PH 318 : Introduction to String Theory (2-1-0-3)

PH 320 : Physics of the Early Universe and Dark Matter (2-1-0-3)

PH 308/PH 408 : Experimental and Theoretical Aspects of Heavy Ion Collisions (2-1-00-3)

PH 322 : Introduction to Quantum Information and Computation (2-0-2-3)

PH 402 : Principles and Applications of Optical Spectroscopy (2-0-2-3)

Curriculum of the BTech Programme
in
Space Science and Engineering
(AY 2023-2024 onwards)

2nd year BTech in Space Science and Engineering
From AY 2024-25 onwards (Batch admitted in and after AY 2023-24)

Semester III

Course Code	Course Name	Weekly Contact Hours L-T-P	Credit
ZZ 2XX	Course -I for Minor Program	X-X-X	3
MA 205	Complex Analysis	3-1-0 (½ semester)	2
MA 207	Differential Equation -II	3-1-0 (½ semester)	2
AA 203/ PH 203	Classical Mechanics	2-1-0	3
AA 205/ PH 205	Electronic Devices and Circuits I	2-1-0	3
AA 207/ PH 207	Wave Phenomena and Optics	2-1-0	3
AA 209/ PH 209	Fundamental Concepts of Solid-State Engineering	2-1-0	3
AA 251/ PH 251	Engineering Physics Lab I	0-0-3	1.5
AA 255/ PH 255	Electronic Devices and Circuits Lab I	0-0-3	1.5
AA 2XX	Department Elective - I	x-x-x	3
		Total	**22/ 25**

Semester IV
From AY 2024-25 onwards (Batch admitted in and after AY 2023-24)

Course Code	Course Name	Weekly Contact Hours L-T-P	Credit
ZZ 2XX	Course II for Minor Program	X-X-X	3
MA 204	Numerical Methods	2-0-2	3
AA 206/ PH 206	Electronic Devices and Circuits II	2-1-0	3
AA 208/ PH 208	Electrodynamics	2-0-0	2

AA 210/ PH 210	Fundamentals of Quantum Mechanics	2-1-0	3
AA 212/ PH 212	Thermal Physics	2-1-0	3
AA 252/ PH 252	Scientific Computing Lab	0-0-2	1
AA 256/ PH 256	Electronic Devices and Circuits Lab - II	0-0-3	1.5
AA 2XX	Department Elective II	x-x-x	3
ZZ 2XX	Institute Elective I	x-x-x	**3**
		Total	**22.5/ 25.5**

3rd Year BTech in Space Science and Engineering
From AY 2025-26 onwards (Batch admitted in and after AY 2023-24)

Semester V

Course Code	**Course Name**	**Weekly Contact Hours L-T-P**	**Credit**
ZZ XXX	Course III - Minor Program	X-X-X	3
AA307	Space Systems - Orbits and Payloads	2-1-0	3
AA309	Detectors for Space - I	2-1-0	3
AA 311	Statistical Physics and Radiative Transfer	2-1-0	3
AA 313	Fluid Dynamics	2-0-0	2
AA 315	Data Analytics and Visualization for Space	1-0-4	3
AA XXX	Departmental Elective III	2-1-0	3
ZZ XXX	Institute Open Elective-II	2-1-0	3
	Total	**13-5-4**	**20/23**

Semester VI
From AY 2025-26 onwards (Batch admitted in and after AY 2023-24)

Course Code	**Course Name**	**Weekly Contact Hours L-T-P**	**Credit**

ZZ XXX	Course IV - Minor Program	X-X-X	3
AA 306	Signals & Communication in Space	2-0-2	3
AA 312	Atmospheric Physics and Remote Sensing	2-1-0	3
AA 308	Guidance, Navigation and Control	2-1-0	3
AA 304	Radiowave Propagation & Antenna Applications	2-0-2	3
AA XXX	Departmental Elective IV	2-0-2	3
AA XXX	Departmental Elective V	2-1-0	3
ZZ XXX	Institute Open Elective - III	2-1-0	3
	Total	**14-4-6**	**21/24**

4th Year BTech in Space Science and Engineering
From AY 2026-27 onwards (Batch admitted in and after AY 2023-24)

Semester VII

Course Code	Course Name	Weekly Contact Hours L-T-P	Credit
AA 499	B Tech Project (BTP) 1. Student can do BTech project either outside the institute or within the institute under a supervision of an IIT Indore Faculty. 2. Summer Internship, if any, will be part of B Tech Project. 3. The choice is to be made latest by 30th April. 4. Duration: 6-7 months during 2 nd week of May to Last week of Nov. 5. Last Date of Thesis submission: 1st week of Dec. 6. Last Date of Submission of Grades: 2nd week of Dec.	0-0-32	16
	Internship 1		1
	Internship 2		1
	Total	**0-0-32**	**18**

Semester VIII
From AY 2026-27 onwards (Batch admitted in and after AY 2023-24)

Course Code	Course Name	Weekly Contact Hours L-T-P	Credit
AA XXX	Departmental Elective - VI	2-1-0	3
AA XXX	Departmental Elective - VII	2-1-0	3
ZZ XXX	Institute Open Elective - IV	2-1-0	3
ZZ XXX	Institute Open Elective - V	2-1-0	3
ZZ XXX	Institute Open Elective - VI	2-1-0	3
	Total	**10-5-0**	**15**

Departmental Electives for Semester III*

Course Code	Course Name	Weekly Contact Hours L-T-P	Credit
AA 201	Introduction to Astronomy	2-1-0	3
AA203	Introduction to Atmospheric and Earth Sciences	2-1-0	3

Departmental Electives for Semester IV*

Course Code	Course Name	Weekly Contact Hours L-T-P	Credit
AA 204	Introduction to Space Exploration	2-1-0	3
AA 202N	Astronomical Techniques	2-1-0	3

Departmental Electives for Semester V*

Course Code	Course Name	Weekly Contact Hours L-T-P	Credit
AA 317	Galaxies and Cosmology	2-1-0	3
AA 303	IoT for Space	2-0-2	3

AA 319	Launch Vehicle and Propulsion Systems	2-1-0	3

Departmental Electives for Semester VI*

Course Code	Course Name	Weekly Contact Hours L-T-P	Credit
AA 310	Satellite Imaging	2-0-2	3
AA 318	Meteorology and Climate Modelling	2-0-2	3
AA 320	Detectors for Space - II	2-0-2	3
AA 322	Computational Electromagnetics	2-0-2	3
AA 301	High Energy Astrophysics and Transient Sky	2-1-0	3
AA374	Computational Fluids and Structures	2-0-2	3

Departmental Electives for Semester VIII*

Course Code	Course Name	Weekly Contact Hours L-T-P	Credit
AA 476/676	Satellite Based Navigation Systems	2-0-2	3
AA 412/612	Microwave Remote Sensing	2-0-2	3
AA 408/608	Astrostatistics	2-1-0	3
AA 474/674	Radio Astronomy	2-1-0	3
AA 472/672	Galactic and Extragalactic Astronomy	2-1-0	3
AA 409/609	Computational Methods in Astronomy and Space Sciences	2-0-2	3
AA404/604	Spacecraft Attitude Control and Dynamics	2-0-2	3

DAASE courses listed as institute open electives for Semester VIII**

Course Code	Course Name	Weekly Contact Hours L-T-P	Credit
AA4XX/6XX	Advanced IoT for Space	2-0-2	3
AA4XX/6XX	Advanced Optical Instrumentation	2-0-2	3
AA 4XX/6XX	Space Economics, Policy & Space Act and Benefits	2-1-0	3

*The list of departmental electives will be updated as and when new courses get approved for the same.
**The list of DAASE courses listed as institute open electives will be updated as and when new courses get approved for the same.

Structure of the Minor programs [from AY 2014-15 to AY 2020-21]

A student has to register and pass at least FIVE courses (three core courses and two elective courses) as prescribed for a minor program in order to get a minor degree in that specialization along with the regular BTech degree in his/her engineering Department. A minor program will run only when at least TEN students register for it. Following minor programs are available from AY 2014-15 onwards.

1. Minor program in Biosciences and Biomedical Engineering (BSBE): To get a minor degree in BSBE, a student needs to register and pass **at least FIVE prescribed** courses ***excluding the core course*** BSE 101 Bio-Sciences for successful minor degree in BSBE.

2. MINOR PROGRAM IN CHEMISTRY: To get a minor degree in Chemistry, a student needs to register and pass **at least FIVE prescribed** courses ***excluding the core course CH 103.*** Following are courses for successful minor degree in Chemistry.

3. Minor Program in HSS: A student needs to register and pass **at least FIVE prescribed courses of Humanities and Social Sciences *excluding the core courses*** HS 159 and HS 108 for successful minor degree in Humanities or Social Sciences.

4. **Minor Program in Astronomy (from AY 2016-17):** To get a minor degree in Astronomy, a student needs to register and pass **at least FIVE prescribed** courses***.*** Following are courses for successful minor degree in Astronomy.

Course structures of various Minor programs

Semester: Minor course	**Minor Program in BSBE**	**Minor Program in Chemistry**	**Minor Program in Humanities and Social Sciences**	**Minor Program in Astronomy (from AY 2016-17 onwards)**
3rd : Minor1	BSE 201: Biophysics	CH 201: Molecules that Change the World	HS 201: Understanding Philosophy HS 203: Psychology HS 205: Sociology HS 207: French Language-I	AA 201: Introduction to Astronomy
4th : Minor 2	BSE 202: Biomedical Technologies	CH 202: Chemistry of Transition Metals and Lanthanides [&]	HS 206: Paradigms and Turning Points [#] HS 208: French Language-II HS 210: Indian Economy HS 211: German Literature and Culture Studies HS 214: History of Indian Culture and Civilization HS 216: Introduction to Hindi Cinema	AA 202N: Astronomical Techniques
5th : Minor 3	BSE 301: Introduction to Molecular Biology	CH 301: Functional Materials	HS 311: Life and Thought of Gandhi HS 313: History of Early Cinema HS 315: Sociology of Science and	AA 301: High Energy Astronomy

			Technology HS 323: International Economics HS 341: Appreciating Indian English Literature	
8th : Two elective courses as Minor 4 and Minor 5	BSE 402: Cancer Diagnosis and Therapy BSE 404/ BSE 604: Biomedical Imaging BSE 405/ BSE 605: Molecular Biophysics BSE 413/ BSE 613: Omics Technologies BSE 417/ BSE 617: Biomolecular Modeling EE 419/ EE 619: Biomedical Optics ME 407/ME 607: Bio-fluid Mechanics	CH 402: Chemistry in Industry CH 404: Chemical Physics CH 406: Nuclear Science	IHS 402: Twentieth Century World History: Critical Perspectives HS 412/ 612: Contemporary Indian Thought HS 418/ 618: Sustainability Studies HS 424/ HS 624: Econometrics-I IHS 422 / HS 622: Development Economics IHS 425: Money and Banking HS 426: Economics of Innovation HS 442/ HS 642: Language and Mind IHS 443/ HS 643: Contemporary Short Fiction IHS 444: Literature of the Twentieth Century IHS 482: Introduction to International Development and Area Studies	AA 404/ AA 604: Spacecraft and Payload Attitude Dynamics, Control and Pointing AA 471N/ AA 671N: Relativity and Cosmology AA 472N/ AA 672N: Galactic and Extragalactic Astronomy AA 474 / AA 674: Basics of Radio Astronomy AA 476/ AA 676: Satellite Based Navigation Systems AA 478/ AA 678: Space Weather

[&] *A student who takes CH 202 will not be allowed to take ME 416/616 in his/her 8th Semester*

Structure of the Minor programs [For AY 2021-22]

A student has to register and pass at least FIVE courses (three core courses and two elective courses) as prescribed for a minor program in order to get a minor degree in that specialization along with the regular BTech degree in his/her engineering Department. A minor program will run only when at least TEN students register for it. Following minor programs are available from AY 2014-15 onwards.

1. Minor program in Biosciences and Biomedical Engineering (BSBE): To get a minor degree in BSBE, a student needs to register and pass **at least FIVE prescribed** courses ***excluding the core course*** BSE 101 Bio-Sciences for successful minor degree in BSBE.

2. MINOR PROGRAM IN CHEMISTRY: To get a minor degree in Chemistry, a student needs to register and pass **at least FIVE prescribed** courses ***excluding the core course CH 103.*** Following are courses for successful minor degree in Chemistry.

3. Minor Program in HSS: A student needs to register and pass **at least FIVE prescribed courses of Humanities and Social Sciences** ***excluding the core courses*** HS 159 and HS 108 for successful minor degree in Humanities or Social Sciences.

4. **Minor Program in Astronomy (from AY 2016-17):** To get a minor degree in Astronomy, a student needs to register and pass **at least FIVE prescribed** courses***.*** Following are courses for successful minor degree in Astronomy.

Course structures of various Minor programs

Semester: Minor course	**Minor Program in BSBE**	**Minor Program in Chemistry**	**Minor Program in Humanities and Social Sciences**	**Minor Program in Astronomy (from AY 2016-17 to AY 2021-22)**
3rd : Minor1	BSE 201: Biophysics	CH 201: Molecules that Change the World	HS 201: Understanding Philosophy HS 203: Psychology HS 205: Sociology HS 207: French Language-I	AA 201: Introduction to Astronomy
4th : Minor 2	BSE 202: Biomedical Technologies	CH 202: Chemistry of Transition Metals and Lanthanides &	HS 206: Paradigms and Turning Points # HS 208: French Language-II HS 210: Indian Economy HS 211: German Literature and Culture Studies HS 214: History of Indian Culture and Civilization HS 216: Introduction to Hindi Cinema	AA 202N: Astronomical Techniques AA 204: Introduction to Space Exploration
5th : Minor 3	BSE 301: Introduction to Molecular Biology	CH 301: Functional Materials	HS 311: Life and Thought of Gandhi HS 313: History of Early Cinema	AA 301: High Energy Astronomy

			HS 315: Sociology of Science and Technology HS 323: International Economics HS 341: Appreciating Indian English Literature	AA 303: IoT for Space Applications
8th : Two elective courses as Minor 4 and Minor 5	BSE 402: Cancer Diagnosis and Therapy BSE 404/ BSE 604: Biomedical Imaging BSE 405/ BSE 605: Molecular Biophysics BSE 413/ BSE 613: Omics Technologies BSE 417/ BSE 617: Biomolecular Modeling BSE 419/ BSE 619: Renewable Energy Technologies EE 419/ EE 619: Biomedical Optics ME 407/ME 607: Bio-fluid Mechanics	CH 402: Chemistry in Industry CH 404: Chemical Physics CH 406: Nuclear Science	IHS 402: Twentieth Century World History: Critical Perspectives HS 412/ 612: Contemporary Indian Thought HS 418/ 618: Sustainability Studies HS 424/ HS 624: Econometrics-I IHS 422 / HS 622: Development Economics IHS 425: Money and Banking HS 426: Economics of Innovation HS 442/ HS 642: Language and Mind IHS 443/ HS 643: Contemporary Short Fiction IHS 444: Literature of the Twentieth Century IHS 482: Introduction to International Development and Area Studies	AA 404/ AA 604: Spacecraft and Payload Attitude Dynamics, Control and Pointing AA 471N/ AA 671N: Relativity and Cosmology AA 472N/ AA 672N: Galactic and Extragalactic Astronomy AA 474 / AA 674: Basics of Radio Astronomy AA 476/ AA 676: Satellite Based Navigation Systems AA 478/ AA 678: Space Weather

[&] *A student who takes CH 202 will not be allowed to take ME 416/616 in his/her 8th Semester*

Structure of the Minor programs [from AY 2022-23 onwards]

A student has to register and pass at least FIVE courses (three core courses and two elective courses) as prescribed for a minor program in order to get a minor degree in that specialization along with the regular BTech degree in his/her engineering Department. A minor program will run only when at least TEN students register for it. Following minor programs are available from AY 2014-15 onwards.

1. Minor program in Biosciences and Biomedical Engineering (BSBE): To get a minor degree in BSBE, a student needs to register and pass **at least FIVE prescribed** courses ***excluding the core course*** BSE 101 Bio-Sciences for successful minor degree in BSBE.

2. MINOR PROGRAM IN CHEMISTRY: To get a minor degree in Chemistry, a student needs to register and pass **at least FIVE prescribed** courses ***excluding the core course CH 103.*** Following are courses for successful minor degree in Chemistry.

3. Minor Program in Economics: A student needs to register and pass **at least FIVE prescribed courses of Humanities and Social Sciences *excluding the core courses*** HS 159 and HS 108 for successful minor degree in Humanities or Social Sciences.

4. **Minor Program in Liberal Arts**
5. **Minor Program in Astronomy and Space Engineering (from AY 2022-23):** To get a minor degree in Astronomy, a student needs to register and pass **at least FIVE prescribed** courses***.*** Following are courses for successful minor degree in Astronomy.

Course structures of various Minor programs

Semester: Minor course	**Minor Program in BSBE**	**Minor Program in Chemistry**	**Minor Program in Economics** **(from AY 2022-23 onwards with BTech batch admitted in AY 2021-22)**	**Minor Program in Liberal Arts (from AY 2022-23 onwards with BTech batch admitted in AY 2021-22)**	**Minor Program in Astronomy (from AY 2016-17 to AY 2021-22)** **Minor Program in Astronomy and Space Engineering (from AY 2022-23 onwards with BTech batch admitted in AY 2021-22)**
3rd : Minor1	BSE 201: Biophysics	CH 201: Molecules that Change the World	HS 209: Intermediate Microeconomics	HS 201: Understanding Philosophy HS 203: Psychology HS 205: Sociology HS 207: French Language-I HS 213: Cognitive	AA 201: Introduction to Astronomy

				Psychology	
4th : Minor 2	BSE 202: Biomedical Technologies	CH 202: Chemistry of Transition Metals and Lanthanides &	HS 210: Indian Economy	HS 206: Paradigms and Turning Points HS 208: French Language-II HS 211: German Literature and Culture Studies HS 212: History of India after Independence, 1947-2000 HS 214: History of Indian Culture and Civilization HS 216: Introduction to Hindi Cinema	AA 202N: Astronomical Techniques AA 204: Introduction to Space Exploration
5th : Minor 3	BSE 301: Introduction to Molecular Biology	CH 301: Functional Materials	HS 323: International Economics HS 325: Industrial Organization	HS 311: Life and Thought of Gandhi HS 313: History of Early Cinema HS 315: Sociology of Science and Technology HS 321: History of Modern Indian Business HS 327: Mind, Action, and Technology HS 341: Appreciating Indian English Literature	AA 301: High Energy Astronomy AA 303: IoT for Space Applications

8th : Two elective courses as Minor 4 and Minor 5	BSE 402: Cancer Diagnosis and Therapy BSE 404/ BSE 604: Biomedical Imaging BSE 405/ BSE 605: Molecular Biophysics BSE 413/ BSE 613: Omics Technologies BSE 417/ BSE 617: Biomolecular Modeling BSE 419/ BSE 619: Renewable Energy Technologies EE 419/ EE 619: Biomedical Optics ME 407/ME 607: Bio-fluid Mechanics	CH 402: Chemistry in Industry CH 404: Chemical Physics CH 406: Nuclear Science	HS418/ 618: Sustainability Studies IHS 422 / HS 622: Development Economics IHS 425: Money and Banking HS 426: Economics of Innovation HS 424/ HS 624 Econometrics-I	IHS 402: Twentieth Century World History: Critical Perspectives HS 412/ 612: Contemporary Indian Thought HS 442/ HS 642: Language and Mind IHS 443/ HS 643: Contemporary Short Fiction IHS 444: Literature of the Twentieth Century IHS 482: Introduction to International Development and Area Studies	AA 404/ AA 604: Spacecraft and Payload Attitude Dynamics, Control and Pointing AA 410/ AA 410: Spatial Informatics AA 412/ AA 612: Microwave Remote Sensing AA 471N/ AA 671N: Relativity and Cosmology AA 472N/ AA 672N: Galactic and Extragalactic Astronomy AA 474 / AA 674: Basics of Radio Astronomy AA 476/ AA 676: Satellite Based Navigation Systems AA 478/ AA 678: Space Weather

Structure of the Minor programs for AY 2024-25 onwards (For all UG batches admitted in and after AY 2023-24)

A student has to register and pass at least FIVE courses (three core courses and two elective courses) as prescribed for a minor program in order to get a minor degree in that specialization along with the regular BTech degree in his/her engineering Department. A minor program will run only when at least TEN students register for it. Following minor programs are available from AY 2014-15 onwards.

1. Minor program in Biosciences and Biomedical Engineering (BSBE): To get a minor degree in BSBE, a student needs to register and pass **at least FIVE prescribed** courses ***excluding the core course*** BSE 101 Bio-Sciences for successful minor degree in BSBE.

2. MINOR PROGRAM IN CHEMISTRY: To get a minor degree in Chemistry, a student needs to register and pass **at least FIVE prescribed** courses ***excluding the core course CH 103.*** Following are courses for successful minor degree in Chemistry.

3. Minor Program in Economics: A student needs to register and pass **at least FIVE prescribed courses of Humanities and Social Sciences *excluding the core courses*** HS 159 and HS 108 for successful minor degree in Humanities or Social Sciences.

4. **Minor Program in Liberal Arts**
5. **Minor Program in Astronomy and Space Engineering (from AY 2022-23):** To get a minor degree in Astronomy, a student needs to register and pass **at least FIVE prescribed** courses***.*** Following are courses for successful minor degree in Astronomy.

Course structures of various Minor programs

Semester: Minor course	**Minor Program in BSBE**	**Minor Program in Chemistry**	**Minor Program in Economics From AY 2024-25 (Batch Admitted in and after AY 2023-24)**	**Minor Program in Liberal Arts From AY 2024-25 (Batch Admitted in and after AY 2023-24)**	**Minor Program in Astronomy From AY 2024-25 (Batch Admitted in and after AY 2023-24)**
3rd : Minor1	BSE 201: Biophysics	CH 201: Molecules that Change the World	HS 209: Intermediate Microeconomics	HS 211: German Literature and Culture Studies HS 212: History of India after Independence, 1947-2000 HS 203: Psychology HS 205: Sociology	AA 201: Introduction to Astronomy

				HS 221 Fundamentals of Linguistics HS 223 Language Variation: Culture and Society	
4^{th} : Minor 2	BSE 202: Biomedical Technologies	CH 202: Chemistry of Transition Metals and Lanthanides[&]	HS 210: Indian Economy	HS 206: Paradigms and Turning Points HS 214: History of Indian Culture and Civilization HS 213: Cognitive Psychology HS 224 Contemporary Short Fiction HS 226 Sociology of Cinema	AA 202N: Astronomical Techniques AA 204: Introduction to Space Exploration
5^{th} : Minor 3	BSE 301: Introduction to Molecular Biology	CH 301: Functional Materials	HS 323: International Economics HS 321: History of Modern Indian Business	HS 311: Life and Thought of Gandhi HS 327: Mind, Action, and Technology HS 341: Appreciating Indian English Literature	AA 301: High Energy Astronomy AA 303: IoT for Space Applications
6^{TH} : Minor 4			HS 325: Industrial Organization	HS 315: Sociology of Science and Technology HS 328 Philosophy and Film HS 330 Sociology of Science and Technology	

7th : (minor project/field study/white paper/domain comprehension (Seminar)/Lab course)	(0-0-4-2) (minor project/field study/white paper/domain comprehension (Seminar)/Lab course)	(0-0-4-2) (minor project/field study/white paper/domain comprehension (Seminar)/Lab course)	(0-0-4-2) (minor project/field study/white paper/domain comprehension (Seminar)/Lab course)	(0-0-4-2) (minor project/field study/white paper/domain comprehension (Seminar)/Lab course)	(0-0-4-2) (minor project/field study/white paper/domain comprehension (Seminar)/Lab course)

Syllabi of 1st Year

Compulsory and Elective

HSS Courses

<table>
<tr><td>1.</td><td>Course Code</td><td>HS 107 [from AY 2010-11 to AY 2013-14]</td></tr>
<tr><td>2.</td><td>Title of the Course</td><td>English Language</td></tr>
<tr><td>3.</td><td>Credit Structure</td><td>L-T-P-Credits
2-0-0-2</td></tr>
<tr><td>4.</td><td>Name of the Concerned Department</td><td>English/HSS</td></tr>
<tr><td>5.</td><td>Pre–requisite, if any</td><td>None</td></tr>
<tr><td>6.</td><td>Scope of the course</td><td></td></tr>
<tr><td>7.</td><td>Course Syllabus</td><td>This course has a double purpose. It introduces literature and its forms and also helps students learn the English language.

The linguistic aspect will be dealt with by concentrating on the dictionary skills and introducing principles of pronunciation, vocabulary development, and syntax. The main topics include:
(a) Pronunciation: basic sounds of English (vowels and consonants) and word-stress
(b) Vocabulary: word-formation (prefixes and suffixes), synonyms and antonyms
(c) Syntax: parts of speech, active and passive voice, direct and indirect speech, tenses, basic sentence patterns, etc.

The literary aspect will be dealt with through suitable texts such as poems, short stories and plays (chosen be the instructors). The main topics for discussion will be:
(a) What is literature?
(b) The nature of literary language (mainly “figurative” language)
(c) The literary forms or genres
(d) Literature and socio-cultural context.</td></tr>
<tr><td>8.</td><td>Suggested Books</td><td>Suitable texts are to be chosen by the instructors from the Texts and References listed below as well as from other sources.
1. W.W.S. Bhaskar and N. S. Prabhu, English through Reading. Books I & II. Macmillan, 1975.
2. X. J. Kennedy, and G. Dana (Eds.) Literature: An Introduction to Fiction, Poetry, and Drama. 10th edition, Longman, 2006.
3. D. Murdoch (Ed.). The Siren's Song: An Anthology of British and American Verse, Orient Longman, 1988.
4. M. Meyer, (Ed.) The Bedford Introduction to Literature: Reading, Thinking, Writing. 6th edition, Bedford/St. Martin's, 2001.
5. Oxford Advanced Learner’s Dictionary. Oxford University Press,</td></tr>
</table>

		(8th edition) 2010 (with CD). 6. P. Sampson, **English Language through Literature: an introduction**. Rutledge, 1996.

1.	Course Code	**HS 111** [for AY 2009-10]
2.	Title of the Course	**Introduction to Philosophy**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Philosophy/HSS
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** The value of Philosophy, Why do we do Philosophy **Epistemology:** Basic Concepts, Belief, Knowledge & Truth, Rationalism & Empiricism, Knowledge & Justification, Scientific Knowledge, Nature and Methodology of Science, Verification/Falsification, Induction & Deduction, Scepticism Ancient and Modern Scepticism, Brain-in-a-Vat **Basic Logic:** Aristotelian Logic, Laws of Thought - Truth Table, Epistemological Paradoxes **Moral Philosophy:** Ethical Reasoning, Problems of Judgment, Moral Dilemmas, Subjectivity - Objectivity
8.	Suggested Books	1. B. Magee, **The Story of Philosophy,** A Dorling Kindersley Book, London, 1998. 2. H. Bergson, **An Introduction to Metaphysics,** Palgrave Macmillan, New York, 2007. 3. M. Clark, **Paradoxes from A to Z,** Routledge, London, 2002. 4. J. Ladyman, **Understanding Philosophy of Science**, Routledge, London, 2002. 5. Stephen, Law, **Philosophy,** A Dorling Kindersley Book, London, 2007. 6. R. Norman, **The Moral Philosophers: An Introduction to Ethics**, Oxford University Press, Oxford, 1998. 7. J. Rawls, **Lectures on the History of Moral Philosophy** Ed. by Barabara Herman, Harvard University Press, Massachusetts, 2000. 8. R. Rorty, **Philosophy and the Mirror of Nature**, Princeton University Press, Princeton, 1979. 9. B. Russell, **The Problems of Philosophy,** Oxford University Press. Oxford, 1998. 10. P. Stokes, **Philosophy: 100 Essential Thinkers**. Enchanted Books, New York, 2002. 11. M. Williams, **Problems of Knowledge: A Critical Introduction to Philosophy,** Oxford University Press, New York, 2001.

1.	Course Code	**HS 113** [for AY 2009-10] **HS 108** [form AY 2010-11 onwards]
2.	Title of the Course	**Economics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Economics/HSS
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Microeconomics:** What is Economics? basic economic problems and nature of economics; demand and supply; consumer choice; individual and market demand; production and cost of production; profit maximization and perfect competition; market structure- monopoly, monopsony, monopolistic competition, and oligopoly; externalities and public goods; factor markets-land, labour and capital market. **Macroeconomics:** National income accounting- income, expenditure and components of GDP; consumption and saving; investment spending and demand for money; financial systems-central bank, money, credit, financial markets and asset prices; income and spending; money, interest and income; fiscal and monetary policies; economic growth and accumulation; aggregate supply- wages, prices and unemployment; inflation.
8.	Suggested Books	1. R.S. Pindyck and D.L. Rubinfeld. **Microeconomics** (7th Edition), Pearson Prentice Hall, New Jersey, 2009. 2. R. Dornbusch, S. Fischer, and R. Startz, **Macroeconomics** (9th Edition), McGraw-Hill Inc. New York, 2004.

1.	Course Code	**HS 115** [for AY 2009-10]
2.	Title of the Course	Reading Literature
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	English/HSS
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Reading of and reading into (interpreting) a variety of literary texts; analyzing the art of literature; evaluation of the context(s) of reading and the reader-text relationship(s)
8.	Suggested Books	Suitable texts will be chosen by the instructor(s) from the Texts and References listed below as well as from other sources. 1. M. Meyer, (Ed.) **The Bedford Introduction of Literature: Reading, Thinking, Writing**. 6th edition, Bedford/St. Martin's, 2001. 2. X.J. Kennedy, and G. Dana, (Ed.) **Literature: An Introduction to Fiction, Poetry, and Drama**. 10th edition, Longman, 2006. 3. S. N. Lawall, (Ed.) **The Norton Anthology of World Literature**. 2nd expanded edition. Vol. A-F, W.W. Norton & Company; 2003

1.	Course Code	**HS 157** [from AY 2010-11 to AY 2013-14]
2.	Title of the Course	**English Language Lab**
3.	Credit Structure	L-T-P-Credits 0-0-2-1
4.	Name of the Concerned Department	English/HSS
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	The Laboratory Course for English Language and Literature is primarily meant to augment the language aspect of the course. The multi-media computer facility will be extensively used for the tutorial/lab sessions. The 8th edition of the *Oxford Advanced Learner's Dictionary* (with CD) will be extensively used along with the internet resources. All the students are expected to have access to the dictionary and they should learn to use it extensively. The CD of the *OALD* contains a section titled "Resources" consisting of Dictionary Skills and Grammar. From the Grammar section, the following topics will be focused upon: articles, regular verbs, tenses and their use, active and passive voice, modal verbs, and reported speech. From the Dictionary Skills section, the following topics will be focused upon: nouns, irregular verbs, adjectives and adverbs, grammatical patterns, the idioms, phrasal verbs and register (formal and informal, technical, slang). The pronunciation aspect will be handled by listening to the pronunciation of words which can be heard from the CD and also by learning the phonetic symbols used for the basic sounds. All these will be further practiced with the use of interactive internet material from the links mentioned below.
8.	Suggested Books	1. D. Jones, **English Pronouncing Dictionary**, (15th edition) Cambridge University Press, 1996 (with CD). 2. **Oxford Advanced Learner's Dictionary**, (8th edition) Oxford University Press, 2010 (with CD). 3. M. Swan, **Practical English Usage**, Oxford University Press, 1996. 4. Internet Resources http://www.ego4u.com (English Grammar Online 4u) http://www.englishpage.com , http://a4esl.org http://sana.tkk.fi/awe/cohesion/signposts/contrast/exercises/1r.html http://www.manythings.org/vq/mc-adj.html

		http://www.ego4u.com/en/cram-up/grammar/adjectives-adverbs/adjectives/exercises http://a4esl.org/q/h/vm/fampeople.html http://a4esl.org/q/f/z/zz32mps.htm http://a4esl.org/q/f/x/xz61mrs.htm http://www.englishpage.com/verbpage/activepassive.html http://www.ego4u.com/en/cram-up/grammar/passive/exercises?simple-present http://www.ego4u.com/en/cram-up/grammar/passive/exercises?simple-past http://www.ego4u.com/en/cram-up/grammar/passive/exercises?future-1 http://www.better-english.com/grammar/passive1.htm

1.	Course Code	**HS 159** [from AY 2014-15 onwards]
2.	Title	**English Language and Communication**
3.	Credit Structure	L-T- P-Credits 0-3-0-3
4.	Name of the School/ Department	Humanities and Social Sciences/ English
5.	Pre–requisite, if any	NIL
6.	Scope of the course	To improve English Reading, Comprehension and Writing skills of the students.
7.	Course Syllabus	-Writing, Reading, Comprehension skills in English - Paragraph Development -Grammar and mechanics
8.	Suggested books	1. M. Swan, *Practical English Usage,* Oxford University Press, 1996. 2. W.W.S. Bhaskar and N. S. Prabhu, English through Reading. Books I & II. Macmillan, 1975. 3. P. Sampson, *English Language through Literature: an introduction*. Rutledge, 1996. 4. Oxford Advanced Learner's Dictionary. Oxford University Press, (8th edition) 2010 (with CD). 5. Bedford Martin Guide to College Writing 6. Fowler Ramsey and Jane Aaron.*The Little Brown Handbook*, Pearson Publications 7. Lunsford, Andrea, Keith Walters, et al. *Everything is an Argument,* **:** Bedford/St. Martin's; Sixth Edition edition (October 5, 2012) 8. Turabian, Kate. *Student's Guide to College Writing,* University of Chicago Press, 4th Edition, 2010.

1.	Course Code	**HS 302**
2.	Title of the Course	**Environnemental Studies: Social Aspects**
3.	Credit Structure	L-T-P-Credits 3-0-0-1.5 **(Half Semester Course)**
4.	Name of the Concerned Department	Economics and Sociology/HSS
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Social Issues and the environment, Public awareness and Human rights, Indicators of sustainability, Governance of Natural Resources - Common pool resources: issues and management. Environmental ethics, Religion and environment, Wilderness and Developing Trends, Environmental movements and Activism, Social Ecology and Bioregionalism, Environmental justice. Environmental economics, Trade and environment, Economics of environmental regulation, Natural resource accounting, Green GDP. Environment and development, Resettlement and rehabilitation of people, Impacts of climate change on economy and society, Vulnerability and adaptation to climate change.
8.	Suggested Books	1. N. Agar, **Life's Intrinsic Value**, Columbia University Press, New York, 2001. 2. Dasgupta, P. and Maler, G. (eds**.), The Environment and Emerging Development Issues**, Vol. I, Oxford University Press, 1997. 3. R. Guha, **Mahatama Gandhi and Environmental Movement"**, *Debating on Gandhi* in by A. Raghuramaraju (ed.), Oxford University Press, New Delhi, 2006. 4. R. Guha and Madhav Gadgil, **Ecology and Equity: The Use and Abuse of Nature in Contemporary India**, Penguin, New Delhi, 1995. 5. Hanley, Nick, Jason F. Shogren and Ben White, **Environmental Economics in Theory and Practice**, MacMillan, New Delhi, 2004 6. A. Naess, and G. Sessions, **Basic Principles of Deep Ecology**, *Ecophilosophy*, Vol.6., 1984. 7. M. Redclift, and G. Woodgate, (eds.), **International Handbook of Environmental Sociology**, Edward Edgar, 1997

Syllabi

of

Compulsory Basic Science Courses

(CBSC)

1.	Course Code	**BSE 102** [from AY 2014-15 onwards]
2.	Title of the Course	**Biosciences**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Biosciences and Biomedical Engineering
5.	Pre–requisite, if any	Nil
6.	Scope of the course	This course intends to give knowledge about the basics of biology to engineering students who might not be in touch with this subject after their matriculation.
7.	Course Syllabus	**Life and its origin**: Requirements for Life, Chemistry of life, Chemistry of water, Origin of life. **Evolutionary History of Biological Diversity:** Phylogeny and the Tree of Life, Bacteria and Archaea, Protists. Plant Diversity I: How Plants Colonized Land, Plant Diversity II: The Evolution of Seed Plants, Fungi, An Overview of Animal Diversity, An Introduction to Invertebrates, The Origin and Evolution of Vertebrates **Cell**: Prokaryotic and Eukaryotic cell, Animal cell and Plant cell, Structure and function of sub cellular organization, membrane and cell physiology, Chromosome and Gene, Genetics **Cell Division**: Mitosis, Meiosis other types of cell divisions, Cancer **Organization of Human body**: Tissues, Organ and Organ System; **Micro- and Macromolecules in living system**: Amino Acid, Proteins, Types of sugar, Carbohydrates, Saturated and unsaturated fatty acid, lipid, Fat, Nucleotides and Nucleic Acid. **Enzymes**: Basic concept, Classification and Function, Role of Enzymes in life. **Ecology and Environment** **Perspective of Biology**
8.	Suggested Books	1. Campbell; **Biology**, 9th edition. Pearson Higher Education 2011 2. Colleen Belk, Virginia Borden Maier; **Biology: Science for Life with Physiology**, Pearson New International Edition, 2013 3. Lehninger & Cox. **Principles of Biochemistry** (5th edition), W.H. Freeman & Company, USA

1.	Course Code	**CH 103** [from AY 2010-11 to AY 2013-14]
2.	Title of the Course	**Chemistry**
3.	Credit Structure	L-T- P-Credits 3-1-0-4
4.	Name of the Concerned Department	Chemistry
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Schrődinger equation:** origin of quantization; applications of particle in a box problem; hydrogen atom; properties of atomic orbitals; many electron atoms; molecular orbital theory; bonding and intermolecular forces. **Thermodynamics:** Fundamental definition and concepts of thermodynamics; Work, heat and energy; First law: C_p and C_v; Second law: entropy; Helmholtz and Gibbs Energy; chemical potential; Third law; phase equilibria; chemical equilibrium. **Chemical kinetics:** Rate laws; elementary reaction and chain reaction. **Periodic table and periodic properties:** basis of periodic table, trends in size, electron affinity, ionization potential and electro-negativity, Use of Ellingham diagram and thermodynamics in the extraction of elements; Transition metal chemistry: inorganic complexes, isomerism, nomenclature; bonding in transition metal complexes; valence bond and crystal field theory, magnetism, bonding aspects, structural distortion; Bioinorganic chemistry: storage and transport proteins; Catalysis: hydrogenation, hydroformylation and olefin metathesis. **Organic Chemistry:** Hűckel treatment of ethylene, butadiene and benzene, concept of aromaticity, configuration, molecular chirality and isomerism, conformation of alkanes and cycloalkanes, reactivity of carbonyl groups (additions, addition-eliminations, reactions due to acidic proton, reactivity of acid halide, ester and amide), functional group inter-conversions involving oxidation and reduction. Introduction to bio-organic chemistry: carbohydrates, amino acids and nucleic acids.
8.	Suggested Books	1. P.W. Atkins, **Physical Chemistry** (7th Edition), Oxford University Press, 2006. 2. I. A. Levine, **Physical Chemistry**, McGrawHill, 2009 3. D.A. McQuarrie and J.D. Simon, **Physical Chemistry - a Molecular Approach**, Viva Books Pvt. Ltd., 1998. 4. R.T. Morrison and R.N. Boyd, **Organic Chemistry**, 5th Ed,

		Prentice Hall of India Pvt. Ltd., 1990 5. G. Solomons and C. Fryhle, **Organic Chemistry**, John Wiley & Sons (Asia) Pte Ltd. 6. J.D. Lee, **Concise Inorganic Chemistry**, (5^{th} Edition), ELBS, 1996. 7. D. F. Shriver and P. W. Atkins, **Inorganic Chemistry,** Oxford University Press, 2006.

1.	Course Code	**CH 103** [from AY 2014-15 onwards]
2.	Title of the Course	**Chemistry**
3.	Credit Structure	L-T-P-Credit 3-1-0-4
4.	Name of the Department	Chemistry
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	This course provides basic knowledge of chemistry involving organic, inorganic and physical chemistry
7.	Course Syllabus	**Linking microscopic and bulk thermodynamic properties:** Distribution of molecular states and relation to entropy, Boltzmann distribution, ensembles, partition functions. **Elucidation of structure and properties:** Experimental techniques, Interaction light with matter, absorption and emission spectra, intensities of spectral lines, Beer-Lambert law, spontaneous and simulated emission, transition moments and selection rules, Franck-Condon principle, lasers and fluorescence. **Chemical Bonding:** Valence Bond Theory (VBT), Molecular Orbital Theory (MOT) **Structure and Bonding of Coordination Complexes:** Tetrahedral, Octahedral, Square planar and Square Pyramidal complexes **Introduction to Organometallic Complexes:** Structure and Bonding **Application of Coordination Complexes, Metal Organic Frameworks (MOFs), and Organometallic Complexes:** Introduction to Metal organic Frameworks, Magnetic materials, Catalysis, Adsorption properties, Metal ions in Biology **Organic Chemistry:** Hűckel treatment of ethylene, butadiene and benzene, concept of aromaticity, orbital symmetry and chemical reactions, conformation of cycloalkanes, reactivity of carbonyl groups due to acidic protons, heterocyclic chemistry (thiophene, furan, pyridine, pyrrole, and indole), neighbouring group effect. Introduction to bio-organic chemistry: steroids, amino acids and nucleic acids.
8.	Suggested Books	**Text Books** 1. P.W. Atkins, J.D. Paula, **Physical Chemistry,** 8^{th} Edn., Oxford University Press, **2006**, ISBN 9780716787594. 2. I. A. Levine, **Physical Chemistry**, McGrawHill, **2009**, ISBN 978-007-2538625. 3. D.A. McQuarrie and J.D. Simon, **Physical Chemistry - A Molecular Approach**, Viva Books Pvt. Ltd., **1998**. 4. R.T. Morrison and R.N. Boyd, **Organic Chemistry**, Prentice Hall of India Pvt. Ltd., 6^{th} Edn., **1992**, ISBN 0-13-643669-2. 5. G. Solomons, C. Fryhle, S. A. Snyder, **Organic Chemistry**, John Wiley & Sons (Asia) Pvt. Ltd., 11^{th} Edn., **2013**, ISBN-10: 1118147391. 6. J. D. Lee, **Concise Inorganic Chemistry**, 5^{th} Edn., ELBS, **1996**, ISBN 978-8126515547.

		7. D. F. Shriver, P. W. Atkins, **Inorganic Chemistry**, Oxford University Press, **2006**, ISBN 978-0199236176. 8. R. C. Mehrotra, A. Singh, **Organometallic Chemistry,** 2nd Edn., New Age International (P) Ltd Publishers, **2007**, ISBN 978-0470210192. 9. 9. D. Farrusseng, **Metal-organic Frameworks: Application from Catalysis to Gas storage**, Wiley, **2011,** ISBN 978-3527328703.

1.	Course Code	**CH 153**
2.	Title of the Course	**Chemistry Lab**
3.	Credit Structure	L-T- P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Chemistry
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Experiments illustrating the concepts of (1) galvanic cells, (2) Thermochemistry, (3) chemical kinetics, (4) equilibrium constant, (5) analysis by oxidation reduction titration.
8.	Suggested Books	Same as the associated theory course CH 103: Chemistry

1.	Course Code	**MA 103** [from AY 2009-10 to AY 2013-14] **MA 105** [from AY 2014-15 onwards]
2.	Title of the Course	**Mathematics-I: Calculus** [from AY 2009-10 to AY 2013-14] **Calculus** [from AY 2014-15 onwards]
3.	Credit Structure	L-T- P-Credits 3-1-0-4
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Review of limits, continuity, differentiability. Mean Value Theorem, Taylor Theorem, Maxima and Minima. Riemann integrals, Fundamental theorem of Calculus, Improper integrals, application to area, volume. Convergence of sequences and series, power series. Partial Derivatives, gradient and directional derivatives, chain rule, maxima and minima, Lagrange multipliers. Double and triple integration, Jacobians and change of variables formula. Parametrization of curves and surfaces, vector fields, line and surface integrals. Divergence and curl, theorems of Green, Gauss, Stokes.
8.	Suggested Books	1. Huges-Hallett et al., **Calculus: Single and Multi Variable** (3rd Edition), John-Wiley & Sons (USA), 2003. 2. J. Stewart, **Calculus** (5th Edition), Thomson, 2003 (Indian Edition). 3. T.M. Apostol, **Calculus: Volumes 1 and 2** (2nd Edition), Wiley Eastern (USA), 1980. 4. G.B. Thomas and R.L. Finney, **Calculus and Analytic Geometry** (9th Edition), ISE Reprint, Addison-Wesley, 1998 (Indian Edition).

1.	Course Code	**MA 104** [from AY 2009-10 to AY 2013-14] **MA 106** [from AY 2014-15 onwards]
2.	Title of the Course	**Mathematics-II: Linear Algebra and Ordinary Differential Equations-I** [from AY 2009-10 to AY 2013-14] **Linear Algebra and Ordinary Differential Equations-I** [from AY 2014-15 onwards]
3.	Credit Structure	L-T- P-Credits 3-1-0-4
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Linear Algebra:** Vectors in R^n, notion of linear independence and dependence, linear span of a set of vectors, vector subspace of R^n, basis of vector subspaces. Systems of linear equations, matrices and Gaussian elimination, row space, null space, and column space, rank of a matrix. Determinants and rank of a matrix in terms of determinants. Abstract vector spaces, linear transformations, matrix of a linear transformation, change of basis and similarity, rank-nullity theorem, Inner product spaces, Gram-Schmidt Process, orthonormal bases, projection and least squares approximations. Eigen values and Eigen vectors, characteristic polynomials, Eigen values of special matrices (orthogonal, unitary, hermitian, symmetric, skew-symmetric, normal). Algebraic and geometric multiplicity, diagonalization by similarity transformations, spectral theorem for real symmetric matrices, application to quadratic forms **Differential Equations-I:** Exact equations, integrating factors and Bernoulli equations. Orthogonal trajectories. Lipschitz condition, Picard's theorem, examples on non-uniqueness. Linear differential equations generalities, Linear differential equations and Wornskians Dimensionality of space of solutions, Abel-Liouville formula, Linear ODEs with constant co-efficients, the characteristic equations, Cauchy Euler equations, Method of undetermined coefficients. Method of variation of parameters, Laplace transformation and generalities, shifting theorems, Convolution theorem.
8.	Suggested Books	1. H. Anton, **Elementary Linear Algebra with Applications** (8th Edition), John-Wiley & Sons, 1995.

		2. G. Strang, **Linear Algebra and its Applications** (4^{th} edition), Thomson, 2006. 3. S. Kumaresan, **Linear Algebra: a Geometric Approach**, Prentice Hall of India, 2000. 5. E. Kreyszig, **Advanced Engineering Mathematics** (8^{th} Edition), John Wiley & Sons, 1999. 5. W.E. Boyce and R. Diprima, **Elementary Differential Equations** (8^{th} Edition), John Wiley & Sons, 2005. 6. T.M. Apostol, **Calculus, Volume 2** (2^{nd} edition), Wiley-Eastern, 1980.

1.	Course Code	**MA 201** [from AY 2009-10 to AY 2013-14] **MA 203** [from AY 2014-15 onwards]
2.	Title of the Course	**Mathematics-III: Complex Analysis and Differential Equations-II** [from AY 2009-10 to AY 2013-14] **Complex Analysis and Differential Equations-II** [from AY 2014-15 onwards]
3.	Credit Structure	L-T- P-Credits 3-1-0-4
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Complex Analysis:** Definitions and properties of analytic functions. Cauchy-Riemann equations, harmonic functions. Power series and their properties. Elementary functions. Cauchy's theorem and its applications, Taylor series and Laurent expansion. Residues and Cauchy's residue formula. Evaluation of improper integrals. Conformal mappings, inversion of Laplace transformations. **Differential Equations-II:** Review of power series and series solutions of ODE's. Legendre equation and Legendre Polynomials. Regular and singular points, method of Frobenius. Bessel's equation and Bessel's functions. Strum-Liouville problems. Fourier series. D 'Alembert solution to the wave equations. Classification of linear second order PDE's in two variables. Laplace, wave, and Heat equations using separation of variables. Vibration of a circular membrane. Heat equation in the half space.
8.	Suggested Books	1. R.V. Churchill and J.W. Brown, **Complex Variables and Applications** (7th edition), McGraw-Hill Inc. New York, 2003. 2. J.M. Howie, **Complex Analysis**, Springer-Verlag, 2004 (Berlin). 3. M.J. Ablowitz and A.S. Fokas, **Complex Variables: Introduction and Applications**, (Indian Edition) Cambridge University Press, 1998. 4. E. Kreyszig, **Advanced Engineering Mathematics** (8th Edition), John Wiley & Sons, 1999(Indian Edition). 5. W.E. Boyce and R. Diprima, **Elementary Differential Equations** (8th Edition), John Wiley & Sons, 2005(USA). 6. R.V. Churchill and J.W. Brown, **Fourier Series and Boundary Value Problems** (7th Edition), McGraw-Hill Inc. 2006(USA).

1.	Course Code	**MA 204**
2.	Title of the Course	**Numerical Methods**
3.	Credit Structure	L-T- P-Credits 3-0-2-4
4.	Name of the Concerned Department	Mathematics
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	• Interpolation by polynomials, divided differences, error of the interpolating polynomial, piecewise linear and cubic spline interpolation. • Numerical integration, composite rules, error formulae. • Solution of a system of linear equations, implementation of Caussian elimination and Gauss-Seidel methods, partial pivoting, row echelon form, LU factorization Cholesky's method, ill-conditioning, norms. • Solution of a nonlinear equation, bisection and secant methods. • Newton's method, rate of convergence, solution of a system of nonlinear equations, numerical solution of ordinary differential equations, Euler and Runge-Kutta methods, multi-step methods, predictor-corrector methods, order of convergence, finite difference methods, numerical solutions of elliptic, parabolic and hyperbolic partial differential equations. • Eigen-value problem, power method, QR method, Gershgorin's theorem. • Exposure to software packages like IMSL subroutines, MATLAB.
8.	Suggested Books	• S.D. Conte and Carle de Boor, **Elementary Numerical Methods – An Algorithmic Approach** (3rd Edition), McGraw-Hill, 1980. • C.E. Forberg, **Introduction to Numerical Methods** (2nd Edition), Addison-Wesley, 1981. • E. Kreyszig, **Advanced Engineering Mathematics** (8th Edition), John Wiley & Sons, 1999. • D. Watkinson, **Fundamentals of Matrix Computations**, Wiley-Interscience (2nd edition), 2002

1.	Course Code	**PH 103** [from AY 2009-10 to AY 2013-14] **PH 105** [from AY 2014-15 onwards]
2.	Title of the Course	**Physics-I: Modern Physics** [from AY 2009-10 to AY 2013-14] **Physics-I** [from AY 2014-15 onwards]
3.	Credit Structure	L-T- P-Credits 2 -1-0-3
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Quantum Mechanics: Review of quantum concepts, Particle nature of light, Photoelectric effect, Compton effect, Waves, Wave packets, Phase and Group velocity, Davisson Germer Experiment, Heisenberg uncertainty principle. Schrodinger equation, Probabilistic interpretation of wave function. One dimensional problems- Particle in a box, Potential well, Potential barrier and Tunneling, Harmonic oscillator. Hydrogen atom. Elements of statistical physics: Maxwellian distribution, Bose-Einstein and Fermi-Dirac distributions. Solid State Physics: Crystalline and Amorphous Solids, Bonding in solids, Ionic Crystals, Covalent Crystals, Defects in crystals, Band Theory of Solids, Brillouin Zones, Origin of Forbidden bands, Semiconductor Devices, Superconductivity, Bound Electron Pairs, Quantum Hall Effect, Landau Levels. Wave Optics: Principle of superposition, Bi-Prism, Interference in thin films, Two Beam and Multiple Beam interferometers. Diffraction at single slit, Two slits and N-Slits, Diffraction grating. Vector nature of light, Malus and Brewster's Laws, Double refraction, Retardation plates, Circularly and Elliptically polarized lights. Lasers: Stimulated and Spontaneous emissions, Einstein's A and B coefficients, Population inversion, Pumping techniques, Resonators, Laser modes, Classes of lasers, Properties of lasers and Laser applications.
8.	Suggested Books	1. A. Beiser, S. Mahajan, S.R. Choudhury, **Concepts of Modern Physics** (6^{th} Edition), McGraw Hill Inc., 2009. 2. S.H. Patil, **Elements of Modern Physics**, Tata McGraw Hill, 1989. 3. K.S. Krane, **Modern Physics** (2^{nd} Edition), John Wiley and Sons, 1996. 4. H.S. Mani and G.K. Mehta, **Introduction to Modern Physics**, East West Books Madras Pvt. Ltd., 1988. 5. A. K. Ghatak, **Optics** (4^{th} Edition), McGraw Hill, 1993.

		6. E. Hecht, *Optics,* Pearson Addison Wesley, 2002. 7. A.K. Ghatak and K. Thyagarajan, **Lasers: Theory and Applications***,* Macmillan India limited, 2003. 8. W. T. Silfvast, **Laser Fundamentals***, 2nd Edition,* Cambridge University Press, 1996. 9. A. Yariv, **Optical Electronics in Modern Communication***,* Oxford University Press, 1997.

1.	Course Code	**PH 104** [from AY 2009-10 to AY 2013-14] **PH 106** [from AY 2014-15 onwards]
2.	Title of the Course	**Physics-II: Electricity and Magnetism** [from AY 2009-10 to AY 2013-14] **Physics-II** [from AY 2014-15 onwards]
3.	Credit Structure	L-T- P-Credits 2 -1-0-3
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Electrostatics:** Coulomb's law, Gauss theorem, electric potential, Laplace's equation, Poisson's equation, electrostatics with conductors, capacitors, dielectrics. Magnetostatics: Biot Savart's law, Ampere's law, Lorentz force. **Magnetic Induction:** Faraday's law, Lenz's law, self and mutual inductance, energy in a magnetic field, LCR circuit, resonance. **Maxwell's equations:** displacement current, electromagnetic waves, plane wave solutions of Maxwell's equations, Poynting vector, wave propagation through a boundary, reflection, refraction, absorption and skin depth.
8.	Suggested Books	1. D. Griffiths, **Introduction to Electrodynamics**, (2nd edition), Prentice Hall of India, New Delhi, 1989. 2. A.S. Mahajan and A. Rangawala, **Electricity and Magnetism**, Tata McGraw Hill, New Delhi, 1989.

1.	Course Code	**PH 154** [from AY 2009-10 to AY 2013-14] **PH 156** [from AY 2014-15 onwards]
2.	Title of the Course	**Physics Lab**
3.	Credit Structure	L-T- P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Physics
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Determination of gravitational constant (g) Effect of magnetic field on materials (Hall Effect and Universal B-H Curve Tracer) Frank Hertz Experiment. LCR Circuit, and Thermal & Electric Conductivity Kundt's Tube Fresnel's Bi-prism Grating Spectrometer Hydrogen Spectrum Specific Charge of Electron (e/m) Newton's Rings
8.	Suggested Books	1. G. L. Squires, ***Practical Physics***, University Press, Cambridge, 1998.

Syllabi

Of

Institute Core (IC) Courses

and

Compulsory Engineering Courses

1.	Course Code	**CS 103**
2.	Title of the Course	**Computer Programming**
3.	Credit Structure	L-T-P-Credits 2-0-0-2
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	This course provides an introduction to problem solving with computers using a modern language such as Java or C/C++. Topics covered will include: 1. Developer fundamentals such as editor, integrated programming environment, Turbo C++ and/or Microsoft Visual C++ Programming environment, modules, libraries. 2. Programming features: Machine representation, primitive types, arrays and records, objects, expressions, control statements, iteration, procedures, functions, and basic i/o. 3. Sample problems in engineering, science, text processing, and numerical methods.
8.	Suggested Books	1. G. Dromey, **How to Solve It by Computer**, Prentice-Hall, Inc., Upper Saddle River, NJ, 1982 2. Coohoon and Davidson**, C++ Program Design: An introduction to Programming and Object- Oriented Design** (3rd edition), Tata McGraw Hill, New Delhi, 2003. 3. Yashwant Kanetkar, **Let us C**. Allied Publishers, 1998. 4. G. Polya, **How to Solve It** (2nd ed.), Doubleday and co. (1957). 5. **The Java Tutorial**, Sun Microsystems. Addison-Wesley, 1999.

1.	**Course Code**	**IC 151**
2.	**Title of Course**	**Computer Programming Laboratory**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Department	Institute Core Course
5.	Pre-requisite, if any	Should be enrolled in parallel in CS 103 or should have already taken and successfully completed the CS 103 course
6.	Scope of the course	To provide students with a thorough understanding of programming fundamentals through the route of practical exercises on the computer system
7.	Course Structure	Students would be made to work through programming assignments on the following topics in C++: 1) Data types 2) Control Statements 3) Functions 4) Pointers and Arrays 5) Dynamic Memory Allocation 6) Classes and Objects 7) Constructors and Destructors 8) Operator Overloading 9) Inheritance 10) Virtual Functions 11) File Handing and I/O Operations
8.	Suggested books	1. R. Lafore, Object Oriented Programming in C++, SAMS Publishing, 2001 2. B. Stroustrup, The C++ Programming Language, Addison-Wesley, 1997

1.	Course Code	**EE 104**
2.	Title of the Course	**Basic Electrical and Electronics Engineering**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Introduction: basic physical laws, basic circuit elements, Kirchoff"s voltage law (KVL), Kirchoff"s current law (KCL), and a few important circuit theorems, simple circuits. Transients in R-L, R-C, R-L-C, Sinusoidal Steady State, Real/ Reactive Power, Three phase power. Working Principles of Transformers/AC/DC machines. Functional Characteristics of Diode, BJT, OP-AMP. Analog circuit examples: rectifiers, amplifiers, oscillators, etc. Digital circuits: AND/OR gates, Flip Flops, DAC/ADC, etc.
8.	Suggested Books	1. L. S. Bobrow, **Fundamentals of Electrical Engineering** (2^{nd} edition), Oxford University Press, New Delhi. 2. Vincent Del Toro, **Electrical Engineering Fundamentals**, Prentice Hall, 1989. 3. K.A. Krishnamurthy and M.R. Raghuveer, **Electrical and Electronics Engineering for Scientists**, Wiley Eastern Ltd., 1993.

1.	Course Code	**EE 154**
2.	Title of the Course	**Basic Electrical and Electronics Engineering Lab**
3.	Credit Structure	L-T-P-Credits 0- 0-2-1
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Following experiments based on the associated theory course EE 104. 1. Familiarization with CRO and function generator 2. Characteristics of passive circuit elements (R,L,C) 3. Verification of network theorems 4. Time and frequency responses of RC, RLC circuits 5. Electronic components and their characteristics: Diode, Zener Diode, Led, Photodetector, Microphone 6. Half-wave rectifier and full-wave rectifier (with and without capacitive filter), Zener regulator and IC regulator. 7. Bipolar Junction Transistor (BJT) circuits to obtain some small signal parameters of BJT. 8. Voltage amplifiers using operational amplifiers to measure and analyze bias quantities (dc currents and voltages) and small-signal gain of the given common-emitter amplifier circuit. 9. Wave shaping and waveform generation using op amps 10. Basic combinatorial circuits 11. Logic design using multiplexers and basic sequential circuits 12. Synchronous and ripple counters
8.	Suggested Books	Same as the associated theory course EE 104: Basic Electrical and Electronics Engineering

1.	Course Code	**ME 104** [from AY 2010-11 to AY 2013-14]
2.	Title of the Course	**Basic Mechanical Engineering**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Thermodynamics:** Definition and scope of thermodynamics, fundamentals and laws of thermodynamics, vapour compression and absorption refrigeration cycles, psychometry and its uses. **Heat Transfer:** Various modes of heat transfer: conduction, convection and radiation, black body, heat exchangers. **Energy Conversion:** Various types of power plants, steam power plants and accessories, renewable energy. **Internal Combustion (IC) Engines:** Otto and diesel cycle, 2-stroke and 4- stroke engines, alternative fuels **Fluid Mechanics:** Fundamental Concepts, Flow through Pipes, Laminar Boundary Layers, Introduction and classification of Turbo machines **Power and Motion Transmission Devices**: Belt drive, Chain drive and Gear drive. Introduction to Flywheels, Governors, Clutches and Brakes.
8.	Suggested Books	1. Y.A. Cengel and M.A. Boles, **Thermodynamics: An Engineering Approach** (6th Edition), Tata McGraw Hill, New Delhi, 2008. 2. P.K. Nag, **Engineering Thermodynamics** (2nd edition), Tata McGraw Hill, New Delhi, 2003. (ISBN: 0-07-460275-6). 3. S.K. Som and G. Biswas, **Introduction to Fluid Mechanics and Fluid Machines** (2nd Edition), Tata McGraw-Hill Publishing Company, New Delhi, 2008. 4. S.S. Rattan, **Theory of Machines**, (2nd Edition) Tata McGraw Hill, New Delhi, 2005.

1.	Course Code	**ME 106** [from AY 2014-15 onward]
2.	Title of the Course	**Basic Mechanical Engineering**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	Introduces all the basic concepts of Mechanical Engineering
7.	Course Syllabus	**Introduction to Manufacturing:** Relating manufacturing, design, assembly, metrology, quality control and service to each other. Selection of manufacturing processes. **Introduction to metal casting processes:** Sand molding and casting process. Outline of popular casting methods with easy examples of products being manufactured by them. Basic idea of steel solidification. **Introduction to joining methods:** Concept of temporary semi-permanent and permanent joints. Shielded metal arc welding and oxy-fuel gas welding processes. Outline of different fusion and non-fusion welding processes and their applications. Idea of weldability. **Introduction to machine tools:** Preliminary idea of basic machine tools, hand tools and their operations. Ways of specifying tools and operations. Composition of cutting tool materials. Introduction to CNC machine tools. **Introduction to metal forming operations:** Fundamentals of mechanical behavior of materials. Basic requirements for bulk deformation of metals. Cold and hot working processes. Application of various forming processes. **Thermal Engineering:** Definition and scope of thermodynamics, fundamentals and laws of thermodynamics, vapour compression and absorption refrigeration cycles, psychometry and its uses. Otto and diesel cycle, 2- stroke and 4- stroke engines, alternative fuels Various types of power plants, steam power plants and accessories, renewable energy. **Power and Motion Transmission Devices**: Belt drive, Chain drive and Gear drive. Introduction to Flywheels, Governors, Clutches and Brakes.
8.	Suggested Books	1. E.P. DeGarmo, J.T. Black, and R. A. Kohser, **Materials and Processes in Manufacturing** (8^{th} edition), Prentice Hall of India Pvt. Limited, New Delhi, 2006.

		2. P.N. Rao, **Manufacturing Technology: Volume-1 and Volume-2** (3rd edition), Tata McGraw Hill, New Delhi, 2009. 3. S.K. Hajra Choudhury, S.K. Bose, and A.K. Hajra Choudhury, **Elements of Workshop Technology: Vol. I and Vol. II** (14th Edition) Media Promoters and Publishers, Mumbai, 2007. 4. M.P. Groover, **Fundamentals of Modern Manufacturing,** John Wiley & Sons Inc (Indian student edition), 2002. 5. Y.A. Cengel and M.A. Boles, **Thermodynamics: An Engineering Approach** (6th Edition), Tata McGraw Hill, New Delhi, 2008. 6. S.S. Rattan, **Theory of Machines**, (2nd Edition) Tata McGraw Hill, New Delhi, 2005.

1.	Course Code	**ME 153** [from AY 2009-10 to AY 2015-16] **IC 153** [from AY 2016-17 onwards]
2.	Title of the Course	**Engineering Graphics**
3.	Credit Structure	L-T- P-Credits 1-0-3-2.5
4.	Name of the Concerned Department	All the Engineering Departments
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Introduction to engineering drawing and orthographic projections; Projection of points and straight line; Projection of planes and solids; Projection of simple machine elements; Development of surfaces, Intersection of surfaces; Construction of isometric views from orthographic projections.
8.	Suggested Books	1. N.D. Bhatt and V.M. Panchal, **Engineering Drawing**, Charotar Publishers, Anand, 2007. 2. W.J. Luzadder and J. M. Duff, **Fundamentals of Engineering Drawing**, Prentice Hall of India, 2001. 3. T. E. French, C.J., Vierck, and R.J. Foster, **Engineering Drawing and Graphic Technology** (14th Edition) McGraw Hill Science/Engg, 1993. 4. A. D. Jolhe, **Engineering Drawing**, Tata McGraw Hill, New Delhi, 2007. 5. M.B. Shah and B.C. Rana, **Engineering Drawing**, Dorling Kindersley (India) Pvt. Ltd, Pearson Education,

1.	Course Code	**ME 154** [from AY 2010-11 to AY 2013-14]
2.	Title of the Course	**Basic Manufacturing Techniques**
3.	Credit Structure	L-T- P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Nil
6.	Scope of the course	
7.	Course Syllabus	**Engineering Materials:** Introduction of engineering materials their types, applications, and manufacturability. **Introduction to Pattern Making and Casting**: Pattern materials, pattern types, hand tools used in the wood working, pattern allowances, colour coding, molding sand composition and properties, sand casting, casting defects and their remedies. **Plastic Parts Manufacturing:** Introduction and typical applications of the commonly used plastic parts manufacturing processes such as extrusion, injection molding, blow molding, rotational molding, compression molding, transfer molding, structural foam molding, thermoforming, etc. **Introduction to Machining:** Machining fundamentals, Types of machining operations, Details and types of basic machine tools such as lathe, milling, and drilling and important machining operations on these machines and types of cutting tools used. Introduction of computer numerical controlled (CNC) machine tools. **Introduction to Joining Methods:** Welding fundamentals, types of welded joints and welding positions, operations and details of gas welding process, manual metal arc welding processes. Soldering and brazing, their applications in electronics industry. **Introduction to Metal Forming Operations:** Working principle and applications of forging, rolling, extrusion, wire drawing, tube drawing, and sheet metal operations. **Practicals:** Simple workshop jobs to be made in the foundry, electric arc welding and gas welding, lathe, milling, and drilling machines. Demonstration of plastic parts manufacturing and Forming machines.
8.	Suggested Books	1. E.P. DeGarmo, J.T. Black, and R. A. Kohser, **Materials and Processes in Manufacturing** (8th edition), Prentice Hall of India Pvt. Limited, New Delhi, 2006. 2. P.N. Rao, **Manufacturing Technology: Volume-1 and Volume-2** (3rd edition), Tata McGraw Hill, New Delhi, 2009. 3. S.K. Hajra Choudhury, S.K. Bose, and A.K. Hajra Choudhury, **Elements of Workshop Technology: Vol. I and Vol. II** (14th Edition) Media Promoters and Publishers, Mumbai, 2007.

		4. M.P. Groover, **Fundamentals of Modern Manufacturing,** John Wiley & Sons Inc (Indian student edition), 2002.

1.	Course Code	**ME 156** [from AY 2014-15 onwards] **IC 156** [from AY 2016-17 onward]
2.	Title of the Course	**Basic Manufacturing Techniques**
3.	Credit Structure	L-T- P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	All the Engineering Departments
5.	Pre–requisite, if any	Nil
6.	Scope of the course	
7.	Course Syllabus	1. Preparation of single piece casting. 2. Preparation of Lap joint in carpentry. 3. Preparation of joint by Arc welding & Gas welding. 4. Preparation of simple job by fitting tool & drilling. 5. Preparation of job on Lathe machine by turning, facing, knurling, drilling etc. 6. Basic Electrical Wiring system. 7. Investigating the casting and weld defects using non-destructive examination. 8. Characterize the defect size, location and distribution using ultrasonic method. 9. Determination of density of the given Casting using Archimedes method.
8.	Suggested Books	

1.	Course Code	**IC 211**
2.	Title of the Course	**Experimental Engineering Lab**
3.	Credit Structure	L-T- P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	All the Engineering Departments and Mathematics
5.	Pre–requisite, if any	Nil
6.	Scope of the course	
7.	Course Syllabus	1. Measurement of Resistance using Kelvin Bridge. 2. Measurement of Inductance using Maxwell Bridge and Measurement of Capacitance using Desauty's and Schearing Bridge. 3. Study of LVDT characteristics. 4. Measurement of Pressure using U-tube manometer, inclined manometer and Dead weight pressure tester. 5. Study of various types of Temperature Measurement Methods 6. Study of Mechatronics sensors. 7. Determination of elastic modulus using 3 point symmetric /asymmetric bending. 8. Determination of surface tension of a given liquid using contact angle measurement. 9. Chain Surveying: To Provide a skeleton or frame work consisting of a number of connected triangles. 10. Prepare and develop a program for data acquisition and presentation from different sensors.
8.	Suggested Books	**Text Books** 1. J. P. Holman, **Experimental Methods for Engineers** (7th Edition), Tata McGraw-Hill, New Delhi, (Special Indian Edition) 2007. 2. E.O. Doebelin, **Engineering Experimentation: Planning, Execution, Reporting**, McGraw-Hill, ISBN: 0070173397, 1995. 3. E.O. Doebelin and D. N. Manik, **Measurement Systems**, McGraw Hill Educations, 2007 **Reference Books** 1. J.P. Holman, **Experimental Methods for Engineers**, McGraw- Hill Inc., New York, 1978. 2. E.O. Doebelin, **Measurement Systems; Application and Design**, McGraw-Hill, 1976. 3. C.F. Jeff Wu, and M.S. Hamada, **Experiments: Planning, Analysis, and Optimization**, Wiley, ISBN: 0471699462, 2009. 4. A.J. Wheeler and A.R. Ganji, **Introduction to Engineering**

		Experimentation, Prentice Hall, ISBN: 0131742760, 1996. 5. W.J. Diamond, **Practical Experiment Designs: for Engineers and Scientists**, Wiley, ISBN: 0471390542, 2001. 6. R.H. Bishop, **Learning with LabVIEW**, Addison Wesley Longman, ISBN: 0201361663, 1999. 7. R.S. Figliola, and D.E. Beasley, **Theory and Design for Mechanical Measurements** - 4th Edition, Wiley, 2006.

1.	Course Code	**ES 302** [from AY 2010-11 onwards]
2.	Title of the Course	**Environnemental Studies: Scientific and Engineering Aspects**
3.	Credit Structure	L-T-P-Credits 3-0-0-1.5 **(Half Semester Course)**
4.	Name of the Concerned Department	Multi-disciplinary
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Multidisciplinary nature of environmental studies, Ecosystems, Biodiversity and its conservation, Indicators of environmental pollution, Environment and human health. Consumption of natural resources and environmental degradation of forests, water, coal, minerals, energy, and land. Sustainable development, Environmental policy and legislation, Environmental impact assessment. Pollution of lakes, rivers, ground water, coasts, and oceans, Science and technology for drinking water and wastewater treatment and issues in management of systems. Solid and hazardous waste management: causes, effects and control measures. Air and noise pollution, science and engineering of pollution control, Global Issues including climate change, global warming, acid rain, ozone layer depletion, nuclear hazards, Disaster management, industrial accidents, floods, earthquakes, cyclones and landslides.
8.	Suggested Books	1. W.P. Cunningham and M.A. Cunningham, **Principles of Environmental Science,** Tata McGraw-Hill Publishing Company, New Delhi, 2002. 2. J.A. Nathanson, **Basic Environmental Technology**, Prentice Hall of India, New Delhi, 2002. 3. S.J. Arceivala, and S.R. Asolekar, **Wastewater Treatment for Pollution Control and Reuse** (3rd Edition), Tata McGraw Publishing Co. Ltd., New Delhi, 2006. 4. S.R. Asolekar, and R. Gopichandran, **Preventive Environmental Management: An Indian Perspective**, Foundation Books Pvt. Ltd., New Delhi, 2005. Some selected book-chapters, monographs and journal papers

Course code	**EE 101**
Title of the course	**Basic Electrical Engineering**
Course Category	Institute Core
Credit Structure	L-T-P-C (1-1-0-2)
Name of the Concerned Department	Electrical Engineering
Prerequisite, if any	None
Scope of the course (Objectives)	The objective of this course is to familiarize the students with different theorems and circuits associated with basic electrical engineering.
Course Outcomes	• To acquire knowledge in different aspects of basic electrical engineering • To understand different theorems and their applications in electrical circuits.
Course Syllabus	**Introduction:** Basic physical laws, Basic circuit elements, Kirchhoff's voltage law (KVL), Kirchhoff's current law (KCL), A few important circuit theorems (Mesh analysis, Nodal analysis, Superposition theorem, Thevenin theorem, Norton theorem, Supernode analysis, Supermesh analysis, Star-delta theorem), simple and complex circuits. **Electrical circuits:** Transients in R-L, R-C, R-L-C, Sinusoidal Steady State, Real/ Reactive Power, Phasors, Three phase power, Magnetic circuit, Working principles of Transformers/AC/DC machines. **Analog circuits:** OP-AMP.
Suggested Books	Textbooks: (1) L. S. Bobrow, **Fundamentals of Electrical Engineering** (2nd edition), Oxford University Press, 1996, ISBN: 0195105095. (2) C. K. Alexander, and M. Sadiku, **Fundamentals of Electric Circuits** (5th edition), McGraw Hill, 2013, ISBN: 1259098591. (3) R. L. Boylestad, and L. Nashelsky, **Electronic Devices and Circuit Theory** (4th edition), Longman Higher Education, 1987, ISBN: 013250457X. Reference books: 1) V. D. Toro, **Electrical Engineering Fundamentals** (2nd edition), Prentice Hall, 1989, ISBN: 9332551766. (2) K. A. Krishnamurthy and M. R. Raghuveer, **Electrical and Electronics Engineering for Scientists and Engineerings**, Wiley-Blackwell, 1994, ISBN: 0470220627. (3) R. A. Gayakwad, **Op-Amps and Linear Integrated Circuits** (4th edition), Pearson, 2015, ISBN: 9332549915.

Course code	**EE 106**
Title of the course	**Basic Electronics Engineering**
Course Category	Institute Elective
Credit Structure	L-T-P-C (1-0-0-1)
Name of the Concerned Department	Electrical Engineering
Prerequisite, if any	None
Scope of the course (Objectives)	The objective of this course is to familiarize the students with the basics of different circuits, electronic devices and components associated with basic electronics engineering.
Course Outcomes	• To acquire knowledge in different aspects of basic electronics engineering • To understand the operational mechanisms of different electronic circuits, devices, and components.
Course Syllabus	**Introduction:** Functional Characteristics of Diode, Circuits (Clippers, clampers), Rectifiers, Bipolar Junction Transistor (BJT). **Digital circuits:** Boolean algebra, Number System, Logic gates, Flip Flops.
Suggested Books	**Text books:** (1) R. L. Boylestad, and L. Nashelsky, **Electronic Devices and Circuit Theory** (4th edition), Longman Higher Education, 1987, ISBN: 013250457X. (2) B. G. Streetman, **Solid State Electronic Devices** (6th edition), Prentice Hall of India, New Delhi, 2006, ISBN: 812033020X. (3) A. S. Sedra and K. C. Smith, **Microelectronic Circuits** (7th edition), Saunder's College Publishing, 2014, ISBN: 9780199339136. (4) J. Millman and A. Grabel, **Microelectronics** (2nd edition), McGraw Hill, International, 2017, ISBN: 0074637363. **Reference books:** (1) H. Taub and D. Schilling, **Digital Integrated Electronics** (1st edition), McGraw Hill, 2017, ISBN: 9780070265080. (2) D. A. Hodges, H. G. Jackson, and R. A. Saleh, **Analysis and Design of Digital Integrated Circuits** (3rd edition), McGraw Hill, 2003, ISBN: 0072283653.

Course code	**ME 101**
Title of the course	**Engineering Mechanics**
Course Category	Basic engineering
Credit Structure	L - T - P - Credits 2-0-0-2
Name of the Concerned Department	Mechanical Engineering/ Civil Engineering
Pre-requisite, if any	This is an introductory course to study and make use of the principles required to remedy engineering mechanics issues. Mathematics and physics Ideas can be applied on this course.
Scope of the course (Objectives)	Engineering mechanics involves the study of forces and their effects on matter, and the use of this knowledge to design and analyse structures, machines, and other systems. It is used to analyse and design structures to understand the behaviour of materials under different loading conditions.
Course Outcomes	➢ To develop ability to model and analysis of mechanical engineering systems using vectoral representation of forces and moments. ➢ To develop skills to use the basic principles of mechanics in engineering applications.
Course Content	1. Introduction to statics and dynamics: Mechanics, Basic Concepts, Scalars and Vectors, Newton's Laws, Units, Laws of Gravitation. 2. Force Systems: Two- and Three-Dimensional Force Systems, Rectangular Components, Moment and Couple, Resultants. 3. Equilibrium: Equilibrium in Two-and Three-Dimensions, System Isolation and Free-Body Diagram. 4. Friction: Introduction, Laws of Coulomb Friction, Equilibrium of Bodies involving Dry friction. 5. Centroid and Moment of Inertia: Centroid of the plane, curve, area, volume, and composite bodies, moment of inertia of plane area, parallel axes theorem. 6. Structures: Plane trusses, method of joints, method of sections, frames, and machines. 7. Kinematics of Rigid Body: Introduction, plane motion of the rigid body, velocity and acceleration under translation and rotational motions. 8. Kinetics of Rigid Body: Introduction, force, mass and Acceleration, Work and Energy, Impulse and Momentum, D'Alembert's principles, and dynamic equilibrium. 9. Simple Stress and Strain: Introduction, normal and shear

	stresses, stress-strain diagrams for ductile and brittle material.
Suggested books	Textbooks: 1. Irving H. Shames, Engineering Mechanics, Pearson Education, Prentice Hall, 2006, ISBN 9788177581232 2. James L. Meriam, L. G. Kraige, J. N. Bolton, Engineering Mechanics: Statics and Dynamics, Ninth edition, Wiley publication, 2018, ISBN: 978-1-119-39262-0 Reference textbook: 3. E.P. Popov, Mechanics of Materials, Second Edition, Prentice Hall of India Private Limited, 2015, ISBN: 9789332559547

Course code	**ME 108**
Title of the course	**Basic Manufacturing Processes**
Course Category	Flexible elective
Credit Structure	L - T - P - Credits 1-0-0-1
Name of the Concerned Department	Mechanical Engineering
Pre-requisite if any	Nil
Scope of the course (Objectives)	It focuses on the design, development, and operation of integrated systems of production to obtain high quality & economically competitive products.
Course Outcomes	➢ This course helps in selecting suitable manufacturing processes to manufacture the products optimally. ➢ This course also recommends the appropriate design of casting process systems, forming processes, welding process and machining (metal cutting) processes.
Course Content	1. Casting: Steps involved in making a casting, its applications, patterns, and types of patterns, pattern allowances and their construction, types of casting processes, solidification of casting. 2. Introduction to machine tools: Preliminary idea of basic machine tools, hand tools and their operations. Ways of specifying tools and operations. Composition of cutting tool materials. 3. Welding: Welding types, Oxy-fuel gas welding, cutting, Outline of different fusion and non-fusion welding processes and their applications. 4. Forming: Hot working, cold working, strain hardening, comparison of properties of cold and hot worked parts, rolling fundamentals 5. Forging processes: Forging operations and principles, tools, forging methods, forging hammers: Rotary forging, forging defects, cold forging.
	Suggested textbooks: 1. P.N. Rao, Manufacturing Technology (Foundation Forming & Welding), Tata McGraw Hill, 2013, ISBN: 978-9383286614 2. J. S. Campbell, Principles of manufacturing materials and processes, Tata McGraw Hill, 1995, ISBN: 9780070992528

	Reference textbooks: 1. S. Kalpakjian and S.R. Scsimid, Manufacturing Engineering and Technology, 4th Edition, Pearson Education, 2001, ISBN: ISBN: 9788177581706 2. R. C. S. Mehta N. S. Gaira, Basic Manufacturing Process, 2017, VIVA BOOKS, ISBN: 978-8171881871

Course code	**ME 110**
Title of the course	**Basic Thermal Engineering**
Course Category	Flexible elective
Credit Structure	L - T - P - Credits 1-0-0-1
Name of the Concerned Department	Mechanical Engineering
Pre-requisite if any	Nil
Scope of the course (Objectives)	This course focuses on basic mechanical engineering starting from thermodynamics, fluid mechanics, Heat transfer to its application in different practical processes, analysis of the Internal combustion engines, and the Refrigeration cycle.
Course Outcomes	➢ Able to obtain knowledge of different aspects of designing of a thermal system. ➢ Get fundamental knowledge of fluid, its properties and behavior under various conditions. ➢ Understand various types of I.C. Engines, refrigeration cycles and Heat transfer modes
Course Content	1. Basic concepts and laws of thermodynamics: Thermodynamic definition and scope, system - boundary, surrounding, thermodynamic systems Properties of system, Law of thermodynamics-Zeroth, first & second laws of thermodynamics. 2. Fluid Mechanics: Fluid statistics, Fluid kinematics, and Fluid dynamics 3. Refrigeration & air conditioning: Working principle of VCR and VAR cycles. Performance of refrigeration cycles 4. IC engines: Working principle of Two Stroke and four stroke engine, petrol, and diesel engine. Engine performance and emissions. 5. Heat Transfer: Introduction -Modes of heat transfer- Conduction, convection, and radiation, Simple problems on conduction.
Suggested books	**Textbooks:** 1. Moran, M.J., Moran, H. N. Shapiro, D.D. Boettner, and M.B. Bailey, “Fundamentals of engineering thermodynamics”. 8th Edition, John Wiley & Sons; (2010), ISBN: 978-1-118-41293-0 2. Y.A. Cengel and M.A. Boles, Thermodynamics: An Engineering Approach (6th Edition), Tata McGraw Hill, New Delhi, 2008, ISBN:

	0071257713 3. F.M. White, Fluid Mechanics, Seventh edition, Tata McGraw Hill, 2008, ISBN: 978-0071333122 **Reference textbook:** 1. W. W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, PHI, (2002), ISBN: 978-0131405707 **2.** J. P. Holman, & Souvik Bhattacharyya, Heat Transfer, 10th Edition, 2017, ISBN: 978-0071069670

Course code	**PH 108**
Title of the course	**Basics of Laser Engineering**
Course Category	Elective for Basic Engineering Module
Credit Structure	L - T - P - Credits 1-0-0-1
Name of the Concerned Department	Physics
Pre-requisite, if any	-----------------------
Scope of the course (Objectives)	Student will learn basic principle of lasers, their functioning and application.
Course Outcomes	Familiarity with the working mechanisms of lasers and it's applications.
Course Content	Stimulated and Spontaneous emissions, Absorption, Einstein's A and B coefficients, Population inversion, Pumping techniques, Resonators, Laser modes, Classes of lasers, Properties of lasers and Laser applications.
Suggested Books	Text Book: 1. A.K. Ghatak and K. Thyagarajan: Lasers: Fundamentals and Applications: Laxmi publications: 2019: ISBN: 978-9352745531 Reference Books: 2. W. T. Silfvast, Laser Fundamentals (2nd Edition): Cambridge University Press: 2004: ISBN: 978-0521833455

Course code	**PH 107**
Title of the course	**Basics of Physics**
Course Category	Core
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Physics
Pre-requisite, if any	None
Scope of the course (Objectives)	Student will learn Basics of Quantum Mechanics and Electromagnetic theory
Course Outcomes	• Understanding of Quantum Mechanical concepts, their need, and applications • To develop ability to solve complex problems if electromagnetism using mathematical methods and tools • Analysis of complex real life problems through examples and physical understanding
Course Content	1.**Quantum Mechanics & Applications**: Review of quantum concepts, Inadequacies of Classical Mechanics – black body radiation, Photoelectric effect, Compton effect, Heisenberg uncertainty principle. Schrodinger equation, Probabilistic interpretation of wave function. One dimensional problems- Particle in a box, Potential well, Potential barrier and Tunnelling, Harmonic oscillator. 2**. Electrostatics**: Divergence and curl of electrostatic fields, electric potential, Poisson's equation, Laplace's equation, Uniqueness theorem, method of images, Separation of variables, multipole expansion, Polarization, bound charges, fields, forces and energy of dielectrics, applications 3**. Magnetostatics**: Biot-Savart law, divergence and curl of magnetic field, vector potential, Magnetic field inside matter, Electromagnetic induction, Faraday's law, Maxwell equations and Poynting's theorem, applications

Suggested Books	**Text Books:** 1. A. Beiser, S. Mahajan, S.R. Choudhury: Concepts of Modern Physics (6th Edition): McGraw Hill Inc: 2009: ISBN-13 : 978-9351341857 2. D. Griffiths: Introduction to Electrodynamics, (2nd edition): Prentice Hall of India: New Delhi: 1989: ISBN-13 : 978-1108822909 **Reference Books:** 1. S.H. Patil: Elements of Modern Physics:Tata McGraw Hill:1989: ISBN: 978-0074602256 2. K.S. Krane : Modern Physics (2nd Edition): John Wiley and Sons: 1996, ISBN: 978-9354244681 3. H.S. Mani and G.K. Mehta: Introduction to Modern Physics: East West Books Madras Pvt. Ltd.: 1988: ISBN: 978-8185095738 4. A.S. Mahajan and A. Rangawala: Electricity and Magnetism: Tata McGraw Hill: New Delhi: 1989 : ISBN: 978-0074602256 5. D. N. Vasudeva : Fundamentals of magnetism and electricity: S. Chand and Company: ISBN: 978-8121909556 6. E. M. Purcell and David Morin: Electricity and Magnetism : Cambridge University Press: ISBN: 978-1107014022 7. H. C. Verma, Classical Electromagnetism, ISBN: 978-9388704823

Course code	**PH 157**
Title of the course	**Physics Lab- I**
Course Category	Core
Credit Structure	L - T - P - Credits 0-0-2-1
Name of the Concerned Department	Physics
Pre-requisite, if any	Nil
Scope of the course (Objectives)	Student will learn to perform experiments in a methodical manner of data acquisition, data analysis and error estimation. They should be able to interpret their results and physical significance.
Course Outcomes	• To conduct and analyse experiments in a scientific way • Learn logical interpretation of the data and physical interpretation
Course Content	1. Effect of magnetic field on materials (Hall Effect and Universal B-H Curve Tracer) 2. Frank Hertz Experiment. 3. LCR Circuit 4. Thermal & Electrical Conductivity 5. Kundt's Tube 6. Fresnel's Bi-prism 7. Grating Spectrometer 8. Hydrogen Spectrum 9. Specific Charge of Electron (e/m) 10. Newton's Rings
Suggested Books	**<u>Text Book:</u>** • Lab Manual **<u>Reference Books:</u>** • G. L. Squires, Practical Physics, University Press, Cambridge, 1998

Course Code	**BSE 102**
Title of the Course	**Biosciences**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Discipline	Biosciences and Biomedical Engineering
Pre–requisite, if any	Nil
Scope of the course (Objectives)	This course intends to refresh the basics of biology to engineering students who might not be in touch with this subject after their matriculation
Course Outcomes	1. Gain an appreciation of vital life processes and principles governing homeostasis of the human body machine 2. Enthuse students to apply engineering principles to biological systems and vice-versa
Course Syllabus	**The perspective of Biology and Life and its origin:** Requirements for Life, Chemistry of life, Chemistry of water, Origin of life. **Evolutionary History of Biological Diversity:** Phylogeny and the Tree of Life, Bacteria and Archaea, Protists. Plant Diversity I: How Plants Colonized Land, Plant Diversity II: The Evolution of Seed Plants, Fungi, An Overview of Animal Diversity, An Introduction to Invertebrates, The Origin and Evolution of Vertebrates **Micro- and Macromolecules in the living system:** Amino Acids, Proteins, Carbohydrates, lipids and Fats, and Nucleic Acids. **Enzymes:** Basic concept, Classification and Function, Enzyme kinetics, Role of Enzymes in life. **Cell:** Prokaryotic and Eukaryotic cells, Animal cell and Plant cell, Structure and function of the sub-cellular organization, membrane and cell physiology, Chromosome and Gene, Genetics. Mitosis, Meiosis, other types of cell divisions, and Cancer **Organization of the Human body:** Tissues, Organs, and the body **Ecology and Environment:** Aquatic and terrestrial biomes, Pollution, Climate change, etc. **Biomedical Imaging and Instrumentation:** Introduction to imaging modalities used in the clinic, and introduction to clinical instrumentations.
Suggested Books	<u>**Text Books:**</u>

	1. Campbell; Biology, 9th edition. Pearson Higher Education 2011 2. Lehninger & Cox. Principles of Biochemistry (5th edition), W.H. Freeman & Company, USA **<u>Reference Books:</u>** 1. Colleen Belk, Virginia Borden Maier; Biology: Science for Life with Physiology, Pearson New International Edition, 2013 2. Khandpur R.S., Handbook of Biomedical Instrumentation (2nd edition), Tata McGraw-Hill Publishing Company Limited, New Delhi

Course Code	**MA 101N**
Title of the Course	**Calculus-I**
Course Category	Institute Core
Credit Structure	L-T- P-Credits 3-1-0-2 (=4/2) (1/2 Semester)
Name of the Concerned Discipline	Mathematics
Pre-requisite, if any	None
Scope of the course	This is a foundation course on single variable calculus for UG students.
Course Outcomes	Students will understand the concepts, like convergence of sequences and series, limits, continuity, differentiability and integrability, and their applications.
Course Syllabus	• Review of limits, continuity, differentiability. • Mean Value Theorem, Taylor Theorem, Maxima and Minima. • Riemann integrals, Fundamental theorem of Calculus, Improper integrals, application to area, volume. • Convergence of sequences and series, power series.
Suggested Books	1. G. B. Thomas, M. D. Weir, J. Hass, F. R. Giordano, **Thomas' Calculus**, Addison Wesley, 2004, 11th Edition, ISBN: 0321185587,9780321185587
Reference Books	2. Huges-Hallett et al., Calculus: Single and Multi-Variable (3rd Edition), John-Wiley & Sons (USA), 2003. ISBN: 1119696550, 9781119696551 3. J. Stewart, Calculus (5th Edition), Thomson, 2003 (Indian Edition). ISBN: 053439339X, 9780534393397 4. T.M. Apostol, Calculus: Volumes 1 and 2 (2nd Edition), Wiley Eastern (USA), 1980. ISBN: 0471000051, 9780471000051 5. G.B. Thomas and R.L. Finney, Calculus and Analytic Geometry (9th Edition), ISE Reprint, Addison-Wesley, 1998 (Indian Edition). ISBN: 0201531747, 978-0201531749

<table>
<tr><td>Course Code</td><td>MA 103N</td></tr>
<tr><td>Title of the Course</td><td>Calculus-II</td></tr>
<tr><td>Course Category</td><td>Institute Core</td></tr>
<tr><td>Credit Structure</td><td>L-T- P-Credits
3-1-0-2 (=4/2) (1/2 Semester)</td></tr>
<tr><td>Name of the Concerned Discipline</td><td>Mathematics</td></tr>
<tr><td>Pre-requisite, if any</td><td>None</td></tr>
<tr><td>Scope of the course</td><td>This is a foundation course on multi-variables calculus for UG students.</td></tr>
<tr><td>Course Outcomes</td><td>Students will understand the concepts, like partial derivatives, gradient, directional derivatives, double and triple integration, and their applications.</td></tr>
<tr><td>Course Syllabus</td><td>• Partial Derivatives, gradient and directional derivatives, chain rule, maxima and minima, Lagrange multipliers.
• Double and triple integration, Jacobians and change of variables formula.
• Parametrization of curves and surfaces, vector fields, line and surface integrals.
• Divergence and curl, theorems of Green, Gauss, Stokes.</td></tr>
<tr><td>Suggested Books</td><td><u>Textbooks:</u>
1. G. B. Thomas, M. D. Weir, J. Hass, F. R. Giordano, Thomas' Calculus, Addison Wesley, 2004, 11th Edition, ISBN: 0321185587,9780321185587
<u>Reference Books:</u>
2. Huges-Hallett et al., Calculus: Single and Multi-Variable (3rd Edition), John-Wiley & Sons (USA), 2003. ISBN: 1119696550, 9781119696551
3. J. Stewart, Calculus (5th Edition), Thomson, 2003 (Indian Edition). ISBN: 053439339X, 9780534393397
4. T.M. Apostol, Calculus: Volumes 1 and 2 (2nd Edition), Wiley Eastern (USA), 1980. ISBN: 0471000051, 9780471000051
5. G.B. Thomas and R.L. Finney, Calculus and Analytic Geometry (9th Edition), ISE Reprint, Addison-Wesley, 1998 (Indian Edition). ISBN: 0201531747, 978-0201531749</td></tr>
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Course Code	**MA 102N**
Title of the Course	**Linear Algebra**
Course Category	Institute Core
Credit Structure	L-T- P-Credits 2-1-0-1.5 (=3/2) (1/2 Semester)
Name of the Concerned Discipline	Mathematics
Pre-requisite, if any	None
Scope of the course	This is a foundation course on linear algebra for UG students.
Course Outcomes	Students will understand solving a system of linear equations and the concepts, like matrices, determinants, vector spaces and linear transformations.
Course Syllabus	• System of linear equations, matrices and Gaussian elimination, rank of a matrix. • Determinants and rank of a matrix in terms of determinants. • Vector spaces, linear independence and dependence, linear span of a set of vectors, vector subspace, basis of vector subspaces, row space, null space and column space, rank-nullity theorem. • Linear transformations, matrix of a linear transformation, change of basis and similarity, Inner product spaces, Gram-Schmidt process, orthonormal bases. • Eigenvalues and eigenvectors, characteristic polynomials, eigenvalues of special matrices, such as orthogonal, unitary, Hermitian, symmetric, skew-symmetric, normal. • Algebraic and geometric multiplicity, diagonalization, spectral theorem for real symmetric matrices.
Suggested Books	**Textbooks:** 1. Gilbert Strang, **Introduction to Linear Algebra**, Fifth Edition (2016), Wellesley-Cambridge Press, ISBN: 978-09802327-7-6 **Reference Books:** 1. H. Anton, Elementary Linear Algebra with Applications (8th Edition), John-Wiley & Sons, 1995. ISBN: 0471669598, 9780471669593 2. G. Strang, Linear Algebra and its Applications (4th edition), Thomson, 2006. ISBN: 0030105676, 9780030105678 3. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice Hall of India, 2000. ISBN: 8120316282, 9788120316287 4. E. Kreyszig, Advanced Engineering Mathematics (8th Edition), John Wiley & Sons, 1999, ISBN 978-0-470-45836-5.

Course Code	**MA 104N**
Title of the Course	**Differential Equations-I**
Course Category	Institute Core
Credit Structure	L-T- P-Credits 2-1-0-1.5 (=3/2) (1/2 Semester)
Name of the Concerned Discipline	Mathematics
Pre-requisite, if any	None
Scope of the course	This is a foundation course on ordinary differential equations for UG students.
Course Outcomes	• Students will be trained to solve various types of ordinary differential equations. • Students will also be exposed to the qualitative theory of ordinary differential equations such as existence and uniqueness.
Course Syllabus	• Exact equations, integrating factors, Orthogonal trajectories. • Lipschitz condition, Picard's theorem. • Linear differential equations generalities, Wronskians, Dimensionality of space of solutions, Abel-Liouville formula, Linear ODEs with constant coefficients, the characteristic equations, Cauchy-Euler equations. • Method of undetermined coefficients. • Method of variation of parameters. • Laplace transformation and generalities, shifting theorems, convolution theorem.
Suggested Books	**Textbooks:** 1. E. Kreyszig, **Advanced Engineering Mathematics** (8th Edition), John Wiley & Sons, 1999, ISBN 978-0-470-45836-5. **Reference Books:** 1. W.E. Boyce and R. Diprima, Elementary Differential Equations (8th Edition), John Wiley & Sons, 2005(USA). ISBN: 0471433381, 9780471433385 2. T.M. Apostol, Calculus, Volume 2 (2nd edition), Wiley-Eastern, 1980. ISBN: 0471000078, 9780471000075 3. G. Simmons, Differential Equations with Applications and Historical Notes, McGraw Hill Education 2nd edition, 2017. ISBN: 0070575401, 9780070575400 4. G. Simmons, Differential Equations: Theory-Technique and Practice, McGraw Hill Education, 1st edition, 2017. ISBN: 0072863153, 9780072863154

1.	Course Code	**CH 105**
2.	Title of the Course	**Chemistry**
3.	Credit Structure	L-T-P-Credit 3-0-0-3
4.	Name of the Department	Chemistry
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	This course provides basic knowledge of chemistry involving organic, inorganic and physical chemistry
7.	Course Syllabus	**Linking microscopic and bulk thermodynamic properties:** Distribution of molecular states and relation to entropy, Boltzmann distribution, ensembles, partition functions. **Elucidation of structure and properties:** Experimental techniques, Interaction light with matter, absorption and emission spectra, intensities of spectral lines, Beer-Lambert law, spontaneous and simulated emission, transition moments and selection rules, Franck-Condon principle, lasers and fluorescence. **Chemical Bonding:** Valence Bond Theory (VBT), Molecular Orbital Theory (MOT) **Structure and Bonding of Coordination Complexes:** Tetrahedral, Octahedral, Square planar and Square Pyramidal complexes **Introduction to Organometallic Complexes:** Structure and Bonding **Application of Coordination Complexes, Metal Organic Frameworks (MOFs), and Organometallic Complexes:** Introduction to Metal organic Frameworks, Magnetic materials, Catalysis, Adsorption properties, Metal ions in Biology **Organic Chemistry:** Hűckel treatment of ethylene, butadiene and benzene, concept of aromaticity, orbital symmetry and chemical reactions, conformation of cycloalkanes, reactivity of carbonyl groups due to acidic protons, heterocyclic chemistry (thiophene, furan, pyridine, pyrrole, and indole), neighbouring group effect. Introduction to bio-organic chemistry: steroids, amino acids and nucleic acids.
8.	Suggested Books	**Text Books** 1. P.W. Atkins, J.D. Paula, **Physical Chemistry,** 8th Edn., Oxford University Press, **2006**, ISBN 9780716787594. 2. I. A. Levine, **Physical Chemistry**, McGrawHill, **2009**, ISBN 978-007-2538625. 3. D.A. McQuarrie and J.D. Simon, **Physical Chemistry - A Molecular Approach**, Viva Books Pvt. Ltd., **1998**. 4. R.T. Morrison and R.N. Boyd, **Organic Chemistry**, Prentice Hall of India Pvt. Ltd., 6th Edn., **1992**, ISBN 0-13-643669-2. 5. G. Solomons, C. Fryhle, S. A. Snyder, **Organic Chemistry**, John Wiley & Sons (Asia) Pvt. Ltd., 11th Edn., **2013**, ISBN-10: 1118147391. 6. J. D. Lee, **Concise Inorganic Chemistry**, 5th Edn., ELBS, **1996**,

		ISBN 978-8126515547. 7. D. F. Shriver, P. W. Atkins, **Inorganic Chemistry**, Oxford University Press, **2006**, ISBN 978-0199236176. 8. R. C. Mehrotra, A. Singh, **Organometallic Chemistry,** 2nd Edn., New Age International (P) Ltd Publishers, **2007**, ISBN 978-0470210192. 9. 9. D. Farrusseng, **Metal-organic Frameworks: Application from Catalysis to Gas storage**, Wiley, **2011,** ISBN 978-3527328703.

Course code	**CH 155**
Title of the course	**Chemistry Lab**
Course Category	Core Course
Credit Structure	L - T - P - Credits 0-0-2-1
Name of the Concerned Department	Chemistry
Pre-requisite, if any	Not Required
Scope of the course (Objectives)	The lab course introduces students to basic chemical methods such as quantitative chemical analysis, separation techniques and useful chemical reactions.
Course Outcomes	1. Basic laboratory skills in chemistry. 2. Data handling and analysis. 3. Experience in safety procedures in a chemical laboratory.
Course Content	1. Formation of Soap-Saponification- A process of converting Esters into Soaps by Addition of Alkali. 2. Estimation of Iron Using Volumetric Analysis. 3. Determination of Hardness of Water by Complexometric Titrations. 4. Determination of Strength of Strong Acid/Base with Conductometric Titrations. 5. Thin Layer Chromatography for Separating Non-Volatile Mixtures. 6. Oscillatory Chemical Reactions for Understanding Non-Equilibrium Thermodynamics.
Suggested Books	1. A. I. Vogel: Textbook of Quantitative Inorganic Analysis 7th Edition: Pearson Education: India: 2012: ISBN 978-8131773710 2. A. I. Vogel: Textbook of Practical Organic Chemistry 5th Edition: Pearson Education: India: 2003: ISBN 978-8177589573 3. Laboratory manual CH-153

Course code	**ES 102**
Title of the course	**Environmental Studies: Scientific and Engineering Aspects**
Course Category	Core / Departmental Elective / **Institute Elective**
Credit Structure	L - T - P - Credits **3-0-0-1.5 (Half Semester Course)**
Name of the Concerned Department	**Multidisciplinary**
Pre-requisite, if any	**None**
Scope of the course (Objectives)	This course aims to impart knowledge regarding various elements of Environmental Science and Engineering, including environmental quality assessment, environmental pollution and control, water and waste management, sustainable resource management, and various environmental legislations.
Course Outcomes	• Understanding the impact of professional engineering solutions in societal and environmental contexts and demonstrating the knowledge of and need for sustainable development.
Course Content	1. Introduction to Environmental Science • Overview of Environmental Studies and its interdisciplinary nature, ecosystem, biodiversity • Importance of Environmental Science in the modern world 2. Environmental Quality Assessment • Physical, Chemical, and Biological Indicators • Monitoring and Assessment of Air, Water, Soil, and Biodiversity 3. Global Environmental Issues, Pollution, and Control • Climate change, global warming, acid rain, ozone layer depletion, nuclear hazards, and natural disaster management. • Types, Causes & Control of Environmental Pollution • Best Management Practices for Pollution Prevention 4. Water and Waste Management • Science and Technology for Drinking Water and Wastewater Treatment • Issues in the Management of Water and Waste Systems (Causes, Effects, and Control Measures) 5. Sustainable Resource Management • Natural Resources (Forests, Water, Coal, Minerals, Energy, and Land) Use and Degradation • Sustainable Development and Environmental Stewardship • Environmental Impact Assessment and Mitigation 6. Environmental Policy and Legislation • Overview of Environmental Laws and Regulations

	• Environmental Impact Assessment • Environmental Compliance and Enforcement.
Suggested Books	**Textbooks:** 1. G. M. Masters and Wendell P. Ela, **"Introduction to Environmental Engineering and Science",** Pearson, Boston, USA, 2018, ISBN-13: 978-0134219076 2. A. Friedland and R. Relyea, **"Essentials of Environmental Science",** W.H. Freeman & Co Ltd; 2nd ed. 2019 edition (14 December 2015), ISBN-13: 978-1319065669 **Reference Books:** 1. J. R. Pfafflin and J. N. Swift, **"Encyclopedia of Environmental Science and Engineering",** Taylor & Francis, Boca Raton, USA, 2013, ISBN-13-978-0849301039

<table>
<tr><td>Course code</td><td>HS 109</td></tr>
<tr><td>Title of the course</td><td>Language and Composition</td></tr>
<tr><td>Course Category</td><td>Core</td></tr>
<tr><td>Credit Structure</td><td>L - T - P - Credits
2-0-0-2</td></tr>
<tr><td>Name of the Concerned Department</td><td>Humanities & Social Sciences</td></tr>
<tr><td>Pre-requisite, if any</td><td>NA</td></tr>
<tr><td>Scope of the course (Objectives)</td><td>To improve English Reading, Comprehension and Writing skills of the students.</td></tr>
<tr><td>Course Outcomes</td><td>This course will teach the tools of peer-reviewing, close-reading, and enable students to write argumentative and persuasive writing.
Develop composition and paragraph writing
Write effective reports and design documentation, make effective presentations.</td></tr>
<tr><td>Course Content</td><td>Writing Effective Sentences
Reading, Comprehension skills in English
Paragraph Development: Thesis, Claim, Evidence, Explanation, Analysis
Different forms of writing- Reflective, Compare and Contrast, argument, visual analysis
Grammar and mechanics
Essay, Report, Proposals, Statement of Purpose</td></tr>
<tr><td>Suggested Books</td><td>Text Books
Bloom, B: Taxonomy of Educational Objectives: The Classification of Educational Goals: Susan Fauer Company, Inc: New York: 1956: ISBN: 058228010
Nadell, J, Comodromos, E.A. and Langan, J: The Longman Reader 9th Edition: Pearson Education Publishing: New Delhi: 2008: ISBN: 0321914139
Reference Books/texts
Chopin, K: “Story of an Hour”: 1894. Vogue Magazine.
Yong, E: “The Butterflies that hear with their wings”. The Atlantic: 2018
Bhattacharjee, K: “Back To Where I Never Belonged”. First Proof: The Penguin Book of New Writing From India: Penguin Books India: Delhi: 2005. ISBN 9780143102441
Minto, Robert: “Entomology of Village Life”, Pro Rege: Vol. 37: No.2, 46-48: 2008</td></tr>
</table>

Suggested Course code	**HS 104**
Title of the course	**Fundamentals of Economics**
Course Category	Core
Credit Structure	L - T - P - Credits 2-0-0-2
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course (Objectives)	The course is designed to introduce students to the fundamental concepts of economics. The key objectives of the course are: • To develop analytical abilities with respect to the key economic aspects. • To critically analyze economic policies, its design, complexities, and potential impacts.
Course Outcomes	• Students will gain expertise in the key concepts of microeconomics and macroeconomics. • Learners will be exposed to real-world economic problems. • Students will be able to comprehend government's economic policy's design.
Course Content	• Being an economist: A scientist and a policy maker. • Principles of economics: Tradeoff, opportunity cost, markets, invisible hand, prices • Market forces of demand and supply, elasticity, and its applications • Theory of Production and Theory of Cost • Microeconomic Thinking and Macroeconomic Models, Circular Flow, National Income Accounting • Production, Consumption, Investment, Government Purchases • Measuring Cost of Living- CPI, GDP Deflators, Inflation • The Monetary System- Functions of Money, Quantity of Money, Interest Rates
Suggested Books	**Text Books** • Rubinfeld, D.L. and Pindyck, R.S.: Microeconomics: Pearson Prentice Hall: New Jersey: 2012:

	9780132857123 • N. Gregory Mankiw: Macroeconomics*:* Macmillan Learning 10th ed.: New Delhi: 2019: 9781319436650 **Reference Books** • N. Gregory Mankiw: Principles of Economics*:* Harcourt: New Delhi: 2020: 0324168624 • R. Dornbusch, S. Fischer, and R. Startz: Macroeconomics: McGraw-Hill Inc: New York: 2017: 9780073375922

Course Code	**HS 117**
Title of the Course	**Stress and Mental Health**
Course Category	Flexible Core
Credit Structure	L-T-P-C 1-0-0-1
Name of the Concerned Department	Humanities and Social Sciences
Pre-requisite if any	None
Scope of the Course (Objective)	Mental health is an important aspect of a healthy lifestyle and its awareness is important. The course aims to analyze the concepts of stress, mental health, and their management.
Course Outcomes	• Learn how to analyse stress in the human body • Identify the factors which lead to stress • Effective management of mental health
Course Content	• Introduction: Nature and physiology of stress; Types of stress; Responses to stress • Stress and Its Effect: Task performance; Cognitive functioning; Burnout; PTSD; Diathesis-Stress Model; Psychological problems and disorders; Positive effects • Psychology and Health: Habits, lifestyle, and health; Depression and heart disease; Stress and cancer; Stress and immune function • Methods of Stress Management and Well-Being Enhancement: Nutrition; Physical exercise; Restoration (Sleep vs Relaxation); Self-regulation; Positive healthy relationships; Enhancing happiness and well-being
Suggested Books	**Textbook(s):** 1. Wayne Weiten, Dana S. Dunn, Elizabeth Yost Hammer: Psychology Applied to Modern Life: Adjustment in the 21st Century: Cengage Learning: USA: 2014: 9781305172081 2. R. Harington: Stress, Health and well-being: Thriving in the 21st century: Wadsworth Publishing: USA: 2013: 9781111831615

Course code	**HS 119**
Title of the course	**Frontiers of Thinking**
Course Category	Flexible Core
Credit Structure	L - T - P - Credits 1-0-0-1
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course (Objectives)	Natural sciences, biological sciences, and human sciences have unique and also mutually challenging approaches to understand reality. The course aims to open up our *thinking and understanding* of reality in these three forms.
Course Outcomes	• Problem Analysis • Recognition of Domain Difference • Life-Long Learning
Course Content	• The Splendors of the cosmic – Cosmic Order • The Wonders of the Natural – Natural Order • The Enigma of the Social – Social Life
Suggested Books	**Text Books** • Crofton, Ian & J. Black, **The Little Book of Big History,** London: Michael Omara Books Ltd.: 2016: 9781782536850 • Lovelock, James, Gaia, Oxford University Press, Oxford, 2016: 9780198784883 **Reference Books** • Ridley, Matt, **The Evolution of Everything,** Harper Collins, London, 2015, 9780007583126 • Harari, Y.N., Sapiens, Penguin Random House, London, 2019: 9781784873646

Course code	**HS 121**
Title of the course	**History of Tribal and Folk Art**
Course Category	Flexible Core
Credit Structure	L - T - P - Credits 1-0-0-1
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course (Objectives)	Through a close study of Tribal and folk art across the centuries, this course examines the histories of the two well-known examples of tribal and folk art- Bhil and Gond- from the beginnings to contemporary times.
Course Outcomes	• Demonstrate knowledge and understanding of Tribal and Folk Art • Appreciate the richness of Indian cultural heritage • Recognise the importance of sustainable and environment-friendly ingredients in creating traditional Indian art
Course Content	• Tribal and folk art in India • Gond artists and artistic traditions • Bhil artists and artistic traditions • Bhil and Gond art after Independence • Field visits to Bhil and Gond artist workshops/workplaces
Suggested Books	**Text Books** • Kaiser, T: Painted Songs: Continuity and Change in Indian Folk Art: Arnoldsche Art Publishers: Zurich: 2012: 9783897903661 • Wolf, G: Signature: Patterns in Gond Art: Tara Books: Delhi: 2010: 9789380340029 **Reference Book** • Bachchan, K: The Bhils- An Ethno-Historic Analysis: Sharada Publishing House: Delhi: 1997: 8185616477

Suggested Course code	**HS 123**
Title of the course	**Cultural Sociology**
Course Category	Flexible Core
Credit Structure	L - T - P - Credits 1-0-0-1
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course (Objectives)	The course will provide an overview of Cultural Sociology, which traverses the relationship between sociology and cultural theory. It will discuss sociological approaches to understanding national, global, or regional cultures. Eventually, it will address key social tensions encoded within popular culture and new media cultures.
Course Outcomes	• Problem Analysis in Cultural Sociology • Communication • Ethics
Course Content	• What is a Cultural System? • Interpretation of Cultures • Distinction, Judgement of Taste • Classical versus Popular Culture • Nation as Culture • Global Culture • Popular Culture • New Media Cultures
Suggested Books	**Text Book** • P. Bourdieu: **Distinction-A Social Critique of the Judgement of Taste,** Harvard University Press, Cambridge, MA : 1987 : 9780674212770 **Reference Book** • J. Fiske, Understanding Popular Culture, Routledge : New York: 1989 : 9780415078764. • Clifford Geertz : The Interpretation of Cultures- Selected Essays : Basic Books : New York : 1973 : 9780465093557

Course code	**HS 102**
Title of the course	**Environmental Studies: Social Aspects**
Course Category	Core
Credit Structure	L - T - P - Credits 2-1-0-3=1.5 (3/2)
Name of the Concerned Department	Humanities and Social Sciences
Pre-requisite, if any	None
Scope of the course (Objectives)	The course is designed to provide an overview of Environmental sociology, via landmark environmental movements and breakthroughs which have shaped the public discourse and consciousness about the environment as a common good. It will engage with some leading influential thinkers and material on the subject.
Course Outcomes	• Acquainting students with discourses and debates on sustainable use of natural resources • Role of technology in engineering the environment and its limitations • Acknowledging geography and biodiversity as key elements of environmental consciousness
Course Content	• Social movements and the environment • Human rights over natural resources • Chipko Movement & Himalayan Ecology • Gandhi and the Environmental consciousness • Environmental conflict with Fashion & International Trade • Environment and Public Relations, Greenwashing • Water Governance • Green Revolution in India • Industrial Farming and Food • 10. Topical discussions around contemporary issues
Suggested Books	**Reference Books** 1. Ramchandra Guha: *The Unquiet Woods: Ecological Change and Peasant Resistance in the Himalaya* : University of California Press : Berkley : 2000 : 9780520222359. 2. Rachel Carson : *Silent Spring* : Houghton Mifflin : Boston, MA : 1962 : 9780395075067.

	3. Ulrich Beck : *Risk Society: Towards a New Modernity* : Sage Publications : Thousand Oaks, CA : 1992 : 9780803983465. 4. E F Schumacher : *Small Is Beautiful: A Study of Economics As If People Mattered* : Vintage : London : 1993: 9780099225614.

Course code	**AA 101**
Title of the course	**Introduction to Space Engineering**
Course Category	Flexible Engineering Elective
Credit Structure	L - T - P - Credits 1-0-0-1
Name of the Concerned Department	Astronomy, Astrophysics and Space Engineering
Scope of the course (Objectives)	The students will be introduced to the basic concept of space engineering and space exploration.
Course Outcomes	The students will be able to appreciate the complex process and physics behind launching and communicating with a space payload and their vast array of applications in solving various problems of the society and advancing the various domains of fundamental sciences.
Course Content	**Module-1** Two-body relative motion equation and polar coordinates, Kepler's laws & Kepler's equation, Trajectory equation, orbital mechanics, Elliptical & circular orbits **Module-2** Overview of Sun and Heliosphere, Remote Sensing from Space; Vertical structure of the Atmosphere and circulations, space environment, space effects from Earth's surface, in situ measurements **Module-3** Telescopes: radio, infrared, optical, X-ray, gamma ray; collecting area, diffraction limit, atmospheric seeing; optics, aperture synthesis, spectroscopy (prisms and gratings). **Module-4** Exoplanets; Basic technique to detect exoplanets; Habitable zones; Search for Extraterrestrial Intelligence
Suggested Books	**Text book:** 1. B. A. Campbell, S. W. McCandless, Jr., **Introduction to Space Sciences and Spacecraft Applications**, Gulf Professional Publishing, 1996, ISBN-978-0- 88415-411-2 2. Kivelson M G & Russel C T, **Introduction to Space Physics**, Cambridge Univ. Press, Cambridge, 1995, ISBN-10, 0521457149 **Reference Books:** 3. Carroll B. W. & Ostlie, D. A., **An introduction to Modern Astrophysics**, Pearson Education-Addison Wesley, 2007. ISBN 978-0805304022

	4. G. Joseph and C Jeganathan, **Fundamentals of Remote Sensing**, Third Edition, Universities Press Pvt. Ltd., Hyderabad, India. 2018. ISBN 978-93- 86235-46-6. 606

Course code	**CE 102**
Title of the course	**Computations in Civil Engineering**
Course Category	Flexible Elective
Credit Structure	L - T - P - Credits 1-0-0-1
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	NIL
Scope of the course (Objectives)	To provide an overview of the role of computations in Civil Engineering.
Course Outcomes	Exposure to some of the computational techniques required in Civil Engineering.
Course Content	Role of differential equations in Civil Engineering, ordinary and partial differential equations; Role of probability in Civil Engineering, Random events, Random variables; Role of machine learning in Civil Engineering.
Suggested Books	• E. Kreyszig, Advanced engineering mathematics, Wiley India Pvt. Ltd, 2015, ISBN: 9788126554232. • Papoulis and S.U. Pillai, Probability, Random Variables and Stochastic Processes, Fourth Edition, McGraw Hill, ISBN-10: 0070486581 • J.R. Benjamin and C.A. Cornell, Probability Statistics and Decision for Civil Engineers, McGraw Hill, 1975, ISBN-10:0486780724

Course code	**IC 152**
Title of the course	**Makerspace**
Course Category	Institute common core course
Credit Structure	L - T - P – Credits 1 - 0 - 6 - 4
Name of the Concerned Department(s)	All the Engineering Departments
Pre-requisite, if any	NIL
Scope of the course (Objectives)	• To foster hands-on learning in the students • To impart basic designing and manufacturing skills • To promote exposure to multidisciplinary areas
Course Learning Outcomes	• Application of the principles and concepts learned in the class to solve interdisciplinary problems. • Collaborate effectively as a part of interdisciplinary teams. • Create a prototype or working model from the given project
Course Content	**Lecture component** **Introduction:** Lab safety and Orientation **Design and Manufacturing** Introduction to Engineering Drawing, Projections, Section of Solids, Orthographic Projections, Section of solids, Development of surfaces (Freehand sketch followed by practice using software); 3D Solid Modelling: Parametric and feature-based modelling; Assembly and disassembly; Workshop Practices: Welding, Carpentry, Machining, Laser cutting, Computer Aided Manufacturing (additive/subtractive) **Systems, Circuits, Drones, and Robotics** Basic Operation of amplifier circuits and networks, Basics of microprocessors and microcontrollers, IoT, Robotics, Basic aerodynamic concepts, Components of Drones – propulsion systems, frames, payloads **Selection and Design of Materials:** Material property charts, Ashby maps **Product Design:** Concepts of product design **Practical component** • Stitching of Aprons using a sewing machine • Modelling of 2D and 3D components • 3D printing of parts, CNC machining of materials, Joining of metals • Simulation of the circuit, Assembly, and testing on Breadboard, the know-how of the Oscilloscope, function

	generator, Power source etc., • Soldering of joints, PCB routing using software, PCB fabrication and testing, Coding and interfacing sensors to Arduino and Raspberry-PI, Basic signal generation and measurements with Arduino **<u>Example list of projects</u>** • IoT-based home automation system, IoT-based car parking management system. • Innovative Road Intersection/Interchange Design, Testing of bridges. • Room temp adjustment based on occupancy – comprises 3 categories: Determination of occupancy, temperature detection, and control. • Scaled-down model of automatic Street light controller – (3D printing + Circuit design) • Design and development of Pick and Place mechanism for robotic application • Design and development of a punching machine using geneva mechanism
Suggested Books	Textbooks: 1) N. D. Bhatt : Engineering Drawing : Charotar Publishers: 2010: ISBN: 9789380358963 2) Mikell P. Groover: Groover's Principles of Modern Manufacturing: Materials, Processes, and Systems: Wiley India: 2018: ISBN: 978-8126573059 3) W H Hayt, J E Kemmerly, and S M Durbin: Engineering Circuit Analysis: 8th edition: Mc Graw-Hill (Indian Edition): 2013: ISBN 978-1259098635 4) A.S. Sedra, K. C. Smith, A.N. Chandorkar: Microelectronic Circuits 7th edition (Indian edition): Oxford University Press: 2017: ISBN: 978-0199476299 5) James Garratt, “Design and Technology” 2nd edition, Cambridge University Press, 1998, ISBN:978-0521648318 Reference Books: 6) S.J. Schoonmaker, Marcel Dekker, Inc: The CAD Guidebook A Basic Manual for Understanding and Improving Computer-Aided Design,., 2002. ISBN: 978-0824708719 7) D.K. Lieu, S.A. Sorby: Visualization, Modeling, and Graphics for Engineering Design, 2nd edition: Cengage Learning:2016: ISBN:978-1285172958 8) K.T. Ulrich, S.D. Eppinger, M. C. Yang: Product Design and Development | 7th Edition: McGraw Hill: 2020: ISBN: 978-9390113231

Course code	**MM 102**
Title of the course	**Introduction to Materials Engineering**
Course Category	Flexible elective
Credit Structure	L-T-P-C (1-0-0-1)
Name of the Concerned Department	Metallurgy Engineering and Materials Science
Prerequisite, if any	None
Scope of the course (Objectives)	The objective of this course is to familiarize the students to the field of science and engineering of materials.
Course Outcomes	Students will be able to understand; 1) structure-property correlations. 2) application of materials in different fields.
Course Syllabus	Classification of materials, structure and properties of materials Introduction and applications of: 1) metals and alloys, 2) polymers, ceramics, and composites 3) advanced and functional materials
Suggested Books	**Text books:** (1) Materials Science and Engineering- An introduction, William D. Callister, Jr. John Wiley and Sons, Inc. **(2)** Materials Science and Engineering- A first course, V Raghavan

Syllabi of
Computer Science and Engineering Courses

1.	Course Code	**CS 205** [from AY 2010-11 to AY 2013-14]
2.	Title of the Course	**Abstractions and Paradigms for Programming**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	A course in Computer Programming
6.	Scope of the course	
7.	Course Syllabus	Review of the program development process, Issues in program design, Structured programming, Data and control abstractions, Programming with assertions. Reasoning about programs and proving correctness of programs. Ideas behind imperative, applicative, object oriented and logic programming paradigms such as typing, expressions, pure functions, recursion, higher order functions, encapsulation, inheritance, goal satisfaction, backtracking, unification. Some of the ideas behind the implementation of the paradigms.
8.	Suggested Books	1. H. Abelson, G.J. Sussman, and J. Sussman, **Structure and Interpretation of Computer Programs** (2nd edition), The MIT Press, 1996. 2. D.A. Watt, **Programming Language Concepts and Paradigms**, Prentice-Hall, 1990. 3. R. Sangal, **Programming Paradigms in LISP**, McGraw Hill, 1991.

1.	**Course Code**	**CS 206**
2.	**Title of the Course**	**Logic Design**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Knowledge of Basic Electronics and Electrical Engineering
6.	Scope of the course	
7.	Course Syllabus	Switching theory: Introduction to number systems, Computer arithmetic, switching function and logic circuits, Combinational Logic, Canonical Logic Forms, K-maps Standard logic (SSI, MSI) vs. programmable logic (PLD, PGA). Finite state machine design: logic, minimization and races. Arithmetic unit, Control unit design, Logic design applications in computer systems, Introduction to computer-aided design Software, FPGA overview, Introduction to design automation and design through Higher level languages like VHDL.
8.	Suggested Books	1. M. Zwonlinski, Digital Systems Design with VHDL, Pearson Education, 2003. 2. R.H. Katz and G. Borriello Contemporary Logic Design (2nd edition), Prentice Hall, 2004. 3. S.H. Unger, The Essence of Logic Circuits, Prentice Hall Inc. Englewood Cliffs, NJ, 1989 4. Foundations of Digital Logic Design, World Scientific Singapore, 1998.

1.	**Course Code**	**CS 208**
2.	**Title of the Course**	**Software Engineering**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Software Situation: problems & causes; Role of Software Engineering; Software Development Paradigms. Function-oriented Methodology: System Engineering Overview; Function-Oriented Modeling Techniques; Function-Oriented Requirements Analysis; Correctness Criteria for Requirements Models; Reducing Complexity; Data Dictionary; Process Specification; Data Design; Architectural Design; Flow Analysis and Conversion Techniques; Design Refinement Measures; Procedural Design; User Interface Design. Object-oriented Methodology: Modeling of Software Requirements and Specifications with Use-Case Diagrams; Object-Oriented Modeling based on UML: Notations, Diagrams, Relationships, Modeling procedures & Applications; System Architecture; User-Interface Design; Game Interfaces and Web-based SE. Implementation: Procedural Design and Implementation. Stepwise Refinement. Software Project Management: Concerns of Management; Project Planning; Measurement and Metrics; Cost Estimation; Scheduling and Team Organization; Overview of SQA; SQA Techniques: qualitative and quantitative; Software Maintenance; Overview of Software Configuration Management; Software Configuration Items and Change Control. Advanced Topics: Component-based Software Engineering; Real-time Software Engineering; Clean-room Software Engineering
8.	Suggested Books	1. R. S. Pressman, Software Engineering: A Practitioner’s Approach (6th Edition), McGraw-Hill, 2006. 2. I. Sommerville, Software Engineering (5th Edition), Addison-Wesley, 1996. 3. C. Ghezzi, J. Mehdi. and M. Dino, Fundamentals of Software Engineering, Prentice-Hall, 1991.

1.	**Course Code**	**CS 255**
2.	**Title of the Course**	**Abstractions and Paradigms for Programming Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	A course in Computer Programming
6.	Scope of the course	
7.	Course Syllabus	This lab course is to be centered around problems and applications that demonstrate the main themes of the associated theory course CS 205. This laboratory would include the sessions for the following topics: 1. Functional Programming Basics using Scheme: Expressions, Naming, Combinations, Procedures, Conditions. 2. Recursion: Procedure v/s Process; Recursive v/s Iterative 3. Scheme: Higher-Order procedures, let, lambda; Procedures as Arguments, General Methods. 4. Lists: Basic Operations using Lists in Scheme 5. Matrix Manipulation in Scheme 6. Tags & Multiple Representations in Scheme 7. Object-Oriented Programming: Classes, Objects using Java 8. Inheritance, Polymorphism, Message Passing in Java 9. Concurrent Programming: Creating Thread, Use Different Functions Related Thread in Java 10. Thread Synchronization & Producer Consumer Problems in Java 11. Logic Programming using Prolog: Domain Variables, Specification of Constraints, Solution Space. 12. Imperative Programs, Loop Invariants.
8.	Suggested Books	Same as CS 205

1.	Course Code	**CS 256**
2.	Title of the Course	**Logic Design Lab**
3.	Credit Structure	L-T-P-Credits 0 -0-3-1.5
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Knowledge of Electronics and Electrical Engineering Lab
6.	Scope of the course	
7.	Course Syllabus	Experiments with Logic Building Blocks using SSI/MSI, Experiments on Design and/or use Minimization tools. Use of VHDL and simulation in Logic Design. A small project on design with the use of tools and MSI and/or PLDs. FPGA basics and programming.
8.	Suggested Books	Same as the associated theory course CS 206: Logic Design

1.	**Course Code**	**CS 258**
2.	**Title of Course**	**Software Engineering Laboratory**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Department	Computer Science and Engineering
5.	Pre-requisite, if any	Should be enrolled in parallel in CS 208 or should have already taken and successfully completed the CS 208 course
6.	Scope of the course	To provide students with an environment in which to experience the process of Software Development by working through 'real world' projects
7.	Course Structure	Students would be made to go through and experience the various phases of the Software Development Life Cycle by working on a real project and sequentially working through the phases. The Software Developments Phases include broadly: 1) Requirements Elicitation 2) Software Design 3) Software Development 4) Software Testing 5) Software Maintenance
8.	Suggested books	1.R. S. Pressman, Software Engineering: A Practitioner's Approach, McGraw Hill, 1982 2. I. Sommerville, Software Engineering, Addison-Wesley, 1996

1.	Course Code	**CS 261** [for AY 2010-11 only]
2.	Title of the Course	**Program Development and Software Design Lab - I**
3.	Credit Structure	L-T-P-Credits 0-1-4-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Knowledge of Computer Programming
6.	Course Syllabus	Longer Programs based on creating and manipulating various data structures. The lab work includes documentation as well as testing.
7.	Scope of the course	
8.	Suggested Books	1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, **Introduction to Algorithms**, (2nd Edition), Prentice Hall India, 2002. 2. D. E. Knuth, **The Art of Computer Programming**, Vol. 1 and 3, (2nd Edition), Addison-Wesley, 1998.

1.	Course Code	**CS 262** [for AY 2010-11 only]
2.	Title of the Course	**Program Development and Software Design Lab - II**
3.	Credit Structure	L-T-P-Credits 0-1-4-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Knowledge of Computer Programming
6.	Scope of the course	
7.	Course Syllabus	Programs based on principles of software design and involving various data structures. The lab work includes documentation as well as testing.
8.	Suggested Books	1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, **Introduction to Algorithms**, (2nd Edition), Prentice Hall India, 2002. 2. D. E. Knuth, **The Art of Computer Programming**, Vol. 1 and 3, (2nd Edition), Addison-Wesley, 1998.

Course Code	**CS 302**
Title of the Course	**Computer Graphics and Visualization**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre–requisite, if any	Computer Programming, Data Structures and Algorithms
Scope of the course	This Course is designed to provide an introduction to the theory and practice of computer graphics and an insight of modern computer graphics systems. Students will understand the basic principles of computer graphics primitives and able to design application specific computer graphics program. This course will also provide familiarity with key algorithms for modelling and rendering graphical data.
Course Syllabus	**Introduction:** Basic of Computer Graphics. **Graphics Systems and Models:** Raster System; Vector System; Scan Conversion; 2D and 3D Graphics Model **Graphics Hardware:** Display Devices; Input Devices; Hard Copy Technology, Display Processors **Raster Graphics Algorithm:** Pixel Concept; Line, Circle, Ellipse, Polygon drawing Algorithms **Visualization Algorithm for Raster Graphics:** Colouring, Filling Scan Conversion Algorithms **2D Computer Graphics:** Homogeneous Coordinates; Window and View Port; 2D Geometric Transformation; 2D Viewing Pipeline **3D Computer Graphics:** Planner Projections; Vanishing Points; 3D Viewing Pipeliine, 3D Geometric Transformations **Colour, Light and Shading:** RGB Colour Model, CMYK Colour Model; YCbCr Color Model, Light Sources; Achromatic and Coloured Light; Illumination and Shading Model; Shadow **Curve and Surface Representation:** Polygon Meshes; Cubic Curves; Bicubic Surfaces. **Solid Model:** Solid Representation; Regularized Boolean Set Representation; Sweep and Primitive Representation, B-Reps; CSG; Quad Tree; Octree; BSP **Clipping:** 2D and 3D Line and Polygon Clipping Algorithms **Visible Surface Detection**: Planner Surface Representation; Visible Line Determination; List Priority Algorithm; Area Subdivision Algorithm; Z-Buffer Algorithm; Visible Surface Detection for BSP and Octree Representation; Ray Tracing **Visualization/Rendering:** Physical Description of Rendering, Image-order and Object-order; Surface and Volume Rendering; Transparency and Alpha Values; Realism; Aliasing and Anti-Aliasing; 3D Texture Mapping; **Visualization Pipeline**: Data Acquisition; Data Reduction; Visibility Transformation; Viewing Transformation and Rendering

Suggested Books	1. D. Hearn, M. P. Baker, ***Computer Graphics. C Version***, Pearson Education , 2nd Eds, 1997 2. D. Hearn, M. P. Baker, ***Computer Graphics with OpenGL***, Pearson Education India , 3rd Eds, 2004 3. F.S. Hill. ***Computer Graphics Using Open GL.*** Prentice Hall. 2001 4. John F. Hughes, Andries van Dam, James D. Foley, Morgan McGuire, Steven K. Feiner, David F. Sklar, Kurt Akeley, ***Computer Graphics, Principles and Practice***, Addison Wesley, 3rd Eds, 2014. 5. W. Schroeder, K. Martin, and B. Lorensen, ***The Visualization Toolkit***, (2nd Edition), Prentice-Hall, Inc., 1998. 6. M. K. Pakhira, ***Computer Graphics, Multimedia and Animation***, PHI, 2nd Eds, 2010

Course Code	**CS 352**
Title of the Course	**Computer Graphics and Visualization Lab**
Credit Structure	L-T-P-Credits 0-0-3-1.5
Name of the Concerned Department	Computer Science and Engineering
Pre–requisite, if any	Computer Programming, Data Structures and Algorithms
Scope of the course	This Course is designed to provide an introduction to the theory and practice of computer graphics and an insight of modern computer graphics systems. Students will understand the basic principles of computer graphics primitives and able to design application specific computer graphics program. This course will also provide familiarity with key algorithms for modelling and rendering graphical data.
Course Syllabus	Assignments based on of applications of computer graphics and visualizations in the fields such as 3D-modeling of architectural and mechanical design; Creating 3D games; Creating 3D models from segmented volume data; Financial data visualization.
Suggested Books	1. D. Hearn, M. P. Baker, ***Computer Graphics. C Version***, Pearson Education , 2nd Eds, 1997 2. D. Hearn, M. P. Baker, ***Computer Graphics with OpenGL***, Pearson Education India , 3rd Eds, 2004 3. F.S. Hill. ***Computer Graphics Using Open GL***. Prentice Hall. 2001 4. John F. Hughes, Andries van Dam, James D. Foley, Morgan McGuire, Steven K. Feiner, David F. Sklar, Kurt Akeley, ***Computer Graphics, Principles and Practice***, Addison Wesley, 3rd Eds, 2014. 5. W. Schroeder, K. Martin, and B. Lorensen, ***The Visualization Toolkit***, (2nd Edition), Prentice-Hall, Inc., 1998. 6. M. K. Pakhira, ***Computer Graphics, Multimedia and Animation***, PHI, 2nd Eds, 2010

1.	Course Code	**CS 353**
2.	Title of the Course	**Operating Systems Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3- 1.5
4.	Name of the Concerned Department	Department of Computer Science & Engineering
5.	Pre-Requisite, if any	Knowledge of Computer Programming
6.	Scope of the course	
7.	Course Syllabus	OS Programming prerequisites: Familiarities with IPC facilities, IPC identifiers, IPC keys, Message queues and their internal and user data structures, System calls related to IPC, Semaphore and Shared memory. (06 hours ≈2 labs). CPU scheduling: Simulation programs for long-term, short-term and medium term schedulers, Simulation for the maintenance of various scheduling queues such as ready, I/O, blocked etc., Implementations of different scheduling algorithms such as FCFS, SJF, Priority scheduling (pre-emptive and Non pre-emptive), Round robin, multilevel feedback queue scheduling and their performance evaluations. (12 hours ≈4 labs). Concurrent Processing and Concurrency Control: Simulation of updating four processes PCBs with shared memory, Implementation of interprocess communication using simulated semaphore through i) shared memory, ii) synchronized producer-consumer problem iii) pipes and message passing (asynchronous and synchronous). Concurrence control with pipes socket for iterative and concurrent servers (12 hours ≈4 labs). File Systems Implementation: creating, removing, accessing and protection and error handling of EXT2 FS, Registering the virtual file system in Kernel, accessing superblock information. (06 hours ≈2 labs).
8.	Suggested Books	**1.** Linus Programmer's Guide documentation **2.** UNIX System V and Related Utilities under Linux

1.	Course Code	**CS 304** [from AY 2010-11 to 2014-15]
2.	Title of the Course	**Artificial Intelligence**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Data Structures and Algorithms
6.	Scope of the course	
7.	Course Syllabus	**Basics of problem-solving:** problem representation paradigms, state space, satisfiability vs optimality, pattern classification problems, example domains. **Search Techniques:** Problem size, complexity, approximation and search; depth, breadth and best search; knowledge based problem solving, artificial neural networks. **Knowledge representation:** First order and non-monotonic logic; rule based, frame and semantic network approaches. **Knowledge Acquisition:** Learnability theory, approaches to learning. **Uncertainty Treatment:** formal and empirical approaches including Bayesian theory, belief functions, certainty factors, and fuzzy sets. **Detailed Discussion from Example Domains:** Industry, Language, Medicine, Verification, Vision, Knowledge Based Systems. **Languages and Machines:** AI languages and systems, special purpose architectures.
8.	Suggested Books	1. S. Russell and P. Norvig, **Artificial Intelligence: A Modern Approach**, Prentice Hall Series in AI, 1995. 2. M. Stefik, **Introduction to Knowledge Systems**, Morgan Kaufman, 1995. 3. P.H. Winston, **Artificial Intelligence** (3rd edition), Addison Wesley, 1995. 4. E. Rich and K. Knight, **Artificial Intelligence**, Tata McGraw Hill, New Delhi 1992. 5. E. Charniack and D. McDermott, **Artificial Intelligence**, Addison Wesley, 1987. 6. 7. N.J. Nilsson, **Principles of Artificial Intelligence**, Morgan Kaufman, 1985.

1.	**Course Code**	**CS 354**
2.	**Title of the Course**	**Computational Intelligence Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Computer Programming, Data structure, Discrete Structure, Design and Analysis of Algorithm
6.	Scope of the course	
7.	Course Syllabus	AI programming : Prolog, LISP, Experiments to support the associated theory course that demonstrate the different applications of Neural, fuzzy, evolutionary and hybrid model; Minor project based on real life applications such as Functional approximation; Time-series prediction; Pattern recognition; Data compression; Control applications, Optimization etc.
8.	Suggested Books	Same as the associated theory course CS 304N: Computational Intelligence

1.	Course Code	**CS 305**
2.	Title of the Course	**Computer Architecture**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	A course in Logic Design
6.	Scope of the course	
7.	Course Syllabus	**Assembly Level Organization:** instruction formats, addressing mechanisms, Architecture and programming of 8085 and or x86 architectures, microprogramming, Arithmetic and Logic Unit. **Memory Systems:** memory hierarchy, main memories, cache, virtual memory, Pipeline processing. **Interfacing and Communication:** I/O, interrupts, buses. Multiprocessor and alternative architectures, Contemporary architectures Computer organization and architecture Lab Machine/Assembly programming, Design of basic computing units.
8.	Suggested Books	1. J.L. Hennessey, D.A. Patterson, **Computer Architecture**: A Quantitative Approach (4th Edition), Morgan Kauffman, 2006. 2. W. Stallings, **Computer Organization and Architecture** (7th edition), Prentice Hall Inc., 2006 3. J.P. Hayes, **Computer Architecture and Organization** (3rd edition), McGraw-Hill Inc. 2002

1.	Course Code	**CS 355**
2.	Title of the Course	**Computer Architecture Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3- 1.5
4.	Name of the Concerned Department	Department of Computer Science & Engineering
5.	Pre-Requisite, if any	A course in Logic Design
6.	Scope of the course	
7.	Course Syllabus	**MIPS Programming through SIMPS:** Familiarities with architecture of RISC Computer R2000/R3000 proposed in MIPS Systems. MIPS Assembly language programming for instruction formats, addressing mechanism, microprogramming to transfer data between register-register, memory-register and architectural programming. (12 hours ≈4 labs) **Architecture-Level Design with Verilog:** Familiarize architecture-level design and synthesis of different components in arithmetic and logic unit. Verilog programming to design basic computing units such as adder, multiplier, BCD converter, Comparator etc. Experiment for datapath synthesis, connecting memory, buffer, external ports and different components in an application specific processing unit. (12 hours ≈4 labs) **Synthesis of a CPU Architecture:** Familiarize the design aspects of a CPU to realize the design in a FPGA kit. Designing a CPU with a selected specification at architectural-level using Verilog, and finally, realizing the architecture in a FPGA kit followed by testing the correctness of the realization. (12 hours ≈4 labs)
8.	Suggested Books	Same as CS 305

1.	Course Code	**CS 306**
2.	Title of the Course	**Computer Networks**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Data Structures and Algorithms
6.	Scope of the course	
7.	Course Syllabus	Design of Computer Networking protocols at all layers: transmission media, data link protocols, media access control, routing and congestion control, admission control, traffic shaping and policing, Internet working (IP) and transport layer protocols (TCP). Performance analysis of networks.
8.	Suggested Books	1. W. Stallings, **Data and Computer Communications** (6^{th} edition), Prentice Hall, 2000. 2. S. Tannenbaum, **Computer Networks** (4^{th} edition), Prentice Hall Inc., 2003. 3. F. Halsall, **Data Communications: Computer Networks and Open Systems** (4^{th} edition), Addison-Wesley, 1996. 4. Walrand and Varaiya, **High Performance Communication Networks**, Morgan Kaufman, 1996. 5. D. E. Comer, **Internet working with TCP/IP: Principles, Protocols, Architecture** (3^{rd} edition), Prentice Hall, 2000. 6. W. R. Stevens, **TCP/IP Illustrated** (Vol. I), Addison Wesley, 1994.

1.	**Course Code**	**CS 356**
2.	**Title of the Course**	**Computer Networks Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Data Structures and Algorithms
6.	Scope of the course	
7.	Course Syllabus	(a) Experimental study of application protocols such as HTTP, FTP, SMTP, using network packet sniffers and analyzers such as Wireshark. (b) Socket programming - Small exercises in socket programming in C/C++/Java. (c) Experiments with packet sniffers to study the TCP protocol. 3-way handshake for connection setup, timer behavior, congestion control behavior. (d) Introduction to ns3 (network simulator) and small simulation exercises to study TCP behavior under different scenarios. (e) Setting up a small IP network in ns3 - configure interfaces, IP addresses and routing protocols to set up a small IP network. Study dynamic behavior using packet sniffers. (f) Experiments with ns3 to study behavior (especially performance of link layer protocols such as Ethernet and 802.11 wireless LAN. (g) Programming with pcap - small example with packet generator using pacp library
8.	Suggested Books	Same as CS 306: Computer Networks

1.	**Course Code**	**CS 357**
2.	**Title of Course**	**Optimization Algorithms and Techniques Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Department	Computer Science and Engineering
5.	Pre-requisite, if any	Data Structures and Algorithms
6.	Scope of the course	
7.	Course Syllabus	Experiments and assignments based upon techniques discussed in CS 307. These are summarized below. * Understanding of Matlab/ Scilab via implementation of Newton's method for solving non-linear system of equations as well as numerical integration. * Analyzing convexity of functions numerically. * Implementation and analysis of Multi-dimensional Unconstrained Optimization algorithms (Steepest Descent, Newton, Gauss-Newton, Quasi-Newton, Conjugate Gradients etc.). * Implementation and analysis of One-dimensional Unconstrained Optimization algorithms (Dichotomous, Quadratic Interpolation, Cubic Interpolation etc.). * Implementation and analysis of Simplex and Interior Point Methods for Linear Program. * Implementation and analysis of Sequential Quadratic Program for solving general Constrained Optimization problem.
8.	Suggested books	Same as the associated theory course CS 307

1.	Course Code	**CS 308**
2.	Title of the Course	**Compiler Techniques**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Automata Theory and Logic, Data Structures and Algorithms, Abstraction and Paradigms in Programming
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Major compilation processes; Compiler phases; front end and back end partitioning. **Lexical Analysis:** Tasks and roles of lexical analyser; Regular expressions; Deterministic finite automata; *LEX* – a lexical analyzer generator. **Context-Free Grammars:** Formal grammar and Backus Naur Form; Derivations; Ambiguous, unambiguous and recursive grammars; Chomsky hierarchy; Parse trees and parsing concepts. **Syntax Analysis:** Top down parsing – recursive descent and LL(1) predictive parsers; First and Follow sets; LL(1) parse table construction; Bottom up and shift reduce parsing; LR parsing; Parse table constructions – *LR(0), SLR(1) and LALR(1); YACC* – a syntax analyser generator. **Extending the Parser:** Syntax directed approach; *YACC's* support for attribute evaluation; Inherited and synthesized attributes; symbol table; Type concepts; Syntax-directed semantic analysis; Run-time storage organization; Intermediate languages – three address code; Syntax-directed intermediate code generation. **Introducing Compiler Backend:** Code optimization techniques and concepts; Target code generation. **A Complete Compiler:** The grammar specification; scanner; parser; code generation; Building and running the compiler; The Assembler and the virtual machine.
8.	Suggested Books	1. A.V. Aho, M.S. Lam, R. Sethi, and J.D. Ullman, **Compilers: Principles, Techniques, and Tools** (2nd Edition), Addison-Wesley 2007. 2. A. Appel, **Modern Compiler Implementation in C/ML/Java**, Cambridge University Press, 2004. 3. D. Grune, H.E. Bal, C.J.H. Jacobs, and K.G. Langendoen: **Modern Compiler Design**, John Wiley & Sons, Inc. 2000. 4. M.L. Scott, **Programming Language Pragmatics**, Morgan Kaufman Publishers, 2006.

1.	Course Code	**CS 358**
2.	Title of the Course	**Compiler Techniques Lab**
3.	Credit Structure	L-T-P-Credits 0 -0-3-1.5
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Same as the associated theory course
6.	Scope of the course	
7.	Course Syllabus	Design and implementation of a compiler for a sufficiently rich subset of a real programming language. The compiler will be automatically generated through use of tools such as LEX, YACC and IBURG.
8.	Suggested Books	1. J.R. Levine, T. Mason, and D. Brown, **LEX and YACC**, O'Reilly & Associates, 1990

1.	Course Code	**CS 401** [From AY 2010-11 to 2013-14]
2.	Title of the Course	**Soft Computing**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	A course in Computer Programming
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Artificial neural networks: feed-forward, recurrent and multi-layer architectures; Supervised and unsupervised learning; Characteristics: adaptability, fault tolerance, generalization; limitations of neuro-computing. **Perceptron:** Linear classifiers; Simple perceptron; Perceptron learning algorithms; ADALINE; MADALINE; Limitation of perceptron dichotomizer. **Multi-Layer Perceptron:** Gradient decent scheme for error minimization; Generalized delta learning rule; Back-propagation learning for multi-layer networks; Multi-layer perceptrons for multi-dimensional functional mappings. **Associated Memory Networks:** Auto-association; Hetero-association; Linear associative networks: Hebbian learning, perfect recall, cross-talk; Bidirectional associative memory; Brain-State-in-a-Box network. **Hopfield Networks:** Binary Hopfield network: basic structure, asynchronous updating, convergence, associative memory; Continuous-valued Hopfield network. Advantages and limitations. **Kohonen Networks:** Self-organizing networks; Similarity measures; Kohonen's winner-take-all network; Geometrical interpretation of Kohonen's learning; Functional specificity of human brain, Kohonen's self-organizing feature map algorithm; Conscience algorithm. **Adaptive Resonance Theory (ART):** ART and stability-plasticity dilemma; ART-1 architecture and algorithm: search, comparison and recognition phases, effect of vigilance. **Radial Basis Function Networks:** Radial Basis Function Networks: radial basis vs. linear basis, Gaussian basis functions, K-means learning, LMS algorithm, comparison with Multi-Layer Perceptron networks. **Support Vector Machines (SVM):** Optimal hyperplane for linear separability, quadratic optimization, SVM for pattern recognition, different kernels for hidden-layer, optimal design of SVM. **Fuzzy Neural Networks and Genetic Algorithms:** Fuzzy sets - Basic Definition; Fuzzy-set-theoretic Operations – Member Function Formulation and Parameterization – Fuzzy Rules and Fuzzy Reasoning, Fuzzy If-Then Rules Fuzzy-neural networks; Neuro-fuzzy systems; Genetic algorithms: selection schemes, operations, hybrid algorithms.

7.	Suggested Books	1. J.S.R.J ang, C.T. Sun and E. Mizutani, "**Neuro-Fuzzy and Soft Computing"**, Prentice Hall of India and Pearson Education, 2004. 2. D.E. Goldberg, "**Genetic Algorithms: Search, Optimization and Machine Learning"**, Addison Wesley, New York, 1989. 3. S. Rajasekaran and G.A.V. Pai**, "Neural Networks, Fuzzy Logic and Genetic Algorithms"**, Prentice Hall of India, 2003. 4. R. Eberhart, P. Simpson and R. Dobbins, **"Computational Intelligence - PC Tools"**, AP Professional, Boston, 1996.

1.	Course Code	**CS 451** [From AY 2010-11 to 2013-14]
2.	Title of the Course	**Soft Computing Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	A course in Computer Programming
6.	Scope of the course	
7.	Course Syllabus	Experiments to support the associated theory course that demonstrate the different applications of soft computing to Optimization; Functional approximation; Time-series prediction; Pattern recognition; Data compression; Control applications.
8.	Suggested Books	Same as the associated theory course CS 401: Soft Computing

1.	Course Code	**CS 401 / CS 601** [from AY 2014-15 onwards]
2.	Title of the Course	**Soft Computing**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department/Discipline	Computer Science and Engineering
5.	Pre–requisite, if any	Discrete Mathematical Structures, Design and Analysis of Algorithms, Computational Intelligence
6.	Scope of the Course	After having basic knowledge of artificial intelligence related to neural, fuzzy and evolutionary approaches, advancements in different areas are to be covered with working in a specific domain. This is by taking a case study to come up with the implementation and results.
7.	Course Syllabus	**Review on Mathematical and theoretical methods on soft computing**: neural networks. RBF structures. Self- organizing networks and methods. Fuzzy logic. Support vector machines and kernel methods. Evolutionary algorithms. **Hybrid Intelligent Systems:** Neuro-fuzzy systems. Neuro-Genetic systems, Evolving neural systems. Neuro-swarm. Hybridization with novel computing paradigms: Quantum computing, DNA computing, membrane computing. Neural dynamic logic and other methods, etc. **Learning and adaptation for novel:** Adaptive systems. Imitation learning. Reconfigurable systems. Supervised, unsupervised, Semi-supervised, reinforcement and statistical algorithms. Stability and convergence analysis. **Applications:** Image and signal processing. Ambient intelligence. process control, and manufacturing. Biometry and bioinformatics. Data mining. Internet modeling, communication and networking. Intelligent systems in education. Human–robot interaction. Time series analysis and prediction etc.
8.	Suggested Books	**Book:** 1. Jang, Roger and Mizutani, “Neuro-Fuzzy and Softcomputing: A Computational Approach to learning and Machine Intelligence”, Pearson. 2. R. John and Ralph Birkenhead, SoftComputing Techniques and Applications (Advances in Intelligent and Softcomputing), 2000, Springer-Verlag. 3. F.O. Karray, C. W. De Silva, SoftComputing and Intelligent System Design: Theory, Tools and Applications, Addison Wesley; 1st Ed. 2004. **Other References:** 1. IEEE Transactions on Fuzzy Systems 2. ACM Transactions on Knowledge Discovery from Data (TKDD) 3. The journal of pattern recognition society, ELSEVIER 4. The journal of Neurocomputing, ELSEVIER

		5. IEEE Transactions on Evolutionary Computation 6. IEEE Transactions on Neural Networks Learning Algorithms 7. Other web resources will be posted on the course website from time to time.

1.	Course Code	**CS 402** [**CS 309** from AY 2015-16 onwards]
2.	Title of the Course	**Parallel Computing**
3.	Credit Structure	L-T-P-Credits 3-0-0-3 / 2-0-2-3 [for AY 2014-15]
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	A course in Computer Programming
6.	Scope of the course	
7.	Course Syllabus	**Introduction to Parallel Algorithms:** Basic schemes for parallelization: list ranking. NC class. Parallel Context Free Grammar Parsing Algorithms. **Distributed Computing:** absence of global states; causal ordering of events. **Distributed architectures:** shared memory and message passing, Programming Models such as PVM; MPI; Linda; ORCA, Distributed algorithms: mutual exclusion, consensus, leader election. Clock synchronization, distributed termination. **Fault Tolerance:** fail-stop and byzantine models.
8.	Suggested Books	1. A. Gibbons, and W. Rytter, **Efficient Parallel Algorithms**, Cambridge University Press, 1989, ISBN: 0521388414. 2. H. Attiya and J. Welch, **Distributed Computing: Fundamentals, Simulations, and Advanced Topics**, McGraw-Hill Inc. New York, 1998. 3. 3. 3. G. F. Colouris, and J. Dollimore, **Distributed Systems: Concepts and Design**, Addison Wesley, 1988. 4. N. Lynch, **Distributed Algorithms**, Morgan Kaufmann, 1996. 5. S. Mullender (Ed.), **Distributed Systems** (2nd Edition), Addison Wesley, 1993. 6. T. Gerard, **Introduction to Distributed Algorithms**, Cambridge University Press, Cambridge, 1994. 7. M. Raynal, **Distributed Algorithms and Protocols**, Wiley, Chichester, 1988. 8. V.C. Barbosa, **An Introduction to Distributed Algorithms**, MIT Press, 1996.

1.	Course Code	**CS 452** [**CS 359** from AY 2015-16 onwards]
2.	Title of the Course	**Parallel computing Lab** [From AY 2010-11 to 2013-14]
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	A course in Computer Programming
6.	Scope of the course	
7.	Course Syllabus	Experiments to support the associated theory course.
8.	Suggested Books	Same as the associated theory course CS 402: Parallel Computing

Course code	**CS 403/ CS 603**
Title of the course	**Machine Learning**
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science & Engineering
Pre-requisite, if any	Artificial Intelligence/Computational Intelligence
Scope of the course	This course provides a broad introduction to machine learning, datamining, and statistical pattern recognition. Topics include: (i) Supervised learning (parametric/non-parametric algorithms, support vector machines, kernels, neural networks). (ii) Unsupervised learning (clustering, dimensionality reduction, recommender systems, deep learning). (iii) Best practices in machine learning (bias/variance theory_ innovation process in machine learning and AI). The course will also draw from numerous case studies and applications, so that candidate's also learn how to apply learning algorithms to build different intelligent systems.
Course Syllabus	Introduction, Machine Learning and AI, Motivations for Studying ML, Supervised and Unsupervised learning, Linear prediction, Maximum likelihood Regularizers, basis functions and cross-validation, Optimisation, Linear and Logistic Regression, Gaussian Discriminant Analysis, Support Vector Machines, Decision Trees, Neural networks architectures and its advances, Ensemble Methods, Clustering, Naive Bayes, Bayesian Statistics, K-Means, Gaussian Mixture Models, Learning Theory, Model Selection.
Suggested Books	1. C. M. Bishop, ***Pattern Recognition and Machine Learning,*** Springer, Heidelberg, 2006, 978-0-387-31073-2 2. T. Mitchell, ***Machine Learning***, McGraw Hill, 1997 (new chapters on line, 2006), New York, 1997, 978—0071154673 3. Duda, Hart and Stork, ***Pattern Classification*** *(2nd ed.),* Wiley Interscience, US, 2000, 978-8126511167

1.	Course Code	**CS 404/ EE 304**
2.	Title of the Course	**Digital Signal Processing**
3.	Credit Structure	L-T-P-Credits 3-1-0-4
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	Signals and Systems Course
6.	Scope of the course	
7.	Course Syllabus	Discrete time signals: Sequences; representation of signals on orthogonal basis; Sampling and reconstruction of signals; Discrete systems: attributes, Z-Transform, Analysis of LSI systems, Frequency analysis, Inverse Systems, Discrete Fourier Transform (DFT), Fast Fourier Transform algorithm, Implementation of Discrete Time Systems Design of FIR Digital filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Lowpass, Bandpass, Bandstop and High pass filters. Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation. Introduction to multirate signal processing. Application of DSP to Speech and Radar signal processing.
8.	Suggested Books	1. A.V. Oppenheim and Schafer, **Discrete Time Signal Processing**, Prentice Hall, 1989. 2. J.G. Proakis and D.G. Manolakis, **Digital Signal Processing: Principles, Algorithms And Applications**, Prentice Hall, 1997. 3. L.R. Rabiner and B. Gold, **Theory and Application of Digital Signal Processing**, Prentice Hall, 1992. 4. J.R. Johnson, **Introduction to Digital Signal Processing**, Prentice Hall, 1992. 5. D.J. DeFatta, J.G. Lucas, and W.S. Hodgkiss, **Digital Signal Processing**, John Wiley & Sons, Singapore, 1988.

1.	Course Code	**CS 406 / CS 606**
2.	Title of the Course	**Data Mining and Data Warehousing**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Computer Science & Engineering
5.	Pre-Requisite, if any	Data Base & Information Systems
6.	Scope of the course	
7.	Course Syllabus	**Data Warehouse and OLAP Technology:** Data warehousing Definition, usage and trends, Data marts, Metadata, Multidimensional data model, Data cubes, Schemas for Multidimensional Database: stars, snowflakes and fact constellations, Data warehouse architecture, OLTP and OLAP, types of OLAP servers: ROLAP, MOLAP, 3- Tier data warehouse architecture, Data warehouse implementation, computation of data cubes, indexing OLAP data, processing OLAP queries. **Data Mining:** Data mining definition & task, data preprocessing, data mining functionalities: Characterization and Discrimination, Mining frequent patterns, Frequent itemset mining methods, associations, and Correlations, Classification and Predictions, Cluster Analysis, Outlier Analysis, Evolution Analysis **Mining complex data objects:** Spatial databases, Multimedia databases, Time series and Sequence data, mining Text Databases and mining Word Wide Web, Applications and Trends in Data Mining
8.	Suggested Books	**1.** Jiawei Han and Micheline Kamber, **Data Mining: Concepts and Techniques**, Second Edition, Elsevier Publication. 2. M. H.Dunham, **Data Mining: Introductory and Advanced Topics**, Pearson Education 2004.

1.	Course Code	**CS 407**
2.	Title of the Course	**Peripherals and Interfaces**
3.	Credit Structure	L-T- P-Credits 2-0-2-3
4.	Name of the Concerned Department	Computer Science & Engineering
5.	Pre–requisite, if any	Computer Architecture
6.	Scope of the course	This course deals with the various aspects of hardware software interfacing with peripherals and associated devices. The course covers the fundamentals of various peripheral devices, its programming through assembly language and architecture. Further, it provides the an avenue for learning concepts of microprocessors, microcontrollers, interrupts and memory access mechanisms.
7.	Course Syllabus	**Basics of Microprocessor:** Design, Memory Subsystems, System Resources, Types and Interrupt handling, 8085 Architecture and its programming, 8086 Architecture and its programming, DMA channel, I/O port addresses. I/O buses, Local bus, DMA controller, PCI, ADC/DAC interfacing with microcontrollers/microprocessors. GPUs, USB, Bluetooth, 8255 interfacing, RAID. Video Hardware, Video display technologies, Introduction to serial communication, 8253/8254 programmable timer and interval counter. I/O Interfaces, USB Basic and Driver model Testing of serial and parallel port, USB mouse/keyboard interfaces. Interrupt Controller, Video/Graphics of Modern Desktop Board, Concepts of Network Interface Card, Design and Integration of Peripheral devices to a computer system as a Case Study.
8.	Suggested books	1. Douglas V. Hall. **Microprocessor and Interfacing: Programming and Hardware.** McGraw Hill Inc. 2. Ramesh S. Gaonkar, **Microprocessor Architecture, Programming and Application with the 8085.** 5th edition, Penram India 3. Stuart R. Ball. **Analog Interfacing to Embedded Microprocessors.** Elsevier, 2014.

1.	Course Code	**CS 408**
2.	Title of the Course	**Algorithms for Convex Programming**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Computer Science & Engineering
5.	Pre-Requisite, if any	
6.	Scope of the course	
7.	Course Syllabus	
8.	Suggested Books	

1.	Course Code	**CS 409 / CS 609**
2.	Title of the Course	**Advanced Topics in Database Management Systems**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Department of Computer Science & Engineering
5.	Pre-Requisite, if any	Data Structures and Algorithms and Database and Information Systems
6.	Scope of the course	
7.	Course Syllabus	**Advanced Data Models:** Enhanced Relational System, Object-Oriented Data Model, Spatial and Temporal Databases, Multimedia Databases. **Query Processing and Optimization:** Query Interpretation and Equivalence Expressions, Cost Estimate in Query Optimization, Semantic Query Optimization. **Transaction Processing and Concurrency Control:** Properties of Transactions, Schedules and Serializability of Schedules, Transaction Failures and Recoverability, High Performance Transaction Systems. **Distributed Databases:** Design of Distributed Databases, Distributed Query Processing, Deadlock Handling, Concurrency Control and Recovery. **Database Security and Authorization:** Database Security Issues, Security and Integrity Violations, Multilevel Security, Discretionary and Mandatory Access Control, Statistical Database Security.
8.	Suggested Books	1. R. Elmasri and S. Navathe, **Fundamentals of Database Systems** (3rd Ed), Benjamin Cummings, 2002. 2. H. F. Korth and A. Silberschatz, **Database System Concepts** (3^{rd} Ed.), McGraw Hill Inc., 2003 3. C. Zaniolo, S. Ceri, C. Faloutsos, Richard T. Snodgrass, V.S. Subrahmanian, R. Zicari, **Advanced Database Systems**, Morgan Kauffmann, 2002

1.	Course Code	**CS 410**
2.	Title of the Course	**Genetic Algorithms**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Department of Computer Science & Engineering
5.	Pre-Requisite, if any	Optimization Algorithms and Techniques
6.	Scope of the course	
7.	Course Syllabus	**Evolutionary Computations:** Biological background, Canonical GA framework, Basic Terminologies, Formulation of Optimization problems into GA framework. **Variations of GAs:** Binary Coded GAs and its variations such as Micro GA, Messy GA, Greedy GA etc., Real Coded GAs, Permutation Encoding GA etc. **GA operators:** Selection, Reproduction, Crossover, Mutation etc. Convergence criteria, Mathematical Construction of Genetic Operators, Schema Theorem of John Holland. Advanced Operators and Techniques in GA: Diploidy and Multiploidy, Inversion and Reordering, Niche and Speciation, Segregation and Translocation. **Multi-Objective GAs:** Non Pareto and Pareto-based GAs, MOGA, NSGA, Niched Pareto Genetic Algorithm. Practice of GA with some real-life problems and GA Programming: Traveling Salesman Problem, Word Matching problem, Topological Planning in Wireless Network, Placement and Routing problem in VLSI Design, Image Processing and Pattern Recognition.
8.	Suggested Books	1. D. E. Goldberg, **Genetic Algorithms in Search , Optimization & Machine Learning**, Pearson Education, 2000. 2. K. Deb, **Multi-Objective Optimization using Evolutionary Algorithms,** John-Wiley & Sons, Ltd. Chichester, 2001. 3. T. Back, David B. Fogel, Z. Michalewicz, **Handbook of Evolutionary Computation**, Oxford University Press, 1999. 4. M. Mitchell, **An Introduction to Genetic Algorithms** (3rd Ed) Bradford Book, 1998.

1.	Course Code	**CS 411/ CS 611**
2.	Title of the Course	**Advanced Algorithms**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Department of Computer Science & Engineering
5.	Pre-Requisite, if any	Data Structures and Algorithms and Design and Analysis of Algorithms
6.	Scope of the course	
7.	Course Syllabus	**Advanced Solutions to Basic Data Structuring Problems:** Binomial heaps and Fibonacci heaps, Red-Black tree, Splay tree, van Emde Boas Priority Queues, Dynamic Data Structures for Graph Connectivity/Reachability. **Bit Tricks Techniques:** Word-level Parallelism, Trans dichotomous Model, O(n) and O (log n) Integer Sorting. **String Algorithms:** Rabin-Karp Fingerprinting Algorithm, Suffix Trees. **Maximum Flows:** Augmenting Paths and Push-Relabel Methods, Minimum Cost Flows, Bipartite Matching. **Linear Programming:** Formulation of Problems as Linear Programs, Duality, Simplex, Interior Point, and Ellipsoid Algorithms. **Online Algorithms:** Ski Rental, River Search Problem, Paging, The k-Server Problem, List Ordering and Move-to-Front. **Approximation Algorithms:** One Way of Coping with NP-Hardness, Greedy Approximation Algorithms, Dynamic Programming and Weakly Polynomial-Time Algorithms, Linear Programming Relaxations, Randomized Rounding, Vertex Cover, Wiring and TSP. **Fixed-Parameter Algorithms:** Parameterized Complexity, Kernelization, Vertex Cover, Connections to Approximation. **Parallel Algorithms:** PRAM. Pointer Jumping and Parallel Prefix. Tree Contraction. Divide and Conquer. Randomized Symmetry Breaking. Maximal Independent Set. **External-Memory Algorithms:** Accounting for the Cost of Accessing Data from Slow Memory. Sorting. B-trees. Buffer Trees. Cache-oblivious Algorithms for Matrix Multiplication and Binary Search. **Computational Geometry:** Convex Hull. Line-segment Intersection. Sweep Lines. Voronoi Diagrams. Range Trees. Seidel's Low-dimensional LP Algorithm.
8.	Suggested Books	1. T. Cormen, C. Leiserson, R. Rivest, and C. Stein. **Introduction to Algorithms**. (3rd Ed). MIT Press, McGraw-Hill, 2010. 2. R. Motwani and P. Raghavan, **Randomized Algorithms**, Cambridge University Press, 1995. 3. V. V. Vazirani, **Approximation Algorithms**, Springer. 2001.

		4. Ravindra K. Ahuja, Thomas L. Magnanti, and James B. Orlin, **Network Flows: Theory, Algorithms, and Applications**, Prentice Hall, 1993.

1.	Course Code	**CS 412/ CS 612**
2.	Title of the Course	**Pattern Recognition**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Computer Science & Engineering
5.	Pre-Requisite, if any	Basics of probability theory, Programming
6.	Scope of the course	This course aim to cover the basic concepts for analyzing patterns and their preprocessing techniques. It also aims to give exposure to various learning algorithms and their applications to various real life applications.
7.	Course Syllabus	1. **Basics of pattern recognition:** Definitions, data sets for pattern recognition, representations of patterns and classes, metric and non-metric proximity measures, feature extraction, statistical and syntactic pattern recognition 2. **Bayesian decision theory:** Classifiers, discriminant functions, decision surfaces, normal density and discriminant functions, discrete features 3. **Parameter estimation methods:** Maximum-likelihood estimation, expectation-maximization method, Bayesian estimation, Gaussian mixture models 4. **Non-parametric techniques:** Density estimation using Parzen-window method, K-nearest neighbor method, nearest neighbor classifier 5. **Dimension reduction methods:** Lineardiscriminant analysis (LDA), principal component analysis (PCA) 6. **Linear discriminant function based classifiers:** Perceptron, support vector machines (SVM) 7. **Non-metric methods for pattern classification :** Non-numeric data or nominal data decision trees 8. **Unsupervised learning and clustering:** Criterion functions for clustering, algorithms for clustering: K-means, Hierarchical and other methods, Cluster validation 9. **Applications:** Biometrics recognition, handwriting recognition, document recognition, multimedia data retrieval, speech recognition, data mining, web searching, network traffic analysis etc.
8.	Suggested Books	1. R. O. Duda, P. E. Hart and D. G. Stork, **Pattern Classification**, John

		Wiley, 2001 2. S. Theodoridis and K. Koutroumbas, **Pattern Recognition**, 4th Ed., Academic Press, 2009 3. C. M. Bishop, **Pattern Recognition and Machine Learning**, Springer, 2006

1.	Course Code	**CS 413**
2.	Title of the Course	**Topics in Artificial Intelligence Programming**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Department of Computer Science & Engineering
5.	Pre-Requisite, if any	Abstraction and Paradigms for Programming and Artificial Intelligence
6.	Scope of the course	
7.	Course Syllabus	**Basics of LISP and PROLOG** **AI Programming techniques**: Heuristic search and efficiency issues in search programs, Min-Max algorithm, Branch and Bound algorithm **Natural language parsing:** symbolic programming, lexical closures, memorization, **Object-oriented representations:** Common Lisp Object System (CLOS), hash tables, functions as first-class objects, macros, structures and lists **Rule-based expert systems:** Expert system with Prolog **Artificial neural networks:** Unsupervised Neural Networks, Destructive Operations, Automated Memorization, Supervised Neural Networks, Reinforce Learning **Game Playing:** Tournament
8.	Suggested Books	1. P. Norvig, **Paradigms of Artificial Intelligence Programming: Case Studies in Common Lisp**, Morgan Kaufmann, 2000. 2. I. Bratko, **Prolog Programming for Artificial Intelligence** (3rd Ed), Pearson Education, 2001.

1.	Course Code	**CS 414/ CS 614**
2.	Title of the Course	**Cloud Computing and Applications**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science & Engineering
5.	Pre-Requisite, if any	UG level courses on Operating Systems, Computer Architecture and Computer Networks
6.	Scope of the Course	To study the technology behind the cloud computing methodology. The course would include many cloud computing service models namely *IaaS*, *SaaS*, and *PaaS* and cloud computing deployment models such as public Cloud, private Cloud and hybrid Cloud. Further, with the exponential growth in Cloud computing services, there is a need to understand the various issues that affect the different stakeholders of Cloud computing. The success story of the cloud computing not only depends on the underlying technology but also on the economics of the Cloud computing resource market. Hence, in this course, we would also cover the concept of Service Level Agreement (SLA), SLA matching techniques, cloud resources management, resource provisioning and sharing, pricing strategies, monitoring risk, trust, and Quality of Service (QoS) etc.
7.	Course Syllabus	**History of Cloud Computing:** Paradigms in Computing, Parallel Computing, Distributed Computing, Grid Computing, Service Computing; Service Oriented Architecture (SOA), Web Services **Cloud Computing:** Definition, Characteristics, Architecture, Components, Service Models, Deployment Models, Virtualization: Server, Storage, Network, Desktop; Hypervisor, Virtual Machine, Multi-tenancy, Opportunities and Risks **Service Level Agreement (SLA):** Definition, Types of SLA, SLA Life Cycle, Issues Related to Cloud SLA, SLA Frameworks: WS-Agreement, WSLA, WSOL, Slang, Bilateral Protocol; Translation of SLAs into Monitoring Specifications, Dynamic Creation of Monitoring Infrastructures, Penalty Management, Runtime Prediction **Cloud Security:** Cloud Security Fundamentals, Vulnerability

		Assessment, Security and Privacy in Cloud, Cloud Computing Security Architecture: Identity Management and Access Control, Autonomic Security; VM Specific Security Techniques **Cloud Application Programming Models:** Cloud File Systems: GFS and HDFS, BigTable, HBase and Dynamo; Map Reduce Programming Model, Hadoop: Hadoop Fundamentals, Hama and other Hadoop Related Services **Cloud Application Development Platforms:** Xen Hypervisor, Amazon Web Service, Windows Azure, Google App Engine, Eucalyptus, Open Stack, Open Nebula
8.	Suggested Books	1. A. T. Velte, **Cloud Computing - A Practical Approach**, McGraw Hills 2. P. Wieder and J.M. Butler, **Service Level Agreements for Cloud Computing**, Springer 3. C. Buan, **Cloud Computing - Web Based Dynamic IT Services**, Springer 4. Tanenbaum and V. Steen, **Distributed Systems: Principles and Paradigms**, Pearson 5. David E.Y. Sarna, **Implementing and Developing Cloud Computing Applications**, CRC Press 6. R. Krutz and R. D. Vines, **Cloud Security**, Wiley-India 7. T. White, **Hadoop: The Definitive Guide**, O'Reilly Media

1.	Course Code	**CS 416/ CS 616**
2.	Title of the Course	**Service Oriented Systems**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	UG Level course on Software Engineering and Computer Networks
6.	Scope of the course	To understand the technical as well as management aspects of service-oriented systems. Emphasis would be on the most common realization of service-oriented systems i.e. web-services
7.	Course Syllabus	• **Introduction:** service explosion in the world, independent services, 'servitization' of products • **Service-oriented systems:** understanding the 'register, find, bind' triangle, loose coupling, Software-as-a-Service, Governance issues Practical realization of service-oriented systems via web services, basics of xml and its use in web-service implementation, http protocol, utility of web-services • **Basic web services stack:** understanding the SOAP protocol, WSDL, UDDI registry. Implementation of web services using the basic web services stack • **Representational State Transfer (REST) web services:** implementation of RESTful web services, REST constraints, comparison of this approach of web-service implementation with that of the basic web-service stack, advantages and limitation of RESTful web services • **Service composition:** understanding of the concepts of service orchestration and service choreography, static versus dynamic service composition, assessment of quality in service compositions, appropriate service selection for compositions, role of the customer in service composition
8.	Suggested Books	1. J. Snell, D. Tidwell, P. Kulchenko. **Programming Web Services with SOAP,** O'Reilly 2. L. Richardson, S. Ruby, D. H. Hansson. **Restful Web Services,** O'Reilly 3. B. A. Christudas, M. Barai, V. Cacello. **Service-Oriented Architecture with Java,** Packt Publishing.

1.	Course Code	**CS 417/ CS 617**
2.	Title of the Course	**Cryptography and Network Security**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department/Discipline	Computer Science and Engineering
5.	Pre–requisite, if any	Discrete Mathematical Structures, Design and Analysis of Algorithms, Computer Networks
6.	Scope of the course	To understand the basic concepts of cryptography, get familiarized with encryption and authentication protocols and look at system level security. We will study block ciphers, stream ciphers, hash functions and public key cryptography and security mechanisms in networks and Internet. In the process we will learn some number theory and algebra.
7.	Course Syllabus	**Introduction:** What is cryptography, classical ciphers, cryptanalysis. **Shannon's theory:** Concept of perfect secrecy, entropy **Symmetric-key Cryptography:** Pseudorandomness, Stream ciphers, Block ciphers, Data Encryption Standards, Advanced Encryption Standards, Modes of operation **Hash-functions:** Data Integrity, Merkle-Damgard construction, Message Authentication Codes **Number Theory:** Euclidean Algorithm, Chinese Remainder Theorem, Primality Testing algorithms, Factoring algorithms **Public-key Cryptography:** RSA, Discrete log problem, Diffie-Hellman key exchange protocol, Signatures schemes Public key Infrastructure, Digital certificates **Network Security:** Network security at application,Security issues in electronic mail, IP Security, Web security, transport layer security and Secure Socket Layer, intrusion detection, malicious software, viruses, worms and related threats, firewalls, trusted systems.
8.	Suggested Books	**Suggested Textbook:** 1. D. R. Stinson: **Cryptography theory and practices,** 3rd Edition, CRC Press, (2006) 2. W. Stalling: **Cryptography and Network security Principles and Practices,** 4th or 5th Edition PHI, 2006/2010 **Other References:** 1. Menezes, P. Oorschot, S. Vanstone: **Handbook of Applied Cryptography** (individual chapters are freely available online at http://www.cacr.math.uwaterloo.ca/hac/)

		2. J. Katz and Y. Lindell: **Introduction to Modern Cryptography.** Chapman & Hall/CRC 2008 3. S. Singh: **The Code Book.** (A good popular introduction to the subject) Other web resources will be posted on the course website from time to time.

1.	Course Code	**CS 418/ CS 618**
2.	Title of the Course	**Systems and Usable Security**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	UG Level Courses on Operating Systems and Computer Networks
6.	Scope of the course	To understand the principles of systems security from an applied viewpoint and obtain hands-on experience on security threats and counter-measures. To study operating systems security, advanced topics on network security, access control and digital rights management, web security and usable security. After the completion of the course, the student will have sound understanding of practical aspects of security and will be able to analyze and design the secure systems.
7.	Course Syllabus	**Introduction:** Computer Security Concepts, threats, Attacks, and Assets **Malicious Software:** Types of Malicious Software (Malware), Infected Content–Viruses, Vulnerability Exploit–Worms, Social Engineering–SPAM E-mail, Trojans, System Corruption, Zombie, Bots, Information Theft–Keyloggers, Phishing, Spyware, Stealthing–Backdoors, Rootkits. **Operating System Security:** System Security Planning, Application Security, Linux/Unix Security, Windows Security, Virtualization Security **Access Control:** Access Control Principles, Subjects, Objects, and Access Rights, UNIX File Access Control, Role-Based Access Control, Attribute based Access Control. **Database Security:** The Need for Database Security, Database Management Systems, Database Access Control, Statistical Databases, Private Information Retrieval, Cloud Security. Digital Rights Management: Multicast security, copyright protection, Digital Finger printing. **Web Security:** Secure E-mail and S/MIME, Domain Keys Identified Mail, Secure Sockets Layer (SSL) and Transport Layer Security (TLS), HTTPS, IPv4 and IPv6 Security, Internet Authentication Applications, Kerberos, X.509, Public-Key Infrastructure, Federated Identity Management. **Wireless Security:** Wireless Security Overview, IEEE 802.11 Wireless LAN Overview, IEEE 802.11i Wireless LAN Security. **Usable Security:** Introduction to privacy, trust and semantic

		security, Visualizing privacy, Web browser security and privacy, Authentication and text passwords, biometrics and graphical passwords.
8.	Suggested Books	1. W. Stallings and L. Brown, **Computer Security: Principles and Practice** (2nd Edition)**,** Prentice Hall, 2011. 2. A. Menezes, P. Oorschot, S. Vanstone: **Handbook of Applied Cryptography (**individual chapters are freely available online at http://www.cacr.math.uwaterloo.ca/hac/) **Other References:** 3. Goodrich and Tamassia, **Introduction to Computer Security,** Addison-Wesley, 2010. 4. Kaufman, Perlman and Speciner, **Network Security: Private Communications in a Public World***, (2nd edition),* Prentice Hall, 2003.

1.	Course Code	**CS 419/ ICS 419/ CS 619**
2.	Title of the Course	**Computer Vision**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	
6.	Scope of the course	Objective of this course is to understand and create artificial vision systems which can reliably extract information from images. Study of vision problems require the basic understanding of image formation, image representation, ways of analyzing the images and patterns present in them. This course aims at providing the knowledge at all these fronts.
7.	Course Syllabus	**Digital Image Processing:** Fundamentals, Types of Image Processing, Image Acquisition Methods, Human Perception of Color and Images, Transformations: Orthogonal, Euclidean, Affine, Projective etc. **Low-level Image Processing:** Image Enhancement in Spatial Domain – Histogram Processing, Contrast Stretching, Log Transformation, Gamma Correction, Smoothing and Sharpening; Logical and Arithmetic Operations, Morphological Image Processing, Image Enhancement in Frequency Domain, Fourier Transform, Convolution and Filtering, Image Restoration. **Image Feature Extraction:** Edge detection – Canny, Sobel, Prewitt, LOG, DOG, Line detector: Hough Transform; Corner detectors – Harris and Hessian Affine; Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis – Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT. **Image Segmentation:** Edge Based Approaches to Segmentation, Region Growing, Texture Segmentation, Object Detection and Segmentation: Graph-cuts, Active Contours, Mean-Shift. **Object Recognition:** Structural Approaches, Model-based Approaches, Appearance and Shape-based Approaches, Probabilistic Paradigms. **Pattern Analysis:** Clustering: K-Means; Gaussian Mixture Model (GMM); Classification – Discriminant Function, Supervised, Semi-supervised, Unsupervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods. **Motion Analysis:** Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis. **Applications and Performance Measures:** CBIR, CBVR, Activity Recognition, Biometrics, Document processing, Super-resolution, Augmented Reality, Security and Surveillance, Performance Evaluation Measures.
8.	Suggested Books	**Text Books** 1. Computer Vision: A Modern Approach, D. A. Forsyth and J.

		Ponce, Pearson Education, 2003. (693 pages), ISBN: 9780130851987. 2. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer-Verlag, 2011. (832 pages), ISBN: 978-1848829343. **Reference Books** 1. Digital Image Processing, Rafael C. Gonzalez and Richard E. Woods, Pearson Education, 2008. (976 Pages), ISBN: 9788131726952. 2. Pattern Classification, R.O. Duda, P.E. Hart and D.G. Stork, Wiley-Interscience, 2000. (654 pages), ISBN: 978-0471056690. 3. Multiple View Geometry in Computer Vision, Richard Hartley and Andrew Zisserman, Cambridge University Press, 2004. (668 pages), ISBN: 978-0521540513. 4. Introduction to Statistical Pattern Recognition, Keinosuke Fukunaga, Academic Press, 1990. (592 pages), ISBN: 978-0122698514.

1.	Course Code	**CS 420/ CS 620**
2.	Title of the Course	**Embedded Systems**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science and Engineering
5.	Pre–requisite, if any	Programming knowledge, Computer Architecture, Operating Systems. CSE students take these subjects in their I, II and III years.
6.	Scope of the course	Embedded systems are becoming more and more ubiquitous and pervasive in our day to day life. Their applications range from domestic household appliances, health-care, defense, transportation, space technology, gaming, infotainment, mobiles, energy generation, etc. Research reports1 reveal that 99% of the microprocessors/software produced annually end up in embedded systems/applications. The course will focus on software issues in embedded systems. It will include demonstrations and getting acquainted with 8/16/32-bit micro-controller and its development environment (starter kits, appropriate compilers and flashers), interrupt programming, resource management, and peripheral interfacing & drivers. The practical part will involve demos and getting started kind of exercises to show the tangible side of taught concepts.
7.	Course Syllabus	1. Introduction to embedded systems: Embedded vs. General purpose computer Systems; Abstract Model; computer-plant interaction and real-time reactive behaviour of embedded control systems. 2. Sequential and continuous control systems; 3. Basic modeling and implementation techniques for sequential and continuous control systems - state machines, function blocks and function block diagrams, which is followed by advanced modelling techniques for complex systems, such as hierarchical and concurrent state machines and hybrid models; 4. Real-time operating systems (RTOS), Real-time kernels, Deploying applications on RTOS/Kernels.
8.	Suggested Books	1. David E. Simon, **Embedded Systems Primer**, Addison-Wesley, 1999, 020161569X / 9780201615692. 2. Tammy Noergaard, **Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers**, 2005, Newnes, ISBN-10: 0750677929, ISBN-13: 978-0750677929 / 9780123821966

1.	Course Code	**CS 422/ CS 622**
2.	Title of the Course	**Numerical Simulation**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Computer Science & Engineering
5.	Pre–requisite, if any (for the students)	Calculus, Linear Algebra and Ordinary Differential Equations, Complex Analysis and Differential Equations, Numerical Methods
6.	Scope of the course	Simulation is a useful tool in almost all areas of engineering and science. This course will introduce computational techniques for simulating applications from Electrical Engineering, Mechanical Engineering, Material Science, Physics, and Operations Research.
7.	Course Syllabus	**Problem Types:** Circuit analysis, structural analysis of automobiles, analyzing drag force in aircrafts, engine thermal analysis, virtual environments for computer games, stock option pricing, electrostatic optimization for biomolecules etc. **Equation Formulation Methods:** Stamping, node-branch, and nodal. **Direct and Iterative Matrix Solution:** Error analysis, dense and sparse matrix factorizations, and Krylov methods. **Nonlinear Systems Solution:** Multi-dimension Newton, fixed-point and functional iterations, and continuation schemes. **Numerical Integration and Monte Carlo Methods:** Newton-Cotes, composite quadrature, Gauss quadrature, multiple integrals, generating samples, random tours, designing and analyzing random paths. **Discretization Methods for Partial Differential Equations:** Finite difference, finite element, multi-grid, and spectral methods.
8.	Suggested books	1. G. Strang, **Computational Science and Engineering**, Wellesley-Cambridge Press (2007). 2. D. Kincaid and W. Cheney, **Numerical Methods: Mathematics of Scientific Computing**, Brooks / Cole (2002). 3. Y. Saad, **Iterative Methods for Sparse Linear Systems**, SIAM (2003). 4. C. T. Kelley, **Solving Nonlinear Equations with Newton's Method**, SIAM (2003). 5. E. L. Allgower and K. Georg, **Introduction to Numerical Continuation Methods**, SIAM (2003). 6. G. S. Fishman, **Monte Carlo Concepts, Algorithms, and Applications**, Springer (1996). 7. W. L. Briggs, V. E. Henson, and S. F. McCormick, **A Multigrid Tutorial**, SIAM (2000).

1.	Course Code	**CS 424**
2.	Title of the Course	**Functional and Logic Programming**
3.	Credit Structure	L-T- P-Credits 2-0-2-3
4.	Name of the Concerned Department	Computer Science & Engineering
5.	Pre–requisite, if any	Computer Programming
6.	Scope of the course	Functional-logic programming integrates most of the features of the classical declarative paradigms, namely of functional programming and of logic programming. From the functional paradigm it inherits named or anonymous functions, nested expressions, efficient reduction strategies, higher-order functions, and types. From the logic paradigm it inherits named relations, logical variables, partial data structures, unification, and built-in search. Applications include Semantic Web programs over metadata as well as Web Services that provide logic inferences and/or functional transformations over XML data.
7.	Course Syllabus	**Introduction to Functional and Logic Programming:** Overview of Declarative Programming, Basic Notions of Functional Programming, Basic Notions of Logic Programming, Basic Notions of Functional-Logic Programming. **Terms in Functional and Logic Programming:** Taxonomy of Terms, Simple Terms, Complex Terms, Term Unification. **Functional and Logic Definition Clauses:** Taxonomy and Syntax of Clauses, Logic Clauses, Functional Clauses, Functional-Logic Clauses. **Higher Order Operations:** Function Composition, Compose as a higher order function, Relational Product as a higher order function. **Case Study:** Study of a Functional-Logic Programming Language (e.g. Relational Functional Markup Language (RFML))
8.	Suggested books	1. J. Kelly, **The Essence of Logic**, , Prentice-Hall of India, 1997 2. H.B. Enderton, **Mathematical Introduction to Logic**, Academic Press, Elsevier, 2001 3. R. Wilensky, **Common LISPcraft**, W. W. Norton & Co., 1986 4. W.F. Clocksin and C.S. Melish, **Programming in Prolog**, Springer-Verlag, 5th Edition, 2004 5. G. Cousineau and M. Mauny, **The Functional Approach to Programming**, Cambridge University Press, 1998

Course Code	**CS 425 / CS 625**
Title of the Course	**Natural Language Processing**
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science & Engineering
Pre-requisite, if any	NA
Scope of the Course	The course is an introductory course in the natural language processing field. This is meant to get students familiar with the text processing techniques as well as more advanced techniques for text processing such as question answering, text summarization, parsing, semantic role labelling, etc.
Course Syllabus	Introduction NLP tasks in syntax, semantics, and pragmatics. Applications such as information extraction, question answering, and machine translation. The problem of ambiguity. The role of machine learning. Brief history of the field. N-gram Language Models The role of language models. Simple N-gram models. Estimating parameters and smoothing. Evaluating language models. Part Of Speech Tagging and Sequence Labeling Lexical syntax. Hidden Markov Models (Forward and Viterbi algorithms and EM training). Basic Neural Networks Any basic introduction to perceptron and backpropagation LSTM Recurrent Neural Networks "Understanding LSTM Networks" optionally the original paper Long Short Term Memory. Syntactic parsing Grammar formalisms and treebanks. Efficient parsing for context-free grammars (CFGs). Statistical parsing and probabilistic CFGs (PCFGs). Lexicalized PCFGs. Neural shift-reduce dependency parsing Semantic Analysis Lexical semantics and word-sense disambiguation. Compositional semantics. Semantic Role Labeling and Semantic Parsing. Information Extraction (IE) Named entity recognition and relation extraction. IE using sequence labeling. Machine Translation (MT) Basic issues in MT. Statistical translation, word alignment, phrase-based translation, and synchronous grammars.
Suggested Books	• D. Jurafsky & J. H. Martin, ***Speech and Language Processing,*** Pearson Education, India : India : 2013 : 9789332518414 • Manning and Schutze, ***Statistical Natural Language Processing***, MIT Press : Cambridge, MA : 1999 : 0262133601 • J. Allen, ***Natural Language Understanding,*** The Benajmins/ Cummings Publishing Company Inc. :1994 : 0-8053-0334-0 • Y. Goldberg and G. Hirst, ***Neural Network Methods in Natural Language Processing,*** Morgan & Claypool Publishers : 2017.: 978-1627052986

Course code	**CS 426 / CS 626**
Title of the course	**Foundations of Cyber-Physical Systems**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Suitable for UG final/ Grad/ PhD students who studied courses of Discrete Mathematics, Automata Theory, Programming, Operating Systems
Scope of the course	This course aims to introduce the basics of Cyber Physical Systems, distinguishing characteristics that sets them apart from their other embedded system incarnations. The essential topics covered would be: Pnueli's Cactus model, real-time Vs. hybrid Vs. reactive systems, formal methods for rigorous analysis of CPS, concurrency, distributed algos (centralised as well as decentralised variants), Disentanglement of their complex nuances with decentralisation. The emphasis would be from systems specification, design and formal analysis perspectives.
Course Syllabus	1. Dynamical systems: Continuous Vs Discrete behaviour, Hybrid behaviour, Reactive Systems, CPS key features, Synchronous Vs. Asynchronous paradigms. 2. Control routine patterns: Different control cycle actuations, Event/ Time - triggered, Static cyclic scheduling. 3. Scheduling: Realtime Scheduling policies, Rate-monotonic, Deadline-monotonic, Utilisation-based Schedulability. 4. Kernels: Real-time kernels and Kernel-based system development. 5. Specification languages: State machines (deterministic, nondeterministic), structural vs behavioural specification 6. Correctness Analysis: Requirements specification via Live, Safe and Precedence properties, Timed Processes & Protocols, Timed Automata, Hybrid Automata (Linear vs Non-linear), Mechanised Proof techniques, Deductive verification, 7. CPS Designs: From various application domains and CPS Case Studies.
Suggested Books	1. A. Platzer, "***Logical Foundations of Cyber-Physical Systems***", Springer, Switzerland, ISBN 978-1-4419-8236-0, 2017. 2. E. A. Lee and S. A. Seshia, "***Introduction to Embedded Systems: A Cyber-Physical Systems Approach***", Second Edition, MIT Press, Cambridge (MA, USA), ISBN 978- 0-262-53381-2, 2017. 3. C. Baier and J. P. Katoen, "***Principles of Model Checking***", MIT Press, London (UK), ISBN: 9780262026499, 2008.

Course code	**CS 427/ CS 627**
Title of the course	Advanced Computer Networks
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite if any	• Computer Networks (UG Level Course) • Operating Systems (UG Level Course)
Scope of the Course	This course will give a background on design principles of highperformance networking devices like switches and routers. It will introduce advanced topics and recent trends in Computer Networks like Software Defined Networking, Data Center Networks, Information Centric Networking and Future Internet. The Learning outcomes are: 1. Introduce PG/UG students to the recent advances and state-of-theart Computer Networking topics (Architecture/Protocol/Systems), and also develop understandings on the future research aspects in networking to help guide the students towards potential MTech/MS/PhD work. 2. Provide insights on the principles and design decisions behind networking aspects, Internet technologies and future research. 3. Expose students to hands-on exercises, work on network simulators and help them design and implement the networking protocols and applications.
Course Syllabus	High Performance Switching and Routing: 1. IP Address Lookup- Trie-based Algorithms, Hardware Lookup. 2. Quality of Service: Need for Packet Classification, Different Classification Methods, TCAM based Classification, Differentiated Service, Traffic Polishing, Traffic Shaping, Packet Scheduling, Queue Management Techniques. 3. Packet Switching: Switching Overview, Switching Fabric, Buffering in Switch Fabric, Multiplane and Multistage Switching Network Softwarization: 1. Software Defined Networking (SDN): Control and Data Plane Separation. Network Operating System (SDN Controllers), Intent based Networking (IBN), Southbound Interface (OpenFlow) and OpenVSwitch. 2. Programmable Networking Devices: P4, Smart Switches, and SmartNICs. 3. Network Virtualization: VirtIO, SR-IOV, and Network Function Virtualization (NFV). Data Centre Networking: 1. Networking Topologies: Fat-Tree, Clos, Leaf-Spine, Docker and Container Networking Interface (CNIs), Kubernetes. Switching in Data Centre Networking, Virtual Switches. 2. High-Performance Computing Networks: HPC System Architectures, HPC Networking Standards, HPC Networking Software, Low Latency Ethernet (10 GbE, 40 GbE, 100 GbE,

	InfiniBand FDR). Named Data Networking: Content Distribution on the Internet, Architectures for Information Centric Networking, Content Naming, Routing and Caching, Security in Named Data Networking.
Suggested Books	1. High Performance Switches and Routers, H. Jonathan Chao, Bin Liu, 2007, John Wiley & Sons, Inc. ISBN-10: 0-470-05367-4 2. Information-Centric Networks: A New Paradigm for the Internet (Focus Series in Networks and Telecommunications), Gabriel M. de Brito, Pedro B. Velloso, Igor M. Moraes, Wiley-ISTE; 1st edition, 2013, ISBN: 9781848214491 3. Information-Centric Networking (ICN): Content Centric Networking (CCNx) and Named Data Networking (NDN) Terminology, B. Wissingh, C. Wood, A. Afanasyev, L. Zhang, D. Oran and C. Tschudin, RFC 8793, June 2020 (All RFCs are free documents) 4. Software-Defined Networks: A Systems Approach, Peterson, Cascone, O'Connor, Vachuska, and Davie, Online Free Reference Book (https://sdn.systemsapproach.org/index.html) 5. Cloud Networking: Understanding Cloud-based Data Centre Networks, Gary Lee (Author), Morgan Kaufmann (Publisher), 2014, ISBN-139780128007280 6. Relevant Request for Comments (RFC) - IETF http://www.ietf.org/rfc.html 7. Research Publications – relevant works will be discussed and distributed time to time

Course code	**CS 428/ CS 628**
Title of the course	**Algorithmic Graph Theory**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science & Engineering
Pre-requisite, if any	Discrete Mathematical Structures, Data Structures and Algorithms.
Scope of the course	This course shall impart basic background on the theoretical concepts of graph theory. The topics covered shall cover basic concepts and algorithmic aspects, such as graph representations, terminologies, and properties of different types of graphs, connectivity properties and algorithms, as well as some advanced topics, such as graph coloring, matching, planarity, and spectral graph theory. Undergraduate and postgraduate students shall get firm foundations in solving real-world problems such as path optimization problems, and other graph-theoretical problems that are relevant to theoretical computer science and operations research.
Course Syllabus	• **Introduction to graphs, trees, and their properties:** Graphs, Representation of Graphs, Various Special Graphs, Walks, Graph Isomorphism, Spanning Trees, Counting Spanning trees in polynomial time, Algorithms for minimum weighted spanning trees. • **Matching Algorithms and Cycles in Graphs:** Matching, Perfect matching, Augmenting path algorithm, Bipartite matching algorithm, Hall Marriage Theorem, Konig's theorem, Matching in general graphs, Tutte's Theorem, Eulerian tour and Seven Bridges problem, Hamiltonian cycles and Travelling Salesman Problem, Necessary Conditions for Hamiltonian Graphs, Sufficient Conditions for Hamiltonian Graphs. • **Coloring and Connectivity in graphs:** Vertex Coloring, Edge Coloring, Brook's theorem, Vizing Conjecture. Vertex and Edge Connectivity, Vertex- and edge-disjoint paths, testing connectivity, Algorithm for the cut-vertices, Algorithm for decomposing connected graph into blocks, Tutte's decomposition, edge-connectivity, Menger's Theorem. • **Network Flow Algorithms:** Basic concepts on flows and networks, max-flow min-cut theorem, Ford-Fulkerson algorithm. • **Planarity in graphs:** Planar graphs, Euler's Formula, Outer Planar Graphs, Kuratowski Theorem, Four Color Theorem. • **Spectral graph theory:** Adjacency matrix, Laplacian matrix, Random regular graphs, Expander graphs, Ramanujan graphs. • **Applications and Case studies:** Social Network Analysis, Complex Network Analysis.

Suggested Books	• D. B. West: Introduction to Graph Theory: Pearson Education: India : 2015: 8178088304. • R. Diestel: Graph Theory: Springer-Verlag: New York: 2000: 0387950141. • R.B. Bapat: Graphs and matrices: Springer. : London: 2010: 9789380250694. • Bondy and U. S. R. Murthy: Graph Theory, Graduate Texts In Mathematics: Springer : Switzerland: 2008: 978-1-84628-969-9. • Alan Gibbons : Algorithmic Graph Theory: Cambridge University Press: 1985: 9780521288811. • T. Cormen and C.E. Leiserson and R.L. Rivest and C. Stein: Introduction to Algorithms: The MIT Press: Third Edition, Sept 2009, 9780-262-03384-8 • Narsingh Deo: Graph Theory with Applications to Engineering and Computer Science: PHI Learning: 9788120301450

Course code	**CS 630/ CS 430**
Title of the course	**Data Center Networking**
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite if any	Students must have knowledge of UG-level computer network courses and have good programming skills in python and C/C++.
Scope of the Course	In this course, students are expected to learn the data center network architectures, their underlying protocols and understand the challenges faced in designing a data center.
Course Syllabus	• Introduction to network architectures—Edge, Metro and Core Networks Evolution of Data Center Networks—a switch-centric DCN, a modular DCN, a wireless DCN, and a hybrid DCN. • Datacenter architectures and their building blocks—Network fabric, cross connect design, Server addressing and routing protocols. Multipath routing. Overview of Software Defined Networking and Network Function Virtualization. • State-of-the-art of data center networking architectures—Fat tree, Helios, VL2, Portland, B-cube, Wavecube etc. • Datacenter telemetry and resource management—traffic engineering, congestion control, load balancing and resource allocation algorithms. Datacenter network performance enhancement strategies. • Challenges involved in building a datacenter—cross-connect and protocol scalability, fault tolerance, security, power etc. Recent advancements in data centers—hybrid datacenter architectures etc..
Suggested Books	**Text Book:** 1) Yang Liu, Jogesh K. Muppala, Malathi Veeraraghavan, Dong Lin, Mounir Hamdi, "Data Center Networks: Topologies, Architectures and Fault-Tolerance Characteristics," Springer, 2013: ISBN-9783319019482. **Reference books:** 1) Guo, D. **"Data center networking: Network topologies and traffic management in large-scale data centers,"** Singapore, Springer, 2022: ISBN—9789811693687. 2) M. Arregoces and M. Portolani, **"Data Center Fundamentals,"** Cisco Press, 2004: ISBN—1587050234. 3) L. Zhang and L. Chen, **"Cloud Data Center Network Architectures and Technologies,"** CRC Press, 2021: ISBN—9780367695705 4) J. Donovan and K. Prabhu, **"Building the Network of the Future: Getting Smarter, Faster, and More Flexible with a Software Centric Approach (100 Cases),"** CRC Press, 2017: ISBN—9781138631526

Course Code	**CS 632/ CS 432**
Title of the Course	**Reinforcement Learning**
Credit Structure	L-T-P-Credit 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Students should have good understanding of linear algebra, probability and statistics, knowledge of algorithm design and analysis, and proficiency in programming.
Scope of the Course	• Learning the basic theory of reinforcement learning. • Understanding a range of reinforcement learning algorithms with their strengths and limitations. • Formulation of reinforcement learning problems for different applications.
Course Syllabus	**Introduction:** Types of machine learning approaches: supervised, unsupervised, reinforcement; Elements of reinforcement learning: agent, environment, policy, reward and value functions **Multi-armed bandits:** Sequential decision making: exploration and exploitation; bandit problem solution: greedy, optimistic-greedy, and epsilon-greedy algorithms; Upper confidence bound bandit algorithm. **Markov Processes:** Markov property, Markov chains, Markov reward process, Markov decision process (MDP), Bellman expectation equation, optimal value function, optimal policy, Bellman optimality equation. **Dynamic Programming:** Dynamic programming for MDP, iterative policy evaluation, policy improvement, policy and value iteration. **Monte Carlo Methods:** Model free reinforcement learning, Monte Carlo policy evaluation and estimation of action values, on- and off-policy **Temporal-Difference Learning:** Temporal-Difference (TD) prediction, TD(0), TD(1), TD(λ), TD control methods: SARSA, Q-Learning and variants. **Function Approximation Methods:** Risk minimization, eligibility trace for function approximation, value function approximation (VFA), Monte Carlo learning and TD learning for policy evaluation with linear VFA. **Policy Gradients:** Policy gradient methods, policy search methods, gradient-free methods, finite difference methods, likelihood ratio policy gradient, bias and variance in reinforcement learning, actor-critic methods.
Suggested Books:	**Text Book:** 1. R. S. Sutton and A. G. Barto, **"Reinforcement Learning - An Introduction"**, MIT Press, Cambridge, USA, 1998, ISBN-13: 978-0262193986 **Reference Books:** 2. P. Winder, **"Reinforcement Learning: Industrial Applications of Intelligent Agents**", O'Reilly Media, Inc, USA, 2020, ISBN-13:978-1098114831 3. K. P. Murphy, "**Machine Learning: A Probabilistic Perspective**", The MIT Press, Cambridge, USA, 2012, ISBN-13: 978-0262018029 4. I. Gridin, "**Practical Deep Reinforcement Learning with Python"**, BPB Publication, India, 2022, ISBN-13: 978-9355512055.

Course Code	**CS 334/ CS 434/ CS 634**
Title of the Course	**Wireless Networks and Applications**
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Students must have knowledge of UG-level computer network courses and have good programming skills in python and C/C++.
Scope of the Course	This course covers a broad range of wireless networking standards including 5G/6G, and reviews important wireless network application areas. This course will provide a basic understanding and working of wireless networks to the students.
Course Syllabus	• Introduction to wireless networks. An overview of layered architecture, addressing and forwarding in LANs and IP networks from a wireless perspective. • IEEE 802.11—Physical Layer Standards, Diversity & Rake Receivers, Spread Spectrum, Multicarrier Modulation and Orthogonal Frequency Division Multiplexing (802.11a and 802.11g). Wireless channel characteristics. • Overview of wireless MAC protocols and management functions. Enhancements to support quality of service (802.11e). Overview of cellular standards GSM, GPRS, CDMA, LTE, 5G/6G and Mobility. • Wireless in today's Internet—TCP over wireless, IEEE 802.11 architecture, IAPP (Inter Access Point Protocol), LoRaWAN, 6LoWPAN. Overview of wireless Ad-hoc networks.
Suggested Books:	**Textbook:** **1.** C. Beard and W. Stallings, **"Wireless Communication Networks and Systems,"** Pearson, first edition, 2015, ISBN: 9780133594171. **Reference Books:** 2. D. Tse, P. Viswanath, **"Fundamentals of Wireless Communication,"** Cambridge University Press, 2005, ISBN: 0521845270. 3. Y. C. Eldar, A. Goldsmith, D. Gündüz, **"Machine Learning and Wireless Communications,"** Cambridge University Press, 2022, ISBN: 1108832989. 4. Savo Glisic, **"Advanced Wireless Networks: Technology and Business Models,"** Wiley, 2016: ISBN—9788126565016. **5.** J. Geier, **"Designing and Deploying 802.11 Wireless Networks: A Practical Guide to Implementing 802.11n and 802.11ac Wireless Networks For Enterprise-Based Applications (Networking Technology),"** Cisco press, 2015: ISBN—9781587144301.

Course code	**CS 209**
Title of the course	**Logic Design**
Course Category	Department core
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	None
Objective(s)	The scope of the course covers the Boolean functions, Boolean arithmetic, combinational circuits, sequential circuits and programmable logic devices.
Course Outcomes	Students will learn about ● Boolean arithmetic, combinational and sequential circuits ● programmable logic devices.
Course Syllabus	● **Number systems and codes:** Digital systems, Binary numbers, Number base conversions, Representation of Negative Numbers, Complements, Error detecting and correcting codes-hamming codes. ● **Boolean algebra and logic gates:** Basic Definitions, Axiomatic Definition of Boolean Algebra, Basic Theorems and Properties of Boolean Algebra, Boolean Functions. ● **Gate-level minimization:** The Map Method - K-map 4 variable, Combinational Logic Circuits: Analysis Procedure, Binary Adder-Subtractor, Parallel Adder, Carry Look Ahead Adder. ● **Sequential circuits:** Latches, Flip-Flops-SR, D, JK and T, realization of FFs, synchronous and asynchronous sequential circuits-State table, and state diagrams, State reduction, ASM Charts, Shift Registers-SISO, SIPO, PISO, PIPO, Design of counters-Modulo-n, Johnson, Ring, Up/Down, Design of Serial Adder, Serial Multiplier, FSM, Moore and Mealy machines - Sequence detector, PLDs. ● **Practical components:** CAD Tool: Intel Quartus/Xilinx ISE ○ Design and implementation of 4-bit digital comparator (without using XOR/XNOR gates). ○ Design and implement at RTL BCD to 7-segment display converter. ○ Flip-Flops and its Applications. ○ Implement the RTL circuit and VHDL of the following sequential circuits: JK Flip Flop. ○ Implement the RTL circuit and VHDL of the following sequential circuits: T-FF. ○ Implement the RTL circuit and VHDL of the following sequential circuits: D-FF. ○ Designing Counters. ○ Design an Asynchronous Mod 10 counter using D- Flip Flop.

Suggested Books	Textbooks: 1. M. Morris Mano and Charles R. Kime, ***Logic and Computer Design Fundamentals***, 5th Edition, Prentice Hall, 2015. ISBN: 978-0133760637 2. R.H. Katz and G. Borriello, ***Contemporary Logic Design*** (2nd edition), Prentice Hall, 2004. ISBN: 978-0201308570

Course code	**CS 210**
Title of the course	**Computer Architecture**
Course Category	Department core
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Knowledge of Logic Design
Objective(s)	● The scope of the course covers computer organization and architectures (MIPS-32 bit). ● The students will learn the concepts of computer technology, instruction set design, computer arithmetic, data path and control unit design of processors and memory systems.
Course Outcomes	Students will learn about ● computer performance and processor architecture ● computer memory systems.
Course Syllabus	● **Introduction:** Computer Technology, performance trends, machine, power trends, memory capacity, # instructions, CPU time, Elapsed time, User CPU time, MIPS, Amdahl's law, problem solving based on performance parameters. ● **Instruction Set:** Instruction set design and architecture, general computer systems organization, computer instructions, addressing modes, ISA classes, MIPS processor arithmetic, instruction format, floating point numbers, double floating point representation, IEEE 754 floating point standard, FP to decimal, and decimal to FP. ● **Register Transfer and Datapath Structures:** Data path structure, Register transfer (RT), CPU pipelining basics, hazards: structural, control, data, preventing pipelining, data forwarding, stalling, etc. ● **Memory:** Memory hierarchy design, cache memory. Direct mapped cache Associative cache, Fully mapped cache, multi-level cache, tags, cache datapath, multi-word cache etc Virtual memory, TBL, physical disk, Multiprocessors, cache coherence, cache consistency.
Suggested Books	Textbooks: 1. D. Patterson, J. Hennessy, ***Computer Organization and Design***, 6th edition, 2020, Elsevier, ISBN: 9780128201091 2. M. M Morris, ***Computer System Architecture***, 3rd edition, Pearson, 2017. ISBN: 9789332585607

<table>
<tr><td>Course code</td><td>CS 264</td></tr>
<tr><td>Title of the course</td><td>Computer Architecture Lab</td></tr>
<tr><td>Course Category</td><td>Department core</td></tr>
<tr><td>Credit Structure</td><td>L - T - P - Credits
0-0-3-1.5</td></tr>
<tr><td>Name of the Concerned Department</td><td>Computer Science and Engineering</td></tr>
<tr><td>Pre-requisite, if any</td><td>Knowledge of Logic Design</td></tr>
<tr><td>Objective(s)</td><td>● The scope of the course covers computer organization and architecture (MIPS-32 bit).
● The students will learn the concepts of computer technology, instruction set design, computer arithmetic, data path and control unit design of processors and memory systems.</td></tr>
<tr><td>Course Outcomes</td><td>Students will learn about
● computer performance and processor architecture
● computer memory systems.</td></tr>
<tr><td>Course Syllabus</td><td>● Comparison of various modern processor architectures.
● Case studies of various performance issues.
● Implementation and handling of strings in MIPS assembly language
● Implementation and handling of loops in MIPS assembly language.
● Implementation and handling of while condition in MIPS assembly language.
● Implementation of functions in MIPS.
● Implementation of conditional branching in MIPS.
● Implementation of consecutive integers in MIPS.
● Implementation of switch case in MIPS. 10: Implementation of dual integer function in same MIPS code.
● Implementation of factorial function in MIPS.
● Implementation of strcpy in MIPS.
● Basic programming in Quartus II tool.
● Coding of CPU Register set design (VHDL, Simulation).
● Design a 32-bit ALU in VHDL and simulate the code.</td></tr>
<tr><td>Suggested Books</td><td>Textbooks:
1. D. Patterson, J. Hennessy, Computer Organization and Design, 6th edition, 2020, Elsevier, ISBN: 9780128201091
2. M. M Morris, Computer System Architecture, 3rd edition, Pearson, 2017. ISBN: 9789332585607</td></tr>
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Course code	**CS 311**
Title of the course	**Parallel Computing**
Course Category	Department core
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite if any	A knowledge of programming in C, C++, or similar, the basics of data structures and the computer architecture are assumed.
Objective(s)	This course will introduce the parallel programming paradigm using different parallel programming languages.
Course outcome	Knowledge of different parallel programming languages
Course Syllabus	● Introduction to parallel computing, Amdahl's law, Computing platforms, Memory hierarchy, Shared memory, Cache coherence and synchronization. ● Interconnection networks and topologies, Routing and embeddings, Physical Organization and Communication Costs in parallel machines. ● Principles of parallel algorithm design—Concurrency, Decomposition and Mapping. ● Parallel programming using Message Passing Interface (MPI) and Shared memory platforms (i.e. OpenMP, Pthreads, CUDA etc.). ● Collective communications. Analytical modeling and metrics analysis of parallel programs. ● Practical components: ○ Experiments to support the associated theory course
Suggested Books	Textbooks: 1. A. Grama, A. Gupta, G. Karypis, and V. Kumar, ***Introduction to Parallel Computing***, Addison-Wesley, 2003, ISBN: 9780201648652 Reference books: 2. B. Chapman, G. Jost, R. van der Pas, ***Using OpenMP: Portable Shared Memory Parallel Programming***, MIT Press, 2008, ISBN: 9780262533027 3. William Gropp, Ewing Lusk, Anthony Skjellum, ***Using MPI: Portable Parallel Programming with the Message-Passing Interface***, MIT Press, 2014, ISBN: 9780262527392

Course code	**CS 313/ MA 313**
Title of the course	**Computer Networks**
Course Category	Department core
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite if any	Knowledge of data structures and algorithms, programming skills in C/C++/python
Objective(s)	This course will introduce computer networking protocols and performance analysis of networks.
Course outcome	Understanding the basic functionalities of computer networks
Course Syllabus	● Network Architecture and protocols. History of networking–Circuit switching and packet switching. Network performance metrics–Throughput and delay ● Application layer–HTTP, DNS, CDN, SMTP, P2P etc., ● Transport layer–UDP and TCP, Reliability and congestion control in TCP. ● Socket programming, Introduction to Network Layer. Routing protocols. Interdomain routing–BGP ● Link layer and physical layer, Performance analysis of networks. Router Architecture, Resource allocation, and QoS, Network simulation version 3 (NS3). ● Introduction to next-generation networks. ● Practical components: ○ Experimental study of application protocols such as HTTP, FTP, SMTP, using network packet sniffers and analyzers ○ Socket programming - Small exercises in socket programming in C/C++/Java. ○ Experiments with packet sniffers to study the TCP protocol. ○ Introduction to ns3 (network simulator) and small simulation exercises to study TCP behavior under different scenarios. ○ Setting up a small IP network in ns3 ○ Experiments with ns3 to study Ethernet and 802.11 wireless LAN. ○ Programming with pcap
Suggested Books	Textbooks: 1. J. Kurose and K. Ross, ***Computer Networking, A Top-Down Approach***, Pearson Education, 8th Ed. 2022. ISBN: 978-9356061316 2. L. Peterson and B. Davie, ***Computer Networks, A Systems Approach***, Morgan Kaufmann Publishers Inc, 6th ed. 2021, ISBN: 978-0128182000 Reference books: 3. W. R. Stevens, ***Unix Network Programming: The Sockets Networking***

	API, Pearson Education, 3rd ed. 2017, ISBN: 978-9332549746 4. Bertsekas and Gallager, ***Data Networks***, Pearson Education 2nd ed., 2015. ISBN:978-9332550476

Course code	**CS 353N**
Title of the course	**Operating Systems Lab**
Course Category	Department core
Credit Structure	L - T - P - Credits 0-0-2-1
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite if any	NA
Objective(s)	This course will introduce the basic components of operating systems and functionalities.
Course outcome	Understanding basic functionalities of operating system for efficient performance of the processes
Course Syllabus	• **OS Programming prerequisites:** Familiarities with IPC facilities, IPC identifiers, IPC keys, Message queues and their internal and user data structures, System calls related to IPC, Semaphore and Shared memory. • **CPU scheduling:** Simulation programs for long-term, short-term and medium term schedulers, Simulation for the maintenance of various scheduling queues such as ready, I/O, blocked etc., Implementations of different scheduling algorithms such as FCFS, SJF, Priority scheduling (preemptive and non-preemptive), Round robin, multilevel feedback queue scheduling and their performance evaluations. • **Concurrent Processing and Concurrency Control:** Simulation of updating processe PCBs with shared memory, Implementation of interprocess communication using simulated semaphore through (i) shared memory, (ii) synchronized producer-consumer problem, (ii) Pipes and message passing (asynchronous and synchronous). Concurrence control with pipes socket for iterative and concurrent servers • **File Systems Implementation:** creating, removing, accessing, protecting and error handling of EXT2 FS, Registering the virtual file system in Kernel, accessing superblock information.
Suggested Books	Textbooks: 1. A. Silberschatz, P.B. Galvin, and G. Gagne, ***Operating System Principles***, 7th edition, John Wiley, 2005. ISBN: 9788126509621 2. A. Silberschatz, P.B. Galvin, and G. Gagne, ***Operating System Concepts***, 9th edition, Wiley, 2018. ISBN: 978-1-118-06333-0 Reference books: 3. W. Stallings, ***Operating Systems: Internals and Design Principles***, 5th edition, Pearson Education, 2005. ISBN: 978-0-13-467095-9

Course code	**CS 357N**
Title of the Course	**Optimization Algorithms and Techniques Lab**
Course Category	Department core
Credit Structure	L - T - P - Credits 0-0-2-1
Name of the Concerned Discipline	Computer Science and Engineering
Pre-requisite, if any	Knowledge of Data Structures and Algorithms
Objective(s)	This is an introductory course in the field of mathematical optimization.
Course Outcomes	At the end of the course, students will know ● The Basics of Optimization, ● Unconstrained and Constrained Optimization, and ● Linear and Quadratic Programming.
Course Syllabus	● Understanding of Matlab/ Scilab via implementation of Newton's method for solving non-linear system of equations as well as numerical integration. ● Analyzing convexity of functions numerically. ● Implementation and analysis of Multi-dimensional Unconstrained Optimization algorithms (Steepest Descent, Newton, Gauss-Newton, Quasi-Newton, Conjugate Gradients etc.). ● Implementation and analysis of One-dimensional Unconstrained Optimization algorithms (Dichotomous, Quadratic Interpolation, Cubic Interpolation etc.). ● Implementation and analysis of Simplex and Interior Point Methods for Linear Program. ● Implementation and analysis of Sequential Quadratic Program for solving general Constrained Optimization problem.
Suggested Books	Textbooks: 1. J. Nocedal and S. J. Wright, ***Numerical Optimization***, 1st Edition, Springer, 2006. ISBN: 78-1-4939-3711-0 Reference books: 2. A. Antoniou and W.-S.g Lu, ***Practical Optimization: Algorithms and Engineering Applications***, 2nd Edition, Springer, 2021. ISBN: 978-1-0716-0843-2

Course code	**CS 302N**
Title of the course	**Computer Graphics and Visualization**
Course Category	Department core
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Knowledge of Programming
Objective(s)	Introduce the theory and practice of computer graphics and an insight of modern graphics systems.
Course Outcomes	● Understand the basic principles of computer graphics primitives. ● Design application-specific computer graphics programs.
Course Syllabus	● **Introduction:** Introduction to computer graphics, Graphics hardware and display devices, Raster and vector graphics, Pixel concept, Raster scan algorithms. ● **2D Computer Graphics:** Homogeneous coordinates, Window and view port, 2D viewing pipeline, 2D geometric transformation. **3D Computer Graphics:** 3D viewing pipeline, 3D geometric transformations, Planner projections. ● **Clipping:** 2D and 3D line and polygon clipping algorithms. ● **Visible Surface Detection**: Planner surface representation, Visible surface determination algorithms. ● **Light, Shading and Color Models:** Illumination and shading models, RGB, CMYK and YCbCr colors model ● **Solid Model:** Solid representation, Regularized Boolean set representation, Sweep and primitive representation, CSG, Quad tree, Octree, BSP ● **Practical Components:** ○ Basics of graphics libraries like OpenGL/DirectX/Others ○ Visualizing graphics algorithms using graphics libraries ○ Visualizing 3D scenes using graphics libraries. ○ Small game designing projects and scientific visualization with graphics libraries
Suggested Books	Textbooks: 1. J. F. Hughes, A. V. Dam, M. McGuire, D. F Sklar, J. D. Foley, S. K. Feiner, and K. Akeley, ***Computer Graphics: Principles and Practice***, Pearson, 2018, ISBN: 978-0321399526. 2. D. D. Hearn, M. P. Baker, and W. Carithers., ***Computer Graphics with Open GL***, Pearson, 2015. ISBN: 9780136053583. Reference Books: 1. M. K. Pakhira, ***Computer Graphics, Multimedia and Animation***, PHI, 2010, ISBN: 9788120341272.

	2. D. D Hearn and M. P. Baker, ***Computer Graphics, C Version***, Pearson, 2002, ISBN: 9788177587654. 3. F. S. Hill, Jr. and S. Kelley, ***Computer Graphics Using OpenGL***, Pearson, 2007, ISBN: 978-0131496705. 4. F. Luna, ***Introduction to 3D Game Programming with DirectX 12***, First Eds., Mercury Learning and Information, 2016. ISBN: 9781942270065.

Course code	**CS 310**
Title of the course	**Software Engineering**
Course Category	Department core
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	None
Objective(s)	Understanding the creation of software applications with the view of meeting certain requirements through designing, testing and building software.
Course Outcomes	● Understanding the concept of software engineering. ● Acquiring fundamental knowledge in mathematics, computer science, programming, and computer systems. ● Understanding some ethical and professional issues that are important for software engineering.
Course Syllabus	● **Software Situation:** problems and causes; Role of Software Engineering; Software Development Paradigms. ● **Function-oriented Methodology:** System Engineering Overview; Function-Oriented Modeling Techniques; Function-Oriented Requirements Analysis; Correctness Criteria for Requirements Models; Reducing Complexity; Data Dictionary; Process Specification; Data Design; Architectural Design; Flow Analysis and Conversion Techniques; Design Refinement Measures; Procedural Design; User Interface Design. ● **Object-oriented Methodology**: Modeling of Software Requirements and Specifications with Use-Case Diagrams; Object-Oriented Modeling based on UML: Notations, Diagrams, Relationships, Modeling procedures and Applications; System Architecture; User-Interface Design; Game Interfaces and Web-based SE. Implementation: Procedural Design and Implementation. Stepwise Refinement. ● **Software Project Management:** Concerns of Management; Project Planning; Measurement and Metrics; Cost Estimation; Scheduling and Team Organization; Overview of SQA; SQA Techniques: qualitative and quantitative; Software Maintenance; Overview of Software Configuration Management; Software Configuration Items and Change Control. ● **Practical components:** ○ Students would be made to go through and experience the various phases of the Software Development Life Cycle – (1) Requirements Elicitation, (2) Software Design, (3) Software Development, (4) Software Testing, and (5) Software Maintenance – by working on a real project
Suggested Books	Textbooks: 1. C. Ghezzi, J. Mehdi. and M. Dino, ***Fundamentals of Software Engineering***, Prentice-Hall, 1991. ISBN: 978-0133056990 2. I. Sommerville, ***Software Engineering*** (5th Edition), Addison-Wesley, 1996. ISBN: 9780201427653

	Reference books: 3. R. S. Pressman, ***Software Engineering: A Practitioner's Approach*** (6^{th} Edition), McGraw-Hill, 2006. ISBN: 978-0073375977

Course code	**CS 308N**
Title of the course	**Compiler Techniques**
Course Category	Department core
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Automata Theory, Data Structures, and Algorithms
Objective(s)	This course will introduce the basics of a Compiler including different phases of Compiler and it's working.
Course Syllabus	• **Introduction:** Major compilation processes; Compiler phases; front end and back end partitioning. • **Lexical Analysis:** Tasks and roles of lexical analyser; Regular expressions; Deterministic finite automata; LEX – a lexical analyzer generator. • **Context-Free Grammars:** Formal grammar; Derivations; Ambiguous, unambiguous and recursive grammars; Chomsky hierarchy; Parse trees and parsing concepts. • **Syntax Analysis:** Top down parsing – recursive descent and LL(1) predictive parsers; First and Follow sets; LL(1) parse table construction; Bottom up and shift reduce parsing; LR parsing; Parse table constructions – LR(0), SLR(1) and LALR(1); YACC – a syntax analyser generator. • **Extending the Parser:** Syntax directed approach; Inherited and synthesized attributes; symbol table; Type concepts; Syntax-directed semantic analysis; Intermediate languages – three address code; Syntax directed intermediate code generation. • **Introducing Compiler Backend:** Code optimization techniques and concepts; Target code generation. • **A Complete Compiler:** The grammar specification; Scanner; parser; Code generation; Building and running the compiler. • **Practical components: D**esign and implementation of a compiler for a sufficiently rich subset of a real programming language. The compiler will be automatically generated through use of tools such as LEX, YACC and IBURG.
Suggested Books	Textbooks: 1. A.V. Aho, M.S. Lam, R. Sethi, and J.D. Ullman, ***Compilers: Principles, Techniques, and Tools*** (2nd Edition), Addison-Wesley 2007. ISBN: 978-0321486813 2. D. Grune, H.E. Bal, C.J.H. Jacobs, and K.G. Langendoen, ***Modern Compiler Design***, John Wiley and Sons, Inc. 2000. ISBN: 978-1461446989 Reference books:

	3. A. Appel, ***Modern Compiler Implementation in C/ML/Java***, Cambridge University Press, 2004. ISBN: 9780521607643 4. M. L. Scott, ***Programming Language Pragmatics***, Morgan Kaufman Publishers, 2006. ISBN: 978-0124104099

Course code	**CS 211**
Title of the course	**UX/UI Design**
Course category	Departmental Elective
Credit Structure	L - T - P – Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite if any	Knowledge of Programming
Objective(s)	Understand the fundamental concepts, techniques, practices, workflows, and tools associated with the practice of user experience design. Understand how to approach UI design in web and mobile experiences.
Course Outcome	Learn main concepts in user experience design and understand the importance of user-centered perspective on UX design. Learn to design user interface by applying interaction design guidelines. Get knowledge about usability testing and undertake further training in this area.
Course Syllabus	● **Introduction:** Introduction to User Experience (UX) design, Understanding users, Principles of UX design, Prototyping. ● **Humans, Technology, and Design Basics:** Humans on the Web, Web use, Web design basics, Principles of UX design. **Designing for Human Psychology:** Human perception, Visual structure - Gestalt principles, Human vision, Memory, Attention. ● **UX Design Process:** Defining problem, User research, Analysis of user insights, Designing and planning the user interface, Information architecture and interaction design, Prototyping, Usability testing. ● **Guidelines and Standards:** Universal-design principles and heuristic guidelines, Jakob Nielsen's principles, Arnold Lund’s expert ratings of usability maxims, Empathy map ● **Practical Components:** ○ Basic HTML, FTP, and ‘uploading’ files to a server. ○ HTML elements and Stylesheets ○ Graphic production and Photoshop ○ Imagemaps, intermediate graphics production, Animated GIFs ○ Dynamic HTML ○ Project front page and graphics
Suggested Books	Textbooks: 1. S. Krug, ***Don’t Make Me Think, Revisited, A Common Sense Approach to Web Usability***, Third Edition, 2014, New Riders, ISBN-10: 9780321965516 2. J. Johnson, ***Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Guidelines***, Third Edition, Morgan Kaufmann Publishers In, 2020, ISBN: 978-0124079144 Reference Books: 3. D. Norman, ***Design of Everyday Things: Revised and Expanded***, New York: Basic Books, Expanded Edition, 2014, ISBN: 978-0465055715 4. J. J. Garret, ***The Elements of User Experience: User-Centered Design for the Web***, New Riders, Second Edition, 2010, ISBN: 978-0321683687 5. K. Goodwin, ***Designing for the Digital Age: How to Create Human-Centered Products and Services***, Wiley, 2009. ISBN: 978-0470229101

Course code	**CS 213**
Title of the course	**Matrix factorizations and applications**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Basic linear algebra
Objective(s) (Objectives)	● This Course is designed to provide an introduction to matrix factorizations. ● This course will also provide familiarity with some algorithms related to matrix factorization.
Course Outcomes	Students will learn various matrix factorizations and their applications
Course Content	● Review of vector spaces, bases ● Cayley-Hamilton Theorem, triangulation, diagonalization, LU, LUP, decompositions ● Linear transformations, rotations, reflections, Gram-Schmidt orthogonalization, QR like decompositions, linear least-square problems ● Eigenvalues, Eigenvectors, normal matrices, eigenvalue decomposition, similar matrices ● Spectral theorem for Hermitian matrices, Cauchy-interlace theorem, Singular value decomposition, Moore-Penrose pseudoinverse
Suggested Books	Textbooks: 1. G. H. Golub, Charles F. Van Loan, ***Matrix Computations***, The Johns Hopkins University Press, 2013. ISBN: 978-1421407944. 2. D. S. Watkins, ***Fundamentals of Matrix Computations***, Wiley, 2010. ISBN: 978-0-470-52833-4. Reference Books: 3. G. Strang, ***Linear Algebra and Its Applications***, 4th Edition, Academic Press, 2006. ISBN- 978-8131501726.

Course code	**CS 215**
Title of the course	**Mathematics for AI and ML**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Basic linear algebra and calculus
Objective(s)	This course is designed to provide an introduction to mathematical foundations, concepts, and constructs for artificial intelligence and machine learning algorithm design.
Course Outcomes	Students will develop a foundation such that advanced courses in this area could be taken (Artificial Intelligence, Machine Learning, Soft Computing, and Computational Intelligence).
Course Content	● **Linear Algebra and Matrix Analysis:** Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Orthonormal Basis, Orthogonal Complement, Orthogonal Projections, Rotations, Eigenvalue Decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation. ● **Vector Calculus and Continuous Optimization:** Gradients of Vector-Valued Functions, Gradients of Matrices, Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series, Unconstrained Optimization, Constrained Optimization and Lagrange Multipliers. ● **Probability and Distributions:** Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Summary Statistics and Independence, Gaussian Distribution, Conjugacy and the Exponential Family, Change of Variables/Inverse Transform. ● **Models and Data:** Models Learning and Selection, Empirical Risk Minimization, Parameter Estimation, Probabilistic Modeling and Inference, Directed Graphical Models, Bayesian Linear Regression, Dimensionality Reduction with Principal Component Analysis, Density Estimation with Gaussian Mixture Models, Classification with Support Vector Machines
Suggested Books	Textbooks: 1. M. P. Deisenroth, A. A. Faisal, and C. S. Ong., ***Mathematics of Machine Learning***, Cambridge University Press, 2020. ISBN: 978-1-1084-5514-5. 2. A. Antoniou and W.-S. Liu, ***Practical Optimization: Algorithms and Engineering Applications***, Springer, 2007. ISBN: 978-0-3877-1106-5. Reference Books: 3. C. Meyers, ***Matrix Analysis and Applied Linear Algebra***, SIAM, 2023. ISBN: 978-1-6119-7745-5. 4. J. K. Blitzstein and J. Hwang, ***Introduction to Probability*, **Chapman and Hall/CRC Texts in Statistical Science, 2019. ISBN: 978-1-1383-6991-7 5. T. Hastie, R. Tibshirani, and J. Friedman, ***The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, **Springer Series in Statistics, 2016**.** ISBN: 978-0-3878-4857-0.

Course code	**CS 212**
Title of the course	**Foundations of Algebraic Graph Theory**
Course category	Department electtive
Credit Structure	L -T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Knowledge of Linear Algebra, Discrete Mathematics
Objective(s)	This course is about ● the analysis of graph properties using matrix theory ● bounds on some intractable graph problems.
Course outcomes	The students will learn analyzing graph properties using matrix theory and bounds on different graph problems
Course Syllabus	● Matrices associated with graphs, adjacency matrix, Laplacian matrix, distance matrix, Seidel Matrix, Spectral Theorem ● Finding number walks, connected components, Counting number of spanning trees, Matrix-Tree Theorem(s) ● Algebraic connectivity, regular graphs, random walks, expanders, Ramanujan Graphs ● Graph Isomorphism problem, graphs determined by the eigenvalues ● Strongly regular graphs, Friendship Theorem, Spectral bounds on NP-hard problems on graphs
Suggested Books	Textbooks: 1. R. B. Bapat, ***Graphs and Matrices***, Hindustan Book Agency, 2014, ISBN: 978-1-4471-6568-2 2. C. Godsil and G. Royle, ***Algebraic Graph Theory***, Springer, 2001, ISBN: 978-0-387-95241-3 Reference books: 3. A. E. Brouwer and W. H. Haemers, ***Spectra of graphs***, Springer, 2011, ISBN: 978-1-4614-1938-9

Course code	**CS 214**
Title of the course	**Foundations of Hardware Security**
Course category	Department elective (Semester 4)
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Course Instructors	Prof. Anirban Sengupta and Dr. Bodhisatwa Majumdar
Pre-requisite, if any	Knowledge of Logic Design, Algorithms
Objective(s)	This course will introduce the basic foundations of Hardware Security and the obfuscation techniques about hardware DSP cores, different techniques for IP protection, hardware design of cryptographic primitives, side channel analysis, hardware Trojans, and physically unclonable functions.
Outcome of the course	• The students will learn the VLSI aspects that relate to hardware security. • The students will acquire the knowledge of different security threats that thwart hardware trust in the VLSI design cycle along with the countermeasures against such threats.
Course Syllabus	• **Introduction to Hardware (IP) Security: Forensic Detective Control and Obfuscation of DSP cores:** Hardware Security, Hardware Security of DSP Core, Security – Energy Tradeoff in High Level Synthesis for Hardware Security of DSP cores • **Forensic Detective Control using Hardware Steganography for IP Core Protection:** Threat Model, Selected Contemporary Approaches - Steganography vs Watermarking vs Cryptography, Limitations of Hardware Watermarking • **Forensic Detective Control using Digital Signature based Watermark for IP Core Protection:** Threat Models of an IP Core, Selected Contemporary Approaches • **Protection of Fault Secured IP Core using Digital Signature based Watermark:** Background on different IP Core Threats and Countermeasures, Threat Model, Selected Contemporary Approaches • **Multi-Level Watermark for IP Protection:** Discussion on Selected Approaches, Salient Features and Advantages of Multi-level Watermark, Embedding Signature as Secret-mark • **Hardware Design of Cryptographic Algorithms:** Hardware Design of Advanced Encryption Standard (AES), Efficient Design of Finite Field Arithmetic on FPGAs • **Side Channel Analysis (SCA):** Introduction to SCA techniques, Power-based SCA • **Hardware Trojans and PUFs:** Overview of Hardware Trojans, Their Effect on Circuit Reliability, Techniques of Hardware Trojan Insertion**,** PUFs: Root-of-trust for Hardware Security
Suggested Books	Textbooks: 1. A. Sengupta, ***Frontiers in Securing Hardware IP: Forensic Detective Control and Obfuscation***, IET, 2020. ISBN: 978-1839530319 2. D. Mukhopadhyay and R.S. Chakraborty, ***Hardware Security:***

	Design, Threats, and Safeguards, CRC Press, 2014. ISBN: 9780429066900 Reference books:

Course Code	**CS 216**
Title of the Course	**Introduction to Blockchain**
Course Instructors	Dr. Subhra Mazumdar and Dr. Bodhisatwa Mazumdar
Course Category	Departmental Elective/ Institute Elective
Credit Structure	L-T-P–Credits 2-1-0-3 (½ semester)
Name of the Concerned Department	Computer Science and Engineering
Prerequisite if any	Programming and Data Structure
Course Objective	This course introduces students to blockchain, and develops familiarity of current technologies, tools, and implementation strategies.
Course Outcomes	Students will develop a clear understanding of Blockchain and its applications.
Course Content	• Primers on Blockchain - Motivation for Blockchain Systems. Introduction to Peer-to-Peer systems and Distributed systems • Preliminaries and Mathematical Background - Cryptographic primitives like hashing, digital signature, encryption, Concepts of basic probability like sample space, independent event, Bayes' theorem, expectation • Introduction to Bitcoin: Bitcoin - Wallet - Blocks - Merkle Tree - hardness of mining - transaction verifiability - anonymity, Proof-of-Work. • Alternate Consensus Mechanisms - Proof of Stake, Proof of Space, Proof of Space time, Proof of Burn, Proof of Authority
Suggested Books	Textbooks: 1. A. M. Antonopoulos, ***Mastering Bitcoin: Programming The Open Blockchain***, O'Reilly, 2017. ISBN: 9789352135745 2. A. Narayanan, J. Bonneau, E. Felten, A. Miller, and S. Goldfeder, ***Bitcoin and cryptocurrency technologies: a comprehensive introduction***, Princeton University Press, 2016. ISBN: 9780691171692 Reference books: 3. A. M. Antonopoulos and G. Wood, ***Mastering Ethereum: Building Smart Contracts and Dapps***, O'reilly Media, 2018. ISBN: 978-9352137961

Course code	**CS 315**
Title of the course	**Introduction to Complexity Theory**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Algorithms, Formal Languages and Automata Theory, Discrete Mathematics
Objective(s)	This Course is designed to provide an overview of Turing machine, the details of the complexity classes and their relationships.
Course Outcomes	Students will be able to understand computational complexity and their significance.
Course Syllabus	• **Introduction to the Turing Machine:** Definition of Turing Machines, Examples, Deterministic and non-deterministic Turing machines, Other variants of Turing machine, The Definition of Algorithm • **Decidability and undecidability:** Reducibility, Undecidable Problems from Language Theory, Mapping Reducibility • **P, NP and NP-completeness:** The Class P, Class NP, NP-hard, NP-completeness, Reducibility between problems, Discussions on different NP-complete problems such as satisfiability, clique, vertex cover, independent set, set cover, TSP, etc. • **Space complexity:** Savitch's Theorem, The Class PSPACE, PSPACE-completeness, Class L and NL, NL-completeness, NL equals coNL
Suggested Books	Textbooks: 1. S. Arora and B. Barak, ***Computational Complexity: A Modern Approach***, Cambridge University Press, 2009. ISBN: 978-0521424264 2. M. Sipser, ***Introduction to the Theory of Computation***, 3rd eds., Cengage Learning, 2012. ISBN: 978-8131525296 Reference Books: 3. S. Rudich and A. Wigderson, ***Computational Complexity Theory***, 1st eds., American Mathematical Society, 2004. ISBN: 978-0821828724

Course code	**CS 317**
Title of the course	**Introduction to Internet of Things**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Basic arduino programming and networking
Objective(s)	This course will introduce the basic components of IoT and their interdependencies, deployment models, and fundamental concepts of IoT networking.
Course outcome	• Understanding basic concepts and functionalities of IoT devices and networking • Developing IoT-based prototype
Course Syllabus	• Introduction to IoT; Sensing, Actuation, Basics of Networking; Basics of Networking; • Communication Protocols; Sensor Networks; Machine-to-Machine Communications, Interoperability in IoT • Arduino Programming; Integration of Sensors and Actuators with Arduino; Introduction to Python Programming, • Implementation of IoT with Raspberry Pi, Implementation of IoT with Raspberry Pi • Cloud Architecture and its functionalities; Introduction to edge architectures and its functionalities • Smart Cities and Smart Homes; Connected Vehicles, Smart Grid, Industrial IoT; Case Study: Agriculture, Healthcare, Activity Monitoring
Suggested Books	Textbook: 1. S. Misra, A. Mukherjee, A. Roy, ***Introduction to IoT***, Cambridge University Press, 2022. ISBN: 978-1108959742 Reference book: 2. A. Bahga and V. Madisetti, ***Internet of Things: A Hands-On Approach***, Orient Blackswan Private Limited, 2015. ISBN: 978-8173719547

<table>
<tr><td>Course code</td><td>CS 319</td></tr>
<tr><td>Title of the course</td><td>Foundations of Cryptography</td></tr>
<tr><td>Course Category</td><td>Department Elective</td></tr>
<tr><td>Credit Structure</td><td>L - T - P - Credits
2-1-0-3</td></tr>
<tr><td>Name of the Concerned Department</td><td>Computer Science and Engineering</td></tr>
<tr><td>Pre-requisite, if any</td><td>Discrete Mathematical Structures, Design and Analysis of Algorithms, Computer Networks</td></tr>
<tr><td>Objective(s)</td><td>● To understand the basic foundations of cryptography, understand the encryption and authentication protocols with security proofs.
● The students will study block ciphers, stream ciphers, hash functions and public key cryptography.</td></tr>
<tr><td>Outcome of the course</td><td>● The students will learn about different proving models, indistinguishability tests about security of encryption algorithms, authentication algorithms, and hashing algorithms.
● Along with gaining knowledge about security bounds, the students will learn some number theory and algebra, wherever required.</td></tr>
<tr><td>Course Syllabus</td><td>● Introduction: Classical ciphers, Cryptanalysis techniques: linear and differential cryptanalysis.
● Number Theory: Euclidean Algorithm, Chinese Remainder Theorem, Primality Testing algorithms, Factoring algorithms, Algebraic Structures: Groups, Rings and Fields.
● Shannon's theory: Concept of perfect secrecy, Entropy, Key equivocation, Unicity Distance, Perfect cipher, Ideal Cipher.
● Symmetric-key Cryptography: Pseudorandomness, Stream ciphers, Block ciphers, Data Encryption Standards, Advanced Encryption Standards, Modes of operation
● Hash-functions: Data Integrity, Merkle-Damgard construction, Message Authentication Codes.
● Public-key Cryptography: RSA, Discrete log problem, DiffieHellman key exchange protocol, Signatures schemes, Public key Infrastructure, Digital certificates.</td></tr>
<tr><td>Suggested Books</td><td>Textbooks:
1. D. R. Stinson, Cryptography: Theory and practices, 3rd Edition, CRC Press, 2006. ISBN: 978-1584885085
2. J. Katz and Y. Lindell, Introduction to Modern Cryptography, Chapman and Hall/CRC, 2020. ISBN: 978-0815354369
Reference books:
3. A. J. Menezes, P. Oorschot, and S. Vanstone, Handbook of Applied Cryptography, CRC Press, 1997. ISBN: 9781138385979
4. W. Stalling, Cryptography and Network security Principles and Practices, 5th Edition Pearson Education, 2017. ISBN: 978-9332585225</td></tr>
</table>

Course code	**CS 321**
Title of the course	**Introduction to Big Data Analysis**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Linear Algebra, Calculus, Data Structures, Algorithms
Objective(s)	To help students to learn and understand the terminologies and core concept behind big data problems, applications, and modern big data computing technologies.
Course Outcomes	Students would be familiar with real-world challenges associated with Big Data.
Course Syllabus	● **Introduction:** Types of Data under Big Data, Characteristics of Big Data, 5 V's of Big Data (Velocity, Volume, Value, Variety and Veracity), Challenges and Applications of Big Data. ● **Technologies:** Apache Spark, HDFS, YARN, Introduction to MapReduce, MapReduce Programming Model with Spark, MapReduce Example: Word Count, Page Rank etc. ● **Storage Platforms:** Introduction to HBase, HBase Internals, Hive, Pig, Ozie, Introduction to Big Data Streaming Platforms for Fast Data, Introduction to Spark Streaming, Kafka. ● **Big Data Machine learning:** Machine Learning with Spark, Introduction to Spark MLlib, Cluster Analysis, Association Analysis.
Suggested Books	Textbooks: 1. R. Kamal and P. Saxena, ***Big Data Analytics, Introduction to Hadoop, Spark, and Machine-Learning***, McGraw Hill Education, 2019. ISBN: 978-9-3531-6496-6. Reference Books: 2. C. Lam, ***Hadoop in Action***, Manning Publications, 2010. ISBN: 978-1-9351-8219-1. 3. H. Karau, A. Konwinski, P. Wendell, and M. Zaharia, ***Learning Spark: Lightning-Fast Big Data Analysis***, O'Reilly, 2015. ISBN: 978-1-4493-5862-4.

Course code	**CS 312**
Title of the course	**Foundations of Secure Computation**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Probability Theory, Discrete Mathematics, Algorithms
Objective(s)	This course will introduce the basic foundations of Secure Computation in present day distributed and computer systems.
Outcome of the Course	● The students will understand formal details and fundamental aspects of secure multiparty computation. ● The topics will enable them to understand security features of computations in distributed systems and applications of secure multiparty computation systems.
Course Syllabus	● **Introduction to Secure Computation:** Cryptography applications in Secure Communication Systems, Privacy Preserving Information Processing Computations, Abstractions and Dimensions of Secure Multiparty Computation ● **Applications of Secure Computation:** Privacy Preserving Data-mining, Secure E-auction, Yao's millionaires' problem, Privacy preserving pattern matching, Privacy preserving machine learning and its goals. ● **Secure Multiparty Computation (MPC):** Availability and confidentiality of sensitive data, Forms of function abstraction, Dimensions to study secure MPC: Protocols for Boolean circuits in asynchronous network, Protocols for arithmetic circuits in asynchronous network. ● **Overview and Basic Concepts of Abstract Algebra and Cryptography**: Characteristics of algebraic structures: Groups, Rings, and Fields, Cryptographic primitives, Real-world communication protocols: SSL, Unconditionally secure and conditionally secure schemes. ● **Secret Sharing:** Problem definition, real-world examples, additive secret sharing, Threshold secret sharing, Shamir's secret sharing, linear secret sharing, general secret sharing, Perfectly secure message transmission. ● **MPC Protocols:** Toy MPC protocol, BGW MPC protocol, Zero Knowledge Protocols, Reliable Broadcast and Byzantine agreement, Exponential Information Gathering (EIG) for Perfectly Secure Byzantine agreement.
Suggested Books	Textbooks: 1. A. Choudhury and A. Patra, ***Secure Multiparty Computation Against Passive Adversaries***, Springer, 2022. ISBN: 978-3-031-12163-0 Reference books: 2. R. Cramer, I. Djere Damgard, and J. B. Nielsen, ***Secure Multiparty Computation and Secret Sharing***, Cambridge University Press, 2015. ISBN: 9781107043053

Course code	**CS 314**
Title of the course	**Computer and Network Security**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Discrete Mathematical Structures, Design and Analysis of Algorithms, Computer Networks
Objective(s)	To understand the network and computer security fundamentals.
Outcome of the course	The students will learn security mechanisms and vulnerabilities in computer systems, networks and the Internet.
Course Syllabus	● **Network Security:** Network security at application, packet Sniffing and Spoofing, Attacks on TCP Protocol, Security issues in electronic mail, IP Security, Web security, Transport layer security and Secure Socket Layer, intrusion detection, malicious software, viruses, worms and related threats, firewalls, trusted systems. ● **Computer Security:** Need for privileged programs, Set-UID mechanism: Attack Surfaces, Unsafe and safe approaches of invoking other programs, Environment variables and attack surfaces, Shellshock attack, Buffer overflow attack, Format string vulnerability: Exploitable scenarios.
Suggested Books	Textbooks: 1. Wenliang Du, ***Computer Security: A Hands-on Approach***, Amazon Digital Services, 2017, ISBN: 978-1548367947 Reference books: 2. W. Stalling, ***Cryptography and Network security Principles and Practices***, 5th Edition PHI, 2010. ISBN: 978-0136097044

Course code	**CS 201/MA 211**
Course category	**Department core**
Title of the course	Discrete Mathematical Structures
Credit Structure	L - T - P – Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Basic courses on mathematics
Objective(s)	This course will introduce the basic concepts of discrete mathematics and its applications.
Course Outcome	● Students will learn about discrete mathematical structures like sets, relations, functions, groups, graphs, etc. ● They will also learn about proof techniques and how to apply them to prove lemmas, theorems, etc.
Course Syllabus	● Elementary counting techniques ● Propositions and predicates, proofs and proof techniques. ● Sets, relations and functions, cardinality ● Posets and lattices: Dilworth`s theorem, inversion and distributive lattices ● Graph theory basics: paths, cycles, trees, connectivity ● Group theory: Lagrange`s theorem, homomorphisms, applications
Suggested Books	Textbooks: 1. K. H. Rosen, ***Discrete Mathematics and Its Applications***, Mc Graw Hill, 2019, ISBN: 9781259676512 Reference books: 2. R. P Grimaldi, ***Discrete and Combinatorial Mathematics***, Pearson, 2017, ISBN: 9788177584240

Course code	**CS 203/ MA 213**
Title of the course	**Data Structures and Algorithms**
Course Category	Department core
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Computer Programming
Objective(s)	● This Course is designed to provide an introduction to the theory and practice of different data structures. ● This course will also provide familiarity with the algorithms for those data structures.
Course Outcomes	Students will learn the uses of data structures to make efficient algorithms
Course Syllabus	● Introduction to data structures, Abstract data types, Analysis of algorithms, Introduction to complexity analysis and measures. ● Arrays – operations and addressing, Linked list (singly, doubly, and circular), Stack ADT and its applications in expression evaluation and recursion, Queue ADT and its variants such as circular queues and double-ended queues. Hashing and hash tables, Recursion. ● Tree ADT, Binary trees – properties and traversals, Binary search trees, Height balanced trees -- AVL trees, Binary heaps, and priority queues. ● Graph ADT, Graph representation, Graph traversal – breadth-first search, depth-first search, and topological ordering, Connected components, cut-vertices, 2-connected components ● Algorithms and data structures for sorting and searching, Order statistics.
Suggested Books	Textbooks: 1. S. Sahni, ***Data structures, algorithms, and applications in C++***, McGraw-Hill, 1998, ISBN: 978-0929306322 2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms***, (3rd Edition), Prentice Hall, 2009. ISBN: 978-81-203-4007-7 Reference Books: 3. D. E. Knuth, ***The Art of Computer Programming: Fundamental Algorithms***, Vol. 1 (3rd Edition, 1997) and Vol 3, (2nd Edition, 1998), Addison-Wesley Professional. ISBN: 978-0137935109 4. M.T. Goodrich, R. Tamassia, and D. Mount, ***Data Structures and Algorithms in C++***, 2nd Edition, Wiley, 2011. ISBN: 978-0-470-38327-8

Course code	**CS 207N**
Title of the course	**Database and Information Systems**
Course Category	Department core
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Knowledge of Data Structures and Algorithms
Objective(s)	This course will introduce the fundamentals of Database Management Systems and practical solutions to create, manipulate, and optimize Databases.
Course outcome	Students will learn about ● The fundamentals of database management ● handling databases
Course Syllabus	● **Introduction to Databases:** Nature of Business Systems and Data Processing, Database Architectures, Schema, Data Models, XML. ● **ER Model:** Entity, Attribute, Relationship, ER Diagrams, UML, Class Diagrams. ● **Relational model and query languages:** Relational algebra and calculus, SQL. ● **Database design and normalization**: Integrities, Anomalies, Functional Dependencies, Normal Forms. ● **Transactions:** Introduction to transactions, Serializability, Recoverability, Concurrency control and recovery. ● **Physical Organization of Databases:** Indexing and Hashing, Single-level indexing, Multi-level indexing, B and B^+ Trees. ● **Query processing and optimization**
Suggested Books	Textbooks: 1. A. Silberschatz, H.F. Korth, and S. Sudarshan, ***Database System Concepts***, 7th Edition, McGraw Hill, 2019. ISBN: 9780078022159 2. R. Elmasri and S. Navathe, ***Fundamentals of Database Systems***, 7th Edition, Pearson, 2015. ISBN: 978-0133970777 Reference books: 3. R. Ramakrishnan and J. Gehrke, ***Database Management Systems***, 3rd Edition, McGraw Hill, 2002. ISBN: 978-0072465631 4. C. J. Date, ***Introduction to Database Systems***, 8th Edition, Pearson, 2003. ISBN 978-0321197849

Course code	**CS 253**
Title of the course	**Data Structures and Algorithms Lab**
Course Category	Department core
Credit Structure	L - T - P - Credits 0-0-3-1.5
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Computer Programming
Objective(s)	This Course is designed to provide ● an introduction to the theory and practice of different data structures ● familiarity with the algorithms for those data structures
Course Outcomes	Students will learn uses of data structures to make efficient algorithms.
Course Syllabus	● Implementation of array, linked list, stack, and queue ● Implementation of tree and graph data structure ● Implementation of sorting and searching, ● Implementation of Hash and hash tables and order statistics.
Suggested Books	Textbooks: 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms***, (3rd Edition), Prentice Hall, 2009. ISBN: 978-81-203-4007-7 Reference Books: 2. D. E. Knuth, ***The Art of Computer Programming: Fundamental Algorithms***, Vol. 1 (3rd Edition, 1997) and Vol 3, (2nd Edition, 1998), Addison-Wesley Professional. ISBN: 978-0137935109 3. M.T. Goodrich, R. Tamassia, and D. Mount, ***Data Structures and Algorithms in C++***, 2nd Edition, Wiley. 2011. ISBN: 978-0-470-38327-8

Course code	**CS 257**
Title of the course	**Database and Information Systems Lab**
Course Category	Department core
Credit Structure	L - T - P - Credits 0-0-3-1.5
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Knowledge of Data Structures and Algorithms
Objective(s)	This course will introduce the fundamentals of Database Management Systems and practical solutions to create, manipulate, and optimize Databases.
Course outcome	Students will learn and implement about ● The fundamentals of database management ● handling database
Course Syllabus	● Use of database systems supporting interactive SQL. ● Two-tier client-server applications using JDBC or ODBC. Three-tier web applications using Java servlets/JDBC or equivalent. ● Design of applications and user interfaces using these systems. ● Data analysis tools. ● Laboratory project.
Suggested Books	Textbooks: 1. A. Silberschatz, H.F. Korth, and S. Sudarshan, ***Database System Concepts***, 7th Edition, McGraw Hill, 2019. ISBN: 9780078022159 2. R. Elmasri and S. Navathe, ***Fundamentals of Database Systems***, 7th Edition, Pearson, 2015. ISBN 978-0133970777 Reference books: 3. R. Ramakrishnan and J. Gehrke, ***Database Management Systems***, 3rd Edition, McGraw Hill, 2002. ISBN: 978-0072465631 4. C. J. Date, ***Introduction to Database Systems***, 8th Edition, Pearson, 2003. ISBN 978-0321197849

Course code	**CS 202 (From AY 2024-25 Onwards)**
Title of the course	**Automata Theory and Logic**
Course Category	Department core
Credit Structure	2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Discrete Mathematical Structures
Objective(s)	To learn computation models, and classifying problem based on their solvability, and time taken by them on the computation models
Course Outcomes	Students will learn computation models and classification of problems based on how efficient they get solved on these models
Course Syllabus	● Finite state machines DFA/NFA/epsilon NFAs ● Regular expressions. Properties of regular languages. Pumping Lemma, Non-regularity, Myhill-Nerode Theorem. ● Push down automata. Properties of context-free grammar, Pumping Lemma for context-free grammar ● Turing hypothesis, Turing computability, Nondeterministic, multi tape and other versions of Turing machines, undecidability, The halting problem, post`s correspondence problem ● Complexity theory, P, NP, reducibility, NP-hard, NP-completeness
Suggested Books	Textbooks: 1. J.E. Hopcroft, R. Motwani, and J. D. Ullman, ***Introduction to Automata Theory, Languages and Computation***, Pearson Education, 2006. ISBN: 0-201-44124-1 2. H. R. Lewis, and C. H. Papadimitriou, ***Elements of the Theory of Computation***, Prentice Hall Inc, 1981. ISBN: 0-13-262478-8 Reference Books: 3. Michael Sipser, ***Introduction to the Theory of Computation***, Thomson, 2006. ISBN: 0-534-95097-3

Course code	**CS 204**
Title of the Course	**Design and Analysis of Algorithms**
Course Category	Department core
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Discipline	Computer Science and Engineering
Pre-requisite, if any	Knowledge of Data Structures and Algorithms
Objective(s)	This is an introductory course in the field of computer algorithms.
Course Outcomes	At the end of the course, students will know the basics of ● algorithm analysis, ● algorithm design, and ● different problem classes.
Course Syllabus	● **Algorithm Analysis:** Time and Space Complexity; Computational Tractability (Best, Average and Worst Cases), Asymptotic Bounds (Lower, Upper and Tight Bounds). ● **Algorithm Design**: Divide and Conquer; Greedy, Dynamic Programming, Branch and Bound. ● **Problem Classes:** Reducibility and Intractability, P, NP, PSPACE, NP-Complete, and NP-Hard.
Suggested Books	Textbooks: 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms*** (Eastern Economy Edition), 3rd Edition, PHI Learning Pvt. Ltd. (Originally MIT Press), 2010. ISBN: 978-8120340077 Reference books: 2. J. Kleinberg and E. Tardos, ***Algorithm Design***, 2nd Edition, Pearson Education, 2022. ISBN: 978-0132131087

<table>
<tr><td>Course code</td><td>CS 254/ MA 254</td></tr>
<tr><td>Title of the Course</td><td>Design and Analysis of Algorithms Laboratory</td></tr>
<tr><td>Course Category</td><td>Department core</td></tr>
<tr><td>Credit Structure</td><td>L - T - P - Credits:
0-0-3-1.5</td></tr>
<tr><td>Name of the Concerned Discipline</td><td>Computer Science and Engineering</td></tr>
<tr><td>Pre-requisite, if any</td><td>Knowledge of Data Structures and Algorithms</td></tr>
<tr><td>Objective(s)</td><td>This is an introductory course in the field of computer algorithms.</td></tr>
<tr><td>Course Outcomes</td><td>At the end of the course, students will know the basics of
algorithm analysis and design
different problem classes.</td></tr>
<tr><td>Course Syllabus</td><td>Runtime analysis of different sorting algorithms and linked lists in best-case, worst-case, and average-case.
Implementation and analysis of algorithms based upon the following design techniques:
Divide and Conquer Strategy (Closest Pair of Points, Integer Multiplication, Matrix Multiplication, Fast Fourier Transform etc.).
Greedy Strategy (Interval Partitioning, Dijkstra's Algorithm, Minimum Spanning Tree etc.).
Dynamic Programming Strategy (Weighted Interval Scheduling, Sequence Alignment, Bellman-Ford Algorithm etc.).</td></tr>
<tr><td>Suggested Books</td><td>Textbooks:
T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, Introduction to Algorithms (Eastern Economy Edition), 3rd Edition, PHI Learning Pvt. Ltd. (Originally MIT Press), 2010. ISBN: 978-8120340077
Reference books:<ol start="2">
J. Kleinberg and E. Tardos, Algorithm Design, 2nd Edition, Pearson Education, 2022. ISBN: 978-0132131087</td></tr>
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Course code	**CS 303/ MA 303**
Title of the course	**Operating Systems**
Course Category	Department core
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite if any	NA
Objective(s)	This course will introduce the basic components of operating systems and functionalities.
Course outcome	Understanding basic functionalities of operating system for efficient performance of the processes
Course Syllabus	● **Introduction:** Overview of important features of computer architectures for OS operation; Service and system performance ● **Multiprogramming:** Concurrency and parallelism; Processes and threads; Process synchronization; Process deadlocks ● **Memory management:** Paging; Segmentation; Virtual memory ● **File systems:** File operations. File protection ● **Case Studies:** Case studies of contemporary operating systems
Suggested Books	Textbooks: 1. A. Silberschatz, P.B. Galvin, and G. Gagne, ***Operating System Principles***, 7th edition, John Wiley, 2005. ISBN 9788126509621 2. A. Silberschatz, P.B. Galvin, and G. Gagne, ***Operating System Concepts***, 9th edition, Wiley, 2018. ISBN 978-1-118-06333-0 Reference books: 3. W. Stallings, ***Operating Systems: Internals and Design Principles***, 5th edition, Pearson Education, 2005. ISBN 978-0-13-467095-9

Course code	**CS 307/ MA 307**
Title of the Course	**Optimization Algorithms and Techniques**
Course Category	Department core
Credit Structure	L-T-P-Credits 2–1–0-3
Name of the Concerned Discipline	Computer Science and Engineering
Pre-requisite, if any	Knowledge of Data Structures and Algorithms
Objective(s)	This is an introductory course in the field of mathematical optimization.
Course Outcomes	At the end of the course, students will know ● The Basics of Optimization, ● Unconstrained and Constrained Optimization, and ● Linear and Quadratic Programming.
Course Syllabus	● **Introduction to Optimization and Math Foundation:** Type of Problems, Examples, Formulations, Applications, Notations, and Convexity. ● **Unconstrained Optimization**: Necessary and Sufficient conditions for a Minima; Linear Search and Trust Region Methods; Multi-dimensional Minimization - Steepest descent, Newton, Gauss Newton, Quasi Newton; One-Dimensional minimization - Dichotomous, Quadratic and Cubic Interpolation. ● **Constrained Optimization:** Conversion to Unconstrained, Lagrange Multipliers, Necessary and Sufficient Conditions for Minima (KKT), and Duality. ● **Linear Programming**: Necessary and Sufficient Conditions for a Minima for a Linear Program, Derivation and Implementation of Simplex, Starting Simplex, and Interior-Point Methods.
Suggested Books	Textbooks: 1. J. Nocedal and S. J. Wright, ***Numerical Optimization***, 1st Edition, Springer, 2006. ISBN: 78-1-4939-3711-0 Reference books: 2. A. Antoniou and W.-S.g Lu, ***Practical Optimization: Algorithms and Engineering Applications***, 2nd Edition, Springer, 2021. ISBN: 978-1-0716-0843-2

Course code	**CS 304N**
Title of the course	**Computational Intelligence**
Course Category	Department core
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Computer Programming, Data structure, and Design and Analysis of Algorithm
Objective(s)	Basics of machine learning techniques
Course Outcomes	Understanding of machine learning techniques and implementation
Course Syllabus	● **Introduction:** Overview, Basics of Problem solving as an Artificial Intelligence problem, Computational Intelligence, Applications. Intelligent Search techniques, Knowledge representation, ● **Methodologies:** Computational intelligence methodologies; Learning, adaptation: Artificial neural networks: feed-forward, recurrent and multi-layer architectures; Supervised and unsupervised learning; Characteristics: adaptability, fault tolerance, generalization; limitations of neuro-computing. ● **Different learning algorithms:** Perceptron, Back propagation, Hopefield, Kohenen networks. Uncertainty treatment: Fuzzy sets - Basic Definition; Fuzzy-set- theoretic Operations – Member Function Formulation and Parameterization – Fuzzy Rules and Fuzzy Reasoning, Fuzzy If-Then Rules Hybrid computational learning : Fuzzy Neural Networks and Evolutionary Algorithms ● **Detailed Discussion from Example Domains:** Industry, Language, Medicine, Verification, Vision, Knowledge Based Systems etc.
Suggested Books	Textbooks: 1. S. Russell and P. Norvig, ***Artificial Intelligence: A Modern Approach***, Pearson, 2010. ISBN: 978-0136042594 2. E. Rich and K. Knight, ***Artificial Intelligence***, McGraw Hill Education, 2017. ISBN: 978-0070087705 Reference books: 3. J.S.R.J ang, C.T. Sun and E. Mizutani, ***Neuro-Fuzzy and Soft Computing***, Prentice Hall of India and Pearson Education, 2004. ISBN: 978-9332549883 4. D.E. Goldberg, ***Genetic Algorithms: Search, Optimization and Machine Learning***, Addison Wesley, 1989. ISBN: 9781584883883 5. S. Rajasekaran and G.A.V. Pai, ***Neural Networks, Fuzzy Logic and Genetic Algorithms***, Prentice Hall, 2003. ISBN: 9788120321861 6. R. Eberhart, P. Simpson and R. Dobbins, ***Computational Intelligence - PC Tools***, AP Professional, 1996. ISBN: 978-0122286308

Course code	**CS 354N**
Title of the course	**Computational Intelligence Lab**
Course Category	Department core
Credit Structure	L-T-P-Credits 0-0-3-1.5
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Computer Programming, Data structure, and Design and Analysis of Algorithm
Objective(s)	Basics of machine learning techniques
Course Outcomes	Understanding of machine learning techniques and implementation
Course Syllabus	● **AI programming:** Prolog, LISP, Experiments to support the associated theory course that demonstrate the different applications of Neural, fuzzy, evolutionary and hybrid model; ● **Implementation:** Minor project based on real life applications such as Functional approximation; Time-series prediction; Pattern recognition; Data compression; Control applications, Optimization etc.
Suggested Books	Textbooks: 1. S. Russell and P. Norvig, ***Artificial Intelligence: A Modern Approach***, Prentice Hall Series in AI, 1995. ISBN: 978-9332543515 2. E. Rich and K. Knight, ***Artificial Intelligence***, Tata McGraw Hill, 1992. ISBN: 978-0-07-067816-3 Reference books: 3. J.S.R.J ang, C.T. Sun and E. Mizutani, ***Neuro-Fuzzy and Soft Computing***, Prentice Hall and Pearson Education, 2004. ISBN: 978-9332549883 4. D.E. Goldberg, ***Genetic Algorithms: Search, Optimization and Machine Learning***, Addison Wesley, 1989. ISBN: 9781584883883 5. S. Rajasekaran and G.A.V. Pai, ***Neural Networks, Fuzzy Logic and Genetic Algorithms***, Prentice Hall, 2003. ISBN: 9788120321861 6. R. Eberhart, P. Simpson and R. Dobbins, ***Computational Intelligence - PC Tools***, AP Professional, 1996. ISBN: 978-0122286308

Course Code	**CS 334/ CS 434/ CS 634**
Title of the Course	**Wireless Networks and Applications**
Credit Structure	L-T-P Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Students must have knowledge of UG-level computer network courses and have good programming skills in python and C/C++.
Scope of the Course	This course covers a broad range of wireless networking standards including 5G/6G, and reviews important wireless network application areas. This course will provide a basic understanding and working of wireless networks to the students.
Course outcome	The students will learn about the new generation network technologies.
Course Syllabus	● Introduction to wireless networks. An overview of layered architecture, addressing and forwarding in LANs and IP networks from a wireless perspective. ● IEEE 802.11 Physical Layer Standards, Diversity and Rake Receivers, Spread Spectrum, Multicarrier Modulation and Orthogonal Frequency Division Multiplexing (802.11a and 802.11g). Wireless channel characteristics. ● Overview of wireless MAC protocols and management functions. Enhancements to support quality of service (802.11e). Overview of cellular standards GSM, GPRS, CDMA, LTE, 5G/6G and Mobility. Wireless in today's Internet TCP over wireless, IEEE 802.11 architecture, IAPP (Inter Access Point Protocol), LoRaWAN, ● 6LoWPAN. Overview of wireless Ad-hoc networks.
Suggested Books:	Textbook: 1. C. Beard and W. Stallings, ***Wireless Communication Networks and Systems***, Pearson, first edition, 2015, ISBN: 9780133594171. Reference Books: 2. D. Tse, P. Viswanath, ***Fundamentals of Wireless Communication***, Cambridge University Press, 2005, ISBN: 0521845270. 3. Y. C. Eldar, A. Goldsmith, D. Gündüz, ***Machine Learning and Wireless Communications***, Cambridge University Press, 2022, ISBN: 1108832989. 4. Savo Glisic, ***Advanced Wireless Networks: Technology and Business Models***, Wiley, 2016. ISBN: 9788126565016. 5. J. Geier, ***Designing and Deploying 802.11 Wireless Networks: A Practical Guide to Implement 802.11n and 802.11ac Wireless Networks For Enterprise-based Applications (Networking Technology),*** Cisco press, 2015. ISBN: 9781587144301.

Course Code	**CS 401 / CS 601**
Title of the Course	**Soft Computing**
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Prerequisite, if any	Discrete Mathematical Structures, Design and Analysis of Algorithms, Computational Intelligence
Scope of the Course	After having basic knowledge of artificial intelligence related to neural, fuzzy and evolutionary approaches, advancements in different areas are to be covered with working in a specific domain. This is by taking a case study to come up with the implementation and results.
Course outcome	The students will learn the theoretical and practical concepts of soft computing, hybrid intelligent systems, adaptation and applications of novel systems.
Course Syllabus	● **Review on Mathematical and theoretical methods on soft computing:** Neural networks. RBF structures. Self- organizing networks and methods. Fuzzy logic. Support vector machines and kernel methods. Evolutionary algorithms. ● **Hybrid Intelligent Systems:** Neuro-fuzzy systems. Neuro-Genetic systems, Evolving neural systems. Neuro-swarm. Hybridization with novel computing paradigms: Quantum computing, DNA computing, membrane computing. Neural dynamic logic and other methods, etc. ● **Learning and adaptation for novel systems:** Adaptive systems. Imitation learning. Reconfigurable systems. Supervised, unsupervised, Semi-supervised, reinforcement and statistical algorithms. Stability and convergence analysis. ● **Applications:** Image and signal processing. Ambient intelligence. process control, and manufacturing. Biometry and bioinformatics. Data mining. Internet modeling, communication and networking. Intelligent systems in education. Human robot interaction. Time series analysis and prediction etc.
Suggested Books	Textbooks: 1. R. Jang and Mizutani, ***Neuro-Fuzzy and Softcomputing: A Computational Approach to Learning and machine Intelligence***, Pearson, 1996. ISBN: 978-0132610667 2. R. John and Ralph Birkenhead, ***SoftComputing Techniques and Applications (Advances in Intelligent and Softcomputing)***, Springer-Verlag, 2000. ISBN: 978-3790812572 Reference books: 3. F.O. Karray, C. W. De Silva, ***SoftComputing and Intelligent System Design: Theory, Tools and Applications***, Addison Wesley; 2009. ISBN: 978-8131723241.

Course code	**CS 403/ CS 603**
Title of the course	**Machine Learning**
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Artificial Intelligence/Computational Intelligence
Objective(s)	● This course provides a broad introduction to machine learning, datamining, and statistical pattern recognition. Topics include supervised learning, unsupervised learning, best practices in machine learning ● The course will also draw from numerous case studies and applications, so that the candidate's alos can learn how to apply learning algorithms to build different intelligent systems.
Course Outcome	The students will learn the basics of ML and its application.
Course Syllabus	● Introduction, Machine Learning and AI, Motivations for Studying ML, ● Supervised and Unsupervised learning, Linear prediction, Maximum likelihood Regularizers, basis functions and cross-validation, Optimisation, ● Linear and Logistic Regression, Gaussian Discriminant Analysis, Support Vector Machines, Decision Trees, Neural networks architectures and its advances, Ensemble Methods, Clustering, Naive Bayes, Bayesian Statistics, K-Means, Gaussian Mixture Models, Learning Theory, Model Selection.
Suggested Books	Texbooks: 1. C. M. Bishop, ***Pattern Recognition and Machine Learning***, Springer, Heidelberg, 2006. ISBN: 978-0-387-31073-2 2. T. Mitchell, ***Machine Learning***, McGraw Hill, 1997 (new chapters on line, 2006), New York, 1997. ISBN: 978-0071154673 Reference books: 3. Duda, Hart and Stork, ***Pattern Classification*** (2nd ed.), Wiley Interscience, US, 2000. ISBN: 978-8126511167

Course Code	CS 406 / CS 606
Title of the Course	**Data Mining and Data Warehousing**
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-Requisite, if any	Basics of Data Base and Information Systems
Objective(s)	The course will cover the advanced concepts of data mining and warehousing
Course outcome	The students will learn the data warehousing and technologies, and data mining.
Course Syllabus	● **Data Warehouse and OLAP Technology:** Data warehousing Definition, usage and trends, Data marts, Metadata, Multidimensional data model, Data cubes, Schemas for Multidimensional Database: stars, snowflakes and fact constellations, Data warehouse architecture, OLTP and OLAP, types of OLAP servers: ROLAP, MOLAP, 3- Tier data warehouse architecture, Data warehouse implementation, computation of data cubes, indexing OLAP data, processing OLAP queries. ● **Data Mining:** Data mining definition and task, data preprocessing, data mining functionalities: Characterization and Discrimination, Mining frequent patterns, Frequent itemset mining methods, associations, and Correlations, Classification and Predictions, Cluster Analysis, Outlier Analysis, Evolution Analysis ● **Mining complex data objects:** Spatial databases, Multimedia databases, Time series and Sequence data, mining Text Databases and mining Word Wide Web, Applications and Trends in Data Mining
Suggested Books	Textbooks: 1. J. Han and M. Kamber, ***Data Mining: Concepts and Techniques***, Elsevier Publication, 2011. ISBN: 978-9380931913 Reference books: 2. M. H. Dunham, ***Data Mining: Introductory and Advanced Topics***, Pearson Education, 2006. ISBN: 978-8177587852

Course Code	**CS 407**
Title of the Course	**Peripherals and Interfaces**
Credit Structure	L-T- P-Credits 2-0-2-3
Name of the Concerned Department_	Computer Science and Engineering
Pre requisite, if any	Computer Architecture
Objective(s)	This course deals with the various aspects of hardware software interfacing with peripherals and associated devices. The course covers the fundamentals of various peripheral devices, its programming through assembly language and architecture. Further, it provides the an avenue for learning concepts of microprocessors, microcontrollers, interrupts and memory access mechanisms.
Course outcome	The students will learn the concepts of ● interfacing techniques with hardwares and softwares ● designing the interface hardware
Course Syllabus	● Basics of Microprocessor: Design, Memory Subsystems, System Resources, Types and Interrupt handling, 8085 Architecture and its programming, 8086 ● Architecture and its programming, DMA channel, I/O port addresses. I/O buses, Local bus, DMA controller, PCI, ADC/DAC interfacing with microcontrollers/microprocessors. ● GPUs, USB, Bluetooth, 8255 interfacing, RAID. Video Hardware, Video display technologies, ● Introduction to serial communication, 8253/8254 programmable timer and interval counter. ● I/O Interfaces, USB Basic and Driver model Testing of serial and parallel port, USB mouse/keyboard interfaces. ● Interrupt Controller, Video/Graphics of Modern Desktop Board, Concepts of Network Interface Card, Design and Integration of Peripheral devices to a computer system as a Case Study.
Suggested books	Textbooks: 1. Douglas V. Hall. ***Microprocessor and Interfacing: Programming and Hardware***. McGraw Hill Inc., 1991. ISBN: 978-0070257429 2. Ramesh S. Gaonkar, ***Microprocessor Architecture, Programming and Application with the 8085***, Penram Int. Pub., 2013. ISBN: 978-8187972884 Reference books: 3. Stuart R. Ball. ***Analog Interfacing to Embedded Microprocessors***, Elsevier, 2003. ISBN: 9780080469973

Course Code	**CS 409 / CS 609**
Title of the Course	**Advanced Topics in Database Management Systems**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Department of Computer Science and Engineering
Pre-Requisite, if any	Data Structures and Algorithms and Database and Information Systems
Objective(s)	The course will cover the advanced topics on database management and security aspects.
Course outcome	The students will learn the advanced topics of data base management
Course Syllabus	• **Advanced Data Models:** Enhanced Relational System, Object-Oriented Data Model, Spatial and Temporal Databases, Multimedia Databases. • **Query Processing and Optimization:** Query Interpretation and Equivalence Expressions, Cost Estimate in Query Optimization, Semantic Query Optimization. • **Transaction Processing and Concurrency Control:** Properties of Transactions, Schedules and Serializability of Schedules, Transaction Failures and Recoverability, High Performance Transaction Systems. Distributed Databases: Design of Distributed Databases, Distributed Query Processing, Deadlock Handling, Concurrency Control and Recovery. • **Database Security and Authorization:** Database Security Issues, Security and Integrity Violations, Multilevel Security, Discretionary and Mandatory Access Control, Statistical Database Security.
Suggested Books	Textbooks: 1. R. Elmasri and S. Navathe, ***Fundamentals of Database Systems***, 7th Edition, Pearson, 2015. ISBN: 978-0133970777 2. H. F. Korth and A. Silberschatz, ***Database System Concepts***, McGraw Hill Inc., 2019. ISBN: 9780078022159 Reference books: 3. C. Zaniolo, S. Ceri, C. Faloutsos, R. T. Snodgrass, V.S. Subrahmanian, R. Zicari, ***Advanced Database Systems,*** Morgan Kauffmann, 1997. ISBN: 978-1558604438

Course Code	**CS 410**
Title of the Course	**Genetic Algorithms**
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department	Department of Computer Science and Engineering
Pre-Requisite, if any	Optimization Algorithms and Techniques
Objective(s)	The course will cover the topics on genetic algorithms
Course outcome	The students will learn the concepts of genetic algorithms
Course Syllabus	● **Evolutionary Computations:** Biological background, Canonical GA ● framework, Basic Terminologies, Formulation of Optimization problems into GA framework. ● **Variations of GAs:** Binary Coded GAs and its variations such as Micro GA, Messy GA, Greedy GA etc., Real Coded GAs, Permutation Encoding GA etc. ● **GA operators:** Selection, Reproduction, Crossover, Mutation etc. Convergence criteria, Mathematical Construction of Genetic Operators, Schema Theorem of John Holland. ● **Advanced Operators and Techniques in GA:** Diploidy and Multiploidy, Inversion and Reordering, Niche and Speciation, Segregation and Translocation. ● **Multi-Objective GAs:** Non Pareto and Pareto-based GAs, MOGA, NSGA, Niched Pareto Genetic Algorithm. ● **Practice of GA with some real-life problems and GA Programming:** Traveling Salesman Problem, Word Matching problem, Topological Planning in Wireless Network, Placement and Routing problem in VLSI Design, Image Processing and Pattern Recognition.
Suggested Books	Textbooks: 1. D. E. Goldberg, Genetic Algorithms in Search , ***Optimization and Machine Learning***, Pearson Education, 2000. ISBN: 978-0201157673 2. K. Deb, ***Multi-Objective Optimization using Evolutionary Algorithms***, John-Wiley and Sons, Ltd. Chichester, 2010. ISBN: 978-8126528042 Reference books: 3. T. Back, David B. Fogel, Z. Michalewicz, ***Handbook of Evolutionary Computation***, Oxford University Press, 1999. ISBN: 978-0750308953 4. M. Mitchell, ***An Introduction to Genetic Algorithms*** (3rd Ed) Bradford Book, 1998. ISBN: 978-0262631853

Course code	CS 411 / CS 611
Title of the course	**Advanced Algorithms**
Course Category	Institute Elective
Credit Structure	2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Data Structures and Algorithms and Design and Analysis of Algorithms and TOC
Objective(s)	This course will introduce the advanced concepts of data structures and algorithm design
Course Outcomes	Students will advanced concepts of data structures and algorithm design
Course Syllabus	• **Advanced data Structures:** Binomial heaps and Fibonacci heaps, Red-Black tree, Splay tree, van Emde Boas Priority Queues. • **String Algorithms:** Rabin-Karp Fingerprinting Algorithm, KMP algorithm, Suffix Tries. • **Computational Geometry:** Convex Hull. Line-segment Intersection. Sweep Lines. Voronoi Diagrams • **Flow Algorithms:** Augmenting Paths and Push-Relabel Methods, Max-flow Min-cut Theorem, Minimum Cost Flows, Bipartite Matching. • **Linear Programming:** Linear Programming Duality, Interior Point method • **Complexity Theory and Approximation Algorithms**: Counting number of spanning trees vs. perfect matching, NPC, Approximation Algorithms
Suggested Books	Textbooks: 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms***, (3rd Edition), Prentice Hall, 2009. ISBN: 978-81-203-4007-7 Reference books: 1. Ravindra Ahuja, Thomas Magnanti, and James Orlin, ***Network Flows: Theory, Algorithms, and Applications***, (Pearson), 1993, ISBN: 978-0136175490 2. Jon Kleinberg and Eva Tardos, ***Algorithm Design***, Pearson, 2005, ISBN 0-321-29535-8

Course Code	**CS 412/ CS 612**
Title of the Course	**Pattern Recognition**
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-Requisite, if any	Basics of probability theory, Programming
Objective(s)	This course aim to cover the basic concepts for analyzing patterns and their preprocessing techniques. It also aims to give exposure to various learning algorithms and their applications to various real life applications.
Course outcome	The students will learn basic concepts for analyzing patterns and their preprocessing techniques
Course Syllabus	• **Basics of pattern recognition:** Definitions, data sets for pattern recognition, representations of patterns and classes, metric and non-metric proximity measures, feature extraction, statistical and syntactic pattern recognition • **Bayesian decision theory:** Classifiers, discriminant functions, decision surfaces, normal density and discriminant functions, discrete features • **Parameter estimation methods:** Maximum-likelihood estimation, expectation-maximization method, Bayesian estimation, Gaussian mixture models • **Non-parametric techniques:** Density estimation using Parzen-window method, K-nearest neighbor method, nearest neighbor classifier • **Dimension reduction methods:** Lineardiscriminant analysis (LDA), principal component analysis (PCA) • **Linear discriminant function based classifiers:** Perceptron, support vector machines (SVM) • **Non-metric methods for pattern classification:** Non-numeric data or nominal data decision trees • **Unsupervised learning and clustering:** Criterion functions for clustering, algorithms for clustering: K-means, Hierarchical and other methods, Cluster validation • **Applications:** Biometrics recognition, handwriting recognition, document recognition, multimedia data retrieval, speech recognition, data mining, web searching, network traffic analysis etc.
Suggested Books	Textbooks: 1. R. O. Duda, P. E. Hart and D. G. Stork, ***Pattern Classification***, John Wiley, 2007. ISBN: 978-8126511167 2. S. Theodoridis and K. Koutroumbas, ***Pattern Recognition***, 4th Ed., Academic Press, 2009. ISBN: 978-1597492720 Reference books: 3. C. M. Bishop, ***Pattern Recognition and Machine Learning***, Springer, 2016. ISBN: 978-1-4939-3843-8

Course Code	**CS 414/ CS 614**
Title of the Course	**Cloud Computing and Applications**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-Requisite, if any	UG level courses on Operating Systems, Computer Architecture and Computer Networks
Scope of the Course	● To study the technology behind the cloud computing methodology. ● Further, with the exponential growth in Cloud computing services, there is a need to understand the various issues that affect the different stakeholders of Cloud computing.
Course outcome	The students will learn basic concepts cloud computing, cloud-based services, and SLA.
Course Syllabus	● **History of Cloud Computing:** Paradigms in Computing, Parallel Computing, Distributed Computing, Grid Computing, Service Computing; Service Oriented Architecture (SOA), Web Services ● **Cloud Computing:** Definition, Characteristics, Architecture, Components, Service Models, Deployment Models, ● **Virtualization:** Server, Storage, Network, Desktop; Hypervisor, Virtual Machine, Multi- tenancy, Opportunities and Risks ● **Service Level Agreement (SLA):** Definition, Types of SLA, SLA Life Cycle, Issues Related to Cloud SLA, SLA Frameworks: WS-Agreement, WSLA, WSOL, Slang, Bilateral Protocol; Translation of SLAs into Monitoring Specifications, Dynamic Creation of Monitoring Infrastructures, Penalty Management, Runtime Prediction ● **Cloud Security:** Cloud Security Fundamentals, Vulnerability Assessment, Security and Privacy in Cloud, Cloud Computing Security Architecture: Identity Management and Access Control, Autonomic Security; VM Specific Security Techniques ● **Cloud Application Programming Models:** Cloud File Systems: GFS and HDFS, BigTable, HBase and Dynamo; Map Reduce Programming Model, Hadoop: Hadoop Fundamentals, Hama and other Hadoop Related Services ● **Cloud Application Development Platforms:** Xen Hypervisor, Amazon Web Service, Windows Azure, Google App Engine, Eucalyptus, Open Stack, Open Nebula
Suggested Books	Textbooks: 1. A. T. Velte, ***Cloud Computing - A Practical Approach***, McGraw Hills, 2017. ISBN: 978-0070683518 2. P. Wieder and J.M. Butler, ***Service Level Agreements for Cloud Computing***, Springer, 2011. ISBN: 978-1461416135 Reference books: 3. C. Buan, ***Cloud Computing - Web Based Dynamic IT Services***,

	Springer, 2011. ISBN: 978-3642209161 4. Tanenbaum and V. Steen, ***Distributed Systems: Principles and Paradigms***, Pearson, 2016. ISBN: 978-1530281756 5. David E.Y. Sarna, ***Implementing and Developing Cloud Computing Applications***, CRC Press, 2010. ISBN: 978-1439830826 6. R. Krutz and R. D. Vines, ***Cloud Security***, Wiley, 2010. ISBN: 978-0470589878 7. T. White, ***Hadoop: The Definitive Guide***, O'Reilly Media, 2009. ISBN: 9780596521974

Course Code	**CS 416/ CS 616**
Title of the Course	**Service Oriented Systems**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department –	Computer Science and Engineering
Pre requisite, if any	UG Level course on Software Engineering and Computer Networks
Objective(s)	● To understand the technical as well as management aspects of service-oriented systems. ● Emphasis would be on the most common realization of service-oriented systems i.e. web-services
Course outcome	The students will learn the basic functionalities of service oriented systems.
Course Syllabus	● **Introduction:** service explosion in the world, independent services, 'servitization' of products ● **Service-oriented systems:** understanding the 'register, find, bind' triangle, loose coupling, Software-as-a-Service, Governance issues Practical realization of service-oriented systems via web services, basics of xml and its use in web-service implementation, http protocol, utility of web-services ● **Basic web services stack:** understanding the SOAP protocol, WSDL, UDDI registry. Implementation of web services using the basic web services stack ● **Representational State Transfer (REST) web services:** implementation of RESTful web services, REST constraints, comparison of this approach of web-service implementation with that of the basic web-service stack, advantages and limitation of RESTful web services ● **Service composition:** understanding of the concepts of service orchestration and service choreography, static versus dynamic service composition, assessment of quality in service compositions, appropriate service selection for compositions, role of the customer in service composition
Suggested Books	Textbooks: 1. J. Snell, D. Tidwell, P. Kulchenko. ***Programming Web Services with SOAP***, O'Reilly, 2001. ISBN: 9780596000950 2. L. Richardson, S. Ruby, D. H. Hansson. ***RESTful Web Services***, O'Reilly, 2007. ISBN: 9780596529260 Reference books: 3. B. A. Christudas, M. Barai,V. Cacello, ***Service-Oriented Architecture with Java***, Packt Publishing, 2008. ISBN: 978-1847193216

Course Code	**CS 418/ CS 618**
Title of the Course	**Systems and Usable Security**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre requisite, if any	UG Level Courses on Operating Systems and Computer Networks
Objective(s)	● To understand the principles of systems security from an applied viewpoint and obtain hands-on experience on security threats and counter-measures. ● To study operating systems security, advanced topics on network security, access control and digital rights management, web security and usable security.
Course outcome	The student will have sound understanding of practical aspects of security and will be able to analyze and design the secure systems.
Course Syllabus	● **Introduction:** Computer Security Concepts, threats, Attacks, and Assets ● **Malicious Software:** Types of Malicious Software (Malware), Infected Content Viruses, Vulnerability Exploit Worms, Social Engineering SPAM E-mail, Trojans, System Corruption, Zombie, Bots, Information Theft Keyloggers, Phishing, Spyware, Stealthing Backdoors, Rootkits. ● **Operating System Security:** System Security Planning, Application Security, Linux/Unix Security, Windows Security, Virtualization Security ● **Access Control:** Access Control Principles, Subjects, Objects, and Access Rights, UNIX File Access Control, Role-Based Access Control, Attribute based Access Control. ● **Database Security:** The Need for Database Security, Database Management Systems, Database Access Control, Statistical Databases, Private Information Retrieval, Cloud Security. ● **Digital Rights Management:** Multicast security, copyright protection, Digital Fingerprinting. ● **Web Security:** Secure E-mail and S/MIME, Domain Keys Identified Mail, Secure Sockets Layer (SSL) and Transport Layer Security (TLS), HTTPS, IPv4 and IPv6 Security, Internet Authentication Applications, Kerberos, X.509, Public-Key Infrastructure, Federated Identity Management. ● **Wireless Security:** Wireless Security Overview, IEEE 802.11 Wireless LAN Overview, IEEE 802.11i Wireless LAN Security. ● **Usable Security:** Introduction to privacy, trust and semantic security, Visualizing privacy, Web browser security and privacy, Authentication and text passwords, biometrics and graphical passwords.

Suggested Books	Textbooks: 1. W. Stallings and L. Brown, ***Computer Security: Principles and Practice*** (2nd Edition), Prentice Hall, 2011. ISBN: 978-0132775069 2. A. Menezes, P. Oorschot, S. Vanstone, ***Handbook of Applied Cryptography***, Jaypee medical, 1996. ISBN: 978-0849385230 Reference books: 3. Goodrich and Tamassia, ***Introduction to Computer Security***, Addison-Wesley, 2011. ISBN: 978-0321512949. 4. Kaufman, Perlman, and Speciner, ***Network Security: Private Communication in a Public World***, (2nd edition), Prentice Hall, 2003. ISBN: 978-0130460196

Course Code	**CS 420/ CS 620**
Title of the Course	**Embedded Systems**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre requisite, if any	Programming knowledge, Computer Architecture, Operating Systems.
Objective(s)	● The course will focus on software issues in embedded systems. ● It will include demonstrations and getting acquainted with 8/16/32-bit micro-controller and its development environment, interrupt programming, resource management, and peripheral interfacing and drivers. ● The practical part will involve demos and getting started kind of exercises to show the tangible side of taught concepts.
Course oucome	The students will learn the basics of embedded systems and its implementation.
Course Syllabus	● Introduction to embedded systems: Embedded vs. General purpose computer Systems; Abstract Model; computer-plant interaction and real-time reactive behaviour of embedded control systems. ● Sequential and continuous control systems; ● Basic modeling and implementation techniques for sequential and continuous control systems - state machines, function blocks and function block diagrams, which is followed by advanced modelling techniques for complex systems, such as hierarchical and concurrent state machines and hybrid models; ● Real-time operating systems (RTOS), Real-time kernels, Deploying applications on RTOS/Kernels.
Suggested Books	Textbooks: 1. David E. Simon, ***Embedded Systems Primer***, Addison-Wesley, 1999, ISBN: 9780201615692. Reference books: 2. T. Noergaard, ***Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers***, Newnes, 2005. ISBN: 978-0750677929

Course Code	**CS 422/ CS 622**
Title of the Course	**Numerical Simulation**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre requisite, if any	Calculus, Linear Algebra and Ordinary Differential Equations, Complex Analysis and Differential Equations, Numerical Methods
Objective(s)	• Simulation is a useful tool in almost all areas of engineering and science. • This course will introduce computational techniques for simulating applications from Electrical Engineering, Mechanical Engineering, Material Science, Physics, and Operations Research.
Course Syllabus	• **Problem Types:** Circuit analysis, structural analysis of automobiles, • analyzing drag force in aircrafts, engine thermal analysis, virtual environments for computer games, stock option pricing, electrostatic optimization for biomolecules etc. • **Equation Formulation Methods:** Stamping, node-branch, and nodal. • **Direct and Iterative Matrix Solution:** Error analysis, dense and sparse matrix factorizations, and Krylov methods. • **Nonlinear Systems Solution:** Multi-dimension Newton, fixed-point and functional iterations, and continuation schemes. • **Numerical Integration and Monte Carlo Methods:** Newton-Cotes, composite quadrature, Gauss quadrature, multiple integrals, generating samples, random tours, designing and analyzing random paths. • **Discretization Methods for Partial Differential Equations**: Finite difference, finite element, multi-grid, and spectral methods.
Suggested books	Textbooks: 1. G. Strang, ***Computational Science and Engineering***, Wellesley-Cambridge Press, 2007. ISBN: 978-0961408817 2. D. Kincaid and W. Cheney, ***Numerical Methods: Mathematics of Scientific Computing***, Brooks / Cole, 2007. ISBN: 978-0495114758 3. Y. Saad, ***Iterative Methods for Sparse Linear Systems***, SIAM, 2003. ISBN: 978-0898715347 4. C. T. Kelley, ***Solving Nonlinear Equations with Newton's Method***, SIAM, 2003. ISBN: 978-0898715460 Reference books: 5. E. L. Allgower and K. Georg, ***Introduction to Numerical Continuation Methods***, SIAM, 2003. ISBN: 978-0-89871-544-6 6. G. S. Fishman, ***Monte Carlo Concepts, Algorithms, and Applications***, Springer, 1996. ISBN: 978-0387945279 7. W. L. Briggs, V. E. Henson, and S. F. McCormick, ***A Multigrid Tutorial***, SIAM, 2000. ISBN: 978-0-89871-950-5

Course Code	**CS 424**
Title of the Course	**Functional and Logic Programming**
Credit Structure	L-T- P-Credits 2-0-2-3
Name of the concerned Department	Computer Science and Engineering
Prerequisite, if any	Computer Programming
Objective(s)	● Functional-logic programming integrates most of the features of the classical declarative paradigms, namely of functional programming and of logic programming. ● From the functional paradigm it inherits named or anonymous functions, nested expressions, efficient reduction strategies, higher-order functions, and types. ● From the logic paradigm it inherits named relations, logical variables, partial data structures, unification, and built-in search.
Course Syllabus	● **Introduction to Functional and Logic Programming:** Overview of Declarative Programming, Basic Notions of Functional Programming, Basic Notions of Logic Programming, Basic Notions of Functional-Logic Programming. ● **Terms in Functional and Logic Programming:** Taxonomy of Terms, Simple Terms, Complex Terms, Term Unification. ● **Functional and Logic Definition Clauses:** Taxonomy and Syntax of Clauses, Logic Clauses, Functional Clauses, Functional-Logic Clauses. ● **Higher Order Operations:** Function Composition, Compose as a higher order function, Relational Product as a higher order function. ● **Case Study:** Study of a Functional-Logic Programming Language (e.g. Relational Functional Markup Language (RFML))
Suggested books	Textbooks: 1. J. Kelly, ***The Essence of Logic***, Prentice-Hall of India, 1997. ISBN: 978-0133963755 2. H.B. Enderton, ***Mathematical Introduction to Logic***, Academic Press, Elsevier, 2001. ISBN: 9780122384523 Reference books: 3. R. Wilensky, ***Common LISPcraft***, W. W. Norton and Co., 1986. ISBN: 978-0393955446 4. W. F. Clocksin and C.S. Melish, ***Programming in Prolo***g, Springer- Verlag, 2012. ISBN: 978-3540006787 5. G. Cousineau and M. Mauny, ***The Functional Approach to Programming***, Cambridge University Press, 1998. ISBN: 978-0521571838

Course code	**CS 425 / CS 625**
Title of the course	**Natural Language Processing**
Course Category	Departmental Elective / Institute Elective
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Familiarity with basic data structures and algorithms, ML concepts will help, though not necessary.
Objective(s)	The course is an introductory course in the natural language processing field. This is meant to get students familiar with the text processing techniques as well as more advanced techniques for text processing such as question answering, text summarization, parsing, semantic role labelling, etc.
Course Outcome	The students will learn: ● Basics of text processing and NLP ● Tokenization, lemmatization, word-embedding ● Applications of NLP to solve real-world problems.
Course Syllabus	● Introduction NLP tasks in syntax, semantics, and pragmatics. Applications such as information extraction, question answering, and machine translation. The problem of ambiguity. The role of machine learning. A brief history of the field. ● N-gram Language Models The role of language models. Simple N-gram models. Estimating parameters and smoothing. Evaluating language models. Part Of Speech Tagging and Sequence Labeling. Hidden Markov Models (Forward and Viterbi algorithms and EM training). ● Syntactic parsing Grammar formalisms and treebanks. Efficient parsing for context-free grammars (CFGs). Statistical parsing and probabilistic CFGs (PCFGs). Lexicalized PCFGs. ● Information Extraction (IE) Named entity recognition and relation extraction. IE using sequence labeling. word-sense disambiguation. Semantic Role Labeling. ● Machine Translation (MT) Basic issues in MT. Statistical translation, word alignment, phrase-based translation, and synchronous grammar. Advanced Concepts: Conversational Systems, chatbots.
Suggested Books	Textbooks: 1. D. Jurafsky and J. H. Martin, ***Speech and Language Processing***, Pearson Education, 2014. ISBN 9780133252934. 2. Manning and Schutze, ***Statistical Natural Language Processing***, MIT Press, 1999, ISBN 0262133601 Reference books: 3. J. Allen, ***Natural Language Understanding***, Pearson, 1994, ISBN: 978-0805303346 4. Y. Goldberg and G. Hirst, ***Neural Network Methods in Natural Language Processing***, Morgan and Claypool Publishers, 2017. ISBN: 978-1627052986

Course code	**CS 426 / CS 626**
Title of the course	**Foundations of Cyber-Physical Systems**
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Discrete Mathematics, Automata Theory, Programming, Operating Systems
Objective(s)	● This course aims to introduce the basics of Cyber Physical Systems, distinguishing characteristics that sets them apart from their other embedded system incarnations. ● The emphasis would be from systems specification, design and formal analysis perspectives.
Course outcome	The students will learn the basics of cyber-physical systems
Course Syllabus	● **Dynamical systems:** Continuous Vs Discrete behaviour, Hybrid behaviour, Reactive Systems, CPS key features, Synchronous Vs. Asynchronous paradigms. ● **Control routine patterns:** Different control cycle actuations, Event/ Time -triggered, Static cyclic scheduling. ● **Scheduling:** Realtime Scheduling policies, Rate-monotonic, Deadline- monotonic, Utilisation-based Schedulability. ● **Kernels:** Real-time kernels and Kernel-based system development. ● **Specification languages:** State machines (deterministic, nondeterministic), structural vs behavioural specification ● **Correctness Analysis:** Requirements specification via Live, Safe and Precedence properties, Timed Processes and Protocols, Timed Automata, Hybrid Automata (Linear vs Non-linear), Mechanised Proof techniques, Deductive verification, 7. CPS Designs: From various application domains and CPS Case Studies.
Suggested Books	Textbooks: 1. A. Platzer, ***Logical Foundations of Cyber-Physical Systems***, Springer, Switzerland, 2017. ISBN 978-1-4419-8236-0 2. E. A. Lee and S. A. Seshia, ***Introduction to Embedded Systems: A Cyber-Physical Systems Approach***, Second Edition, MIT Press, Cambridge, 2017. ISBN 978- 0-262-53381-2 Reference books: 3. C. Baier and J. P. Katoen, ***Principles of Model Checking***, MIT Press, London, 2008. ISBN: 9780262026499

Course code	**CS 427/ CS 627**
Title of the course	**Advanced Computer Networks**
Credit Structure	L-T-P Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite if any	Computer Networks and Operating Systems
Scope of the Course	• This course will give a background on design principles of highperformance networking devices like switches and routers. • It will introduce advanced topics and recent trends in Computer Networks like Software Defined Networking, Data Center Networks, Information Centric Networking and Future Internet.
Course outcome	• Introduce PG/UG students to the recent advances and state-of-the art Computer Networking topics and develop understandings on the future research aspects in networking to help guide the students towards potential MTech/MS/PhD work. • Provide insights on the principles and design decisions behind networking aspects, Internet technologies and future research. • Expose students to hands-on exercises, work on network simulators and help them design and implement the networking protocols and applications.
Course Syllabus	• **High Performance Switching and Routing:** IP Address Lookup- Trie-based Algorithms, Hardware Lookup. Quality of Service – Need for Packet Classification, Different Classification Methods, TCAM based Classification, Differentiated Service, Traffic Polishing, Traffic Shaping, Packet Scheduling, Queue Management Techniques.Packet Switching: Switching Overview, Switching Fabric, Buffering in Switch Fabric, Multiplane and Multistage Switching Network • **Softwarization:** Software Defined Networking (SDN): Control and Data Plane Separation. Network Operating System (SDN Controllers), Intent based Networking (IBN), Southbound Interface (OpenFlow) and OpenVSwitch. Programmable Networking Devices, Network Virtualization: VirtIO, SR-IOV, and Network Function Virtualization (NFV). • **Data Centre Networking:** Networking Topologies: Fat-Tree, Clos, Leaf-Spine, Docker and Container Networking Interface (CNIs), Kubernetes. Switching in Data Centre Networking, Virtual Switches. High-Performance Computing Networks: HPC System Architectures, HPC Networking Standards, HPC Networking Software, Low Latency Ethernet (10 GbE, 40 GbE, 100 GbE, InfiniBand FDR). • **Named Data Networking:** Content Distribution on the Internet, Architectures for Information Centric Networking, Content Naming, Routing and Caching, Security in Named Data Networking.
Suggested Books	Textbooks: 1. H. J. Chao, B. Liu, ***High Performance Switches and Routers***, John

	Wiley and Sons, Inc, 2007. ISBN-10: 0-470-05367-4 2. G. M. de Brito, P. B. Velloso, and I. M. Moraes, ***Information-Centric Networks: A New Paradigm for the Internet***, Wiley-ISTE, 2013, ISBN: 9781848214491 Reference books: 3. Gary Lee, ***Cloud Networking: Understanding Cloud-based Data Centre Networks***, Morgan Kaufmann, 2014. ISBN: 139780128007280

Course code	**CS 428/ CS 628**
Title of the course	**Algorithmic Graph Theory**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Discrete Mathematical Structures, Data Structures and Algorithms.
Objective(s)	● This course shall impart basic background on the theoretical concepts of graph theory. ● The topics covered shall cover basic concepts and algorithmic aspects, such as graph representations, terminologies, and properties of different types of graphs, connectivity properties and algorithms, as well as some advanced topics, such as graph coloring, matching, planarity, and spectral graph theory.
Course outcome	The students will get firm foundations in solving real-world problems such as path optimization problems, and other graph- theoretical problems that are relevant to theoretical computer science and operations research.
Course Syllabus	● **Introduction to graphs, trees, and their properties:** Graphs, Representation of Graphs, Various Special Graphs, Walks, Graph Isomorphism, Spanning Trees, Counting Spanning trees in polynomial time, Algorithms for minimum weighted spanning trees. ● **Matching Algorithms and Cycles in Graphs:** Matching, Perfect matching, Augmenting path algorithm, Bipartite matching algorithm, Hall Marriage ● The Eulerian tour and Seven Bridges problem, Hamiltonian cycles and Travelling Salesman Problem, Necessary Conditions for Hamiltonian Graphs, Sufficient Conditions for Hamiltonian Graphs. ● **Coloring and Connectivity in graphs:** Vertex Coloring, Edge Coloring, Brook's theorem, Vizing Conjecture. Vertex and Edge Connectivity, Vertex- and edge-disjoint paths, testing connectivity, Algorithm for the cut-vertices, Algorithm for decomposing connected graph into blocks, Tutte's decomposition, edgec-onnectivity, Menger's Theorem. ● **Network Flow Algorithms:** Basic concepts on flows and networks, max-flow min-cut theorem, Ford-Fulkerson algorithm. ● **Planarity in graphs:** Planar graphs, Euler's Formula, Outer Planar Graphs, Kuratowski Theorem, Four Color Theorem. ● **Spectral graph theory:** Adjacency matrix, Laplacian matrix, Random regular graphs, Expander graphs, Ramanujan graphs. ● **Applications and Case studies:** Social Network Analysis, Complex ● Network Analysis.
Suggested Books	Textbooks: 1. D. B. West, ***Introduction to Graph Theory***, Pearson Education, 2015. ISBN: 8178088304. 2. R. Diestel, ***Graph Theory***, Springer-Verlag, 2000. ISBN: 0387950141. 3. R.B. Bapat, ***Graphs and matrices***, Springer, 2010. ISBN: 9789380250694. Reference books: 4. Bondy and U. S. R. Murthy, ***Graph Theory, Graduate Texts In Mathematics***, Springer, 2008. ISBN: 978-1-84628-969-9.

	5. Alan Gibbons, ***Algorithmic Graph Theory***, Cambridge University Press, 1985. ISBN: 9780521288811. 6. T. Cormen and C.E. Leiserson and R.L. Rivest and C. Stein, ***Introduction to Algorithms***, The MIT Press, 2009. ISBN: 9780-262-03384-8 7. N. Deo, ***Graph Theory with Applications to Engineering and Computer Science***, PHI Learning, 1979. ISBN: 9788120301450

Course code	**CS 430/ CS 630**
Title of the course	**Data Center Networking**
Credit Structure	L-T-P- Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite if any	Students must have knowledge of UG-level computer network courses and have good programming skills in python and C/C++.
Scope of the Course	In this course, students are expected to learn the data center network architectures, their underlying protocols and understand the challenges faced in designing a data center.
Course outocme	The students will learn the data center network architectures, their underlying protocols.
Course Syllabus	● Introduction to network architectures Edge, Metro and Core Networks Evolution of Data Center Networks a switch-centric DCN, a modular DCN, a wireless DCN, and a hybrid DCN. ● Datacenter architectures and their building blocks Network fabric, cross connect design, Server addressing and routing protocols. Multipath routing. Overview of Software Defined Networking and Network Function Virtualization. ● State-of-the-art of data center networking architectures Fat tree, Helios, VL2, Portland, B-cube, Wavecube etc. ● Datacenter telemetry and resource management traffic engineering, congestion control, load balancing and resource allocation algorithms. Datacenter network performance enhancement strategies. ● Challenges involved in building a datacenter cross-connect and protocol scalability, fault tolerance, security, power etc. Recent advancements in data centers hybrid datacenter architectures etc..
Suggested Books	Textbooks: 1. Y. Liu, J. K. Muppala, M. Veeraraghavan, D. Lin, and M. Hamdi, ***Data Center Networks: Topologies, Architectures and FaultTolerance Characteristics***, Springer, 2013. ISBN: 9783319019482. Reference books: 2. Guo, D. ***Data center networking: Network topologies and traffic management in large-scale data centers***, Singapore, Springer, 2022. ISBN: 9789811693687. 3. M. Arregoces and M. Portolani, ***Data Center Fundamentals***, Cisco Press, 2004. ISBN: 1587050234. 4. L. Zhang and L. Chen, ***Cloud Data Center Network Architectures and Technologies***, CRC Press, 2021. ISBN: 9780367695705 5. J. Donovan and K. Prabhu, ***Building the Network of the Future: Getting Smarter, Faster, and More Flexible with a Software Centric Approach (100 Cases)***, CRC Press, 2017. ISBN: 9781138631526

Course Code	**CS 432/ CS 632**
Title of the Course	**Reinforcement Learning**
Credit Structure	L-T-P-Credit 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Linear algebra, probability and statistics, knowledge of algorithm design and analysis, and proficiency in programming.
Scope of the Course	● Learning the basic theory of reinforcement learning. ● Understanding a range of reinforcement learning algorithms with their strengths and limitations. ● Formulation of reinforcement learning problems for differen applications.
Course Syllabus	● **Introduction:** Types of machine learning approaches: supervised, unsupervised, reinforcement; Elements of reinforcement learning: agent, environment, policy, reward and value functions ● **Multi-armed bandits:** Sequential decision making: exploration and exploitation; bandit problem solution: greedy, optimistic-greedy, and epsilon-greedy algorithms; Upper confidence bound bandit algorithm. Markov Processes: Markov property, Markov chains, Markov reward process, Markov decision process (MDP), Bellman expectation equation, optimal value function, optimal policy, Bellman optimality equation. Dynamic Programming: Dynamic programming for MDP, iterative policy evaluation, policy improvement, policy and value iteration. ● **Monte Carlo Methods:** Model free reinforcement learning, Monte Carlo policy evaluation and estimation of action values, on- and off-policy ● **Temporal-Difference Learning:** Temporal-Difference (TD) prediction, TD(0), TD(1), TD(λ), TD control methods: SARSA, Q-Learning and variants. ● **Function Approximation Methods:** Risk minimization, eligibility trace for function approximation, value function approximation (VFA), Monte Carlo learning and TD learning for policy evaluation with linear VFA. ● **Policy Gradients:** Policy gradient methods, policy search methods, gradient-free methods, finite difference methods, likelihood ratio policy gradient, bias and variance in reinforcement learning, actor-critic methods.
Suggested Books:	Textbooks: 1. R. S. Sutton and A. G. Barto, ***Reinforcement Learning - An Introduction***, MIT Press, Cambridge, 1998. ISBN: 978-0262193986 Reference Books: 2. P. Winder, ***Reinforcement Learning: Industrial Applications of Intelligent Agents***, O'Reilly Media, Inc, 2020. ISBN: 978-1098114831

	3. K. P. Murphy, ***Machine Learning: A Probabilistic Perspective***, The MIT Press, 2012. ISBN: 978-0262018029 4. I. Gridin, ***Practical Deep Reinforcement Learning with Python***, BPB Publication, 2022. ISBN: 978-9355512055

Course code	**CS 435/ CS 635**
Title of the course	**Deep Learning**
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Discipline	Computer Science and Engineering
Pre-requisite, if any	Linear algebra, probability, optimization
Objective(s)	• This is an introductory course in the field of deep learning. • The course will cover latest advancement in the field of deep learning.
Course outcome	The students will learn the basics of deep learning and its applications.
Course Syllabus	• History of Deep Learning, Deep Learning Success Stories • McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm. Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks. FeedForward Neural Networks, Backpropagation. Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp. • Autoencoders and relation to PCA, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders. Regularization: Bias Variance Tradeo , L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying. • Greedy Layerwise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization. Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet. Learning Vectorial Representations of Words. Recurrent Neural Networks, Backpropagation through time. Encoder Decoder Models, Attention Mechanism.
Suggested Books	Textbooks: 1. Ian Goodfellow,Yoshua Bengio, and Aaron Courville, ***Deep Learning***, MIT Press, 2016. ISBN: 978-0262035613 2. Li Deng and Dong Yu, ***Deep Learning Methods and Applications***, NOW Publishers, 2014. ISBN : 978-1601988140 Reference books: 3. Charu C. Aggarwal, ***Neural Networks and Deep Learning: A Textbook***, Springer, 2018. ISBN: 978-3319944623 4. Eugene Charniak, ***Introduction to Deep Learning***, MIT Press, 2019. ISBN: 978-0262039512

Course Code	**CS 438/ CS 638**
Title of the Course	**Network Softwarization and Management**
Course Category	Departmental Elective
Credit Structure	L-T-P–Credits 2-0-2-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite if any	Knowledge of Computer Networks
Course Objective	This course will take a retrospective look at how network softwarization evolved in the past decade, discuss its current promises, enablers, and challenges, and finally speculate what direction it will take in the future.
Course Outcomes	Students will get an idea of how modern telecom networks are being softwarized and also understand the key design principles and obstacles in the process through hands-on experience.
Course Content	● Turmoil in the telecom industry: need for network softwarization, Service provider network design, Architecture of forwarding elements, Ethernet evolution: Carrier Ethernet, IP/MPLS networks and traffic engineering, Segment routing. ● Software-defined networking (SDN), SD-WANs, SDN architectures in optical and data-center networks, Data-plane programmability, Network Virtualization – VXLAN and NVGRE, SDN experiments. ● Network Function Virtualization (NFV): vision and obstacles, Edge/Cloud-native networking, Application of virtualization in designing next-generation cellular networks (5G and beyond) – vRANs, Network slicing. ● Modern network management paradigms, OpenConfig, AI-assisted network management, Self-driving and Zero-touch networking, Network digital twins, Measurements in softwarized networks. ● Impact of softwarization on core, edge, and access networks, Verification/debugging of softwarized networks, Availability/Reliability and security challenges, Rise of the open-source ecosystem, Softwarization status of a few service provider networks.
Suggested Books	Textbooks: 1. J. Donovan and K. Prabhu, ***Building the Network of the Future, Getting Smarter, Faster, and More Flexible with a Software Centric Approach***, Chapman and Hall/CRC, 2017, ISBN: 978-1138631526 2. W. Stallings, ***Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud***, Pearson Education, 2016, ISBN: 978-9332573864 Reference books: 3. G. Varghese and J. Xu, ***Network Algorithmics An Interdisciplinary Approach to Designing Fast Networked Devices***, Morgan Kaufmann, 2022. ISBN: 978-0128099278

Course code	**CS 440/640**
Title of the course	**Distributed Network Algorithms**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Discrete Mathematics, Data Structures and Algorithms, Design and Analysis of Algorithms
Course objective	● This course will cover the fundamentals of distributed network algorithms. ● With the rise and evolving characteristics of Internet and blockchain systems, along with paradigm shift from single processor computing to multi-processor computing, it is imperative to understand the fundamentals of distributed network algorithms. ● The students will gain knowledge of computation mechanisms of distributed systems, and how they are different from the computation theory of single processor computation.
Course outcome	● Students will be able to model a distributed computing problem and design algorithm to address the problem. They will also be able to prove the correctness of the algorithm and analyse its complexity. ● They will also be able to design and analyse distributed algorithms for real-life distributed systems.
Course Syllabus	● **Models:** Distributed network models, Performance of distributed algorithms: complexity measures: time complexity, message complexity. ● **Distributed Broadcast, Shortest Path and Tree Algorithms:** Broadcast, Lower bound for broadcast, Tree Broadcast, Convergecast on tree, Upcast, Downcast, Constructing a BFS Tree, Information spreading, A global distributed shortest path algorithm, Distributed Bellman Ford algorithm. ● **Leader Election and Distributed Consensus:** Leader election in ring network, Leader election in a complete network, Leader election in general distributed network, Consensus in synchronous and asynchronous distributed system, Consensus under fault, Byzantine generals problem, Paxos algorithm. ● **Local Symmetry Breaking:** Maximum independent set, Coloring, Deterministic symmetry breaking, ● **Minimum Spanning Tree:** Gallagar-Humblet-Spira (GHS) algorithm, Pipeline Algorithm, Garay-Kutten-Peleg (GKP) Algorithm
Suggested Books	Textbooks: 1. D. Peleg, ***Distributed Computing A Locality Sensitive Approach***, Society for Industrial and Applied Mathematics, 2000. ISBN: 978-0898714647 2. N. Lynch, ***Distributed Algorithms***, Morgan Kaufmann Publishers, 1996, ISBN: 978-1558603486 Reference books: 3. M. Singhal and N. G. Shivaratri, ***Advanced Concepts in Operating Systems***, McGraw Hill Education, 2017, ISBN: 978-0070472686

Course code	**CS 442**
Title of the course	**Generative AI**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Pre-requisite, if any	Machine Learning
Objective(s)	● This course is designed to provide an overview of Generative AI. ● Gain foundational knowledge of LLMs, practical skills, and a functional understanding of how generative AI works.
Course Outcomes	● Students will dive into the latest research on Generative AI to understand how companies are creating value with cutting-edge technology. ● They will learn the best practices of prompt engineering and fine-tuning LLMs.
Course Content	● Machine Learning Basics: Classification and regression, supervised, unsupervised, and self-supervised. ● Introduction to the large language model (LLMs), large vision models (LVM), large speech model (LSM). ● Prompt Engineering: In-context learning, types of prompting— chain of thoughts, tree-of thoughts, Retrieval-augmented generation. ● LLM Fine-Tuning—Need for fine-tuning, instruction fine-tuning and parameter efficient fine-tuning ● Building App with LLMs, Benchmarking the LLMs, Security and Legal implications.
Suggested Books	Textbooks: 1. J. Alammar and M. Grootendorst, ***Hands-On Large Language Models***, O'Reilly Media Inc., 2024. ISBN: 9781098150969 (In Print) Reference books: 2. S. Kublik, and S. Saboo, ***GPT-3: Building Innovative NLP Products Using Large Language Models***, O'Reilly Media, 2023. ISBN: 978-1098113629

Course Code	**CS 444/ CS 644**
Title of the Course	**Advanced Blockchain**
Course Category	Departmental Elective
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Computer Science and Engineering
Prerequisite if any	Discrete Mathematics, Data Structure and Algorithms
Course Objective	This course will offer in-depth understanding of theoretical underpinnings, applications, best practices and research activities in the domain of Blockchain.
Course Outcomes	Students will develop a clear understanding of state-of-the-art Blockchain Technology, open research challenges and future directions.
Course Content	• Introduction to Blockchain Stacks and its layers, synchronous model and the Dolev-Strong protocol for Byzantine broadcast, asynchronous, partially synchronous model, PBFT, Tendermint and Hotstuff protocol • Deep Dive into Bitcoin, Longest Chain consensus and Formal security guarantees of Proof-of-Work, Selfish Mining Attack and Incentive Compatibility • Longest Chain vs Byzantine Fault Tolerance, Ouroboros, Ouroboros-Praos, Algorand, Availability - Finality Dilemma & Finality Gadgets • Security and Privacy in Blockchain, Introduction to Monero and ZCash • Scalability in Blockchain: Lightning Network, Sidechains, Rollups, Sharding
Suggested Books	Textbooks: 1. R. Wattenhofer, ***Blockchain Science: Distributed Ledger Technology***. Inverted Forest Publishing, 2019, ISBN: 9781793471734 2. A. Narayanan, J. Bonneau, E. Felten, A. Miller, and S. Goldfeder. ***Bitcoin and cryptocurrency technologies: a comprehensive introduction***. Princeton University Press, 2016. ISBN: 9780691171692 3. V. Gramoili, ***Blockchain Scalability and its Foundations in Distributed Systems***, Springer, 2022. ISBN 978-3-031-12577-5 Reference books: 4. Serhack, ***Mastering Monero: The future of Private transactions***, 2018, ISBN: 978-1731079961 5. A. M. Antonopoulos, O. Osuntokun, and R. Pickhardt,

	Mastering the lightning network, O'Reilly Media, Inc., 2021, ISBN: 9781492054863

Course code	**CS 446/ CS 646**
Title of the course	**Blockchain for Responsible Computing**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Computer Science & Engineering
Pre-requisite, if any	Programming and Basic knowledge of Software Engineering
Course objective	● To understand trust and accountability stack with blockchain technology. ● To understand the ethical and societal implications of blockchain's features. ● To explore and understand the responsible computing practices with blockchain.
Course outcome	Students gain implementing skills with applied blockchain tech for the needed responsibility computing. Students will explore the blockchain fabric as distributed technology to enhance trust, transparency and accountability across domains.
Course Syllabus	● Centralized vs Decentralized Computing, Local vs Distributed systems, On premises vs cloud instances, Foundations of Blockchain, Decentralized ledger, Consensus ● Privacy and data protection Considerations in Blockchain, Challenges in Blockchain, Smart contracts, Protection against fraud and cyber-vulnerabilities ● Blockchain and Sustainable Development Goals, Blockchain in Supply Chain/I4.0/Health Applications -Trust brokerage, Traceability, transparency, and responsible sourcing_ Ethical/privacy and fairness considerations ● Blockchain development, Creating and deploying smart contracts, Debugging and security testing, Responsible coding practices in blockchain ● Regulatory and Legal Considerations with Blockchain, Compliance with legal requirements of the land, Case Studies and Industry Trends, Real projects guidelines

Suggested Books	Textbooks: 1. SK H. Islam, A. Kumar Pal, D. Samanta, S. Bhattacharyya, ***Blockchain Technology for Emerging Applications***, Elsevier, 2022. ISBN: 9780323901949 2. A. Lipton and A. Treccani, ***Blockchain And Distributed Ledgers : Mathematics, Technology, And Economics***, World Scientific Publishing Co Pte Ltd, 2021. ISBN: 978-9811221514 Reference books: 3. I. Bashir, ***Mastering Blockchain****,* Packt Publishing, 2020. ISBN: 978-1839213199

Syllabi
of
Electrical Engineering Courses

1.	Course Code	**EE 202**
2.	Title of the Course	**Signals and Systems**
3.	Credit Structure	L-T-P-Credits 3-1-0-4
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Continuous-time signals and systems:** signal characteristics; common signals; properties of continuous-time systems. **Continuous linear time-invariant systems:** impulse response; convolution; linear constant-coefficient differential equations. Fourier series, Fourier transform; Laplace transform; system analysis; frequency response; analog filters. State-space analysis for continuous-time systems Discrete-time signals and systems Discrete-time LTI systems: convolution; difference equations. Sampling
8.	Suggested Books	1. R.F. Ziemer, W.H. Tranter, and D.R. Fannin, **Signals and Systems: Continuous and Discrete** (4th Edition), Prentice Hall, 1998. 2. A.V. Oppenheim, A.S. Willsky, and I.T. Young, **Signals and Systems**, Prentice Hall, 1983. 3. B.P. Lathi, **Signal Processing and Linear Systems**, Oxford University Press, 1998.

1.	Course Code	**EE 253**
2.	Title of the Course	**Electronic Devices Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Following experiments to based on the associated theory course EE 203: Electronic Devices. 1. Simple Measurements with the Oscilloscope. 2. To measure the DC I-V Characteristics of diodes. 3. Analysis of diode circuits (Clipping Circuits, Voltage Doublers, Rectified Differentiator, Precision Rectifier). 4. To measure the reverse-bias capacitance of p-n junction capacitance 5. To measure the minority carrier lifetime in a semiconductor photodiode. 6. To obtain the I-V characteristics of bipolar transistors and computer transistor parameters. 7. To obtain some small signal parameters of Bipolar Junction Transistors (BJTs). 8. To measure and analyze bias quantities (DC currents and voltages) and small-signal gain of the given common-emitter amplifier circuit. 9. To obtain MOSFET parameters from DC current-voltage measurements.
8.	Suggested Books	Same as the associated theory course on Electronic Devices

.	Course Code	**EE 205**
2.	Title of the Course	**Introduction to Electrical Systems**
3.	Credit Structure	L-T-P-Credits 3-1-0-4
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Steady state AC circuit analysis, Phasors, 3 phase circuits, Magnetic circuits and Mutual inductance, Transformers, DC machines, Induction machines (single and three phase), Synchronous machines, Introduction to Power Engineering.
8.	Suggested Books	1. Wildi, **Electric Machines, Drives and Power Systems**, Pearson Education Singapore, 2007. 2. V. Del Toro, **Electrical Engineering Fundamentals**, Prentice Hall, 1989. 3. A. Fitzgerald, C. Kingsley, S. Umans, **Electric Machinery**, Tata McGraw Hill, 2002. 4. I.J. Nagrath, **Basic Electrical Engineering**, Tata McGraw Hill, India. 1988. 5. P.C. Sen, **Principles of Electrical Machines and Power Electronics**, John Wiley and Sons 1989.

1.	Course Code	**EE 206**
2.	Title of the Course	**Electrical Machines and Power Electronics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Operating characteristics of power semi-conductor devices, principle of operation of single and three phase AC-DC line commutated converters. Principle of operation DC-DC (buck, boost, buck-boost, cuk, fly-back and forward) converters, Introduction to unity power factor converters. Principle of operation single phase and 3-phase DC-AC converters, PWM techniques. Review of principles of operation of DC, induction and synchronous machines. Operating Characteristics of DC and AC machines, Speed control of DC and induction motors.
8.	Suggested Books	1. L. Umanand, **Power Electronics: Essentials and Applications**, Wiley India, 2009. 2. P.C. Sen, **Principles of Electric Machines and Power Electronics** (2nd Edition), John Wiley & Sons-1996. 3. M.H. Rashid, **Power Electronics Circuits, Devices and Applications**, Third Edition, Prentice-Hall of India Private Limited, New Delhi-2004. 4. G.K. Dubey, **Fundamentals of Electric Drives** (2nd Edition), Narosa Publishing House, 2007.

1.	Course Code	**EE 256**
2.	Title of the Course	**Electrical Machines Lab**
3.	Credit Structure	L-T-P-Credits 0- 0-4-2
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**1. Parallel Operation of Two Single Phase Transformers** Objectives: 1) To determine and verify the polarity of the individual single-phase transformers. 2) To find the impedance of the single phase transformers by short circuit test. 3) To study parallel operation of (the above) two single phase transformers and observe the load sharing between them **2. Determination of the characteristic of a DC Shunt Generator** Objectives: 1) To plot the open circuit characteristics (O.C.C) of a DC shunt generator and to determine its critical resistance. 2) To find the residual magnetism in field. 3) To plot the external characteristics of a DC shunt generator by loading the generator. **3. “V” and “inverse V” curves of synchronous motor at no load and constant load.** Objectives: 1) To plot the characteristics of a synchronous machine in terms of variation of armature current with field current when the load and input voltage to the machine is constant. **4. Synchronization of alternators: Using synchroscope.** Objectives: 1) To Study synchronization method of alternator with grid **<u>Power Electronics Experiments</u>** **1. Study of 1-phase AC to DC controlled converter (both fully controlled and half controlled).**

		Objectives: 1) To study voltage and current waveforms for different firing angles and loads for half controlled and fully controlled rectifier for R and R-L Loads. **2. Study of 3- PHASE Fully Controlled Rectifier.** Objectives: 1) To observe various waveforms with R and R-L loads for fully controlled converters. 2) To plot graphs of mean load voltage against firing delay angles for R and R-L loads. 3) To study variation of power factor against delay angle. **3. To study the switching characteristics of MOSFET and IGBT.** Objectives: 1) Observe the ON and OFF transition waveforms for MOSFET and IGBT. 2) Estimate ON and OFF switching time components for MOSFET and IGBT. **4. Study of various PWM Techniques for Single and Three Phase Inverter with R-L Load.** Objectives: 1) Study of output voltage and current waveforms for different PWM techniques for single phase inverter for R-L load 2) Study of output voltage and current waveforms for different PWM techniques for three phase inverter for R-L load. 3) Extracting harmonic spectrum information 4) for various PWM Techniques. **5. Mini Project** Objectives: In mini project, the emphasis will be on to design and develop a power electronic circuit for given specifications. In this way, student will be familiar with various aspects of power electronic circuit design like PCB design, magnetics design, component selection etc.
8.	Suggested Books	Same as the associated theory course EE 206

1.	Course Code	**EE 208**
2.	Title of the Course	**Digital Systems**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Review of basic combinational and sequential logic, Review of digital electronics, Digital Logic Families: TTL, CMOS etc., Number systems and basic digital arithmetic, Finite State Machine Design, Analysis and Synthesis, Introduction to Hardware Description Language, Array based logic elements (Memory, PLA, FPGA), Special Topics (such as processor design, testing and verification, special digital systems, asynchronous state machines etc.)
8.	Suggested Books	1. J.F. Wakerly, **Digital Design, Principles and Practices** (4th Edition), Pearson Education, 2005. 2. Charles H Roth, **Digital Systems Design using VHDL**, Thomson Learning, 1998. 3. H. Taub and D. Schilling**, Digital Integrated Electronics**, McGraw Hill, 1977. 4. D.A. Hodges and H.G. Jackson**, Analysis and Design of Digital Integrated Circuits** (International Student Edition), McGraw Hill, 1983. 5. F.J. Hill and G.L. Peterson, **Switching Theory and Logic Design**, John Wiley, 1981. 6. Z. Kohavi, **Switching and Finite Automata Theory**, McGraw Hill, 1970.

1.	Course Code	**EE 258**
2.	Title of the Course	**Digital Systems Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Following experiments based on the associated theory course EE 208: Digital Systems 1. Introduction to Logic Circuits: To gain familiarity with digital integrated circuits by setting up simple logic circuits. 2. Combinational Logic Circuits: Use of TTL adder, multiplexer and decoder. 3. Sequential Circuits: To try out some elementary sequential circuits. 4. Counters and Shift Registers: To use the 7490 decade counter and 7495 shift register. 5. Timer Circuits and DAC: To learn about (a) open-collector TTL, (b) 555 timer circuits, (C) Digital to Analog Converter. 6. CMOS Logic Gates: (i) Observe and plot transfer characteristic of a CMOS inverter, (ii) Measure noise margin and propagation delay of a CMOS inverter. (iii) Test simple CMOS logic gate circuits.
8.	Suggested Books	Same as the associated theory course EE 208: Digital Systems

1.	Course Code	**EE 301**
2.	Title of the Course	**Microprocessors**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	Digital Systems Course
6.	Scope of the course	
7.	Course Syllabus	A block diagram view of a general purpose processor; elements of hardware and software architectures; introductory data and control paths concepts, registers and memory organization. Instruction set basics and assembly language programming: Instruction structure and addressing modes, instruction encoding, detailed study of 8085A instruction set and interfacing basics: memory interfacing, principles of I/O interfacing, polled and interrupt I/O handshaking principles. Examples of I/O devices: parallel port, serial port, keypad, display, etc. Introductory microcontrollers.
8.	Suggested Books	1. R.S. Gaonkar, **Microprocessor Architecture: Programming and Applications with the 8085/8080A**, Penram International Publishing, 1996. 2. D.A. Patterson, and J.H. Hennessy, **Computer Organization and Design The hardware and software interface**, Morgan Kaufman Publishers. 3. D. Hall, **Microprocessors Interfacing**, Tata McGraw Hill, New Delhi, 1991. 4. K.J. Ayala, **The 8051 Microcontroller**, Penram International Publishing, 1996.

1.	Course Code	**EE 351**
2.	Title of the Course	**Microprocessors Lab**
3.	Credit Structure	L-T-P-Credits 0- 0-3-1.5
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	Following are the objective of this lab course are to familiarize the students with (i) 8085-microprocessor kit based experiments. (ii) Software experiment to demonstrate the use of the instruction set and assembly language programming. (iii) Hardware experiments for memory interfacing, parallel port, serial ports, interrupt driven I/O. (iv) Simple microcontrollers based experiments.
7.	Course Syllabus	Following experiments based on the associated theory course EE 301: Microprocessor 1. Familiarization with the 8085 kit 2. (SW1) Software - 1 3. (SW2) Software - 2 4. (SW3) Software - 3 5.(HW1) Interfacing of 8255 in Mode 0 6. (HW2) Interfacing of 8255 in Mode 1 7.(HW3) Interfacing of ADC and DAC with 8085 8 . (HW4) Study of Interrupts and interfacing of 8253 Time 9. (HW5) Interfacing of USART 8251 10. (HW6) Introduction to Microcontroller
7.	Suggested Books	Same as the associated theory course EE 301: Microprocessors

1.	Course Code	**EE 352**
2.	Title of the Course	**Control Systems Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	
6.	Scope of the course	
7.	Course Syllabus	**1. Control System Design for Speed control application using Root Locus Method** Objectives: 1) Develop a physics-based model for a DC motor 2) For the DC motor, develop a model based on system identification using open-loop step response. 3) Design a speed controller for the physics-based model using Root locus method. 4) Simulate this controller 5) Re-design the controller for the identified model, simulate this controller and implement it practically. **2. Control System Design for Speed control application using Bode Plot** Objectives: 1) Develop a physics-based model for a DC motor 2) For the DC motor, develop a model based on system identification using open-loop step response. 3) Design a speed controller for the physics-based model using Bode plot method. 4) Simulate this controller 5) Re-design the controller for the identified model, simulate this controller and implement it practically. **3. Control of speed using armature current** Objectives: 1) To control the speed of the pmdc motor using feedback of current 2) Back emf speed control 3) Speed control using armature current

		4. Mini-project involving temperature sensor Objectives: This would be a good team project involving projects like temperature control. The physical model would be developed and a suitable controller would be designed in theory and then experimented practically. All the principles learnt in the course would be used to implement this project
8.	Suggested Books	Same as the associated theory course EE 302 Control Systems

1.	Course Code	**EE 303**
2.	Title of the Course	**Probability and Random Processes**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Sets and set operations; Probability space; Conditional probability and Bayes theorem; Combinatorial probability and sampling models; Discrete random variables, probability mass function, probability distribution function, example random variables and distributions; Continuous random variables, probability density function, probability distribution function, example distributions; Joint distributions, functions of one and two random variables, moments of random variables; Conditional distribution, densities and moments; Characteristic functions of a random variable; Markov, Chebyshev and Chernoff bounds; Random sequences and modes of convergence (everywhere, almost everywhere, probability, distribution and mean square); Limit theorems; Strong and weak laws of large numbers, central limit theorem. Random process, Stationary processes, Mean and covariance functions. Ergodicity. Transmission of random process through LTI. Power spectral density.
8.	Suggested Books	1. H. Stark and J. Woods, **Probability and Random Processes with Applications to Signal Processing**, Third Edition, Pearson Education. (Indian Edition is available). 2. A. Papoulis and S.U. Pillai, **Probability, Random Variables and Stochastic Processes**, Fourth Edition, McGraw Hill. (Indian Edition is available). 3. K.L. Chung, **Introduction to Probability Theory with Stochastic Processes**, Springer International Student Edition. 4. P.G. Hoel, S.C. Port and C.J. Stone, **Introduction to Probability**, UBS Publishers, 5. S. Ross, **Introduction to Stochastic Models**, Harcourt Asia, Academic Press.

1.	Course Code	**EE 304/CS 404**
2.	Title of the Course	**Digital Signal Processing**
3.	Credit Structure	L-T-P-Credits 3-1-0-4
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	Signals and Systems Course
6.	Scope of the course	
7.	Course Syllabus	Discrete time signals: Sequences; representation of signals on orthogonal basis; Sampling and reconstruction of signals; Discrete systems: attributes, Z-Transform, Analysis of LSI systems, Frequency analysis, Inverse Systems, Discrete Fourier Transform (DFT), Fast Fourier Transform algorithm, Implementation of Discrete Time Systems Design of FIR Digital filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Lowpass, Bandpass, Bandstop and High pass filters. Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation. Introduction to multirate signal processing. Application of DSP to Speech and Radar signal processing.
8.	Suggested Books	1. A.V. Oppenheim and Schafer, **Discrete Time Signal Processing**, Prentice Hall, 1989. 2. J.G. Proakis and D.G. Manolakis, **Digital Signal Processing: Principles, Algorithms And Applications**, Prentice Hall, 1997. 3. L.R. Rabiner and B. Gold, **Theory and Application of Digital Signal Processing**, Prentice Hall, 1992. 4. J.R. Johnson, **Introduction to Digital Signal Processing**, Prentice Hall, 1992. 5. D.J. DeFatta, J.G. Lucas, and W.S. Hodgkiss, **Digital Signal Processing**, John Wiley & Sons, Singapore, 1988.

1.	Course Code	**EE 356**
2.	Title of the Course	**Communications Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Communication Lab I (Analog Communication Lab)** **EXPERIMENT NO: 1** **NAME** Amplitude Modulation (AM) Transmitter **AIM** To study AM modulator and its variants. **DESCRIPTION** A. To study the operation of a DSB AM modulator B. To calculate the modulation index of an AM modulated wave C. To study the operation of a DSB-suppressed carrier AM modulator D. To study the operation of an SSB-suppressed carrier AM modulator *Generate the above waveforms using SDR.* **EXPERIMENT NO: 2** **NAME** Amplitude Demodulation Receiver **AIM** To study of double sideband (DSB) AM reception. **DESCRIPTION** A. To study DSB AM reception using envelope detector via cable B. To study DSB AM reception using envelope detector via antenna C. To study SSB AM reception using product detector *Study B using SDR - BOARD and RTL-SDR. Study the impact of changing various parameters.* **EXPERIMENT NO: 3** **NAME** Frequency Modulation (FM) Transmitter **AIM**

		Study of FM. **DESCRIPTION** A. To plot the modulation characteristic of varactor modulator B. To calculate the modulation sensitivity of varactor modulator C. To observe and measure frequency deviation and modulation index of FM D. To study frequency modulation using reactance modulator and measure the frequency deviation *Generate the above waveforms using SDR – Board.* **EXPERIMENT NO: 4** **NAME** Frequency Demodulation Receiver **AIM** Study of frequency demodulation. **DESCRIPTION** A. To plot the demodulation characteristic of the FM demodulator (Foster-Seeley demodulator) B. To study the ratio detector C. To study the phase locked loop (PLL) detector *Study and create demodulator circuits using SDR - Board and RTL-SDR.* **EXPERIMENT NO: 5** **NAME** FM amateur radio One-way using SDR **AIM** Real time transfer of FM modulated voice **DESCRIPTION** A. To transmit FM uncompressed voice using GNU-Radio and SDR-Board B. Transmit on ISM band. C. Create a receiver to demodulate the FM and playback the voice at the receiver in real-time. **EXPERIMENT NO: 6** **NAME** Noise spectral density measurement **AIM** Effect of noise on various analog systems. **DESCRIPTION** A. To examine the operation of a noise generator

		B. To measure the signal-to-noise ratio C. To measure the noise power and noise power spectral density C. To examine the operation of a signal attenuation network **EXPERIMENT NO: 7** **NAME** Pulse Amplitude Modulation (PAM) and Demodulation **AIM** To set up a PAM modulator and demodulator circuits and to observe the waveforms. **DESCRIPTION** After completing this experiment, students will be able to set up PAM modulator and demodulator circuits and identify the waveforms. *Implement and study the same using SDR – Board.* **EXPERIMENT NO: 8** **NAME** Pulse Width Modulation (PWM) and Demodulation **AIM** To set up a PWM modulator and demodulator circuits and to observe and plot the waveforms. **DESCRIPTION** After completing this experiment, the students will be able to set up PWM modulator and demodulator circuits and to identify PWM waveform. *Implement and study the same using SDR – Board.* **EXPERIMENT NO: 9** **NAME** Pulse Position Modulation (PPM) and Demodulation **AIM** To set up a PPM modulator and demodulator circuits and to observe and plot the waveforms. **DESCRIPTION** After completing this experiment, the students will be able to set up PPM modulator circuit using IC 555, demodulator using transistor and to identify PPM waveform. *Implement and study the same using SDR – Board.*

EXPERIMENT NO: 10

NAME

Pulse Code Modulation (PCM) and Demodulation

AIM

To set up a PCM modulator and demodulator, and observe the waveforms

DESCRIPTION

After completing this experiment, the students will be able to set up a PCM modulator and to generate a PCM encoded output for a given analog input.

Implement and study the same using SDR – Board.

EXPERIMENT NO: 11

NAME

Delta Modulation (DM) and Demodulation

AIM

To set up a DM modulator and demodulator, and observe the waveforms

DESCRIPTION

After completing this experiment, the students will be able to set up a DM and to generate a DM encoded output for a given analog input.

Implement and study the same using SDR – Board.

EXPERIMENT NO: 12

NAME

MATLAB Simulation for PCM Modulation and Demodulation

AIM

To Generate a PCM modulation and demodulation signals using MATLAB

DESCRIPTION

After completing this experiment, the students will be able to set up a PCM modulator and to generate a PCM encoded output using MATLAB.

EXPERIMENT NO: 13

NAME

MATLAB Simulation for DM modulation and Demodulation

AIM

To generate a DM modulation and demodulation signals using MATLAB

DESCRIPTION

1. After completing this experiment, the students will be able to set up a DM modulator and to generate a DM encoded output using MATLAB.

Communication Lab II (Digital Communication Lab)

EXPERIMENT NO: 1

NAME

Pseudo noise (PN) sequence generation

AIM

To generate a PN sequence and verify its auto-correlation property.

DESCRIPTION

A. To generate a 15 length PN sequence using shift register (IC 7495)

B. To generate a 7 length PN sequence using flip-flop

To understand the random signals characteristics, it is important to generate a PN code sequence. In fact, a PN code sequence is a pseudo-random sequence of 1's & 0's, representing noise like carrier used for bandwidth spreading of the signal energy. It has properties equivalent those of white noise, and hence, it is interesting to verify its auto-correlation property. It can be utilized for the study of a direct-sequence spread-spectrum (DSSS) system.

Using GNU Radio on SDR board, generate the PN sequence.

EXPERIMENT NO: 2

NAME

Line coding and eye-pattern.

AIM

To study various line coding schemes and corresponding eye-patterns.

DESCRIPTION

A. The purpose of this experiment is to be familiarized with the basics of line coding, i.e., mapping bits to pulses

B. Understanding the Nyquist criterion; transmission rates via bandlimited channels; assessment of maximum transmission rate

In a digital communication system, the line coding is a part of digital signal processing that can be applied on the signal before it is connected to the analog signal. Line coding offers advantages in spectrum shaping, filtering, bit clock recovery, error detection, bandwidth usage & so on.

The eye-pattern study helps in understanding that in digital communication systems, the clock or timing information must be recovered from the data at the receiver.

EXPERIMENT NO: 3

NAME

Clock and data recovery scheme

AIM

To understand the clock and data recovery circuits.

DESCRIPTION

This experiment is intended to transmit a bit stream and recover the clock from bit stream itself at the receiver. In a digital communication system, the clock or timing information would be recovered from the data at the receiver. The clock recovery circuits employ some form of a phase-locked loop (PLL).

EXPERIMENT NO: 4

NAME

Amplitude Shift Keying (ASK) Modulation and Demodulation

AIM

To set up ASK modulator and demodulator circuits and to observe the waveforms.

DESCRIPTION

ASK is a digital modulation scheme where the binary data is transmitted using a carrier signal with two different amplitude levels. For binary 0 and 1, the carrier switches between these two levels. In its simplest form, a carrier is sent during one input and no carrier is sent during the other. This kind of modulation scheme is called on-off keying. After completing this experiment, the students will be able to a) set up ASK modulator and demodulator circuits and b) identify ASK waveforms.

Implement the same on GNU Radio and SDR board.

EXPERIMENT NO: 5

NAME

Phase Shift Keying (PSK) Modulation and Demodulation

AIM

To set up Binary Phase Shift Keying (BPSK) modulator and demodulator circuits and to observe the waveforms.

DESCRIPTION

BPSK is digital transmission scheme where the binary data is transmitted using out of phase signals. During logic '0' a preset number of cycles of a sinusoidal carrier signal is transmitted and during logic '1' the same number of cycles of the carrier signal is transmitted but with 180^0 phase shift. After completing this experiment, the students will be able to a) set up BPSK modulator and demodulator circuits and b) identify BPSK waveform.

Implement the same on GNU Radio and SDR board.

EXPERIMENT NO: 6

NAME

Frequency Shift Keying (FSK) Modulation and Demodulation

AIM

To set up FSK modulator and demodulator circuits and to observe the waveforms.

DESCRIPTION

FSK is a digital modulation scheme where the digital data is transmitted using a high frequency carrier signal. For logic '0' and '1' the carrier signal switches between two preset frequencies, hence the name FSK. After completing this experiment, the students will be able to a) set up FSK modulator and demodulator circuits and b) identify FSK waveform.

Implement the same on GNU Radio and SDR board.

EXPERIMENT NO: 7

NAME

MATLAB simulation for Quadrature Phase Shift Keying (QPSK) Modulation and Demodulation

AIM

To generate a QPSK modulation and demodulation signals using MATLAB.

DESCRIPTION

As its name implies, QPSK is a variation of BPSK. QPSK is a DSBSC modulation scheme also but it sends two bits of digital information a time (without the use of another carrier frequency). After completing this experiment, the students will be able to a) set up a QPSK modulator and demodulator using MATLAB and b) identify QPSK waveform.

Implement the same on GNU Radio, transmit the same on ISM band using SDR board.

EXPERIMENT NO: 8

NAME

MATLAB simulation for ASK Modulation and Demodulation

AIM

To generate an ASK modulation and demodulation signals using MATLAB.

DESCRIPTION

After completing this experiment, the students will be able to a) set up a ASK modulator and demodulator using MATLAB and b) identify ASK waveform.

EXPERIMENT NO: 9

NAME

MATLAB simulation for Differential Phase Shift Keying (DPSK) Modulation and Demodulation

AIM

To generate a DPSK modulation and demodulation signals using MATLAB.

DESCRIPTION

It is the version of BPSK. In DPSK, there is no absolute carrier phase reference, instead transmitted signal itself used as phase reference. After completing this experiment, the students will be able to a) set up a DPSK modulator and demodulator using MATLAB and b) identify DPSK waveform.

Implement the same on GNU Radio, transmit the same on ISM band using SDR board.

EXPERIMENT NO: 10

NAME

MATLAB simulation for FSK Modulation and Demodulation

AIM

To generate a FSK modulation and demodulation signals using MATLAB.

DESCRIPTION

After completing this experiment, the students will be able to a) set up a FSK modulator and demodulator using MATLAB and b) identify FSK waveform.

EXPERIMENT NO: 11

NAME

SDR based channel performance measurements

AIM

Channel performance measurement in terms of Spectral Bandwidth, Symbol Rate, Bit Rate, Channel Capacity, Channel Utilization, Signal to Noise Ratio, Bit Error Rate (BER), Latency, Jitter, Eye Diagram, Constellation diagram

DESCRIPTION

After completing this experiment, the students will be able to understand all the channel performance measurement parameters.

EXPERIMENT NO: 12

NAME

Source coding

AIM

To generate and evaluate the efficiency of variable length source coding using

DESCRIPTION

A variable length source coding like Huffman coding is an efficient coding technique for digital communications which depends on the frequency of occurrence of a data item. This can lead to a source code whose average code word length approaches the entropy H(x) of that source.

EXPERIMENT NO: 13

NAME

Error Detection and Correction

AIM

To implement the error detection and correction codes to handle bit errors using MATLAB.

DESCRIPTION

Error detection and correction are techniques that enable reliable delivery of digital data over unreliable communication channels. Many communication channels are subject to channel noise, and thus errors may be introduced during transmission from the source to a receiver. Error detection techniques allow detecting such

		errors, while error correction enables reconstruction of the original data in many cases.
8.	Suggested Books	Same as the associated theory course EE 306: Digital Communications

1.	Course Code	**EE 307**
2.	Title of the Course	**Communication Systems**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Review of signals and systems, Frequency domain of signals, Principles of Amplitude Modulation Systems- DSB, SSB and VSB modulations. Angle Modulation., Representation of FM and PM signals. Spectral characteristics of angle modulated signals. Review of probability and random process. Gaussian and white noise characteristics. Noise in amplitude modulation systems. Noise in Frequency modulation systems. Pre-emphasis and De-emphasis. Threshold effect in angle modulation. Pulse modulation. Sampling process. Pulse Amplitude and Pulse code modulation (PCM). Differential pulse code modulation. Delta modulation. Noise considerations in PCM. Time Division multiplexing. Digital Multiplexers.
8.	Suggested Books	1. S. Haykin, **Communications Systems**, John Wiley and Sons, 2001. 2. J.G. Proakis, and M. Salehi, **Communication Systems Engineering**, Pearson Education, 2002. 3. Taub, and D.L. Schilling, **Principles of Communication Systems**, Tata McGraw Hill, 2001.

1.	Course Code	**EE 308**
2.	Title of the Course	**Power Systems**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Evolution of Power Systems, Energy Sources Structure of Bulk Power Systems Basic three phase system concepts Power System Components: Generators, Loads, Transformers, Transmission Lines etc. Modeling, Performance and Constraints of these components Formulation/Solution of steady state equations for interconnected systems: Balanced and Unbalanced systems. Positive Sequence Network, Per Unit System, Ybus formation Simple example of a loadflow solution Introduction to generator swing equations and stability issues, Simple Example of Loss of synchronism Interconnected System Operation and Control: Operational Objectives, Frequency Control, Voltage Control and Power Flow Control: introduction to HVDC transmission and FACTS. Economic Issues in Power Systems. Analysis of Faulted Power Systems and Protection: Unbalanced System Analysis using Sequence Components, Equipment Protection Schemes: Overcurrent, Differential and Distance Protection, Relay coordination Preventive Control and Emergency Control (System Protection Schemes) Blackouts and Restoration
8.	Suggested Books	1. O.I Elgerd, **Electric energy systems theory-An Introduction** (2nd edition), Tata McGraw Hill, New Delhi, 1982. 2. J.D. Glover, M.S. Sarma, **Power Systems Analysis and Design**, Nelson Engineering, 2007. 3. A.R. Bergen and V. Vittal, **Power Systems Analysis**, Pearson Education Asia, New Delhi, 2002. 4. P. Kundur, **Power System Stability and Control**, MGraw Hill, 1993.

1.	Course Code	**EE 309**
2.	Title of the Course	**Electrical Measurements and Instrumentation**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Part 1 Measurements and measurement systems, Errors in measurement and their statistical analysis, Dynamic characteristics of instruments, Circuit components and measurement of resistances, Potentiometers, A.C. Bridges, Primary sensing elements and transducers, Measurements of non-electrical quantities, Chemical sensors and analytical instruments Part 2 Analog Instruments, Galvanometers, Analog Ammeters, Voltmeters and Ohmmeters, Measurement of Power and Watt meters, Magnetic Measurements, Optoelectronic Measurement, Cathode Ray Oscilloscope (CRO), Instruments for Generation and Analysis of Waveform, Signal Analysers, High Frequency Measurements, Signal Conditioning, Data Acquisition Systems.
8.	Suggested Books	1. A. K. Sawhney and P. Sawhney **Educational and Technical Publishers** (Most recent edition) H.S. Kalsi McGraw-Hill Education (India) Pvt Ltd. (Most recent edition) 3. Ernest O.Doebelin, **Measurement systems Application and Design, International Student Edition**, IV Edition, McGraw Hill Book Company, 1998. 4. R.K.Jain, **Mechanical and Industrial Measurements**, Khanna Publishers, New Delhi, 1999. 5. P.Holman, **Experimental Methods for Engineers International** Student Edition, McGraw Hill Book Company, 1971. 6. Ernest O.Doebelin, **Measurement systems application and design international** student Edition, Tata McGraw Hill Publishing Co., New Delhi, 1999. 7. D.Patranabis, **Principles of Industrial Instrumentation Tata** McGraw Hill Publishing Co., New Delhi, 1999.

1.	Course Code	**EE 401** [from AY 2010-11 to 2014-15] **EE 311** [from AY 2014-15 onwards]
2.	Title of the Course	**VLSI Systems and Design**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Introduction to Solid State Electronics. MOS transistor theory. CMOS processing technology. CMOS circuit and logic design. Fully complementary, transmission gate and dynamic logic. Design of latches, registers, memory, PLA's adders, counters and multipliers in CMOS.
8.	Suggested Books	1. Watse follow Informity and K. Eshroghian, **Principles of CMOS VLSI Design: A Systems Perspective**, Adison-Wesley, 1985. 2. C.A Mead and L.A. Canway, **Introduction to VLSI Systems**, Adison-Wesley, 1980.

1.	Course Code	**EE 403** [from AY 2010-11 to 2014-15]
2.	Title of the Course	**Digital Systems Design**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Top-Down Design, FSM, Case study, Meta-stability, Synchronization. VHDL: Different Descriptions, Simulations Cycles, Process, Loops, Delay Models, Library, Functions, Procedures, Synthesis, Test bench. PLD: SPLDs, Programming, Applications, CPLDs, MAX7000, APEX, Design Flow, Timing. FPGA: Logic Blocks, Routing Architecture, Design Flow, Virtex-II, SX-A, Programming, PAR, Applications. Testing : Fault models, Different faults, Fault simulation, ATPG, DFT, Boundary scan, BIST
8.	Suggested Books	1. J.F. Wakerly, **Digital Design: Principles and Practices**, Prentice Hall. 2. K. Skahil, **VHDL for Programmable logic**, Addison Wesly. 3. M. Abramovici, **Digital Systems Testing and Testable Design**, Jaico Publishing.

1.	Course Code	**EE 453** [from AY 2010-11 to 2014-15]
2.	Title of the Course	**Digital Systems Design Lab**
3.	Credit Structure	L-T-P-Credits 0 -0-3-1.5
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Following broad experiments based on the associated theory courses EE 403: Digital Systems Design 1. VHDL simulation of Combinational logic circuits. 2. VHDL simulation of sequential logic circuits. 3. VHDL simulation of FSM. 4. Synthesis of combinational and sequential logic circuits. 5. FPGA implementation of Combinational and sequential circuits.
8.	Suggested Books	Same as the associated theory course EE 403: Digital Systems Design.

1.	Course Code	**EE 411**
2.	Title of the Course	**Communication Systems Theory**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Brief review of signal analysis:** Fourier transforms; signal representation and decomposition; deterministic and non-deterministic signals; applications to the study of communication systems. **Communication systems:** essential components; modulation; transmission, reception; ideal and non-ideal communication systems; system level analysis **Random variables and processes:** probability density functions, discrete and continuous densities; marginal and joint densities; conditional probabilities and functions of random variables; collection of random variables and stochastic processes **Mathematical representation of signals and noise:** noise as a stochastic process; Gaussian random variables and processes; mean, correlation functions, covariance functions; stationary and white Gaussian noise; power spectral densities; **Comparative study of modulation techniques on S/N ratio basis:** the effect of noise on different modulation techniques; figures of merit; amplitude modulation in the presence of noise; frequency modulation in the presence of noise; noise in digital communication systems and how it may be handled
8.	Suggested Books	1. H. Taub and D.L. Shilling, **Principles of Communication Systems**, McGraw Hill International Student Edition,1971. 2. M. Schwartz**, Information Transmission, Modulation and Noise**, McGraw Hill, 1980.

1.	Course Code	**EE 412/ EE 612**
2.	Title of the Course	**Digital Communication Systems**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Elements of digital communication systems: source coding, channel coding, modulation/demodulation, Information and channel capacity: Discrete communication channels and their analysis. Baseband data transmission of analog signals. Time-division multiplexing of digital signals. Synchronization methods.
8.	Suggested Books	1. K.S. Shanmugam, **Digital and Analog Communication Systems**, Wiley International Publication, 1980. 2. M. Schwartz, **Information Transmission, Modulation and Noise**, McGraw Hill International Student Edition, 1980. 3. J.J. Proakis, **Digital Communications**, 2nd edition, McGraw Hill 1989. 4. S.S. Haykin**, An Introduction to Analog and Digital Communication Systems**, Wiley Eastern, 1989.

1.	Course Code	**EE 413**
2.	Title of the Course	**Discrete Data and Digital Control**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	EE 302: Control Systems
6.	Scope of the course	
7.	Course Syllabus	**Sampling and data reconstruction processes:** Sampled - Data control systems, ideal sampler, sampling theorem, sample and hold operations, frequency domain considerations. **Z-transforms:** Properties Inverse, applications to solution of difference equations, convolution sums; **Stability of discrete systems:** location of poles, Jury's stability criterion, stability analysis through bilinear transforms. **Design of digital control systems:** PID controllers and frequency domain compensation design, state variable methods and the discrete linear regulator problem.
8.	Suggested Books	1. M. Gopal, **Digital Control Engineering**, Wiley Eastern, 1988. 2. K.J Astrom, and B. Wittenmark, **Computer Controlled Systems**, 2nd edition Prentice -Hall India 1994 3. R. Isermann, **Digital Control**, Vol 1 Narosa Publications, 1993.

1.	Course Code	**EE 414**
2.	Title of the Course	**Special Semiconductor Devices**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Metal semiconductor contacts, MIS and MOS devices. Power semiconductor devices. Hetero-junction devices. Optoelectronic devices. Microwave semiconductor devices. Quantum well devices. Semiconductor memories.
8.	Suggested Books	1. K.N. Kwok, **Complete Guide to Semiconductor Devices**, McGraw-Hill, 1995. 2. S.M. Sze, **Physics of Semiconductor Devices**, Wiley Eastern, 1981. 3. S.K. Ghandhi, **Semiconductor Power Devices**, Wiley Interscience, 1977. 4. B.J. Baliga, **Modern Power Devices**, Wiley Interscience, 1987. 5. P. Bhattacharya**, Semiconductor Optoelectronic Devices**, Prentice-Hall India, 1995.

1.	Course Code	**EE 415**
2.	Title of the Course	**Electronic Instrumentation**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Instrumentation and isolation amplifiers. Analog switches, S/H circuits, multiplexers and demultiplexers, sampling and quantization, antialiasing filters, Data converters, V/F, F/V, A/D, D/A conversion. Data acquisition system. Signal measurement in the presence of noise. Noise in Electronic systems, design of low noise circuits, Programmable instruments and digital interfacing: serial, parallel. GPIB.
8.	Suggested Books	1. B.H. Oliver and J.M. Cage**, Electronic Measurements and Instrumentation**, McGraw Hill, 1971. 2. J.A. Alloca, **Electronic Instrumentation**, Prentice Hall, 1987. 3. S. Soclof, **Applications of Analog Integrated Circuits**, Prentice Hall, India, 1990. 4. A.J. Bowels, **Digital Instrumentation**, McGraw Hill, 1986. 5. C.S. Rangan, G.R. Sarma, V.S.V. Mani, **Instrumentation Devices and Systems**, Tata McGraw-Hill, 1990. 6. T.S. Rathore, **Digital Measurement Techniques**, Narosa, New Delhi, 1996.

1.	Course Code	**EE 416**
2.	Title of the Course	**Industrial Instrumentation**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Instrumentation systems. Static and dynamic characteristics of instruments, noise in measurement systems. **Instrumentation systems for physical measurements:** Measurement and control of displacement, strain, force, torque acceleration, temperature and flow. **Non destructive testing:** Ultrasonic and eddy current. **Signal Conditioning and acquisition:** Signal conditioning, signal transmission methods; Data loggers, PC based data acquisition systems, Interfacing and bus standards, programmable logic controllers and their industrial applications.
8.	Suggested Books	1. E.O. Doebelin, **Measurement Systems**, McGraw Hill, 1991. 2. J.P. Bentley, **Principle of Measurement Systems**, John Wiley and Sons, 1987. 3. C.S. Rangan, G.R. Sharma, V.S.V. Mani**,** **Instrumentation Devices and Systems**, Tata McGraw Hill, 1997. 4. D.V.S. Murthy, **Transducers and Instrumentation**, Prentice Hall, 1997. 5. M. Tooley, **PC Based Instrumentation and Control**, Newnes, 1997. 6. R. Randolf, K.G. Kingham, **Instrumentation Technology**, Vol. 5, Butter-worth, 1995.

1.	Course Code	**EE 417**
2.	Title of the Course	**Analog Filters**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Filter preliminaries:** Terminology; Magnitude and Phase responses; Classification (LPF, HPF, BPF, APF etc.,) **Approximation Theory:** Butterworth, Chebychev, Elliptic and Bessel Filters; Frequency Transformation. **Sensitivity:** Basic concepts; Application to filters - Q sensitivity, wp sensitivity. Elements of passive network synthesis: Properties and synthesis of LC, RC driving point and transfer functions; Singly- and Doubly-terminated ladder networks. **Basics of Active Filter Synthesis:** RC-OPAMP circuits, Biquad circuits based on negative feedback and positive feedback topologies; Active networks based on passive ladder structures; Effects of real OPAMPS on active filters. Introduction to Switched-Capacitor Filters: The MOS switch; Simulation of resistors using Switched -Capacitor circuits.
8.	Suggested Books	1. G. Daryanani, **Principles of Active Networks Synthesis and Design**, John Wiley and Sons, 1976. 2. A.S. Sedra and P.O. Brockett, **Filter Theory and Design: Active and Passive**, Matrix Publishers, 1978. 3. M.E. Van Valkenburg, **Analog Filter Design**, Holt, Rinehart and Winston, 1982. 4. G.S. Moschytz and P. Horn, **Active Filter Design Hand-Book**, John Wiley and Sons, 1981. 5. G.S. Moschytz: (Ed.), **MOS Switched Capacitor Filters: Analysis and Design**, IEEE Press, 1981.

1.	Course Code	**EE 418**
2.	Title of the Course	**Control Systems Design**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	Control Systems
6.	Scope of the course	
7.	Course Syllabus	**Introduction to design:** State-space models; Performance measures like ISE, ITAE; Quadratic indices; Controllability and Observability. **Linear Quadratic Regulator (LQR):** Performance index; Optimal control law; Algebraic Riccati eqn.; Frequency-domain interpretation. Linear Quadratic Gaussian (LQG): Statistical descriptions of noise; Kalman filter; Stability margins. **H Design:** Uncertainty descriptions; Robustness measures; Formulation for control-synthesis; Riccati eqn.; Model-order reduction. **Case studies:** Inverted pendulum; Missile guidance; Process control.
8.	Suggested Books	1. B. Friedland, **Control System Design**, McGraw Hill 1986. 2. B.D.O. Anderson and J.B. Moore, **Optimal Control: LQ Methods**, Prentice Hall of India, New Delhi, 1989. 3. J.C. Doyle, B.A. Francis and A.R. Tannenbaum, **Feedback Control Theory**, Maxwell Macmilan International Ed., 1992.

1.	Course Code	**EE 419/ EE 619**
2.	Title of the Course	**Biomedical Optics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned	Electrical Engineering
5.	Pre–requisite, if any	Fundamentals of Electromagnetic wave theory and optics.
6.	Scope of the course	
7.	Course Syllabus	**Introduction to tissue engineering:** Cells as therapeutic agents, cellular fate processes, cell differentiation, cell division, cell death/apoptosis, types of tissues and their functions, tumors and cancers. Interaction of light with cells and tissues, spectroscopy, optical biopsy, optics of blood, tissue phantoms, absorption and fluorescence spectroscopy. **Bioimaging:** Transmission microscopy, Phase contrast Microscopy, Fluorescence Microscopy, Multi-photon Microscopy, Optical Coherence Tomography. **Optical Biosensors:** Principles of optical biosensing, Fiber-optic biosensors, Interferometric biosensors, Surface Plasmon Resonance biosensors. Case studies of cellular and biomolecular imaging.
8.	Suggested Books	**Text Books** 1. Valery V. Tuchin, **Handbook of Optical Biomedical Diagnostics,** Kluwer Academic Publishers, 2004, ISBN: 1402075766 2. Paras N Prasad, **Intrduction to Biophotonics**, John Wiley and Sons, 2003, ISBN: 9780471287704. **Reference Books** 1. M.H. Niemz, **Laser-Tissue Interactions: Fundamental and Applications (Biological and Medical Physics, Biomedical Engineering)** Springer, 2007, ISBN: 978-3540721918 2. R.W. Waynant, **Lasers in Medicine**, CRC Press, 2002, ISBN: 0-8493-1146-2. 3. B. O.Palsson, **Tissue Engineering**, CRC Press 2003.

1.	Course Code	**EE 420/ EE 220**
2.	Title of the Course	**IC Fabrication Technology**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	
6.	Scope of the Course	
7.	Course Syllabus	**Introduction** to microelectronic fabrication **Semiconductor substrate:** Phase diagram and solid solubility, Crystal structure, Crystal defects, Crystal growth **Diffusion:** Atomistic models of diffusion, Analytic solutions of Fick's law, Diffusion coefficients, Two step diffusion, Diffusion system **Thermal Oxidation:** The Deal-Grove model, The initial oxidation, Oxide characterization, Oxidation induced stacking faults, Oxidation systems **Ion implantation:** Ion implantation system, Vertical projected range, Channeling effect, Implantation damage, Problems and concerns **Optical lithography:** Overview, Source systems, Contact/proximity printers. Projection printers, Alignment **Photo resist:** Contrast curves, Applying and developing photo resist **Etching:** Wet etching, Plasma etching, Ion milling, Reactive ion etching, Liftoff **Chemical Vapor Deposition:** CVD system, Advanced CVD systems, **Epitaxial growth:** Wafer cleaning and native oxide removal, The thermal dynamics, Surface reactions, Do pants, Defects in epitaxial growth, MOCVD, MBE and CBE **Contacts and metallization:** Junction and oxide isolation, Si on insulator, Schottky and Ohmic contacts, Multilevel metallization **CMOS technologies:** Device behavior, Basic 3 μm technologies, Device scaling **Circuit Manufacturing:** Yield, Particle control, Design of experiments, Computer integrated manufacturing.
8.	Suggested Books	1. Stephen A. Campbell, ***The Science and Engineering of Microelectronic Fabrication***, 2nd edition (Oxford University Press, 2001) 2. Sorab K. Gandhi, ***VLSI Fabrication Principles***, *2nd Edition* (John Wiley & Sons, Inc., 1994)

1.	Course Code	**EE 421 / 621**
2.	Title of the Course	**MOS Devices & Modeling**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	Knowledge of basic physics of diodes, BJTs, FETs, MOS structure. Semiconductors, Junctions and MOSFET
6.	Scope of the Course	
7.	Course Syllabus	**Overview:** Introduction, Semiconductors, Conduction, Contact Potentials, P-N Junction, Overview of the MOS Transistor. **Two Terminal MOS Structure:** Flat-band voltage, Potential balance & charge balance, Effect of Gate-substrate voltage on surface condition, Inversion, Small signal capacitance; **Three Terminal MOS Structure:** Contacting the inversion layer, Body effect, Regions of inversion, Pinch-of f voltage. **Four Terminal MOS Transistor :** Transistor regions of operation, general charge sheet models , regions of inversion in terms of terminal voltage, strong inversion, weak inversion, moderate inversion, interpolation models , effective mobility, temperature effects, breakdown p-channel MOS FET, enhancement and depletion type, model parameter values , model accuracy etc. **Small dimension effects:** channel length modulation, barrier lowering, two dimensional charge sharing and threshold voltage, punch- through, carrier velocity saturation, hot carrier effect s, scaling, and effect s of surf ace and drain series resistance, effects due to thin oxides and high doping. Sub threshold regions, Advanced SOI structures. **CMOS Device Design**: Scaling, Threshold voltage, MOSFET channel length.
8.	Suggested Books	**Text:** 1. Yuan Taur & Tak H. Ning (Cambridge), **Fundamentals of Modern VLSI Devices** 2. Yannis Tisividi s (Oxford), The MOS Transistor (2nd edition) **Reference:** 1. B.G. Streetman, Solid State Electronics Devices, Prentice Hall of India, New Delhi. 2. D.A. Neaman, Semiconductor Physics and Devices, McGraw-Hill.

1.	Course Code	**EE 424/ EE 724**
2.	Title of the Course	**Advanced Micro-processes and Nanotechnology**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering Department
5.	Pre–requisite, if any	A course on semiconductor device physics, MOSFETs and VLSI
6.	Scope of the Course	
7.	Course Syllabus	**Methodologies for nanotechnology:** Introduction and classification, general properties of atoms and solids, effects at the nanometer scale, Fabrication methods for nanostructures. **Characterization methodologies for Nanotechnology:** classification of characterization methods, microscopic techniques, Electron microscopy, Scanning probe techniques, Diffraction techniques, spectroscopic techniques. **Semiconductor nanostructures:** General aspects of semiconductor physics, Quantum confinement in semiconductor nanostructures, fabrication techniques, Physical processes nanostructures, some applications of semiconductor nanostructures. **Silicon MOSFETs:** Moore's Law, Scaling down of devices, Low frequency noises in MOSFETs, Short Channel Effect, DIBL, GIDL, recent developments and challenges in MOSFETs. **Single electron devices:** Coulomb blockade effect, Single Electron Transistor, SET based detector, RF-SET, Single Electron Spectroscopy etc. **Molecular materials and devices:** Organic materials, some examples of organic semiconductors, charge carrier injection and transport, Optical properties of organic semiconductors, applications and devices involving organic semiconductors viz. Organic Field Effect Transistors, Organic Light Emitting Diodes, Organic Photovoltaic's including Dye sensitized solar cells.
8.	Suggested Books	1. S. M. Sze, *Physics of semiconductor devices*, John Wiley and Sons, 1981, ISBN: 0-471-05661-8 2. R. Kelsall, I. Hamley and M. Geoghegan, *Nanoscale Science and Technology*, John Wiley and Sons Ltd, 2005, ISBN: 0-470-85086-8. 3. K. Morigaki, *Physics of amorphous semiconductors*, Imperial College Press, 1999, ISBN: 981-02-1381-6. 4. P. Richman, *MOS Field Effect Transistors and Integrated Circuits*, John Wiley and Sons Ltd, 1973, ISBN: 0-471-72030-5. 5. Y. Taur and T-H. Ning, *Fundamentals of Modern VLSI Devices*,

		Cambridge University Press, 1998, ISBN: 978-0-521-55959-1. 6. G. Hadziioannou and G. Malliaras, *Semiconducting Polymers: Chemistry, Physics and Engineering*, Wiley Interscience, 2007, ISBN: 978-3-527-31271-9.

1.	Course code	**EE 427**
2.	Title of the course	**Physics of Semiconductor Devices**
3.	Credit structure	L-T-P-Credits 2-1-0-3
4.	Name of the concerned Department	Electrical Engineering
5.	Pre-requisite, if any	Electronic devices
6.	Scope of the course	
7.	Course syllabus	**Introduction to semiconductor physics:** Review of quantum mechanics; electrons in periodic lattices; crystal structure; chemical bonding; crystal lattices; semiconductor materials. **Properties of Semiconductors:** Energy bands; carrier concentrations; carrier transport phenomena; phonon, optical and thermal properties, hetero-junctions and nano-structures. **Physical concepts of p-n Junction:** depletion region; current-voltage characteristics, transient and A-C conditions; effects of contact potential; recombination and generation in the transition region; metal-semiconductor contacts. **Physics of transistors:** The bipolar transistor-static, small signal and switching characteristics; high current and high frequency effects; hetero-junction bipolar transistors. **The MOS transistor:** basic device characteristics; short channel effects and device scaling; hot carrier effects; Junction field effect transistors; metal-insulator-semiconductor capacitors; MOSFETs, device characteristics, structures, scaling and challenges; applications.
8.	Suggested books	1. S. M. Sze and Kwok K. Ng, **Physics of semiconductor devices**, 2007 John Wiley & Sons, Inc. 2. S. M. Sze, **Modern semiconductor device physics**, Wiley-Interscience publication, ISBN: 0-471-15237-4. 3. E. H. Nicollian and J. R. Brews, **MOS Physics and Technology**, John Wiley, 1982. 4. J.P. Colinge, C.A. Colinge**, Physics of Semiconductor devices; Basic principles**, Springer 2002, ISBN: 0-387-28523-7. 5. V.K. Vashchenko, V.F. Sinkevitch, **Physical**

		limitations of semiconductor devices, Springer 2008, ISBN: 978-0-387-74513-8.

1.	Course Code	**EE 429/ EE 629**
2.	Title of the Course	**Nanotechnology and Nanoelectronics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	
6.	Scope of the Course	
7.	Course Syllabus	**Fundamentals of solid state engineering:** Future of semiconductor device and research, Applications in food, energy, transportation, communication, entertainment, health and medicine etc. Necessity of innovative technology and prospect for future. **Crystalline properties of solid:** Crystal lattice and seven crystal systems, The unit cell concept, The Weigner-Seitz cell, Bravais lattices, Space and point groups, Miller indices, reciprocal lattice, Brillouin zone. **Semiconductor heterostructures and low-dimensional quantum structures:** Energy bands, Application of model solid theory, Anderson model for heterojunctions, Multiple quantum wells (MQWs) and super lattices, Two-dimensional nanostructure: quantum well, One-dimensional nanostructure: quantum wire, Zero-dimensional nanostructure: quantum dot, Optical properties of low-dimensional structures, Examples and applications in real world. **Fabrication of nanostructures:** Basic compound semiconductors, Bulk single crystal growth techniques, Epitaxial growth techniques, Physical vapor deposition and sputtering, Thermodynamics and kinetics of growths, Nan scale growth modes **Characterization Techniques:** Structural, X-ray diffraction, Electron microscopy, Energy dispersive analysis using X-rays, Auger electron spectroscopy, X-ray photoelectron spectroscopy, Secondary ion mass spectroscopy, Rutherford backscattering, Scanning probe microscopy, Optical, Photoluminescence spectroscopy, Cathodoluminescence spectroscopy, Reflectance measurement, Absorbance measurement, Ellipsometry, Raman spectroscopy, Fourier transform spectroscopy, Electrical Resistivity, Hall effect, Capacitance techniques, Electrochemical capacitance-voltage profiling **Innovative devices based on nanostructures:** Resonant tunneling diode, Quantum cascade laser, Carbon nanotube

		devices, Single electron transistor
8.	Suggested Books	1. M. Razeghi, *Fundamentals of Solid State Engineering*, 2nd Edition (Springer, 2006) 2. W. R. Fahrner, *Nanotechnology and Nan electronics: Materials, Devices, Measurement Techniques* (Springer-Verlag Berlin Heidelberg 2005) 3. R. W. Kelsall, I. W. Hamley, and M. Geoghegan, *Nanoscale Science and Technology* (John Wiley & Sons Ltd, England 2005)

1.	Course Code	**EE 430/ EE 630**
2.	Title of the Course	**Analog CMOS IC Design**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical
5.	Pre–requisite, if any	Knowledge of MOSFET device operation, physics and technology.
6.	Scope of the Course	
7.	Course Syllabus	**Basic MOS Device Physics:** MOSFET as a switch, MOSFET structure and symbol, MOSFET I-V characteristics, Threshold voltage, Second Order Effects, MOSFET layout, capacitances, small signal model, long channel and short channel models. **Short Channel Effects and Device Models:** Scaling theory, short channel effects, threshold voltage variation, mobility degradation with vertical field, velocity saturation, hot carrier effects, output impedance variation with drain source voltage, BSIM model, charge and capacitance modeling, temperature dependence. **Single-Stage Amplifiers:** Basic concepts, Common-source stage, source follower, common-gate stage, cascade stage. **Differential Amplifiers:** Single ended and differential operation, basic differential pair, common mode response, differential pair with MOS loads, Gilbert cell. **Passive and Active Current Mirrors:** Basic current mirrors, Cascade current mirrors, Active current mirrors. **Nonlinearity and Mismatch:** Nonlinearity of differential circuits, effect of negative feedback on nonlinearity, capacitor nonlinearity, linearization techniques, offset cancellation techniques, reduction of noise by offset cancellation, alternative definition of CMRR.
8.	Suggested Books	1. B. Razavi, Design of Analog CMOS Integrated Circuits, Tata McGraw-Hill, New Delhi, 2002 (ISBN: 978-0-07-052903-8). 2. P.E. Allen and D.R. Holberg, CMOS Analog Circuit Design, Oxford University Press, New Delhi, 2010 (ISBN: 978-0-19-806440-4). 3. D.M. Binkley, Tradeoffs and Optimization in Analog CMOS Design, Wiley, 2008 (ISBN: 978-0-470-03136-0).

1.	Course Code	**EE 431/ IEE 431/ EE 631**
2.	Title of the Course	**Organic Electronics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department/Discipline	Electrical Engineering
5.	Pre–requisite, if any	Basic Semiconductor Physics/ Basic electronics
6.	Scope of the course	
7.	Course Syllabus	Background towards molecular electronics, surfaces and interfaces, structures and organization. Introduction to Schrodinger equation, Hartree-Fock Theory, Density Functional Theory. Molecular Solids, π-conjugated polymers, one dimensional band structure of linear conjugated polymers, optical absorption and emission in conjugated oligomers/polymers. Device motivation for interface studies, Metal-semiconductor and Metal-Insulator-Semiconductor Interface. Charge transport in conjugated polymers. Hopping and Multiple trap and release model. Interface effects viz. Dipole, doping, band bending etc. in organic semiconductor devices. Materials and Interface Engineering in Organic Light Emitting Diodes (OLEDs). OLED materials and device architecture for full color displays and solid state lighting. Theory and operation principle of Organic Field Effect Transistors (OFETs). Interface Characterization, Threshold Voltage and subthreshold swing and charge carrier mobility in OFETs. Application of OFETs in Displays. Organic Photovoltaic Devices (OPDs) using Polymer-Fullerene Bulk heterojunction thin films. Interface effects and improvement in Polymer Solar Cells (PSCs) efficiency. Introduction to some other advanced concepts viz. Organic electrochromic materials and devices, multiphoton absorbing materials and devices and Nonvolatile Organic Thin Film Memory Device.
8.	Suggested Books	1. S. M. Sze, ***Physics of semiconductor devices***, John Wiley and Sons, 1981, ISBN: 0-471-05661-8 2. R. Kelsall, I. Hamley and M. Geoghegan, ***Nanoscale Science and Technology***, John Wiley and Sons Ltd, 2005, ISBN: 0-470-85086-8. 3. K. Morigaki, ***Physics of amorphous semiconductors***, Imperial College Press, 1999, ISBN: 981-02-1381-6. 4. G. Hadziioannou and G. Malliaras, ***Semiconducting Polymers: Chemistry, Physics and Engineering*****,** Wiley Interscience, 2007, ISBN: 978-3-527-31271-9. 5. **F. So, Organic Electronics: Materials Processing, Devices**

		and Applications, CRC Press, 2010, ISBN: 978-1-4200-7290-7. 6. **Conjugated Polymer Surfaces and Interfaces**, Cambridge University Press, 1996, ISBN: 0-521-47206-7.

1.	Course Code	**EE 432/ EE 632**
2.	Title of the Course	**Optoelectronics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	
6.	Scope of the Course	
7.	Course Syllabus	**Fundamentals of Lasers:** The Einstein A and B coefficient approach to the photon-atom interaction, Based on this approach, examines semi-classical quantum theory of the laser to illustrate the general applicability of the rate equation, Description of light detection. **Laser Physics and Dynamics:** Threshold condition for laser oscillation, Gain saturation, Multimode Oscillation, Amplified spontaneous emission, Laser efficiency, CW laser **Different Sources of Lasers:** Solid state lasers, Color center lasers, Gas lasers, Dye lasers, Chemical lasers, Semiconductor lasers.
8.	Suggested Books	1. Joseph T. Verde yen, Laser Electronics, 3rd edition (prentice-Hall, 1995) 2. E. Siegman, Introduction to Lasers and Masers (New York: McGraw-Hill Company, 1971) 3. C. Casey, Jr. and M. B. Panish, Heterostructure lasers (New York: Academic Press, 1978)

1	Course code	**EE 435 /EE 635**
2	Title of the course	**VLSI Technology**
3	Credit structure	L-T-P-C 2-1-0-3
4	Name of the concerned Department	Electrical Engineering
5	Pre-requisite (if any)	None
6	Scope of the course	This course is designed to introduce the state of the art fabrication technology used in fabrication of standard Si based CMOS Nano-devices and Very Large Scale Integrated Circuits based on them.
7	Course syllabus	**General overview of VLSI technology** Introduction to VLSI technology, underlying processes, clean room, wafer cleaning procedures and physical limits of technology, Moore's law, top-down and bottom up approach. **General fabrication processes** Oxidation, diffusion, ion-implantation, wet chemical etching, dry etching and deposition techniques. **Lithographic techniques** Advancement of lithography with scaling down of devices, Figure of merits, NA and depth of focus, Issues pertaining to lithography, MTF, PCM, patterning, mask generation, Advanced lithographic techniques viz. Immersion lithography, e-beam/ion-beam lithography, X-ray lithography. **Silicides and interconnects** Silicidation, contact issues in MOSFETs, metal silicides, interconnects, resistance of interconnects, skin effect, fringing capacitances, crosstalk, lumped/distributed RC delay model, Elmore model, interconnect design for VLSI applications. **Process sequences** Process sequences for Bipolar, n-MOS and CMOS technologies.
8	Suggested books	1. S. K. Gandhi, VLSI Fabrication principles, 2nd edition, (John Wiley & Sons Inc., 1994). (ISBN: 9780471580058). 2. S. M. Sze, VLSI Technology, 2nd Edition, (McGraw Hill Co. Inc., New York, 1988).

		(ISBN:9780070627352). 3. C. Y. Chang & S. M. Sze, VLSI Technology, (McGraw Hill Co.Inc., New York, 1996). (ISBN: 9780070630628). 4. James Plummer, M.Deal and P.Griffin, Silicon VLSI Technology, Prentice Hall Electronics and Series, 2000 VLSI. (ISBN: 9780130850379). 5. Stephen Campbell, The Science and Engineering of Microelectronics, Oxford University Press, 1996. (ISBN: 9780195136050).

1.	Course Code	**EE 436**
2.	Title of the Course	**Microwave and Satellite Communication**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	Electromagnetic Waves
6.	Scope of the course	
7.	Course Syllabus	**Microwave components:** Tees, circulators, directional couplers, attenuators, phase shifters, S-parameter analysis of microwave components. **Microwave sources:** Klystron, microwave semiconductor devices, low noise microwave amplifiers, parametric amplifiers. Physical media and link components: Microwave bands for **Satellite communication:** Satellite microwave link calculations; Earth station components, parabolic dish antennas, G/T ratio. **Modulation Schemes used in satellite links:** FDMA, TDMA and packet switched systems; spread spectrum techniques and CDMA systems. **Satellite systems:** Satellite classes; satellite orbits: launching of a satellite and their monitoring. Low orbit satellites for mobile communication.
8.	Suggested Books	1. R.E. Collin, **Foundations of Microwave Engineering**, (2^{nd} edition) McGraw Hill, 1992. 2. D.M. Pozar, **Microwave Engineering**, John Wiley, 1996. 3. Pratt and Bostian, **Satellite Communication**, John Wiley International 1986.

1.	Course Code	**EE 438**
2.	Title of the Course	**Computer Control and Automation of Power Systems**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction to energy control centers**: Various states of a power system; SCADA systems and RTUs. **EMS software:** State estimation; Optimal power flow; Reactive power control; Operator request loadflow; Contingency analysis. **Active power control:** Speed control of generators; Tie line control; Frequency control; Generation scheduling in an interconnected system; Automatic generation control; Primary and secondary control; Economic dispatch; Performance criteria under transient and steady state conditions. **Computer aided protection:** Introduction; Basic configuration; Line, bus, generator, transformer protection; Numeric relays and application of DSP to protection. **Automation:** Monitoring, Protection and control; IEDs; Adaptive relaying.
8.	Suggested Books	1. A.G. Phadke, and J.S. Thorp, **Computer Relaying for Power Systems**, John Wiley & Sons, New York, 1988. 2. O.I. Elgerd, **Electric Energy System Theory**, Tata McGraw Hill, New Delhi, 1982. 3. P. Kundur, **Power System Stability and Control**, McGraw Hill Inc. New York, 1995. Selected papers from IEEE Computer Applications in Power.

1.	Course Code	**EE 441/ EE 641**
2.	Title of the Course	**Advanced Signal Processing**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Electrical Engineering
5.	Pre–requisite, if any	Signals and Systems
6.	Scope of the Course	The goal of advanced digital signal processing course is to provide a comprehensive coverage of signal processing methods and tools, including leading algorithms for various applications.
7.	Course Syllabus	Review of discrete-time signals and systems concepts, Z-transform properties, Sampling, Multirate signal processing, discrete Fourier transform (DFT), Fourier-Bessel expansion, discrete cosine transform (DCT), short time Fourier transform (STFT), continuous wavelet transform (CWT), discrete wavelet transform (DWT), Wigner-Ville distribution (WVD), adaptive signal decomposition, empirical mode decomposition, parametric signal processing, data compression, signal and image processing applications.
8.	Suggested Books	1. L. Cohen, **Time-Frequency Analysis**, Prentice Hall, 1995, ISBN: 0135945321. 2. S. Mallat, **A Wavelet Tour of Signal Processing (**2nd edition**)**, Academic Press, 2008, ISBN: 012466606X. 3. T. K. Moon and W. C. Stirling, **Mathematical Methods and Algorithms for Signal Processing**, Prentice Hall, August 1999, ISBN: 978-0201361865. 4. Proakis and Manolakis, **Digital Signal Processing** (4th edition), Prentice Hall, 2007, ISBN: 0131873741. 5. Selected research papers.

Course code	**EE 450/ EE 650**
Title of the course	**Internet of Things (IoT) Networks**
Credit Structure	L - T - P - Credits 2 - 1 - 0 - 3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Students are expected to have basic knowledge of Probability Theory, Signal Processing and Communications.
Scope of the course	To get acquainted with the networking aspects of the Internet of Things (IoT). Students will gain state-of-the-art knowledge with typical IoT inspired networking concepts.
Course Syllabus	**Introduction to IoT Networks:** What is IoT network? Types of IoT networks available for IoT devices; Networking protocols; Understanding layers of network in IoT space; Cooperative and Cognitive wireless Sensor and Ad-hoc networks. **IoT Networks in the pre-5G Era:** Cellular (3G/4G) networks; Local and Personal Area Networks (LAN/PAN); 6LoWPAN; Low Power Wide Area Networks (LPWAN); Mesh networks; Key players for LPWAN: SigFox (ultra-narrow band), and LoRaWAN (long range Wireless Area Network); 4G LTE networks: LTE-M (Cat-M1 chipset) and Narrowband IoT (NB-IoT); Applications to Machine-to-Machine (M2M) connections; Limitation on capacity of LTE/LTE-Advanced networks. **Evolution of 5G-IoT Network and Beyond:** Usage scenarios for 5G/6G networks; International Telecommunication Union (ITU) supporting IoT devices: Enhanced Mobile Broadband (eMBB), Massive Machine-type Communications (mMTC), and Ultra-reliable and Low-Latency Communications (URLLC); 5G New Radio (NR) technology; Learning driven 6G-IoT networks. **IoT Network Modelling, Performance, and Security:** Stochastic Modelling; Performance Metrics and Evaluation; Spectral and Energy Efficiency analysis; Basic IoT network Security requirements; Securing different stack layers (e.g., LANs, network, transport); Low-powered IoT-based networks: Energy consumption versus harvesting prospects. **IoT Applications:** Internet of Vehicles (IoV); Drones/UAVs as Flying IoT; Resource management and mobility management; Vehicular/Mobile Edge/Cloud Computing; Industrial IoT (IIoT): Exploration of wireless IoT networks for Smart Manufacturing; Industry 4.0; Internet of Molecular Things (IoMT); Internet of Space (IoS); Internet of Everything (IoE).
Suggested Books	1. D. Hanes, G. Salgueiro, P. Grossetete, R. Barton, J. Henry, **IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things**', Cisco Press, NJ, 2017, ISBN: 9780134307091

	2. P. Lea, **‘Internet of Things for Architects’**, Packt (sic) Publishing, UK, 2018, ISBN: 9781788470599 3. N. H. Mahmood, N. Marchenko, M. Gidlund, P. Popovski, **‘Wireless Networks and Industrial IoT: Applications, Challenges and Enablers’**, Springer Nature, Switzerland, 2021, ISBN: 978-3-030-51472-3 4. S. Misra, A. Mukherjee, and A. Roy, **‘Introduction to IoT’**, Cambridge University Press, UK, 2021, ISBN: 9781108913560

Course code	**EE 455/ EE 655**
Title of the course	**Optical Wireless Communications**
Course Category	Departmental/ Open Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Students are expected to have a basic knowledge in Probability Theory, Signal Processing, and Communication
Scope of the course (Objectives)	• To give a basic understanding on modelling two different optical wireless communication (OWC) systems (i.e., Free Space Optics (FSO), Visible Light Communication (VLC)) • To discuss techniques for analyzing and improving the performance of OWC links.
Course Outcomes	• Student should be able to model the transmitter, receiver, and OWC channel. • To analyze the performance of OWC links over various environments. • To provide solutions for improving the performance of OWC links.
Course Content	1. **Introduction to OWC:** Introduction to FSO, VLC and its applications, Relevance of OWC in 6G communication and industry 5.0. 2. **System Modelling:** FSO and VLC transmitter design, Modulation techniques, OWC receivers 3. **Channel Modelling:** Terrestrial and satellite FSO communication scenarios, Aerial-platform based FSO communication, Propagation models for VLC. 4. **Performance Analysis:** Outage, Symbol error probability and Channel capacity analyses 5. **Link Performance Improvement Techniques:** Relaying technique, Spatial diversity, Aperture averaging, Hybrid OWC/RF Communication.
Suggested Books	**Text Books:** 1. H. Kaushal, V. K. Jain, S. Kar: Free Space Optical Communication: Springer: India: 2017: ISBN 978-81-322-3689-4 2. M. Uysal, C. Capsoni, Z. Ghassemlooy, A. Boucouvalas, E. Udvary: Optical Wireless Communications An Emerging Technology: Springer: Switzerland: 2016: ISBN 13:978-1-4398-5235-4 **Reference Books:** 3. Z. Ghassemlooy, W. Popoola, S. Rajbhandari : Optical

	Wireless Communications System and Channel Modelling with MATLAB: CRC Press (Taylor & Francis Group): NewYork: 2013: ISBN 13: 978-1-4398-5235-4 4. Arun K Majumdar: Optical Wireless Communications for Broadband Global Internet Connectivity: Elsevier: Amsterdam, Netherlands: 2019: ISBN 978-0-12-813365-1

Course code	**EE 483/ EE 683**
Title of the course	**Error Correcting Codes**
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Digital Communications (UG)
Scope of the course	To provide an introduction to various traditional and modern error correction codes that are very much useful in improving the reliability of digital/wireless communication and storage systems.
Course Syllabus	**Introduction:** Need for Forward Error Correction (FEC) codes and interleavers in digital/wireless communication and storage systems, Groups, Fields, Binary field arithmetic, Construction of Galois field, Basic properties of Galois field, Computations using Galois field arithmetic, Irreducible, Minimal and Primitive polynomials, Design of interleavers including Block interleaver, Convolutional interleaver, Helical interleaver, Random Interleaver, etc. and its applications **BCH & RS codes:** Binary & non-binary Bose-Chaudhuri-Hocquenghem (BCH) codes, Reed-Solomon (RS) codes, Generator polynomials, Encoding and Decoding of RS & BCH codes. **Concatenated codes:** Serial concatenated codes and its applications. **Product codes:** Multi-dimensional product codes, Encoding, LLR-based decoding techniques. **LDPC codes:** Tanner graph, Protograph LDPC code construction, encoding, LDPC codes in 4G and 5G wireless standards, Message passing decoding algorithm. **Polar codes**: Generator matrix, Frozen bits, Various representation of polar codes, Encoder design, Successive cancellation (SC) decoder, SC list decoder, Polar codes in 5G standards. **Codes Parameter Estimation:** Basic blind code parameter estimation techniques of RS codes, LDPC codes, Product Codes, Polar Codes and Interleavers.
Suggested Books	1. S. Lin and D. J. Costello, ***Error Control Coding***, 2nd Edition, Pearson Press, 2005, ISBN-13: 978-0130426727 2. R. E. Blahut, ***Algebraic Codes for Data Transmission***, 2nd Edition, Cambridge University Press, 2003, ISBN-13: 978-0511800467 3. W. C. Huffman and V. Pless, ***Fundamentals of Error Correcting Codes***, 1st Edition Cambridge University Press, 2003, ISBN-13: 978-0521131704

Course code	**EE 484/ EE 684**
Title of the course	**Power System Protection**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite	Basics of power systems
Scope of the course (Objectives)	The course will cover up-to-date technology in the field of power system protection emphasizing the current practices in Indian power system and make aware of the present challenges in this domain. The course will also provide a scope to learn different power system simulation software and realize relay operation using case studies.
Course Outcomes	1. dentify different types of faults in power systems. 2. eview different protection techniques applied in power systems. 3. nalyse different challenges in current grid scenario and review some advanced protection solutions.
Course Content	1. **undamentals of power system protection:** Overview of a protection arrangement and its characteristics, Current Transformer, Potential Transformer, circuit breaker operation, fault analysis. 2. **rotective relay operation and phasor estimation:** Basic architecture and operating principle of digital relays, fault detection, phasor estimation. 3. **vercurrent relaying for phase and earth faults:** Working principle of overcurrent relays and their coordination, concept of directional overcurrent relay. 4. **ransmission line protection:** Distance relaying, protection for different line configurations, power swing and load encroachment, line differential protection.

	5. **ransformer, busbar, generator, and motor protection:** Differential protection, stator fault protection, rotor fault protection, abnormal operation protection. 6. **ide Area Protection & Challenges in the present grid scenario:** Introduction to Wide Area Measurement Systems (WAMS), concept of Wide Area Protection, protection challenges in the presence of converter-based renewable sources.
Suggested Books	**Text Books:** • tanley H. Horowitz, and Arun G. Phadke. *Power system relaying*. John Wiley & Sons, 2008 (3rd Ed.), ISBN 978-0-470-05712-4. • run G. Phadke, and James S. Thorp. *Computer relaying for power systems*. John Wiley & Sons, 2009 (2nd Ed.), ISBN 978-0-470-05713-1. **Reference Books:** • Héctor J. Altuve Ferrer, and Edmund O. Schweitzer, eds. *Modern solutions for protection, control, and monitoring of electric power systems*. Pullman, WA, USA: Schweitzer Engineering Laboratories, 2010, ISBN-13: 978-0-9725026-3-4. • Gerhard Ziegler. *Numerical differential protection: principles and applications*. John Wiley & Sons, 2012 (2nd Ed.), ISBN 978-3-89578-670-9. • Gerhard Ziegler. *Numerical distance protection: principles and applications*. John Wiley & Sons, 2011 (4th Ed.), ISBN 978-3-89578-381-4.

Course code	**EE 201**
Title of the course	**Network Theory**
Course Category	Department Core Course
Credit Structure	L - T - P - C (2-1-0-3)
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Familiarization with the analysis of various electrical devices and circuits.
Course Outcomes	Foundation for electric circuit analysis using various approaches
Course Content	• Graphs of networks; current and voltage spaces of graphs and their representations: incidence, cutset and circuit matrices; Tellegen's Theorem. • Formal study of methods of analysis such as nodal, modified nodal, cutset, loop analysis for linear networks. • Multiport representation for networks with particular emphasis on 2-ports. Time domain analysis of R, L, M, C, controlled sources, networks using state space methods. • Introduction to *s*-domain methods.
Suggested Books	**Text Books** 1. O. Wing, **Classical Circuit Theory,** Springer, 2009, ISBN: 0387097392. 2. S. Ghosh, **Network Theory: Analysis and Synthesis,** 1st edition, Prentice Hall of India, 2005, ISBN: 8120326385. **Reference Books** 3. N. Balabanian and T. A. Bickart, **Linear Network Theory: Analysis, Properties** 1st edition, Design and Synthesis, Weber Systems, 1981, ISBN: 091646010X. 4. L. O. Chua, C. A. Desoer, and E. S. Kuh, **Linear and Nonlinear Circuits** 1st edition, McGraw - Hill International Edition, 1987, ISBN: 0070108986.

Course code	**EE 203**
Title of the course	**Electronic Devices**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Fundamentals on different electronic devices and their operational principles
Course Outcomes	• Knowledge of semiconductor devices and different types of diodes • Working of diodes, transistors, and their various applications
Course Content	• Modeling devices: Static characteristics of ideal two terminal and three terminal devices; Small signal models of non-linear devices. • Introduction to semiconductor equations and carrier statistics: Poisson's and continuity equations, Fermi-Dirac statistics and Boltzmann approximation to the Fermi-Dirac statistics. • Semiconductor Diodes: Barrier formation in metal-semiconductor junctions, PN homo- and hetero- junctions; CV characteristics and dopant profiling; IV characteristics; Small signal models of diodes; Some Applications of diodes. • Field Effect Devices: JFET/HFET, MIS structures and MOSFET operation; JFET characteristics and small signal models; MOS capacitor CV and concept of accumulation, depletion and inversion; MOSFET characteristics and small signal models. • Bipolar transistors: IV characteristics and Ebers-Moll model; small signal models; Charge storage and transient response. • Discrete transistor amplifiers: Common emitter and common source amplifiers; Emitter and source followers.

Suggested books	**Text Books** 1. D. A. Neamen, **Semiconductor Physics and Devices**, Third edition, McGraw Hill, 2002, ISBN: 0071231129. 2. E. S. Yang, **Microelectronic Devices**, 1st edition, McGraw Hill, 1988, ISBN: 0071003746. 3. B. G. Streetman, **Solid State Electronic Devices**, 6th edition, Prentice Hall of India, 2006, ISBN: 812033020X. **Reference Books** 4. J. Millman and A. Grabel, **Microelectronics**, 2nd edition, McGraw Hill, International, 2017, ISBN: 0074637363. 5. A. S. Sedra and K. C. Smith, **Microelectronic Circuits**, 8th edition, Oxford University Press, 2020, ISBN: 978-01908534646. 6. R.T. Howe and C.G. Sodini, **Microelectronics: An integrated Approach**, Prentice Hall International, 1996, ISBN: 0135885183.

Course code	**EE 207**
Title of the course	**Electric Machines**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Introduction to the construction and working principles of various Electrical Machines
Course Outcomes	• Foundation for Electrical Machines and three-phase systems • Analysis of the various types of Electrical machines
Course Content	• 3-phase circuits: Types of Connections, Power definitions and Measurements, Basics of Unbalanced 3-Phase Circuits. • Review of Magnetic circuits and Mutual inductance, Electro-mechanical Energy Conversion principles. • Transformers: Construction and principle, Equivalent circuit, Efficiency and Voltage Regulation, Basics of Three Phase Transformer. • DC machines: Construction and Principle of DC Generator, DC Motor, operating characteristics, speed control of DC motors. • Three Phase Induction Motor: Construction, Principle, Equivalent Circuit, operating characteristics Efficiency, Speed Control. • Introduction to Synchronous machines – generators and motors, Special Machines.
Suggested Books	**Text Books** 1. T. Wildi, **Electric Machines, Drives and Power Systems,** 6th edition, Pearson Education, 2013, ISBN: 933251853X. 2. I. J. Nagrath, and D. P. Kothari, **Electric Machines**, 5th edition, Tata McGraw Hill, India, 2017, ISBN:

	935260640X. 3. A. Fitzgerald, C. Kingsley, and S. Umans, **Electric Machinery**, 7th edition, McGraw Hill – Indian Edition, 2020, ISBN: 9389949661. **Reference Books** 4. A. Hughes, B. Drury, **Electric Motors and Drives: Fundamentals, Types and Applications,** 5th edition, Newnes, 2019, ISBN: 978-0081026151. 5. S. J. Chapman, **Electric Machinery Fundamentals,** 4th edition, McGraw Hill Education,2017, ISBN: 978-0071070522. 6. P.C. Sen, **Principles of Electric Machines and Power Electronics,** 2nd edition, Wiley 2007, ISBN: 978-8126511013.

Course code	**EE 209**
Title of the course	**Digital Systems**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Gain knowledge of different logic families and digital electronic concepts
Course Outcomes	• Foundations of different logic families and logic elements • Familiarization with different hardware description languages
Course Content	• Basic combinational and sequential logic circuits, Digital Electronic fundamentals, • Digital Logic Families: TTL, CMOS etc., • Number systems and basic digital arithmetic, • Finite State Machine Design, Analysis and Synthesis, • Introduction to Hardware Description Language, • Array based logic elements (Memory, PLA, FPGA), • Special Topics (such as processor design, testing and verification, special digital systems, asynchronous state machines etc.)
Suggested Books	**Text Books** 1. J. F. Wakerly, **Digital Design: Principles and Practices**, 4th edition, Pearson Education, 2005, ISBN: 8131713660. 2. C. H. Roth, **Digital Systems Design using VHDL,** 1st edition, CL Engineering, 1998, ISBN: 053495099X. **Reference Books** 3. H. Taub and D. Schilling, **Digital Integrated Electronics**, McGraw Hill, 2017, ISBN: 9780070265080. 4. D. A. Hodges and H. G. Jackson, **Analysis and Design of Digital Integrated Circuits**, 3rd edition, McGraw Hill, 2003, ISBN: 0072283653. 5. F. J. Hill and G. L. Peterson, **Introduction to Switching**

	Theory and Logic Design, 3rd edition, John Wiley, 2009, ISBN: 8126520310. 6. Z. Kohavi and N. K. Jha, **Switching and Finite Automata Theory**, 3rd edition, Cambridge University Press, 2009, ISBN: 1118108108.

Course code	**EE 253N**
Title of the course	**Electronic Devices Lab**
Course Category	Department Lab
Credit Structure	L - T - P - Credits 0-0-2-1
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Familiarization with the various electronic devices and their operating principles
Course Outcomes	• Gain better understanding of concepts taught in the associated Electronic Devices Course. • Analysis on different electronic devices by hands-on measurement of their characteristics
Course Content	A representative list of experiments: • To understand and measure circuits with digital storage oscilloscope • To measure the DC I-V characteristics of diodes • To analyze different diode circuits (clipping circuits, voltage doublers, rectified differentiator, precision rectifier) • To measure the reverse-bias capacitance of p-n junction capacitance • To measure the minority carrier lifetime in a semiconductor photodiode. • To obtain the I-V characteristics of bipolar transistors and computer transistor parameters. • To obtain small signal parameters of bipolar junction transistors (BJTs). • To measure and analyze bias quantities (DC currents and voltages) and small-signal gain of the given common-emitter amplifier circuit.
Suggested Books	**Reference Books** 1. R. L. Boylestad, and L. Nashelsky, **Electronic Devices and Circuit Theory**, 4th edition, Longman Higher Education, 1987, ISBN: 013250457X. 2. B. G. Streetman, **Solid State Electronic Devices**, 6th edition, Prentice Hall of India, 2006, ISBN: 812033020X. 3. A. S. Sedra and K. C. Smith, **Microelectronic Circuits**,

	8th edition, Oxford University Press, 2020, ISBN: 978-01908534646. 4. D. A. Neamen, **Semiconductor Physics and Devices**, 3rd edition, McGraw Hill, 2002, ISBN: 0071231129.

Course code	**EE 259**
Title of the course	**Digital Systems Lab**
Course Category	Department Lab
Credit Structure	L - T - P - Credits 0-0-2-1
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Hands on experience with digital electronic circuits and various logic families
Course Outcomes	• Gain better understanding of concepts taught in the associated Digital Systems course. • To get familiar with various digital circuits by carrying out experiments using logic gates and logic circuits
Course Content	A representative list of experiments in this lab: • Introduction to Logic Circuits: To gain familiarity with digital integrated circuits by setting up simple logic circuits. • Combinational Logic Circuits: Use of TTL adder, multiplexer and decoder. • Sequential Circuits: To study the elementary sequential circuits. • Counters and Shift Registers: To use the 7490 decade counter and 7495 shift register. • Timer Circuits and DAC: To learn about (a) open-collector TTL, (b) 555 timer circuits, (C) Digital to Analog Converter. • CMOS Logic Gates: (i) Observe and plot transfer characteristic of a CMOS inverter, (ii) Measure noise margin and propagation delay of a CMOS inverter, (iii) Test simple CMOS logic gate circuits.
Suggested Books	**Reference Books** 1. J. F. Wakerly, **Digital Design: Principles and Practices**, 4th edition, Pearson Education, 2005, ISBN: 8131713660. 2. C. H. Roth, **Digital Systems Design using VHDL,** 1st edition, CL Engineering, 1998, ISBN: 053495099X. 3. H. Taub and D. Schilling, **Digital Integrated Electronics**, McGraw Hill, 2017, ISBN: 9780070265080. 4. D. A. Hodges and H. G. Jackson, **Analysis and Design**

	of Digital Integrated Circuits, 3rd edition, McGraw Hill, 2003, ISBN: 0072283653. 5. F. J. Hill and G. L. Peterson, **Introduction to Switching Theory and Logic Design,** 3rd edition, John Wiley, 2009, ISBN: 8126520310. 6. Z. Kohavi and N. K. Jha, **Switching and Finite Automata Theory**, 3rd edition, Cambridge University Press, 2009, ISBN: 1118108108.

Course code	**EE 251**
Title of the course	**Electrical Networks Lab**
Course Category	Department Lab
Credit Structure	L - T - P - Credits 0-0-2-1
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Hands on experience with devices and circuits associated with electrical networks
Course Outcomes	• Gain better understanding of concepts taught in the associated course on Network Theory. • Knowledge of different electrical circuits and their measuring instruments.
Course Content	A representative list of experiments in this lab is as follows: • Characterization of passive circuit elements (R, L and C) • Verification of network theorems: a) Norton theorem, b) Thevenin theorem, c) Superposition theorem. • Analysis of multi-port network parameters (ABCD parameter, h-parameter). • Time and frequency responses of RL, RC, and RLC circuits. • Characterization of half-wave rectifier and full-wave rectifier (with and without capacitive filter).
Suggested Books	**Reference books** 1. L. S. Bobrow, **Fundamentals of Electrical Engineering,** 2nd edition, Oxford University Press, 1996, ISBN: 0195105095. 2. C. K. Alexander, and M. Sadiku, **Fundamentals of Electric Circuits,** 5th edition, McGraw Hill, 2013, ISBN: 1259098591. 3. R. L. Boylestad, and L. Nashelsky, **Electronic Devices and Circuit Theory**, 4th edition, Longman Higher Education, 1987, ISBN: 013250457X.

	4. V. D. Toro, **Electrical Engineering Fundamentals,** 2nd edition, Prentice Hall, 1989, ISBN: 9332551766.

Course code	**EE 211**
Title of the course	**Applied Probability for Communication Engineering**
Course Category	Departmental Elective
Credit Structure	L-T-P-C (2-1-0-3)
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	• Familiarization with the key concepts in probability theory and random variables. • Connection of concepts with various examples in real-life and applications in communications.
Course Outcomes	• Application of various concepts in probability and random variables in solving communication systems problems. • Concepts implementation using software tools.
Course Content	• Applications of Probability Concepts in Communication Systems. • Set operations, Probability space, Conditional probability, Bayes theorem. • Discrete random variables, Probability mass function (PMF), Cumulative distribution function (CDF), Example distributions. • Continuous random variables, Probability density function (PDF), CDF, Example distributions. • Joint distributions, Moments of random variables, Moment generating function (MGF), Characteristic function of random variables. • Conditional distributions, densities and moments. • Functions of one and two random variables. • Chebyshev inequality, Laws of large numbers, Central limit theorem (CLT) • Applications of Random Variables in Wireless Communications and its implementation using software tools.
Suggested Books	**Text Books** 1. A. Papoulis and S.U. Pillai, **Probability, Random Variables and Stochastic Processes**, 4th edition, McGraw Hill Education, 2017, ISBN-13: 978-0070486584.

	2. H. Hsu, **Probability, Random Variables and Random Processes** (Schaum's Outlines), McGraw Hill Education, 2017, ISBN-13: 978-0070589506. 3. S. Ross, **A First Course in Probability**, 9th edition, Pearson Education, 2019, ISBN-13 978-9353065607. **Reference Books** 4. D. C. Montgomery and G. C Runger, **Applied Statistics and Probability for Engineers**, 6th Edition, Wiley, 2016. ISBN-13: 978-8126562947. 5. J. L Devore, **Probability and Statistics for Engineering and the Sciences**, 9th edition, Cengage: Metric Version, 2020, ISBN-13 978-9353506247.

Course Code	**EE 213**
Title of the Course	**Fundamentals of Optimization**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	• Foundational understanding of optimization techniques applicable in the Electrical Engineering domain. • Imparts basics of mathematical modeling, linear programming, integer programming and various other optimization algorithms.
Course Outcomes	• Understand the fundamental concepts of optimization and their relevance in engineering. • Familiarization with the various solution methods for optimization problems. • Hands-on experience with the optimization techniques for real-world engineering applications using software tools.
Course Syllabus	• **Introduction to Mathematical Optimization:** Classification of Optimization problems, Real-world examples: Assignment and Transportation Problems, Least Squares and Estimation Problems, Portfolio Management, Shortest Path, Job Scheduling, Matching Problems, Knapsack and Travelling Salesman Problems. • **Linear Programming (LP) and Duality theory:** The Simplex Algorithm, Geometry: Feasible Regions, Convexity, and Extreme Points, Duality Theory: min-max problems and zero-sum games, Weak and strong duality theorems, Farkas Lemma. Applications: Shortest path, max-flow min-cut theorems, and resulting algorithms. • **Integer Programming (IP):** Knapsack Problem: LP relaxation, Dynamic Programming, Traveling Salesman Problem, Facility location, Crew scheduling. • **Nonlinear Optimization:**

	Convexity: Functions, Epigraphs, and Feasible Regions, Optimality Conditions for the Differentiable Case and KKT Theorem, Optimality Conditions Based on Lagrangians. • **Application of Software tools for solving Optimization Problems**: Solving N Variables Constrained and Unconstrained Functions using software tools, Examples of linear programming problems with continuous and integer variables using software.
Suggested Textbooks	**Textbooks** 1. D. P. Bertsekas, **Nonlinear Programming**. 2nd ed. Athena Scientific Press, 1999. ISBN: 1886529000. 2. B. Dimitris, and J. Tsitsiklis. **Introduction to Linear Optimization**. Belmont, MA: Athena Scientific, 1997. ISBN: 9781886529199. **Reference Books** 3. N. Jorge, W. J. Stephen, **Numerical Optimization**, Springer, 2006. ISBN:978-0-387-40065-5. 4. F. S. Hillier, G. J. Lieberman, **Introduction to Operations Research**. 7th edition, McGraw-Hill, 2001, ISBN-13: 978-0072535105. 5. M. S. Bazaraa, H. D. Sherali, C. M. Shetty, **Nonlinear Programming: Theory and Algorithms**, 3rdedition, 2006, Wiley, ISBN: 978-0-471-48600-8.

Course code	**EE 202N**
Title of the course	**Signals and Systems**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	• To be familiar with time and frequency domain representations of signals and linear systems • To understand the inter-relation between time and frequency domains • To develop mathematical skills in order to analyze signals and systems based on transform techniques
Course Outcomes	Knowledge of time and frequency domains and analysis and processing techniques for signals and systems.
Course Content	• **Continuous-time and discrete-time signals and systems:** signal characteristics, common signals, properties of continuous-time systems and discrete-time systems. • **Continuous and discrete linear time-invariant systems:** impulse response, convolution, linear constant-coefficient differential equations and difference equations. • **Signal transforms:** Fourier series, Fourier transform, Laplace transform, analysis of signals and systems using transforms. • **Sampling:** Sampling theorem, sampling techniques, reconstruction of signals.
Suggested Books	**Text Books** 1. R. F. Ziemer, W.H. Tranter, and D. R. Fannin: **Signals and Systems: Continuous and Discrete**, 4th edition, Prentice Hall: 1998: 978134964560. 2. A. V. Oppenheim, A.S. Willsky, and I. T. Young:

	Signals and Systems Prentice Hall: 1983: 9780138097318. **Reference Books** 3. B. P. Lathi: **Signal Processing and Linear Systems**: Oxford University Press: 1998: 9780198062288.

Course code	**EE 204**
Title of the course	**Analog Circuits**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Learn and understand the working of the various types of operational amplifier circuits and analyze their performance.
Course Outcomes	• Understand the basics of operational amplifier circuits, different types of circuits – working and analysis • Analysis and design of operational amplifier circuits for the given specifications
Course Content	• **Introduction to operational amplifiers:** The difference amplifier and the ideal operational amplifier models, concept of negative feedback and virtual short; Analysis of simple operational amplifier circuits; Frequency response of amplifiers, Bode plots. • **Feedback:** Feedback topologies and analysis for discrete transistor amplifiers; stability of feedback circuits using Barkhausen criteria. • **Linear applications of operational amplifiers:** Instrumentation and Isolation amplifiers; Current and voltage sources; Active filters. • **Non-linear applications of operational amplifiers:** Comparators, clippers and clampers; Linearization amplifiers; Precision rectifiers; Logarithmic amplifiers, multifunction circuits and true RMS convertors. • **Waveform Generation:** Sinusoidal feedback oscillators; Relaxation oscillators, square-triangle oscillators. • **Real operational amplifiers:** Current sources and active loads, difference, intermediate and output stages including Miller capacitors for frequency computation;

	Operational amplifier parameters; Effects of real operational amplifier parameters on circuit performance. • **Analog and Digital interface circuits:** A/D, D/A Converters, S/H circuits and multiplexers.
Suggested Books	**Text Books** 1. S. Franco, **Design with Operational Amplifiers and Analog Integrated Circuits**, Tata McGraw Hill, 4th edition, 2016: 9352601947. 2. J. V. Wait, L.P. Huelsman and GA Korn**, Introduction to Operational Amplifier theory and applications,** McGraw Hill, New York, 1991: 0070677700. 3. J. Millman and A. Grabel**, Microelectronics**, 2nd edition, McGraw Hill, 2017: 0074637363. **Reference Books** 4. P. Horowitz and W. Hill, **The Art of Electronics**, 3rd edition, Cambridge University Press, 2015: 0521685001. 5. A. S. Sedra and K.C. Smith, **Microelectronic Circuits**, 8th edition, Oxford University Press, 2020: 978-0190853464. 6. R. Paul, G. Robert, G. Meyer, **Analysis and Design of Analog Integrated Circuits**, 5th edition, Wiley, 2015: 0470245999.

Course code	**EE 212**
Title of the course	**Power Electronics**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Fundamentals of the various types of Power Electronic converters and analysis of their performance.
Course Outcomes	• Understanding the basics of power electronic switches and different types of converters • Design/development of basic PE converters using software tools
Course Content	• Introduction to Power Electronics, fundamentals of power conversion, operating characteristics of power semi-conductor devices, conduction and switching losses, basics of heat sink design, basics of snubber circuits. • Principle of operation of single and three phase AC-DC line commutated converter/ rectifiers. • Principle of operation and design of DC-DC (buck, boost, buck-boost, Cuk, fly-back and forward) converters, • Principle of operation of single phase and 3-phase DC-AC converters/ inverters, PWM techniques. • Introduction to AC-AC and Matrix converters.

	Text Books 1. Robbins, N. Mohan, Undeland, **Power Electronics: Converters Applications and Design**, 3rd edition: Wiley: ISBN: 2007, 9788126510900,978-8126510900. 2. L. Umanand, **Power Electronics: Essentials and Applications**: Wiley: 2011, ISBN: 9788126519453, 978-8126519453. 3. R. W. Erickson, D. Maksimovi´c, **Fundamentals of Power Electronics,** 3rd edition: Springer; 2020, ISBN: 3030438791, 978-3030438791. **Reference Books** 4. M. H. Rashid, **Power Electronics Circuits, Devices and Applications,** 4th edition: Pearson Education: ISBN: 9332584583, 978-8120345317. 5. B. K. Bose, **Modern Power Electronics and AC Drives,** 1st edition: Pearson Education: ISBN: 978-9332557550. 6. P.C. Sen, **Principles of Electric Machines and Power Electronics,** 2nd edition, Wiley 2007, ISBN: 978-8126511013.

Course code	**EE 254**
Title of the course	**Analog Circuits Lab**
Course Category	Department Lab
Credit Structure	L - T - P - Credits 0- 0-3-1.5
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Gaining hands-on experience with the working of the basic operational amplifier circuits
Course Outcomes	• Gain better understanding of concepts taught in the associated Analog Circuits course. • Engineering knowledge: Working, design and analysis of operational amplifier circuits • Familiarization with basic simulation software.
Course Content	A representative list of experiments in this lab: • Study the working of inverting, non-inverting, differentiator and integrator circuits using operational amplifier circuits. • Study and measurements of the non-ideal parameters of LM741 including its frequency response. • Study two stage RC coupled Amplifier and analyze its gain and bandwidth. • Study of difference and instrumentation amplifiers. • Realization of Trans-conductance and Trans-impedance Amplifiers. • Design Challenge -1 (Differential equation solver) (simulation). • Study working of Half/Full wave Precision rectifier, and log and antilog amplifier circuits. • Study the working of active filter circuits. • Study the working of Wien Bridge and Phase shift oscillator circuits. • Study the working of Schmitt trigger and multi-vibrator circuits. • Study Astable and Monostable Multivibrator circuit using IC 555 timer. • Design Challenge- 2 (Over/ under voltage warning) (simulation). • Study the voltage regulator circuits (simulation).

	• Study the functions of ADCs and DACs.
Suggested Books	**Reference Books** 1. S. Franco, **Design with Operational Amplifiers and Analog Integrated Circuits**, Tata McGraw Hill, 4th edition, 2016: 9352601947. 2. J. V. Wait, L. P. Huelsman and G. A. Korn**, Introduction to Operational Amplifier theory and applications,** McGraw Hill, 1991: 0070677700. 3. A. S. Sedra and K. C. Smith, **Microelectronic Circuits**, 7th edition, Oxford University Press, 2017: 9780199476299.

Course code	**EE 252**
Title of the course	**Electric Machines and Power Electronics Lab**
Course Category	Department Lab
Credit Structure	L - T - P - Credits 0-0-3-1.5
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Electric Machines
Course Objectives	To get familiar with the working of the basic AC and DC Electrical Machines and Power Electronic Converter circuits.
Course Outcomes	• Gain better understanding of concepts taught in the associated courses. • Engineering knowledge and hands on experience: AC and DC Electrical Machines, Power Electronic Converter operation. • Develop skill in simulation and analysis of Electric Machines and Power Electronic converters.
Course Content	A representative list of experiments in this lab: • Short Circuit and Open circuit and loading tests on a Single-Phase Transformer. • Speed control of a Separately Excited DC motor. • Open Circuit and Load Tests on a Separately Excited DC Generator. • Speed control by *V/f* control method and loading test on a 3-phase Squirrel Cage Induction Motor. • V and inverted V curves of a synchronous motor. • Study of DC-DC Buck and Boost Converters with different filters and loads. • Study of controlled AC-DC Rectifier. • Study of AC-AC Converter. • Study of PWM schemes and Single-phase DC-AC Inverter.

Suggested Books	**Reference Books** 1. T. Wildi, **Electric Machines, Drives and Power Systems:** Pearson Education: 2013: 933251853X, 978-9332518537. 2. I. J. Nagrath, D. P. Kothari, **Electric Machines**, 5th edition: Tata McGraw Hill: 2017: 935260640X, 978-9352606405. **3.** L. Umanand, **Power Electronics: Essentials and Applications**: Wiley: 2011: 9788126519453, 978-8126519453.

Course code	**EE 214**
Title of the course	**Electronic Instrumentation**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basics of Electrical Engineering
Course Objectives	To familiarize students with different types of electronic instruments, their construction and principle of working.
Course Outcomes	• Knowledge of error and uncertainty analysis and characteristics of measurement systems. • To understand the working principle of various electronic instruments
Course Contents	• **Errors in measurement:** Introduction to measurement and instrumentation systems, Errors in measurement, classification of errors, correlation of experimental data, propagation, and probabilistic estimation of errors in measurement systems, overall error budgeting of measurement systems. • **Dynamic characteristics of measurement systems:** Static and dynamic characteristics of instruments, order of measurement systems, dynamic response of a measurement system to different elementary input signals viz. step input, ramp input and sinusoidal inputs. • **Analog Electronic Instruments:** Transistor Voltmeter Circuits, Operational amplifier-based voltmeter circuits, Digital voltmeters, Digital multimeters, and AC electronic meters. • **Signal conditioning and Data acquisition systems:** Instrumentation and isolation amplifiers, Analog switches, S/H circuits, multiplexers and demultiplexers, sampling and quantization, antialiasing filters, Data converters, V/F, F/V, A/D, D/A conversions. Signal conditioning, signal transmission methods; Data loggers, PC based data acquisition systems, Interfacing and bus standards, programmable logic controllers and their industrial applications. Data acquisition system. Signal measurement in the presence of noise. design of low noise circuits, Programmable instruments, and digital interfacing: serial, parallel. GPIB.

	• **Instrumentation systems for physical measurements:** Measurement of displacement, strain, force, torque, acceleration, temperature and flow rate, quarter, half, and full bridge arrangements for measurement of physical quantities.
Suggested Books	**Text Books** 1. J. A. Alloca, **Electronic Instrumentation**, Prentice Hall, 1987, ISBN: 0835916332. 2. D. A. Bell, **Electronic Measurements and Instrumentation**, Oxford University Press, 3rd edition. ISBN: 019569614X. 3. E. O. Doebelin, **Measurement systems Application and Design**, International Student Edition, 4th edition, McGraw Hill Book Company, 1998, ISBN: 0070173354. **Reference Books** 4. B. H. Oliver and J. M. Cage, **Electronic Measurements and Instrumentation**, McGraw Hill, 1971, ISBN: 978007013938. 5. V. D. Toro, **Electrical Engineering Fundamentals,** 2nd edition, Prentice Hall, 1989, ISBN: 9332551766. 6. A. J. Bouwens, **Digital Instrumentation**, McGraw Hill, 1986, ISBN: 0070067120.

Course code	**EE 216**
Title of the course	**Machine Learning for Signal Processing**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basics of Probability Theory and Random Variables and Linear Algebra
Course Objectives	• To provide a foundational understanding of machine learning. • To introduce several applications of machine learning in signal and image processing to build intelligent systems.
Course Outcomes	• Understanding of theoretical underpinnings of machine learning. • Implement and apply a variety of machine learning methods to real-world problems involving signals and images. • Assess and improve the performance of machine learning models on different types of data sets.
Course Content	• Introduction to various applications of machine learning in signal processing, including signal classification tasks such as speaker recognition, diagnosis of medical conditions through the analysis of biomedical signals and images. • Fundamentals - Motivation for Studying Machine Learning, Probability Density Functions, Class-conditional Density, Priors and Posteriors, Multidimensional Data, Covariance Matrix. • Supervised Learning - Linear and Logistic Regression, K-Nearest Neighbour Classifier, Bayesian Classifier, Discriminant Analysis, Support Vector Machines, Decision Trees, Perceptron, Neural Networks - Activation Functions, Backpropagation Algorithm, Architectures. • Unsupervised Learning – Principal Component Analysis, Clustering, K-Means Clustering, Hierarchical Clustering, Expectation Maximization Algorithm, Gaussian Mixture Models.

	• Model Selection and Performance Evaluation - Training, Validation and Testing, Overfitting, Regularization, Accuracy, Sensitivity, Specificity, Positive Predictive Value, Receiver Operating Characteristics. • Introduction to Deep Learning.
Suggested Books	**Text Books** 1. T. Mitchell, **Machine Learning**, McGraw Hill Education, 2017, 1st edition, ISBN: 9781259096952. 2. C. M. Bishop, **Pattern Recognition and Machine Learning**, Springer, 2006, ISBN: 978-1493938438. **Reference Books** 3. B. Yegnanarayana, **Artificial Neural Networks**, Prentice Hall India, 1999, ISBN: 978-8120312531. 4. R. O. Duda, P. E. Hart and D. G. Stork, **Pattern Classification**, Wiley, 2021, 2nd edition, ISBN: 9789354244391.

Course code	**EE 301N**
Title of the course	**Microprocessors and Digital Systems Design**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Digital Systems
Course Objectives	Exposure to different processors, controllers and their applications in embedded systems
Course Outcomes	• Introduction to different architectures of processors and controllers and their software interface • Familiarization with embedded programming and application of the same to real-time controllers • Concepts of digital design and industrial hardware applications
Course Content	• Architectures of processors and microcontrollers, Data and control path concepts, registers and memory organization; RISC Vs. CISC Architecture • Instruction sets and assembly language programming, timing diagrams. • Memory and I/O interfacing: Handhsaking signals, principles of polling and interrupts, communication with peripheral devices • Digital System Design: Finite State machines, Introduction fo FPGA, Verilog / VHDL programming, Sysem on Programmable chip design development

Suggested Books	**Text Books** 1. D. V. Hall, **Microprocessors and Interfacing**, Tata McGraw Hill, 1991, ISBN: 978-1259006159. 2. R. S. Gaonkar, **Microprocessor Architecture: Programming and Applications with the 8085/8080A**, Penram International Publishing, 2013, 6th edition., ISBN: 978-8187972884. 3. K. J. Ayala, **The 8051 Microcontroller: Architecture, Programming and Applications,** Cengage Learning, 2nd edition., ISBN: 978-8131500880. **Reference Books** 4. J. F. Wakerly, **Digital Design: Principles and Practices**, 4th edition, Pearson Education India, 2008, ISBN: 978-9332508125. 5. D. A. Patterson, and J. H. Hennessy, **Computer Organization and Design The hardware and software interface**, Morgan Kaufman Publishers, 2016, ISBN: 978-0128017333.

Course code	**EE 313**
Title of the course	**Communication Systems Theory**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2 - 1 - 0 – 3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Impart the basic concepts of Communication Systems and Probability Theory
Course Outcomes	▪ Distinguish between different types of Communication Systems ▪ Analyze distinct receiver characteristics ▪ Map the basic concepts from Probability Theory to Communication Systems
Course Content	• **Communication Systems:** Introduction to Communication Systems, Signals and Signal Space, Analysis and Transmission of Signals Amplitude Modulation and Demodulation – SSB, DSB and VSB, Angle Modulation and Demodulation, • Representation of FM and PM, Spectral Characteristics of Angle Modulation, Pulse Modulation, Sampling Process, PCM, Delta Modulation, Multiplexers. • **Random Process for communication systems:** Concept of Probability, Random Variables, Statistical functions (PDF, CDF, MGF), Central Limit Theorem, Classification of Random Processes, Power Spectral Density, Transmission of Random Processes Through LTI System.
Suggested Books	**Text Books** 1. B. P. Lathi and Z. Ding, **Modern Digital and Analog Communication Systems** [International 4th Edition], Oxford University Press, 2011, ISBN: 978-0198073802. 2. S. Haykin, **Communications Systems**, John Wiley and Sons, 2001, ISBN: 978-8126509041. **Reference Books**

	3. A. Papoulis and S. U. Pillai, **Probability, Random Variables and Stochastic Processes**: McGraw Hill Education, 4th edition, 2017: ISBN: 978-0070486584. 4. J. Ravichandran, **Probability and Random Processes for Engineers**: Dreamtech Press (Wiley): 2019: ISBN: 978-9389520026.

Course code	**EE 305**
Title of the course	**Electromagnetic Waves**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	To deliver the concepts and techniques of electromagnetics used to solve engineering problems.
Course Outcomes	• Application of electromagnetic (EM) principles to understand the working of radio frequency (RF) components • Understanding the meaning and significance of performance specifications of RF components
Course Content	• **Introduction:** Overview of static electric and magnetic fields, Steady electric currents, Time-varying EM fields, Maxwell's equations, Boundary conditions, Plane EM waves, Wave equations, Propagation in free space and other mediums, Phase velocity and group velocity, Poynting vector, Polarization, Reflection and refraction of EM waves at conducting and dielectric boundaries. • **Transmission Lines:** Transverse electromagnetic (TEM) wave, Transmission line equations, Characteristic impedance, Wave propagation along infinite and finite transmission lines, Transmission lines as circuit elements, Transients on Lines, Smith chart, Single and double stub matching. • **Waveguides:** Guiding structures, Transverse electric (TE) wave, Transverse magnetic (TM) wave, Waves in guided media, Parallel plate waveguide, Rectangular waveguide, Cavity resonator. • **Radiating Structures:** Basic theory of antennas and radiation characteristics, Elementary types of antennas.

Suggested Books	**Text Books** 1. D. K. Cheng, **Field and Wave Electromagnetics,** 2nd edition, Pearson Education, 1989, ISBN: 0201128195. 2. M. N. O. Sadiku, **Principles of Electromagnetics**, 6th edition, Oxford University Press, 2009, ISBN: 0199461856. 3. W. A. Haytt, J. A. Buck, and M. J. Aktar, **Engineering Electromagnetics**, 8th edition, Tata McGraw Hill, 2017, ISBN: 9339203275. **Reference Books** 4. R. E. Collin, **Foundations for Microwave Engineering**, 2nd edition, John Wiley and Sons, 2000, ISBN: 9780780360310. 5. D. M. Pozar, **Microwave Engineering**, 4th edition, John Wiley and Sons, 2013, ISBN: 9780470631553. 6. D. K. Misra, **Radio-frequency and Microwave Communication Circuits,** 2nd edition, John Wiley and Sons, 2004, ISBN: 9780471478737.

Course code	**EE 315**
Title of the course	**Power Systems**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	To provide a brief overview of the structure, and operation of power systems and enable students to perform basic analysis of the system.
Course Outcomes	• Understanding the difference between conventional and modern power systems. • Modelling of transmission lines, loads and the components of power system. • Knowledge of various operational problems in power systems and their analysis.
Course Content	• Introduction to power systems and its structure • Calculation of transmission line parameters • Analyzing the performance of transmission lines • Representation of power system components • Fault analysis • Load flow analysis • Power system stability
Suggested Books	**Text Books** 1. J. D. Glover, M. S. Sarma and T. J. Overbye, **Power Systems Analysis and Design**, Cengage learning, 2008, 4th edition, ISBN:13 978-0-534-54884-1. 2. D. P. Kothari and I. J. Nagrath, **Power System Engineering**, Tata McGraw Hill, 2003, 3rd edition, ISBN:13 978-0-07-049489-3. 3. J. J. Grainger and W. D. Stevenson, **Power System Analysis**, 4th edition, Tata McGraw Hill, 1994, ISBN: 0-07-113338-0.

	Reference Books 4. O. L. Elgerd, **Electric Energy Systems Theory: An Introduction**, Tata McGraw Hill, 1982, 2nd edition, ISBN:13 978-0070192300. 5. T. Gonen, **Electric Power Transmission System Engineering Analysis and Design**, CRC Press, 2009, 2nd edition, ISBN: 978-1-4398-0254-0.

Course code	**EE 317**
Title of the course	**Digital Signal Processing**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Knowledge of Signals and Systems
Course Objectives	• Introduction to the theory of digital signal processing. • Development of time and frequency domain techniques and algorithms for solving discrete-time signal processing problems.
Course Outcomes	• Proficiency in DSP techniques and algorithms for signal analysis, filtering, compression, and manipulation. • Ability to design and implement DSP solutions for real-world applications. • Strong foundation for careers in telecommunications, audio processing, image and video analysis.
Course Content	• **Brief review of discrete-time signals and systems**: Representation and classification of discrete-time signals and systems, Simple manipulations, Sampling and reconstruction, and discrete convolution and correlation. • **Z-Transform:** Forward transform, Inverse transform, Properties, and One-sided Z-transform. • **Frequency analysis:** Discrete-time Fourier series (DTFS), Discrete-time Fourier transform (DTFT), Discrete Fourier transform (DFT), Fast Fourier transform algorithms, Discrete Cosine transform (DCT). • **Design of digital filters:** Design of FIR filters, Design of IIR Filters • **Introduction to multi-rate signal processing.**

Suggested Books	**Text Books** 1. J. G. Proakis and D. G. Manolakis, **Digital Signal Processing: Principles, Algorithms, and Applications**, 4th edition., Pearson Education India, 2007. ISBN: 978-81-317-1000-5. 2. A. V. Oppenheim and Schafer, **Discrete Time Signal Processing**, Prentice Hall, 1989. ISBN: 13-9780132162920. **Reference Books** 3. S. K. Mitra, **Digital Signal Processing – A Computer-based Approach**, 4th edition, McGraw Hill Education, 2013, ISBN: 978-1259098581. 4. L. R. Rabiner and B. Gold, **Theory and Application of Digital Signal Processing**, Prentice Hall, 1992. ISBN: 13-9780139141010. 5. J. R. Johnson, **Introduction to Digital Signal Processing**, Prentice Hall, 1992. ISBN: 13-9788120307605.

Course code	**EE 351N**
Title of the course	**Microprocessors and Digital Systems Design Lab**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 0-0-2-1
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Knowledge of Digital Systems
Course Objectives	Familiarization of embedded programming and hardware concepts as an addition to the theory course
Course Outcomes	• Experimentation to have understanding of hardware and embedded programming • Understanding industry requirements, reading datasheets and system development in embedded systems
Course Content	A representative list of experiments in this lab are as follows: • Familiarization of a microcomputer • Embedded programming • Assembly level programming and timing diagrams • Introduction to micro-controllers and embedded C programming • Interfacting with I/O devices • Usage of Timer and Interrupts • Introduction to FPGA programming • Verilog / VHDL implementation of FSM (Finite State Machine) • Introduction to system development in System on Programmable Chip (SoPC) Design
Suggested Books	**Reference Books** 1. D. V. Hall, **Microprocessors and Interfacing**, Tata McGraw Hill,1991, ISBN: 978-1259006159. 2. R. S. Gaonkar, **Microprocessor Architecture: Programming and Applications with the**

	8085/8080A, Penram International Publishing, 2013, 6th edition, ISBN: 978-8187972884. 3. K. J. Ayala, **The 8051 Microcontroller: Architecture, Programming and Applications,** Cengage Learning, 2nd edition., ISBN: 978-8131500880. 4. D. A. Patterson, and J. H. Hennessy, **Computer Organization and Design The hardware and software interface**, Morgan Kaufman Publishers, 2016, ISBN: 978-0128017333.

Course Code	**EE 319**
Title of the Course	**Design and Analysis of Communication Networks**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of Department	Electrical Engineering
Course Objectives	• Introduction to Queuing Theory and its application to analyze communication protocols. • Knowledge of MAC protocols, event-based programming for communication network simulations.
Course Outcomes	• Equip students with basics of communication networks. • Familiarization with protocols used in wired and wireless communication networks. • Simulation platform for the implementation of communication networks
Course Syllabus	• **Introduction to Data Networks and Motivation for Queuing Theory:** Basics of communication networks and layers. Queues in MAC layer and scheduling problems. • **General Description of a Queuing System:** Stochastic Processes, Discrete-Time Markov Chains – Homogeneity, reducibility, periodicity, recurrent null and recurrent non-null Markov chains, Chapman-Kolmogorov Equations, Birth-death Process, and relation to Exponential and Poisson distributions. • **Queuing Analysis using Markov Chains:** Kendal's notation of queuing systems, M/M/1, M/M/m, M/M/1/K, Method of Stages, PASTA property, Bulk Arrivals and bulk service, Network of Queues, Burke's and Jackson's Theorems. M/G/1 queues using Imbedded Markov Chain Technique, P-K Formula, G/G/1 and Lindley's Equation. • **Application to Telecom Networks and MAC protocol Analysis:** Aloha, Slotted Aloha, Stability Analysis, CSMA-CD and CSMA-CA (IEEE 802.11). • **Tutorials:** Use of network simulator: Event Based Programming, OMNet++ to create queues and network of queues and evaluate the performance from simulation and match with theory. Simulate and evaluate the performance of MAC protocols in

	OMNET++.
Suggested Books	**Text Books** 1. L. Kleinrock, **Queueing Systems, Volume I: Theory: 1**, 1st Edition, Wiley-Interscience, 1975, ISBN: 9780471491101. 2. D. Bertsekas, and R. Gallager, **Data networks,** 2nd Edition**,** Prentice Hall India Learning Private Limited, 1992, ISBN: 978-8120307803. **Reference Books** 3. S.K. Bose, **An introduction to queueing systems**, 1st Edition, Springer Science and Business Media, 2002, ISBN: 978-1-4615-0001-8. 4. J.F. Shortle. J. M. Thompson, D. Gross., and C.M. Harris **Fundamentals of queueing theory,** 2018, John Wiley and Sons, ISBN: 9781118943526. 5. A. Papoulis, S. Pillai, **Probability and Statistics,** 4th Edition, McGraw Hill Education, 2017, ISBN: 978-0070486584.

Course code	**EE 321**
Title of the course	**Design of Photovoltaic Systems**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basic knowledge of Analog and Power Electronics
Course Objectives	A design-oriented course on photovoltaic (PV) systems: enable students to perform design and analysis of the PV cell electrical characteristics and interconnections and design integrated systems.
Course Outcomes	• Modelling of photovoltaic (PV) cells, systems, understanding their operation and control aspects. • Knowledge of various components in photovoltaic systems and their design and performance analysis, use of simulation tools.
Course Content	• **Introduction to PV Cells and Materials:** Potential of solar power in India, Applications of PV, Classifications of PV system architectures, Working principles of solar cells, Various solar cell materials. • **PV Output Characteristics and Circuit Models:** I-V Characteristics, Equivalent circuit models, temperature effects, series and parallel inter-connections, performance indices. • **Energy from the Sun:** Solar geometry fundamentals, incident energy estimation, Sizing of PV systems: standalone and grid connected cases. • **Maximum Power Point Tracking Concepts:** Basic Power Conditioning Circuits DC-DC Converters, PV battery interfaces, DC-AC Converters, PV grid interfaces, Various MPPT Algorithms, Design and simulation examples. • **Balance of system components:** Energy storage and power electronic interface sizing with examples. • **Design of Integrated PV systems:** Design examples

	of solar PV systems: solar lanterns, water pumping, residential applications: roof-top installation sizing for homes, building integrated PV systems. • **Costing and Life cycle analysis:** Solar PV arrays and balance of system life cycle and cost analysis. • **Safety Standards, Guidance and Regulation:** Interconnection Standards, System Integration with Low Voltage Networks, System integration with medium voltage networks.
Suggested Books	**Text Books** 1. W. Xiao, **Photovoltaic Power System: Modeling, Design, and Control,** 1st edition, Wiley, 2017, ISBN: 978-1119280347. 2. C. S. Solanki, **Solar Photovoltaics- Fundamentals, Technologies and Applications,** 3rd edition, Prentice Hall India Learning, 2014, ISBN: 978-8120351110. **Reference Books** 3. G. Petrone, G. Spagnuolo, M. Vitelli, N. Femia, **Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic Systems,** 1st edition, CRC Press Ltd., 2012, ISBN: 978-1466506909. 4. H. S. Ruschenbach, **Solar Cell Array Design Handbook: The Principles and Technology of Photovoltaic Energy Conversion**, Springer, 2014, ISBN: 978-9401179171. 5. Y. A. Jieb, E. Hossain, **Photovoltaic Systems: Fundamentals and Applications**, 1st edition, Springer, 2021, ISBN: 978-3030897796.

Course code	**EE 302**
Title of the course	**Control Systems**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Signals and Systems
Course Objectives	• Introduction to the theory and practice of control systems engineering (limited to the analysis and design of linear feedback systems.) • Analysis and design of feedback systems to meet specified requirements.
Course Outcomes	• Knowledge of mathematical modelling techniques for dynamic systems. • Performance and stability analysis techniques for linear dynamic systems. • Design techniques for feedback control for linear dynamic systems.
Course Content	• Basic concepts: Notion of feedback; open- and closed-loop systems. • Modeling and representations of control systems: Ordinary differential equations; Transfer functions; Block diagrams; Signal flow graphs; State-space representations. • Performance and stability: Time-domain analysis; Second-order systems; Characteristic-equation and roots; Routh-Hurwitz criteria. • Root-locus technique: Properties of and sketching the root locus; Design of compensators using root locus. • Frequency-domain techniques: Frequency responses; Bode-plots; Gain-margin and phase-margin; Nyquist plots; Compensator design: Proportional, PI and PID controllers; Lead-lag compensators. • State-space concepts: Controllability; Observability; pole placement result; Minimal representations.

Suggested Books	**Text Books** 1. N. S. Nise, **Control Systems Engineering**, 8th edition, Wiley, 2019. ISBN: 978-1-119-47422-7. 2. G. Franklin, J. D. Powell and A. Emami-Naeini, **Feedback Control of Dynamic Systems**, 8th edition, Pearson Education, 2021. ISBN-13: 978-0-137-51683-4. 3. F. Golnarghi and B. C. Kuo, **Automatic Control Systems**, 10th edition, McGraw Hill Education, 2018, ISBN-13: 978-9-387-57297-3. **Reference Books** 4. I. J. Nagrath and M. Gopal, **Control Systems Engineering**, 7th edition, New Age International Publishers, 2022, ISBN : 978-81-951755-8-1. 5. R. C. Dorf and R. H. Bishop, **Modern Control Systems**, 14th edition, Pearson, 2021, ISBN: 978-1-292-42237-4.

Course code	**EE 306**
Title of the course	**Digital Communications**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2 - 1 - 0 - 3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Knowledge of Probability and Random Processes and Communication Systems
Course Objectives	Impart the basic concepts of Digital Communications.
Course Outcomes	▪ Distinguish between various types of Digital Modulation techniques. ▪ Analyze distinct digital equalization methods. ▪ Perform sequence detection pertaining to Digital signal processing.
Course Content	• Review of Random Processes and Spectral analysis. • Elements of Detection Theory. Optimum detection of signals in noise. Coherent communication with waveforms- Probability of Error evaluations. Baseband Pulse Transmission- Inter-symbol Interference and Nyquist criterion. • Pass-band Digital Modulation schemes- Phase Shift Keying, Frequency Shift Keying, Quadrature Amplitude Modulation, Continuous Phase Modulation and Minimum Shift Keying. • Digital Modulation trade-offs. Optimum demodulation of digital signals over band-limited channels- Maximum likelihood sequence detection (Viterbi receiver). • Equalization Techniques. Synchronization and Carrier Recovery for Digital modulation.
Suggested Books	**Text Books** 1. J. M. Wozencraft, and I. M. Jacobs, **Principles of Communication Engineering,** John Wiley, 1965. ISBN: 978-0881335545 2. J. R. Barry, E.A. Lee, and D.G. Messerschmitt, **Digital Communication**, Kluwer Academic Publishers, 2004. ISBN: 978-1461349754 **Reference Books** 3. J. G. Proakis, **Digital Communications**, 4th edition, McGraw Hill, 2000. ISBN: 978-0071181839.

Course code	**EE 310**
Title of the course	**VLSI Systems and Technology**
Course Category	Department Core Course
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basic knowledge of Semiconductor Devices, Digital Electronics/Systems and Analog Circuits.
Course Objectives	• Involve students in the design and development of semiconductor chips • Hands on experience through a lab component using industry standard electronic design automation (EDA) tools and hardware description languages (HDL).
Course Outcomes	• To get familiar of industry standard EDA tools and HDL. • To introduce the concept of CMOS to GDS-II and RTL to GDS-II design flow to design the chip at appropriate technology node. • To get exposure of sending designs for tape-out and testing the chip.
Course Content	• VLSI Design Flow and Integrated Circuits (IC) Design Matrix, Introduction of Hardware Description Language (HDL), CMOS Manufacturing Process, MOS Transistor Layout and Design Rules, IC Packaging, • MOS Transistor Theory and Characteristics, CMOS Inverter Characteristics (Static and Dynamic), CMOS Inverter Performance Matrix (Delay, Power, Energy, Area), Static CMOS Logic Design, • Dynamic CMOS Logic Design, Combinational Logic Circuit Design (Multiplexer, Adder, Subtractor etc.), Sequential Logic Circuit Design (Latches, Flip-Flops, Counter, Register etc.), Semiconductor memories (SRAM, DRAM etc.)

Suggested Books	**Text Books** 1. N. H. E. Weste and D. M. Harris, **CMOS VLSI Design: A Circuit and Systems Perspective**, 4th edition, Pearson, Adison-Wesley, 2011, ISBN: 9780321547743. 2. J. M. Rabaey, A. P. Chandrakasan and B. Nikolic, **Digital Integrated Circuits: A Design Perspective**, 2nd edition, Pearson Education India, 2016, ISBN: 9789332573925. **Reference Books** 3. S. Palnitkar, **Verilog HDL: A Guide to Digital Design and Synthesis**, Pearson Education, Inc. and Dorling Kindersley, 2003, ISBN 13: 9788177589184.

Course code	**EE 352N**
Title of the course	**Control Systems Lab**
Course Category	Department Lab
Credit Structure	L - T - P - Credits 0-0-3-1.5
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	• Introduction to simulation and experimental aspects of control systems engineering. • Analysis and design of feedback systems to meet specified requirements and specifications that include stability, transient response, and steady-state performance.
Course Outcomes	• Gain better understanding of concepts taught in the associated Control Systems theory course. • Design of PI, PID controllers for feedback control of DC Motor System. • Develop expertise for stability analysis and controller design.
Course Content	A representative list of experiments for this lab: • Response of first-order and second-order systems • Modeling of DC motor and speed Control • Ziegler-Nichols tuning of speed controller of DC motor. • Open-loop response of the systems (gain, integrator, first-order lag, first-order lag with integrator, first-order lag with two integrators, transport lag, first-order lag with transport lag) • Closed-loop responses (gain, integrator, first-order lag, first-order lag with integrator, first-order lag with two integrators, transport lag, first-order lag with Transport lag) • Determination the following characteristics of the transfer function: a) Plotting of the pole-zero plot in *s*-plane. b) Determination of the close-loop transfer function and the block diagram. c) Plotting of unit step response of given transfer function and finds delay time, rise time, peak time and peak overshoot.

	d) Determination of the time response of given system subjected to any arbitrary input. e) Determining the steady-state errors of a given transfer function. f) Root locus plot of the given transfer function, locate closed loop poles for different values of K. • Generation of Bode Plot for transfer function and evaluation of relative stability through gain and phase margin analysis. • Construction of Nyquist plot for the given transfer function and analyze the closed-loop stability. Assess relative stability - gain and phase margin measurements. • Measurement of Resistance using Kelvin Bridge. • Measurement of Inductance using Maxwell Bridge and • Measurement of Capacitance using Desauty's and Schearing Bridge. • Study of linear variable differential transformer (LVDT) characteristics.
Suggested Books	**Reference Books** **1.** N. S. Nise, **Control Systems Engineering**, 8th edition, Wiley, 2019. ISBN: 978-1-119-47422-7. **2.** G. Franklin, J. D. Powell and A. E. Naeini, **Feedback Control of Dynamic Systems**, 8th edition, Pearson Education, 2021. ISBN-13: 978-0-137-51683-4. **3.** F. Golnarghi and B. C. Kuo, **Automatic Control Systems**, 10th edition, McGraw Hill Education, 2018, ISBN-13: 978-9-387-57297-3. **4.** J. A. Alloca, **Electronic Instrumentation**, Prentice Hall, 1987, ISBN: 0835916332. **5.** D. A. Bell, **Electronic Measurements and Instrumentation**, Oxford University Press, 3rd edition. ISBN: 019569614X.

Course code	**EE 356N**
Title of the course	**Communications Lab**
Course Category	Department Lab
Credit Structure	L - T - P - Credits 0 - 0 - 2- 1
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	None
Course Objectives	Experimentation on the basic concepts of Analog and Digital Communication Systems
Course Outcomes	• Gain better understanding of concepts taught in the associated communication courses. • Distinguish between different types of transmitters and receivers in Communication Systems • Validation of Modulation and Demodulation schemes
Course Content	A representative list of experiments in the lab are: a) Analog Communications: • To study different types of Amplitude Modulators and Demodulators. • Study of FM and Frequency Demodulation Receiver. • To set up a PAM modulator and demodulator circuits and to observe the waveforms. • To set up a PWM modulator and demodulator circuits and to observe and plot the waveforms. • To set up a PPM modulator and demodulator circuits and to observe and plot the waveforms. • To set up a PCM modulator and demodulator, and observe the waveforms • To set up a DM modulator and demodulator, and observe the waveforms b) Digital Communications: • To understand basics of sampling and generate a PN sequence and verify its auto-correlation property. • To study various line coding schemes and corresponding eye-patterns. • To set up ASK modulator and demodulator circuits and to observe the waveforms. • To set up Binary Phase Shift Keying (BPSK)

	modulator and demodulator circuits and to observe the waveforms. • To set up FSK modulator and demodulator circuits and to observe the waveforms. • To generate a QPSK modulation and demodulation signals using MATLAB. • To generate a DPSK modulation and demodulation signals using MATLAB.
Suggested Books	**Reference Books** 1. J. M. Wozencraft, and I.M. Jacobs, **Principles of Communication Engineering,** John Wiley, 1965. ISBN: 978-0881335545. 2. J. R. Barry, E. A. Lee, and D. G. Messerschmitt, **Digital Communication**, Kluwer Academic Publishers, 2004. ISBN: 978-1461349754. 3. J. G. Proakis, **Digital Communications**, 4^{th} edition, McGraw Hill, 2000. ISBN: 978-0071181839. 4. B. P. Lathi and Zhi Ding, **Modern Digital and Analog Communication Systems** [International 4^{th} edition, Oxford University Press, 2011, ISBN: 978-0198073802.

Course code	**EE 312**
Title of the course	**Microwave and Satellite Communication**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Electromagnetic Waves and Communication System Theory
Course Objectives	Exposure to the concepts and techniques of microwave and satellite communication systems.
Course Outcomes	• Apply electromagnetic (EM) principles to understand the working of radio frequency (RF) components. • Understanding of designing satellite communication links and how satellite communication works.
Course Content	• **Introduction to Microwave Communication:** Transverse electromagnetic (TEM) wave, Transmission line, Guiding structures, Transverse electric (TE) wave, Transverse magnetic (TM) wave, Waveguides, Cavity resonators. • **Microwave components:** S-parameter analysis of microwave components, Tees, circulators, directional couplers, attenuators, phase shifters. • **Microwave sources:** Klystron, Magnetron, Travelling wave tubes (TWTs), Backward wave oscillators (BWOs), Microwave semiconductor devices, Tunnel, PIN, and GUNN diodes; Microwave amplifiers. • **Introduction to Satellite Communication (SATCOM):** Overview and Applications of SATCOMs, Satellite Orbits and Launch Vehicles, Different Types of Satellite Systems, Satellite Subsystems, Telemetry, Tracking, Command and Monitoring (TTC and M), Communication Subsystems. • **Satellite Link Design:** Transmission Theory, Noise Temperature and G/T ratio, Design of Uplink and Downlink.

	• **Multiple Access Schemes:** FDMA, TDMA and packet switched systems; spread spectrum techniques and CDMA systems.
	Text Books 1. D. M. Pozar, **Microwave Engineering**, 4th edition, John Wiley and Sons, 2013, ISBN: 978-0470631553. 2. R. E. Collin, **Foundations for Microwave Engineering**, 2nd edition, John Wiley and Sons,2000, ISBN: 978-0-780-36031-0. 3. T. Pratt, J. Allnutt, **Satellite Communications,** 3rd edition, John Wiley and Sons, 2020, ISBN: 978-1119482178. **Reference books** 4. S. Y. Liao, **Microwave devices and circuits**, Pearson, ISBN No. 8177583530. 5. D. K. Misra, **Radio-frequency and Microwave Communication Circuits,** 2nd edition, John Wiley and Sons, USA, 2004, ISBN: 9780471478737. 6. D. Roddy, **Satellite Communications,** 4th edition, McGraw-Hill Education, 2017, ISBN: 978-0070077850.

Course Code	**EE 314**
Title of the Course	**Restructured Power Systems**
Course Category	Department Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any (for the students)	Fundamentals of Power Systems
Course Objectives	Exposure to the necessity of restructuring of power systems and the philosophy of operation of restructured power systems.
Course Outcomes	• Understanding the difference between operation of conventional and restructured power systems. • Knowledge of different market models and recognition of the new challenges emerging due to market-based operation of the power system.
Course Content	• **Introduction:** Difference between conventional and restructured power systems, reasons for restructuring of power system, key market entities and their responsibilities, various models of electricity supply industry. • **Trading of Electricity:** Various trading mechanisms, various types of markets to trade electricity, electricity market models in different countries, market clearing process, bidding strategies, market power and its mitigation. • **Operational Challenges:** Available transfer capability, transmission system congestion and its management. • **Transmission Pricing and Ancillary Services:** Power wheeling charges, various cost components, methods of transmission pricing, types of ancillary services and ways to obtain them.
Suggested Books	**Text Books** 8. M. Shahidehpour and M. Alomoush, **Restructured Electrical Power Systems: Operation, Trading and Volatility**, CRC Press, 2001, ISBN: 9781138582330. 9. L. Philipson and H. L. Willis, **Understanding Electric Utilities and Deregulation**, CRC Press, 2005, 2nd

	edition, ISBN: 978-0824727734. 10. S. A. Khaparde and A. R. Abhyankar, **Restructured Power System**, Alpha Science International Ltd, 2015, ISBN: 978-1842653111. **Reference Books** 11. K. Bhattachrya, M. Bollen and J. Daalder, **Operation of Restructured Power Systems**, Springer, 2001, 1st edition, ISBN: 978-1461355670. 12. L. L. Lai, **Power System Restructuring and Deregulation**, Wiley, 2001, ISBN: 47149500X.

Course code	**EE 316**
Title of the course	**RF devices for guided and wireless transmission**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Understanding of Electromagnetic Waves
Course Objectives	To provide an understanding of RF modules in wired and wireless transmission.
Course Outcomes	• Identify RF modules in any communication system. • Analyze and design different types of RF devices and systems.
Course Content	• **Transmission Line:** Review of transmission line, Smith Chart, Impedance matching, TEM, TE and TM modes, Coaxial cable, microstrip, stripline, coplanar waveguide, etc. • **Passive guiding devices:** Microstrip and waveguide-based devices of power splitter and combiners, couplers, filters, attenuator. • **Active guided devices:** Switches, phase shifters, amplifiers, low noise amplifers, mixer, oscillators. • **Radiating Structures:** Physical concept of radiation, antenna fundamentals, Friis transmission equation, wire antennas- dipole, monopole, loop, helical, Yagi-uda, Aperture antennas- slot, microstrip, horn, reflector, broadband antennas, Antenna arrays. • **Microwave Systems:** Use case of guided and radiating structures, few examples: Mobile Phone Architecture, Gound penetrating Radar, Vector Network Analyzer, RF Energy Harvesting, etc.
Suggested Books	**Text Books** 13. D. M. Pozar, **Microwave Engineering**, 4th edition, John Wiley and Sons, 2013, ISBN: 978-0470631553.

	14. R. E. Collin, **Foundations for Microwave Engineering**, 2nd edition, John Wiley and Sons, 2000, ISBN: 978-0-780-36031-0. 15. C. A. Balanis, **Antenna Theory: Analysis and Design**, John Wiley and Sons, 2005, ISBN: 978-0471667827. **Reference Books** 16. S. Y. Liao, **Microwave devices and circuits**, Pearson, ISBN: 8177583530. 17. D. K. Misra, **Radio-frequency and Microwave Communication Circuits**, 2nd edition, John Wiley and Sons, 2004, ISBN: 9780471478737.

Course code	**EE 410/ 610**
Title of the course	**Power Electronics Applications to Power Transmission**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Power Systems and Power Electronics
Course Objectives	Impart the applications of power electronics specifically in power transmission to improve system performance along with their advantages and disadvantages.
Course Outcomes	• Ability to analyze the HVDC transmission system and specific situations when they are beneficial • Understand the usage of different FACTS devices
Course Content	• Introduction to power electronics applications to power system • HVDC Transmission • Analysis of HVDC converters • HVDC control, maloperation and protection of converters • Basic FACTS controllers: SVC, STATCOM, TCSC, SSSC, TCPAR, UPFC, IPFC • Modeling of FACTS controllers • Improvement in system performance with FACTS controllers
Suggested Books	**Text Books** 1. K. R. Padiyar, **HVDC Power Transmission Systems**, New Age International (P) Limited, 2015, ISBN: 9788122437850. 2. N.G. Hingorani and L. Gyugyi, **Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems**, Wiley, 2000, ISBN: 9780780334557.

	Reference Books 3. J. Arrillaga, **High Voltage Direct Current Transmission**, IET, 1998, ISBN: 9780852969410. 4. E. W. Kimbark, “**Direct Current Transmission-Volume I**”, Wiley-Interscience, 1971, ISBN: 0471475807. 5. Y. H. Song and A. T. Johns, **Flexible AC Transmission System**, IEEE Press,1999, ISBN: 978-0852967713. 6. R. M. Mathur and R. K. Varma, **Thyristor-Based FACTS Controllers for Electrical Power Systems**, IEEE Press and John Wiley, 2002, ISBN: 9780471206439.

Course code	**EE 422/622**
Title of the course	**Digital Circuit Design**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basic knowledge of MOS transistor theory and CMOS circuit design
Course Objectives	• To develop the concepts of designing circuits associated with signal processing methods.
Course Outcomes	• Understanding the fundamentals of MOS logic design. • Skills in simulation of combinational and sequential MOS logic and memories.
Course Content	• Module 1: MOS scaling, Short channel effects, MOSFET models, Nano CMOS, Effects of gate oxide tunnelling, high-k dielectrics, Advanced CMOS structures, SOI, MOSFET capacitances, MOSFET models for calculation, Transistors and Layout, CMOS layout elements, SPICE simulation of MOSFET I-V characteristics and parameter extraction. • Module 2: CMOS inverter, static characteristics, noise margin, dynamic characteristics, inverter design for a given VTC and speed, effect of input rise time and fall time, power dissipation, energy and power delay product, sizing chain of inverters, latch up effect-Simulation of static and dynamic characteristics. • Module 3: Combinational and sequential MOS logic design, static properties, propagation delay, Elmore delay model, power consumption, low power design techniques, rationed logic, pseudo NMOS inverter, DCVSL, PTL, DPTL and Transmission gate logic, dynamic CMOS design, speed and power considerations, Domino logic and its derivatives, C2MOS, TSPC registers, NORA CMOS.

	• Module 4: Semiconductor memories, SRAM and DRAM, BiCMOS logic - static and dynamic behavior - Delay and power consumption in BiCMOS Logic.
Suggested Books	**Text Books** 1. S. M. Kang and Y. Leblebici, **CMOS Digital Integrated Circuits Analysis and Design**, 3rd edition, Tata McGraw Hill, 2003, ISBN: 978-0- 07-053077-5. 2. J. M. Rabaey, A. P. Chandrakasan and B. Nikolic, **Digital Integrated Circuits: A Design Perspective,** 2nd edition, Prentice Hall, 2003, ISBN: 978-0130909961. **Reference Books** 3. D. A. Hodges, H. G. Jackson, and R. A. Saleh, **Analysis and Design of Digital Integrated Circuits**, 3rd edition, McGraw Hill, 2004, ISBN: 978-0070593756.

Course code	**EE 426/626**
Title of the course	**MOSFET Reliability Issues**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basic knowledge of MOS device and technology
Course Objectives	• Understanding of the various phenomena causing failures in MOSFETs • Impart knowledge on the mechanisms of the causes for failures and the possible work arounds.
Course Outcomes	• Knowledge of the various mechanisms causing reliability issues in the modern CMOS devices and testing aspects.
Course Content	• Evolution of VLSI Device Technology: Modern CMOS Devices, MOSFET I-V characteristics, Substrate bias and temperature dependence of threshold voltage, Channel mobility, inversion layer capacitance effect. Short channel effects, velocity saturation, channel length modulation, source-drain series resistance, MOSFET breakdown. • High Field Effects: Impact ionization and avalanche breakdown, Band to band tunneling, Tunneling into and through silicon dioxide, Injection of hot carriers from silicon into silicon dioxide, High field effects in gated diodes. • Modeling Hot carrier Effects: Substrate current model, Gate current model, Correlation between gate and substrate current, Mechanism of MOSFET degradation, Impact of degradation on circuit performance, Temperature dependence of device degradation. • Electrostatic Discharge Damage: Introduction to reliability concepts and modeling. Triboelectricity, ESD control, On-chip protection, ESD models and testing, ESD models and testing procedures, failure models.

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- Metal Electro migration: Phenomenon of Electro migration, Theoretical and empirical relations, Effects of stress and gases on electro migration, effects of geometric variation and defects, Electro migration at the contacts and windows, layered metallization, Electro migration in polysilicon, Electro migration under pulsed currents.

- Dielectric Breakdown: Introduction, Complex nature of oxide breakdown, Oxide breakdown strength distribution, TDDB life test, Oxide defects, Concept of distance to fail, Step stress techniques, correlation of ramp test data to TDDB data.

- Packaging Relation Reliability Issues: Effects of moisture, Detection and package evaluation, stress in packaging, Issues related to die bonding, Solder joint problem, Electrolytic corrosion, Accelerated reliability tests for packages

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<tr><td>Suggested Books</td><td>

Text Books

1. Y. Taur and T. H. Ning, **Fundamentals of Modern VLSI Devices,** Cambridge University Press, ISBN: 0-521-55959 6.
2. N. Arora, **MOSFET Modeling for VLSI Simulation: Theory and Practice**, World Scientific, ISBN-13 978-981-256-862-5.

Reference Books

3. Y. Leblebici, S.M. Kang, **Hot-Carrier Reliability of MOS VLSI Circuits,** Springer, 1993, ISBN 978-0-792393528.
4. A. W. Strong, E. Y. Wu, R.P. Vollertsen, J. Sune, G. L. Rosa, T. D. Sullivan, S. E. Rauch III, **Reliability Wearout Mechanisms in Advanced CMOS Technologies**, Wiley-IEEE Press, 1999, ISBN: 978-0471731726.

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Course code	**EE 428/628**
Title of the course	**Advanced Memory Technology**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Fundamentals of Electronic Devices, and VLSI Systems and Technology
Course Objectives	• Provide a background on the evaluation on the memory technologies (both optical/ electronic). • Knowledge on non-volatile and volatile memories. • Over view of emerging memory technologies and their importance
Course Outcomes	• Exposure to memory technologies and state of the art in the domain, challenges and future research directions.
Course Content	• Introduction to memory devices: Evolution and history; archival data storage; advances in optical memories. • Nonvolatile memories: Magnetic memories, HDDs; Silicon based thin film transistor nonvolatile memories; Flash memories, classification and operation; challenges; advancements. • Volatile memories: Random access memories, classification and operation; SRAM.S, DRAM.S., history and challenges. • Emerging memory technologies: Phase Change Memory (PCM); Magnetoresistive Random Access Memory (MRAM); Ferroelectric Random Access Memory (FeRAM); Comparison and future directions.
Suggested Books	**Text Books** **1.** T. Y. Tseng and S.M. Sze, **Nonvolatile memories-Materials, Devices and Applications**, American Scientific Publishers; Volume 1 and 2, 2012, ISBN:

	978-1588832504. **2.** J. Brewer and M. Gill, **Nonvolatile memory technologies with emphasis on Flash**, IEEE Press series on microelectronic systems, Wiley-Interscience 2008, ISBN: 978-0471-77002-2. **Reference Books** **3.** S. Raoux and M. Wuttig, **Phase change materials-Science and Applications**, Springer, 2009, ISBN:978-0-387-84873-0.

Course code	**EE 434/634**
Title of the course	**Semiconductor Based Sensors**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Knowledge of Electronic Devices
Course Objectives	• Familirization with the various types of sensors and their principles of operation • Integrated sensors and practical applications in the field
Course Outcomes	• Fundamentals of semiconductor based sensors and their applications.
Course Content	• Introduction: Introduction and classification of sensors, sensors and transducers, Semiconductor sensors and their classification, sensor characterization, Evolution of semiconductor sensors. • Semiconductor Sensors Technologies: Introduction to basic fabrication processes, Micromechanical Process Design, Bulk Micromachining, surface micromachining, other manufacturing techniques, Applied Statistics and Probability in semiconductor manufacturing. • Mechanical Sensors: Piezoresistivity, and Piezoresistive sensors, Capacitive sensors, Piezoelectric materials and acoustic sensors, SAW based sensors, strain gauge and cantilever based sensors. Thermal sensors, Thermal sensing elements, Micro/Nanoelectromechanical sensors (MEMS/ NEMS). • Magnetic and Optical sensors: Integrated Hall sensors, magnetotransistors, photodiodes and phototransistors, HgCdTe based Infrared sensors, High energy photodiodes.

	• Chemical and Biosensors: Introduction to interaction of gaseous species at semiconductor surfaces, thin film based sensors, Field Effect Transistor (FET) devices for gas/ ion sensing, Immobilization of enzymes in biosensors, Transduction principles and packaging on biosensors. • Integrated Sensors: Introduction, System Organization and Functions, Interface electronics, Examples of Integrated sensors.
Suggested Books	**Text Books** **1.** M. Gad-el-Hak, **The MEMS Handbook**, CRC Press, 2005, ISBN: 0- 8493-0077-0. **2.** S. M. Sze, **Semiconductor Sensors**, J. Wiley, 1994, ISBN: 978- 0471546092. **3.** R. Shinar and J. Shinar, **Organic Electronics in Sensors and Biotechnology**, Mc Graw Hill, 2009, ISBN: 978-0071596756. **Reference Books** **4.** J. W. Gardner, **Microsensors: Principles and Applications**, Wiley, 1994 ISBN: 978-0471941361. **5.** S. Middelhoek, S. Audet, **Silicon Sensors**, Academic Press, 1989, ISBN: 0- 12-495051-5. **6.** R. F. Wolffenbuttel, **Silicon Sensors and Circuits: On Chip compatibility**, Chapman and Hall, 1995 ISBN: 0-412-70970-8.

Course code	**EE 438/ EE 638**
Title of the course	**System on Programmable Chip Design**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Digial Systems, Microprocessor and Microcontrollers
Course Objectives	• Familirization with the FPGA fundamentals • Experimentation on latest system on chip technologies and understand industrial applications
Course Outcomes	• Understand the fundamentals of hardware description language and progamming field programmable gate array (FPGA) • Familiarization with System on Chip concepts and applications • Design solutions for industry applications related to digital electronics
Course Content	• Introduction Driving Forces for SoC - Components of SoC - Design flow of SoC - Hardware/Software nature of SoC - Design Trade-offs - SoC Applications. • System-level Design Processor selection, Concepts in Processor Architecture: Instruction set architecture (ISA), CISC, RISC-Processor evolution: Soft and Firm processors, Custom-Designed processors- on-chip memory. • IP based system design Introduction to IP Based design, Types of IP, IP across design hierarchy, IP life cycle, Creating and using IP - Technical concerns on IP reuse – IP integration - IP evaluation on FPGA prototypes. • Interconnection On-chip Buses: basic architecture, topologies, arbitration and protocols, Bus standards like

	AMBA. Network-onchip: Architecture-topologies-switching strategies - routing algorithms - flow control. • SOC implementation Study of processor IP, Memory IP, wrapper Design - Real-time operating system (RTOS), Peripheral interface and components, High-density FPGAs - EDA tools used for SOC design. SoC testing.
Suggested Books	**Text Books** ~~18.~~13. L. H. Crockett, R. A. Elliot, M. A. Enderwitz, **The Zynq Book: Embedded Processing with the Arm Cortex-A9 on the Xilinx Zynq-7000 All Programmable Soc.** Strathclyde Academic Media, 2014, ISBN:978099297870. ~~19.~~14. M. J. Flynn, W. Luk, **Computer system Design: System-onChip**, Wiley-India, 2011, ISBN: 978-0-470-64336-5. ~~20.~~15. S. Pasricha, N. Dutt, **On Chip Communication Architectures: System on Chip Interconnect**, Morgan Kaufmann Publishers.1st edition, 2008, ISBN-13: 9780123738929. **Reference Books** ~~21.~~16. W. H. Wolf, **Computers as Components: Principles of Embedded Computing System Design**, Elsevier, 2008, 2nd edition, ISBN:9780080886213. ~~22.~~17. P. Schaumont, **A Practical Introduction to Hardware/Software Co-design**, Springer, 2012. 2nd edition, ISBN:9781461437369. ~~23.~~18. W. Wolf, **Modern VLSI Design: IP Based Design**, Prentice-Hall India, 4th edition, 2009, ISBN: 978-0137145003.

Course code	**EE 440/640**
Title of the course	**Analog and Mixed Signal IC Design**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Knowledge about basic electronics and basic electrical circuits
Course Objectives	• Make students well adept in the area of Analog and mixed signal IC design
Course Outcomes	• Understand the design challenges associated with mixed IC design • Analysis of various analog and mixed signal circuits with practical examples.
Course Content	• Basic Analog Building Blocks: Switches, active resistors, current sources, current mirrors, current and voltage sources, Wilson and Widlar current mirrors, basic bipolar and CMOS process technology, D-A and A-D converters, filter design considerations. • Amplifiers: CMOS based differential and operational amplifiers, multipliers, modulators, quasi differential amplifier, errors due to mismatch, replication principle, qualitative analysis, common mode response, frequency response, noise performance of differential amplifiers. • Advanced Analog and Mixed Signal Design: Mixed signal blocks and design issues, design of high speed comparators, Opamps, design of sample and hold circuits, design of CMOS based analog multipliers and dividers, switched capacitor filters, frequency compensation schemes viz. Miller compensation.

Suggested Books	**Text Books** 1. R. Gregorian and G. C. Temes, **Analog MOS Integrated Circuits for Signal Processing**, John Wiley and Sons, 1986, ISBN:1978-0137145003. 2. R. Geiger, P. E Allen and N. Stradder, **VLSI Design Techniques for Analog and Digital Circuits**, Mc-Graw Hill International Edition, 1990, ISBN: 9780070232532. **Reference Books** 3. P. E Allen and D. R Holberg, **CMOS Analog Design Circuit**, Oxford University Press, 2002. ISBN: 9780199937424.

Course code	**EE 446/646**
Title of the course	**Information and Coding Theory**
Course Category	Departmental Elective
Credit Structure	L - T - P – Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Concepts of probability theory, statistics, with understanding of signal processing and communications. *Note the student should not get confused “Information Coding” with “Software code writing / coding”
Course Objectives	Baics of quantitative theory of information and its applications to reliable, and efficient communication systems design
Course Outcomes	• Engineering knowledge: Apply the knowledge of mathematics, communications and signal processing to the solution of complex communication system design problems. • Design/development of solutions: Design solutions for complex, and both wireless and wireline communication systems.
Course Content	• Information measure and entropy, information rate, joint and conditional entropies, mutual information • Discrete memoryless channels, BSC, BEC, channel capacity, Shannon limit. • Source coding, adaptive Huffman coding, arithmetic coding, LZW, Hamming weight, Hamming distance, minimum distance decoding. • Single parity codes, Hamming codes, repetition codes, linear block codes, cyclic codes, convolutional codes. • Sequential and probabilistic decoding, principle of Turbo coding, burst error-correcting codes. • Introduction to some commercial coding techniques.

Suggested Books	**Text Books** 1. T. M. Cover and J. A. Thomas**, Elements of Inform Theory,** 2nd edition, Wiley-Interscience, 2006, ISBN: 0471241959. 2. R. Gallagher, **Information Theory and Rel Communication**, Wiley; 1968, ISBN: 978-047129048 **Reference Books** 3. R. Bose**, Information Theory, Coding Cryptography,** Tata McGraw Hill Education Pvt. 2007, ISBN: 978-0070151512. 4. K. Sayood, **Introduction to Data Compression** edition, Morgan Kaufmann; 2012, ISBN: 0124157965. 5. S. Gravano, **Introduction to Error Control Codes**, C University Press, 2001, ISBN: 978-0198562313.

Course code	**EE 447/ 647**
Title of the course	**Advanced Photonics**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0 - 3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Not Applicable
Course Objectives	• Fundamentals of optoelectronics, photonics and its multidisciplinary applications including optical fiber communication. • Basics and technology of photonic devices, components and systems including device fabrication.
Course Outcomes	• Understand concepts and advances in Photonics Technology including major optical devices and components • Learn optical wave propagation in structured media, modal coupling, and their multidisciplinary applications. • Knowledge of semiconductor photonics, Nano-photonics and its applications.
Course Content	• **Introduction to Optical Fiber Communication**: Nature of light; optical communication; optical fibers; propagation of light in optical fibers; transmission characteristics of optical fibers; fabrication of optical fibers. • **Planar Optical Waveguides, Passive Devices and Components**: Waveguide classification, step-index waveguides, graded-index waveguides, Coupled mode theory, grating in waveguide structure, bent waveguides, Optical Cross Connects, directional coupler, Bragg reflectors, waveguide filters, Arrayed Waveguide Grating (AWG), Multiplexer, Demultiplexer.

	• **Active Photonics Devices:** Spontaneous and stimulated emission, emission from semiconductors, LEDs – Basics and Technology, Semiconductor injection lasers, Single frequency lasers, VCSEL, Optical amplifiers, Photodetectors, Electro-optic modulator, Electro-absorption modulator, Graphene based optoelectronic devices. • **Silicon Photonics**: Introduction, CMOS compatible fabrication, Silicon-on-insulator (SOI) Technology, silicon modulators, non-linear silicon photonics, lasers on silicon, CMOS-Photonic hybrid integration, Silicon-germanium photodetector. • **Elements of Nano-photonics** Photonic crystals and their applications, Surface plasmon polaritons, Slow light and its applications, Introduction to Optical Interconnects.
Suggested Books	**Text Books** 1. J.M. Senior, **Optical Fiber Communications**, Pearson Education, 2009, ISBN: 8131732665, 9788131732663. 2. Amnon Yariv and Pochi Yeh, Photonics, **Optical Electronics in Modern Communication**, 6th edition, Oxford Press, 2006, ISBN: 9780195179460. 3. B. E. A. Saleh and M. C. Teich**, Fundamentals of Photonics**, Wiley, 2007, ISBN: 9780471358329. **Reference Books** 4. Ghatak and Thyagarajan, **Introduction to Fiber Optics**, Cambridge University Press, 2013, ISBN: 9780521577854. 5. Keiser, **Optical Fiber Communications**, Tata McGraw 2011, ISBN: 0070648107. 6. Chuang, **Physics of Optoelectronic Devices**, Wiley, 2008, ISBN 9780470293195.

Course code	**EE 448/648**
Title of the course	**Antennas and Propagation**
Course Category	Department Elective
Credit Structure	L - T - P – Credits 3-0-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Electromagnetic Waves
Course Objectives	To provide an in-depth understanding of antenna fundamentals, modern antenna concepts and practical antenna design for various applications.
Course Outcomes	● Understand the foundational design aspects and performance parameters of antennas. ● Critically analyze and characterize antennas from antenna parameters and design antenna arrays with required radiation pattern characteristics.
Course Content	• **Introduction:** Antenna theorems and definitions, radiation patterns, beamwidth, directivity, gain, efficiency, bandwidth, polarization, input impedance, Friis transmission equation and radar equation. • **Potential functions and theorems:** Vector potential for electric and magnetic current source, duality theorem, reciprocity theorem, reaction theorem. • **Single-element antennas:** Linear wire antennas, loop antennas, travelling wave antennas, broadband antennas, aperture antennas, microstrip antennas, reflector antennas, antenna measurements. • **Antenna arrays:** Array theorems, two-element linear array, N-element linear array, array factor, super directivity, planar array, circular array. • **Antennas for modern communication:** Circularly polarized antennas, base station antennas (cellular / Wi-Fi / GPS / WiMAX), multiple-input multiple-output (MIMO) antennas, smart antennas.
Suggested Books	**Text Books**

	1. C. A. Balanis, **Antenna Theory: Analysis and Design**, John Wiley and Sons, 2005, ISBN: 978-0471667827. 2. J. D. Kraus, R. J. Marhefka, and A. S. Khan, **Antennas and Wave Propagation**, McGraw-Hill, 2017, ISBN: 978-9352606184. 3. R. S. Elliot, **Antenna Theory and Design**, Wiley-IEEE Press, 2003, ISBN: 9780471449966. **Reference Books** 4. T. A. Milligan, **Modern Antenna Design**, Wiley-IEEE, Press, 2005, ISBN: 978-0-471457763. 5. J. L. Volakis, **Antenna engineering handbook**, New York, McGraw-Hill, 2007, ISBN: 978-0071475747. 6. W. L. Stutzman and G. A. Thiele, **Antenna Theory and Design,** John Wiley and Sons, 2012, ISBN: 978-0470576649.

Course code	**EE 450N/650N**
Title of the course	**IoT Communication Networks**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Students are expected to have basic knowledge of Probability Theory, Signal Processing and Communications.
Course Objectives	• To get acquainted with the networking aspects of the Internet of Things (IoT). • Gain state-of-the-art knowledge with typical IoT inspired networking concepts
Course Outcomes	• **Foundational Understanding:** Gain insight into IoT network types, protocols, and the layered structure, including wireless sensor networks and cellular technologies. • **Evolutionary Analysis:** Explore the transition from pre-5G to 5G/6G • **Applications:** Investigate real-world implementations of IoT networks in domains like IoV, drones, industrial IoT, and beyond.
Course Content	• **Introduction to IoT Networks:** What is IoT network? Types of IoT networks available for IoT devices; Networking protocols; Understanding layers of network in IoT space; Cooperative and Cognitive wireless Sensor and Ad-hoc networks. • **IoT Networks in the pre-5G Era:** Cellular (3G/4G) networks; Local and Personal Area Networks (LAN/PAN); 6LoWPAN; Low Power Wide Area Networks (LPWAN); Mesh networks; Key players for LPWAN: SigFox (ultra-narrow band), and LoRaWAN (long range Wireless Area Network); 4G LTE networks: LTE-M (Cat-M1 chipset) and Narrowband IoT (NB-IoT); Applications to Machine-to-Machine (M2M) connections; Limitation on capacity of LTE/LTE-Advanced networks. • **Evolution of 5G-IoT Network and Beyond:** Usage scenarios for 5G/6G networks; International Telecommunication Union (ITU) supporting IoT devices: Enhanced Mobile Broadband (eMBB), Massive Machine-type Communications (mMTC), and Ultra-reliable

	and Low-Latency Communications (URLLC); 5G New Radio (NR) technology; Learning driven 6G-IoT networks. • **IoT Network Modelling, Performance, and Security:** Stochastic Modelling; Performance Metrics and Evaluation; Spectral and Energy Efficiency analysis; Basic IoT network Security requirements; Securing different stack layers (e.g., LANs, network, transport); Low-powered IoT-based networks: Energy consumption versus harvesting prospects. • **IoT Applications:** Internet of Vehicles (IoV); Drones/UAVs as Flying IoT; Resource management and mobility management; Vehicular/Mobile Edge/Cloud Computing; Industrial IoT (IIoT): Exploration of wireless IoT networks for Smart Manufacturing; Industry 4.0; Internet of Molecular Things (IoMT); Internet of Space (IoS); Internet of Everything (IoE).
Suggested Books	**Text Books:** 1. D. Hanes, G. Salgueiro, P. Grossetete, R. Barton, J. Henry**, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things,** Cisco Press, 2017, ISBN: 9780134307091. 2. P. Lea, **Internet of Things for Architects,** Packt (sic) Publishing, 2018, ISBN: 9781788470599. **Reference Books:** 3. N. H. Mahmood, N. Marchenko, M. Gidlund, P. Popovski, **Wireless Networks and Industrial IoT: Applications, Challenges and Enablers,** Springer Nature, Switzerland, 2021, ISBN: 978-3-030-51472- 4. S. Misra, A. Mukherjee, and A. Roy, **Introduction to IoT,** Cambridge University Press, 2021, ISBN: 9781108913560.

Syllabi
of
Mechanical Engineering Courses

1.	Course Code	**ME 201**
2.	Title of the Course	**Solid Mechanics**
3.	Credit Structure	L-T-P-Credits 3-1-0-4
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Analysis of Axially Loaded Components, Statically Determinate and Indeterminate Problems; Castigliano's Theorem. Stress and Strain Tensors. Mohr Circle. Stress-strain Relations; Stress-strain-temperature Relations. **Analysis of Bending and Shear Loaded Components:** Beams; Shear Force and Bending Moment Diagrams. Stresses in Beams. Torsion of Circular Shaft. Basic Equations of Elasticity. **Material Testing:** Properties under tension, impact, fatigue and creep. Strain Rosettes. Introduction to Elastic-plastic Bending of Beams and Torsion of Circular Shaft. Thick Cylinder; Interference Fit; Rotating Disc.
8.	Suggested Books	1. S.H. Crandall, N.C. Dahl, and T.J. Lardner, **An Introduction to Mechanics of Solids**, McGraw Hill, 1978. 2. E.P. Popov, **Introduction to Mechanics of Solids**, Prentice Hall of India,1993. 3. J. Case and A.H. Chilver, **Strength of Materials and Structures**, Edward Arnold, 1980. 4. L.S. Srinath, P. Desai, N.S. Murthy, and A.S. Murthy, **Strength of Materials**, Macmillan India, 1997. 5. F.P. Beer, E.R. Johnston, **Mechanics of Materials**, Tata McGraw Hill, 2010, 5th ed., New Delhi.

1.	Course Code	**ME 251**
2.	Title of the Course	**Solid Mechanics Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Exp.1 Experiments associated with tensile testing Exp.2 Experiments associated with torsion testing Exp.3 Experiments associated with buckling Exp.4 Experiments associated with hardness and micro-hardness testing Exp.5 Experiments associated with fatigue testing and impact testing Exp.6 Experiments associated with beam bending Exp.7 Experiments associated with strain gauges Exp.8 Experiments associated with photo-elasticity Exp.9 Experiments associated with creep test and biaxial loading experiments
8.	Suggested Books	1. S.H. Crandall, N.C. Dahl, and T.J. Lardner, **An Introduction to Mechanics of Solids**, McGraw Hill, 1978. 2. J.W. Dally, and W.F. Riley, **Experimental Stress Analysis**, McGraw Hill,1987. 3. E.O. Doebelin and D.N. Manik, **Measurement Systems: Applications and Design**, Tata McGraw Hill, New Delhi, 2007.

1.	Course Code	**ME 202**
2.	Title of the Course	**Strength of Materials**
3.	Credit Structure	L-T-P-Credits 3-1-0-4
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	A course in Solid Mechanics
6.	Scope of the course	
7.	Course Syllabus	Bending of Curved Bars. Unsymmetrical Bending. Introduction to Bending of Thin, Plates and Shells. Deflection of Beams: Methods based on integration, Singularity function, Energy Principles (virtual work, minimum potential energy, reciprocal theorem, etc.), Superposition Principle, etc. Statically Indeterminate Problems: Continuous Beams, Buckling of beams, Euler load, Secant and Rankine-Gordon Formulae. Theories of Failure. Introduction to Griffith Theory. Torsion of Thin Box Sections. Thermal Stress Analysis for Rectangular and Circular Plates. Photoelasticity.
8.	Suggested Books	1. L.S. Srinath, **Advanced Mechanics of Solids** (2nd edition), Tata McGraw Hill, 2003. 2. S.P. Timoshenko, and J.N. Goodier, **Theory of Elasticity**, McGraw Hill, (International Students Edition), 1982. 3. S.H. Crandall, N.C. Dahl, and T.J. Lardner, **An Introduction to Mechanics of Solids**, McGraw Hill, 1978. 4. E.P. Popov, **Introduction to Mechanics of Solids**, Prentice Hall of India,1993. 5. J. Case and A.H. Chilver, **Strength of Materials and Structures**, Edward Arnold, 1980.

1.	Course Code	**ME 203**
2.	Title of the Course	**Fluid Mechanics**
3.	Credit Structure	L-T- P-Credits 3-1-0-4
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Introduction and Fundamental Concepts, Fluid Statics, Flow Kinematics, Conservation Equations and Analysis of Finite Control Volume, Applications of Equations of Motion and Mechanical Energy, Dimensional Analysis, Flow of Ideal Fluids, Viscous Incompressible Flows, Laminar Boundary Layers, Flow through Pipes.
8.	Suggested Books	**Text Books** 1. R.W. Fox and A.T. McDonald, **Fluid Mechanics**, John Wiley International, **2005**. 2. F.M. White, **Fluid Mechanics**, Tata McGraw Hill, 2008. **Reference Books** 1. S.K. Som and G. Biswas, **Introduction to Fluid Mechanics and Fluid Machines** (2nd Edition), Tata McGraw-Hill Publishing Company, New Delhi, 2008 2. V.L. Streeter and E.B. Wylie **Fluid Mechanics**, McGraw-Hill, 1983. 3. S.W. Yuan, **Foundation of Fluid Mechanics** (2nd Ed), Prentice Hall, 1988.

1.	Course Code	**ME 204**
2.	Title of the Course	**Fluid Machinery**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	A course in Fluid Mechanics
6.	Scope of the course	
7.	Course Syllabus	Introduction and classification of Turbo-machines, Compressible fluid flows, Gas turbine systems, Centrifugal and axial flow compressors, Steam and Hydraulic Turbines, Fluid Pumping Machines, Cavitation, Fans and Blowers.
8.	Suggested Books	**Text Books** 1. S.K. Som and G. Biswas, **Introduction to Fluid Mechanics and Fluid Machines** (2nd Edition), Tata McGraw-Hill Publishing Company, New Delhi, 2008. 2. N.S. Govind Rao, **Fluid Flow Machines**, Tata McGraw Hill, New Delhi, 1998. 3. S.L. Dixon, **Fluid Mechanics and Thermodynamics of Turbomachinery** (5th edition), Butterworth-Heinemann, Oxford, 2005. 4. E. Logan, **Turbomachinery: Basic Theory and Applications**, (2nd edition), CRC Press, London, 2002. **Reference Books** 1. A.T. Sayers, **Hydraulics and Compressible flow in Turbomachines**, McGraw Hill, 1990 2. A.J. Stepanoff, **Centrifugal and Axial Flow pumps**, Wiley, 1967 3. D.G. Shepherd, **Principles of Turbomachinery**, Macmillian, 1956.

1.	Course Code	**ME 254**
2.	Title of the Course	**Fluid Mechanics and Machinery Lab**
3.	Credit Structure	L-T- P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	ME-203: Fluid Mechanics
6.	Scope of the course	
7.	Course Syllabus	Experiments for (i) Measurement of Friction factor in pipes for turbulent flow conditions, (ii) Evaluation of Losses due to pipe fittings, (iii) Measurement of force due to impact of jets, (iv) Demonstration of Bernoulli's Theorem, (v) Visualization of flow regimes in channels, (vi) Determination of laminar velocity profile and friction factor in pipe flow, (vii) Determination of performance characteristics of Francis turbine, Pellton turbine, centrifugal pump, and blower.
8.	Suggested Books	1. R.W. Fox and A.T. McDonald, **Fluid Mechanics**, John Wiley International, **2005**. 2. S. K. Som and G. Biswas, **Introduction to Fluid Mechanics and Fluid Machine**s (2nd Edition), Tata McGraw-Hill, New Delhi, 2008.

1.	Course Code	**ME 206**
2.	Title of the Course	**Thermodynamics**
3.	Credit Structure	L-T-P-Credits 3-1-0-4
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Thermodynamics and its engineering application, Terminology used in engineering thermodynamics, concept of system, surroundings, boundaries, universe, work, energy, heat. Classification of system, types of boundaries: fixed, moving and imaginary. Equilibrium, processes, interactions, Zeroth law of thermodynamics. **Heat-Work interaction:** Thermodynamic definition of work. Characteristics of the work interaction. Evaluation of different kinds of work: displacement, shaft work, electrical work. **Equation of Ideal Gas:** Difference between ideal and real gases, equations of state, evolution of properties of ideal gases. Van-der-Waals equation of state for real gases, compressibility factor. Properties of steam, introduction to steam tables. **First law of Thermodynamics:** Statement for a cycle, derivation of the First law for processes, energy, internal energy, enthalpy. Extension of the First law to control volume; steady state-steady flow energy equation. **Second law of Thermodynamics:** Kelvin-Planck and Clausius statements and their equivalence, Clausius inequality, entropy, evaluation of entropy, principle of increase of entropy. Formulation of second law for closed and open systems. Property relations, Maxwell's equations. Applications to equations of state Introduction to availability, irreversibility and exergy. **Power Cycles:** Carnot cycle. Vapor power cycles – Rankine cycle and its modifications. Air standard cycles – Otto, Diesel, Brayton cycles.
8.	Suggested Books	**Text books** 1. Y.A. Cengel and M.A. Boles, **Thermodynamics: An Engineering Approach** (6^{th} Edition), Tata McGraw Hill, New Delhi, 2008. 2. M.J. Moran and H.N. Shapiro, **Fundamentals of Engineering Thermodynamics** (6^{th} Edition), Wiley (ISBN: 978-471-78735-8). 3. M.L. Mathur and F.S. Mehta, **Steam and Other Tables (with Mollier Chart)**, Jain Brothers, New Delhi, 2005. **Reference Books**

		1. C. Borgnakke, R.E. Sonntag, **Fundamentals of Thermodynamics** (7th edition), Willey, ISBN 978-0-470-04192-5. 2. A. Bejan, **Advanced Engineering Thermodynamics**, Willey, ISBN: 978-0-471-67763-5. 3. P.L. Dhar, **Engineering Thermodynamics: A Generalized Approach**, Elsevier, ISBN: 8131214699. 4. Y.A. Cengel, and M.A. Boles **Thermodynamics: An Engineering Approach**, (7th edition), McGraw-Hill Inc. 5. M.J. Moran, and H.N. Shapiro, **Fundamentals of Engineering Thermodynamics** (6th edition), Willey, 1995.

1.	Course Code	**ME 257**
2.	Title of the Course	**Machine Drawing**
3.	Credit Structure	L-T-P-Credits 1-0-3-2.5
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	A course in Engineering Graphics
6.	Scope of the course	
7.	Course Syllabus	Exp.1 Introduction to design process and drawings. Exp.2 Review of sectioning, Drawing standards, Dimensioning and notes. Exp.3 Fasteners and Joints: Screws, Bolts and nuts, Riveted joints, Pins, Locking devices, Welded joints, Pipe joints, Unions and valves. Cotter and Knuckle Joints. Assembly drawings with sectioning and bill of materials. Exp.4 Machine Assemblies: involving machine elements like shafts, couplings, bearing, pulleys, gears, belts, brackets. Detailed part drawings from assembly drawings. Engine mechanisms assembly and disassembly. Exp.5 Tool drawings including jigs and fixtures. Exp.6 Production drawings: Limits, Fits and Tolerances, Dimensional and geometric tolerances, Surface finish symbols. Exp.7 Layout drawings: Schematics, process and instrumentation diagrams, piping drawings. Exp.8 Structural drawings: examples for reading and interpretation. Exp.9 Computer aided drawing and drafting (CADD): use of software packages for engineering drawings and drafting.
8.	Suggested Books	1. N.D. Bhatt, and V.M. Panchal, **Machine Drawing**, Charotar Publishing House, 2009. 2. N. Sidheswar, P. Kannaiah, and V.V.S. Sastry, **Machine Drawing**, Tata McGraw Hill New Delhi, 1980. 3. Bureau of Indian Standards, **SP 46: 1988.**

1.	Course Code	**ME 258**
2.	Title of the Course	**Manufacturing Processes Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	A course in Basic Manufacturing Techniques
6.	Scope of the course	
7.	Course Syllabus	Exp.1 (a) Preparation of a core for producing a typical hollow-shaped part by the sand casting process. (b) Preparation of a Sand mold using the two-piece pattern and the core prepared in practical no.a, and production of the desired casting. Exp.2 (a) To prepare a single 'V' butt joint using MIG/MAG welding process and die penetrant testing. (b) Welding Metallurgy (MIG/MAG) <u>Exp.3 Demonstration of non-traditional and CNC tools</u> Exp.4 Manufacturing of thread and cylindrical grinding. Exp.5 Surface grinding and manufacturing of tapped holes in square plate
8.	Suggested Books	Same as associated theory course ME 208: Theory of Manufacturing Processes.

1.	Course Code	**ME 301**
2.	Title of the Course	**Heat Transfer**
3.	Credit Structure	L-T-P-Credits 3-1-0-4
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Modes of heat transfer and their mechanism. **Conduction:** Introduction to conduction; Thermal conductivity, diffusivity and heat generation; derivation of general heat conduction equation in Cartesian coordinate, boundary value problems, steady state conduction with heat generation and extended surfaces. Lamped capacitance and simple transient models. Finite difference formulation of differential equations, solution methods for system of algebraic equations. **Convection:** Forced and free convection, mass, momentum and energy conservation equations, non dimensional numbers, hydrodynamic and thermal boundary layer, basics of heat transfer in external and internal laminar and turbulent flows. Free convection from plate: Governing equations and non-dimensionalization. Similarity and integral solutions for vertical plate. Free convection for other cases; Mixed convection Introduction to pool boiling; correlations. **Radiation:** Basic concepts; Planck, Wien and Stefan-Boltzmann laws. Irradiation; solid angle; radiation intensity. Heat exchange between two surfaces. Shape factor: Definition, common configurations. Radiation exchange between two diffuse-gray surfaces. **Heat Exchangers:** Applications and classification of heat exchangers; Fouling factor. Design analysis using LMTD method. Performance analysis using ϵ - NTU method. Design considerations for heat exchangers.
8.	Suggested Books	**Text Books** 1. J.P. Holman, **Heat Transfer** (10th edition), Tata McGraw Hill, New Delhi (ISBN: 9780071267694). 2. F.P. Incropera, and D.P. Dewitt, **Fundamentals of Heat and Mass Transfer** (5th edition) Wiley India, (ISBN: 9788126512614). **Reference Books** 1. F.P. Incropera, and D.P. Dewitt, **Fundamentals of Heat and Mass Transfer** (5th edition), John Wiley & Sons, New York, 2002, (ISBN: 978-0-470-05554-0).

		2. A.F. Mills, **Basic Heat and Mass Transfer**, Prentice Hall, 1998. (ISBN: 0130962473) 3. Y.A. Cengel and A. Ghajar, **Heat and Mass Transfer: Fundamentals and Applications,** McGraw-Hill, (ISBN: 0077366646). 4. M. Necati Ozisik, **Heat Transfer: A Basic Approach**, McGraw-Hill, 1984. (ISBN: 0070479828)

1.	Course Code	**ME 351**
2.	Title of the Course	**Heat Transfer Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Objective/Scope of the course	
7.	Course Syllabus	Exp.1 **Objective: 1** • Determination of coefficient of thermal conduction (thermal conductivity) of gases and liquids. Exp.2 **Objective: 2** • Study of heat transfer in free and forced convection modes. • Study the forced convection: In this experiment, the effect of flow velocity on the convection heat transfer is observed by recording and calculating different parameters at different values of air flow velocity. Exp.3 **Objective: 3** • To study the parameters governing steady state one dimensional heat conduction in radial direction and also to study the initial unsteady state heat conduction. Exp.4 **Objective: 4** • Study of Different types of Heat Exchangers (Tubular, Shell and tube and Plate type HE) apparatus. • To investigate the effect of changes in hot and cold fluid flow rate on the temperature efficiencies and overall heat transfer coefficient. (For cocurrent and counter flow) • To investigate the effect of driving force with cocurrent and counter current flow. • To investigate the heat loss from Heat Exchangers by replacing the cold fluid by hot fluid and vice-versa. (For cocurrent and counter current flow) Exp.5 **Objective: 5** • Study of one dimensional steady state linear heat conduction and understanding the significance of contact resistance. • Temperature distribution measurement for steady state conduction through a plane wall. • Temperature distribution measurement for steady state conduction through a composite wall and determine the overall heat transfer coefficient. • Determination of thermal conductivity of a metal specimen • To verify that the temperature gradient is inversely proportional to the cross sectional area for one dimensional conduction. • Demonstration of the effect of contact resistance on thermal conduction Exp.6 **Objective: 6**

		• Determination and comparison of Thermal Conductivity of different insulating and building materials (Cork, Plaster, POM etc) Exp.7 **Objective: 7** • Verification of different laws of radiation (Lambert's distance law, Lambert's direction law, Stefan Boltzmann's law and Kirchhoff's law)
8.	Suggested Books	Same as associated theory course

1.	Course Code	**ME 302**
2.	Title of the Course	**Applied Thermodynamics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	A course in Thermodynamics
6.	Scope of the course	
7.	Course Syllabus	Introduction to Energy Resources, Heat Engines. **Review of First Law of Thermodynamics:** for Closed and Open Systems. Classification of cycles as Open/Closed, Refrigeration/Power, Multi-component/Single- component, Internal combustion/ external combustion, etc. **Performance parameters:** Net work, thermal efficiency, heat rate, specific fuel consumption, work ratio, specific output, mean effective pressure, volumetric efficiency, COP, refrigeration effect. Carnot vs. other cycles. **Stoichiometry:** General stoichiometry and definition of terms (rich mixture, lean mixtures). **Combustion:** Heat of formation, Heat of reaction, Calorific Value of fuel, Estimation methods for Calorific values, Exhaust Gas Analysis, Orsat Apparatus. **Power Cycles:** Otto Cycles, Diesel Cycles, Air-standard cycles and Actual cycles, Dual cycle, p-theta diagram. Brayton cycle with explanation of various terms Modifications of Brayton cycle. Rankine cycle, Modifications to Rankine cycle, Feed water Heaters and analysis, Moisture separators, application of Rankine to Nuclear power plants. **Introduction of Internal Combustion (IC) Engines:** Spark ignition (SI) and compression ignition (CI) engines, combustion and knocking in SI and CI engines, Carburetion. **Introduction of Refrigeration and Air Conditioning:** Vapour Compression and Reverse Brayton Cycles Vapour Absorption Cycles. Psychometry. **Compressors:** Reciprocating, rotary and centrifugal compressors.
8.	Suggested Books	**Text Books** 1. M.J. Moran and H.N. Shapiro, **Fundamentals of Engineering Thermodynamics** (6th Edition), Wiley (ISBN: 978-471-78735-8). 2. Y.A. Cengel and M.A. Boles, **Thermodynamics: An Engineering Approach** (6th Edition), Tata McGraw Hill, New Delhi, 2008. (ISBN:

		0070262179). **Reference Books** 1. G.F.C. Rogers, and Y.R. Mayhew, **Engineering Thermodynamics: Work and Heat Transfer** (4th edition), Longman, England, 1992. 2. Granet, and M. Bluestein, **Thermodynamics and Heat Power**, Prentice Hall (ISBN: 0131106724). 3. E. Logan, **Thermodynamics Process and Application**, Marcel Dekker, 1999. (ISBN: 0824799593) 4. C. Wu, **Thermodynamics and Heat Powered Cycles: A Cognitive Engineering Approach**, Nova Science Publishers, 2006. (ISBN: 978-1-60692-626-0)

1.	Course Code	**ME 352**
2.	Title of the Course	**Applied Thermodynamics Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Exp.1 **Objective:1** • To investigate the effect of cooling load on "Approach to wet bulb" and the application of the steady flow equation to selected systems to draw up energy and mass balances. • To investigate the effect of the packing density on the performance of a cooling tower and pressure drop across column Exp.2 **Objective: 2** • Demonstration of vapour compression refrigeration or heat pump cycle with visual observation of the important processes. • Study the effect of condenser load on vapor compression refrigeration cycle performance. • Study the effect of evaporator load on vapor compression refrigeration cycle performance. Exp.3 **Objective: 3** • Demonstration of the Rankine cycle • Study the effect of boiler pressure on turbine power output and calculation of efficiencies related to Rankine cycle Exp.4 **Objectives: 4** • To draw the following air conditioning processes on the psychometric chart and analyze them thermodynamically. • Sensible heating (ii) heating and Humidification (iii) Cooling and De-humidification. • To determine the energy and mass transfer rates at heater, boiler and refrigeration unit. • To study effect of adiabatic mixing of different quantities of air in two different states and plot on psychometric chart. Exp.5 **Objective: 5** • Study of jet engine Exp.6 **Objective: 6** • To study the performance of 4 cylinders, 4 strokes, Petrol engine coupled with eddy current dynamometer. • Calculate heat balance sheet for SI engine. Exp.7 **Objective: 7** • To study the performance of 4 cylinders, 4 strokes, Diesel engine coupled with eddy current dynamometer. • Calculate heat balance sheet for CI engine Exp.8 **Objective: 8**

		• To find the calorific value of a sample fuel using Bomb Calorimeter.
8.	Suggested Books	Same as associated theory course

1.	Course Code	**ME 303**
2.	Title of the Course	**Kinematics and Dynamics of Machines**
3.	Credit Structure	L-T-P-Credits 3-1-0-4
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Mechanisms:** Introduction to different types of mechanisms, Analysis of position, velocity and acceleration along with their diagram. **Cam and Follower:** Design of Cam-Follower Mechanisms. **Gears and Gear train:** Gear tooth profiles, spur gears and helical gears. Epicyclic Gear trains. **Dynamics of Machines:** Dynamic analysis of different mechanisms, Balancing. **Mechanical Vibrations:** Analysis and applications of discrete and continuous system of vibration.
8.	Suggested Books	1. B. Paul, **Kinematics and Dynamics of Planar Mechanisms**, Prentice Hall, 1979. 2. J.J. Uicker, G.R. Pennock, and J.E. Shigley, **Theory of Machines and Mechanisms** (3rd edition), Oxford University Press, New York, 2005. 3. S.S. Rattan, **Theory of Machines** (2nd edition), Tata McGraw Hill, New Delhi, 2005. 4. R.L. Norton, **Design of Machinery** (3rd edition), Tata McGraw Hill, New Delhi, 2005. 5. F.S. Tse, I.E. Morse, and R.T. Hinkle, **Mechanical Vibrations**, CBS Publishers and Distributors, 1983. 6. J.S. Rao, and K. Gupta, **Introductory Course on Vibrations**, Wiley Eastern, 1984. 7. J.P. Den Hartog, **Mechanical Vibrations**, McGraw Hill, 1956.

1.	Course Code	**ME 353**
2.	Title of the Course	**Kinematics and Dynamics of Machines Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Exp.1 Experiments on velocity Exp.2 Experiments on static force and acceleration analysis of mechanisms Exp.3 Experiments on friction Exp.4 Experiments on belt drives and cam-follower Exp.5 Experiments on balancing Exp.6 Experiments on bearings Exp.7 Experiments on gyroscopes Exp.8 Experiments on mechanical vibrations
8.	Suggested Books	1. J.J. Uicker, G.R. Pennock, and J.E. Shigley, **Theory of Machines and Mechanisms** (3rd edition), Oxford University Press, New York, 2005. 2. S.S. Rattan, **Theory of Machines** (2nd edition), Tata McGraw Hill, New Delhi, 2005.

1.	Course Code	**ME 304**
2.	Title of the Course	**Instrumentation and Control Systems**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Characteristics of Instruments:** Instrument and measurement systems, classification of instruments, elements of measurements systems, measurement system performance-type of errors. Dynamic characteristics –filtering and signal analysis-Fourier transforms. **Transducers and sensing elements:** Mass sensing elements, thermal detectors, thermo-couples, hydro pneumatic sensors, mechano-electrical transformation, simple transducer element, LVDT, differential, velocity, acceleration-Piezo-electric, magneto-striction transducer-optical instrumentation-Interferometer. **Microprocessor and its application:** Functional architecture of microprocessors-instruction set –Basic concept of memory interfacing -memory mapping- stepper motor and temperature control. **Data Acquisition and Interfacing:** Elements of data loggers, Input condition, Analog to Digital(A/D) and Digital to Analog (D/A) conversion, Computer based Data Acquisition, Programmable Logic Controller, Switching diagram, interfacing of mechanical systems. **Introduction to control systems:** Concept of Feedback, open and closed loop, Negative Feedback in control systems, Impulse response and transfer functions of linear systems, modelling of mechanical system elements, sensors and encoders in control systems –DC motor in control systems- linearization of nonlinear systems.
8.	Suggested Books	**Text books:** 1) James.W.Dally,William F.Riley, Instrumentation for engineering measurments, Wiley India Edition (ISBN 978-81-265-2801-1) 2) Ernest O. Doebelin, Dhanesh N. Manik, Measurement systems, Tata McGraw Hill (ISBN 978-0-07-061672-8). 3) B.C. Kuo, Automatic control systems, (4th edition), Printence hall of India, NewDelhi,1985. 4) R.S. Goankar, Microprocessor Architecture: Programming and and application with the 8085/8080A, penram international publishing, 1986. **Reference Books:** 1) A.K.Sawhney, **A course in electrical and electronics**

		measurements and instrumentation, Dhanpat Rai & C, 17th edition, NewDelhi 2) Safa O.Kasap, **Optoelectronics and photonics principles and practices,** Pearson (ISBN-978-81-317-2468-2) 3) T. G. Beckwith, J. H. Lienhard, R. D. Marangoni **Mechanical Measurements,** Pearson (ISBN-978-81-317-17188-9) 4) S. O. Kasap, **Optoelectronics and photonics principles and practices,** Pearson (ISBN-978-81-317-2468-2) 5) I.J. Nagrath and M. Gopal, **Control system engineering**, (2nd Edition) Wiley Eastern, New Delhi,1982.

1.	Course Code	**ME 354**
2.	Title of the Course	**Instrumentation and Control Systems Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Mechanical and Electrical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	Exp.1 **Transducer Kit:** a) Displacement measurement with electro-mechanical transducers b) Temperatures gradient measurement with Heat Transducers Exp.2 **Process control trainer:** Heating Element controlled by thyrisistor circuits Exp.3 **Michelson's Interferometer:** a) Calibration of Slip gauges b) Wavelength Measurement of monochromatic light c) Measurement of Change in pressure Exp.4 **Optical Instrumentation:** a) Characteristics of LDR b) Measurement of Groove spacing in a CD by its reflection grating c) optical based thickness measurement using Ellipsometry Exp.5 **Microprocessor based:** a) Basic Study b) DC motor position control Stepper motor Milli step interfacing with 8051microcontroller Exp.6 Experimental implementation of different controller behavior in Swinging Pendulum Interfaced using MATLAB Simulink. **Digital PID controller based:** a) Dc motor speed control module (fast process) b) Temperature control system (slow process) PLC based Interfacing of multiple cylinder sequences in electro pneumatic systems Exp.7 Study on PLC based Interfacing of micro controlled XY Stage for Laser based marking Exp.8 Characteristics measurement using Impedance Analyzer Exp.10 Experiments in Hydraulic trainer kit Exp.11 Experiments on Optical fibre sensor kit Exp.12 Experiments on Autotronics trainer kit
8.	Suggested Books	Same as associated theory course

1.	Course Code	**ME 305**
2.	Title of the Course	**Machining Science and Metrology**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Theory of Machining:** Concept of generatrix and directrix, classification of machining processes, chip formation: mechanism, chip types, chip control, tool geometry: single point cutting tool geometry, specifications in different standards, selection of tool angles, mechanics of single point orthogonal machining: Merchant's circle, force, velocity, shear angle, and power consumption relations, cutting tool wear and tool life: wear mechanisms, wear criterion, Taylor's tool life equation, facing test, variables affecting tool life; Machinability and its measures, economics of machining. **Finishing and Superfinishing Processes:** Principles and applications of honing, superfinishing, lapping, polishing, buffing, shot-peening, and burnishing. **Advanced Machining Processes:** Process principle, equipment, analysis and applications of advanced machining processes such as Abrasive Jet Machining (AJM), Ultrasonic Machining (USM), Electro Chemical Machining (ECM), Chemical Machining (CHM), Electro-Discharge Machining (EDM), Wire Electro Discharge Machining (WEDM), Electron Beam Machining (EBM), and Laser Beam Machining (LBM). **Metrology:** Introduction, inspection types and principles, basic inspection methods, characteristics of measuring instrument, measurement errors, linear measurement: line and end standards, gauge blocks, comparators, dial gauge, angular measurement: gauge block, clinometer, sine-bar, autocollimators, radius and taper measurement, measurement of screw threads and gears. **Limits and Fits:** Limits, fits, and dimensional and geometrical or form tolerances, computer vision system based measurement, coordinate measuring machines, measurement of form tolerances, measurement of surface roughness: surface roughness terminology, different methods of surface roughness measurement.
8.	Suggested Books	1. A. Ghosh, and A.K. Mallik, **Manufacturing Science,** Affiliated East-West press Pvt. Ltd., 1985. 2. G.K. Lal, **Introduction to Machining Science**, New Age

		International Publishers, 1996. 3. G. Boothroyd, and W.A. Knight**, Fundamentals of Machining and Machine Tools**, Marcel Dekker, 1989. 4. V. K. Jain, **Advanced Machining Processes**, Allied Publishers, New Delhi, 2002. (ISBN 81-7764-294-4) 5. G.F. Benedict, **Nontraditional Manufacturing Processes**, Marcel Dekker, Inc. New York, 1987. (ISBN 0-8247-7352-7) 6. J.F.W. Gayler, and C.R. Shotbolt, **Metrology for Engineers**, ELBS, 1990. 7. I.C. Gupta, **Text Book of Engineering Metrology,** Dhanpat Rai Publishing Co. New Delhi, 2003.

1.	Course Code	**ME 355**
2.	Title of the Course	**Machining Science and Metrology Lab**
3.	Credit Structure	L-T- P-Credits 0-0-2-1
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Nil
6.	Scope of the course	
7.	Course Syllabus	Exp.1 To find the wedge angle with the help of a sine bar Exp.2 Measurement of thread parameters using tool makers microscope Exp.3 To determine the temperature of tool-work interface using a tool work thermocouple Exp.4 Estimation of tool life of a HSS cutting tool during turning of C-20 steel bar using Taylor's relation Exp.5 Measurement of cutting forces by using lathe dynamometer Exp.6 Measurement of cutting forces by using drill dynamometer Exp.7 The effects of cutting velocity, nose radius and feed rate on surface roughness Exp.8 Effect of speed and feed on chip morphology
8.	Suggested Books	Same as associated theory course ME 305: Machining Science and Metrology

1.	Course Code	**ME 306**
2.	Title of the Course	**Machine Design - I**
3.	Credit Structure	L-T- P-Credits 2-2-0-4
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Solid Mechanics, Strength of Materials and Kinematics and Dynamics of Machines
6.	Scope of the course	The objectives of this course are to develop in mechanical engineering students the knowledge and skills required 1. To apply engineering analysis principles and methods to the proper analysis of a variety of common mechanical system components. 2. To design these mechanical system components so as to perform safely their intended functions in harmony with other components of the system. 3. To use information resources to identify appropriate and elegant component solutions for mechanical system design problems, locate sources for these components, and understand the analysis and design methods for these components. 4. To conform to the right codes and standards. 5. To solve an open-ended design problem involving cost, drawings, and structural analysis.
7.	Course Syllabus	**Introduction and Design for Strength:** Fundamentals of machine design: Brief overview of design and manufacturing**,** Stresses in machine elements, Strain analysis. Design for Strength: Design for static loading, Stress Concentration, Design for dynamic loading, and Low and high cycle fatigue. **Fasteners and Power Screws:** Fasteners: Types of fasteners - Pins and keys, Threaded Fasteners and Design of bolted joints**.** Power Screws: Power Screw drives and their efficiency and Design of power screws. **Couplings and Springs:** Couplings: Introduction, types and uses, design procedures for rigid and flexible rubber-bushed couplings**.** Springs: Introduction to Design of Helical Springs, Design of Helical Springs for Variable Load and Design of Leaf Springs. **Shafts and Cylinders:** Shafts: Introduction to shaft and its design based on strength and Design of shaft for variable load and based on stiffness. Cylinders: Thin and thick cylinders, Stresses due to internal and external pressures, and Design principles for cylinders. **Welded and Riveted Joints:** Riveted Joints: Types and Uses, Design of Riveted Joints. Welded Joints: Types and Uses, Design of Welded Joints and Design of Adhesive Joints. Design of Joints for Special Loading: Design of Eccentrically Loaded Bolted/Riveted

		Joints and Welded Joints, and Design of Joints with Variable Loading.
8.	Suggested Books	1. J.E. Shigley, **Mechanical Engineering Design**, Tata McGraw Hill, 2008, ISBN:0070668612. 2. B.J. Hamrock, and S.R. Schmid, **Fundamentals of Machine Elements**, Tata McGraw Hill, 2005, ISBN:0072976829. 3. R.L. Norton, **Machine Design**, Pearson Education, 2012, ISBN-10: 0131481908. 4. M.F Spotts, **Design of Machine Elements**, Prentice Hall India, 1991, ISBN: 9788177584219. 5. V. Bhandari, **Design of Machine Elements**, Tata McGraw Hill, 2007, ISBN: 9780070611412. 6. A. S. Hall, A. R. Holowenko and H. G. Laughlin, **Schaum's Outline of Machine Design**, McGraw Hill, 2010, ISBN: 9780070255951.

1.	Course Code	**ME 307**
2.	Title of the Course	**Principles of Industrial Engineering**
3.	Credit Structure	L-T-P-Credits 3-0-0-3 [from AY 2010-11 to AY 2013-14] 2-0-2-3 [from AY 2014-15 onwards]
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Organization:** Factory system, principles of organization, types of organization and their selection. **Plant Layout:** Site selection, types of layout, factors affecting layout, plant building, flexibility and expandability, materials handling devices. **Production Planning and Control:** Functions, forecasting, routing, operations planning; Gantt chart, work order, dispatching and follow-up; CPM and PERT techniques. **Inventory Control:** Scope, purchasing and storing, economic lot size; ABC Analysis. **Work Study:** Scope, work measurement and method study, standard data, ergonomics and its industrial applications. **Industrial Relations:** Labour welfare, wage and incentives, absenteeism and labour turnover.
8.	Suggested Books	1. E.S. Buffa, and R.K. Sarin, **Modern Production / Operations Management**, John Wiley & Sons, 1994. 2. R.S. Russell, and B.W. Taylor, **Operations Management**, Pearson Education, 2003. 3. C.A. Jocobs, **Production and Operations Management**", Tata McGraw Hill, 1999. 4. H.B. Maynard, **Industrial Engineering Handbook**, McGraw Hill, 2001.

1.	Course Code	**ME 308**
2.	Title of the Course	**Quality Management**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Different definitions, dimensions, and aspects of quality, Traditional and modern view of Quality Control, Different Philosophies by Quality Gurus. **Modern Quality Control Technologies:** Quality engineering using Taguchi Methods, Off-line and On-line quality control, Concepts of Robust Design, Taguchi Loss Function, Quality Function Deployment (QFD) . **Process Capability (PC) Analysis and Statistical Process Control (SPC):** Manufacturing process variability, manufacturing process capability, and tolerances; Tools/methods used in SPC: Control Charts, Pareto charts, Fishbone diagram, etc. Implementation of SPC. **Control Charts:** Theory and applications of control charts; Controls charts for variables: charts averages, ranges, and standard deviation; Control charts for attributes: p and c charts; Fraction defective and number of defects per unit; Different adaptation of control charts. **Acceptance Sampling:** Concept of acceptance sampling; Sampling by attributes: Single and double sampling plans, Use of Dodge Romming and Military standard sampling tables, Construction and use of operating characteristic (OC) curves; Sampling by variables: Continuous sampling plans. **Reliability:** Concept and definition, Measurement and test of reliability, Design for reliability (DFR), Concepts of Maintainability and Availability. **Total Quality Management (TQM):** Concept and philosophy, Scope, Applications, Implementation, Quality circles: objectives, structures, and techniques.
8.	Suggested Books	**Text book** 1. A. Mitra, **Fundamentals of Quality Control and Improvement** (2nd edition), Prentice Hall of India, New Delhi, 2005. **Reference books** 1. D.C. Montgomery, **Introduction to Statistical Quality Control** (3rd edition), John-Wiley & Sons Inc. New York, 1996.

		2. E. Grant, and R. Leavenworth, **Statistical Quality Control**, McGraw-Hill Inc. New York, 1996. 3. G. Taguchi, **Introduction to Quality Engineering**, Kraus Int. Publications, 1986. 4. D.H. Besterfield, M.C. Besterfield, G. Besterfield, and S.M. Besterfield, **Total Quality Management**, Prentice Hall International Inc. 1996.

1.	Course Code	**ME 401**
2.	Title of the Course	**Machine Design - II**
3.	Credit Structure	L-T- P-Credits 2-2-0-4
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Machine Design - I
6.	Scope of the course	The objectives of this course are to develop in mechanical engineering students the knowledge and skills required 1. To apply engineering analysis principles and methods to the proper analysis of a variety of common mechanical system components. 2. To design these mechanical system components so as to perform safely their intended functions in harmony with other components of the system. 3. To use information resources to identify appropriate and elegant component solutions for mechanical system design problems, locate sources for these components, and understand the analysis and design methods for these components. 4. To conform to the right codes and standards. 5. To solve an open-ended design problem involving cost, drawings, and structural analysis.
7.	Course Syllabus	**Introduction:** Different theories of failure and design based on theories. Design for fatigue, design for creep and design for wear and corrosion. **Design of Gears:** Law of gearing - conjugate action and gear tooth profile-basics Analysis of forces on spur, helical, bevel and worm gears. Design procedure of various gears. **Design of belt and chain drives:** Belt drives: Introduction to Belt drives, Design of Flat Belt drives and Design of V- Belt drives. Chain drives: Introduction and classification, design procedure for chain drive. **Design of Bearings:** Brief overview of bearings, Design of Fluid Film bearings and Rolling contact bearings. **Brakes and Clutches** Brakes: Types, Design of shoe brakes, and Design of Band and Disc Brakes. Clutches: Types, Plate clutches – design for uniform pressure and wear.

8.	Suggested Books	1. J.E. Shigley, **Mechanical Engineering Design**, Tata McGraw Hill, 2008. ISBN:0070668612. 2. B.J. Hamrock, and S.R. Schmid, **Fundamentals of Machine Elements**, Tata McGraw Hill, 2005. ISBN:0072976829 3. R.L. Norton, **Machine Design**, Pearson Education, 2012. ISBN-10: 0131481908 4. M.F Spotts, **Design of Machine Elements**, Prentice Hall India, 1991. ISBN: 9788177584219 5. V. Bhandari, **Design of Machine Elements**, Tata McGraw Hill, 2007. ISBN: 9780070611412 6. Alfred S. Hall, A. R. Holowenko, H. G. Laughlin, **Schaum's Outline of Machine Design**, McGraw Hill, 2010. ISBN: 9780070255951 7. D.G. Ullman, **The Mechanical Design Process**, Tata McGraw Hill, 2008. ISBN: 9780072975741

Course Code	**ME 406/ ME 606**
Title of the Course	**Smart Materials based Energy Harvesters Design**
Credit Structure	L-T-P-Credit 2-1-0-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	Introduction of Materials Science
Scope of the course	The main scope of this course is to develop an understanding of various aspects of smart materials energy harvesters design.
Course Syllabus	**Thermoelectric energy harvesting:** Thermoelectric principles and phenomena, conversion efficiency and figure-of-merit, performance and behaviors of thermoelectric devices; waste heat recovery and power generation, energy harvesting applications of thermoelectric devices. **Piezoelectric:** Piezoelectric material structure and properties; processing parameter effect on piezoelectricity; effects of material constants and mechanical damping on power generation. Modeling of piezoelectric energy harvesters; mechanical designs of piezoelectric energy harvester; design of a bistable piezoelectric energy harvester; performance evaluation of vibration-based piezoelectric energy scavengers; piezoelectric energy harvester with magnets; piezoelectric energy harvesting equivalent circuit models, applications of piezoelectric energy harvesting systems. **Pyroelectric:** Pyroelectric materials structure and properties; effect of processing parameters, poling techniques, electroding on energy harvesting; waste thermal, solar and phase change material embedded energy harvesting system; electrical circuit model for actual energy harvesting potential.
Suggested Books	**Text Book** 1. R. Funahashi, **Thermoelectric Energy Conversion**, Elsevier Woodhead Publishing, 2021, ISBN:978-0-12-818535-3 2. S. Priya and D. J. Inman, **Energy Harvesting Technologies**, Springer, 2009. ISBN: 978038776464 3. Q. Xu and L. M. Tam, **Mechanical Design of Piezoelectric Energy Harvesters**, Elsevier, 2021, ISBN: 9780128236536 **Reference Book** 1. R. Kumar and R. Singh, **Thermoelectricity and Advanced Thermoelectric Material**, Elsevier Woodhead Publishing, 2021, ISBN:9780128199848 2. D. M. Rowe, CRC Handbook of Themoelectrics, 1995. ISBN 9780367248161 3. A. Erturk, Daniel J. Inman, **Piezoelectric Energy Harvesting**, John Wiley & Sons, 2011, Print ISBN: 9780470682548. 4. H. Huang and J. F. Scott **Ferroelectric Materials for Energy Applications**, Wiley-VCH, 2018, ISBN:9783527807505

1	Course Code	**ME 407/ ME 607**
2	Title of the course	**Biofluid Mechanics**
3	Credit Structure	L-T-P-Credits ~~2-1-0-3~~ 2-0-2-3 *from AY 2021-22*
4	Name of Department	Mechanical Engineering
5	Pre-requisites, if any	None
6	Scope of the course	(a) To understand the physiology and anatomy of different systems in the human body (b) To integrate fluid mechanics concepts to model biological flows in the human body (c) To identify specific diseases and to analyze how they are related to fluid mechanics.
7	Course Syllabus	**Introduction:** Introduction to fluid mechanics, and human physiology in relation to heart, lungs and blood vessels. **Cardiovascular structure and function:** Electro-cardiogram, heart valves, cardiac cycles, heart sounds, coronary circulation, microcirculation, lymphatic circulation. **Pulmonary Anatomy, Pulmonary physiology and Respiration:** Respiratory system, alveolar ventilation, mechanics of breathing, airway resistance, gas exchange and transport, pulmonary pathophysiology, respiration in extreme environment. **Hematology and Blood Rhelogy:** Elements of blood, blood characteristics, viscosity measurement, erythorcytes, leukocytes; blood types, plasma. **Anatomy and Physiology of Blood vessels:** General structure & types of arteries, mechanics of arterial walls, compliance, vascular pathologies, stents, coronary artery bypass grafting. **Mechanics of Heart Valves:** Aortic and pulmonic valves; Mitral and Tricuspid valves; Pressure gradients across a stenotic heart valve; Prosthetic mechanical valves; Prosthetic tissue valves. **Pulsatile flow in large arteries:** Introduction to blood flow in large arteries, pulsatile flow in tubes, instability in pulsatile flow. Mathematical modeling: Introduction to finite difference, finite volume & finite element methods, non-Newtonian flow models, modeling of flow through Mitral valve, modeling of blood flow in vascular system.

8	Suggested Books	**Text Book** 1. L. White and J.M. Fine, **Applied biofluid mechanics**, *McGraw Hill* 2007 (ISBN: 5551694623). 2. J.N. Mazumdar, **Biofluid Mechanics**, *World Scientific*, Singapore, 2004 (ISBN: 981-02-3801-0) **Reference Books** 1. L. White, **Biomechanics in Cardiovascular Systems**, *McGraw Hill*, 2006. 2. C. Kleinstruer, **Biofluid Dynamics: Principles and Applications,** *CRC Press*, *Taylor and Francis Group*, 2006. 3. M. Zamir, **The Physics of Pulsatile Flow,** Springer Verlag, New York, 2000. 4. Sir James Lighhill, **Mathematical Biofluid Dynamics,** *Society for Industrial and Applied Mathematics, Philadelphia*, 1975 (ISBN: 0-89871-014-6)

Course code	**ME 408/ ME 608**
Title of the course	Hybrid Electric Vehicles
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	Basic knowledge of Mechanical and Electrical Engineering
Scope of the course	This course is designed for final year undergraduate students and masters students who want to develop their knowledge about hybrid electric vehicles. Conventional I.C. Engine and electric powered vehicle will be analysed along with requirement of hybrid vehicle. Various mechanical layouts of hybrid powertrains will be examined to understand how they influence the performance and complexity of the powertrain. Sizing of the powertrains, Energy Management system and controls in the hybrid powertrain modes will be examined.
Course Syllabus	History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, and Switch Reluctance Motor drives. Energy Storage: Energy Storage Requirements in Hybrid and Electric Vehicles with Battery, Fuel Cell, Super Capacitor, and Flywheel based energy storage, Hybridization of different energy storage devices. Matching the electric machine and the internal combustion engine. Energy Management Strategies.
Suggested Books	1. I. Husain, ***Electric and Hybrid Vehicles*: Design Fundamentals,** CRC Press, Washington, 2011, 9781439811757 2. J. Larminie, J. Lowry, ***Electric Vehicle Technology Explained***, 2nd edition, John Wiley & Sons Ltd, U.K., 2012, 9788126557608

	3. B. D. McNicol, D. A. J. Rand, ***Power Sources for Electric Vehicles,*** Elsevier publications, New York, 1988, 044442315X 4. S. Leitman, ***Build Your Own Electric Vehicle***, McGraw Hill, 1st Edition, WW, 2013, 978-0830642328

1.	Course Code	**ME 411/ ME 611**
2.	Title of the Course	**Refrigeration and Air Conditioning**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	A course on Thermodynamics
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Single stage and multistage vapour compression refrigeration systems, psychrometry and psychrometric processes. **Vapour Absorption Refrigeration Systems:** Aqua-ammonia absorption refrigeration system, Lithum bromide-water absorption systems, p-t-x chart, enthalpy concentration chart, three fluid electrolux system, multistage absorption system, resorption absorption refrigeration, new mixtures for absorption systems. **Non-conventional Refrigeration Systems:** Water refrigeration, Vortex and pulse tube refrigeration systems, thermoelectric refrigeration systems, multistage thermoelectric systems. **Refrigerant Compressors:** Type of compressors; Reciprocating compressors: Volumetric efficiency, performance characteristic, capacity control, construction features, rotary compressors, screw compressors, centrifugal compressors, scroll compressors. **Infiltration and Ventilation:** Basic concepts and terminology, driving mechanism of infiltration and ventilation, indoor air quality, natural ventilation, residential air leakage, residential ventilation, residential ventilation requirements, simplified models of residential ventilation and infiltration. **Fenestration:** Fenestration components, determination of energy flow; U-factor, solar heat gain and visible transmission, shading, visual and thermal controls, air leakage, day lighting, selecting fenestration, condensation resistance, occupant comfort and acceptance. **Cooling Load Calculations:** Residential cooling and heating load calculations: features, calculation approach, residential heat balance method, residential cooling load factor method, cooling load, heating load, nonresidential cooling and heating load calculations. **Duct Design and Space Air Diffusion:** Room air distribution, total, static and velocity pressures, friction loss in ducts, dynamic loss in ducts, air duct design, equal friction method, static regain method, velocity reduction method, fitting loss coefficient, air diffusion: principles of jet behavior, room air diffusion methods. **Pipe Sizing:** Pressure drop equations, water piping, hydronic system piping, steam piping, gas piping and fuel oil piping.
8.	Suggested Books	1. W.F. Stoecker, and J.W. Jones, **Elementary Refrigeration and Air conditioning**, McGraw Hill, 2002. 2. R.J. Dosset, **Principles of Refrigeration**, Pearson Education Asia, 2002.

		3. C.P. Arora, **Refrigeration and Air conditioning**, Tata-MCGraw Hill, 2002. 4. M. Prasad, **Refrigeration and Air Conditioning**, New Age International, 2004. 5. ASHRAE Handbook (Fundamentals), 2005.

1.	Course Code	**ME 412**
2.	Title of the Course	**Energy Conversion**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Thermodynamics
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Fundamentals of thermodynamics**,** Classification of Energy Sources, Various methods of conversion to Electrical Energy and their efficiencies, availability analysis of energy conversion cycles. **Conversion of hydro energy**: Essential features and elements, Principal Auxiliaries, Plant Layout , Classification of Hydro power plants, Hydraulic Turbines, Water wheel Generators. **Conversion of thermal energy:** Coal fired power plants, Essential features and elements, Principal Auxiliaries, Plant Layout, Steam Turbines, Turbo Alternators. Gas Electric power plants, Diesel Electric power plants**.** **Conversion of nuclear energy**: Fundamentals of nuclear fission. Fission reactor design considerations, Basic construction and comparison of various types of nuclear reactors, Plant Layout, Risks and Safety measures, Nuclear fuels. **Advanced systems:** Combined cycles, cogeneration, trigeneration **Conversion of other forms of energy**: Solar to thermal energy-Solar collectors, Electromagnetic to electrical energy-Photo voltaics, Chemical to electrical energy-Fuel cells Comparison of various energy conversion systems, their prospects and limitations. **Thermodynamics of Energy Conservation**: Basic principle. Optimum use of prime-movers, energy efficient housekeeping, energy recovery in thermal systems, waste heat recovery techniques, thermal insulation. Thermal energy audit in heating, ventilation and air conditioning.
8.	Suggested Books	1. D.Yogi Goswami, and Frank Kreith, **Energy conversion**, CRC Pr I Llc, 2007, **ISBN:** 9781420044317. 2. M.M. El-Wakil, **Power Plant Technology**, McGraw Hill, 2002. 3. E.B. Norris, and E. Therkelsen, **Heat Power**, McGraw Hill, 1999. 4. Paul O Callaghan, **Energy Management**, McGraw Hill, 1993. 5. Paul O Callaghan, **Design and Management for Energy Conservation**, Pergamon, ISBN: 0080272878

1.	Course Code	**ME 413/ ME 613**
2.	Title of the Course	**IC Engines**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Basic Nomenclature, Classification of IC Engines, working principle of 2-stroke and 4-stroke SI and CI engines. Air stand, fuel-air and actual cycles for SI and CI engines. Engine performance parameters. Valve and port timing diagrams. **Combustion:** *In SI Engines* - Combustion initiation, Flame development and propagation, ignition lag, preignition, normal and abnormal combustion-knocking, physical and chemical aspects of knocking, effect of operating parameter and chemical structure on knocking tendency, Octane number, design considerations of combustion chamber, Stratified charge combustion, Concept of lean burning engines. *In CI Engines***-** Various stages of combustion-Vaporization of fuel droplets and spray formation **Engine Accessories:** *SI Engines* - Carburetors**,** Properties of air-fuel mixtures, mixture requirement, Main metering system, Idling system, Economizer system, acceleration pump and cold starting system. Spark plug, fly wheel, DTS-I system. Nozzle lip, venturi depression, calculation of fuel jet and venturi throat diameter for given air fuel ratio, Battery and magneto ignition system and their comparative study, firing order, Ignition timing, Petrol Injection system, electronic fuel injection, advantage and disadvantage of petrol injection. *CI Engine*- Fuel pump, types of fuel injector, fly-wheel, types of piston and properties, high pressure pipe, Governor- Necessity of governing, various methods of governing. Fuel injection system- Requirement, types of nozzle, atomization, spray penetration and spray direction, multiple point fuel injection system, injection timing, common rail fuel injection system. **Cooling and Lubrication Systems:** Cooling requirement, air cooling, liquid cooling, type of liquid cooling system, advantage and disadvantage of air cooling and water cooling system, Antifreeze mixture. Function of lubricating system, properties of lubricating oil, wet sump, dry sump and mist lubrication system. **Fuels:** Basic requirement of I.C. Engine fuels, requirement of an ideal gasoline, structure of petroleum, effect of fuel structure on combustion, volatility of liquid fuels, effect of volatility on engine performance for starting, vapor lock, acceleration, percolation, carburetor icing, and crank case dilution, Alternative fuels-Bio Diesel types, Compressed Natural Gas, Hydrogen Energy- Solid, Liquid, Gas. Fuel Cells. **Emissions:** Emissions from SI and CI engines, types of emission gasses, emission control system, types of emission control system, EGR system.
8.	Suggested Books	1. J. B. Heywood, **Internal Combustion Engine**, McGraw Hill,

		ISBN-0-07-100499-8; , 2. V. Ganeshan, **Internal Combustion Engine**, Tata McGraw Hill, 1992. 3. M.L. Mathur and R.P. Sharma, **A Course in Internal Combustion Engines,** Dhanpat Rai and Sons 4. V. Ganeshan, **Computer simulation of SI Engine Process**, Orient, 1996.

1.	Course Code	**ME 414**
2.	Title of the Course	**Power Plant Engineering**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Energy sources for generation of electric power, energy policy of India, present status and future trends, major power plants in India. **Thermal Power Plants:** Selection of site, general layout of the plant, major components-boilers, economizers, super-heaters, air pre-heaters, fuels; Fuel and ash handling equipment's; High pressure Boilers; Steam turbines; Station heat balance and plant efficiency. **Diesel Power Plants:** Diesel engine, engine performance and operation, super charging; Diesel Electric Power plant layout. **Gas Turbine Power Plants:** Gas turbine power plants, basic cycles, cycle calculation, the ideal and real operating cycles, components and layout. **Hydro Power Plants:** Classification of hydro-plants, selection of site, rain fall and run off, calculation of storage capacity, plant layout, estimation of power available, selection of hydraulic turbines and their governing. **Nuclear Power Plants:** Introduction; Atomic structure and radio-activities nuclear reactions, binding energy; Nuclear Reactors; Types of reactors: Pressurized water reactors, boiling heater reactors; Heavy water-cooled and moderated (CANDU) reactor; Gas-cooled reactors; Liquid metal cooled reactors. Indian Nuclear power installations, comparison between Nuclear and Thermal plants. **Non-Conventional Power Plants:** Geothermal power plants; Tidal power plants; Wind power plants; Solar power plants; M.H.D. Generators. **Power Plant Economics:** Plant investment costs, fixed charges; Operation cost, energy cost, depreciation and operating costs on the selection of equipments, incremental cost, comparison of fixed and operating costs.
8.	Suggested Books	1. P.J. Potter, **Power Plant Theory and Design**, Kreiger Pub. Co., 1988. 2. M.M. El-Wakil, **Power Plant Technology**, McGraw Hill, 2002. 3. E.B. Norris, and E. Therkelsen, Heat Power, McGraw Hill,

		1999. 4. J.H. Rust, **Nuclear Power Plant Engineering**, Haralson Pub Co., 1999. 5. Central Electricity Generating Board, **Modern Power Station Practical**, Pergamon Press, 1992.

1.	Course Code	**ME 416/ ME 616**
2.	Title of the Course	**Non-Conventional Energy Sources**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	To inculcate energy consciousness and environment sensitivity among engineering graduates
7.	Course Syllabus	**Introduction:** Energy resources; conventional and non-conventional, Energy and infrastructural development; Ecosystems, the environment and its cycles, energy and environment relationship **Solar energy:** Solar radiation, radiation measurement and predictions; solar thermal conversions, basics, flat plate collectors-liquid and air type, theory of flat plate collectors, selective coating, advances collectors,; concentrators; Solar water heater, solar dryer; Solar phtovoltaic, science and technology of photovoltaic devices. organic PV cells **Wind Energy:** Metrology of wind speed distribution, energy estimation of wind regimes; Wing energy conversion, power torque and speed characteristics, wind turbine; Application of wind energy **Biomass:** Biomass sources, CO_2 fixation potential of biomass, physicochemical characterstics of biomass as fuel; Biomass conversion, biochemical, chemical and thermal; biogas production mechanism, technology, types of digesters, plant design, biogas plant manure-utilization and manure values; Biomass gasification and combustion; anaerobic digestion of biomass; biomass utilization to produce solis, liquid and gaseous fuels **Hydro-energy**: Overview of micro, mini and small hydro system; hydrology; elemnets of turbine; assessment of hydropower; selection and design criteria of turbines; speed and voltage regulations; Ocean energy; principle of ocean thermal energy conversion system, principles of ocean wave energy and tidal energy conversion **Geothermal energy**: Origin of geothermal resources, types of geothermal deposits; **Hydrogen energy**; Hydrogen production and storage; Fuel cells, principles of working, basic thermodynamics

8.	Suggested Books	1) Donald K**., Biomass for renewable energy, Fuels and chemicals**, Academic press 2) S.P. Sukhatme: **Solar energy principles of thermal collection and storage**, 2nd edition, Tata McGraw Hill 3) G. Boyle, **Renewable energy: Power for sustainable future**, Oxforfd OUP 4) J. Twidell and T. Weir, **Renewable Energy Resources**. 5) T. B. Johansson, H. Kelly, A.K.N. Reddy, R. H. William, **Renewable Energy- Sources for fuels and Electricity**.

1.	Course Code	**ME 418/ ME 618**
2.	Title of the Course	**Computational Fluid Dynamics (CFD)**
3.	Credit Structure	L-T-P-Credits ~~2-1-0-3~~ 2-0-2-3 (from AY 2021-22)
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Heat Transfer
6.	Scope of the course	
7.	Course Syllabus	Control volume discretization of heat conduction equation in Cartesian and general curvilinear coordinate systems – Dirichlet, Neumann and Periodic boundary conditions; Gauss Seidel, TDMA, TVA, STONE, CD algorithms for solving resulting algebraic equations; convergence and accuracy and multigrid methods for convergence enhancement; General equations for boundary layer flows with heat and mass transfer and chemical reaction; boundary conforming transformation of equations, control volume discretization of equations; marching integration; application to wall boundary layers, free shear layers and mixing layers with and without comport equations in Cartesian and curvilinear coordinates; control volume discretization of equations; staggered and non-staggered grids; pressure correction algorithm; time marching predictor-corrector algorithm; application to recirculating elliptic flows and partially parabolic flows; compressible flows and shock capturing. Diffusion models; turbulence – zero, one and two equation models; stress equation models; low Reynolds number models; algebraic models; equivalent flux models. Source laws; Combustion models, radiation models, porous body models, mass sources; Numerical grid generation; algebraic, parabolic and elliptic equations.
8.	Suggested Books	1. S.V. Patankar, **Conduction and Laminar Fluid Flow**, Innovative Press, 1992. 2. S.V. Patankar, **Numerical Heat Transfer and Fluid Flow**, Academic Press, 1983. 3. S.V. Patankar, and D.B. Spalding, **Heat and Mass Transfer in Boundary Layers**, Academic Press, 1968. 4. W.M. Kays, **Convective Heat and Mass Transfer** (6^{th} edition), Tata McGraw Hill, New Delhi, 1992. 5. C.A.J. Fletcher, **Computational Techniques for Fluid Dynamics** (Vol. 1 & 2), Springer Verlag, 1988.

Course Code	**ME 420/ ME 620**
Title of the Course	**Alternative Cooling Technologies**
Credit Structure	L-T-P-Credit (2-1-0-3)
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	None
Scope of the course	To inculcate various cooling technique available apart from the conventional vapor compression and absorption method among engineering graduates
Course Syllabus	**Introduction:** Cooling methods; conventional and nonconventional cooling technologies; requirement of the alternative cooling **Heat activated cooling methods:** adsorption, Vuilleumier heat pump and ejector, working principle; waste heat to cooling integration; **Gas based cooling system:** Working principle and design of Thermoacoustic, Brayton cooler, J-T cryocooler, Stirling cooler, Vortex-tube, Pulse-tube; representation on T-s and h-s diagrams; and their applications **Solid state cooling:** Cooling potential in solids; working principle, types of solid state refrigeration system, design of Thermoelectric, Thermoionic, Electrocaloric, Magnetocaloric, Mechanocaloric and their current status;. **Liquid-vapor cooling:** Principle of liquid-vapor based cooling system: Membrane heat pump; Metal hydride Transcritical CO_2 heat pump; Malone heat pump
Suggested Books	**Text Book** 1. C. P. Arora; **Refrigeration and Air Conditioning**, 3rd edition, Tata McGraw Hill, New Delhi, 2009, ISBN- 9780070083905 2. T. Correia and Q. Zhang; Electrocaloric Materials: New Generation of Coolers, Springer, 2014, ISBN-9783642402647 **Reference Book** 1. A. Ameen, Refrigeration and Air Conditioning, Prentice-Hall India Pvt. Lmt. New Delhi, 2012, ISBN-9788120326712 2. R. Wang, L. Wang and J. Wu, Adsorption Refrigeration Technology: Theory and Application, John Wiley and Sons. Singapore Pvt. Ltd., 2014, ISBN- 9781118197431 3. A. Kitanovski, J. Tušek, U. Tomc et al. Magnetocaloric Energy Conversion: From Theory to applications, Springer, 2015, ISBN-9783319087412

1.	Course Code	**ME 431**
2.	Title of the Course	**Mechanical Vibrations**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Simple Harmonic motion, Fourier analysis, Conservative systems. **Systems Having Single Degree of Freedom:** Free vibrations of systems without damping, equilibrium and energy methods for determining natural frequency; Rayleigh's method; Equivalent systems, systems with compound springs, shaft of different diameters; Free vibrations of system with viscous damping, over damped, critically and under damped systems, logarithmic decrement; Coulomb and structural damping; Forced vibrations of systems with viscous damping, equivalent viscous damping, power consumption in vibrating system, impressed forces due to unbalanced masses and excitation of supports, vibration isolation, transmissibility, commercial isolators; Vibration isolation using ER fluids. **Systems with two Degrees of Freedom:** Free undamped vibrations, static and dynamic coupling, principal modes of vibration, undamped dynamic vibration absorber, centrifugal pendulum absorber. **Multi-Degree of Freedom Systems:** Influence coefficients, eigen values and eigen vectors, matrix iteration; Dunkerley and Rayleigh's method. **Continuous Systems:** Vibration of strings, free longitudinal vibrations of prismatic bars, torsional vibrations of circular shafts, lateral vibrations of uniform beams. **Vibration Measuring Instruments:** Principle of frequency, displacement, velocity and acceleration measuring instruments, distortion effect. **Whirling of Shafts:** Whirling of light flexible vertical/horizontal shaft with an unbalanced disc at the centre of its length with and without damping.
8.	Suggested Books	1. W.T. Thomson, **Theory of Vibration and Applications**, Prentice Hall, 1979. 2. R.F. Steidel, **An Introduction to Mechanical Vibration**, John Wiley and Sons, 1979. 3. M.P. Norton, and D. Karczub, **Fundamentals of Noise and**

		Vibration Analysis for Engineers (2nd edition), Cambridge University Press, 2003. 4. J.S. Rao, and K. Gupta, **Theory and Practice of Mechanical Vibrations**, New Age International (Pvt.) Ltd. New Delhi, 1999.

Course code	ME 432/ ME 632
Title of the course	**Vibrations and Noise Control**
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	NA
Scope of the course	With the increasing demand of noise and vibration engineers in industry, this course is designed to know theoretical and practical aspects of noise and vibration. This course covers basics of noise and vibration, measurement and analysis of noise and vibration, control of noise and vibration and industrial case studies.
Course Syllabus	**Introduction:** Basic vibration theory, vibration of one degree, two degrees, and multi-degrees of freedom systems. **Transient vibrations**, vibration of beams. **Measurement and Analysis of Vibrations:** Lagrange's equation, vibration measuring and analyzing instruments. Various types of transducers, data acquisition system, vibration analysis techniques **Design for vibration control**: Vibration absorbers, viscoelastic damping, active vibration control. **Fundamentals of Noise**: One dimensional wave equation, Sound propagation in 3-D space, some important acoustic quantities and relations, additive effects of sound. **Measurement of sound:** Various types of transducers, measurement of sound pressure, sound intensity and sound power. **Noise Control:** Principles of passive noise control, sound absorption, noise barriers. **Case studies:** Source identification and fault detection from noise and vibration signals in mechanical systems such as bearings, gears, fans, blower and pumps, electrical equipment etc.
Suggested Books	• W.T. Thomson, **Theory of Vibration and Applications**, Prentice Hall, 1979, ISBN-13: 978-0136510680 • R.F. Steidel, **An Introduction to Mechanical Vibration**, John Wiley and Sons, 1979, ISBN-13: 978-0471845454 • J.S. Rao, and K. Gupta, **Theory and Practice of Mechanical Vibrations**, New Age International (Pvt) Ltd. New Delhi, 1999, ISBN-13: 978-8122412154 • Brandt, Anders, **Noise and vibration analysis : signal analysis and experimental procedures,** John Wiley & Sons, West Sussex, 2011, ISBN-13: 978-0470746448 • Cheremisinoff, Nicholas, **Noise control in industry : a practical guide,** Noyes Publications, New Jersey, 2003, ISBN-13: 978-0815513995 • Fahy, Frank and Walker, John, **Fundamentals of noise and**

	vibration, Taylor and Francis, London, 1998, ISBN-13: 978-0419227007 • Norton, M.P and Karczub, D.G**, Fundamentals of noise and vibrations analysis for engineers**, Cambridge University press , New York , 2003, ISBN-13: 978-0521499132

1.	Course Code	**ME 433**
2.	Title of the Course	**Condition Monitoring and Diagnostics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Introduction to condition based maintenance, application and economic benefits. Typical defects in gears and rolling element bearings **Vibrations of Gears and Bearings:** Vibration characteristics of non-defective gears; Vibration characteristics of non-defective bearings; Vibration characteristics of defective gears; Vibration characteristics of defective bearings. **Monitoring Methods:** Early time domain methods, spectral methods, cepstral methods, envelope methods. **Vibration Analysis:** Vibration- simple harmonic motion concept, vibration monitoring equipment, system monitors and vibration limit detectors, vibration monitoring examples, critical vibration levels. **Sound Monitoring:** Sound frequencies, sound loudness measurement, acoustic power, sound measurement, sound level meters, sound analyzers, sound signal data processing, sound monitoring. **Discrete Frequencies:** Simple vibrations, transverse vibration of bars-approximate frequency calculations, more precise evaluations-overtones, torsional oscillation of flywheel-bearing shafts, belt drives, whirling of shafts, gear excitation, rolling element bearing, blade vibration, cam mechanism vibration. **Machine Condition Indicators:** RMS value, peak value and crest factor, kurtosis, defect severity index. **Measurement Techniques:** Instrumentation, data acquisition, signal filtering, signal analysis - online and offline techniques, normalized order analysis. **Signal Processing Tools:** Sample rate and aliasing**, t**ime and frequency domain analysis. **Case Studies:** Practical applications of diagnostic maintenance, condition monitoring of mechanical and electrical machines.
8.	Suggested Books	1. M.P. Norton, and D. Karczub, **Fundamentals of Noise and Vibration Analysis for Engineers** (2nd edition), Cambridge University Press, 2003.

		2. R.A. Collacott, **Mechanical Fault Diagnosis and Condition Monitoring**, Chapman & Hall, 1977. 3. F.J. Fahy, and J.G. Walker**, Fundamentals of Sound and Vibration**, Spon Press, 1998. 4. M. Abom, **Sound and Vibration**, KTH, 2006. 5. Davies, **Handbook of Condition Monitoring- Techniques and Methodology**, Springer, 2006.

Course code	**ME 434/ ME 634**
Title of the course	**Principles of Product Design**
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	NA
Scope of the course	The scope of the course is to integrate the design, marketing, engineering, and business functions of the firm in creating a new product. The course is intended to provide the following benefits: •Competence with a set of tools and methods for product design and development. • Describe an engineering design and development process •Ability to coordinate multiple, interdisciplinary tasks to achieve a common objective. •Employ engineering, scientific, and mathematical principles to execute a design from concept to finished product. •Reinforcement of specific knowledge from other courses through practice and reflection in an action-oriented setting.
Course Syllabus	Overview of the Design Process – Philosophy of Engineering Design, Steps involved in the Design Process S curves, Communications during design process. Understanding the customer need – Steps involved in developing Engineering Design Specifications. The technique of Quality Function Deployment (QFD). Case studies in QFD. Functional Design – Functions in engineering Design. Basics of Function Structure – Functional Basis, Functional decomposition and flow. Product Concept – Various methods of concept generation. The method of theory of the resolution of invention-related tasks (TRIZ). Concept Selection and methods of evaluation. Embodiment design- product architecture, configuration, parametric design, systems approach and other consideration of embodiment design. An introduction to product metrics. Product evaluation techniques.
Suggested Books	• K. Otto and K. Wood, **Product Design: Techniques in Reverse Engineering and New Product Development**, Pearson, New Jersey, 2001, ISBN 978-0130212719 • D.G. Ullman, **The Mechanical Design Process**, McGraw-Hill, New York, 2009, ISBN 978-0072975741 • G. Dieter and L. Schmidt, **Engineering Design (Mechanical Engineering)**, McGraw-Hill, New York, 2012, ISBN 978-0073398143 • K.T. Ulrich and S.D. Eppinger, **Product Design and Development**, McGraw-Hill, New York, 2007, ISBN 978-0073101422

1.	Course Code	**ME 435**
2.	Title of the Course	**Experimental Stress Analysis**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Basic equations in elasticity, state of strain, brittle coating method, crack patterns produced by direct loading, refrigeration method, releasing method, effect of coating thickness and environment. **Photoelasticity Methods:** behaviour of light, plane polarised and circular polariscope, isochromatic and isoclinic fringe patterns for two dimensional photoelasticity, three dimensional photoelasticity, model slicing and shear difference method, birefringent coating method. **Strain Measurement Methods:** types of gauges, electric strain gauge, strain rosette analysis, three element, delta, four element rosette, strain gauge circuits and recording instrument. **Misc. Topics:** Moire fringe technique, surface strain measurements and flexural studies, Grid analysis, X-ray techniques and holography, Motion measurements.
8.	Suggested Books	1. J .W. Dally, and W.P. Riely, **Experimental Stress Analysis**, McGraw Hill Book Co., 1978. 2. G.S. Holister, **Experimental Stress Analysis**, Cambridge University Press, 1967. 3. R.C. Dove, and P.H. Adams, **Experimental Stress Analysis and Motion Measurements**, Prentice Hall, 1965.

1.	Course Code	**ME 436 / ME 736**
2.	Title of the Course	**Finite Element Analysis (FEA)**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Basic Concepts:** Introduction, Weak formulations, Weighted residual methods, Variational formulations, weighted residual, collocation, subdomain, least square and Galerkin's method, virtual work principle. **One-Dimensional Problems:** Basis steps, Discretization, Element equations, Linear and quadratic shape functions, Assembly, Local and global stiffness matrix and its properties, boundary conditions, penalty approach, multipoint constraints, Applications to solid mechanics, heat and fluid mechanics problems, axisymmetric problems, Transient problems. **Trusses:** Plane truss, local and global coordinate systems, stress calculations, temperature effect on truss members, solution of practical problems. **Beams and Frames**: Euler Bernoulli beam element, Rayleigh beam element, frame element, problems. **Two-Dimensional Problems:** Single variables in 2-D, triangular and rectangular elements, constant strain triangle, isoparametric formulation, higher order elements, six node tringle, nine node quadrilateral, master elements, numerical integration, computer implementation. **Scalar Field Problems:** Torsion, heat transfer, heat transfer in thin fins, potential flow problems. **Elasticity Problems**: Review of equations of elasticity, stress-strain and strain-displacement relations, dynamic problems on vibrations, plane stress and plane strain problems.
8.	Suggested Books	1. J.N. Reddy, **An Introduction to Finite Element Method** (3rd edition), Tata McGraw-Hill, 2005. 2. S.S. Rao, **The Finite Element Method in Engineering** (4th edition) Elsevier Science, 2005. 3. K.H. Huebner, D.L. Dewhirst, D.E. Smith, and T.G. Byrom, **The Finite Element Method for Engineers** (4th edition), John Wiley and Sons, 2001. 4. J. Fish, and T. Belytschko, **A First Course in Finite Elements**, John Wiley and Sons, 2007. 5. J. Chaskalovic, **Finite Element Methods for Engineering**

		Sciences, Springer, 2008.

Course code	**ME 437/ ME 637**
Title of the course	**Fracture Mechanics**
Credit Structure	L - T - P – Credits 2-1-0-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	Theory of elasticity
Scope of the course	This course introduces the fundamental concepts of the fracture mechanics useful in designing high risk products such as nuclear plants, airplanes, space vehicles, submarines, etc. This course will not only provide enough background to work in industries but also build foundation to start research in the area of fracture mechanics, computational fracture mechanics and mechanical behaviour of materials.
Course Syllabus	Introduction and overview, Energy concepts in fracture mechanics: atomistic view of fracture, Griffith energy balance, Irwin-Orowan extension, Energy release rate G and R curve; Linear elastic fracture mechanics: stress and displacement fields near crack tip for mode-I, II and III fracture, stress intensity factor K, relation between G and K, small scale yielding conditions, Irwin's plastic zone correction, Dugdale model, Fracture toughness Kc, Westergaard method, Principle of superposition, Non Linear fracture mechanics; J Integral, Plastic crack tip (HRR) fields, Ductile fracture criterion, J Integral Testing, J-controlled crack growth and stability, Engineering approach to Plastic Fracture; Fatigue Failure.
Suggested Books	• T.L. Anderson, **Fracture Mechanics – Fundamentals & Applications**, CRC press, 3rd Edn., 2005, ISBN-10: 0849316561. • M.F.Kanninen and C.H.Popelar, **Advanced Fracture Mechanics**, Oxford press, 1985, ISBN-10: 0195035321 • D. Broek, **Elementary Engineering Fracture Mechanics**, Martinus Nijhoff publishers, 1982, ISBN-13:- 978-90-247-2580-9 • Kare Hellan, **Introduction to Fracture Mechanics**, McGraw Hill, 1984, ISBN-10: 0070280487

1.	Course Code	**ME 438 / ME 738**
2.	Title of the Course	**Composite Materials**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Nil
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** classifications, terminologies, manufacturing processes. **Macro-mechanical analysis of lamina:** Hooke's law for anisotropic, monoclinic, orthotropic, transversely isotropic and isotropic materials–2D Unidirectional and angle ply lamina – Strength theories of lamina. **Micro-mechanical analysis of lamina:** Volume and mass fraction, density and void content – Evaluation of Elastic module, Ultimate strength of unidirectional lamina. **Macro-mechanical analysis of laminates:** Laminate code, Stress strain relations – In-plane and Flexural modulus, Hydrothermal effects. **Failure Analysis and Design:** Special cases of laminates, symmetric, cross ply, angle ply and anti-symmetric laminates, failure criteria and failure modes.
8.	Suggested Books	1. Jones, R M, ***Mechanics of Composite Materials*****,** Scripta Book Co. 2. Agarwal, B D and Broutman, J. D, ***Analysis and Performance of Fiber Composites*****,** New York, John Willey and Sons, 1990 3. Mallik, P. K, ***Fiber reinforced composites : materials, manufacturing and design,*** New York- Marcel and Dekker, 1993 (2nd edition) 4. Arthur, K Kaw, ***Mechanics of Composite Materials***, CRC Press, 1997. 5. Reddy J N, ***Mechanics of Laminated Composite Plates***, CRC Press 6. Mallik, P. K, ***Composite Engineering Hand Book***, New York, Marcel and Dekker, 1997 (2nd edition)

Course code	**ME 439/ ME 639**
Title of the course	**Mechanical Behavior of Materials**
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	NA
Scope of the course	This course will discuss crystal structure, basic mechanism of plastic deformation and their influence on the mechanical behavior of metallic materials. In addition, it will provide an understanding of the atomistic modelling of solid materials to characterize their mechanical behavior.
Course Syllabus	Introduction and overview, Elastic deformation, Crystal structure, Theory of dislocation (edge, screw and mixed dislocations, cross slip, Peirls-Nabarro stress, Peach-Koehler equation, Frank-Read source), Twining, Plastic deformation in single and polycrystal, Strengthening mechanisms, Hardening mechanisms, Atomic/molecular structure of nanomaterials and their synthesis, overview of nanomechanical testing methods, atomistic modelling tools (DFT, tight-binding modelling, MD with their advantages and limitations), Functionalization, Size-scale strength, Nano-biomechanics and nanocomposites
Suggested Books	• William F. Hosford, **Mechanical behavior of materials**, Cambridge University Press, 2 edition, New York, 2009, ISBN 978-0521195690 • G.E. Dieter, **Mechanical Metallurgy**, McGraw-Hill, London, 1988, ISBN 0–07–016893–8 • Andrew Leach, **Molecular Modelling: Principles and Applications,** Pearson, London, 2001, ISBN 978-0582382107 • Alan Hinchliffe, **Molecular Modelling for Beginners**, John Wiley & Sons Ltd., United Kingdom, 2008, ISBN 978-0470513149

1.	Course Code	**ME 440 / ME 640**
2.	Title of the Course	**Smart Materials and Structures**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Intelligent materials:** Primitive functions of intelligent materials; Intelligence inherent in materials; Materials intelligently harmonizing with humanity; Intelligent biological materials. **Smart Materials and Structural Systems:** Actuator materials; Sensing technologies; Micro-sensors; Intelligent systems; Hybrid smart materials; Passive sensory smart structures; Reactive actuator-based smart structures; Active sensing and reactive smart structures; Smart skins **Electro-Rheological (ER) Fluids:** Suspensions and electro-rheological fluids; The electro-rheological phenomenon; Charge migration mechanism for the dispersed phase; Electro-rheological fluid actuators. **Piezoelectric Materials:** Background; Piezoelectricity; Industrial piezoelectric materials; Smart materials featuring piezoelectric elements. **Shape Memory Materials (SMM):** Background on shape-memory-alloys; Applications of shape-memory-alloys; Continuum applications: structures and machine systems; Discrete applications; Impediments to applications of shape-memory-alloys; Shape-memory-plastics. **Fiber-optics:** an overview; Advantages of fiber-optics; Light propagation in an optical fiber; Embedding optical fibers in fibrous polymeric thermosets; Fiber-optic strain sensors. **The piezoelectric Vibrations Absorber Systems:** Introduction; The single mode absorber, theory, design solution, extension including viscous modal damping, the electromechanical coupling coefficient, inductance, experimental results; The multimode absorber, derivation of transfer function, design solution, self-tuning absorber, performance function, control scheme.
8.	Suggested Books	1. M.V. Gandhi, and B.S. Thompson, **Smart Materials and structures** (2^{nd} edition), Chapman & Hall, 1992.

		2. Guran, H.S. Tzou, G.L. Anderson, and M. Natori, **Structure Systems: Smart Structures, Devices and System** (Part 1), and **Materials and Structures** (Part 2), World Scientific Publications, 1998. 3. U. Gabbert, and H.S. Tzou, **Smart Structures and Structuronic System**, Kluwer Academic Publishers, 2001. 4. H.T. Banks, R.C. Smith, and Y.W. Qang, **Smart Material structures: Modeling, Estimation and Control** (6th edition), John Wiley & Sons, 1997.

Course code	**ME 641/ ME 441**
Title of the course	**Design of Laminated Composite Structures**
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	Solid Mechanics, Strength of Materials, Composite Materials
Scope of the course	This course introduces various aspects of composite structural design based on different applications. This course is intended to educate the students in basics, advantages, design, fabrication, and applications of composite materials in various advanced structures.
Course Syllabus	Introduction to different thermo-set and thermo-plastic composites, manufacturing process of thermo-set and thermo-plastic composites, application of thermo-set and thermo-plastic composites based on the design requirement, Design of composite beams, review of laminate strength and failure theories , experimental testing of the composites for stiffness and strength parameters, Introduction to fatigue of composite materials, design and analysis of composite beams, shear flow and shear center calculation in thin walled closed sections, analysis of loads and load paths in the advanced industrial composite structures such as wind turbine rotor blade and gas turbine compressor fan blade, Selection of ply angles based on the load paths.
Suggested Books	• Isaac M. Daniel , Ori Ishai, **Engineering mechanics of composite materials**, Oxford university press, New Delhi, 2011, ISBN 019568580-6 • Carl T. Herakovich: **Mechanics of fibrous composites,** Wiley Publications, Newyork, 1998, ISBN: 978-0-471-10636-4 • Louis C. Dorworth, Ginger L. Gardiner, Greg M. Mellema, **Essentials of advanced composite fabrication & repair**, Aviation supplies & Academics, Inc., Newyork, 2009, ISBN 978-1-61954-229-7 • Christos Kassapoglou, **Design and analysis of composite structures with applications to aerospace structures**, Wiley publications, The Netherlands, 2011, ISBN9781118401606

Course code	**ME 443/ ME 643**
Title of the course	**Micromechanics and Nanomechanics**
Credit Structure	L - T - P – Credits 2-1-0-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	NA
Scope of the course	This course is designed for students from diverse fields of study. This course provides a single window for students to comprehend wide range of subjects/research topics of advanced micro- and nano-materials and prepare them to characterize multifunctional behavior of advanced material systems. The first part of the subject includes modules of fundamentals of micromechanics. The second part of the subject includes modules on useful concepts in molecular modeling. A partial focus of the subject is to provide a hands-on training in the application of computer modeling of SOLID materials at the atomic scale.
Course Syllabus	Introduction to micromechanics and nanomechanics. Preliminaries of continuum mechanics, micromechanical homogenization theory: Ergodicity principle, representative volume element, eigenstrains and eigenstress, inclusions and inhomogeneities; Effective moduli of heterogeneous materials (single and multi-inclusion approaches), Hill's bounds, Voigt and Reuss bounds, Hashin-shtrikman variational principles Micromechanical damage theory. Basics of atomistic, interatomic potentials, lattice defects; Molecular statics and dynamics: time integration, temperature and pressure control, statistical ensembles, potential field, Virial stress; Bohr's correspondence principle; Multiscale modeling; Structural mechanics of carbon-based and boron nitride-based nanomaterials.
Suggested Books	• S. Nemat-Nasser and M. Hori, **Micromechanics: Overall Properties of Heterogeneous Materials**, North Holland, Amsterdam, 1998, ISBN 978-0444500847 • Shaofan Li and Xin-Lin Gao, **Handbook of Micromechanics and Nanomechanics**, Taylor & Francis Group, LLC, Boca Raton, 2013, ISBN 978-981-4411-24-0 • Jianmin Qu and Mohammed Cherkaoui: **Fundamentals of Micromechanics of Solids,** John Wiley & Sons Inc., New Jersey, 2006 ISBN 978-0-471-46451-8 • Alan Hinchliffe, **Molecular Modelling for Beginners**, John Wiley & Sons Ltd., United Kingdom, 2008 ISBN 978-0470513149

1.	Course Code	**ME 444/ ME 644**
2.	Title of the Course	**Robotics**
3.	Credit Structure	L-T-P-Credit 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Introduction to robots – Robot manipulators – Mobile robots – Robot anatomy – Coordinate systems, Work envelope – Types and classification – Specifications – Sensors – Actuators and drives. **Forward and Inverse Kinematics:** Introduction – Representation of position and orientation of a rigid body – Homogeneous transformations – Forward and inverse kinematics problems – Denavit-Hartenberg (D-H) notations and parameters – Representation of joints, link representation using D-H parameters – Closed-form solutions – Geometric and Numerical methods. **Velocity and Statics analysis:** Linear and angular velocity of links – Velocity propagation – Jacobians for robotic manipulators – Statics and force transformation of robotic manipulators – Singularity analysis. **Robot Dynamic analysis:** Introduction – Forward and inverse dynamics – Mass and inertia of links - Lagrangian formulation for equations of motion for robotic manipulators – Newton-Euler formulation method – Dynamic modelling – State space representation of dynamic equations of robotic manipulators. **Trajectory Planning and Control:** Joint and Cartesian space trajectory planning and generation – Classical control concepts using the example of control of a single link – Independent joint PID control – Control of a multi-link manipulator – Nonlinear model based control schemes – Simulation and experimental case studies on robotic manipulators.
8.	Suggested Books	1. J. J. Craig, **Introduction to Robotics: Mechanics and Control,** John Wiley & Sons Inc., 2004 2. M.W. Spong, Seth Hutchinson, M. Vidyasagar, **Robot Modeling and Control**, John Wiley & Sons Inc., 2006.

		3. J.R. Schilling, **Fundamentals of Robotics: Analysis and Control** Prentice Hall India, 1992. 4. K. Fu, R. Gonzalez and C.S.G. Lee, **Robotics: Control, Sensing, Vision and Intelligence,** McGraw- Hill, 1987. 5. A. Ghosal, **Robotics: Fundamental Concepts and Analysis** Oxford University Press, 2008.

Course code	ME 445/ ME 645
Title of the course	**Mobile Robotics**
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	NA
Scope of the course	This course provides an introduction to mobile robotic systems and motion control methods with such systems from a computational and real-time perspective. •Students will understand the algorithmic approach towards designing intelligent and autonomous mobile robotic systems. •Students will learn about a variety of mobile robotic platforms, their applications and uses. •Students will learn the basics mechanical and electrical systems of these mobile robots, including sensors, locomotion and manipulation hardware.
Course Syllabus	Introduction to Mobile Robots - Tasks of mobile robots, robot_s manufacturers, type of obstacles and challenges, tele-robotics, philosophy of robotics, service robotics, types of environment representation. Ground Robots: Wheeled and Legged Robots, Aerial Robots, Underwater Robots and Surface Robots. Kinematics and Dynamics of Wheeled Mobile Robots (two, three, four - wheeled robots, omni-directional and macanum wheeled robots). Sensors for localization: magnetic and optic position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, GNSS and Sensors for navigation: tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder, visual system, Kinect. Localization and Mapping in mobile robotics. Motion Control of Mobile Robots (Model and Motion based Controllers): Lyapunov-based Motion Control Designs and Case Studies. Understand the current application and limitations of Mobile Robots. Introduction to Mobile Manipulators and Cooperative Mobile Robots.
Suggested Books	1. R Siegwart, IR Nourbakhsh, D Scaramuzza, ***Introduction to Autonomous Mobile Robots***, The MIT Press, USA , 2011, 9780262015356 2. SG Tzafestas, ***Introduction to Mobile Robot Control***, Elsevier, USA, 2014, 9780124170490 3. A Kelly, ***Mobile Robotics***, Mathematics, Models, and Methods, Cambridge University Press, USA, 2013, 9781107031159 4. G Dudek, M Jenkin, ***Computational Principles of Mobile Robotics,*** Cambridge University Press, USA, 2010, 9780521692120

1.	Course Code	**ME 446 / ME 646**
2.	Title of the Course	**Dynamics and Control Systems**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering / School of Engineering
5.	Pre–requisite, if any	Courses on Controls and Kinematics & Dynamics of the Machines
6.	Scope of the course	The Scope of the Courses of this course are to develop in mechanical engineering students the knowledge and skills required • To establish the fundamental techniques for modeling dynamic systems. • To analyze and manipulate system models in the time and frequency domain. • To develop an understanding of feedback control systems and the parameters that influence their stability and performance.
7.	Course Syllabus	**Dynamic Modelling of Systems:** Introduction to Dynamics, Systems and Control. Dynamic modelling of systems. Lumped system. Modelling of translational and rotational mechanical spring-mass-damper systems. Nonlinear systems and Linearization of nonlinear systems. Numerical computations and simulations with MATLAB / MATHEMATICA, and simulations in MSC ADAMS. **Analysis of Linear Systems:** Introduction, Laplace transform, Transfer functions, System response, Stability analysis, Routh-Hurwitz criteria. Time domain analysis: Root locus method. Frequency domain analysis: Bode plot and Nyquist plot. Numerical computations with MATLAB. **Linear Feedback Control Systems:** Lead and Lag compensator, Design and analysis of linear feedback control systems using time and frequency domain techniques. Numerical computations with MATLAB. Proportional (P), proportional-derivative (PD), proportional-integral (PI) and proportional-integral-derivative (PID) controller, Gain tuning methods and modifications. Case studies on PID Controller and its applications. **Analysis of Systems in State Space:** Concept of state and state variables. State space representation of dynamic systems. State models of linear time invariant systems, State transition matrix, and Solution of state equations. Controllability and Observability. Numerical computations with MATLAB. **State Space Controllers and Observers for Linear systems:** Full state feedback controller and Pole

		placement technique. Design of full state feedback controller. State observer and design of state observer with controller. Numerical computations and simulations with MATLAB.
8.	Suggested Books	1. K. Ogata, **Modern Control Engineering, 5/e**, Prentice Hall India, 2003. 2. B.C.Kuo, **Automatic Control Systems, 7/e**, Prentice Hall India, 2003. 3. N.S. Nise, **Control Systems Engineering, 4/e**, John Wiley, 2003. 4. M. Gopal, **Control Systems, 2/e**, Tata McGraw-Hill, 2000. 5. G. F. Franklin, **Feedback Control of Dynamic Systems, 6/e**, Pearson Edition, 2009. 6. R.C. Dorf and R.H. Bishop, **Modern Control Systems, 12/e**, Prentice Hall India, 2011. 7. C.L. Phillips, and R.D. Harbour, **Feedback Control Systems, 2/e**, Prentice Hall, 1991. 8. I.J. Nagrath and M. Gopal, **Control System Engineering, 2/e**, Wiley Eastern, 1982.

1.	Course Code	**ME 448 / ME 648**
2.	Title of the Course	**MEMS and Micro-system Design**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering Department
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	**Introduction to MEMS and Micro-systems:** Micro-electro-mechanical- systems (MEMS) and micro-system products, the multidisciplinary nature of micro-systems, scaling laws in miniaturization, application of micro system in other industries, intrinsic characteristics of MEMS. **Micro-actuators and Micro-sensors:** Micro-sensors, acoustic wave sensors, biomedical and nano-sensors, chemical sensors, optical sensors, pressure sensors, themal sensors, micro-actuation through thermal forces, SMA-Piezo electric crystals, and electrostatic forces, magnetic actuation, micro-grippers, micro-motors, micro-valaves, micropumps, micro-accelelrometers. **Materials, Mechanics and design of micro-systems:** Silicon as a substrate, compounds, piezo-resisitors, polymers and packaging materials, micro-fabrication and micro-etching: static bending of thin plates, thermo mechanics and thin film mechanics. **Case studies of MEMS Products:** Micro-fluidic devices, micro/nano transducers, blood pressure sensor, microphone-acceleration sensors, gyroscope, an overview of micro-system packaging.
8.	Suggested Books	1) Tai-Ran Hsu, **MEMS and Micro system Design and Manufacturing**, Tata McGraw Hill, ISBN 07-239391-2. 2) Chang Liu, **Foundation of MEMS**, Pearson Education, ISBN (978-81-317-6475-6) 3) Guozhong Cao,Ying, **Nanostructure and Nano materials, synthesis, properties and applications**, World Scientific Publishing Co. 2011 4) Robert Kelsall, Ian W.Hamley, Mark Geoghegan, **NanoScale Science and Technology**, ISBN 13:978047085086 5) Lifeng Chi, **Nano technology-Volume 8: Nanostructured surfaces**, Wiley Publication, ISBN13:9783527317394.

1.	Course Code	**ME 451 / ME 751**
2.	Title of the Course	**Theory of Advanced Machining Processes**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	To introduce the process principle, mechanism and modeling of material removal, parametric analysis, applications, limitations of various advanced machining processes and the derived and hybrid processes based on them.
7.	Course Syllabus	**Introduction:** Types of advanced machining processes (AMPs); evolution, and need. **Mechanical Type AMPs:** process principle and elements; Mechanism of material removal, parametric analysis; Shape and material applications; Operational characteristics; Limitations of USM, AJM, WJM, AWJM processes. **Advanced Fine Finishing Process:** Process principle, process equipment, Parametric analysis, Applications of Abrasive Flow Machining (AFM); Magnetic Abrasive Finishing; Magneto Rheological Abrasive Finishing (MRF) processes. **Chemical Type AMPs:** Process principle and details of Chemical Machining (CHM); Photo-Chemical Machining (PCM), and Bio-Chemical Machining processes (BCM). **Electro Chemical Type AMPs:** ECM-Process principle, mechanism of material removal; Kinematics and dynamics and dynamics of ECM; Tooling design; Choice and analysis of process parameters; Surface finish and accuracy. **Thermal Type AMPs:** Working principle; Power circuits; Mechanism of material removal; Process parameters and characteristics; Surface finish and accuracy, Shape and materials applications, limitations of EDM, LBM, EBM, IBM, PAM processes. **Derived and Hybrid AMPs:** Introduction of processes like rotary ultra sonic machining (RUM), electro stream drilling (ESD), shaped tube electro machining (STEM), wire electro discharge machining (WEDM), electro chemical grinding (ECG), electro chemical honing (ECH), electro chemical deburring (ECD), and electro-chemical spark

		machining (ECSM).
8.	Suggested Books	1. G.F. Benedict, **Nontraditional Manufacturing Processes**, Marcel Dekker, Inc., 1987. 2. V.K. Jain, **Advanced Machining Processes**, Allied Publishers, 2002. 3. A. Ghosh, and A.K. Mallik, **Manufacturing Science**, Affiliated East-West Press Ltd, 1985. 4. P.C. Pandey, and H.S. Shan, **Modern Machining Processes**, Tata McGraw-Hill Publishing Co. Ltd, 1977. 5. J.A. McGeough, **Advance Methods of Machining**, Chapman and Hall, 1988.

1.	Course Code	**ME 453 / ME 653**
2.	Title of the Course	**Computer Aided Manufacturing (CAM)**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Introduction to manufacturing systems and their performance analysis; Introduction to Automation; Introduction to Computer Integrated Manufacturing (CIM). **Numerical Control (NC):** Introduction, Numerical Control – its growth and development, Components of NC system, Input devices, Control systems – point to point, straight cut, and continuous path NC, Open loop and closed loop NC systems, NC interpolations – linear, circular, helical, parabolic and cubic interpolation, Applications of NC systems, Merits and demerits. **Extensions of NC:** Concepts of Computer Numerical Control (CNC), Machining Center, and Direct Numerical Control (DNC), and their advantages. **Robotics:** Robot anatomy and related attributes, Robot control systems – limited sequence, playback with point to point, playback with continuous and intelligent control, End effectors – gripper, tools, Sensors in Robotics – tactile sensors, proximity, optical sensors and machine vision, Applications of industrial robots, Robot programming. **Material Handling and Storage:** Overview of Material Handling Equipments, Automated material handling equipments – AGVs, Conveyor systems, Performance analysis of material handling systems, Automated material storage systems – ASRS and Carousel storage, Analysis of automated storage systems. **Manufacturing Support Functions:** Introduction to Group Technology (GT), Computer Aided Process Planning (CAPP), Material Requirement Planning MRP (MRP), Capacity Planning, Scheduling etc.
8.	Suggested Books	1. M.P. Groover, **Automation, Production systems and Computer Integrated Manufacturing**, Prentice-Hall Inc. Englewood Cliffs 1987. (ISBN087692-618-7) 2. N. Singh, **Systems Approach to Computer Integrated Design and Manufacturing**, John Wiley & Sons, 1996. Sons (ISBN0-471-58517-3) 3. T.C. Chang, R.A. Wysk, and H.P. Wang, **Computer Aided**

		Manufacturing, Prentice Hall Inc. New Jersey, 1991, (ISBN0-13-161571-8) 4. Y. Koren, **Computer Control of Manufacturing Systems**, McGraw Hill Inc., 1983. (ISBN 007-035-3417) 5. M. Lynch**, Computer Numerical Control for Machining**, , McGraw-Hill Inc. 1992. (ISBN 0-07-039223-4) 6. M. Sava, and J. Pusztai, **Computer Numerical Control Programming**, Prentice Hall, 1990. (ISBN 0-13-156084-0)

1.	Course Code	**ME 454 / ME 654**
2.	Title of the Course	**Rapid Product Manufacturing**
3.	Credit Structure	L-T- P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	To introduce various concepts of involved in rapid product manufacturing starting from product modeling, reverse engineering, product data exchange, concurrent engineering, rapid prototyping, and rapid tooling
7.	Course Syllabus	**Product Modeling and Reverse Engineering:** Wireframe modeling; Surface modeling – Boundary representation; Solid modeling: CSG; Concept of reverse engineering. **Product Data Exchange:** Neutral file formats for product data exchange- DXF, IGES, STEP. **Concurrent Engineering:** Concept of concurrent engineering; Design for X; Design for manufacturability (DFM); design for assemblability (DFA); Design for reliability (DFR); Design for quality (DFQ) **Rapid Prototyping (RP) Methods:** Liquid based RP methods – Stereolithography apparatus (SLA), Solid Ground Curing (SGC), Solid Creation System (SCS), etc.; Solid based RP methods: Fused Deposition Modeling (FDM), Laminated Object Manufacturing (LOM), etc. Powder based RP methods– Selective Laser Sintering (SLS), 3D printing (3DP), Ballistic Particle Manufacturing (BPM), etc. **Rapid Tooling (RT):** Introduction, various techniques of RT.
8.	Suggested Books	1. M.M. Anderson, and L. Hein, **"Integrated Product Development",** IFS Publication, Springer Verlag, Berlin, 1987. 2. I. Zeid "CAD/CAM: **Theory and Practice"**, , Tata McGraw Hill, New Delhi, 1998 (ISBN 0-07-463126-8) 3. M. E. Mortenson, **"Geometric Modeling",** John Wiley & Sons, New York, 1985 (ISBN 0-471-88279-8) 4. G.Q. Huang, **"Design for X: Concurrent Engineering Imperatives",** Chapman and Hall, London, 1996 (ISBN 0-412-78750-4) 5. G. Boothroyd, P. Dewhurst, and W. Knight, **"Product Design for Manufacture and Assembly (2nd Edition)"**, Marcel Dekker, New York, 2002 (ISBN 0-08247-0584-7) 6. C.K. Chua, and K.F. Leong, **"Rapid Prototyping: Principles and Applications in Manufacturing",** John

		Wiley & Sons. Inc. Singapore, 1997. 7. A.K. Chitale, and R.C. Gutpa, **“Product Design and Manufacturing”**, Prentice Hall of India, New Delhi, 1997.

1.	Course Code	**ME 456 / ME 756**
2.	Title of the Course	**Industrial Automation**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Basic Concepts:** Introduction of Mechanization and Automation, Classification and Strategies of Automation, Reasons for and Arguments against Automation. Mechanical, Electrical, Hydraulic, and Pneumatic Devices and Controls. **High Volume Manufacturing or Hard Automation:** Automated Flow Lines, Types of Automatic Transfer Mechanisms, Design and Fabrication Considerations, Analysis of Automated Flow Lines. **Assembly Automation:** Assembly Systems and their Types, Manual Assembly Lines and Line Balancing, Automated Assembly Lines and their Types, Automatic Assembly Transfer Systems, Automatic Feeding and Orienting Devices:- Vibratory and Mechanical Feeders and their types, Orientation of Parts, Performance and Economics of Assembly Systems, Feasibility Study for Assembly Automation. **Design for Assembly:** Design for Manual Assembly, Design for High-Speed Automatic Assembly, Design for Robot Assembly. **Flexible Automation:** Introduction of Group Technology (GT), Steps in Implementing GT, Part Families and Machine Cell Formation, Introduction of Flexible Manufacturing Systems (FMS). **Programmable Automation:** Brief Introduction of Numerical Control (NC), Computer Numerical Control (CNC), Machining Centers, Programmable Robots, Direct Numerical Control (DNC), and Adaptive Control.
8.	Suggested Books	1. M.P. Groover, **Automation, Production systems and Computer Integrated Manufacturing**, Prentice-Hall Inc. Englewood Cliffs 1987. (ISBN087692-618-7) 2. G. Boothroyd, **Assembly Automation and Product Design**, Marcel Dekker, New York, 1992. 3. G. Boothroyd, C. Poli, and L. E. Murch, **Automatic Assembly**, Marcel Dekker Inc. New York, 1982. 4. G. Boothroyd, P. Dewhurst, and W. Knight, **Product Design for Manufacture and Assembly** (2nd Edition), Marcel Dekker, New York, 2002.

1	Course Code	**ME 458 / ME 658**
2	Title of the course	**Laser based Measurements and Micro-Manufacturing**
3	Credit Structure	L-T-P-Credit 2-1-0-3
4	Name of the Concerned Department	Mechanical Engineering
5	Pre-Requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Thermal Process in laser material interaction:** Introduction to working of Laser- Absorption of laser radiation-optical properties of materials-Macroscopic transport-conductive heat transfer. Thermal effects using laser – laser heating- melting- vapor expansion and recoil pressure-Plasma formation-Hydrodynamic stability of transient melts-modelling of laser ablation and plume prorogation **Laser based micro-manufacturing:**Laser based micro-manufacturing-casting-forming/shaping-joining-micro- drilling- Laser micromachining mechanism-laser cutting of various materials- -Three dimensional machining- laser micro-machining mechanism-laser ablation-laser assisted chemical etching **Laser induced surface processing:** Laser based hardening, Laser cladding Laser ablation-Laser assisted chemical etching-laser micromachining-direct writing technique-mask projection-laser based interference processing and combined techniques. Laser shock processing, laser dressing of grinding wheels, Laser marking, laser direct writing, Laser micro-stereo lithography, and Laser tissue interaction –(Photochemical-photo disruptive interactions) **Ultra fast laser interaction and dynamics of laser based micro fabrication:** Femto-second laser interaction with metals- Femto-second laser interaction with semiconductor materials-Laser induced periodic surface structure formation(LIPSS) formation by Femto second laser-second laser- Laser processing of organic materials, Ultrafast phase explosion-nonlinear absorption and breakdown in dielectric materials-generation of highly energetic particle-vapour kinetics-Pico-second laser plasma's **Characterization and diagnosis using lasers:** In situ and Ex-situ diagnostics measurements- Surface topographical measurements using- optical Instruments-scanning optical technique-Triangulation instruments-Confocal instruments-Laser's in AFM. Surface composition and property diagnosis using, In- situ measurement techniques- Laser

		Induced Break down Spectroscopy (LIBS)- Shadow graphic techniques, Ex-situ measurements-Raman Spectroscopy analysis. Surface evaluation using Holographic techniques.
8	Suggested books	**Text books:** 1) John. C. Ion, **Laser processing of engineering materials-principal**, procedures and industrial applications, Elsevier Butterworth-Heinemann, ISBN 0750660791. 2) Narendra B.Dahotre, Sandip P.Harimkar,**Laser fabrication and maching of materials,** ISBN (978-0-387-7234-3) 3) Jacques Perriere, Eric Million, Eric Fo Garassy, **Recent advances in Laser processing of materials**, European Material research Society, Elsevier Publictaions. 4) K.Ding and L.Ye, **Laser shock peening performance and processes simulations**, Woodhead publishing in materials. 5) Richard K.Leach, **Fundamental principles of engineering nanometrology**, Elesevier publication 6) R.Hull, R.M.Osgood, J.Parisi, H. Warlimont, **The Theory of laser material processing,heat and mass transfer in modern technology**-springer series in material science.

1.	Course Code	**ME 459 / ME 659**
2.	Title of the Course	**Micro and Precision Manufacturing**
3.	Credit Structure	L-T- P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Basic courses related to manufacturing engineering
6.	Scope of the Course	To expose the students about the concepts of micro and precision manufacturing, the various processes involved in it and, the metrology of the micro and precision manufactured components
7.	Course Syllabus	**Micro-manufacturing:** Introduction to micromachining, milling-machining and nanotechnology, different fabrication and other processes involved and related process parameters, application of miniaturized components. **Micro-machines:** Mesoscopic domain of micromachines - introduction, biological systems, cells as machines, role of proteins, physics of micromechanism, future prospects. **Precision manufacturing:** Introduction, concept of accuracy, tolerance and fits, influence of different factors on the maintainability of accuracy of the machine tools and the product, compensation of thermal errors and location errors, effects of vibration and tool wear, dimensioning and dimensional chains, microfinishing processes. Characterization techniques for products manufactured out of micro and precision manufacturing. **Metrology and Characterization Techniques for Micro and Precision Manufactured Products:** – Profilometric, Microscopic and diffractometric techniques. **Scales in Tribology,** micromechanical mechanisms involved, tribochemical reactions, measurement of hardness and wear resistance at micro and nano-scale.

8.	Suggested Books	1. I. Fujimasa, **Micromachines: A New Era in Mechanical Engineering**, Oxford Science Publications, ISBN: 9780198565284. 2. J. P. Davim, M. J. Jackson, **Nano and Micromachining**, Wiley-ISTE, ISBN: 9781848211032. 3. N.P. Mahalik, **Micromanufacturing and Nanotechnology**, Springer, ISBN: 9783540253778. 4. P.C. Pandey and H.S. Shan, **Modern Machining Processes**, Tata McGraw Hill Publication, ISBN: 9780070965539. 5. V.K. Jain, **Introduction to Micromachining**, Narosa Publishing House, New Delhi, 2010. 6. Y. Qin, **Micromanufacturing Engineering and Technology**, Elsevier, 2010, ISBN-13: 978-0-8155-1545-6. 7. R. L. Murty, **Precision Engineering in Manufacturing**, New Age International Publishers, ISBN: 9788122407501. 8. C. R. Brundle, C. A. Evans, Shaun Wilson, **Encyclopedia of Materials Characterization: Surfaces, Interfaces, Thin Films, Material Characterization Series, Surfaces, Interfaces, Thin Films,** Butterworth-Heinemann, ISBN: 9780750691680.

1.	Course Code	**ME 460/ ME 660**
2.	Title of the Course	**Technology of Surface coating**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the Course	To expose students towards different surface coating techniques
7.	Course Syllabus	Lecture Significance of surface engineered materials in modern engineering applications. Role of surface coating and surface modification technologies in obtaining required surface characteristics of a product. Substrate preparation by chemical, mechanical, electro-chemical and other routes. Structure and working principle of various coating processes: Chemical Vapour Deposition (CVD) with variants, Physical Vapour Deposition (PVD) with variants, Electro-plating processes, Electroless deposition, Thermal Spray Processes. Various process parameters controlling the yield of coating and various surface properties of the coating. Physical and mechanical characterization of coating: hardness, roughness, thickness, adhesion, phases and microstructure of different coatings. Various methods for evaluating the performance of the coating. Case study: Application of coating materials on cutting tools. Practical 1) Preparation of steel substrates by sand blasting/chemical /machining with desired roughness. (1 hr) 2) Demonstration of thermal evaporation technique. Deposition of a coating material (Al/Ni/Cu) on steel substrate by thermal evaporation technique. (2-3 hrs.) 3) Demonstration of flash evaporation technique. (1 hr) 4) Demonstration of magnetron sputtering technique.

		Deposition of coating material (Al/Cu) on steel substrate by sputtering. (2-3 hrs.) 5) Demonstration of Electron beam evaporation technique. (1 hr) 6) Demonstration of Laser beam deposition. (1 hr) 7) Physical and mechanical characterisation of the deposited coating (measuring surface roughness, microhardness). (2-3 hrs)
8.	Suggested Books	1. A. A. Tracton, **Coatings Technology: Fundamentals, Testing, and Processing Techniques**, CRC Press Inc. ISBN 13: 9781420044065. 2. A. A. Tracton, **Coatings Materials and Surface Coatings**, CRC Press ISBN 13: 9781420044041. 3. R. F. Bunshah (Ed.) **Handbook of Hard Coatings: Deposition Technologies, Properties and Applications,** ISBN 13: 9780815514381 ISBN 10: 0815514387 4. M. Cartier, **Handbook of Surface Treatment and Coatings**, 9781860583759 ISBN 10: 186058375X 5. T. Provder, J. Baghdachi (Eds.) **Smart Coatings** (Vol. 2), ISBN 13: 9780841272187 ISBN 10: 0841272182 6. Gerhard Franz, **Low Pressure Plasmas and Microstructuring Technology**, ISBN 13: 9783540858485 ISBN 10: 3540858482

Course code	**ME 464/ ME 764**
Title of the course	**Microrobotics**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	NA
Scope of the course	The main objective of the course is to focus on the fundamentals of the physical laws that predominate at the micro scale for fabricating small device and bio-inspired microrobots
Course Syllabus	Scaling laws for designing macro, micro and nano systems: scaling laws in fluids, electo-magnetism, thermodynamics, optics and quantum effect. Micro-mechanics, design and selection of materials for micro- robotics systems, control for surface walkers. Introduction to different micro-fabrication techniques. Micro actuators and micro sensors: micro force sensors and tactile sensors, Magnetic actuation, electrostatic actuation, piezo electric actuation, shape memory alloy and conducting polymer based actuation, stick slip, comb drive actuator, micro-pumps, micro engines, magnetic helical micro machines, haptic interface and sensory skin for robotic systems Micro-manipulation: Mechanics of micro-manipulation, Atomic force microscope as micro/Nano robot, micro manipulation in particle assembly, 3D micro/Nano fiber pulling, integrated nano tool carrier, micro-assembly, micro air vehicles (MAVS) and multi robot systems. Bio- inspired micro-mechanics: Microscale propulsion, locomotion in liquids, modeling of propulsion systems, micro mechanical flying insect, Gecko inspired climbing robots, bio-inspired fibrillar adhesive, lizard inspired water runner robot, water strider inspired water walker robot, Magnetic swimming micro-robot for bio-medical application, medical micro-robots for endoscopy and other applications.
Suggested Books	1. N. Chaillet, S. Regnier, **Microrobotics for Micromanipulation**, Wiley, IST, 2010, ISBN 978-1-84821-186-5 2. Y. Bellouard, **Microrobotics, methods and applications**, CRC Press, 2009, ISBN 9781420061956 3. Fatikow, Sergej, Rembold, Ulrich, **Microsystem technology and microrobotics,** Spirnger publication, 2000, ISBN 978-3-662-03450-7 4. Ananthasuresh, **Micro and Smart Systems: Technology and Modelling**, Wiley, 2012, India, ISBN:9780470919392

1.	Course Code	**ME 471/ ME 671**
2.	Title of the Course	**Operations Research**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Origin and development of operations research, general methodology of OR, applications of OR to industrial problems. **Linear Programming Problems:** Different types of models, formulation of linear programming problems (LPPs), product-mix problems, deterministic models, graphical solution. **Simplex Method:** Simplex algorithm, computational procedure in simplex method, applications of simplex technique to industrial problems. **Duality and Sensitivity:** Duality and its concept, dual linear programming, application of elementary sensitivity analysis. **Linear Optimization Techniques:** Integer programming problems (IPPs), assignment models: mathematical formulation, methods of solutions, transportation problems: methods of obtaining optimal solution degeneracy in transportation problems, transshipment problems. **Game Problems:** Introduction and scope of game problems in business and industry, min-max criterion and optimal strategy, solution of two-person zero-sum game, game problem as a special case of linear programming. **Queuing Problems:** Queuing systems and concepts, classification of queuing situations; Kendall's notation, solution of queuing problems, single channel, single stage, finite and infinite queues with Poisson arrival and exponential service time, applications to industrial problems.
8.	Suggested Books	1. H.A. Taha, **An Introduction to Operations Research** (6th edition), Prentice Hall of India, 2001. 2. F.J. Hillier, G.J. Lieberman, **Introduction to Operations Research** (7th edition), Holden Day Inc., 2001. 3. H.M. Wagner, **Principles of Operations Research**, Prentice Hall of India, 1980. 4. D. Gross, and C.M. Harris, **Fundamentals of Queuing Theory** (2nd edition), John Wiely & sons, NY, 1985.

1.	Course Code	**ME 472/ ME 672**
2.	Title of the Course	**Reliability Engineering**
3.	Credit Structure	L-T- P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	
6.	Scope of the course	To introduce the various concepts of reliability, its assessment, and its applicability to different products and processes. Also, to introduce the concepts of availability and maintainability.
7.	Course Syllabus	**Fundamentals of reliability:** Scope of reliability engineering, concept of bath tub curve, types of failure data, reliability estimations, constant failure rate models, time dependent failure rate models, concept of failure on demand. **System reliability assessment:** Reliability estimation of series/parallel/mixed/complex system configurations. **Design for reliability:** Capturing user's reliability requirements, reliability and/or redundancy allocation/optimization, design methods, FMEA/FMECA, reliability testing (burn-in testing, reliability assurance testing, reliability growth testing, accelerated life testing), fault tree analysis. **Availability assessment:** Point, mission and steady state availability, Markov modeling approach for availability estimation. **Maintainability and maintenance:** Maintainability assessment, and design for maintainability, concept of maintenance, types of maintenance, maintenance optimization. **Warranty management:** Types of warranty, reliability and warranty. **Practical applications of reliability engineering to systems, products and processes:** Case studies
8.	Suggested Books	1. Charles Ebeling, **An Introduction to Reliability and Maintainability Engineering,** Waveland Pr Inc; 2 Har/Cdr edition, 2009. 2. Igor Bazovsky, **Reliability Theory and Practice,** Dover Publications (October, 2004). 3. Patrick O'Connor, **Practical Reliability Engineering**, John Wiley & Sons Inc. 2002. 4. Gregg K. Hobbs, **Accelerated Reliability Engineering: HALT and HASS,** Wiley, 2000. Suggested web page: www.weibull.com

1.	Course Code	**ME 473**
2.	Title of the Course	**Engineering Optimization**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Introduction:** Need for optimization and historical development, classification and formulation of optimization problem, classical optimization methods, differential calculus, Lagrangian theory, **Unconstrained Optimization Techniques:** one-variable optimization techniques -Bracketing methods, Region-elimination methods, Point-estimation method, Gradient based methods. Multi-variable optimization: Unidirectional search, Direct search methods, Gradient-based methods. **Constrained Optimization Techniques:** Kuhn-Tucker (KT) conditions, Transformation methods - Methods of multipliers and Penalty function method, Direct search methods for Constrained optimization, Linearized search techniques, Sensitivity analysis, Feasible direction method, Gradient project method, Generalized reduced gradient method. **Special Optimization Methods:** Integer programming and geometric programming. **Examples and applications** of the above methods in the recent engineering design problems.
8.	Suggested Books	1. K. Deb, **"Optimization for Engineering Design: Algorithms and Examples",** Prentice Hall of India, New Delhi, 1995. 2. S.S. Rao, **Optimization - Theory and Applications**, Wiley Eastern Ltd, 1978. 3. J.S. Arora, **Introduction to Optimum Design**, McGraw- Hill Book Co, 1989. 4. R.L. Fox, **Optimization Methods for Engineering Design**, Addison Wesley, 1971.

1.	Course Code	**ME 474**
2.	Title of the Course	**Non-traditional optimization techniques**
3.	Credit Structure	L-T- P-Credits 2-0-2-3
4.	Name of the Concerned Department	Mechanical Engineering
5.	Pre–requisite, if any	Operations research/Engineering optimization
6.	Scope of the course	To introduce various non-traditional optimization techniques and its applicability to real world engineering problems.
7.	Course Syllabus	**Introduction:** Traditional vs non-traditional optimization, need for non-traditional optimization techniques, evolution of non-traditional optimization techniques in engineering. **Introduction to some non-traditional optimization algorithms:** Genetic Algorithms, Simulated Annealing, Particle Swarm Optimization, Tabu Search, Ant-Colony Algorithms, Bee-colony algorithms, Artificial Neural Network (ANN) based Optimization. **Applications of non-traditional optimization techniques for solving real-world complex industrial problems**
8.	Suggested Books	1. Kalyanmoy Deb, **Optimization for Engineering Design: Algorithms and Examples**, PHI, New Delhi, 2005 2. Goldberg, D.E., Genetic **Algorithms in Search, Optimization, and Machine, Learning**, Addision-Wesley, 1989. 3. Kalyanmoy Deb, **Multi-Objective Optimization using Evolutionary Algorithms,** John-Wiley & Sons, Ltd. Chichester, 2001. 4. Fred Glover, Gary A. Kochenberger **Handbook of metaheuristics**, Springer, 2003 5. Teofilo F. Gonzalez, **Handbook of Approximation Algorithms and Metaheuristics**, Chapman & Hall/CRC Computer and Information Science Series,Taylor & Francis Group, 1 edition (May 15, 2007)

Course Code	**ME 479/ ME 679**
Title of the Course	**Additive Manufacturing**
Credit Structure	L-T- P-Credits (2-0-2-3)
Name of the Dept.	Mechanical Engineering
Pre–requisite, if any	Basic knowledge of different manufacturing processes
Scope of the course	To impart knowledge about philosophy of additive manufacturing (AM) which is one of the most important enablers of Industry 4.0 and evolution of different types of AM processes, state-of-art research in their field, capabilities, limitations, applications.
Course Syllabus	**1. Introduction:** Philosophy of additive manufacturing (AM) and its role in Industry 4.0; its advantages over subtractive, deformative and formative manufacturing processes; Evolution of different AM processes; classification of different AM processes (i.e. direct energy deposition (DED) or diffusion based processes, energy-beam based processes, arc-based processes, plasma-based processes, solid-state processes) and their comparative study; Different forms of deposition materials and their comparative study; Concept of track, layers, dilution, aspect ratio, different efficiencies in AM; Major application areas of AM processes including rapid prototyping (RP), rapid tooling (RT), rapid manufacturing (RM). **2. Energy-beam based AM Processes:** Laser-beam based AM processes i.e. **s**elective laser sintering (SLS), direct metal laser sintering (DMLS), direct metal deposition (DMD), laser engineered net shaping (LENS), direct laser forming/fabrication (DLF), laser rapid manufacturing (LRM), laser metal wire deposition (LMWD); Electron-beam based AM processes. **3. Arc-based AM processes:** AM processes using arc for deposition: manual metal arc (MMA) based, gas metal arc (GMA) based, gas tungsten arc (GTA) based, metal active gas (MAG) based, hybrid layered manufacturing (HLM) **4. Transferred arc-based AM Processes:** Processes using arc for plasma formation: Plasma transferred arc (PTA) based, micro-plasma transferred arc (μ-PTA) based, plasma wire deposition (PWD), 3D micro-deposition (3DMD) **5. Solid state AM Processes:** AM processes in which deposition material is not melted: Rotary friction-based deposition (RFD), Linear friction-based (LFD), Friction deposition (FD), Friction surfacing (FS), Friction assisted seam deposition (FASD), Friction stir based deposition (FSD). **6. Advanced Topics:** Issues of dimensional and geometrical accuracy, surface finish, inter-layer bonding, microstructure, scaling of production, productivity, energy consumption, modeling, parametric optimization, and sustainability in AM. **Practical classes** will be conducted for AM processes based on laser beam, micro-plasma transferred arc, and some AM processes based on arc.
Readings material Text Book	1. C.K. Chua, and K.F. Leong, **3D Printing and Additive Manufacturing: Principles and Applications**, World Scientific Publishing Co. Pvt. Ltd. Singapore, 2017 (ISBN: 978-9-8131-

	4675-4)
Readings material Reference book	2. R. Noorani, **3D Printing: Technology, Applications, and Selection,** CRC Press, Boca Raton, 2017 (ISBN: 978-1-4987-8375-0) 3. T.S. Srivatsan, T.S. Sudarshan (Editors) **Additive Manufacturing: Innovations, Advances, and Applications** (1st Edition), CRC Press, Boca Raton, 2015 (ISBN: 978-1-4987-1477-8) 4. I. Gibson, D.W. Rosen, B. Stucker, **Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing** (2nd edition), Springer-Verlag, New York, 2015 (ISBN 978-1-4939-2112-6)

Course code	**ME 480 / ME 680**
Title of the course	**Laser Material Processing and systems**
Course Category	Core / Departmental Elective
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Department of Mechanical Engineering
Pre-requisite, if any	Nil
Scope of the course (Objectives)	The objective of this course is to understand the fundamentals of the laser application in manufacturing, involved physics, design functions and parametric constrains.
Course Outcomes	Engineering Knowledge: The fundamental of laser material processing and involved physics. The role of laser and delivery systems to execute the different modalities of manufacturing. Design of application-oriented laser systems and parametric control.
Course Content	**Lasers based Manufacturing:** **Laser matter interaction;** Fundamentals of Lasers; Laser Beam Characteristics; Reflection or Absorption: Effect of Wavelength, Temperature, Surface Films, Angle of Incidence, Materials and Surface Roughness. **Laser Cutting, Drilling and Piercing:** Introduction; Drilling Process Variations; Percussion and Single- or Double-shot Drilling; Trepanning, Helical Trepanning; Applications of Laser Drilling; Methods of Cutting - Vaporization Cutting/Drilling, Fusion Cutting – Melt and Blow, Reactive Fusion Cutting; Controlled Fracture; Scribing; Cold Cutting; Laser-assisted Oxygen Cutting – LASOX Process **Laser Welding:** Introduction; Process Arrangement; Process Mechanisms – conduction, Keyholes and Plasmas; Operating Characteristics – Power, Spot Size and Mode, Wavelength, Speed, Focal Position, Joint Geometries, Gas Shroud and Gas Pressure; Arc- augmented Laser Welding,. **Laser Surface Treatment:** Introduction; Laser Heat Treatment; Laser Surface Melting - Solidification Mechanisms; Surface Texturing; Laser Surface Alloying and Cladding; Particle Injection; Laser-assisted Cold Spray Process; Laser shock peening: physics, process and applications; Laser forming physics, process and applications; Laser based additive

	manufacturing, laser safety; **Laser systems for manufacturing**: Principles and working of CO_2 , Nd:YAG, fibre, Excimer, diode lasers; Optical Components - Lens Doublets, Collimators, Metal Optics; Graded-index Lenses; Laser Scanning Systems; Fiber Delivery Systems. ; Laser Machining; Arc-augmented Laser Cutting; System design for various modalities of the laser cutting and parametric control. Twin-beam Laser Welding, Walking and Spinning Beams; Laser Welding of Plastics; Various architecture designs for the laser welding systems. Laser based Additive Design of application-oriented laser systems and parametric control.
Suggested Books	**Textbooks** 1. William M. Steen, Jyotirmoy Mazumder, Laser Material Processing, Springer London, London, 2010, ISBN 978-1-84996-062-5 2. Peter Schaaf, Laser Processing of Materials Fundamentals, applications and Developments, Springer Berlin, Heidelberg, 2010, ISBN 978-3-642-13281-0 **Reference book and publications** 3. Narendra B. Dahotre, Sandip P. Harimkar, Laser Fabrication and Machining of Materials, Springer New York, NY, 2008, ISBN 978-1-4899-7371-9 4. Jyotsna Dutta Majumdar, Indranil Manna, Laser-Assisted Fabrication of Materials, Springer Berlin, Heidelberg, 2013, ISBN 978-3-642-28358-1

1.	**Course code**	**ME 203N**
2.	**Course title**	Fluid Mechanics
3.	Course Category	Core
4.	Credit Structure	L-T-P-Credits 2-1-0-3
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	● Comprehensive study of fluid properties, statics, and dynamics for a deep understanding of fluid behavior. ● Application-oriented focus on fluid mechanics in engineering systems, preparing students for practical challenges.
8.	Course Outcomes	● Demonstrate a thorough understanding of fluid properties, statics, and dynamics, enabling them to analyze and predict fluid behavior in diverse scenarios. ● Apply fluid mechanics concepts to engineering systems,
9.	Course Content	● **Introduction**: Definition and classification of fluids, concept of continuum, properties of fluids ● **Fluid Statics**: Variation of pressure in as static fluid, forces on submerged surfaces, stability of floating bodies ● **Fluid Kinematics**: Lagrangian and Eulerian Approaches, acceleration of fluid, streamlines, path lines and streak lines ● **Integral relations for control volume**: Reynolds transport theorem, conservation of mass, linear and angular momentum ● **Differential relations for fluid flow**: differential equation for mass and linear momentum ● **Inviscid & Irrotational Flows**: Euler equation, Bernoulli's equation, and its applications ● **Viscous flows in pipes**: Laminar and turbulent pipe flow, friction factor, Moody diagram, minor and major losses ● **Dimensional analysis and similitude**: Buckingham-pi theorem, similarities (geometric, kinematic and dynamic).
10	Suggested Books	**Text Books:** 1. R.W. Fox and A.T. McDonald, **Fluid Mechanics**, **(8th Edition),** John Wiley International, 2011. ISBN: 9780470547557. 2. F.M. White, **Fluid Mechanics**, **(6th Edition),** Tata McGraw Hill, 2011. ISBN: 9780071333122. **Reference Books** 3. S.K. Som and G. Biswas, **Introduction to Fluid Mechanics and Fluid Machines (2nd Edition)**, Tata McGraw-Hill Publishing Company,2008, ISBN: 9780070702592. 4. V.L. Streeter and E.B. Wylie **Fluid Mechanics**, McGraw-Hill, 1983, ISBN: 9780070622425. 5. S.W. Yuan, **Foundation of Fluid Mechanics (2nd Edition)**, Prentice Hall, 1977, ISBN: 9780133298475.

1.	**Course code**	**ME 205N**
2.	**Course title**	**Materials Science and Engineering**
3.	Course Category	Core
4.	Credit Structure	L-T-P-Credits 2-1-0-1.5 (Half-Semester)
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Scope of the CourseObjectives	• Provide students with a solid foundation in the principles, historical context, and classification of materials.
8.	Course Outcome	• Students will develop a deep understanding of materials science and engineering, encompassing atomic structure, mechanical properties, imperfections, and phase transformations. This knowledge will enable them to analyze and predict material behavior. • Students will acquire practical skills to apply their understanding in addressing real-world challenges related to materials.
9.	Course Content	• **Introduction**: Classification of materials, Futuristic materials. • **Structure of solids**: Crystalline and non-crystalline materials, Structure - Unit cell and space lattices, Coordination number, APF • **Dislocations and Strengthening Mechanisms:** Defects, Strengthening by Grain Size Reduction, Solid-Solution Strengthening, Strain Hardening, Precipitation hardening. • **Phase diagrams and phase transformations**: Basic definitions; Gibbs phase rule, Iron-Carbon Phase diagram; TTT Diagram • Concept of elastic and plastic deformation; Tensile properties of materials • **Creep and Fracture:** Creep mechanism-Effects of Stress, Temperature, Alloying, Fracture, Fatigue, The S–N Curve, Factors affecting Fatigue Life. • Heat treatment; Properties of non-ferrous alloys
10.	Suggested Books	**Text Books** 1. W.D. Callister, **Material Science for Engineers: An Introduction**, John Wily and Sons, Inc., 2006. ISBN: 0471736961 2. C.S. Barrett, T.B. Massalski, **Structure of Metals**, McGraw Hill, 1966. ISBN: 9780070038155. 3. D.R. Askeland, P.P. Fulay, W.J. Wright, **The Science and Engineering of Materials,** Global Engineering, 2010. ISBN: 9780495296023. **Reference books** 4. P.E.J. Flewitt, R.K.Wild, **Physical Methods for Material Characterization,** Institute of Physics Publishing, 2003. ISBN: 0750308087. 5. J.B. Benedict. **Recent Advances in Crystallography**, In Tech., 2012. ISBN 9789535107545.

1.	**Course code**	**ME 207**
2.	**Course title**	**Principles of Industrial Engineering**
3.	Course Category	Core
4.	Credit Structure	L-T-P-Credits 2-1-0-3
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Scope of the Course Objectives	• The course aims to introduce the students to various techniques used in industries to achieve effectiveness and efficiency in operations.
8.	Course Outcome	• Basic understanding of planning and control of operations, design and improvement of processes, formulation and evaluation of projects, management of logistics operations, as well as development of industrial processes.
9.	Course Content	• **Plant Layout:** Site selection, types of layout, factors affecting layout, plant building, flexibility and expandability, materials handling devices. • **Production Planning and Control:** Forecasting, Master Production Scheduling (MPS), Material Requirements Planning (MRP), aggregate production planning, machine loading, production scheduling. • **Inventory Control:** Various models of inventory control such as EOQ, price discount, production lot sizing, inventory control under uncertainty. Selective inventory control. • **Work Study:** Scope, work measurement and method study, standard data, ergonomics and its industrial applications. • **Project Management:** CPM and PERT • **Emerging concepts and philosophies:** JIT, KANBAN, 5S, introduction to digital manufacturing, etc.
10.	Suggested Books	**Text Books** 1. E.S. Buffa, **Modern Production / Operations Management**, **(8th Edition)**. India: Wiley India Pvt. Limited, 2001. ISBN: 9788126513727. 2. Russell, R. S., Taylor, B. W. **Operations Management: Along the Supply Chain,** Wiley, 2009. ISBN: 9780470233795. 3. Eilon, S. **Elements of Production Planning and Control**. United Kingdom, Macmillan, 1962. ISBN: 9780023318009. **Reference Books** 4. Chase, R. B., Jacobs, F. R., Aquilano, N. J. **Operations Management for Competitive Advantage,** McGraw-Hill/Irwin. 2007. ISBN: 9780071260480. 5. Maynard, H. B., Hodson, W. K. **Maynard's Industrial Engineering Handbook**, McGraw-Hill, 1992. ISBN: 9780070410862.

1.	**Course code**	**ME 202N**
2.	**Course title**	**Strength of Materials**
3.	Course Category	Core
4.	Credit Structure	L-T-P-Credits 2-1-0-3
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	A course in Solid Mechanics
7.	Objectives	● The objective of the course is to learn about the deformation and stresses developed in the simple structures under mechanical loads. ● The understanding of the stress analysis of different deformable structures.
8.	Course Outcomes	● Students will be able to learn stress-strain calculations involved for different structures. ● Stress and strain analysis of beams with advanced geometrical features and buckling phenomena, and the role of failure theories for different materials.
9.	Course Content	● **Advanced Topics in Bending:** Bending of Curved Bars. Unsymmetrical Bending. ● **Deflection of Beams:** Differential Equations of the Deflection Curve, Methods based on integration, Singularity function, ● **Energy Principles**: External Work and Strain Energy, Virtual Work, Minimum Potential Energy, Reciprocal Theorem, Superposition Principle, etc. ● **Columns and Struts**: Buckling of columns and struts, Euler load, Secant Formula. ● T**heories of Failure**: Theories of failure for different materials. Introduction to Griffith Theory. Photoelasticity.
10.	Suggested Books	**Textbooks** 1. L.S. Srinath, **Advanced Mechanics of Solids, (2nd Edition)**, Tata McGraw Hill, 2003, ISBN: 9780070494817. 2. S.P. Timoshenko, and J.N. Goodier, **Theory of Elasticity**, McGraw Hill, (International Students Edition), 2017, ISBN: 9780070701229. 3. S.H. Crandall, N.C. Dahl, and T.J. Lardner, **An Introduction to Mechanics of Solids**, McGraw Hill, 1978, ISBN: 9780070134416. **Reference Books** 4. E.P. Popov, **Introduction to Mechanics of Solids**, Prentice Hall of India, 1993, ISBN: 9780134877693. 5. J. Case and A.H. Chilver, **Strength of Materials and Structures**, **(4th Edition),** Edward Arnold, 1999. ISBN: 9780470379804.

1.	**Course code**	**ME 201N**
2.	**Course title**	**Solid Mechanics**
3.	**Course Category**	Core
4.	**Credit Structure**	L-T-P-Credits 2-1-0-3
5.	**Department**	Mechanical Engineering
6.	**Pre–requisite, if any**	None
7.	**Objectives**	● Provide students with a solid foundation in solid mechanics, covering essential topics like stress, strain, and material behavior to establish a fundamental understanding of the mechanical response of materials.
8.	**Course Outcomes**	● Analyze and predict the mechanical response of materials. ● Students will demonstrate practical skills in applying solid mechanics principles to solve engineering problems, and preparing them for roles in engineering and related disciplines.
9.	**Course Content**	● **Introduction:** Analysis of Axially Loaded Components, Statically Determinate and Indeterminate Problems ● **Stress and Strain:** Stress-strain Relations; Stress-strain temperature Relations; Mohr Circle. ● **Shear Forces and Bending Moments:** Analysis of Bending and Shear Loaded Components: Beams; Shear Force and Bending Moment Diagrams. Stresses in Beams. Basic Equations of Elasticity. ● **Material Testing:** Properties under Tension, Impact, Fatigue and Creep. ● **Torsion:** Introduction, Deformation of Circular Shaft, Stresses and Angle of Twist in Elastic Range. ● **Beam Bending:** Introduction to Elastic-plastic Bending of Beams, Bending of Symmetrical and Unsymmetrical Sections. ● **Thick Cylinder:** Introduction, Solution of General Problem, Special Cases.
10.	**Suggested Books**	**Text Books** 1. S.H. Crandall, N.C. Dahl, and T.J. Lardner, **An Introduction to Mechanics of Solids**, McGraw Hill, 1978. ISBN: 9780070134416. 2. E.P. Popov, **Introduction to Mechanics of Solids**, Prentice Hall,1993, ISBN: 9780134877693. 3. F.P. Beer, E.R. Johnston, **Mechanics of Materials**,**(5th Edition),** Tata McGraw Hill, , 2012, ISBN: 9780070153899. **Reference Books** 4. L.S. Srinath, P. Desai, N.S. Murthy, and A.S. Murthy, **Strength of Materials**, Macmillan India, 2000, ISBN: 9780333923924. 5. J. Case and A.H. Chilver, **Strength of Materials and Structures**, **(4th Edition),** Edward Arnold,1999. ISBN: 9780470379804.

1.	**Course Code**	**ME 209**
2.	**Course title**	**Thermodynamics**
3.	Course Category	Core
4.	Credit Structure	L-T-P-Credits 2-1-0-3
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	A course in Basic Thermal Engineering
7.	Objectives	● The objective of this course is imparting knowledge to mechanical engineering students about the laws of thermodynamics and their applications.
8.	Course Outcomes	● Students will know in detail about various vocabularies related to thermodynamics. ● They will get adequate knowledge on the application of thermodynamics laws for various real life applications.
9.	Course Content	● **Introduction**: Applications, terminologies, system, boundaries: fixed, moving and imaginary, equilibrium, processes, interactions, Zeroth law of thermodynamics. Work interaction, various kinds of work. ● **Equation of Ideal Gas**: Ideal and real gasses, equations of state, evolution of properties of ideal gasses. Van-der-Waals equation of state for real gasses, compressibility factor; Properties of pure substances. ● **First Law of Thermodynamics**: Statement for a cycle, derivation of the first law for closed systems, energy, internal energy, enthalpy, extension of the first law to control volume; state-steady flow energy equation, transient system analysis. ● **Second Law of Thermodynamics**: Kelvin-Planck and Clausius statements, Clausius inequality, entropy, evaluation of entropy, principle of increase of entropy, entropy generation, formulation of 2^{nd} law for closed and open systems; Availability, irreversibility, and exergy. ● **Thermodynamic Property Relations**: Maxwell relations, Clapeyron relation, Joule-Thomson coefficient, generalized relationship for change in u, h, s and c_p
10	Suggested Books	**Text Books** 1. Y.A. Cengel, M.A. Boles, and M. Kanoglu: **Thermodynamics- An Engineering Approach, (9th Edition)**, McGraw Hill, 2019, ISBN: 9789353165741. 2. M.J. Moran and H.N. Shapiro, **Fundamentals of Engineering Thermodynamics, (7th Edition)**, Wiley, ISBN: 9780470495902. 3. C. Borgnakke, R.E. Sonntag, **Fundamentals of Thermodynamics, (10th Edition)**, Wiley, ISBN 9780470041925. **Reference Books** 4. A. Bejan, **Advanced Engineering Thermodynamics, (4th Edition)**, Wiley, 2016, ISBN: 9781119245964. 5. P.L. Dhar, **Engineering Thermodynamics: A**

		Generalized Approach, Elsevier, 2008, ISBN: 9788131214695. 6. M.J. Moran and H.N. Shapiro, **Fundamentals of Engineering Thermodynamics, (7th Edition)**,Wiley, 2010, ISBN: 9780470495902. 7. PK Nag, **Engineering Thermodynamics**, (6th Edition), McGraw Hill Education, 2017, ISBN: 9789352606429

1.	**Course code**	**ME 251N**
2.	**Course title**	**Solid Mechanics Lab**
3.	Course Category	Core
4.	Credit Structure	L-T-P-Credits 0-0-2-1
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	• Explore the mechanical properties of materials and enhance understanding through practical applications.
8.	Course Outcomes	• Develop practical skills in materials testing through hands-on experiments in tensile testing, torsion testing, hardness & microhardness testing, impact testing, strain gauges, photo-elasticity, and creep tests.
9.	Course Content	**<u>List of representative experiments:</u>** • Tensile testing experiment. • Torsion testing experiment. • Hardness & microhardness testing experiment. • Impact testing experiment. • Strain gauges experiment. • Photo-elasticity experiment. • Creep tests experiment.
10.	Suggested Books	**Reference Books** 1. S.H. Crandall, N.C. Dahl, and T.J. Lardner, **An Introduction to Mechanics of Solids**, McGraw Hill, 1978, ISBN: 9780070134416. 2. J.W. Dally, and W.F. Riley, **Experimental Stress Analysis**, McGraw Hill, 1987, ISBN: 9780070152182. 3. E.O. Doebelin and D.N. Manik, **Measurement Systems: Applications and Design**, Tata McGraw Hill, 2007, ISBN: 9780070616721. 4. L.S. Srinath, P. Desai, N.S. Murthy, and A.S. Murthy, **Strength of Materials**, 2000, ISBN: 9780333923924. 5. F.P. Beer, E.R. Johnston, **Mechanics of Materials**,**(5th Edition),** Tata McGraw Hill, , 2012, ISBN: 9780070153899.

1.	**Course code**	**ME 217**
2.	**Course title**	**Industrial Data Analytics**
3.	Course Category	**Elective**
4.	Credit Structure	L - T - P - Credits 2-1-0-3
5.	Department	Mechanical Engineering
6.	Prerequisite, if any	NA
7.	Scope of the Course Objectives	● The course is designed to teach how to choose and use various data-driven tools to solve analytical challenges in modern-day industries
8.	Course Outcome	● Basic understanding of building end-to-end data and analytical pipeline to develop and deploy data analytics solutions. ● Be able to choose and implement essential data science tools on real-life industrial problems using Python.
9.	Course Syllabus	● **Introduction**: Introduction to Data Science and Analytics; Artificial Intelligence (AI); Industry 4.0; Industrial Internet of Things; The need for Industrial Analytics; The role of a Data Scientist in industry. ● **Challenges in Industry**: Types of industries; types of assets; types of enterprise goals; ● **Data and Related Challenges**: Data sources; Most common industrial data types; data storage and retrieval; data context; data and communication standards. ● **Data Collection**: Identifying critical data; identifying appropriate data collection mechanisms; DAQ systems; Fundamentals of Signal Processing and Transmission ● **Data Inference and Visualization**: Exploratory data analysis; Data synchronization, segmentation, and pre-processing; data visualization basics; selection of visual tools for effective information delivery. ● **Data Analysis**: Types of algorithms; descriptive, diagnostic, predictive, and prescriptive analysis; Analytical tool selection; constructing analytical pipelines; model performance assessment. ● **Insight Delivery**: Algorithm deployment; long-term performance validation; deployment platforms; model performance monitoring platforms; introduction to model retraining and adaptation

10.	Suggested Books	**Text Books** 1. R. Hill, S. Berry, **Guide to Industrial Analytics**, Solving Data Science Problems for Manufacturing and IoT, Springer International Publishing, 2021, ISBN: 9783030791049 2. A. Kelleher, A. Kelleher, **Machine Learning in Production**, Developing and Optimizing Data Science Workflows and Applications, Pearson Education, 2019, ISBN:9780134116563 **Reference Books** 3. K. P. Murphy, **Machine Learning**, A Probabilistic Perspective, MIT Press, 2012,ISBN: 9780262018029. 4. J. Lee, **Industrial AI**, **Applications with Sustainable Performance**, Springer Nature, 2020, ISBN:9789811521447.

1.	**Course code**	**ME 219**
2.	**Course title**	**Energy Storage Systems**
3.	Course Category	Department Elective
4.	Credit Structure	L - T - P - Credits 2-1-0-1.5 (Half-Semester)
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	This course thoroughly covers different energy storage systems, their real-world applications, and their environmental and future implications.
8.	Course Outcomes	● Learn about different energy storage methods. ● Develop the ability to create and apply energy storage solutions for real-world energy challenges.
9.	Course Content	● **Energy Storage Fundamentals:** Role in energy sector, historical context and current relevance, terminologies and metrics. ● **Thermal, and Mechanical Energy Storage systems**: Sensible and Latent heat systems; Thermochemical, Pumped hydro, Gravity, Compressed air, and Flywheel systems. ● **Chemical, and Electrochemical Energy Storage systems**: Hydrogen storage systems, synthetic natural gas, and solar fuels. Flow battery energy storage; Paper, and Flexible batteries. ● **Electrical and Hybrid Energy Storage Systems**: Capacitor, Supercapacitor, and Superconducting magnetic energy storage; Pumped thermal energy storage. ● **Grid Integration, Environmental**, **Economic, and Future Considerations:** Comprehensive exploration of grid integration, applications, and considerations, cost analysis, government policies, global energy storage status, comparative analysis, TRL.
10.	Suggested Books	**Text Books** 1. R.A. Huggins. **Energy Storage: Fundamentals, Materials and Applications. Springer, (2nd Edition)**, Springer, 2016. ISBN: 9783319212388. 2. A. Rufer. **Energy Storage: Systems and Components**. CRC Press, 2018. ISBN: 9781138082625. 3. E. Dincer and M. Rosen. **Thermal Energy Storage: Systems and Applications, (2nd Edition)**, Wiley, 2011, ISBN: 9780470747063. **Reference Books** 4. Francisco Díaz-González, F. Sumper, O. Gomis-Bellmunt. **Energy storage in power systems.** Wiley, 2016. ISBN: 9781118971321. 5. K. Brun, T. Allison and R. Dennis. **Thermal, Mechanical, and Hybrid Chemical Energy Storage Systems**. Academic Press, 2021. ISBN: 9780128198926.

1.	**Course code**	**ME 221**
2.	**Course title**	**Optical Measurement Techniques in Fluid Mechanics**
3.	Course Category	Department Elective
4.	Credit Structure	L - T - P - Credits 2-1-0-1.5 (Half-Semester)
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	● To establish a fundamental understanding of experimental measurements in fluid mechanics.
8.	Course Outcomes	● Students will be get understanding of optics and light to measure fluid flow ● Students will be able to design optical setup for measurements
9.	Course Content	● **Basics of Imaging:** Lens, Focusing, Depth of field, Diffraction limits, Light sheet generation, Imaging fundamentals, Wave propagation and Scattering from small particles. ● **Velocity measurement:** Particle image velocimetry, particle tracking velocimetry, particle streak velocimetry ● **Flow measurement:** Shadowgraphy, Schlieren, Background oriented Schlieren, Interferometry. ● **Particle measurement:** Interference, Laser Doppler velocimetry, Phase Doppler Technique, Interferometric particle imaging. ● **Laser Induced Fluorescence techniques:** Fluorescence and phosphorescence principles, temperature measurements in a liquid, temperature and concentration measurement in a gas, line and planar configurations.
10.	Suggested Books	**Text Books** 1. Goldstein, R. J. 1996. **Fluid Mechanics Measurements, 2nd Edition, Taylor and Francis**. ISBN: 9780203755723. 2. Tropea, C., Foss, J.F. and Yarin A. 2007 **Handbook of Experimental Fluid Mechanics,** Springer: Berlin. ISBN: 9783662491621. **Reference Books** 3. Adrian R.J. and Westerweel J. **Particle Image Velocimetry**. Cambridge University Press, 2010. ISBN: 9780521440080 4. A. Eckbreth., **Laser Diagnostics for Combustion Temperature and species**, CRC press, 1996 ISBN: 9789056995324

1.	**Course code**	**ME 223**
2.	**Course title**	**Design Thinking**
3.	Course Category	Department Elective
4.	Credit Structure	L - T - P - Credits 2-1-0-1.5 (Half-Semester)
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	● The course is designed to teach how to use design thinking to generate innovative ideas and solutions. The course objective is to prepare student to see opportunities and make them learn how to take the many ideas and determine which ones are likely to produce specific, desired outcomes
8.	Course Outcomes	● Basic understanding of design thinking, creativity and innovation. ● Be able to see opportunities, generate ideas and identify product needs. ● Understand process of converting idea in product specifications
9.	Course Content	● **Introduction to Design Thinking**: Understanding Design Thinking Skills, Core Principles, The Foundation of Design Thinking, The Collaborative Nature of Interdisciplinary Teams for Design Thinking, Exercises and Case-Based Discussions. ● **Development Processes and Organizations:** Concept Development: The Front-End Process, Adapting the Generic Product Development Process. ● **Opportunity Identification**: Tournament Structure of Opportunity Identification, Opportunity Identification Process. ● **Identifying Customer Needs**: Gather Raw Data from Customers, Organize the Needs into a Hierarchy, Establish the Relative Importance of the Needs. ● **Product Specifications**: Understanding Specifications, Timing for Establishing Specifications, Establishing Target Specifications, and the Quality Function Deployment Method.
10.	Suggested Books	**Text Books** 1. Karl T. Ulrich, Steven D. Eppinger, , Maria C. Yang, Product **Design and Development, 7th Edition,** McGraw Hill, 2020, ISBN: 9789390113231. 2. 2. J. Liedtka, A. King, and K. Bennett, **Solving Problems with Design Thinking,** Columbia Business School Publishing, 2013, ISBN: 9780231163569. **Reference Books** 3. D.G. Ullman, **The Mechanical Design Process**, 6th edition, David Ullman LLC, 2017, ISBN: 9780999357804. 4. I. Mootee, **Design Thinking for Strategic Innovation**, John Wiley & Sons 2013, ISBN: 9781118620120.

1.	**Course code**	**ME 225**
2.	**Course title**	**Fundamentals of Vibrations**
3.	Course Category	Department Elective
4.	Credit Structure	L - T - P - Credits 2-1-0-1.5 (Half-Semester)
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	● Students will understand the vibration response of simple systems. ● Students will understand the methods to find out natural frequencies of a system.
8.	Course Outcomes	● Students will be able to make mathematical models for vibration of simple systems. ● Students will be able to perform Modal Analysis and Harmonic Analysis of Multi Degrees Freedom Systems.
9.	Course Content	● **Vibration of Single Degree of Freedom (SDOF) Systems:** Free vibration and harmonically excited vibration response of undamped and viscously damped SDOF system, Transient response of SDOF system for impulse excitation and arbitrary excitation. ● **Vibration of Multi Degrees of Freedom (MDOF) Systems:** Natural frequencies and Mode shapes of a MDOF system, Free vibration response of a MDOF system for given initial conditions, Forced harmonic excited vibration response of a MDOF system.
10.	Suggested Books	**Text Books** 1. W. T. Thomson, M. D. Dahleh, and C. Padmanabhan, **Theory of Vibration with Applications**, **5th Edition**, Pearson, 2008, ISBN: 9788131704820. 2. L. Meirovitch, **Fundamentals of Vibrations**, Waveland Press, 2010, ISBN: 9781577666912. **Reference Books** 3. L. E. Kinsler, A. R. Frey, A. B. Coppens, and J. V. Sanders, **Fundamentals of Acoustics**, **4th Edition**, 2000, ISBN: 9780471847892. 4. S. S. Rao, **Mechanical Vibrations**, **5th Edition**, Pearson, 2011, ISBN: 9780132128193.

1.	**Course code**	**ME 227**
2.	**Course title**	**Plastic Parts Manufacturing**
3.	Course Category	Department Elective
4.	Credit Structure	L - T - P - Credits 2-0-2-1.5 (Half-Semester)
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	● To expose the students about design considerations and different manufacturing processes for the plastic parts
8.	Course Outcomes	● The student will learn different processes used for manufacturing different types of plastic parts used in different daily use products, home appliances, computer peripherals, industrial products etc.
9.	Course Content	● **Requirements for manufacturing**: Types, Classifications and Properties of plastics; Functional, Mechanical Strength, Wear Resistance, Hollowness, Transparency, Decoration, Characteristics of different manufacturing processes for plastic parts ● **Manufacturing Processes**: Working principles, Types, Applications, Advantages, and Limitations of different plastic parts manufacturing processes such as Extrusion; Blow Moulding; Injection Moulding; Rotational Moulding; Compression Moulding; Transfer Moulding; Structural Foam Moulding; Thermoforming; Casting; Potting; Encapsulation; Cold forming; Solid-phase forming ● Economics of plastic parts manufacturing
10.	Suggested Books	**Text Books** 1. M.P. Groover, F**undamentals of Modern Manufacturing: Materials, Processes, and Systems (7th edition)**, John-Wiley & Sons Inc. 2020, ISBN: 9781119722014. 2. E. P. DeGarmo, J. T Black, R. A. Kohser, **Materials and Processes in Manufacturing**, Prentice Hall of India, New Delhi, 1997, ISBN: 9780132613712. **Reference Books** 3. Akira Kobayashi, **Machining of Plastics**, McGraw-Hill; First Edition (January 1, 1967), ISBN: 9780070352667 4. S. Kalpakjian, S.R. Schmid, **Manufacturing Engineering and Technology** (8th edition), Pearson Education Asia, New Delhi, 2020, ISBN:9780135228609. 5. P.N. Rao, **Manufacturing Technology: Vol 1 (4th edition),** McGraw Hill Education (India) Pvt. Ltd, New Delhi, 2013, ISBN: 9781259062575.

1.	**Course code**	**ME 204N**
2.	**Course title**	**Fluid Machinery**
3.	Course Category	Core
4.	Credit Structure	L-T- P-Credits 2-0-0-2
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	A course in Fluid Mechanics
7.	Objectives	● Provide students with a foundational understanding of fluid machinery principles, including the operation, design, and analysis of pumps, turbines, and compressors.
8.	Course Outcome	● Demonstrate comprehensive understanding and practical aspects in fluid machinery, covering design, operation, and analysis of pumps, turbines, compressors. ● Apply knowledge to contribute effectively to fluid system design, operation, and optimization across various industries.
9.	Course Content	● **Introduction**: Definition and classification of turbo machines and fluid pumping machines. ● **Pumps**: Introduction to rotodynamic pumps, working principles and energy transfer in a centrifugal pump, Euler's turbomachinery equation, velocity triangles, characteristics of a centrifugal pump, operating point, cavitation, principle of similarity, specific speed, series, and parallel combination of pumps, Compressors. ● **Turbines**: Classification of turbines, Pelton, Francis and Kaplan, draft tube, cavitation in turbines. ● **Introduction to compressible flow**: Thermodynamic relations and speed of sound, stagnation, and sonic properties, effects of area variation on properties in isentropic flow, properties in an isentropic flow, choking in a converging nozzle, isentropic flow through, convergent-divergent duct, Fanno flow, Raleigh flows, normal shock and oblique shock.
10.	Reference Books	**Text Books** 1. S.K. Som and G. Biswas, **Introduction to Fluid Mechanics and Fluid Machines, (2nd Edition),** Tata McGraw-Hill Publishing Company, 2008, ISBN: 9780070667624. 2. N.S. Govind Rao, **Fluid Flow Machines**, Tata McGraw Hill, 1998, ISBN: 9780074518542. 3. S.L. Dixon, **Fluid Mechanics and Thermodynamics of Turbomachinery, (5th Edition),** Butterworth-Heinemann, 2005, ISBN: 9780080470627. 4. E. Logan, **Turbomachinery: Basic Theory and Applications, (2nd Edition)**, CRC Press, 2002, ISBN: 9780429159770. **Reference Books** 5. A.T.Sayers, **Hydraulics and Compressible flow in Turbomachines**, McGraw Hill, 1990, ISBN: 9780077072193.

		6. A.J. Stepanoff, **Centrifugal and Axial Flow pumps**, Wiley, 1967, ISBN: 9780471821373. 7. D.G. Shepherd, **Principles of Turbomachinery**, Macmillian, 1956, ISBN: 9780024096609.

1.	**Course code**	**ME 208**
2.	**Course title**	**Theory of Manufacturing Processes**
3.	Course Category	Core
4.	Credit Structure	2-1-0-3
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	• Develop a fundamental understanding of the basic manufacturing techniques and tools, including Casting, Forming, Welding and Powder Metallurgy.
8.	Course Outcomes	• Develop an understanding about different manufacturing processes, capabilities, limitations, and remedies. • Identifying a manufacturing method for a series of processes to be adopted for fabrication of a product.
9.	Course Content	• **Theory of Casting processes:** Dispensable and permanent mould processes; Analysis of melting, pouring and solidification phenomena; Cooling and solidification of castings; Cooling curves; Nucleation and Dendrite formation; Various casting defects their inspection remedies: Design of gating and risering system. • **Theory of Joining processes:** Fusion and solid-state welding; Thermal effects in welding, cooling rate, structure in weld, heat affected zones, distortion and residual stresses; weld quality; weldability or joinability; weld joint design; welding defects and inspection, hard facing, brazing and soldering. • **Theory of Metal Forming Processes: (A) Theoretical Background:** Concept of stress and strain tensor, hydrostatic and deviatoric components, elastic stress-strain relations, strain energy, anisotropy of elastic behavior; Theory of Plasticity: true stress and strain, flow curve, concept of anelastic, hysteresis, and visco-elastic behavior, Bauschinger effect, Tresca and Von- Mises yield criteria, anisotropy in yielding, octahedral normal and shear stresses and strains, invariants of stress and strains, flow rules or plastic stress-strain relations. **(B) Analysis of Metal Forming Processes:** Introduction of forming process analysis methods (slab method, uniform deformation energy method, limit analysis); analysis of drawing, extrusion, rolling, forging, deep drawing, and bending, forming defects, formability & workability, temperature & lubrication aspects in forming; sheet metal working.

Text Books

1. R.W. Heine, C.R. Loper, and P.C. Rosenthal, **Principles of Metal Casting, (21st reprint),** Tata McGraw-Hill, 1997,ISBN: 9780070993488.
2. G.E. Dieter, **Mechanical Metallurgy**, McGraw Hill Book Company (UK) Ltd. 1988, ISBN: 9781259064794.
3. A. Ghosh and A.K. Mallik, **Manufacturing Science**, Affiliated East West Press, 2001,ISBN: 9788176710636.
4. E.P. DeGarmo, J.T. Black, and R.A. Kohser, **Materials and Processes in Manufacturing, (8th Edition)**, Prentice Hall of India Pvt. Limited, 2006, ISBN: 9780023286216.

Reference books

5. HMT, **Production Technology**, Tata McGraw Hill, 1980, ISBN: 9780070964432.
6. Lange, K., & Pöhlandt, K. **Handbook of metal forming**,1985. **Society of Manufacturing Engineers,** ISBN: 978-0872634572.
7. S. Kuo, **Welding Metallurgy**, John-Wiley & Sons Inc. 2003, ISBN: 978-0471434917.

1.	**Course code**	**ME 214**
2.	Course title	Introduction to Additive Manufacturing
3.	**Course Category**	Department Core
4.	**Credit Structure**	L-T- P-Credits 2-1-0-1.5 (Half-Semester)
5.	**Department**	Mechanical Engineering
6.	**Pre–requisite, if any**	Basic knowledge of different manufacturing processes
7.	**Objectives**	● This course aims to introduce the additive manufacturing process, its fundamentals, types, and its capability in various engineering and other applications.
8.	**Course Outcomes**	● Engineering Knowledge: Develop an understanding of the fundamentals of additive manufacturing and the process steps involved. ● Design of application-oriented additive manufacturing product, choice of appropriate method and parametric control.
9.	**Course Content**	● **Introduction:** Process fundamentals, the global developments and adaptability of AM, advantages, limitations, and future scopes. ● **Steps involved**: CAD modeling, appropriate file formatting (STL, AMF, etc.), slicing methods, fabrication and post-processing. ● **Classification:** Classification as per ISO/ASTM standards, including VAT Photopolymerization, Binder Jetting, Material Jetting, Material Extrusion, Powder Bed Fusion, Sheet Lamination and Directed Energy Deposition; associated process parameters in these processes. ● **Design and analysis:** Design of various application-oriented AM products, selection of material and methods, identification of process parameters and steps. ● **Post-processing:** Types of post processing for AM, discussion on geometrical accuracy, energy consumption, defects and other aspects.
10.	**Suggested Books**	**Textbooks** 1. I.Gibson, D.W. Rosen, B. Stucker, **Additive Manufacturing Technologies**, 2e, Springer-Verlag, New York, 2015. ISBN 9781493921126 2. C.K. Chua, K.F. Leong. **3D Printing and Additive Manufacturing: Principles and Applications**, World Scientific Publishing Co. Pvt. Ltd., Singapore, 2017, ISBN: 978-9-8131-4675-4 **Reference book** 3. L.W. Liou, and F.W. Liou, **Rapid Prototyping and Engineering applications: A toolbox for prototype development**, CRC Press, New York, 2011, ISBN 9780429029721 4. A. Gebhardt, J. Kessler, and, L. Thurn. **3D Printing: Understanding Additive Manufacturing**, Hanser

		Publications,Germany, 2019, ISBN: 978-1-56990-702-3

1.	**Course code**	**ME 256**
2.	**Course title**	**Computer Aided Machine Drawing**
3.	Course Category	Core
4.	Credit Structure	L-T-P-Credits (1-0-2-2)
5.	Department	Mechanical Engineering
6.	Pre–requisite, If any	None
7.	Objectives	● This course is dedicated for learning the skill to interpret, to prepare machine drawings and their assembly process using the standard conventions and also to build on visualization power to imagine, analyze and communicate.
8.	Course Outcome	● Students will master fundamental design processes and advanced drawing techniques to produce precise and comprehensive engineering drawings.
9.	Course Content	● **Introduction**: Introduction to design process and drawings. ● **Review of Fundamentals**: Review of sectioning, Drawing standards, Dimensioning and notes. ● **Computer Aided Drawing**: Use of software packages for engineering drawings and drafting. - **Production drawings**: Limits, Fits and Tolerances, Dimensional and geometric tolerances, Computer Aided Tolerances,Tolerance Stacks, Surface finish representations and symbols. - **Jigs and Fixtures**: Tool drawings including jigs and fixtures. - **Fasteners and Joints**: Screws, Bolts and nuts, Riveted joints, Pins,Locking devices, Welded joints, Pipe joints, Unions and valves. Cotter and Knuckle Joints. Assembly drawings with sectioning and bill of materials. - **Machine Assemblies**: Involving machine elements like shafts, couplings, bearing, pulleys, gears, belts, brackets. Detailed part drawings from assembly drawings. Engine mechanisms assembly and disassembly. - **Layout drawings**: Schematics, process and instrumentation diagrams, piping drawings. - **Structural drawings**: examples for reading and interpretation.
10.	Suggested Books	**Text Books** 1. N.D. Bhatt, and V.M. Panchal, **Machine Drawing**, Charotar Publishing House, 2009, ISBN: 9788185594958. 2. R K Dhawan, **A Textbook of Machine Drawing**, S Chand, 2015, ISBN: 9789385676499. 3. Foster, L. W. **Introduction to geometric dimensioning and tolerancing**. National Tooling & Machining Association,1996,ISBN:978-0910399180 4. Meadows, James D. **Geometric dimensioning and tolerancing: applications, analysis & measurement**. 2009, American Society of Mechanical Engineers, ISBN: 978-0971440166

		Reference Books 5. N. Sidheswar, P. Kannaiah, and V.V.S. Sastry, **Machine Drawing**, Tata McGraw Hill, 1980, ISBN: 9780074603376.

1.	**Course code**	**ME 254N**
2.	**Course title**	**Fluid Mechanics and Machinery Lab**
3.	Course Category	Core
4.	Credit Structure	L-T-P-Credits 0-0-2-1
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	● Students will grasp fluid mechanics principles through experiments, including orifice characteristics, flow measurements, fluid machinery performance, pipe losses analysis, and applications of Bernoulli's theorem, leading to aerodynamics understanding in a wind tunnel.
8.	Course Outcomes	● Develop a comprehensive understanding of fluid mechanics principles and their practical applications through hands-on experiments. ● Gain proficiency in utilizing a range of instruments and techniques for fluid flow measurement and machinery performance assessment.
9.	Course Content	**List of representative experiments:** ● Determination of the coefficient of discharge, velocity and contraction of a small orifice. ● Flow measurement through notches. ● Flow Measurement through venturi nozzle, orifice meter, nozzle meter, rotameter and magnetic flow meter. ● Determination of performance characteristics of Francis turbine, Pellton turbine and centrifugal pump. ● Measurement of major and minor losses in pipes. ● Demonstration of Bernoulli’s theorem. ● Measurement inside a wind tunnel: pressure and velocity.
10.	Suggested Books	**Reference Books** 1. R.W. Fox and A.T. McDonald, **Fluid Mechanics**, John Wiley International, 2005, ISBN: 9780470547557. 2. S. K. Som and G. Biswas, **Introduction to Fluid Mechanics and Fluid Machines, (2nd Edition)**, Tata McGraw-Hill, 2008, ISBN: 9780070702592.

1.	**Course code**	**ME 258N**
2.	**Course title**	**Manufacturing Processes Lab**
3.	Course Category	Core
4.	Credit Structure	L-T-P-Credits (0-0-2-1)
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	The student will be able to understand the effect of process parameters, and related possible defects in different types of manufacturing processes.
8.	Course Outcomes	Understanding of different manufacturing processes related to Casting, Forming, welding and powder compaction.
9.	Course Content	List of representative experiments: ● Foundry and Molding: (a) Preparation of a core for producing a typical hollow-shaped part by the sand-casting process. Measurement of green strength of core. (b) Demonstration of centrifugal casting of aluminum pipe, including calculation of RPM and wall thickness for given volume of liquid metal. (c) Preparation of a sand mold using the two-piece pattern and the core preparation and production of the desired casting. (d) Measurement of green strength of sand mould. (e) Simulation of casting for demonstrating hot spots in the mould using E-Foundry. ● Welding: (a) To prepare two different samples of ‘V’ butt joints using MIG and TIG welding processes. (b) Resistance welding lap joint preparation. (c) To perform die penetrant test for both the samples prepared by TIG and MIG (Exp. 2.a). (d) To check strength and formability of welded joints by performing a bending test. ● Metal forming: (a) Design, development and manufacturing of typical sheet-metal product using various forming processes namely (i) sheet shearing, (ii) sheet roll-bending, (iii) nibbling and (iv) deep drawing. (b) Sheet metal forming of V shape, effect of nose radius (5, 10 & 20 mm), bend angle (60o, 90o & 120o) and measure the spring back. (c) Perform cold rolling operation on Aluminum sheet and estimate the strain that occurred during the process. (d) Perform wire drawing operation on Aluminum wire and estimate the strain that occurred during the process. (e) Demonstration of Injection molding, and evaluate mass flow rate. ● Powder Compaction: Execution of green compaction, sintering of aluminum/ plastic pallet power for the making of solid cylinder.
1	Suggested	**Reference Books**

0	Books	1. E.P. DeGarmo, J.T. Black, and R.A. Kohser, **Materials and Processes in Manufacturing**, Prentice Hall of India Pvt. Limited, 2006, ISBN: 9780023286216. 2. S. Kuo, **Welding Metallurgy**, John-Wiley & Sons Inc. 2003, ISBN: 1119524814. 3. R.W. Heine, C.R. Loper, and P.C. Rosenthal, **Principles of Metal Casting,** Tata McGraw-Hill, 1997,ISBN: 9780070993488. 4. G.E. Dieter, **Mechanical Metallurgy**, McGraw Hill Book Company Ltd. 1988, ISBN: 9781259064794. 5. A. Ghosh and A.K. Mallik, **Manufacturing Science**, Affiliated East West Press, 2001. ISBN: 9788176710636. 6. HMT, **Production Technology**, Tata McGraw Hill, 1980. ISBN: 9780070964432.

1.	**Course code**	**ME 216**
2.	Course title	Thermal Systems and Applications
3.	**Course Category**	Department Elective
4.	**Credit Structure**	L-T- P-Credits 2-1-0-1.5 (Half-Semester)
5.	**Department**	Mechanical Engineering
6.	**Pre–requisite, if any**	None
7.	**Objectives**	● This subject explores the fundamental principles of thermal systems and their ubiquitous applications in everyday life, including heating, cooling, energy efficiency, and thermal comfort.
8.	**Course Outcomes**	● Develop a foundational understanding of thermal systems, including their principles and practical applications in daily life and various industries. ● Explore the sustainability and emerging technologies related to thermal systems.
9.	**Course Content**	● **Foundations of Thermal Systems:** The importance of thermal systems in daily life; Historical developments in thermal science ● **Heating and Cooling Systems:** Residential heating/cooling systems; Heat exchangers; AC and refrigeration technology; Insulations and energy efficiency in homes ● **Thermal Systems in Common Applications:** Solar and geothermal heating and cooling systems; Cooking, food preservation, and thermal applications; Designing clothing for various environments; Electronics cooling and thermal management. ● **Thermal Systems in Transportation and Sustainability:** Vehicle engine cooling/heating systems; Energy-efficient transportation technologies; Innovations in vehicle thermal management. ● **Future Trends and Green Engineering:** Thermal considerations in product design; Thermal systems across industries; Emerging thermal technologies and their applications
10.	**Suggested Books**	**Text Books:** 1. M. Moran, H. Shapiro, B. Munson, D. DeWitt, **Introduction to Thermal Systems Engineering**, Wiley, 2002, ISBN: 9780471204909 2. T.H. Kuehn, J.W. Ramsey, J.L. Threlkeld, **Thermal Environmental Engineering**, Prentice Hall, 1998, ISBN: 9780139172205 3. G.M. Masters, **Renewable Energy and Efficient Electric Systems**, Pearson, 2004, ISBN: 9780136155319 **Reference Books** 4. J.H. Lund and T.L. Boyd, **Geothermal Heat Pump and Heat Engines**, IGI Global, 2008, ISBN: 9781599043368 5. J.T. Williams, **Textiles for Cold Weather Apparel**, Woodhead Publishing, 2009, ISBN: 9781845694111 6. C.J.M. Lasance and A. Ortega (Editors), **Thermal Management of Electronic Systems II**, Kluwer Academic Publishers, 1997, ISBN: 9780792347638 7. M. Concepcion, **Automotive Cooling System Basics**, CreateSpace Independent Publishing Platform, 2012, ISBN: 9781479328072

1.	**Course code**	**ME 218**
2.	**Course title**	**Quality Management**
3.	Course Category	Department Elective
4.	Credit Structure	L-T-P-Credits 2-1-0-1.5 (Half-Sem)
5.	Department	Mechanical Engineering
6.	Pre–requisite, if any	None
7.	Objectives	● Develop a fundamental understanding of techniques for statistical quality control.
8.	Course Outcomes	● Develop quality-oriented critical thinking in designing products and processes. ● Learn to select and apply tools to achieve, maintain and improve quality in industrial applications
9.	Course Content	● **Introduction**: Different definitions, dimensions, and aspects of quality, Traditional and modern view of Quality Control, Different Philosophies by Quality Gurus, Quality Function Deployment (QFD). ● **Process Capability (PC) Analysis and Statistical Process Control (SPC)**: Manufacturing process variability, manufacturing process capability, and tolerances; Tools/methods used in SPC: Control Charts, Pareto charts, Fishbone diagram, etc. Implementation of SPC. ● **Control Charts:** Theory and applications of control charts; Control charts for variables: charts averages, ranges, and standard deviation; Control charts for attributes: p and c charts; Fraction defective and number of defects per unit; Different adaptation of control charts. Other advanced quality control charts such as CUSUM, EWMA. ● **Acceptance Sampling:** Concept of acceptance sampling; Sampling by attributes: Single and double sampling plans, Use of Dodge Romming and Military standard sampling tables, Construction and use of operating characteristic (OC) curves; Sampling by variables: Continuous sampling plans.
10.	Suggested Books (Textbooks, Reference Books)	**Textbook** 1. Mitra, A.. **Fundamentals of Quality Control and Improvement**, Wiley, 2016. ISBN: 9781118705148. 2. Montgomery, D. C.. **Introduction to Statistical Quality Control,** Wiley, 2020. ISBN: 9781119723097. **Reference Books** 3. Grant, E. L., Leavenworth, R. S.**Statistical Quality Control**, McGraw-Hill, 1996. ISBN: 978007844354. 4. Taguchi, G., Chowdhury, S. Wu, Y.. **Taguchi's Quality Engineering Handbook,** Wiley, 2005. ISBN: 9780471413349.

1.	**Course code**	**ME 220**
2.	**Course title**	**Fundamentals of Acoustics**
3.	Course Category	Departmental Elective
4.	Credit Structure	L-T-P Credits 2-1-0-1.5 (Half-Semester)
5.	Department	Mechanical Engineering
6.	Prerequisite, if any	None
7.	Objectives	● This course will give the foundation of acoustics. ● Students will understand the propagation of plane waves, 3-D waves, and symmetric spherical waves.
8.	Course Outcomes	● Students will be able to find frequencies of higher order modes in circular and rectangular ducts, and acoustic pressure fields. ● Find the criteria for near field and far field for symmetric spherical waves. ● Design an impedance tube for the desired frequency range of interest.
9.	Course Content	● **Acoustic Plane Waves**: Plane wave equation, Energy density of plane waves, Acoustic Intensity, Decibel Levels: Sound Intensity Level, Sound Pressure Level, and Sound Power Level. ● **3-D Waves in Rectangular and Cylindrical Waveguides**: 3-D Wave Equation in Cartesian and Cylindrical Coordinate Systems, Mode shapes of a cross-section, Acoustic pressure and acoustic particle velocity in waveguides. ● **Symmetric Spherical Waves**: Acoustic pressure and acoustic particle velocity of symmetric spherical waves, Concepts of far field and near field. ● **Impedance Tube**: Design of an impedance tube for a frequency range of interest, Transmission and Absorption Characteristics Measurements in Impedance tube.
10.	Suggested Books	**Text Books** 1. L. E. Kinsler, A. R. Frey, A. B. Coppens, and J. V. Sanders, **Fundamentals of Acoustics**, **4th Edition**, Wiley, 2000, ISBN: 9780471847892. 2. D. T. Blackstock, **Fundamentals of Physical Acoustics,** Wiley, 2000, ISBN: 9780471847892. **Reference Books** 3. J. W. S. Rayleigh, **The Theory of Sound: Volume II, 2nd Edition,** Dover Publications, 1998, ISBN: 9780486602936**.** 4. A. D. Pierce, **Acoustics: An Introduction to Its Physical Principles and Applications, 3rd Edition,** ASA Press, 2019, ISBN: 9783030112134.

1.	**Course code**	**ME 222**
2.	**Course title**	**Introduction to Experimental Aerodynamics**
3.	Course Category	Departmental Elective
4.	Credit Structure	L-T-P Credits 2-1-0-1.5 (Half-Semester)
5.	Department	Mechanical Engineering
6.	Prerequisite, if any	None
7.	Objectives	● Introduce students to fundamental principles of experimental aerodynamics. ● Develop skills in basic experimental techniques and data analysis in aerodynamics.
8.	Course Outcomes	● Students will demonstrate understanding of basic principles of experimental aerodynamics and its applications. ● Students will be able to effectively conduct and analyze simple aerodynamic experiments, laying the groundwork for further study in the field.
9.	Course Content	● **Introduction to Experimental Aerodynamics**: Basic concepts, significance in aerospace engineering. Experimental Methods: Wind tunnels, pressure measurements, force balance, flow visualization techniques. ● **Measurement Techniques**: Pressure Measurement - pressure sensors, pressure taps, and manometers. Flow visualization techniques - smoke flow, oil flow, and particle image velocimetry (PIV). ● **Wind Tunnel Testing:** Types of wind tunnels, testing procedures, and instrumentation. Boundary Layer Measurements - Boundary layer probes, hot-wire anemometry. ● **Aerodynamic Forces and Moments Force**: Force balance and torque balance. Calculation of Aerodynamic Coefficients - Lift, drag, and moment coefficients. ● **Airfoil and wind testing**: Lift and drag measurement of airfoils in wind tunnels; measurement of lift and drag on wind models.
10.	Suggested Books	**Text Books** 1. S. Discetti and A. Ianiro, **Experimental Aerodynamics**, CRC Press, 2017, ISBN: 9781498704014. 2. J.J. Bertin and R.M. Cummings, **Aerodynamics for Engineers**, 5e, Pearson Education International, 2009. ISBN: 9780132272681. **Reference Books** 3. J.P. Holman, **Experimental methods for Engineering**, McGraw Hill, 2007, ISBN: 9780070295957. 4. J.B. Barlow, W.H.Rae Jr., A. Pope, **Low-speed Wind Tunnel Testing**, 3e, John Wily and Sons. ISBN: 9788126525683

1.	**Course code**	**ME 224**
2.	**Course title**	**Fundamentals of Microscale Flows**
3.	Course Category	Departmental Elective
4.	Credit Structure	L - T - P Credits 2-1-0-1.5 (Half-Semester)
5.	Department	Mechanical Engineering
6.	Prerequisite, if any	Fluid Mechanics
7.	Objectives	● The course aims to provide an understanding of the unique characteristics and behaviors of fluid flows at the microscale level, including phenomena such as microfluidics, nanofluidics, and rarefied gas flows. ● Encourage critical thinking and exploration of future advancements and societal implications of microfluidics.
8.	Course Outcomes	● Students will be equipped with the knowledge, and skills necessary to understand, analyze, and apply microscale flows in various engineering and scientific contexts. ● Students will be able to recognize the interdisciplinary nature of microscale flows and their applications.
9.	Course Content	● **Introduction to Microscale Flows**: Definition and significance of microscale flows, applications in various fields (biomedical, chemical engineering, aerospace, etc.), historical overview and development of microfluidics; Review of fluid mechanics fundamentals. ● **Scaling Laws and Dimensional Analysis**: Introduction to scaling laws for microscale flows, dimensionless numbers relevant to microfluidics, application of dimensional analysis to predict flow behavior. ● **Applications of Microscale Flows:** Lab-on-a-chip systems for medical diagnostics, microreactors for chemical synthesis, Microscale heat exchangers and cooling systems, microfluidic bioreactors and cell manipulation, emerging trends and future directions in microfluidics. ● **Introduction to Microfabrication Techniques**: Overview of microfabrication methods (photolithography, soft lithography, micromachining, etc.), Fabrication of microfluidic devices, surface modifications, and functionalization for microfluidic applications.
10.	Suggested Books	**Text Books** 1. Nguyen, N. T., Werely,S. T., **Fundamentals and applications of Microfluidics**, Artech house Inc., 2002. ISBN: 9781630813642. 2. Tabeling, P., **Introduction to microfluidics**, Oxford University Press Inc., 2005. ISBN: 9780198568643. **Reference Books** 3. Kirby, B.J., **Micro- and Nanoscale Fluid Mechanics**: Transport in Microfluidic Devices, Cambridge University Press, 2010. ISBN- 9781139489836**.** 4. Madou, M. J., **Fundamentals of Microfabrication**, CRC press, 2002. ISBN: 9781315274225.

1.	**Course code**	**ME 228**
2.	**Course title**	**High Strain Rate Forming Process**
3.	Course Category	Departmental Elective
4.	Credit Structure	L - T - P Credits 2-1-0-1.5 (Half-Semester)
5.	Department	Mechanical Engineering
6.	Prerequisite, if any	Basic Manufacturing
7.	Objectives	● The course aims to introduce students to the principle, procedure and applications of forming process recent advances in the forming.
8.	Course Outcomes	● Students will be able to understand the concept of different advanced forming processes. ● Able to approach forming processes both analytically and numerically
9.	Course Content	● **Introduction:** State of stress, Components of stress, symmetry of stress tensor, principal stresses, Stress deviator, Octahedral shear stress and shear strain theory, Hot, cold and warm working, Residual stresses, Spring back ● **Recent Advances:** Super plastic forming, Electro-magnetic forming, Electro-hydraulic forming, Explosive forming, Vaporising Foil Actuator metal forming, Hydroforming, Laser Forming, Micro forming, P/M forging, Isothermal forging, High speed hot forging, High speed stamping process, computer application in forming. ● **Applications in Industry:** Utilization of bulk sheet/plate metal forming in sectors like defence, aerospace, shipbuilding, and automotive industries. Techniques for forming complex geometries for applications in space exploration, solar panels, and general manufacturing.
10.	Suggested Books	**Text Books** 1. Dieter G.E., **Mechanical Metallurgy**, McGraw Hill, Co., S.I. Edition, 1988, ISBN: 9780071004068. 2. Nagpal G.R. **Metal forming processes**, Khanna publishers, New Delhi, 2004, ISBN: 9788174090171 **Reference Books** 3. ***ASM Metals Handbook: Forming and Forging, Volume 14***. ASM International, 1996. ISBN: 9780871700209 4. Serope Kalpakjian, Steven R Schmid, **Manufacturing Process for Engineering Materials**, 4th Edition, Pearson Education, 2017, ISBN: 9780134290553. 5. Edward M.Mielink, **Metal working Science Engineering**, McGraw Hill, Inc, 1990, ISBN: 9780070419056.

Syllabi
of
Civil Engineering Courses

(Based on syllabi of Civil Engineering Courses of IIT Bombay)
(From AY 2017-18 onwards)

1.	Course Code	**CE 201**
2.	Title of the Course	**Solid Mechanics**
3.	Credit Structure	L-T- P-Credits 3-1-0-4
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Rigid and deformable solids; Method of sections for evaluating internal forces in bodies - review of free body diagrams; Axial force, shear and bending moment diagrams; Concept of stress, normal and shear stress; Concept of strain , normal and shear strains; Constitutive relations, Hook?s law; Axially loaded members force and deflections; Bending and shearing stresses in beams of symmetrical cross-section concept of shear flow; Inelastic bending of beam; Torsion of circular shafts; Stress in cylindrical and spherical shells; Combined stress; principals of superposition and its limitations; Transformation of plane stress and strain, principal stress and strains, Mohr’s circle, strain methods; Bending deflection of simple beams by direct integration methods; Buckling of compression methods.
8.	Suggested Books	1. S.M.A. Kazioni, **Solid Mechanics** (1st revised ed.), Tata McGraw Hill, New Delhi, 1988. 2. E.P. Popoo, **Introduction to Mechanics of Solids**, Prentice Hill of India, New Delhi, 1973. 3. S.H. Crandall, N.C. Dahl and T.V. Lardner, **Mechanics of Solids: An Introduction**, McGraw Hill International, Tokyo, 1994.

1.	Course Code	**CE 251**
2.	Title of the Course	**Solid Mechanics Lab.**
3.	Credit Structure	L-T- P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Experiment on axial tension of mild steel and cast iron; compression on concrete; bending of beams; buckling of columns. Experiments on shear centre; continuous and interconnected beams; unsymmetrical bending of angle sections; buckling of columns of various cross-section and end conditions.
8.	Suggested Books	1. David, Troxell, **Inspection and Testing of Engineering Materials**, Wskocil.

1.	Course Code	**CE 257**
2.	Title of the Course	**Civil Engineering Drawing**
3.	Credit Structure	L-T- P-Credits 1-0-3-2.5
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	The course provide students with a basic understanding of civil engineering drawings· It also enables students to understand the details of construction of different building elements and envision the completed form of the building infrastructure.
7.	Course Syllabus	Drawing of various details of residential buildings, framed buildings in steel and concrete. Industrial and laboratory buildings. Principles of planning. Relation of frame work details, floors and roofing systems, masonry, load bearing and non-load bearing walls. Working drawings of building.
8.	Suggested Books	1. Malik R S and Meo G S, ***Civil Engineering Drawing***, Cengage India Private Limited, Delhi, 2016, ISBN-9788131526132 2. G. Singh. Craig, ***Civil Engineering Drawing***, Standard Publishers & distributors, New Delhi, 2009, ISBN-13-978-8180140044 3. M G Shah, C M Kale, S Y Patki, ***Building drawing with an integrated approach to Built Environment Drawing,*** Tata Mc Graw Hill Publishing co. Ltd, New Delhi, 2007, ISBN-13-978-0071077873

1.	Course Code	**CE 202**
2.	Title of the Course	**Structural Mechanics-I**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Analysis of Statically Determinate Structures: Determination of forces in trusses, frames, arches, and cables; Principle of virtual work; Energy Principle; Maxwell's and Betti's laws; Computation of Displacements - moment area method, conjugate beam method, virtual work methods; Influence Lines - Equilibrium methods, Muller Breslau principle; concepts of flexibility and stiffness. Introduction to statically Indeterminate Structures: Concept of state indeterminacy-determination of static redundancy; concept of compatibility conditions; applications to axially loaded members; single beams.
8.	Suggested Books	1. H.H. West, **Fundamentals of Structural Analysis**, John Wiley, New York, 1993. 2. C.H. Norns, J.B. Wilbur, S. Utku, **Elementary Structural Analysis**, 3rd McGraw-Hill International, Tokyo, 1976. 3. C.S. Reddy, **Basic Structural Analysis** (2nd ed.) Tata McGraw Hill, New Delhi, 1996.

1.	Course Code	**CE 203**
2.	Title of the Course	**Fluid Mechanics-I**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Definition, properties and classifications of fluids. Kinematics of fluid flow. Generalized continuity equation. Irrotational motion and solutions to Laplace equation. Dynamics of fluid flow. Euler and Bernoulli's theorems. Impulse momentum theory and applications. Flow of fluids in closed conduits. Laminar and turbulent flows in the light of boundary layer concepts. Darcy-Weisbach equation, Moody's diagram. Minor losses. Drag on immersed bodies, concepts of separation, drag force, circulation and lift force. Dimensional Analysis, Model Similitude, theory and applications.
8.	Suggested Books	1. R.A. Granger, **Fluid Mechanics**, Holt Reinhart and Winstaw, 1985. 2. V.L. Streeter E.B. and Wylie, **Fluid Mechanics**, McGraw Hill Book Co., 1983. 3. R.L. Daugherthy, J.B. Franzini, E.J. Finnermore; **Fluid Mechanics with Engineering Application**, McGraw Hill, International Ed: 1989. 4. LP.N. Modi, S.M. Seth, **Hydraulics and Fluid Mechanics**; Standard Book House, New Delhi

1.	Course Code	**CE 253**
2.	Title of the Course	**Fluid Mechanics Lab-I**
3.	Credit Structure	L-T- P-Credits 0-0-2-1
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Ideal fluid motion past a two dimensional circular cylinder by means of an electrical analog; study of boundary layer growth in a wind tunnel. Drag on a circular cylinder, Minor transition losses in pipes. Determination of friction factor of pipes. Flow measurement by Orifices, venturimeter and notches; computations of various coefficients involving jet flow through orifice. Demonstration experiments. Bernoulli apparatus, Reynolds apparatus, Magnus effect.
8.	Suggested Books	1. Lamox W.r., **Laboratory work in Hydraulics**, Granada Publishers, London, 1979.

1.	Course Code	**CE 204**
2.	Title of the Course	**Fluid Mechanics-II**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Introduction to Navier-Stokes equations. Exact solutions for simple cases of flow, plane Poiseuilee flow. Couette flow. Hydro-dynamics of lubrications problems. Problems of flow through porous media. Application of boundary layer theory to concepts of flow separation phenomena, circulation and lift. Aerofoil characteristics. Network theory as applied to pipe grids, unsteady flow in close conduits. Functions of a surge chamber.
8.	Suggested Books	1. R.A. Granger, **Fluid Mechanics**, Holt Reinhart and Winstaw, 1985. 2. V.L. Streeter and EB Wylie, **Fluid Mechanics**, McGraw Hill Book Co., 1983. 3. R.L. Daugherthy, J.B. Franzini, E.J. Finnemore,"**Fluid Mechanics with Engineering Applications**", McGraw Hill, International Ed: 1989. 4. **Herman Schlichting: Boundary Layer Theory**: McGraw Hill, 1979.

1.	Course Code	**CE 254**
2.	Title of the Course	**Fluid Mechanics Lab-II**
3.	Credit Structure	L-T- P-Credits 0-0-2-1
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Application of Hele-Shaw Model to compute dam seepage. Deformation of fluid viscosity for Hagen Poiseuille flow conditions. Electric analog for the pipe solution networks. Flow net studies around circular cylinder. Verification of Darcy's law.
8.	Suggested Books	1. Lamox W.R. **Laboratory Work in Hydraulics** Granada Publishers, London 1979. 2. S. Narasimhan (Ed.) **Engineering Fluid Mechan**ics Vol. II, Orient Longmans Ltd., New Delhi, 1973. 3. V.L. Streeter, E.B. Wylie, **Fluid Mechanics**, McGraw Hill, 1985.

1.	Course Code	**CE 206**
2.	Title of the Course	**Geodesy-I**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Design data surveys: Control surveys- horizontal and vertical; Topographic Mapping; route surveys. Traversing- compass, theodolite and plane table; Levelling-spirit and trigonometrical; Tacheometry and subtense measurements; Areas and Volumes; Setting out works.
8.	Suggested Books	1. B.C. Punmia, A.K. Jain and A.K. Jain, **Surveying, Vol. 1 and II**, Laxmi Publications (P) Ltd., New Delhi, 1996. 2. K.R. Arora, **Surveying, vol. I and II**, Standard Book House, Delhi, 1998. 3. R.E. Davis, F.s. Foote and J.w. Kelly, **Surveying; Theory and Practice**, McGraw Hill Book Company, New York, 1966. 4. D. Clark and J. Clendinning, **Plane and Geodetic Surveying, Vol. I and II**, Constable and Company, London, 1958.

1.	Course Code	**CE 256**
2.	Title of the Course	**Geodesy Lab-I**
3.	Credit Structure	L-T- P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Horizontal control-compass, plane table and theodolite traversing; plotting traverses and mapping details; vertical control-spirit levelling, tacheometry and trigonometric levelling; curve setting.
8.	Suggested Books	Same as CE 206

1.	Course Code	**CE 208**
2.	Title of the Course	**Water and Wastewater Engineering**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Essentials of water, Quantity of water, Domestic water standards; Sources of water and their yield, population forecast, Design period; Intakes, pumping and Transportation of water; Water distribution systems and analysis; Appurtenances of water transport and distribution systems. Essentials of waste water engineering, Quantities of Waste water and storm water, waste water characteristics; Water and waste water plumbing systems, Waste water collection systems, Design of Sewerage systems, Pumping of waste water; Unit operations; Processes of water treatment, sedimentation and flocculation; slow and rapid sand filters; chlorination and other disinfecting methods; primary and secondary waste water treatment, activated sludge trickling filters, sludge digestion, drying and disposal.
8.	Suggested Books	1. G.M. Fair, J.C. Geyer, D.A. Okan, **Elements of Water Supply and Wastewater Disposal**, John Wiley and Sons Inc., 1971. 2. Terence, J. McGhee **Water Supply and Sewerage**, McGraw Hill Book Co., 1991. 3. M.J. Hammer, **Water and Waste Water Technology**, John Wiley and Sons, New York, 1986. 4. CPHEEO: **Manual on water supply and treatment**, Ministry of Urban Development, 1991. 5. CPHEEO: **Manual on Sewerage and Sewage Treatment**, Ministry of Works and Housing, New Delhi, 1980.

Course code	**CE 301**
Title of the course	**Hydrology**
Credit Structure	L - T - P – Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	NA
Scope of the course	Hydrology is the study of the physical processes that illustrate how water is transferred from oceans to atmosphere, to land surface, and then back to oceans. Students are exposed to the basic principles and processes that govern the hydrologic cycle, with a special attention to the processes that happen over the land surfaces, since these are directly related to our survival and are fundamental drivers of landscape changes. The course is designed for learning physical principals of hydrology as well as techniques to solve many practical hydrologic problems, including flood routing, flood frequency estimation, surface runoff estimation.
Course Syllabus	**Introduction:** Definition and scope, Hydrologic cycle, Hydrologic systems, Water budget **Precipitation:** Forms and formation, Point measurements, Areal estimation **Evaporation and Evapotranspiration:** Mechanisms and measurements, Classification of evapotranspiration processes, Transpiration, Interception losses, Potential and actual evapotranspiration, Reference-crop evapotranspiration. **Infiltration:** Processes and measurement, Sorption, Infiltration capacity, formulations, Catchment scale infiltration. **Overland flow and runoff:** Streamflow generation, measurement, and formulations, watershed and stream network, Streamflow response: Hydrographs, Unit Hydrograph theory, Convolution, S-curve hydrograph, Flow duration curve, Mass curve, Flood routing, Simple rainfall-runoff models **Flood frequency analysis:** Random variables, Extreme value distributions, Return period, Risk and Reliability, Intensity-Duration curves **Groundwater Hydrology:** Properties of porous materials, Aquifers, Darcy's law, Basic principles of saturated and unsaturated subsurface flow.
Suggested Books	1. P. B. Bedient, W. C. Huber,B. E. Vieux, ***Hydrology and Floodplain Analysis***, Pearson Education Limited, Harlow,

	Essex, England, 2018:0134751973 2. S. L. Dingman, ***Physical Hydrology***, Waveland Press, Inc, Long Grove, Illinois, USA, 2014, 1478611189 3. G. M. Hornberger, P. L. Wiberg, J. P. Raffensperger, P. D`odorico, ***Elements of Physical Hydrology,*** Johns Hopkins University Press, Baltimore, Maryland, USA, 2014, 1421413736 4. V. T. Chow, D. Maidment, L. Mays, ***Applied Hydrology,*** McGraw-Hill Professional, New York, USA, 2013, 007174391X

1.	Course Code	**CE 361**
2.	Title of the Course	**Design of Open Channel Flow**
3.	Credit Structure	L-T- P-Credits 1-0-2-2
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Open channel flow. Energy, momentum and pressure correction factors of momentum and energy equations. Specific force. Properties of critical flow. Uniform flow, its properties, design of channels for uniform flow. Gradually varied flow theory, profile computation and use in design of channels. Rapidly varied flow, flow over spillways, hydraulic jump, its location, control and stabilization. Unsteady flow, basic equations, uniformly progressive flow, velocity of flood wave discharge for unsteady flow, flood routing (reservoir and stream flow). Computation of surface profiles in gradually varied flow, location of hydraulic jump and flood routing. Channel Design and Transitions - Energy Dissipators, spillways.
8.	Suggested Books	1. V. T. Chow, **Open Channel Hydraulics**, McGraw Hill, 1975. 2. K.G. Rangaraju, **Flow in Open Channels**, Tata McGraw Hill Publication Co. Ltd., New Delhi, 1993. 3. K. Subramanya, **Flow in Open Channels**, Tata McGraw Hill Publication Co. Ltd., New Delhi, 1992. 4. R.H. French, **Open Channel Hydraulics**, McGraw Hill Book Co., New York 1986.

1.	Course Code	**CE 302**
2.	Title of the Course	**Geodesy-II**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	Exposure to Geodesy-I
6.	Objectives of the course	
7.	Course Syllabus	Geodetic surveying; triangulation and precise levelling, theory of errors; method of least squares, adjustment of surveying observations; precision and accuracy evaluation; electronic measurements in surveying; field astronomy fundamentals. Spherical trigonometry, determination of terrestrial co-ordinates and Azimuth.
8.	Suggested Books	1. G.L. Hosmer, Geodesy, John Wiley & sons, New York, 1946. 2. B.C. Punmia, A.K. Jain and A.K. Jain, Surveying, Vol. II and III, Laxmi Publications(P) Ltd., New Delhi, 1997. 3. K.R. Arora, Surveying, Vol. II and III, Standard Book House, Delhi, 1998. 4. J.B. Mackie, The Elements of Astronomy for surveyors, Charles Griffin and Company Ltd. High Wycombe, England, 1985. 5. C.D. Burnside, Electromagnetic Distance Measurement, Crosby Lockwood and Son Ltd., London, 1971.

1.	Course Code	**CE 352**
2.	Title of the Course	**Geodesy Lab-II**
3.	Credit Structure	L-T- P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Based on CE 302
8.	Suggested Books	Same as CE 302

1.	Course Code	**CE 303**
2.	Title of the Course	**Soil Mechanics-I**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	Soil mechanics deals with the engineering behavior of soil. The subject provides fundamental understanding of physical and mechanical properties of soils. Students will acquire basic knowledge in engineering design of geotechnical systems.
7.	Course Syllabus	Origin, Particle Size Analysis, Soil Characteristics-Atterberg's limit, Soil classification, surface tension, capillary attraction. Effective stress Principle, flow through soils, flow nets. Compaction of soils. Stresses in soil, contact pressure. Consolidation of soils, settlement of compressible layers. Shear strength of soils, Mohr Coulomb Theory, Failure theories.
8.	Suggested Books	**Text Books** 1. B. M. Das and K. Shobhan, ***Principles of Geotechnical Engineering with Mind Tap***, Cengage India Private Limited, Delhi, 2016, ISBN, 9788131526132 2. J.A. Knappett and R.F. Craig, ***Soil Mechanics,*** CRC Press, New York, 2012, ISBN-13, 978-0415561266 3. V.N.S. Murthy, ***Textbook of Soil Mechanics and Foundation Engineering,*** Geotechnical Engineering series, CBS Publishers, New Delhi, 2008, ISBN-13-9788123913629 4. S.K. Shukla, ***Core Concepts of Geotechnical Engineering***, ICE Publishing, London, UK, 2015, ISBN-13, 978-0727758590 **Reference Books** 5. B. M. Das and N.Sivakugan, ***Fundamentals of Geotechnical Engineering,*** Cengage India Private Limited, Delhi, 2017, ISBN: 9789386858139

1.	Course Code	**CE 353**
2.	Title of the Course	**Soil Mechanics Laboratory-I**
3.	Credit Structure	L-T- P-Credits 0-0-2-1
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	To acquire hands on experience of measuring and interpreting soil properties.
7.	Course Syllabus	Identification of soils, Determination of physical properties, Consistency limits, Determination of soil permeability and compaction, characteristics of soils, Consolidation, Unconfined compression test, direct shear test, Vane shear test, Triaxial test, California bearing ratio test
8.	Suggested Books	1. Relevant Indian Codes of practice 2. J.E. Bowles, ***Physical and Geotechnical Properties of soils***, McGraw Hill International Editions, 1990, 0070067724 3. T.W. Lambe, ***Soil Testing for Engineers***, Wiley, 1960, 0471511838 4. B M Das**, *Soil mechanics laboratory manual*,** Oxford University Press, 2012, 0199846375 5. T.W. Lambe, ***Soil Mechanics*****,** John Wiley & Sons, 1969, 0471511927 6. 6. Head, K. H., ***Manaual of soil laboratory testing***, Volume 1, 2 and 3, Pentech press, 1980, 1904445365.

1.	Course Code	**CE 304**
2.	Title of the Course	**Soil Mechanics II**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	Exposer to Soil Mechanics-I
6.	Objectives of the course	
7.	Course Syllabus	Surface and subsurface investigations. Boring and sampling. Fieldtests, introduction to airphoto interpretation. Theories of earth pressure and retaining walls excavation, bracing, stability of slopes. Earth and rock fill dams. Bearing capacity of soils. Design and construction of shallow footings, rafts, pile foundations, caisson and coffer dams, anchored bulkheads.
8.	Suggested Books	1. R.F. Craig, **Soil Mechanics**, ELBS & Van Nestrand, 4th Edition, 1987, 2. R.B. Peck, W.E. Hanson and T.H. Thornburn, **Foundation Engineering**, John Wiley, 1963. 3. V.N.S. Murthy, **Soil Mechanics and Foundation Engineering, Vol-II**, Saikripa Technical Consultants, Bangalore, 1991.

1.	Course Code	**CE 354**
2.	Title of the Course	**Soil Mechanics Laboratory-II**
3.	Credit Structure	L-T- P-Credits 0-0-2-1
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	To acquire hands on measuring strength soil properties through invasive and non invasive field tests.
7.	Course Syllabus	Field Tests: Standard Penetration test, Plate Load, Dynamic Cone Penetration test, Multichannel analysis of surface wave test, Ground penetration radar, Electrical resistivity tomography
8.	Suggested Books	1. Relevant Indian Codes of practice 2. J.E. Bowles, ***Physical and Geotechnical Properties of soils*****,** McGraw Hill International Editions, 1990, 0070067724 3. T.W. Lambe, ***Soil Testing for Engineers***, Wiley, 1960, 0471511838 4. B M Das**,** ***Soil mechanics laboratory manual*****,** Oxford University Press, 2012, 0199846375 5. T.W. Lambe, ***Soil Mechanics*****,** John Wiley & Sons, 1969, 0471511927 6. Head, K. H., ***Manaual of soil laboratory testing***, Volume 1, 2 and 3, Pentech press, 1980, 1904445365.

1.	Course Code	**CE 305**
2.	Title of the Course	**Structural Mechanics-II**
3.	Credit Structure	L-T- P-Credits 2 -1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	Exposure to Structural Mechanics-I
6.	Objectives of the course	
7.	Course Syllabus	Analysis of Statically Indeterminate Structures: Review of Statical Indeterminancy; Force Method - application to trusses, beams, frames, arches; concept of kinematic indeterminancy - degrees of freedom; Development of slope - deflection equations; concept of stiffness; Displacement method and applications; Influence lines using Muller Breslau principle; Moment distribution method and application to beams and simple frames.
8.	Suggested Books	1. H.H. West, **Fundamentals of Structural analysis** John Wiley, New York, 1993. 2. C.H. Norris, J.B. Wilbur and S. Utku, **Elementary Structural Analysis**, McGraw Hill Tokyo, 1976. 3. C.S. Reddy, **Basic Structural analysis** Tata McGraw Hill, New Delhi, 1996.

1.	Course Code	**CE 306**
2.	Title of the Course	**Structural Mechanics-III**
3.	Credit Structure	L-T- P-Credits 2-0-1-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	Exposure to Structural Mechanics-I and Structural Mechanics-III
6.	Objectives of the course	
7.	Course Syllabus	Matrix formulation of force and displacement methods: Solution of simultaneous equations; Stiffness matrix approach with reference to computer application; generation of 1-dimensional frame element stiffness matrix, flexibility and displacement approaches, Torsional effects; Concept of local effects, generation of load vector, Effects of finite joints; Application to plane frames, space frames, grid structures, Finite Element Method for 2-D plane problems - introduction.
8.	Suggested Books	1. W. Weaver and J.M. Gore, **Matrix Analysis of framed structures. 3rd ed**. Von Nastrand, New York, 1990. 2. J.S. Przemieniecki, **Theory of Matrix Structural Analysis**, Dover, New York, 1968. 3. G.S. Bandit, and S.P. Gupta, **Structural analysis - a Matrix Approach**, Tata McGraw Hill, New Delhi 1994. 4. M.B. Karchi, **Matrix Methods of Structural analysis**, Wiley Eastern, New Delhi, 1993.

1.	Course Code	**CE 307**
2.	Title of the Course	**Design of Structures-I**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Design basis of reinforced concrete structures-slab design; simply supported, continuous and two way - Beam design; rectangular; tee, ell, doubly reinforced, continuous - column; Concentric, eccentric, short and long columns - Footing: simple, combined - staircases - joint detailing.
8.	Suggested Books	1. J. Krishna, and O.P. Jain, **Plain and Reinforcement Concrete - Vol. I & II**, Nemchand Bros, Roorkee, 1968 2. IS-456-1983 **Code of Practice for Plain and Reinforced Concrete**. 3. P.Dayaratnam: **Design of Reinforced Concrete Structures, Third Edition**, Oxford-IBM Publications, New Delhi 1989. 4. S.N. Sinha: **Reinforced Concrete Design**, Tata McGraw Hill New Delhi, 1990.

1.	Course Code	**CE 357**
2.	Title of the Course	**Design Lab-I**
3.	Credit Structure	L-T- P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Design and drawing of continuous or two way slabs; continuous beam; column with a footing; joint details beam-slab; beam-column and column-footing.
8.	Suggested Books	1. J. Krishna, and O.P. Jain, **Plain and Reinforcement Concrete – Vol-I & II**, Nemchand Bros, Roorkee, 1968 2. IS-456-1983 **Code of Practice for Plain and Reinforced Concrete**. 3. P.Dayaratnam: **Design of Reinforced Concrete Structures, Third Edition**, Oxford-IBM Publications, New Delhi 1989. 4. S.N. Sinha: **Reinforced Concrete Design**, Tata McGraw Hill New Delhi, 1990.

1.	Course Code	**CE 308**
2.	Title of the Course	**Design of Structures-II**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Basic of designing steel structures - Rivetted, bolted and welded connections - tension and compression members - built up members - beam design - built up beams - laced and battened columns - welded and rivetted column bases - moment resistant connections - semi rigid connections - design of supports.
8.	Suggested Books	1. A.S. Arya and J.L. Ajmani, **Design of Steel Structures; Nemchand Bros**, Roorkee, 1990. 2. S.M.A. Kazimi and R.S. Jindal, **Design of Steel Structures Prentice Hall (India)**, New Delhi, 1981. 3. S.K. Duggal, **Design of Steel Structures**, Tata McGraw Hill, New Delhi, 1993.

1.	Course Code	**CE 358**
2.	Title of the Course	**Design Lab-II**
3.	Credit Structure	L-T- P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Design and drawing of built-up compression members; plate girder design, design and drawing of laced/battened columns with base plate; moment resistant designs.
8.	Suggested Books	Same as CE 308

Course code	CE 309
Title of the course	**Engineering Geology**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	NA
Scope of the course	Engineering geology is a subject for practical applications of geological knowledge to engineering projects. Engineering geologists provide geological and geotechnical recommendations, analysis, and design associated with various types of structures.
Course Syllabus	Introduction, Origin, Age and development, Interior and composition of the earth, Plate tectonics, Continental drift, Sea floor spreading, Evolution of the Himalaya, Mineralogy, Chemical analysis of rocks and minerals, Rock and soil minerals, Physical properties of minerals, Susceptibility of minerals to alteration, Basics of optical mineralogy, Instrumentation in engineering geology (SEM, SRD), Classification of Rock, Types of rock and origin: Igneous (extrusive and intrusive), Sedimentary and Metamorphic, ternary diagrams, definitions (structure, texture), Igneous Rock Agents, structure, texture, IUGG classification of intrusive and extrusive rocks, Metamorphic Rock Causes of metamorphism (stress, temperature, tectonism, pore fluid), recrystallization, phase change, structure and texture, Sedimentary Rock Sedimentation environments, structure, textural classification of siliclastic and carbonate rock, Structures: Folds, Faults, Joints, Subsurface exploration geologic investigations for site selection of dams, reservoirs, tunnels, bridges and highways, Geologic and seism tectonic setting of India Geologic provinces of India and their surficial and subsurface geology, seismo-tectonics of the Indian plate, seismic zones of India, Geological Hazards Major geological hazards, Geological considerations in design of constructed facilities and infrastructure, causes and classification of landslides, stability assessment for soil and rock slopes, mitigation of landslide hazard, effect of earthquakes on constructed facilities and infrastructure, geotechnical and structural considerations in mitigation of earthquake hazard.
Suggested Books	1. L. G. de Vallejo and M. Ferrer, ***Geological Engineering***, CRC Press (Tayler and Francis), Balkema, 2011, 9780415413527, CAT# SW3524 2. S. Gangopadhyay, ***Engineering Geology,*** Oxford Publication, 2013, 9780198086352 3. A. C. Mclean and C. D. Gribble, ***Geology for Civil Engineers,*** E&FN Spon, 1995, 13, 978-0419160007 4. P. Singh, ***Text Book of Engineering and General Geology***, S.K. Kataria and Sons, New Delhi, 2013, ISBN-13, 978-9350142677

Course code	**CE 359**
Title of the course	**Engineering Geology Laboratory**
Credit Structure	L - T - P - Credits 0-0-3-1.5
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	NA
Scope of the course	To learn geological mapping, interpretation of Geological data and Physical and Mechanical characterization of Minerals and Rocks.
Course Syllabus	Geological Maps, Geological Mapping, outcrops, apparent and true dips, three point problems, depth and thickness problems, joints, faults, Megascopic and Microscopic identification of Minerals and Rocks, Engineering properties of rocks, refraction and resistivity methods, Guided tour through representative geological formations and structures.
Suggested Books	1. M.P. Billings, ***Structural Geology***, PHI Learning Private Ltd., New Delhi, 2010, 8120300590 2. P.K. Mukerjee, ***A Text Book of Geology,*** World Press Pvt. Ltd., Kolkatta, 2013, 8187567546 3. M.S. Krishnan, ***Geology of India and Burma,*** CBS Pub., Delhi, 1999, 8123900120 4. T. Ramamurty, ***Engineering in Rocks for Slopes, Foundations and Tunnels,*** PHI Learning Pvt. Ltd., Delhi, 2014, 9788120348790

1.	Course Code	**CE 310**
2.	Title of the Course	**Transportation Engineering-I**
3.	Credit Structure	L-T- P-Credits 3-0-2-4
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	**Transportation Systems Engineering:** Definition and Objectives of Transportation Systems - Various fields of transportation engineering; Role of transportation in society - economical, social, political and environmental significance; Different modes of travel and their coordination with respect to Indian conditions; Introduction to transportation planning process - planning models and mass transit systems; Terminals - passenger and freight; Transportation demand and supply; Transportation costs; Vehicle motion - resistances, vehicle performance relationships, work, energy and fuel consumption; **Highway Engineering:** Highway planning - basic principles, road development and planning in India; Highway alignment; Geometric design of highways - design of cross-section, horizontal and vertical elements, IRC specifications; **Highway Pavements:** Pavement materials; Requirements and tests on pavement materials; Classification of pavements and design factors; Design of flexible pavements - traffic factors, failure criteria, empirical mechanistic method of design, IRC-CBR design method, Asphalt institute method and AASHTO method; Design of rigid pavements - stresses in plain CC pavements, IRC method of plain CC pavement design, Joints in CC pavement, joint spacing and reinforcement across joints, tie bars and dowel bars; Pavement construction and maintenance; Stabilised roads; Drainage. **Traffic Engineering:** Traffic characteristics; Traffic studies and their use; Traffic control devices; Intersections. **Transportation Engineering Lab:** Laboratory testing of subgrade soils, aggregates, bituminous binders and mixes for their suitability in road construction with reference to BIS; Traffic studies; Pavement evaluation tests.
8.	Suggested Books	1. E.R. Morlok, **An Introduction to Transportation Engineering and Planning**, McGraw Hill International, 1970.

		2. W.W. Hay, **Introduction to Transportation Engineering (2^{nd} Ed)**. John Wiley and Sons, New York, 1988 3. C.S. Papacostas, **Fundamentals of Transportation Engineering**, Prentice Hall of India, New Delhi, 1987 4. B.G. Hutchinson, **Principles of Urban transportation Planning**, McGraw Hill Book Company, 1974. 5. S.K. Khanna, C.E.G. Justo, **Highway Engineering**, Nemchand Bros., Roorkee, 1991 6. P.H. Wright, **Highway Engineering**, John Wiley and Sons, New York, 1996 7. L.R. Kadiyali, **Traffic Engineering and Transportation Planning**. Khanna Publishers, New Delhi, 1987 8. Y.H. Huang, **Pavement analysis and Design. Prentice Hall**, Englewood Cliffs, New Jersey, 1993

Course Code	**CE 401/ CE 601**
Title of the Course	**Mechanics of Advanced Composite Materials and Structures**
Course Category	Core
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Department of Civil Engineering
Pre–requisite, if any	Nil
Course Objective	To understand the mechanics, analysis, and design of composite 2D structural elements.
Course Outcomes	• To be able to apply shear deformation models for analysis of composite structures. • To be able to formulate geometrically nonlinear equilibrium equations of composite structural elements. • To be able to formulate nonlinear code for hygrothermal analysis of composite structural elements.
Course Content	1. Introduction of composites, constituent materials, constitutive relationships for varying stackings, 2. Nonlinear analysis of composite 2D structural elements, 3. Nonlinear hygrothermal analysis, 4. Shear deformation theories for composite structures, 5. Nonlinear numerical analysis of composite structures.
Suggested Books	Textbooks: 1. M. Mukhopadhyay: *Mechanics of Composite Materials and Structures*: Universities Press: 2005: ISBN: 9788173714771 2. R. M Jones: *Mechanics of Composite Materials*: CRC Press: 2018: ISBN: 9781498711067 3. J.N Reddy: *Mechanics of Laminated Composite Plates and Shells*: CRC Press: 2003: ISBN: 9780203502808. 4. A.N. Palazotto and S.T. Dennis: *Nonlinear Analysis of Shell Structures*: AIAA Education Series: 1992: ISBN: 9781600860911. 5. Laszlo P. Kollar and George S. Springer: *Mechanics of Composite Structures*: Cambridge University Press: 2003: ISBN: 9781139439596. Reference Books: 1. Yi-Ming Fu: *Nonlinear Analyses of Laminated Plates and Shells with Damage*, WIT Press: 2013: ISBN: 9781845646905. 2. E. Carrera, F. A. Fazzolari, M. Cinefra: *Thermal Stress*

	Analysis of Composite Beams, Plates and Shells: Computational Modelling and Applications, Academic Press: 2015: ISBN: 9780124200937. 3. M. Amabili: *Nonlinear Vibrations and Stability of Shells and Plates*, Cambridge University Press: 2008: ISBN: 9781139469029. 4. F. Tornabene, M. Bacciocchi, *Anisotropic Doubly Curved Shells Higher-Order Strong and Weak Formulations for Arbitrarily Shaped Shell Structures*, Società Editrice Esculapio: 2019: ISBN: 9788835328995.

1.	Course Code	**CE 402/ CE 602**
2.	Title of the Course	**Water Resources Engineering**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	Exposure of Hydrology
6.	Objectives of the course	
7.	Course Syllabus	Rainfall and runoff, hydrograph analysis, peaks flows. Reservoir planning and operation, run-of the river schemes, storage schemes. Dams and spillways, intakes, water-conductor systems, tunnels, surge-tanks, penstocks and anchor blocks. Hydro-electric power classification and investigations. Turbines, powerhouse, irrigation, crop requirements and yields, water planning. Weirs on permeable foundations. Canals layout, stable channels, and silt control, canal losses and water-logging.
8.	Suggested Books	1. R.K. Linsley and J.L.H. Paulhus, **Water Resources Engineering**, McGraw Hill Book Co., 1992. 2. W.P. Creager and J.D. Justin, **Hydroelectric Handbook**, John Wiley, 1968. 3. Bharat Singh, **Fundamentals of Irrigation Engineering**, Nemchand Bros., Roorkee, 1957. 4. P.N. Modi, **Irrigation water Resources and Water Power Engineering**, Standard Book House, New Delhi, 1990.

1.	Course Code	**CE 404**
2.	Title of the Course	**Design of Structures-III**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Design of RCC water tanks, silos, bunkers and simple bridges - Design of steel roof trusses, steel frames - Design of industrial buildings - Design of residential buildings-Design of arches and shells.
8.	Suggested Books	1. J. Krishna and O.P. Jain, **Plain and Reinforced Concrete, Vol. I and II**, Nemchand Bros. Roorkee, 1968. 2. IS 456, 1978. **Code of Practice for Plain and Reinforced concrete**. 3. **Design Aids for R.C. to IS 456-1978**, ISI-SP-16-sand-T, 1980. 4. S.M.A. Kazimi and R.S. Jindal, **Design of Steel Structures**, Prentice Hall (India), New Delhi,1981. 5. S.K. Duggal, **Design of Steel Structures,** Tata McGraw Hill, New Delhi, 1993. 6. P. Dayaratnam, **Design of Reinforced Concrete Structures**, Third Edition, Oxford - IBM Publishing Co, New Delhi, 1989. 7. S.N. Sinha, **Reinforced Concrete Design**, Tata McGraw Hill, New Delhi, 1990.

1.	Course Code	**CE 406**
2.	Title of the Course	**Transportation Engineering-II**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	Exposure to Transportation Engineering-II
6.	Objectives of the course	
7.	Course Syllabus	**Airport Planning and Design:** Aircraft characteristics related to airport design; Airport configuration - runway configurations, relation of terminal area to runways, runway orientation; Geometric design of the airfield - ICAO and FAA design standards, runways, taxiways, holding aprons and aprons; Planning and design of the terminal area - apron-gate system, size and number of gates, aircraft parking configurations, the passenger terminal system; airport lighting and marking; air traffic control; airport planning and air travel demand forecasting; Structural design of airfield pavements. **Railway Engineering:** Indian Railway Track - different gauges, cross sections, coning of wheels; Tractive resistances; Track components - rails, rail failures, sleepers, rail fixtures and fastenings and ballast; Geometric design of the track; Points and crossings Track junctions; Stations and yards; Signalling and interlocking; Track stresses; Track construction and maintenance.
8.	Suggested Books	1. R. Horonjeff, F.X. Mckelvey, **Planning & Design of airports**, Mc Graw Hill, New York, 1994 2. S.K. Khanna, M.G. Arora, S.S. Jain, **Airport Planning and Design**, Nemchand Bros., Roorkee, 1994 3. N. Ashford, P.H. Wright, **Airport engineering**, John Wiley, New York, 1979 4. S.C. Sexena, S.P. Arora, **A text Book of Railway Engineering**, Dhanpat Rai & Sons, New Delhi, 1990 5. J.S. Mundary, **Railway Track Engineering**, Tata McGraw Hill, New Delhi. 6. M.M. Agarwal, **Indian Railway Track,** Sachdeva Press, Mayapuri, New Delhi, 1991 7. W.W. Hay, **Railroad Engineering**, John Wiley and Sons, New York, 1988 8. S.K. Khanna, C.E.G. Justo, **Highway Material Testing** - a Laboratory Relevant IRC and BIS standards, 1991.

1.	Course Code	**CE 408**
2.	Title of the Course	**Foundation Engineering**
3.	Credit Structure	L-T- P-Credits 2-0-2-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Explorations, sampling geophysical investigations. Bearing capacity, settlement. Design of footings and rafts. Foundations subjected to eccentric loads and moments. Footings on slopes. Contact pressure distributions. Subgrade modulus. Earth pressure theories. Pile Foundations, driving stresses, load tests, pile groups, pile caps, lateral loads. Bridge foundations caissons, coffer dams. Excavation; and dewatering for foundations. Failures and strengthening. Foundations on weak soils, reclaimed areas, swelling soils etc. Machine foundations.
8.	Suggested Books	1 R.B. Peck W.E. Hanson and T.H. Thornburn, **Foundation Engineering**, John Wiley, 1963. 2 Gopal Ranjan and A.S.R. Rao, **Basic and Applied soil Mechanics**, Wiley Eastern, 1991. 3 V.N.S. Murthy, **Soil Mechanics and Foundation Engineering,** Vol-II, Saikripa Technical Consultants, Bangalore, 1991. 4 M.R. Hausmann, **Engineering Principles of Ground Modification**, McGraw Hill International Edition, 1990.

1.	Course Code	**CE 410/ CE 610**
2.	Title of the Course	**Offshore engineering**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Linear theory of waves, brief description of higher order wave theories, random waves, probability theories. Morison? equation, wave forces on fixed and floating structures and fluid structure interaction. Soil exploration beneath seabed, criteria of foundation design in offshore environment, pile behaviour under cyclic lateral loading, development of p-y curves. Analysis of piles and foundations of gravity platforms, soil liquefaction under cyclic stresses. Various types of offshore structures and evaluation of their environmental loads. Structural idealization and analysis of forces due to wind, waves and for linear static behaviour. Wave force on inclined members, analysis of joints in offshore structures, stress concentration and fatigue life prediction. Elementary aspects of dynamic analysis and response.
8.	Suggested Books	1 T. Sarapkaya and M. Isaacson, **Mechanics of Wave Forces on Offshore Structures**, Van Nostrand, Reinhold Co., N.Y., 1981. 2 C.A. Brebbla and S. Walker, **Dynamic analysis of Offshore Structures**, Newnes Butterworth, London, 1979.

Course code	**CE 412/ CE 612**
Title of the course	**Sustainable Construction**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Basic understanding of Building Materials and Building Construction
Scope of the course	This course aims to expose the students to the environmental challenges associated with the construction industry, and their management through the use of sustainable construction practices. This course will cover the use of alternate/green materials and the benefits associated with it. Students will also be exposed to emerging concepts like Life Cycle Assessment, Circular Economy, and Building Information Modelling. It is expected by the end of this course students will be able to understand and appreciate the concept of Sustainability in Construction Practices.
Course Syllabus	Sustainability in Construction: Concept of sustainability in construction, Carbon footprint, Embodied energy, Resource Management, Zero waste, 3R concept in construction Waste Utilization in Construction: Circular Economy, Value addition, local materials, Supplementary Cementitious Materials, Blended Cements, Recycled Aggregates, Refuse Derived Fuel Building Products: Fly Ash Bricks, Hollow Blocks, Precast Walls, Products for modular construction Biomaterials: Bamboo, Straw Bale, Bio Cementing, Plant-based Natural Fibers, Durability of Bio-Based Building Materials Green Building Design: Introduction to Green Building, Low Energy/ Energy Efficient Building Units, Landscape Management, Building Information Modelling (BIM) Assessment Methods: Life Cycle Assessment (LCA), Leadership in Energy & Environmental Design (LEED), Green Rating for Integrated Habitat Assessment (GRIHA).
Suggested Books	1. C. J. Kibert, ***Sustainable Construction, Green Building Design and Delivery****,* John Wiley & Sons, Inc, New Jersey, 2016, 9781119055174. 2. F. Dodds, L. Beg, K. Hardcastle, M. Campbell, R. Fairclough and T. Callanan, ***Eco-efficient construction and building materials,*** Woodhead Publishing India Private Limited, New Delhi, 2014,9780857097675 3. G. M. Sabnis, ***Green Building with Concrete, Sustainable Design and Construction,*** CRC Press, Florida, 2015, 9781498704113 4. BIS, ***Coarse and Fine Aggregate for Concrete,*** *Specification,* Bureau of Indian Standards, New Delhi, 2016

Course Code	**CE 414/ CE 614**
Title of the Course	**Design of Short and Medium Span Bridges**
Credit Structure	L-T-P- Credits 2-1-0-3
Name of theConcerned Discipline	Civil Engineering
Pre–requisite, ifany	Design of concrete structures and design of steel structures
Objectives of the course	To provide the students a thorough understanding on the analysis and design of different types of short and medium span bridges.
Course Syllabus	• Introduction-Definition, components of a bridge, classification of bridges, selection of site, and economical span. Standard specifications for road and railways bridges, width of carriage way, clearances, types of bridges and their suitability, Indian Road Congress (IRC) loading, Indian Railway Standard (IRS) Loads and permissible stresses. • Design of RCC and PSC slab culvert bridges. • Design of RCC and PSC T-beam bridges. • Design of single span steel truss bridges and plate girder bridges. • Design of bearings, pier and pier cap.
Suggested Books	**Text Books:** • D. J. Victor, **Essentials of Bridge Engineering**, 6th Edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2008 • N. K. Raju, **Design of Bridges,** 3rd Edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2006 • N. Rajgopal, **Bridge Superstructure,** Narosa Publishing House,New Delhi, 2006 • V. K. Raina, **Concrete bridge Practice, Analysis: Design and Economics**, TMH, 2002 **Reference Books:** • E. Ellobody, **Finite Element Analysis and Design of Steel and Steel–Concrete Composite Bridges**, Elsevier Science, 2014, • J. Romo, **High-speed Railway Bridges - Concept Design Guideline**, Wiley, 2023. • H. Xia, N. Zhang, W. Guo, **Dynamic Interaction of Train-Bridge Systems in High-Speed Railways - Theory and Applications**, Springer Berlin Heidelberg, 2017.

Course Code	**CE 618/ CE 418**
Title of the Course	**Disaster Management**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre–requisite, if any	None
Objectives of the course	To understand different types of disaster, their forecasting, prevention and mitigation methods. The course is intended to create scientific awareness amongst graduates.
Course Syllabus	Terminology-Disaster;Hazard;Vulnnerability;Risk;disaster management. Types, Causes and Consequences- Geological, hydro-meteorological, biological, technological, anthropogenic, climate change and urban disasters. Disaster management cycle- pre-disaster (risk assessment, mapping, zonation, prevention and mitigation, early warning, preparedness, awareness); during disaster (evacuation, communication, search and rescue, command system, relief and rehabilitation); post disaster (damage and needs assessment, restoration, recovery, reconstruction, hyogo framework). Disaster Management in India – Disaster profile, disaster management act, national policy, national guidelines, role of government, role of agencies. Applications of Science and Technology- GIS, GPS, RS; Early warnings and communication; Planning and development; disaster safe designs; Institutions In India.
Suggested Books	1. Coppola D P, 2007. ***Introduction to International Disaster Management***, Elsevier Science (B/H), London. 2. ***An overview on natural & man-made disasters and their reduction***, R K Bhandani, CSIR, New Delhi 3. ***Manual on natural disaster management in India***, M C Gupta, NIDM, New Delhi 4. ***Encyclopedia of disaster management, Vol I, II and IIIL Disaster management policy and administration***, S L Goyal, Deep & Deep, New Delhi, 2006 5. ***Disasters in India Studies of grim reality***, Anu Kapur & others, 2005, 283 pages, Rawat Publishers, Jaipur 6. ***Natural Disasters***, David Alexander, Kluwer Academic London, 1999, 632 pages 7. ***High Power Committee Report***, 2001, J.C. Pant 8. ***World Disasters Report***, 2009. International Federation of Red Cross and Red Crescent, Switzerland 9. ***Encyclopedia of Disasters – Environmental Catastrophes and Human Tragedies***, Vol. 1 & 2, Angus M. Gunn, Greenwood Press, 2008 10. ***Disaster Management Act 2005***, Publisher by Govt. of India 11. ***Management of Natural Disasters in developing countries***, H.N. Srivastava & G.D. Gupta, Daya Publishers, Delhi, 2006, 201 pages 12. Publications of National Disaster Management Authority (NDMA) on Various Templates and Guidelines for Disaster Management

1.	Course Code	**CE 422**
2.	Title of the Course	**Hydraulic Structures**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Detailed stress analysis of gravity dam, stress concentration around openings. Principles of design of outlets and galleries. Design of pen stocks and anchor blocks. Detailed design of high head and spillway gates. Analysis and design of surge chambers. Design of locks and jetties. Design of beams on elastic foundations as applied to dock floors
8.	Suggested Books	1 W.P. Creager, J.D. Justin and J. Hinds, **Engineering for Dams, Vol. II and III** Wiley, 1968. 2 D. Quinn, **Design and Construction of Ports and Marine Structures**, McGraw Hill,1973. 3 C.V. Davis, **Handbook of Applied Hydraulics**, McGraw Hill, New York, 1993. 4 **U.S. Deptt. Of Interior Design of Small Dams**, U.S. Govt. Printing Press, Washington DC 1975.

1.	Course Code	**CE 424**
2.	Title of the Course	**Ground Water Hydrology**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Occurance of groundwater aquifer types. Exploration of groundwater. Groundwater budget. Resistivity methods. Darcy’s law and its limitations. Formulation of governing equations for groundwater movement. Flow nets and its uses. Hydraulics of flow towards wells. Aquifer unsteady flow. Theis, Jacob and Chow”s methods multiple well system. Artificial recharge. Infiltration. Mechanics of recharge, stream aquifer interaction. Water logging. Theory of subsurface drainage. Seawater intrusion and its control, Approximate solution. Digital, Analog and Simple finite difference models for groundwater flow. Groundwater quality, Groundwater development and management.
8.	Suggested Books	1 H.M. Raghunath, **Groundwater, 2nd Edition** Wiley Eastern Ltd., 1987. 2 D.K. Todd, **Groundwater Hydrology**, John Wiley and Sons, 1980. 3 D.B. McWhorteer, D.K. Sundada, **Ground-Water Hydrology and Hydraulics**, Water Resources Publications, Fort Collins Colorado, U.S.A. 1977. 4 C.W. Fetter, **Applied Hydrogeology, 2nd Edition**, CBS Publishers and Distributors, New Delhi, 1990.

1.	Course Code	**CE 426**
2.	Title of the Course	**Water Resources System**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Objective of water resources development, economic analysis and discounting techniques, conditions of project optimality, graphic optimization techniques for multipurpose projects, analytical optimization techniques for water resources projected by linear programming, non-linear programming and dynamic programming, optimization by simulation, mathematical models for large scale multipurpose projects, different case studies, stochastic optimization techniques, water quality subsystems, optimum operation model for reservoir systems by incremental dynamic programming, sequencing of multipurpose project.
8.	Suggested Books	1. M. Arthur, **Design of Water Resources Systems**, MacMillan, 1962. 2. L.D. James, R. R. Leo, **Economics of Water Resources Planning**, McGraw Hill, New York, 1971. 3. W.A. Hall, J.A. Dracup, **Water Resources Systems Engineering**, McGraw Hill, New York, 1970.

Course Code	**CE 428/ CE 628**
Title of the Course	**Theory of Plates and Shells**
Course Category	Departmental Elective
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Department of Civil Engineering
Pre–requisite, if any	Nil
Course Objective	To understand the basic concept, mathematical modeling, behavior and analysis of plate and shell structures.
Course Outcomes	• To be able to compute stresses and strains on thin plates and shells. • To be able to formulate the buckling loads of plates and shells. • To be able to formulation finite element code for solution of plate and shell equations.
Course Content	1. Thin plates and shells - Kirchoff theory, strains and stresses, constitutive relations, equilibrium equations, buckling, and numerical solutions. 2. Thick plates and shells - Reissner-Mindlin-Naghadi theories, shear correction factors, equilibrium equations, buckling, and numerical solutions. 3. Membrane and bending theories; shallow shell theory; equilibrium equations for simple shell forms considering membrane. 4. Finite Element formulations of plate and shell elements.
Suggested Books	Textbooks: 1. S.P Timoshenko and S.W. Krieger: *Theory of Plates and Shells*, Tata McGraw-Hill Edition: 2010: 9780070701250 2. J.N Reddy: *Theory and Analysis of Elastic Plates and Shells*, CRC Press: 2006: 9780849384165 3. G.S Ramaswamy: *Design and Construction of Concrete Shell Roofs*, CBS Publishers and Distributors Pvt. Ltd: 2005: 9788123909905 4. Robert Millard Jones: *Buckling of Bars, Plates, and Shells*, Bull Ridge Publishing: 2006: ISBN: 9780978722302. Reference Books: 1. M. Reza Eslami: *Buckling and Postbuckling of Beams, Plates, and Shells*, Springer International Publishing: 2017: ISBN: 9783319623689. 2. E. Carrera, S. Brischetto, P. Nali: *Plates and Shells for Smart Structures - Classical and Advanced Theories for Modeling and Analysis*, Wiley: 2011: ISBN: 9781119951124.

	3. M. S. Qatu: Vibration of Laminated Shells and Plates, Elsevier Science: 2004: ISBN: 9780080474762.

Course Code	**CE 430/ CE 430**
Title of the Course	**Elastic Stability**
Course Category	Departmental Elective
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Department of Civil Engineering
Pre–requisite, if any	NIL
Course Objective	To understand different states of structural stability and solution approaches for the critical loads
Course Outcomes	• To be able to compute bifurcation points on the equilibrium path. • To be able to calculate buckling loads of beam-column, truss, frame, and plates. • To be able to solve stability equations using different numerical approaches.
Course Content	1. Definition, bifurcation of equilibrium, types of buckling, 2. Stability analysis of structural problems - beam-column, truss, plates and frames. 3. Approximate methods - Rayleigh, Timoshenko, and Ritz methods. 4. Numerical approaches to solve the non-linear stability problems.
Suggested Books	Textbooks: 1. NGR Iyengar: *Elastic Stability of Structural Elements*: Macmillan India: 2007: ISBN: 9780230631861 2. S.P. Timoshenko, J.M. Gere: *Theory of Elastic Stability*: Dover Publications: 2012: ISBN: 9780486134802 3. A. Kumar: Stability of Structures: McGraw-Hill Education: 1998: ISBN: 978-0074515167. 4. George J. Simitses: *An Introduction to the Elastic Stability of Structures*: Krieger Publishing Company: 1986: ISBN: 978-0898749144 Reference Books: 1. D. Bushnell: *Computerized Buckling Analysis of Shells*, Springer Netherlands: 2012: ISBN: 9789400950634. 2. S. Jerath: *Structural Stability Theory and Practice Buckling of Columns, Beams, Plates, and Shells*, Wiley: 2020: ISBN: 9781119694496. 3. M. Pignataro, N. Rizzi, A. Luongo: *Stability, Bifurcation and Postcritical Behaviour of Elastic Structures*, Elsevier Science: 2013: ISBN: 9781483290836. 4. G. Simitses, D. H Hodges, *Fundamentals of Structural Stability*, Elsevier Science: 2006: ISBN: 9780750678759.

1.	Course Code	**CE 432/ CE 632**
2.	Title of the Course	**Plastic Analysis and Design**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Yield conditions and concepts of simple plastic collapse, collapse criterion, virtual work in elasto-plastic state, theorems of plastic collapse, methods of analysis and design. Graphical method, method of combining mechanisms, computer aided elasto-plastic analysis, interaction diagrams, applications to planar and space structures – multi-bay frames,, multistoried frames, grids, arches, virendeel girders, deflection at collapse, incremental collapse, minimum weight analysis, variable repeated loads, shakedown analysis, combined stress problems.
8.	Suggested Books	1 J. Heyman, **Beams and Framed Structues**, Second ed., Pergmon Press, Oxford. 2 B.G. Neal, **Plastic Methods of Structural analysis**, Chapman and Hall. 3 M.R. Horne, **Plastic theory of structures**, 2nd Ed., Pergamon Press, 1979. 4 H.B. Harrison, **Structural analysis and Design**, 2ndf Ed., Pergman Press. 5 P.G. Hodge, (Jr.), **Plastic Analysis of Structures**, McGraw Hill. 6 J.A. Koing, **Shakedown of Elastic-Plastic Structures**, Elsevier, 1987. 7 A.A. Cyras, **Mathematical Models for the analysis and Optimization of Elasto Plastic Structures**, Ellis Horwood Ltd., 1983. 8 J. Baker and J. Heyman, **Plastic Design of Frames**, Cambridge University Press, 1969. 9 B.P.Parikh, J.H. Daniels and L. Lu, **Plastic Design of Multi-story frames Design aids**, Lehigh University, Bethlhem Pennsylvania.

Course code	**CE 434/ CE 634**
Title of the course	**Numerical Methods in Civil Engineering**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	NA
Scope of the course	This course is designed for mainly engineering students to enhance their numerical techniques. In engineering, many complex problems do not have explicit analytical solutions, and in these cases, numerical techniques are extremely beneficial. In addition to providing basic numerical strategies, this course introduces some advanced concepts for solving non-linear differential and integral equations, which are expected to be helpful in B Tech, M Tech, and Ph.D. thesis works.
Course Syllabus	Computer applications in Civil Engineering, typical problem categories, techniques for linear problems, techniques for nonlinear problems. Iterative solutions for linear and non linear systems. Algorithms in time domain using Runge - Kutta methods. Newmark B-method and finite-difference approaches, concept of stability of algorithm, propagation of errors in different algorithms. Numerical Differentiation, Difference operators (forward, backward and central difference). Stability and accuracy of solutions. Application of finite difference operators to solve initial and boundary value problems. Numerical solutions of integral equations, Types of integral equations. Fredholm integral equations of the first and second kind. Fredholm_s Alternative theorem. Collocation and Galerkin methods for solving integral equations. Use of commercial software for Civil Engineering Problems
Suggested Books	1. A. Jennujs, ***Matrix computations for Engineers and Scientists***, John Wiley & Sons, Rumford, ME, USA, 1977, 978-0471994213 2. S.D. Conte and C-de Boor, ***Elementary Numerical Analysis***, **An algorithmic approach**, McGraw Hill, New York, USA , 1980 , 978-0070662285 3. G. Dahlquist and Å. Bjorck, ***Numerical Methods***, Dover Books, NY, USA , 2003 , 978-0486428079 4. S.Guha and R. Srivastava, ***Numerical Methods,*** *O*xford University Press, 2010, 019-569348-5

1.	Course Code	**CE 436**
2.	Title of the Course	**Finite Element Analysis**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Principles of discretization; Element stiffness mass formulation based on direct, variational and weighted residual techniques and displacements, hybrid stress and mixed approaches, shape functions and numerical integrations, convergence; displacement formulations for rectangular, triangular and isoparametric elements for two dimensional and axisymmetric stress analysis; thin and thick plates and shells; Semi-analytical formulations; Three dimensional elements and degenerated forms; Stiffener elements and modifications such as use of different coordinate systems, use of nonconforming modes and penalty functions; Application to layered composite plate/ shells, bridge, roof, nuclear and offshore structures; Hybrid stress and mixed formulations for plates.
8.	Suggested Books	1. O.C. Zienkiewicz, **The Finite Element Method**, Tata McGraw Hill, 1977.

1.	Course Code	**CE 438**
2.	Title of the Course	**Probabilistic and Statistical Methods in Civil Engineering**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Role of probability in Civil Engineering; Random events, Random variables; functions of random variables; moments and expectations; Common probabilistic models - normal, lognormal, Poisson, extremal; estimation of parameters; goodness of fit tests; regression and correlation analyses, Introduction to structural reliability; FORM; elements of quality assurance and acceptance sampling.
8.	Suggested Books	1. H.S. Ang and W.H. Tang, **Probability Concepts in Engineering Planning and Design**, John Wiley, 1975. 2. J.R. Benjamin and C.A. Cornell, **Probability Statistics and Decision for Civil Engineers**, McGraw Hill, 1975. 3. R. Ranganathan, **Reliability Analysis and Design of Structures**, Tata McGraw Hill, New Delhi, 1990.

1.	Course Code	**CE 442**
2.	Title of the Course	**Machine Foundations**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Principles of SHM, forced and damped vibrations in soil media. Tests for evaluation of dynamic coefficients. Design of simple foundations for turbo-generators, reciprocating engines of horizontal and vertical type, forge hammer etc. Machine foundation on sands and clays.
8.	Suggested Books	1. D.D. Barkan, **Dynamics of Bases and Foundations,** McGraw Hill, 1962. 2. W.T. Thompson, **Mechanical Vibrations**, George Allen Unwin Ltd. 3. S.P. Timoshenko et. al. **Vibration Problems in Engineering**, John Wiley.

Course code	**CE 444/ CE 644**
Title of the course	**Solid Waste Engineering and Management**
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department	Civil Engineering
Pre-requisite if any	NA
Scope of the course	This course aims to impart knowledge regarding various elements of waste management, including Municipal and Industrial sources highlighting the related engineering principles, processes, and treatment.
Course Outcomes	Understanding the impact of professional engineering solutions in societal and environmental contexts and demonstrating the knowledge of and need for sustainable development.
Course Syllabus	1. **ntroduction to Solid Waste Management**: Definitions; Classification of Wastes; Different waste streams and their sources; Waste generation rates and its Quantification; Waste Composition; Solid waste management system in India. 2. **olid Waste Management Strategies & Technologies**: Concept of 3R’s, Municipal Solid Waste Management functional system, Biological Treatment (Anaerobic digestion, Composting), Thermal Treatment (Pyrolysis, Incineration), Refused derived fuels, Sanitary Landfilling; Lifecycle Assessment approach in Solid Waste Management Systems. 3. **ngineering Aspects of Solid Waste Management**: Concept of Circular Economy, Appropriate Waste Processing Technology Selection techniques, Sampling and Physico-chemical characterization of Solid Wastes; Design of Reactors/Engineering systems for treatment of Organic waste streams viz composting, biomethanation, RDF and Gasification, Kinetics of organic waste degradation, Site Selection for landfills, Design aspects of Sanitary Engineered landfills. 4. **egislations for Solid Waste Management**: Salient features of Indian Legislations on management and handling of different waste streams, Overview of various Government Initiatives including Swachh Bharat Mission, GOBAR-dhan (Galvanizing Organic Bio-Agro Resources) Scheme, Jal Shakti Abhiyaan,

	Waste to Energy. 5. **ractical Demonstrations**: Real-time practical demonstration of solid waste sampling techniques, Characterization, and Treatment of solid waste. 6. **ite Visits:** Case studies of different cities of India, Visiting Operational Waste to Energy plants/Biogas plants/Composting plants/ Waste Recycling plants/Sanitary Landfill sites.
Suggested Books	**Textbooks:** • Tchobanoglous, G., Theisen, H., & Vigil, S. A.: Integrated Solid Waste Management: Engineering Principles and Management Issues: McGraw-Hill Education: New York, USA: 2019: 9781259848789 **Reference Books:** • Kumar, S.: Municipal Solid Waste Management in Developing Countries: CRC Press: New Delhi, India: 2020: ISBN-13: 978-0367574284.

1.	Course Code	**CE 448**
2.	Title of the Course	**Prestressed Concrete Design**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Pre-stressing concepts, materials, systems of prestressing and losses. Introduction to working stress method, limit state analysis and design of members for bending. Shear torsion and axial forces. End block design. Deflections, use of relevant codes of practice.
8.	Suggested Books	1. T.Y. Lin, **Design of Prestressed Concrete Structures**, Asia Publishing House, 1955. 2. N.Krishnaraju, **Prestressed Concrete**, Tata McGraw Hill, New Delhi, 1981. 3. Y. Guyan, **Limit State Design of Prestressed Concrete**, Applied Science Publishers, 1972.

Course Code	**CE 648/ CE 448**
Title of the Course	**Prestressed Concrete Design**
Course Category	Core
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Department of Civil Engineering
Pre–requisite, if any	Nil
Course Objective	To study the effect of initial stresses in the concrete for structural engineering applications.
Course Outcomes	• Learning of initial stress effect into the concrete • Stress and strain behavior of Prestressed concrete • Design of prestressed structural elements
Course Content	1. Introduction of prestressing, Materials required Prestressing systems and methods of prestressing, Analysis of prestressed concrete sections, and prestress losses. 2. Prestressed concrete slabs, beams, tank, and pipes, Prediction of long-term deflections due to creep and shrinkage, use of relevant codes of practice, 3. Partial prestressing, Methods of achieving partial prestressing, Merits and demerits of partial prestressing.
Suggested Books	Textbook 1. Prestressed Concrete by N. Krishna Raju, 2018, Edition: 6th Publisher: McGraw Hill Education. ISBN: 978-9387886209 2. Design Of Prestressed Concrete by H. Nilson 1987, Edition: 2nd Publisher: John Wiley & Sons, ISBN: 978-0471830726 Reference Book 3. Design of Prestressed Concrete Structures by Tung-Yen Lin, 2010 Edition: 3rd, Publisher: John Wiley & Sons, ISBN: 978-9812531179

1.	Course Code	**CE 462/ CE 662**
2.	Title of the Course	**Structural Dynamics**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	SDOF System - Equation of Motion; Generalized SDOF system; Free Vibration; Harmonic Load; Periodic Load; Impulse Load; General Loads (Time and Frequency Domain analysis); Introduction of Nonlinear analysis; Seismic analysis. MDOF Systems - Systems - Property matrices; Undamped Free Vibration; Mode Superposition Techniques ; Practical Free-Vibration Analysis; Buildings; Seismic analysis; Code Provision.
8.	Suggested Books	1. R.W. Clough, J. Penzlen, **Dynamics of Structures (2nd Ed.)**, McGraw Hill, 2nd ed. 1993. 2. M. Paz, **Structural Dynamics: Theory and Computation**, Van Nostrand, 1985. 3. IS: 1893-1984, **Criteria for Earthquake Resistant Design of Structures**.

1.	Course Code	**CE 464/ CE 664**
2.	Title of the Course	**Advanced Solid Mechanics**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	Exposure to Solid Mechanics
6.	Objectives of the course	
7.	Course Syllabus	Introduction to elasticity theory; Simple 2D/3D problems and their solutions; Pure bending of beams with unsymmetrical section; Shear Center; Thermal stresses; Torsion of noncircular members; Curved Beams; Beams on elastic foundation; Plasticity; failure theories; Energy methods; Thermal stresses; Introduction to viscoplasticity and viscoplasticity; Numerical methods; Coupled axial force and bending moment problems; coupled torsion and bending moment problems.
8.	Suggested Books	1. A.P. Boresi and O.M. Sidebottom, **Advanced Mechanics of Materials**, Fifth Edition, Wiley, Singapore, 1992. 2. S.P. Timoshenko-**Strength of Materials Vol. 2 (3rd** Edition) CBS Publishers Delhi, 1991.

1.	Course Code	**CE 470**
2.	Title of the Course	**Transportation Planning**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Development objectives and goals, five year plans, levels of planning (urban and regional), regional planning and development theories and techniques, types and delineation of regions. Human settlement patterns. Role of transport in national development. Social, economic and political functions. Transport system and its subsystems. Transport modes and technologies. Family of modes; vehicles, travel ways, stops, stations and garages, operational performance, cost, energy, present and future roles. Road transport, rail transport, air transport, water transport new and future modes. Transport economics, theories, techniques, costs and benefits. Transport systems planning. Travel demand forecasting methods and models. Intermodel mix network optimization theories and techniques. Decision making. Transport and energy type and quantity of energy, efficiency, constrains, transport and environment transport management (policy, organisation, legal provisions), integration and coordination, information systems, data base.
8.	Suggested Books	1. Prakash Rao and Sundaram, **Regional Development Planning in India**, Vikas Publishing House, 1974. 2. B.G. Hutchinson, **Introduction to Urban Transportation Systems Planning**, McGraw Hill, 1974. 3. Vukan R. Vuchic, **Urban Public Transportation Systems and Technology**, Prentice Hall Inc., N.J., 1981. 4. G.E. Gray and L.A. Hoel, **Public transportation Planning Operations and Management**, Prentice Hall Inc., N.J., 1979.

Course Code	**CE 674/ CE 474**
Title of the Course	**Road Safety**
Credit Structure	L-T-P-Credit 2-0-2-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any (for the students)	None
Course Objective	The course is designed to provide an overview on road safety of engineering and behavioural aspects. Through his course students will gain basic understanding of the road environment, road safety issues, role of human errors (road users) and the application of this knowledge, knowledge concerning the causes, analysis and consequences of accidents, road safety measures and audit.
Course Syllabus	*Introduction to Road Safety Engineering:* accidents, causes of crash, characteristics and type of road crashes, road safety issues, road safety scenario of India, factors contributing to road accidents, contribution and consequences of speeding; *Driver Cognition and Automotive User-Experience:* situation awareness, distracted driving, fatigue, stress, in-vehicle and out-vehicle information processing, human-machine collaborations for automated driving, road rage & aggressive driving, aging & driving, emergency Response Support, drugs & alcohol; *Accident Data Collection & Management; Crash Investigation & Analysis; Accident Remedial Schemes:* process, detailed site analysis, measuring the effectiveness of accident remedial schemes; *Road Safety Measures and Culture:* road alignments, road sign and pavements markings, street lighting and traffic signal, pedestrian facilities, training, education, awareness of traffic rules, rehabilitation, law-enforcement; Road Safety Audit (RSA).

Suggested Books	5. B. E. Porter (2011). ***Handbook of Traffic Psychology***, Elsevier Science Academic Press. ISBN: 9780123819857, 0123819857. 6. D. Shinar (2017). ***Traffic Safety and Human Behavior***, Emerald Publishing Limited. ISBN: 9781786352217, 1786352214. 7. E. Rune, H. Alena, V. Truls (2009) ***The Handbook of Road Safety Measures*** by Emerald Group Publishing, 2nd Edition. 8. Highway safety manual (2010). American Association of State Highway and Transportation Officials: Washington, DC, USA. 9. IRC:SP:88 (2010). Manual on road Safety Audit, Indian Roads Congress New Delhi, India: IRC. 10. M. Belcher, P. Steve, P. Cook (2008). ***Practical Road Safety Auditing*** by Thomas Telford Publishing. 11. M. O. Haque (2008). ***Road Safety: Data Collection, Analysis, Monitoring, And Countermeasure Evaluations With Cases***, University Press of America. 12. Walsh, I. D. (2011). ***ICE manual of highway design and management***. ICE Publishing

1.	Course Code	**CE 480**
2.	Title of the Course	**Computer Aided Design of Civil Engineering Systems**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Essential features in a design software, User-machine interface, Computer graphics - coordinate systems and transformations, automatic generation of input-mapping techniques, display of response quickness, Use of object oriented programming. Software for various design tasks, Heuristic approaches in Civil Engineering. Tools for developing programmes involving heuristic search Expert system shells and object oriented languages, Rule based systems, Neural networks.
8.	Suggested Books	1. Newman W.M., and Sproull, R.F. **Principles of Interactive Computer Graphics**, McGraw Hill, N.Y. 1988. 2. Adeli H., **Interactive Microcomputer-aided structural steel design**, A New Generation, Prentice Hall, N.J., 1990. 3. Adeli H., and Balasubramanyam, K.V., **Expert Systems for Structural Design**, Prentice Hall, N.J., 1991. 4. Schildt H., Using C++, Borland-Osborne/ McGraw Hill, 1991.

1.	Course Code	**CE 482**
2.	Title of the Course	**Construction Management**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Basic of construction industry organization structure. Engineering economy in construction projects-personnel, monitoring and control work study in constructions - contracting. Bidding and law for engineers-value engineering, safety engineering etc.
8.	Suggested Books	1. A. Balters, **Network for Planning and Scheduling**, McGraw Hill Co., London, 1975. 2. R.L. Peurifoy, **Constructions Planning Equipments and Materials**, McGraw Hill Co., 1975. 3. J.L. Reggs. **Engineering Economics**, McGraw Hill Co., 1976. 4. L.D. Miles, **Techniques of Value analysis and Engineering**, McGraw Hill co., 1970.

Course Code	**CE 484/ CE 684**
Title of the Course	**Advanced Concrete Technology**
Credit Structure	L-T- P-Credits 2-0-2-3
Name of the Concerned Department	Civil Engineering
Pre–requisite, if any	Basic knowledge of Building Materials and Concrete
Scope of the course	This course aims to develop the understanding of properties, advances and findings in the field of multifunctional concretes, focusing on the principles, design and fabrication, test and characterization, performance and mechanism, and their applications in infrastructures. It's designed to discuss the challenges in the development and application of multifunctional concretes, providing useful theory, ideas and principles.
Course Syllabus	**<u>Durability of Concrete</u>:** Early-age and the long-term performance of concrete, including issues such as its ability to be placed and compacted, properties and performance characteristics, structural movements, strength development, fire resistance and durability performance. **<u>Testing, Quality Assurance, Repair and Maintenance of Concrete</u>:** Quality concepts and quality control of concretes, and test methods used both in laboratories and on site for measuring physical and chemical properties of concrete in fresh and hardened states. **Multifunctional <u>Concrete Production</u>:** Types of concretes that can be used for different applications. Concepts for self-compacting concrete, functionally graded concrete, self-healing concrete, 3-D printed concrete, high performance concrete, fibre reinforced concrete, geopolymer concrete.
Suggested Books	1. Zongjin Li , ***Advanced Concrete Technology*,** John Wiley and Sons, 2011, 9780470437438 2. Mark Alexander, Arnon Bentur and Sidney Mindess, ***Durability of Concrete: Design and Construction***, CRC Press, 2011, 9781138746749 3. John Newman and B S Choo ***Advanced Concrete Technology 4*,** Butterworth-Heinemann, 2003, 9780080489995

1.	Course Code	**CE 486**
2.	Title of the Course	**Rock Mechanics and Tunnelling Technology**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Engineering properties of rocks, Surface and sub-surface investigation in rock including geophysical studies, Weathering of rocks, Discontinuities, Field and laboratory testing of rocks and rock masses, Stress-strain characteristics, Deformability of rocks, Friction and Shear strength, Slope stability, effect of water, analysis and design of tunnels, Blasting, Bolting, Tunnelling techniques, Application numerical techniques.
8.	Suggested Books	1. R.E. Goodman, **Introduction to Rock Mechanics**, John Wiley and Sons, New York, 1989. 2. JACGER, Charles, **Rock Mechanics and Engineering**, Cambridge University Press, London, 1972. 3. Megaw, T.M. and J.V. Bartlett, Tunnels: **Planning, Design, Construction, International Edition,** Ellis Horwood Limited, John Wiley and sons, New York, 1983.

1.	Course Code	**CE 488**
2.	Title of the Course	**Environmental Geotechnics**
3.	Credit Structure	L-T- P-Credits 2-0-2-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Hazardous wastes, Physical, Chemical and Mineralogical characterization, Geoenvironmental hazards: Natural and man made, Recycle and Reuse of Industrial waste(s). Role of Geotechnical engineering in environmental protection, Surface and subsurface contamination, Characterization of contaminated ground, Geoenvironmental site investigation and site assessment technologies.
8.	Suggested Books	1. Y.B. Acar, D.E. Daniel, **Geoenvironmental 2000: Characterization, Containment, Remediation & Performance in Environmental Geotechnics**," ASCE, NY. 2. D.S. Hari, R.R. Krishna **Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies,** Wiley. USA 3. I.S. Oweis, R.P. Khera, **Geotechnology of Waste Management**" 2nd Ed, PSW Publishing Company, USA. 4. J.F. Rees, **Contaminated Land Treatment Technologies** SCI, Elsevier Applied Science, NY, USA.

1.	Course Code	**CE 490**
2.	Title of the Course	**Elements of Remote Sensing**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Radiation principles and interactions; Photography, photogrammetry, photo interpretation elements and applications; Satellite imaging; Multispectral, thermal, hyperspectral scanners and radiometers; Microwave radar imaging; Visual interpretation and digital analysis of imagery and applications.
8.	Suggested Books	1. T.M. Lilles, R.W. Kiefer, **Remote Sensing and Image Interpretation**, John Wiley & Sons, New York, 1994. 2. J.B. Campbell, **Introduction to Remote Sensing**, Taylor & Francis, London, 1996. 3. F.F. Sabins, **Remote Sensing: Principles and Interpretation**, W.H. Freeman and Company, New York, 1997. 4. R.N. Colwell, (Editor-in-Chief), **Manual of Remote Sensing, Vol. I & II**, American Society of Photogrammetry, Falls Church, Virginia, 1983.

1.	Course Code	**CE 492**
2.	Title of the Course	**Reinforced Earth**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Civil Engineering
5.	Pre–requisite, if any (for the students)	None
6.	Objectives of the course	
7.	Course Syllabus	Principle of reinforcement of ground. Various reinforcing methods such as sand drain soil nailing, geotextiles, geocones and geosynthetic materials. Mechanics of interaction between reinforcing element and soil. Properties of reinforcing materials. Applications of reinforcing techniques to the practical problems such as retaining walls, slopes, footings etc. Design methods.
8.	Suggested Books	

Course code	**CE 494/ CE 694**
Title of the course	**Earthquake Engineering**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Basic Knowledge of Structural Dynamics and Soil Mechanics
Scope of the course	This course introduces the fundamental concepts of earthquake engineering.
Course Syllabus	Importance of Earthquake Engineering, Fundamentals of Earthquake Engineering, Introduction to geotechnical earthquake engineering, Damaging Effects of Earthquakes, Earthquake Ground Motions, Seismic hazard analysis: probabilistic seismic hazard analysis (PSHA) and deterministic seismic hazard analysis (DSHA), Seismic Regions of the World, Earthquake Genesis, Characterization of Strong Ground Motions, Seismic Vulnerability Assessment of Building, Geotechnical Earthquake Engineering.
Suggested Books	1. R. Villaverde, ***Fundamental Concepts of Earthquake Engineering,*** Taylor & Francis, New York, 2009, 978-1-4200-6495-7 2. S. L. Kramer, ***Geotechnical Earthquake Engineering,*** Prentice Hall, United States of America, 1996, 978-0133749434 3. Sucuoğlu, Halûk, Akkar, Sinan, ***Basic Earthquake Engineering,*** Springer, Switzerland, 2014, 978-3-319-01026-7 4. M. Beer, I. A. Kougioumtzoglou, E. Patelli, I. Siu-Kui Au, ***Encyclopedia of Earthquake Engineering,*** Springer, Brazil, 2015 : 978-3-642-35345-1

Course code	**CE 496/ CE 696**
Title of the course	**Safety of Dams and Reservoirs**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Basic knowledge of water resources engineering
Objective of the course	The non-availability of water in the right place at the right time has lead the civilization to store surplus water in man-made reservoirs by constructing dams--large barriers in the flow path of rivers. Historically, these reservoirs have been used to supply water for drinking purposes, agriculture, and to generate hydroelectricity. Although vital assets, the management of such large water resources systems remains challenging. Dam failures pose significant threats to life, environment, and the local economy. Such failures may result from multiple reasons, large-magnitude floods being the most common and perhaps the least predictable. Over the last few decades, studies have found increasing trends in the frequency and magnitude of floods over the globe. The situation is expected to exacerbate with the changing climate over the next few decades. The aim of the course is to provide basic knowledge to manage and safeguard dams and reservoirs. This course provides introductory technical aspects of planning, design, operation, and maintenance of dams and reservoirs. In addition, topics covering risk management under a changing climate are introduced.
Course Syllabus	Introduction to planning, design, operation and maintenance of dams and reservoirs. Types of dams; causes of dam failures, flood failures and overtopping, backwater flooding, breaching, slope failure, internal erosion and shear stress in foundations. Principles of design of dams: Design flood, probable maximum floods, geologic and seismological considerations, stability analyses, environmental considerations. Uncertainty, risk, reliability, and resilience analyses of dams and reservoirs. Operation of dams: Modelling dam and reservoir systems. Rule curves and forecast-based policies, a brief introduction to optimization models. Design and operational challenges under a non-stationarity climate. Maintenance of dams: Silt and scouring, monitoring and instrumentation;

	Repair, rehabilitation, and removal of Dams.
Suggested Books	• D. P. Loucks, E. V. Beek, ***Water Resources Systems Planning and Management: An introduction to methods, models,and applications***, Springer International Publishing, Gewerbestrasse, Switzerland, 2017, 978-3-319-44232-7 • A. Pepper, ***Maintaining the Safety of our Dams and Reservoirs***, ICE Publishing, London, United Kingdom, 2014, 9780727760340. • Committee on the Safety of Existing Dams Water Science and Technology Board Commission on Engineering and Technical Systems National Research Council, ***Safety of Existing Dams: Evaluation and Improvement***, Washington, D.C., USA, 1983, 978-0-309-03387-9

Course Code	**CE 205**
Title of the Course	**Strength of Materials**
Course Category	Core
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Nil
Objective of the Course	To develop fundamental knowledge of the mechanics of Civil Engineering Structures.
Course Outcomes	• Knowledge of the concept of stress and strain. • Knowledge of the behavior of structural elements like beams and columns under compression, tension, shear, bending, and torsion.
Course Syllabus	**Rigid and Deformable Solids-** Method of sections for evaluating internal forces in bodies - review of free body diagrams, Constitutive relations, Hook's law. **Shear Force and Bending Moment-** Axial force, shear force, and bending moment diagrams. **Simple Stress and Strain-** Concept of normal and shear stress, Concept of normal and shear strains, Transformation of plane stress and strain, principal stress and strains, Mohr's circle. **Theory of Column-** Axially loaded members force and deflections, Buckling of compression members. **Bending and Shear Stress-** Bending and shearing stresses in beams of symmetrical cross-section concept of shear flow, Shear Centre, Inelastic bending of a beam. **Torsion and Pressure Vessels-** Torsion of circular shafts, Stress in cylindrical and spherical shells. **Deflection of Beams-** Bending deflection of simple beams by direct integration methods, Strain Energy methods, Combined stress, Principals of superposition and its limitation.
Suggested Books	Textbooks: 1. S. Timoshenko , ***Strength of Materials*****, Part I and II** , CBS Publishers and Distributors , 2021 , ISBN:978-8123910307 2. R. C. Hibbeler , ***Mechanics of Materials***, Pearson Prentice Hall , 2022 , ISBN:978-9354492259 3. E. P. Popov , ***Engineering Mechanics of Solids*** , Prentice Hall , 2009 , ISBN:978-8120321076 Reference books:

	4. S.H. Crandall, N.C. Dahl and T.V. Lardner , ***Mechanics of Solids, An Introduction*** , McGraw Hill International , 2017 , ISBN: 978-0071070034 5. L. S. Srinath , ***Advanced Mechanics of Solids*** , Tata McGraw-Hill , 2017 , ISBN: 978-0070139886

Course code	**CE 203N**
Title of the course	**Fluid Mechanics**
Course Category	Core
Credit Structure	L – T – P – Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Nil
Objective of the course	To impart the basic concepts of fluid mechanics and gain knowledge about the methods of solving real life problems involving fluids and gives approaches for flow measurement, fluid flow through pipes and boundary layer theory.
Course Outcomes	• Knowledge of fluid and pressure properties and their measurement • Analysis of forces on immersed plane and curved plates, frictional losses in laminar and turbulent flows and analyze flow between reservoirs. • Solve flow problems using continuity equations and energy equations.
Course Content	**Fluid Statics & Kinematics** - Fluid properties, Rheology of fluids, System and control volume, Pascal's law, Pressure and its measurement, Buoyancy and stability, Lagrangian and Eulerian descriptions, Flow visualization, Deformation of fluid elements, Vorticity and rotationality, Velocity potential and stream function. **Fluid Dynamics**- Euler's equation of motion, Conservation of mass, Bernoulli's equation, Linear and angular momentum equations – their applications. **Dimensional Analysis**- Buckingham's pi-theorem, Rayleigh's method, Dimensionless numbers, Model similarities, Distorted models. **Flow Through Pipes**- Reynolds experiment, Laminar and turbulent flow in pipes, Darcy-Weisbach equation, Moody's diagram, Head loss computation, Hydraulic and energy grade lines, Analysis of multi-pipe systems. **Flow Measurement**- Conventional and advanced flow measuring devices.
Suggested Books	Textbooks: 1. M.K. Goyal , ***Fluid Mechanics and Hydraulic Machines*** , PHI Learning Pvt. Ltd. , 2015 , ISBN: 978-81-203-5117-2 2. G.L. Asawa , ***Fluid Flow in Pipes and Channels*** , CBS Publishers , 2008, ISBN: 978-8123917238 Reference books: 3. Y.A. Cengel, and J.M. Cimbala , ***Fluid Mechanics* (4th Edition)** , McGraw-Hill , 2019 , ISBN: 978-9353166212 4. V.L. Streeter, E.B. Wylie and K.W. Bedford , ***Fluid Mechanics* (9th Edition)** , McGraw-Hill , 2014 , ISBN: 978-0070625372

Course code	**CE 253N**
Title of the course	**Fluid Mechanics Lab**
Course Category	Core
Credit Structure	L – T – P – Credits 0 – 0 – 3 – 1.5
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	None
Objective of the course	To acquire hands-on experience in measuring and interpreting various phenomenon for the fluid.
Course Outcomes	• Understand the basic fluid properties. • Understand different flow measurement techniques and procedures. • Verify the basic principles of fluid flow.
Course Content	**Students will perform following representative experiments:** • Determination of the metacentric height of a given vessel under unloaded and loaded conditions. • Visualization of streamlines and path lines using flow visualization channel. • Determination of coefficient of discharge using a Venturi meter. • Demonstrate Bernoulli’s theorem using Bernoulli's apparatus. • To study the free and forced vortex apparatus. • To study the impact of jets. • To observe the phenomenon of cavitation. • Determination of coefficient of discharge using orifice, notches, and weir. • Determination of friction factors of pipes using the concept of the Darcy-Weisbach equation. • Determination of minor losses in pipes. • Analyzing laminar and turbulent flow conditions on a Reynolds apparatus.
Suggested Books	Reference books: 1. G.L. Asawa , ***Laboratory Work in Hydraulic Engineering*** , New Age International Private Limited , 2006 , ISBN: 978-8122418101 2. S. Singh , ***Experiments in Fluid Mechanics*** , Prentice Hall India Learning Private Limited , 2012 , ISBN: 978-8120345119

Course Code	**CE 207**
Title of the Course	**Building Materials**
Course Category	Core
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Nil
Objective of the Course	This course aims to introduce different materials and their properties that can be used for civil engineering applications.
Course Outcomes	• Knowledge about different materials available for use in building construction. • Understanding of mechanical behavior of building materials. • Awareness about green building materials.
Course Syllabus	**Introduction:** Classification, characterization, engineering properties of building materials and comparative analyses. **Aggregate, Cement and Bricks-** Cement, cement composition, types of cement and its comparative analysis, Aggregate, Admixtures, Lime, Bricks and blocks. **Concrete-** Water for concrete making and curing, Concrete and its types, Design mix of concrete. **Metals and Alloys**- Steel, ferrous metals, Aluminum and Copper. **Other Load-bearing Materials-** Timber, Laminates, Ceramics, Refractories, Glass, Asphalt. **Other Non-load Bearing Materials-** Rubber, Plastic, Asbestos, Paints and varnishes, Adhesives. **Alternative Materials-** Bamboo, Geopolymer. **Students will perform following representative experiments:** • To determine the normal consistency, setting time, fineness, specific gravity and soundness of cement. • To determine the compressive strength test of hydraulic cement. • To perform Slump test, Compaction factor test, and Vee-bee consistometer. • To determine the compressive, flexural, and tensile strength of cubic concrete specimens. • To perform particle size distribution of fine and coarse aggregates. • Determination of specific gravity of fine and coarse aggregates. • To determine the flakiness index, elongation index, and angularity number test of aggregates. • To perform aggregate impact value, crushing value, and abrasion value tests. • To perform tile abrasion test.

	• To perform water absorption and efflorescence test on bricks
Suggested Books	Textbooks: 1. S.K. Duggal, ***Building Materials*** , CRC Press , 2017 , ISBN: 9781351462976 2. N. Subramanian, ***Building Materials – Testing and Sustainability*** , Oxford University Press , 2019 , ISBN: 9780199497218 3. P.C. Varghese, ***Building Materials*** , PHI Learning , 2015 , ISBN: 978-8120350915 Reference Books 4. B. Cather and D. Doran, ***Construction Materials Reference Book*** , CRC Press , 2013 , ISBN: 978-0750663762 5. M.L. Gambhir, ***Concrete Technology*** , McGraw Hill , 2013 , ISBN: 9781259062551

Course code	**CE 209**
Title of the course	**Surveying**
Course Category	Core
Credit Structure	L - T - P - Credits 2 - 1 - 0 - 3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Nil
Objective of the course	This course aims to understand the basics of field surveying and to be able to execute mapping and setting out of the different civil engineering projects.
Course Outcomes	• Knowledge of planning a survey, taking accurate measurements, booking the field, plot, and adjusting the traverse for civil engineering applications. • Knowledge to utilize a variety of conventional instruments involved in surveying about accuracy and utility.
Course Content	**Basic Concepts of Surveying-** Control surveys - horizontal and vertical, Topographic Mapping, Route surveys. **Plane Table Surveying-** Plane table, Plane and Geodetic surveying. **Compass and Theodolite Surveying-** Compass traversing, Theodolite traversing, Open and closed traversing. **Levelling and Contouring-** Levelling-spirit, Trigonometric levelling, Tachometric levelling, Precise levelling, Triangulation and trilateration. **Total Station-** Total station, Errors and adjustments, Global Navigation Satellite System (GNSS). **Application of Geoinformatics tools-** Geographic Information System (GIS), Global Positioning System (GPS) mapping, Unmanned Aerial Vehicles (UAVs).
Suggested Books	Textbooks: 1. N.N.Basak, ***Surveying & Levelling***, McGraw Hill Education (2nd Edition), 2017, ISBN: 9789332901537 2. P.V.Rao and V.Akella, ***Textbook of Surveying***, PHI Learning, 2015, ISBN: 9788120349919. Reference Books: 1. J. M. Anderson and E. M. Mikhail, ***Surveying Theory and Practice***, McGraw Hill Ltd., 7th Edition , 2017 , ISBN : 978-1259025648. 2. B. Kavanagh and T. Mastin , ***Surveying Principles and Applications***, Pearson , 2013 , ISBN , 9780137009404

Course code	**CE 255**
Title of the course	**Strength of Materials Lab**
Course Category	Core
Credit Structure	L-T- P-Credits 0-0-2-1
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Nil
Objective of the course	To develop experimental knowledge of the mechanics of Civil Engineering Structures.
Course Outcomes	• Knowledge of various experiments to understand the deformation behavior of materials and simple structural components.
Course Content	**Students will perform following representative experiments:** • To determine the axial tension of mild steel and cast iron. • To study the compression of concrete, bending of beams, and buckling of columns. • To conduct experiments on the shear centre. • To study continuous and interconnected beams. • To analyse the unsymmetrical bending of angle sections. • To study buckling of columns of various cross-section and end conditions. • To study deflection in a curved ring beam using Castigliano's Theorem.
Suggested Books	Reference books: 1. S. Timoshenko , ***Strength of Materials*, Part I and II** , CBS Publishers and Distributors , 2021 , ISBN: 978-8123910307 2. R. C. Hibbeler , ***Mechanics of Materials***, Pearson Prentice Hall , 2022 , ISBN: 978-9354492259 3. E. P. Popov , ***Engineering Mechanics of Solids***: Prentice Hall , 2009 , ISBN, 978-8120321076 4. L. S. Srinath , ***Advanced Mechanics of Solids*** , Tata McGraw-Hill , 2017 , ISBN: 978-0070139886

Course code	**CE 259**
Title of the course	**Surveying Lab**
Course Category	Core
Credit Structure	L - T - P - Credits 0 - 0 - 2 – 1
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Nil
Objective of the course	The course will provide exposure to various laboratory instruments such as levels, theodolite, total station, GNSS.
Course Outcomes	• Knowledge of controlling the accumulation of errors in survey projects. • Understanding use of survey instruments in carrying out survey, collect data, write reports and able to perform required calculations to achieve the objective for different types of surveying for different engineering projects.
Course Content	**Students will perform following representative experiments:** • Surveying of an area by chain, and compass survey (closed traverse) and plotting. • Determine the distance between two inaccessible points with a compass. • Radiation method, intersection methods by plane table survey. • To study levelling – longitudinal and cross-section and plotting. • To study measurement of horizontal and vertical angles by theodolite. • To study trigonometric leveling using theodolite. • Determination of height, remote elevation, and distance between inaccessible points using a total station. • To study the Global Positioning System instrument and its accessories. • To study differential global positioning systems. • To study mapping using a Geographic Information System.
Suggested Books	Reference Books 1. N.N.Basak***, Surveying & Levelling***, McGraw Hill Education (2nd Edition), 2017, ISBN: 978-9332901537 2. P.V.Rao and V.Akella, ***Textbook of Surveying***, PHI Learning, 2015, ISBN: 9788120349919. 3. B. Kavanagh and T. Mastin , ***Surveying Principles and Applications***, Pearson , 2013 , ISBN: 9780137009404. 4. J. M. Anderson and E. M. Mikhail, ***Surveying Theory and Practice***, 7th Edition , 2017 , ISBN: 978-1259025648

Course code	**CE 210**
Title of the course	**Structural Analysis I**
Course Category	Core
Credit Structure	L-T- P-Credits 2 -1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Exposure to the basics of the Strength of materials
Objective of the course	To introduce the analysis of determinate structures.
Course Outcomes	• Knowledge of the analysis of determinate structures.
Course Content	**Statically Determinate Structures-** Determination of forces in trusses, frames, arches, and cables. **Deflection in Structures-** Principle of virtual work, Energy Principle, Maxwell's and Betti's laws. **Computation of Displacements-** Moment area method, Conjugate beam method, Virtual work methods. **Influence Line Diagrams and Rolling Loads-** Equilibrium methods, Muller Breslau principle, Concepts of flexibility and stiffness.
Suggested Books	Textbooks: 1. C.S. Reddy , ***Basic Structural Analysis*** , Tata McGraw Hill , 1996 , ISBN , 978-0074623664. 2. R.C. Hibbeler , ***Structural Analysis*** , Pearson/Prentice Hall , Upper Saddle River, N.J , 2006 , ISBN: 978-9332586147 3. H.H. West , ***Fundamentals of Structural Analysis*** , John Wiley , New York , 1993 , ISBN: 9788126531295 Reference books: 4. J.C. McCormac , ***Structural Analysis***, Using Classical and Matrix Methods, 4th Edition , Hoboken , 2007 , ISBN: 978-0470036082 5. D. Menon , ***Structural Analysis*** , Narosa Publishing House , 2018 , ISBN: 978-81-7319-939-4

Course code	**CE 212**
Title of the Course	**Soil Mechanics-I**
Course Category	Core
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Prerequisite, if any	None
Objective of the course	To provide a fundamental understanding of soils' physical and mechanical properties. Students will acquire basic knowledge of the engineering design of geotechnical systems.
Course Outcomes	• Knowledge of properties of soil. • Understanding the compaction, consolidation and shear strength parameters of soil.
Course Content	**Origin of Soils and Rocks-** Introduction and basic inter-relationships. **Index Properties**- Index properties of soil and aggregates, Atterberg limits. **Soil Structure and Clay Mineralogy-** Soil structure, Mineralogy of soils, IS soil classification. **Soil Compaction-** Laboratory compaction, Factors affecting soil compaction, Field compaction, Soil-water statics. **Concept of Effective Stress-** Effective stress, Capillarity phenomenon in soil, Flow through soils, Quicksand condition. **Permeability-** Permeability and methods for its determination, Construction of flownets. **Vertical Stress Distribution in Soil from Surface-** Boussinesq theory, Westergard theory, Newmark's chart, Contact pressures. **Consolidation of Soils-** Settlement of compressible soil layers, Terzaghi's 1D consolidation theory. **Shear Strength of Soils-** Mohr-Coulomb theory, Failure theories.
Suggested Books	Textbooks: 1. V. N. S. Murthy, ***Geotechnical Engineering, Principles and Practices of Soil Mechanics and Foundation Engineering***, CRC Press, 2003 , ISBN: 978-0824708733 2. T. W. Lambe and R. V. Whitman, ***Soil Mechanics***, Wiley , 2010, ISBN: 978-8126517794 Reference books 3. K. Terzaghi, R.B. Peck, G. Mesri, ***Soil Mechanics in Engineering Practice***, Wiley, 2009, ISBN: 978-8126523818. 4. J. Knappett and R.F. Craig, ***Craig's Soil Mechanics***, CRC Press, 2012, ISBN: 978-0415561266

Course Code	**CE 214**
Title of the Course	**Engineering Geology**
Course Category	Core
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Nil
Objective of the Course	To provide the student with the practical applications of geological knowledge for engineering projects, geological and geotechnical recommendations.
Course Outcomes	• Identify and classify various minerals and rocks based on their engineering properties. • Assessment and mitigation of geological hazards. • Develop a native construction plan incorporating all relevant geology aspects using seismic and electrical methods.
Course Syllabus	**Introduction**- Origin, Age, Development and interior of Earth, Plate tectonics, Continental drift, Sea floor spreading, Evolution of the Himalaya. **Mineralogy**- Physical and chemical properties of rocks and minerals, Optical mineralogy. **Rock Classification**- Igneous, Sedimentary and Metamorphic, Ternary diagrams, IUGG classification of intrusive and extrusive rocks, Metamorphism Causes, Textural classification of rocks. **Structural Geology**- Folds, Faults, Joints, Subsurface exploration, Geologic investigations for site selection of engineering structures, Instrumentation in engineering geology. **Geological Hazards and Mitigation**- Seismic zones and seismo-tectonics of India, Major geological hazards, Effect of earthquakes on infrastructure, Geotechnical and structural considerations in earthquake hazard mitigation. **Students will perform following representative experiments:** • To prepare geological maps and mapping, outcrops, apparent and true dips. • To study three-point problems, depth and thickness problems, joints, faults. • To conduct megascopic and microscopic identification of minerals and rocks. • To study engineering properties of rocks, refraction and resistivity methods. • A guided tour through representative geological formations and structures.
Suggested	Textbooks:

Books	1. L. G. de Vallejo and M. Ferrer, ***Geological Engineering***, CRC Press, 2011, ISBN: 9780415413527 2. Gangopadhyay, ***Engineering Geology***, Oxford Publication, 2013, ISBN: 9780198086352 Reference books 3. C. Mclean and C. D. Gribble, ***Geology for Civil Engineers***, CRC Press, 2017, ISBN: 978-1138465824

Course code	**CE 252**
Title of the Course	**Soil Mechanics Lab-I**
Course Category	Core
Credit Structure	L-T- P-Credits 0-0-2-1
Name of the Concerned Department	Civil Engineering
Prerequisite, if any (for the students)	None
Objective of the course	To acquire hands-on experience in measuring and interpreting soil properties.
Course Outcomes	• Practical Knowledge on different properties of soil.
Course Content	**Students will perform following representative experiments:** • Determination of moisture content of the given soil sample. • Determine the in situ density of natural or compacted soils using sand pouring cylinders. • To study particle size distribution using sieve analysis and hydrometer analysis. • To find out the specific gravity of soil. • To determine the relative density of given coarse grained Material. • To study Atterberg limit. • To conduct compaction of soil. • To determine the coefficient of permeability of a soil using constant head method. • To determine the coefficient of permeability of a soil using falling head method. • To conduct consolidation of soil. • To perform shear tests.
Suggested Books	Reference books 1. V. N. S. Murthy, ***Geotechnical Engineering, Principles and Practices of Soil Mechanics and Foundation Engineering***, CRC Press, 2003, ISBN: 978-0824708733 2. T. W. Lambe and R. V. Whitman, ***Soil Mechanics***, Wiley , 2010, ISBN: 978-8126517794 3. K. Terzaghi, R.B. Peck, G. Mesri, ***Soil Mechanics in Engineering Practice***, Wiley, 2009, ISBN: 978-8126523818. 4. J. Knappett and R.F. Craig, ***Craig's Soil Mechanics***, CRC Press, 2012, ISBN: 978-0415561266

Course code	**CE 218**
Title of the course	**Environmental Engineering**
Course Category	Core
Credit Structure	L - T – P Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	NA
Objective of the course	To provide students with a strong background on processes and operations used to address major environmental issues and to understand the role of unit processes in water and wastewater treatment systems and in air and noise pollution systems.
Course Outcomes	• Understanding the basics of water supply, treatment methods, and distribution networks and gather overview on wastewater treatment processes. • Knowledge of solid waste management and developing vision for a waste-free world and sustainable options for living.
Course Content	**Water Supply Engineering-** Sources, quality standards, and testing of water and its treatment, Characteristics of water, Pollutants in water and their effects, Estimation of water demand, Water treatment units, Water distribution networks. **Wastewater Engineering-** Planning and design of domestic wastewater systems, Sewage collection, and disposal, Plumbing systems. Components and layout of sewerage system, Sludge management, Industrial waste waters and Effluent treatment plants. **Solid Waste Management-** Sources and classification, Planning and design of solid waste disposal and management system, Beneficial aspects of waste and its utilization. **Air and Noise pollution-** Concepts, Measurement techniques, General methodology and control measures.
Suggested Books	Textbooks: 1. H.S. Peavy, D.R. Rowe, and G. Tchobanoglous, ***Environmental Engineering*** , McGraw Hill ,2013, ISBN: 9789351340263. 2. N.N.Basak, ***Environmental Engineering***, McGraw Hill, 2017, ISBN: 978-0070494633 Reference books: 3. Metcalf and Eddy, F. L. Burton, H. D. Stensel, and G. Tchobanoglous , ***Wastewater Engineering, Treatment and Reuse*** , McGraw Hill , 2003 , ISBN: 978-0070418783

Course code	**CE 258**
Title of the course	**Environmental Engineering Lab**
Course Category	Core
Credit Structure	L - T – P-Credits 0 – 0 – 2 - 1
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	NA
Objective of the course	It will impart Practical Knowledge on different chemical, physical and biological properties
Course Outcomes	• Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
Course Content	**Students will perform following representative experiments:** • Determination of pH using pH meter, electrical conductivity using EC meter, and temperature using Temperature meter for water and wastewater samples. • Determination of alkalinity and acidity. • Determination of hardness. • Determination of turbidity and optimum dose of alum. • Determination of solids. • Determination of dissolved oxygen and bio-chemical oxygen demand. • Determination of chemical oxygen demand. • Determination of Most Probable Number (MPN) • Determination of nutrients / heavy metals. • Determination of ambient air quality/measurement of noise levels. Site visit to Water treatment plant/ Sewage Treatment Plant/ Effluent Treatment Plant
Suggested Books	Reference Books 1. American Public Health Association, ***Standard Methods for the Examination of Water and Wastewate****r*, American Public Health Association,, 2017, ISBN: 978-0875532875 2. Metcalf and Eddy, F. L. Burton, H. D. Stensel, and G. Tchobanoglous, ***Wastewater Engineering, Treatment and Reuse***, McGraw Hill, 2003, ISBN: 978-0070418783

Course code	**CE 211**
Title of the course	**Smart Cities**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	Nil
Objective of the course	The objective of the course is to provide an understanding of the impact that Civil Engineering has on society at large and in the global arena including the impacts of Civil Engineering projects on infrastructure, energy consumption and generation, and sustainability of the environment.
Course Outcomes	• Understanding of the impacts of Civil Engineering in Urbanization. • Knowledge of the sustainability of structures and the Environment. • Awareness of global environmental issues and mitigation strategies.
Course Content	**Introduction-** Recent major Civil Engineering breakthroughs and innovations, Present day world and future projections, concept of smart cities, dimensions, standards and performance benchmarks, Smart city mission in India. **Smart Buildings-** Planning aspects of Green and energy efficient buildings, Green building ratings, Zero Carbon cities, Conservation, repairs and rehabilitation of structures and heritage structures. **Futuristic Transportation**: Tunnels, Multi-modal Transport systems, Hyper Loop. **Environmental Impacts and Control-** Innovations in solid waste management, Water purification, Wastewater treatment, Atmospheric pollution and mitigation measures, Environmental Impact Assessment, Smart water projects **Disaster Resilient Cities**- Flood Control, Earthquake Resistant Structures, Climate Smart Infrastructure.
Suggested Books	Textbooks: 1. A. Kumar, ***Introduction to Smart Cities***, Pearson India, 2019, ISBN: 978-9353439576 2. R. John Glasson, A. Theriveland and R. Chandwic, ***Introduction to Environmental Impact Assessment***, Taylor and Francis, 2011, ISBN: 978-0415664707 Reference Books:

	3. S. Wang, ***Intelligent Buildings and Building Automation,*** Routledge, 2009, ISBN: 978-0415475716

Course code	**CE 213**
Title of the course	**Optimization Methods for Civil Engineering**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	None
Objective of the course	The course aims to teach students the fundamentals of classical and non-classical optimization techniques and their application in solving real-world civil engineering optimization problems.
Course Outcomes	• Define the concept of a system and outline the steps involved in applying a systems approach to water resources engineering. • Utilize optimization techniques, including linear programming and the simplex method. • Create simulation models for deterministic and stochastic reservoir operating policies.
Course Content	**System Concepts**- Definition, classification, and characteristics of systems, Scope and steps in systems engineering, Need for systems approach to water resources and irrigation. **Linear Programming-** Introduction to operations research - linear programming, Problem formulation, Graphical solution, Solution by simplex method - sensitivity analysis, Application to design and operation of reservoir, Case studies. **Dynamic Programming-** Bellman's optimality criteria, Problem formulation and solutions, Application to design and operation of reservoirs, Case studies. **Simulation,** Basic principles and concepts, Random variant and random process, Monte Carlo techniques, Model development - inputs and outputs, Case studies. **Advanced Optimization Techniques-** Integer and parametric linear programming, Goal programming, Discrete differential and incremental dynamic programming, Linear decision rule models, Stochastic dynamic programming models.
Suggested Books	Textbooks: 1. K. Deb, ***Optimization for Engineering Design-Algorithms and Examples***, Prentice, 2012, India, ISBN: 978-8120346789 2. S. Vedula and P.P. Majumdar, ***Water Resources Systems – Modeling Techniques and Analysis***, Tata McGraw Hill, 2010, ISBN: 9780070590892 Reference books:

	3. A. Ravindran, G.V. Reklaitis, and K.M. Ragsdell , ***Engineering optimization, methods and applications***. John Wiley and Sons, 2006, ISBN: 978-0-471-55814-9 4. S.S. Rao, ***Engineering optimization, theory and practice*** , John Wiley and Sons, 2019 , ISBN: 978-0470274835

Course code	**CE 222**
Title of the Course	**Estimation and Costing**
Course Category	Departmental Elective
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite if any	Nil
Objective of the course	To impart knowledge about estimation and costing, which is essential for the planning, execution, and economic viability of any civil engineering project.
Course Outcomes	• Understanding different types of estimation techniques. • Knowledge about different types of building items and their costing. • Knowledge about the valuation of the building assets.
Course Content	**Introduction-** Importance of estimation, Different types of estimates, General and detailed specifications. **Methods of Estimation-** Items of work for estimates, units, and measurement of items. **Detailed Estimation of Buildings-** Detailed estimates, Analysis of rates, material, and other cost considerations, Resource planning through analysis of rates, market rates, Schedule of rates, non-scheduled items, and cost indices for building material and labor. **Valuation of Assets-** Standard terminology, Factors affecting the values of property, Methods of valuation, years purchase, capitalized value, sinking fund, depreciation.
Suggested Books	Textbooks: 1. B.N. Dutta, ***Estimating and Costing in Civil Engineering***, Theory and Practice, CBS Publishers and Distributors , 2022 , ISBN: 9788174767707 2. J. Williams and S. Gedes, ***Estimating for Building and Civil Engineering Work*** , CRC Press, 2013 , ISBN: 9780750627979 Reference books: 3. SP 27, 1987 (Reaffirmed 2003), **Handbook of Method of Measurement of Buildings Work**,1987, ISBN: 81-7061-002-8

Course code	**CE 220**
Title of the course	**Water Resources Planning and Management**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Civil Engineering
Pre-requisite, if any	None
Objective of the course	The course objective is to cover history, economics, uncertainty, systems analysis, flood mitigation, and sustainable water resource management, providing a well-rounded foundation for careers in water resources and related fields.
Course Outcomes	• Understanding water resource history and challenges • Learning economic planning and uncertainty analysis • Acquiring skills in systems analysis and optimization
Course Content	**Introduction**- History of water resources development, Water resources of India, Problems and perspectives. **Economics of Water Resources Planning**- Cost-benefit analysis of water resources projects, Water pricing and water allocation, Principles of planning and financing water resources projects. **Uncertainty Concepts**- Methods for uncertainty analysis and applications in water resources planning. **Systems Analysis**- Systems concepts, Conventional and evolutionary optimization techniques, Interfacing optimizers with process simulators for design and management applications. **Flood Mitigation and Management**- Structural and nonstructural measures, Optimal flood mitigation plan, Flood damage estimation, Flood control systems, Decision support systems, Coastal zone management.
Suggested Books	Textbooks: 1. S.K. Jain and V.P. Singh, ***Water resources systems planning and management***. Elsevier, 2003, ISBN: 9780444514295 Reference Books: 2. D.P. Loucks and E. van Beek , ***Water resource systems planning and management***, An introduction to methods, models, and applications. Springer, 2017, ISBN: 978-3-319-83017

Syllabi

of

Metallurgy Engineering and Materials Science Courses

(From AY 2017-18 onwards)

1.	Course Code	**MM 201**
2.	Title of the Course	**Mechanics of Materials**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Elastic and plastic behaviour, stress–strain relationship for elastic behaviour, elements of plastic deformation of metallic materials. Mohr's circle, yielding theories Elements of theory of plasticity, dislocation theory properties of dislocation, stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, dispersion hardening Ductile and brittle fracture, Charpy and Izod testing, significance of DBTT, ECT, NDT and FATT; elements of fractography - Griffith's theory, LEFM– COD and J integral – determination of KIC, COD and J integral Characteristics of fatigue failure, initiation and propagation of fatigue cracks, factors affecting fatigue strength and methods of improving fatigue behaviour – testing analysis of fatigue data, mechanics of fatigue crack propagation, corrosion fatigue Introduction to creep - creep mechanisms, creep curve, variables affecting creep, accelerated creep testing, development of creep resistant alloys, Larsen Miller parameter - Manson Hafred parameter.
8.	Suggested Books	1. G.E. Dieter, **Mechanical Metallurgy**, McGraw Hill Inc. New York, 1988. 2. R.M. Rose, L.A. Shepard, J. Wulff, **Structure and Properties of Materials**, Volume III, 4th Edition, John Wiley, 1984.

1.	Course Code	**MM 251**
2.	Title of the Course	**Mechanics of Materials Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Tensile tests on cylindrical or plate specimens; Fracture Mechanics tests; Fatigue Tests (axial and bending); Impact and Thermal Shock testing of the large area samples; Residual stress measurement; Fatigue tests (axial and bending); Modulus of Elatcicty, Flexural test; Poisson ratio flexural test; Cantilever flexural test
8.	Suggested Books	**1.** Suryanarayana, **Testing of Metallic Materials**, Prentice Hall India, New Delhi, 1979.

Course Code	MM 252
Title of the Course	**Casting and Welding Technology Lab**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits 0-0-2-1
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre–requisite, if any	None
Objectives of the Course	This lab course demonstrates experiments in different types of casting and welding technology.
Outcomes	Students will be able to learn experimental skills in casting and welding technology.
Course Syllabus	**List of Representative Experiments** • To study and observe various stages of casting through demonstration of Sand- Casting Process (a) To prepare a pattern for given object for lost form casting. (b) To prepare a molasses sand mold from the prepared pattern • Preparation of as-cast and suction cast Cu-Sn alloy through demonstration of Vacuum arc melting cum suction casting technique. • Preparation of light-weight Al-based alloy through demonstration of stir casting cum squeeze casting technique. • Casting of Steel through demonstration of Induction melting cum casting technique. • To study TIG and MIG welding process. To prepare weld joint and to study on effect of process parameter on weld joint • To study CMT welding Process. To prepare weld joint using CMT welding, study on effect of process parameter on weld joint • To study friction stir welding Process. To prepare weld joint using friction stir welding, study on effect of process parameter on weld joint. • To study Diffusion welding process. To prepare weld joint using diffusion welding, study on effect of process parameter on weld joint
Suggested Books	**Reference Books:** 1. A. K. Chakraborti, Casting Technology and Cast Alloys, Prentice Hall India New Delhi, 2005, ISBN: 978-8120327795. 2. G. J. Davies, Solidification and Casting, Applied Science Publishers Ltd, London, 1973, ISBN: 0-853345562. 3. P. L. Jain, Principles of Foundry Technology, McGraw Hill Education, 2017, ISBN: 978-0070151291. 4. Lindberg and Braton, Welding and Other Joining Processes, Ally & Bacon Inc., Boston, 1976, ISBN: 978-0205050000. 5. L.M. Gourd, Principles of Welding Technology (2nd Edition), ELBS Longman, 1986, ISBN: 978-8176490290.

1.	Course Code	**MM 202**
2.	Title of the Course	**Extractive Metallurgy**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Minerals of economic importance, commination techniques, size classification, Flotation, gravity and other methods of mineral processing; agglomeration, pyro- hydro- and electro-metallurgical processes; material and energy balances; principles and processes for the extraction of non-ferrous metals – aluminum, copper, zinc, lead, magnesium, nickel, titanium and other rare metals; iron and steel making – principles, role structure and properties of slags, metallurgical coke, blast furnace, direct reduction processes, primary and secondary steel making, ladle metallurgy operations including deoxidation, desulphurization, sulphide shape control, inert gas rinsing and vacuum reactors; secondary refining processes including AOD, VAD, VOD, VAR and ESR; ingot and continuous casting; stainless steel making, furnaces and refractories.
8.	Suggested Books	1. T. Rosenqvist, **Principles of Extractive Metallurgy**, McGraw-Hill Book Company, New York, 1983 2. H.S. Ray and A. Ghosh**, Principles of Extractive Metallurgy**, Wiley Eastern Ltd., New Delhi, 1991) 3. H.S. Ray, R. Sridhar, K.P. Abraham, **Extraction of Nonferrous Metals**, Affiliated East West Press Pvt Ltd., New Delhi, 2007. 4. H.S. Ray, B.P Singh, S Bhattacharjee, **Energy in Minerals and Metallurgical Processes**, Allied Publishers Ltd, New Delhi, 2005. 5. W.H. Dennis, **Extractive Metallurgy**, Philosophical Library, New York, 1965. 6. F. Habashi, **Principles of Extractive Metallurgy**, Vol.1, Gordon and Breach, New York, 1969. 7. W.G. Davenport, A.K. Biswas, **Extractive Metallurgy of Copper**, Pergamon Publishing Company. 8. J.L. Bray, **Non-ferrous Production Metallurgy**, Wiley, New York, 1954. 9. Handbook of Extractive Metallurgy: Fathi Habashi; Wiley-VCH

1.	Course Code	**MM 203**
2.	Title of the Course	**Physical Metallurgy-I**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	**Classification of transformations:** Phase Transformation of first degree and second degree, Energy aspects of first degree and second degree, Energy aspects of homogeneous and heterogeneous nucleation, nucleation ratio, fraction transformed at constant rates of nucleation and growth, Nucleation in solids. Austenite-Pearlite transformation, role of diffusion and temperature on lamellar spacing. **Bainite transformation:** Nature of carbide in bainite, upper and lower bainite, isothermal transformation in austempered ductile iron. **Martensitic transformation:** Crystallographic aspects and mechanism of atom movements, comparison between twinning and martensitic transformation, effect of grain size, Plastic deformation, arrested cooling on kinetics. **Order-Disordered transformations:** Common structures in ordered alloys, Variation of order with temperature, Determination of degree of ordering, Effect of ordering on properties, applications. **Precipitation hardening:** Structural changes, Mechanism and integration of reactions, Effect of retrogression, Double peaks, Spinoidal decomposition. Recovery, recrystallization and grain growth: property changes, Driving forces, N-G aspects, annealing twins, textures in cold worked and annealed alloys, polygonization.
8.	Suggested Books	1. V. Raghavan, **Solid State Phase Transformations**. PHI Learning Pvt. Ltd., 1987. 2. D.A. Porter, E.E. Kenneth, M. Sherif, **Phase Transformations in Metals and Alloys**, CRC press, 2009. 3. P. Haasen, **Phase Transformations in Materials**. Wiley-VCH, 1991. ISBN 3-527-30256-5 4. R.W. Cahn, **Phase Transformations in Materials**. VCH, 1991 - Technology & Engineering, ISBN 3527268189, 9783527268184 5. R.E. Smallman, **Modern Physical Metallurgy**, Elsevier, 2013, ISBN: 9780080982236 (e-book); 9780080982045 (printed book) 6. R. Abbaschian, L. Abbaschian, R.E. Reed-Hill, **Physical Metallurgy Principles**, Cengage Learning Stamford, USA, 2010, ISBN 0495082546.

1.	Course Code	**MM 204**
2.	Title of the Course	**Physical Metallurgy-II**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	**Plastic deformation of single crystal:** Lattice defects, Slip in perfect lattice, easy glide, slip by dislocation movement, Critical resolved shear stress for slip, deformation by twinning, Stacking faults, Strain hardening of single crystal. **Dislocation Theory:** Methods of observation of dislocations, Elastic properties of dislocations, strain energy of dislocations. Forces on and between dislocations, Dislocations in FCC and other crystal structures. Multiplication of dislocations. Dislocation pileups, Strengthening of dislocations. Work hardening. **Diffusion in solids:** Fick's laws of diffusion, Solutions of Fick's law and their applications to metallurgical problems, Kirkendall effect, Atomic movements in diffusion. **Strengthening mechanisms:** Strengthening by grain boundaries, Yield point phenomenon, Strain ageing, Solid solution strengthening from fine particles, fiber strengthening, strengthening due to point defects, Cold Working. **Phase Transformations:** Nucleation and growth considerations, Homogeneous and heterogeneous nucleation. Martensitic transformations, Order-disorder changes, Precipitation hardening, Solution treatment Aging treatment, Nucleation of precipitates, Theories of structural changes during ageing, Study of Al-Cu system, Theories of precipitation hardening. Fractures: Theoretical strength of materials, Types of fractures, Griffith theory of brittle fracture, ductile to brittle transition, ductile fracture, Notch effects.
8.	Suggested Books	1. R. Abbaschian, L. Abbaschian, R.E. Reed-Hill, **Physical Metallurgy Principles**, Cengage Learning Stamford, USA, 2010, ISBN 0495082546. **2.** R.E. Smallman, **Modern Physical Metallurgy**, Elsevier, 2013, ISBN: 9780080982236 (e-book); 9780080982045 (printed book) 3. G.E. Dieter, **Mechanical Metallurgy**, McGraw Hill Inc. New York, 1988. 4. Brophy, Rose and Wulff, **Thermodynamics of Structure** (Vol. II), Wiley Eastern Pvt. Ltd. New Delhi. 5. Hayden, Moffat and Wulff, **The Structure and Properties of Materials**, Vol. III (Mechanical Behavior) Wiley Eastern Pvt. Ltd. New Delhi.

		6. H. Derek, **Introduction to Dislocations**, Pergamon Press.

1.	Course Code	**MM 254**
2.	Title of the Course	**Physical Metallurgy Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Introduction to metallographic specimen preparation; Metallography and Image analysis; Optical microscopy of ferrous and non ferrous samples; Quantitative Metallography; X-Ray diffraction in material analysis; Nucleation, recovery and recrystallization behaviors analysis; Thermal analysis for phase transformation studies.
8.	Suggested Books	Same as MM 203 and MM 204

1.	Course Code	**ME 205** [from AY 2010-11 to AY 2015-16] **MM 205** [for AY 2016-17 only]
2.	Title of the Course	**Materials Science**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgical Engineering/Mechanical Engineering
5.	Pre–requisite, if any	Nil
6.	Scope of the course	
7.	Course Syllabus	Introduction and classification of Engineering Materials Structure of Metals and Alloys Iron-carbon Phase Diagrams Classification and Properties of Steels, Properties and Industrial applications of alloys steels, tool steels, stainless steels and cast irons. Principles of Heat Treatment of Steels and alloys, Case-Hardening of steels. Properties and uses of non-ferrous materials: Brasses and bronzes, aluminum and its alloys, zinc, tin alloys, nickel and titanium alloys. Mechanical behavior of metals. Cold and hot working of metals. Fracture, fatigue and creep behavior of metals. Corrosion and its prevention.
8.	Suggested Books	**Text Books** 1. W.D. Callister, Jr., "**Materials Science and Engineering**", Wiley India (P) Ltd., 2007. 2. V. Raghvan, **Material Science and Engineering,** Prentice Hall of India Pvt. Ltd. New Delhi. 3. G.E. Dieter, **Mechanical Metallurgy**, McGraw Hill Book Company (UK) Ltd. London, 1988. 4. R.E. Reed-Hill; **Physical Metallurgy Principles** (4th Edition), Cengage Learning, 2003 **Reference Books** 1. F.C. Compbell '**Elements of Metallurgy and Engineering Alloys'**, ASM International, Ohio, 2008 2. R.E. Smallman, A.H.W. Nagan, "**Physical Metallurgy and Advanced Materials**', 7th edition, Elsevier, 2007 3. D.A. Porter and K.E. Easterling, **Phase Transformations in Metals and Alloys**, 2nd edition, Chapman and Hall, London 1992

1.	Course Code	**MM 205** [from AY 2017-18 onwards]
2.	Title of the Course	**Materials Science**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Historical perspective of Materials Science. Why study properties of materials. Classification of materials. Advanced Materials, Future materials and modern materials Atomic Structure, Interatomic Bonding and Structure of Crystalline Solids Atomic structure. Atomic bonding in solids, Crystal structures, Crystalline and non-crystalline materials. Miller indices. Anisotropic elasticity. Elastic behavior of composites. Structure and properties of polymers. Structure and properties of ceramics. Imperfections in Solids Point defects. Theoretical yield point. Line defects and dislocations. Interfacial defects. Bulk or volume defects. Atomic vibrations Module 4: Mechanical Properties of Metals Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves Yielding under multi-axial stress. Yield criteria and macroscopic aspects of plastic deformation. Property variability and design factors Diffusion mechanisms. Steady and non-steady state diffusion. Factors that influence diffusion. Non-equilibrium transformation and microstructure Dislocations and Strengthening Mechanisms Dislocation and plastic deformation. Mechanisms of strengthening in metals. Recovery, recrystallization and grain growth. Strengthening by second phase particles. Optimum distribution of particles. Lattice resistance to dislocation motion Phase Diagrams Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Kinetics of nucleation and growth. The iron-carbon system. Phase transformations. Transformation rate effects and TTT diagrams. Microstructure and property changes in iron-carbon system. Ductile and brittle fracture. Fracture mechanics. Impact fracture. Ductile brittle transition. Fatigue. Crack initiation and propagation. Crack propagation rate. Creep. Generalized creep behavior. Stress and temperature effects Applications and Processing of Metals and Alloys Types of metals and alloys. Fabrication of metals. Thermal processing of metals. Heat treatment. Precipitation hardening.
8.	Suggested Books	1. W.D. Callister, **Material Science for Engineers: An Introduction**, John Wily and Sons, Inc. ISBN-10: 0471736961 2. C.S. Barrett, T.B. Massalski, **Structure of Metals**, McGraw Hill,

		New York. ISBN 0070038155 9780070038158 3. D.R. Askeland, P.P. Fulay, W.J. Wright, **The Science and Engineering of Materials**, Global Engineering, ISBN-10: 0495296023 4. P.E.J. Flewitt, R.K. Wild, **Physical Methods for Material Characterization**, Institute of Physics Publishing. 5. J.B. Benedict. Recent Advances in Crystallography, , In Tech. ISBN 978-953-51-0754-5 6. B.D. Cullity Addison **Elements of X-ray Diffraction**, Wesley Publishing Co. 7. A.R. West, **Solid State Chemistry and its Applications**, Wiley Student Edition, ISBN10: 497001471

1.	Course Code	**MM 206**
2.	Title of the Course	**Transport Phenomenon**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Fundamentals of momentum transport. Nature of fluids, Compressibility, Newton's law of viscosity, Newtonian fluid, No-slip condition, Transition to turbulence, Bernoulli equation, Fundamentals of heat transport, Fourier's law of heat conduction, Heat transfer from sphere and circular cylinder, Multiphase flow, Gas-liquid two-phase flow, Solid-liquid two-phase flow, Measurement method, Pressure, Velocity, Heat transfer coefficient, Bubble characteristics such as gas holdup. Mixing and separation, Mixing methods, Separation methods. Transport phenomena in real processes, Refining process, Continuous casting process
8.	Suggested Books	1. A. Ghosh, **Text Book of Materials and Metallurgical Thermodynamics**, Prentice Hall of India Pvt. Ltd. New Delhi 2003. 2. A. K. Mohanty, **Rate Processes in Metallurgy**, Prentice-Hall India Ltd., 2000. 3. G.H. Geiger and D.R. Poirer, **Transport Phenomena in Metallurgy**, Addison- Wesley Publishing Co., Reading, Mass., 1974. 4. Y.K. Rao, **Stoichiometry and Thermodynamics of Metallurgical Processes**, Cambridge Univ. Press, 1985. 5. O.J. Ilegbusi, M. Iguchi, and W. Wahnsiedler, **Mathematical and Physical Modeling of Materials Processing Operations**, Chapman & Hall, 1999.

1.	Course Code	**MM 207**
2.	Title of the Course	**Thermodynamics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Laws of thermodynamics, concepts of reversibility, internal energy, enthalpy, entropy, maximum work, free energy, Maxwell's equations and Gibbs-Helmholtz equation, Clausius-Clapeyron equation, fugacity, activity and equilibrium constant, Sigma function, Concept of chemical potential, homogeneous and heterogeneous equilibria, phase rule, Thermodynamics of solutions, concepts of partial molal properties, Thermodynamics of reversible cells, basic kinetic laws, order of reactions, rate constant, elementary and complex reactions, rate limiting steps, Arrhenius equations, theories of reaction rates – simple collision theory, activated complex theory
8.	Suggested Books	1. A. Ghosh, **Text Book of Materials and Metallurgical Thermodynamics**, Prentice Hall of India Pvt. Ltd. New Delhi, 2003. 2. D.R. Gaskell, **Introduction to Thermodynamics of Materials**, Taylor and Francis, 2003. 3. G.S. Upadhyaya, R.K Dube, **Problems in Metallurgical Thermodynamics and Kinetics**, Pergamon, NewYork, 1982 4. Y.K. Rao, **Stoichiometry and Thermodynamics of Metallurgical Processes**, Cambridge Univ. Press, 1985. 5. J.J. Moore, **Chemical Metallurgy**, Butterworh-Heinemann, 1994.

Course Code	MM 208
Title of the Course	**Theory of Metal Forming**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre–requisite, if any	None
Objectives of the Course	The course emphasizes the fundamental principles of plastic deformation of metals, mechanics associated with the metal forming, mathematical analysis of various forming methods and recent advancements in metal forming.
Outcomes	• Knowledge of mathematical formulation for a given forming process • Application of the knowledge to various forming processes • Analyse the experimental data and able to construct the processing maps
Course Syllabus	• Plasticity: Mohr's circle representation of a state of stress, Yield criteria, Plastic stress vs. strain relations • Mechanics of Metal Forming: Slab analysis, Uniform deformation energy, Slip line field theory, Upper and lower bound methods etc. Concepts of friction hill • Forming Processes: Analysis of plastic deformation in Forging, Rolling, Extrusion, Drawing, Process parameters and Design considerations, Defects and remedies in the forming processes, Sheet metal forming, Forming Limit Diagram • Metallurgical aspects of Metal forming: Concepts of strain rate sensitivity and its importance, Superplasticity, Workability, Introduction to Processing maps and their construction, Microstructural mechanisms during metal working • Advances in Forming: Laser shock forming, HERF techniques, Super-plastic forming, Hydro-forming, Stretch forming etc.
Suggested Books	**Text Books:** 1. G. Dieter, Mechanical Metallurgy, 1988, McGraw Hill, ISBN: 9780071004060. **Reference Books:** 2. W. F. Hosford, R. M. Caddell, Metal Forming: Mechanics and Metallurgy, Cambridge University Press, 2007, ISBN: 9780511354533. 3. A. Sluzalec, Theory of Metal Forming Plasticity: Classical and Advanced Topics, Springer, 2003, ISBN: 9783540406488.

1.	Course Code	**MM 258**
2.	Title of the Course	**Metal Forming Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Experiments on Hot rolling; cold rolling open die forging, closed die forging, Deep drawing, Extrusion, super plastic forming, Hydro forming
8.	Suggested Books	Same as MM 208

Course Code	**MM 258N**
Title of the Course	**Metal Forming Lab**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits 0-0-2-1
Name of the Concerned Discipline	Metallurgical Engineering and Materials Science
Pre–requisite, if any	None
Objectives of the Course	This lab course covers experiments to understand various metal forming processes
Outcomes	• To understand the principles of various metal forming methods. • To analyse the processing parameters and quality control aspects in different processes
Course Syllabus	**List of Representative Experiments:** • Introduction and hands-on training of basic instruments used in metal forming • Determining strain distribution on the stretched aluminium and steel sheets • Open-die forging of steel and aluminium • Close-die forging of steel and aluminium • Determining friction and wear (in relation to the metal forming operations) • Sheet metal forming and determination of FLD at room temperature • Cold and hot rolling of metallic samples • Wire drawing of metallic samples • Extrusion of metallic samples • Quality Control: NDT tests in metal forming • Application of forming: Designing the process flow and manufacturing the actual components • Introduction to metal forming industry practices (with the help of educational videos)
Suggested Books	**Reference Books:** 1. G. Dieter, Mechanical Metallurgy, McGraw Hill, 1988, ISBN: 9780071004060 2. W. F. Hosford, R. M. Caddell, Metal Forming: Mechanics and Metallurgy, Cambridge University Press, 2007, ISBN: 9780511354533. 3. H.S. Ray, B.P Singh, S Bhattacharjee, Energy in Minerals and Metallurgical Processes, Allied Publishers Ltd, 2005, ISBN: 9788177648744.

Course Code	**MM 209**
Title of the Course	**Structure of Materials**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits 2-1-0-1.5 (half semester)
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre–requisite, if any	None
Objectives of the Course	This course discusses about the basic crystallography of solids and the crystal structures of various materials
Outcomes	To understand the crystal structures of various materials which are very important to understand their physical, chemical and mechanical properties
Course Syllabus	• Atomic interactions and bonding • Periodicity in Crystals, Weigner-Seitz Unit Cell, Number of lattice points per Unit Cell, Crystal Systems, Miller Indices of planes and directions, Miller-Bravais Indices • Symmetry elements and point groups • Crystal structures: SC, BCC, FCC, HCP, DC, complex structures or compounds, Reciprocal lattice • Packing of equal spheres in 2-dimensions and 3-dimensions, Voids in Close Packing Size and Coordination of the Voids, Packing of unequal spheres in 3-dimensions and effect of radius ratio
Suggested Books	**Text Books:** 1. W. D. Callister, Jr., Materials Science and Engineering, Wiley, 2007, ISBN: 9781118324578. 2. C. Kittel, Introduction to Solid State Physics, John Wiley & Sons, 2015, ISBN: 8126535180. **Reference Books:** 3. A.R. West, Solid State Chemistry and its Applications, Wiley, 2014, ISBN: 9781119942948.

Course Code	MM 210
Title of theCourse	Powder Metallurgy and Additive Manufacturing
Course Category	Departmental Core
Credit Structure	L-T-P-Credits 2-1-0-1.5 (half semester)
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre-requisite,if any	None
Objectives ofthe Course	This course will cover the principles and practices of metal powderproduction, sintering techniques and basics of additive manufacturing.
Outcomes	To understand the basics and applications of powder metallurgytechniques for engineering applications and additive manufacturing
Course Syllabus	• **Introduction:** Powder Metallurgy Overview, Indian KnowledgeSystem • **Powder production and characteristics:** Mechanical, Chemical, and Physical Production methods, Powdercharacteristics and treatment • **Powder Compaction and Sintering:** Die Compaction, IsostaticCompaction, Green Strength, Solid State Sintering, Hot IsostaticCompaction, Liquid Phase Sintering, Spark Plasma Sintering, Post Sintering Operations and Quality Control • **Introduction to Additive manufacturing:** Binder Jetting, Directed Energy Deposition, Powder Bed Fusion, Laser beam melting, Selective laser sintering • 3D printing of metallic and polymer systems • Typical components manufactured by powder metallurgy
SuggestedBooks	**Text Books:** 1. Anish Upadhyay, Powder Metallurgy: Science, Technologyand Materials, University Press, 2011, ISBN: 9788173717178. 2. R.M. German, Powder Metallurgy- Principles and Applications, MPIF, Princeton, 1994, ISBN: 0976205718. 3. C.K. Chua, and K.F. Leong, 3D Printing and AdditiveManufacturing: Principles and Applications, World Scientific Publishing, 2017, ISBN: 9789813146754. **Reference Books:** 4. P.C. Angelo, R. Subramaniam, Powder Metallurgy - Science, Technology and Application, Prentice Hall India, 2008, ISBN: 9789391818487. 5. ASM Handbook, Vol. 7, Powder Metallurgy, ASM International, 2010, ISBN: 9781627080893.

Course Code	**MM 211**
Title of the Course	**Physics of Materials**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits 2-1-0-1.5 (half semester)
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre–requisite, if any	None
Objectives of the Course	To understand the physical properties of materials using physics concepts
Outcomes	To acquire the knowledge on physical properties of materials using classical and quantum mechanical aspects.
Course Syllabus	• Brief about statistical distributions (MB, FD, BE), Ideal gas, electron gas, Drude model for electron gas, limitation of Drude model, Drude-Sommerfeld model • Free electron theory, Density of energy states, Fermi energy, Fermi surface • Electron in periodic potential, Kronig-Penney model, Nearly free-electron model, Tight-binding approximation, Reciprocal space, Brillouin zones
Suggested Books	**Text Books:** 1. C. Kittel, Introduction to Solid state physics, Wiley, 2017, ISBN: 9788126535187. 2. A. Piroth, Fundamentals of the Physics of Solids, Springer-Verlag, 2009, ISBN: 9783540853152. **Reference Books:** 3. A. Moliton, Solid State Physics for Electronics, Wiley, 2009, ISBN: 9781848210622.

Course Code	**MM 212**
Title of the Course	**Casting and Welding Technology**
Course Category	Departmental Core
Credit Structure	L-T-P- Credits0-0- 2-1
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre–requisite,if any	None
Objectives ofthe Course	This lab course demonstrates experiments in different types of castingand welding technology.
Outcomes	Students will be able to learn experimental skills in casting and weldingtechnology.
Course Syllabus	**List of Representative Experiments** • To study and observe various stages of casting throughdemonstration of Sand- Casting Process (a) To prepare a pattern for given object for lost foam casting. (b) To prepare a molasses sand mold from the prepared pattern • Preparation of as-cast and suction cast Cu-Sn alloy throughdemonstration of Vacuum arc melting cum suction casting technique. • Preparation of light-weight Al-based alloy through demonstration ofstir casting cum squeeze casting technique. • Casting of Steel through demonstration of Induction melting cumcasting technique. • To study TIG and MIG welding process. To prepare weld joint andto study on effect of process parameter on weld joint • To study CMT welding Process. To prepare weld joint using CMTwelding, study on effect of process parameter on weld joint • To study friction stir welding Process. To prepare weld joint using friction stir welding, study on effect of process parameter on weldjoint. • To study Diffusion welding process. To prepare weld joint usingdiffusion welding, study on effect of process parameter on weld joint
Suggested Books	**Reference Books:** 1. A. K. Chakraborti, Casting Technology and Cast Alloys, Prentice Hall India New Delhi, 2005, ISBN: 978-8120327795. 2. G. J. Davies, Solidification and Casting, Applied Science Publishers Ltd, London, 1973, ISBN: 0-853345562. 3. P. L. Jain, Principles of Foundry Technology, McGraw Hill Education, 2017, ISBN: 978-0070151291. 4. Lindberg and Braton, Welding and Other Joining Processes, Ally & Bacon Inc., Boston, 1976, ISBN: 978- 0205050000.

	5. L.M. Gourd, Principles of Welding Technology (2nd Edition),ELBS Longman, 1986, ISBN: 978-8176490290.

Course Code	**MM 214**
Title of the Course	**Materials Characterization**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits2-0-2-3
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre–requisite,if any	None
Objectives ofthe Course	This course will cover the basic principles of X-ray diffraction, scanning electron microscopy and transmission electron microscopy and spectroscopy techniques with instrument details and data acquiring methods
Outcomes	Knowledge of basics of crystallography, Learning of SEM and TEM images analyse and electron diffraction patterns, Understanding and analysis of materials properties using spectroscopic and other techniques.
Course Syllabus	● Spectroscopy: UV-Visible Absorption, Fluorescence and Emission, FT-IR, Raman, XPS, XAS, ARPES, SIMS, XANES, ● X-ray diffraction: Bragg's law, Ewald Sphere, Laue Equations; Powder Diffraction Method, Diffractometer; Structure Factor, Crystal Structure Determination; Peak Broadening; Crystallite Size and Strain Determination; Order-Disorder Transformation; Residual Stress; GI XRD, ● Microscopy: Optical micrography, Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Microanalysis (EDS), Wavelength Dispersive X-ray microanalysis (WDS); EPMA, Scanning tunnelling microscopy (STM), Atomic force microscopy (AFM), Transmission Electron Microscopy (TEM): SADP, STEM, HAADF imaging; EELS, ● Thermal characterization techniques: DSC, TGA, DTA, Dilatometry, ● Representative list of experiments: ▪ Optical bandgap calculation of metal oxide films using UV Visible spectrometer ▪ Study relative emission properties of doped and undoped metal oxide films using Fluorescence ▪ Analyse the surface group polymer materials using FT-IR ▪ Analyze X-ray diffraction patterns of different samples ▪ Microstructural analysis using optical microscope and SEM ▪ TGA analysis of ceramic and polymer samples
Suggested Books	**Text Books:** 1. C.N. Banwell, E. M. McCash, Fundamentals of MolecularSpectroscopy, McGraw Hill, 2017, ISBN: 9352601734. 2. B. D. Cullity, Elements of X-Ray Diffraction, Pearson,

	2001, ISBN: 0201610914. 3. J.I. Goldstein, A.D. Romig, D.E. Newbury, C.E. Lyman, P. Echlin, C. Fiori, D.C. Joy, E. Lifshin, Scanning Electron Microscopy and X-Ray Microanalysis: A Textbook for Biologists, Materials Scientists and Geologists; Springer, 2018,ISBN: 149396674X. 4. D. B. Williams, C. Barry Carter, Transmission Electron Microscopy -A Textbook for Materials Science; Springer, 2009,ISBN: 038776500X. **Reference Books:** 5. H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, InstrumentalMethods of Analysis, C.B.S. Publishers, 1991, ISBN: 0534981445.

Course Code	MM 215
Title of the Course	**Mechanical Behavior of Materials**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre–requisite, if any	None
Objectives of the Course	To introduce the students to basic concepts of plasticity and mechanism of plastic deformation and its relevance to engineering applications
Outcomes	• To understand the different aspects of plasticity. • To know the importance of dislocations in plastic deformation of metals and understand the relevant mechanism for slip and strengthening of metals.
Course Syllabus	• Elasticity: Tensor algebra: Properties of Vectors and Tensor, Transformation of vectors and tensor, Cauchy's stress tensor, Stress deviator, Strain tensor, Elastic stress-strain relations for isotropic solids, strain energy density • Plasticity: Stress-strain curve, Engineering and true values of stress and strains, Elementary theories of plasticity, Theoretical shear strength of crystalline materials, Dislocation theory, Peierls-Nabarro stress, CRSS, Slip and twinning, Dislocation energy and velocity, Schmid analysis • Strengthening mechanisms: Strain hardening of FCC single crystal, Work hardening, Solid Solution Strengthening, Grain boundary Strengthening, Precipitation and dispersion hardening • Fracture and Failure: Ductile and brittle fracture, Charpy and Izod testing, the significance of DBTT, NDT, and FATT, Stress concentration factor, Strain energy release rate, Griffith's theory, LEFM approach, Determination of KIC • Fatigue: Characteristics of fatigue failure, S-N curve, Low and high cycle fatigue, Fatigue crack growth • Creep: Creep curve, Creep mechanisms, Introduction to Ashby map and their construction, Larsen Miller parameter, Development of creep resistant alloys
Suggested Books	**Text Books:** 1. G. Dieter, Mechanical Metallurgy, McGraw-Hill, 1988, ISBN: 9780071004060. 2. T. H. Courtney, Mechanical Behavior of Materials, Waveland Pr Inc, 2005, ISBN: 1577664256. **Reference Books:** 3. R.W. Hertzberg et.al, Deformation & Fracture Mechanics of Engineering Materials, Wiley, 2012, ISBN: 9780470527801.

	4. W. F. Hosford, R. M. Caddell, Metal Forming: Mechanics and Metallurgy, Cambridge University Press, 2007, ISBN: 9780511354533. 5. M. Meyers, K. Chawla, Mechanical Behavior of Materials, Cambridge University Press, 2008, ISBN: 9780511810947.

Course Code	**MM 216**
Title of the Course	**Physical Metallurgy**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits2-1-0-3
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre-requisite,if any	None
Objectives of the Course	This course covers the basic concepts of diffusion, alloy theory, crystal interface and boundaries along with industrial application of metallic and ceramic phase diagrams.
Outcomes	To understand the basics of materials-structure-properties correlations andphase diagrams.
Course Syllabus	- Review of structure of metals and crystal defects: Interface coherence, Interfacial energy effects, Misfit strain effects - Diffusion in solids: Fick's laws of diffusion, diffusion mechanism, Kirkendall effect, Darken's equations, Glissile interface, Interfacemigration - Theory of alloy Phases: Hume-Rothery rule, Solid solution, Intermediate phases, Solid state immiscibility - Phase diagrams: Phase rule, Unary, Binary and Ternary systems,Lever rule, Microstructures, Invariant reactions - Iron-carbon phase diagram: steels and cast irons, Classification offerrous system, International standards - Nucleation rate and different type of growth considerations, TTTand CCT diagrams - Case studies of simple ceramics systems
Suggested Books	**Text Books:** 1. R. Abbaschian, L. Abbaschian, R. E. Reed-Hill, Physical Metallurgy Principles, Cengage Learning, 2009, ISBN: 9780495082545. 2. R.E. Smallman, Modern Physical Metallurgy, Elsevier, 2013,ISBN: 9780080982045. **Reference Books:** 3. D.A. Porter, E.E. Kenneth, M. Sherif; Phase Transformations inMetals and Alloys, CRC press, 2009, ISBN: 9781439883570. 4. F. C. Campbell; Phase Diagrams: Understanding the Basics,ASM International, 2012, ISBN: 9781615038350.

Course Code	**MM 217**
Title of the Course	**Transport Phenomena**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre–requisite, if any	None
Objectives of the Course	The course focuses on the concepts of fluid flow, heat transfer and mass transfer with behaviour and processing of engineering materials.
Outcomes	To learn: • Mathematical foundations of transport phenomena • Fundamental of Momentum transfer, Heat transfer, mass transfer
Course Syllabus	• Mathematical foundations of transport phenomena, Tensors, Control volume formulation and concept of balance • Fundamentals of momentum transport: Navier-Stokes equation, Nature of fluids, Compressibility, Newton's law of viscosity, Newtonian and non-Newtonian fluids, No-slip and No-Shear conditions, Transition to turbulence, Boundary layer theory, Bernoulli equation, exact solutions for simple geometries: rectangular, cylindrical and spherical coordinate systems. Friction factors and correlations. Application of fluid flow solutions to materials processing. • Fundamentals of heat transport: Governing equations for heat transfer, Fourier's law of heat conduction, Exact solutions for heat transfer problems, Empirical correlations, Heat transfer from sphere and circular cylinder, Heat transfer coefficient, Radiation: Black body radiation, Stefan-Boltzman Law, Kirchhoff's Law, heat transfer coupled with fluid flow. • Fundamentals of Mass transfer, Significance of dimensionless numbers, Similarity across transport phenomena.
Suggested Books	**Text Books:** 1. D.R. Poirier and G.H. Geiger: Transport phenomena in materials processing, Springer, ISBN: 9783319485652. 2. R. B. Bird, W. E. Stewart, E. N. Lightfoot: Transport phenomena, Wiley, ISBN: 9788126508082. **Reference Books:** 3. J. R. Welty, C. E. Wicks, R. E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, Wiley, 2008, ISBN: 9780470128688. 4. R. W. Fox, A. T. McDonald, Introduction to Fluid Mechanics, Wiley, 2010, ISBN: 9780470547557.

Course Code	**MM 219**
Title of the Course	**Thermodynamics of Materials**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre-requisite, if any	None
Objectives ofthe Course	The course focuses on basic concept, thermodynamic functions, thermodynamic solutions, phase equilibria, electrochemical cell, reaction equilibria and Free energy composition diagram.
Outcomes	• To learn about the basic concept of thermodynamics, • To understand thermodynamics of solutions, phase equilibria, electrochemical cells, reaction equilibria and free energy compositiondiagram for binary system.
Course Syllabus	• Introduction: Laws of thermodynamics and its applications, Carnot Cycle, Statistical interpretation of entropy and disorder • Thermodynamic functions: Helmholtz free energy, Gibbs free energy, Maxwell's relations, Gibbs-Helmholtz equations • Thermodynamic of open systems: Concept of Chemical potential, fugacity, activity • Thermodynamics of solutions: Raoult's and Henry's Law, activity of a component, Regular solutions, Gibbs-Duhem equation and its application, non-ideal solutions, Sievert's Law, activity and alternative standard states, dilute solutions and interaction parameters. • Phase equilibria in single component system: variation of Gibbs free energy with temperature and pressure, Clausius-Clapeyron equation, P-T diagram • Reaction Equilibria: Equilibrium constant, Reaction equilibria for (a) homogeneous reactions consisting of gas mixtures, (b) heterogeneous reactions consisting of condensed phases and gas mixtures, Ellingham Diagram • Introduction to Free energy composition diagram

Suggest edBooks	**Text Books:** 1. R. A. Swalin, Thermodynamics of Solids, Wiley-VCH; 1972,ISBN**:** 970471838548. 2. D. R. Gaskell, Introduction to Thermodynamics of Materials,CRC Press, 2008, ISBN: 9781439851500. **Reference Books:** 3. L. Darken and R. W. Gury, Physical Chemistry of Metals, CBSPublisher, 2002, ISBN**:** 9788123914794. 4. D.A. Porter and K.E. Easterling, Phase Transformation CRCPress, 2009, ISBN: 9781420062106. 5. D.A. Porter, K.E. Easterling, M. Sherif; Phase Transformationsin Metals and Alloys, CRC Press, 2009, ISBN: 9781439883570.

Course code	**MM 228**
Title of thecourse	**Ceramic Science and Technology**
Course Category	Department Elective
Credit Structure	L - T - P – Credits 2-1-0-1.5 (half semester)
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre-requisite,if any	None
Objectives ofthe course	The course provides fundamental aspects of ceramics and theirapplications.
Outcomes	• To acquire knowledge of fundamental principles that govern thestructure of ionically & covalently bonded ceramics, including glasses, refractories, electro ceramics, etc. • To gain insights into defect formation mechanisms in ceramics andtheir impact on the functional properties of the ceramics
Course Syllabus	• Definitions and classifications; Pauling's rules. • **A Few Important Binary & Complex Structure:** Rock-Salt, Fluorite, Spinel, Perovskite, Silicates, Mullite, Olivine, Garnet, etc. • Sintering Phenomenon in Polycrystalline Ceramics • **Defects in Ceramics:** Stoichiometric and non-stoichiometric defects; Kröger-Vink notation; Defect equilibria & Brouwer diagrams. • **Glass:** Definition; Formation mechanism; Structure models;Zachariasen's rules; Network formers, modifiers, and intermediates. • **Application of Ceramic Materials:** Glass industry; Glazes &Enamels; Whitewares; Cement & Concrete; Advanced ceramics - energy storage, microelectromechanical systems,optoelectronic devices, etc

Suggest edBooks	**Text Books:** 1. D. Kingery, H. K. Bowen, and D. R. Uhlmann, Introduction to Ceramics, 2nd Edition, Wiley India Pvt. Ltd., 2012, ISBN:978-8126539994. **Reference Books:** 2. Richard J. D. Tilley, Defects in Solids, John Wiley & Sons,2018, ISBN: 9780470077948. 3. Anthony R. West, Solid State Chemistry and its Applications,Wiley, 2014, ISBN: 978-1119942948. 4. K. P. Misra and R.D.K. Misra, Ceramic Science and Engineering: Basics to Recent Advancements, Elsevier, 2022, ISBN: 9780323899567.

Course Code	**MM 230**
Title of the Course	**Diffusion in Solids**
Course Categor y	Department Elective
Credit Structure	L-T-P-Credits 2-1-0-1.5 (half semester)
Name of the Concerned Departmen t	Metallurgical Engineering and Materials Science
Pre-requisite if any	Familiarity with materials science fundamentals, encompassing materials thermodynamics and material structures, is preferred.
Objectives ofthe Course	This course provides in-depth understanding of solid-state diffusionprocesses and explores its significance in practical applications.
Outcomes	• To get understanding of diffusion phenomena • To be able to solve diffusion equations for various processes andselecting appropriate diffusion coefficient types
Course Syllabu s	• Laws of diffusion: Basic concepts of thermodynamics related to diffusion, Various frames of reference used for measuring diffusion fluxes, application of diffusion to various metallurgical processes • Atomic mechanism of diffusion: Formation of defects, mechanisms of diffusion, concept of random walk, diffusion in ordered phases • Diffusion parameters: Various diffusion coefficients, experimental determination, Matano-Boltzmann analysis, Den Broeder and Wagner's approach, Problem of finding the initial contact plane.
Suggest edBooks	**Text Books:** 1. P. Shewmon, Diffusion in solids, Springer, 2016, ISBN:9780873391054. 2. J. Philibert, Atom movements: Diffusion and mass transports insolids, EDP Sciences, 2012, ISBN: 2759801721. **Reference Books:** 3. H. Mehrer, Diffusion in solids: fundamentals, methods, materials,diffusion-controlled processes, Springer, 2009, ISBN: 0263849058. 4. D. A. Porter, and K. E. Easterling, Phase transformations in metalsand alloys, Nelson Thornes Ltd, 2009, ISBN: 0412450305.

Course code	**MM 232**
Title of the course	**Thin Film Technology**
Course Category	Department Elective
Credit Structure	L-T-P-Credits 2-1-0-1.5 (half semester)
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre-requisite ifany	Fundamentals of Materials Science
Objectives ofthe Course	This course introduces the concepts of physics of vacuum science, thinfilm formation and the various methods to develop thin films.
Outcomes	Upon completion of the course, students will understand the science ofthin film growth, various technologies to develop thin films and their applications.
Course syllabus	Fundamentals of nucleation and film formation, Introduction to vacuumscience and technology, Thin film deposition techniques: Physical Vapour Depositions: resistive heating and electron beam evaporations, sputtering, magnetron sputtering, reactive sputtering, RF sputtering, pulsed laser deposition. Chemical Vapour Deposition Methods: atmospheric pressure (APCVD), low pressure (LPCVD), Ultra-High Vacuum (UHVCVD), Microwave Plasma-Assisted (MPCVD), plasma enhanced (PECVD); Atomic layer deposition, Molecular beam epitaxy (MBE).
Suggested Books	**Text Books:** 1. K. L. Chopra, Thin Film Phenomena, McGraw-Hill, 1969,ISBN: 9780070107991. 2. M. Ohring, The Materials Science of Thin Films, AcademicPress Inc., 1991, ISBN: 9780125249904. **Reference Books:** 3. A. Gowsami, Thin Film Fundamentals, New Age International1996, ISBN: 978-8122408584.

Course Code	**MM 257**
Title of the Course	**Metallography Lab**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits0-0-2-1
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre-requisite,if any	None
Objectives ofthe Course	This lab course demonstrates the experiments to understand the fundamentaland microstructural aspects of Physical Metallurgy
Outcomes	• To learn various metallographic preparation techniques. • To learn experimental and numerical methods for analysis in PhysicalMetallurgy
Course Syllabus	**List of Representative Experiments:** • Metallographic sample preparation (grinding, polishing) of ferrous alloys, and non-ferrousalloys • Metallographic sample preparation of ceramic and compositesamples • Optical Microscopy of typical carbon steel and stainless-steelsamples • Optical microscopy of cast irons • Optical Microscopy of typical non-ferrous samples • Optical microscopy of typical ceramic and composite samples • Effect of different etchants to observe microstructure of steel samples • Quantitative microstructural analysis • Determination of ASTM grain size and Inclusion rating of steel • Effect of cooling rate on microstructure evolution of steel samples • Microstructure observations of cold worked, hot worked, annealedand decarburised samples

Suggested Books	**Reference Books:** 1. R. Abbaschian, L. Abbaschian, R. E. Reed-Hill, Physical Metallurgy Principles, Cengage Learning, 2009, ISBN: 970495082545. 2. D.A. Porter, K.E. Easterling, M. Sherif, Phase Transformations in Metals and Alloys, CRC Press, ISBN: 9781439883570. 3. F. C. Campbell, Phase Diagrams: Understanding the Basics, ASMInternational, ISBN: 9781615038350. 4. R.E. Smallman, Modern Physical Metallurgy, Elsevier, 2013, ISBN: 9780080982045.

Course Code	**MM 255**
Title of the Course	**Mechanical Behaviour of Materials Lab**
Course Category	Departmental Core
Credit Structure	L-T-P-Credits 0-0-2-1
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre-requisite, if any	None
Objectives of the Course	This lab course demonstrates basic experiments to understand mechanical behavior of materials
Outcomes	To learn various experiments about mechanical properties of materials and understand its analysis
Course Syllabus	**List of Representative Experiments:** • Determination of Brinell, Vickers, and Rockwell hardness of materials • Determination of impact toughness by Izod and Charpy method • Determination of quasi-static tensile and compression properties of the given metallic alloys at room/high temperatures from the stress vs. strain curves • Determination of bending strength of materials and fracture toughness measurement using the three-point bending method. • Determination of full-field displacement of a given tensile / compression sample using digital image correlation. • Development of the creep curve of a given sample • Determination of high strain rate compression strength of given metallic sample • Fractographic examination using SEM
Suggested Books	**Reference Books:** 1. A.V.K. Suryanarayana, Testing of Metallic Materials, Prentice Hall, 1979, ISBN: 9789352300372. 2. G. Dieter, Mechanical Metallurgy, 1988, McGraw Hill, 1988, ISBN: 9780071004060.

Course Code	**MM 221**
Title of the Course	**Finite Element Simulations in Materials**
Course Category	Department Elective
Credit Structure	L-T-P-Credits 2-1-0-1.5 (half semester)
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre–requisite, if any	None
Objectives of the Course	The course covers the basic concepts of finite element methods analysis
Outcomes	• Learning of basic concepts of FEM • Application of FEM analysis for problems in materials engineering
Course Syllabus	• **Basic concepts:** The standard discrete system, Finite elements of an elastic continuum-displacement approach, Generalization of the finite element concepts; weighted residual and variational approaches. Strong form and weak form. • **Finite element method:** Displacement approach, Stiffness matrix and boundary conditions, Natural coordinates, Element types: triangular, rectangular, quadrilateral, Isoparametric elements and numerical integration: One dimensional and two dimensional. • **Application to structural mechanics problems:** plane stress and plane strains. Few examples on solving boundary value problems using MATLAB/ABAQUS/COMSOL software.
Suggested Books	**Text Books:** 1. C. S. Krishnamoorty, Finite Element Analysis, McGraw Hill, 2017, ISBN: 9780074622100. 2. D. V. Hutton, Fundamentals of Finite Element Analysis, McGraw Hill, 2017, ISBN: 9780070601222. **Reference Books:** 3. S. S. Rao, Finite Element Method in Engineering, Elsevier, 2004, ISBN: 0750678283. 4. Erik G. Thompson, Introduction to the Finite Element Method: Theory, Programming and Applications, Wiley, 2004, ISBN: 9780471267539. 5. H. C. Martin, G. F. Carey, Introduction to Finite Element Analysis - Theory and Application, McGraw Hill, 1975, ISBN: 0070994390.

Course Code	**MM 223**
Title of the Course	**Statistical Mechanics for Materials Science**
Course Category	Department Elective
Credit Structure	L-T-P-Credits 2-1-0-1.5 (half semester)
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre–requisite, if any	None
Objectives of the Course	Understanding the fundamental ideas of statistical mechanics and its importance in materials science and engineering
Outcomes	To apply the concepts of statistical mechanics in materials engineering
Course Syllabus	• **Introduction to statistical mechanics**: Significance of statistical mechanics, Probability & Statistics, Concept of Macrostate, Microstate and Ensembles • **Classical Statistical Mechanics**: Microcanonical, Canonical and Grand Canonical ensemble, Phase Space, Maxwell-Boltzmann Distribution Law • **Quantum Statistical Mechanics**: Identical particles, Fermions and Bosons, Fermi- Dirac distribution function. Effect of temperature on Fermi-Dirac distribution function, Density of States, Fermi-energy. Bose Einstein distribution function and Bose- Einstein Condensation, Materials properties based on quantum statistical mechanics
Suggested Books	**Text Books:** 1.B. Bagchi, Statistical Mechanics for Chemistry and Materials Science, CRC Press, 2018, ISBN: 9780429833601. 2. R. K. Pathria, Statistical Mechanics, Oxford, 1997, ISBN: 0750624698. **Reference Books:** 3. K. Huang, Statistical Mechanics, Wiley, 2008, ISBN: 9788126518494.

Course Code	**MM 225**
Title of the course	**Materials Economics and Sustainability**
Course Category	Department Elective
Credit structure	2-1-0-1.5 (half semester)
Name of the concerned department	Metallurgical Engineering and Materials Science
Pre-requisite, if any	Nil
Objectives of the course	The course aims to provide students with knowledge of economic considerations in materials engineering and importance of materials sustainability
Outcomes	• Economic impact of materials • Material selection towards sustainability and understanding of materials for future trends
Course syllabus	• Introduction to the relationship between material cost, abundance, and usage, cost of Materials: raw materials, processing/purification, materials transport etc, The technological aspect of material cost, role of materials economy in manufacturing • Economics of engineering materials design and selection, cost reduction using materials engineering • Application-driven economics and future materials, Sustainable materials and circular economy, life cycle of important metals, market analysis of engineering materials; Production, consumption and price trends of metals
Suggested books	**Text Books:** 1. M. F. Ashby, Materials and Sustainable Development, Butterworth-Heinemann, 2015, ISBN: 0081001762. 2. P. Heck, Material Flow Management Systems, Technology and Finance for a Sustainable Future, Springer, ISBN: 9783540360155 **Reference Books:** 3. A. G. Peñas, Gaurav Sharma, New Materials for a Circular Economy, Materials Research Forum, 2023, ISBN: 1644902621. .

Course Code	**MM 229**
Title of the Course	**Nucleation and Crystal Growth**
Course Category	Department Elective
Credit Structure	L-T-P-Credits 2-1-0-1.5 (half semester)
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre-requisite, if any	Fundamentals of Materials Science
Objectives of the Course	To introduce the students with the fundamentals physical processes involved in the nucleation and growth of crystals
Outcomes	Upon completion of the course, students are expected to gain an understanding of the fundamental physical and chemical processes which are involved in crystal growth.
Course Syllabus	• Nucleation phenomena, concepts of critical nucleus, types of nucleation, theory of nucleation, mechanism and growth kinetics ofisolated crystals. • Introduction to various crystal growth techniques (solution, gel, meltand vapour), low temperature solution growth, high temperature solution growth, solubility phase diagram, types of gels, Single and double diffusion method, chemical reduction method, Bridgman Technique, Czochralski Technique, Zone melting Technique, hydrothermal method.
Suggested Books	**Text Books:** 1. I. V. Markov, Crystal Growth for Beginners, World Scientific,2004, ISBN: 9789812382450. 2. H.L. Bhat, Introduction to Crystal Growth: Principles and Practice, Taylor & Francis, CRC Press, 2014, ISBN: 9781439883334. **Reference Books:** 3. G. Dhanaraj, K. Byrappa, V. Prasad, M. Dudley. Handbook ofCrystal Growth, Springer, 2010, ISBN: 9783540741824.

1.	Course Code	**MM 301**
2.	Title of the Course	**Polymer Technology**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Chemistry of high polymers: Monomers, functionality, degree of polymerizations, classification of polymers, glass transition, melting transition, criteria for rubberiness, polymerization methods: addition and condensation; their kinetics, metallocene polymers and other newer techniques of polymerization, copolymerization, monomer reactivity ratios and its significance, kinetics, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for copolymerization-bulk, solution, suspension, emulsion. Polymer Characterization: Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, polymer crystallinity, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques. Synthesis and properties: Commodity and general purpose thermoplastics: PE, PP, PS, PVC, Polyesters, Acrylic, PU polymers. Engineering Plastics: Nylon, PC, PBT, PSU, PPO, ABS, Fluoropolymers Thermosetting polymers: PF, MF, UF, Epoxy, Unsaturated polyester, Alkyds. Natural and synthetic rubbers: Recovery of NR hydrocarbon from latex, SBR, Nitrile, CR, CSM, EPDM, IIR, BR, Silicone, TPE. environmental stress cracking resistance
8.	Suggested Books	1.

1.	Course Code	**MM 351**
2.	Title of the Course	**Polymer Technology Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Polymer testing: Mechanical-static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness. Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, swelling, ageing resistance
8.	Suggested Books	Same as MM 301

1.	Course Code	**MM 302**
2.	Title of the Course	**Welding and Foundry Engineering**
3.	Credit Structure	L-T-P-Credits: 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	**Casting Process:** Introduction to casting, pattern materials, allowances, coding, types, moulds, mould making, sand, properties, types and testing of sands, core making, type of cores, single box, two box and 3 box moulding processes, runner, riser and gate. **Special Casting Processes:** Pressure die casting, Centrifugal, continuous, investment, shell moulding, squeeze, electro slag casting, CO_2 moulding, Plaster mould castings, Antioch process, Slush casting **Welding Processes:** Introduction to soldering, brazing and welding types of joining, plane of welding, edge preparation, filler material, flux, shielding gases, fusion welding, gas welding, gas flame types, manual arc welding, arc theory, power supply, braze welding, Thermit welding, Resistance welding, spot, seam, projection, percussion & flash. **Special Welding Processes:** Atomic, H_2 arc welding, Shielded gas arc welding, GMAW, GTAW, Submerged arc welding, Electro slag welding, friction welding, explosive welding, Underwater welding, Diffusion bonding, EBW, LBW, PAW, Stud welding, welding of dissimilar materials, Friction stir welding.
8.	Suggested Books	1. Lindberg and Braton, **Welding and Other Joining Processes**, Ally & Bacon Inc., Boston, 1976. 2. Flinn, **Fundamentals of Metal Casting**, Addison-Wesley, Reading, 1963. 3. J. Szekely, J.E. Evans, J.K. Brimacambe, **The Mathematical and Physical Modelling of Primary Metal Processing Operations**, Wiley, 1988. 4. H.S. Ray, **Kinetics of Metallurgical Reactions**, Oxford & IBH Publishing Co. Pvt. Ltd., 1993. 5. J. Szekely, J.W. Evans and H.Y. Sohn, **Gas–Solid Reactions**, Academic Press, New York, 1976. 6. L.M. Gourd, **Principles of Welding Technology (**2ndEdition**)**, ELBS Longman, 1986. 7. A. C. Davies, **Welding**, Cambridge University Press, 1996. 8. P. L. Jain, **Principles of Foundry Technology**, Tata McGraw Hill, 2001. 9. Heine, Loper and Rosenthal, **Principles of Metal Casting**, Tata McGraw Hill, 1996 10. A. K. Chakraborti, **Casting Technology and Cast Alloys**,

		Prentice Hall India New Delhi, 2005.

1.	Course Code	**MM 352**
2.	Title of the Course	**Welding and Foundry Engineering Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	GMA & MMA Welding Practice and Demonstration + TIG Welding Demonstration & Polymer Joining 1 Brazing and Gas Welding Practice and Demonstration Demonstration & Practice of thermocole pattern making, molasses mold making + Demonstration of green sand mold making, and metal pouring in both molds
8.	Suggested Books	1. Lindberg and Braton, **Welding and Other Joining Processes**, Ally & Bacon Inc., Boston, 1976. 2. Flinn, **Fundamentals of Metal Casting**, Addison-Wesley, Reading, 1963. 3. J. Szekely, J.E. Evans, J.K. Brimacambe, **The Mathematical and Physical Modelling of Primary Metal Processing Operations**, Wiley, 1988. 4. H.S. Ray, **Kinetics of Metallurgical Reactions**, Oxford & IBH Publishing Co. Pvt. Ltd., 1993. 5. J. Szekely, J.W. Evans and H.Y. Sohn, **Gas–Solid Reactions**, Academic Press, New York, 1976. 6. L.M. Gourd, **Principles of Welding Technology (**2nd Edition**)**, ELBS Longman, 1986. 7. A. C. Davies, **Welding**, Cambridge University Press, 1996. 8. P. L. Jain, **Principles of Foundry Technology**, Tata McGraw Hill, 2001. 9. Heine, Loper and Rosenthal, **Principles of Metal Casting**, Tata McGraw Hill, 1996 10. A. K. Chakraborti, **Casting Technology and Cast Alloys**, Prentice Hall India New Delhi, 2005.

1.	Course Code	**MM 303**
2.	Title of the Course	**Introduction to Electrochemistry**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	**Electrode-electrolyte interface:** The electrical double layer. The Helmholtz-Perrin parallel-plate model, Gouy-Chapman diffuse-charge model and the Stern model. **Corrosion:** Electrochemical mechanism of corrosion. Types of corrosion, various methods of corrosion control. D.C **Polarography:** Dropping mercury electrode-polarography Instrumentation-polarogram. **Types of limiting Currents:** Adsorption, Diffusion, Kinetic. Ilkovic equation and its consequences. Applications of polarography. Determination of stability constant of complex. **Cyclic Voltammetry:** Principle, instrumentation, reversible and irreversible cyclic voltammograms. Applications. Cyclic voltammetric study of insecticide parathion. **Electro-Organic synthesis:** Electro chemical reduction of carboxylic acids, Electrochemical reduction of nitro compounds. **Anodic oxidation of metals:** Characteristics of anodic oxide films. Instrumentation –break down voltage. Industrial applications of anodic oxide films
8.	Suggested Books	1. J.O.M. Bockris, A.K.N. Reddy, **Modern Electrochemistry** Plenum Publishers, 2000 2. S. Glasstone, **Introduction to Electrochemistry**, 2012 3. D. Pletcher, **Industrial Electrochemistry**, Chapman & Hall 4. Lowenheim, **Fundamental Principles of Modern Electroplating**, John Wiley & Sons Inc. New York, 2011

1.	Course Code	**MM 304**
2.	Title of the Course	**Corrosion Engineering**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	The technology & evaluation of corrosion. Economics, safety, electrochemical nature of corrosion, the forms of corrosion and corrosion rate determination. Electrochemical thermodynamics and electrode potential. Electrode sign conventions, potential/pH diagrams, and experimental measurements. Electrochemical kinetics of corrosion. Faraday's Law, mixed potential theory, experimental methods, and instrumentation. Passivity and properties of passive films on metals. Alloy evaluation and experimental methods. Polarization methods for measuring corrosion rates. Tafel extrapolation & polarization resistance, instrumental methods and commercial corrosion monitoring devices. Galvanic, concentration cell, pitting and crevice corrosion. How to characterize the different forms of corrosion, their evaluation and prevention methods. Effects of metallurgical structure on corrosion. Intergranular corrosion, weldment corrosion, and susceptibility to hydrogen damage. Corrosion in selected corrosive environments. Specific examples of typical corrosion problems encountered in engineering applications, sulfur bearing solutions, soils, acids, and concrete. Coatings & inhibitors. Organic coatings, paints, metallic coatings, inhibitors. Materials selection and design. Alloy selection, designing to prevent corrosion, and economics
8.	Suggested Books	1. M.G. Fontana, N.D. Greene, **Corrosion Engineering**, McGraw-Hill, New York, 1978. 2. H.H. Uhlig, R.W. Revie, **Corrosion and Corrosion Control** (3^{rd} Ed), Jonh Wiley & Sons Inc. New York, 1985. 3. K.R. Trethewey, J. Chamberlain, **Corrosion for Students of Science and Engineering**, Longman Sci. & Technical, 1988. 4. A.J. Bard, L.R. Faulkner**, Electrochemical Methods: Fundamentals & Applications**, John Wiley & Sons Inc. New York, 1980.

1.	Course Code	**MM 354**
2.	Title of the Course	**Corrosion Engineering Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Principle of corrosion protection, methods of corrosion protection, better design, materials selection, barrier coatings, cathodic protection, anodic protection, inhibitor chemicals. Tools for corrosion inspection, corrosion monitoring, corrosion management
8.	Suggested Books	1. M.G. Fontana, N.D. Greene, **Corrosion Engineering**, McGraw-Hill, New York, 1978. 2. H.H. Uhlig, R.W. Revie, **Corrosion and Corrosion Control** (3^{rd} Ed), Jonh Wiley & Sons Inc. New York, 1985. 3. K.R. Trethewey, J. Chamberlain, **Corrosion for Students of Science and Engineering**, Longman Sci. & Technical, 1988. 4. A.J. Bard, L.R. Faulkner**, Electrochemical Methods: Fundamentals & Applications**, John Wiley & Sons Inc. New York, 1980.

1.	Course Code	**MM 305**
2.	Title of the Course	**Iron and Steel Making**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Classification of furnaces; different kinds of furnaces; heat balance, energy conservation and energy audit; parts, construction and design aspects of blast furnace (B/F), ancillary equipment; blast furnace instrumentation Blast furnace reactions; partitioning of solute elements between the metal and the slag; reactions in blast furnace; blast furnace slags; mass balance and heat balance calculations Blast furnace operations; B/F irregularities and remedial measures, B/F refractories and causes of failure, modern trends in B/F technology; overview of direct reduction processes, electric smelting; production of DRI (HBI/Sponge iron) Review of traditional steel making; thermodynamics of steelmaking; air/O2 impurity interaction, slag metal interaction; foaming slag; removal of S and P; de-oxidizers, refining, alloying Open hearth furnace; Bessemer converter; bottom blown and top blown processes; slag practices and sequencing; LD, VD, AOD and VOD; ladle metallurgy and injection metallurgy; electric arc furnace and DRI usage; ingot casting and continuous casting; energy, environmental and quality considerations
8.	Suggested Books	1. O. P. Gupta, **Elements of Fuels, Furnace and Refractories** (2nd Edition), Khanna Publications Delhi, 1990. 2. G.R, Bashforth, **Manufacture of Iron and Steel** (Vol. I-IV), Asia Publ., 1996. 3. R.H. Tupkary, V.R., Tupkary **Modern Iron Making**, Khanna Publications, Delhi, 2004

1.	Course Code	**MM 306**
2.	Title of the Course	**Powder Metallurgy**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Introduction: Development of powder metallurgy-scope of powder metallurgy, characterization of metal powders, physical properties-particle size and shape determination, technological properties-apparent density, flow rate etc. and chemical properties. Powder manufacture: Reduction, electrolysis, and atomization processes. Compaction and sintering: Die compaction and other consolidation techniques, sintering, sintering with liquid phase. Powder metallurgy products: Bearing, filters, friction parts, hard metals, refractory metals, contact materials, magnetic materials, structural parts, dispersion strengthened materials.
8.	Suggested Books	1. G.S. Upadhyaya, **Powder Metallurgy Technology**, Cambridge International Science Publishing, 1998. 2. P.C. Angelo, R. Subramaniam, **Powder Metallurgy - Science, Technology and Application,** Prentice Hall India Ltd. New Delhi, 2008. 3. R.M. German, P**owder Metallurgy- Principles and Applications**, MPIF, Priceton, 1994. 4. ASM Handbook, Vol. 7, Powder Metallurgy, ASM International, 2010.

1.	Course Code	**MM 307**
2.	Title of the Course	**Composites**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Introduction General characteristics of composites; advantages and disadvantages, application trends. Basic Materials Characteristics of fibers, matrices, interface bonding, adhesives; microstructure of composites. Processing/Manufacturing Traditional and novel approaches; process fundamentals. Composite Micromechanics Basic concepts, stiffness, strength, thermal and moisture expansion. Composite Mechanics Theory Laminate theory; use of a computer based analysis package; macromechanical behavior of a ply, out-of-plane effects. Failure and Strength Design Failure criteria, Laminate Strength, Stress Concentrations. Composite Behavior and Applications How do actual composites for aerospace, automotive, sporting goods, high temperature applications behave? Problem areas, long-term performance, influence of structural geometries
8.	Suggested Books	1. K.K. Chawala, **Composite Materials** (2^{nd} ed.), Springer-Verlag, New York, 1987. 2. P.M. Ajayan, L.S. Schadler, P.V. Braun, **Nanocomposite Science and Technology**, Wiley-VCH Verlag GmbH Co. KGaA, Weinheim, 2003. 3. V.V. Vasiliev, E.V. Morozov, **Mechanics and Analysis of Composite Materials**, Elsevier Science Ltd, The Boulevard, Langford Lane, Kidlington, Oxford OX5 lGB, UK, 2001. 4. K.K. Chawala, **Ceramic Matrix Composites**, (1^{st} ed.), Chapman & Hall, London, 1993 5. G. Piatti, **Advances in Composite Materials**, Applied Science Publishers Ltd., London, 1978

1.	Course Code	**MM 357**
2.	Title of the Course	**Composites Development Lab**
3.	Credit Structure	L-T-P-Credits 0-0-3-1.5
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Fabrication of Metal Matrix Composites: Commonly used Matrices,Basic Requirements in Selection of constituents, solidification processing of composites - XD process, Spray processes - Osprey Process, Rapid solidification processing, Dispersion Processes - Stir-casting & Compocasting,Screw extrusion, Liquid metal impregnation technique - Squeeze casting,Pressure infiltration, Lanxide process, Pinciple of molten alloy infiltration, rheological behaviour of meltparticle slurry, Synthesis of In situ Composites; Fabrication of Polymer Matrix Composites - Commonly used Matrices Basic Requirements in selection of Constituents, Moulding method, Low pressure closed moulding, pultrusion, Filament winding, Fabrication of ceramic matrix composites - Various techniques of vapour deposition, Liquid phase method and Hot pressing etc., Fabrication of nano-composites
8.	Suggested Books	1. K.K. Chawala, **Composite Materials** (2nd ed.), Springer-Verlag, New York, 1987. 2. P.M. Ajayan, L.S. Schadler, P.V. Braun, **Nanocomposite Science and Technology**, Wiley-VCH Verlag GmbH Co. KGaA, Weinheim, 2003. 3. V.V. Vasiliev, E.V. Morozov, **Mechanics and Analysis of Composite Materials**, Elsevier Science Ltd, The Boulevard, Langford Lane, Kidlington, Oxford OX5 lGB, UK, 2001. 4. K.K. Chawala, **Ceramic Matrix Composites**, (1st ed.), Chapman & Hall, London, 1993 5. G. Piatti, **Advances in Composite Materials**, Applied Science Publishers Ltd., London, 1978

1.	Course Code	**MM 308**
2.	Title of the Course	**Thin films and Nano-Structures**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Physics of low-dimensional materials, 1D, 2D and 3D confinement, Density of states, Excitons, Coulomb blockade, Surface plasmon, Size and surface dependence of physical, electronic, optical, luminescence, thermodynamical, magnetic, catalysis, gas sensing and mechanical properties. Physical and chemical techniques for nanomaterial synthesis, Assembling and self organization of nanostructures, Nanoscale manipulation, N Physical Vapor Deposition - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species Evaporation of elements, compounds, alloys, Raoult's law; e-beam, pulsed laser and ion beam evaporation, Glow Discharge and Plasma, Sputtering - mechanisms and yield, dc and rf sputtering, Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Hybrid and Modified PVD- Ion plating, reactive evaporation, ion beam assisted deposition, Chemical Vapor Deposition - reaction chemistry and thermodynamics of CVD; Thermal CVD, laser & plasma enhanced CVD, Chemical Techniques - Spray Pyrolysis, Electrodeposition, Sol-Gel and LB Techniques, Nucleation & Growth: capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & mechanisms, amorphous thin films, Epitaxy - homo, hetero and coherent epilayers, lattice misfit and imperfections, epitaxy of compound semiconductors, scope of devices and applications.
8.	Suggested Books	1. D. Mobius, R. Miller, **Organized Monolayers and Assemblies: Structure, Processes and Function**, Elsevier Science 2004 2. M. Rieth, **Nano Engineering in Science & Technology,** World Scientific Publishing Co., Inc 2003 3. K. Holmberg, B. Jonsson, B. Kronberg, B. Lindman, **Surfactants and Polymers in Aqueous Solution**, Wiley 2004. 4. J. Lyklema, **Fundamentals of Interface and Colloid Science**, Academic Press, 5. Z.L Wang **Characterization of Nanophase Materials,** Wiley VCH, 2000.

		6. G. Schmidt, **Nanoparticles: From theory to applications**, Wiley, 2004. 7. D.F. Evans and W. Hkan, **The Colloidal Domain: Where Physics, Chemistry, Biology, and Technology Meet**, Wiley VCH 1999.

1.	Course Code	**MM 309**
2.	Title of the Course	**Computational Methods for Materials**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Atomistic Level Modelling: Review of thermodynamic laws, micro & macro state, ergodic system, partition function, statistical mechanics, thermodynamic ensembles, Monte Carlo simulation- Markov process, algorithm and application of MC simulation (percolation problem etc). molecular dynamics- force fields, MD algorithm, accelerating MD, verlet algo, leap frog method, velocity verlet method, gear algo, particle mesh method, multipole method, fast multipole method. multiscale modelling & simulation of materials, System size vs computation time, Parallel processing. Ab Initio Methods: Density functional theory, quantum mechanics, schrodinger wave equation, many particle system, car parrinello method, born openheimer approximation, hohenberg-kohn theorem, kohn sham formulation, local density approximation, bloch's theorem, pseudo potential, energy minimisation techniques, examples of crystals and non-crystals. Lattice Mesoscale methods: Lattice gas automata, lattice director model. Coarse graining: Particle based models-Lattice gas model, connolly williams approximation, spatial models, dynamic (temporal) models, application to polymer and polar materials. grain continuum modelling, computational micro-mechanics, multiscale coupling. Term Paper on application of Multiscale Modelling to Composite damage Dislocation behaviour Phase field modelling Modelling of grain growth and microstructure in polycrystalline materials Modelling of structural materials And other recent advances based on literature survey
8.	Suggested Books	1. K. Ohno, K. Esfarjani, Y. Kawazoe, **Computational Material Science,** Springer, 2003. 2. Z. H. Barber, **Introduction to Materials Modeling**, Maney Publishing, 2001.

1.	Course Code	**MM 310**
2.	Title of the Course	**Ceramics Technology**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	**Refractories:** Classification, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application. **Whitewares:** Classification and type of Whitewares, Elementary idea of manufacturing process technology including body preparation, basic properties and application areas. **Ceramic Coatings:** Types of glazes and enamels, Elementary ideas on compositions, Process of enameling & glazing and their properties. **Glass:** Definition of glass, Basic concepts of glass structure, Batch materials and minor ingredients and their functions, Elementary concept of glass manufacturing process, Different types of glasses, Application of glasses. **Cement and Concrete:** Concept of hydraulic materials, Basic raw materials, Manufacturing process, Basic compositions of OPC, Compound formation, setting and hardening, Tests of cement and concrete.
8.	Suggested Books	1. M. Barsoum, M.W. Barsoum, **Fundamentals of Ceramics**, CRC Press, 2002, ISBN 9780750309028. 2. F. Singer, **Industrial Ceramics,** Springer, 2013. ISBN: 9401752591. 3. W.D. Kingery, **Introduction to Ceramics,** 1960, ISBN: 0471478601. 4. F.H. Norton, **Elements of Ceramics,** 1952 ISBN: 9780201053067 5. W.F. Smith, **Principles of Materials Science and Engineering,** 1986, ISBN: 0073529249.

Course Code	**MM 405/ MM 605**
Title of the	**Green Hydrogen: Materials and Technologies**

1.	Course Code	**MM 402/ MM 602**
2.	Title of the Course	**Design and Selection of Materials**
3.	Credit Structure	L-T-P-Credits: 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Materials and Design, Evolution of Engineering Materials, Material Resource in Indian Context, Classification of Materials, Materials Selection for automotive and aerospace. Material Properties; The Role of Crystal Structure. Metals and Metallic Structure, metallic alloys, ceramics & glasses, Introduction to Polymeric Materials, Phases and microstructure of Polymers, Polymers for Mechanical Design, Material Selection using Ashby Method, Case Studies, Multiple Constraints in material selection, Multiple Objectives, Role of Materials in Shaping the Product Character
8.	Suggested Books	1. M.F. Ashby, **Materials Selection in Mechanical Design**, 4th Edition, Elsevier, San Francisco, 2011; ISBN 978-1-85617-663-7. 2. Cambridge Engineering Selector (CES EduPack), Granta Design Limited, Cambridge, UK, 2010, www.grantadesign.com. Cases studies provided by the instructor 3. W.D. Callister, Materials Science for Engineering: An Introduction, 7th Edition, Wiley, 2007. ISB 978-0-471-73696-7.

Course	
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Discipline	Metallurgy Engineering and Materials Science
Pre-requisite, if any	Fundamental knowledge of materials science, materials synthesis/fabrication, materials characterization and electrochemistry
Scope of the Course	The course provides the learning on various aspects of green hydrogen energy: fundamentals of materials and technologies for green hydrogen production, storage and its applications.
Course Syllabus	**1. HYDROGEN ENERGY OVERVIEW:** Green hydrogen in global energy scenarios. **2. METHODS AND TECHNOLOGIES FOR GREEN HYDROGEN PRODUCTION:** Water-electrolysis: mechanisms of oxygen evolution reaction and hydrogen evolution reaction. Solar driven water splitting: photocatalytic & Photoelectrochemical, Biological and bio-electrochemical, Thermochemical, Electrolyzer Technologies: alkaline water electrolyser, proton exchange membrane, solid oxide electrolyzer, anion exchange membrane, proton conducting ceramic. **3. MATERIALS FOR GREEN HYDROGEN PRODUCTION**: Catalytic materials based on different electrolyzer technologies, solar driven water splitting, thermochemical and bio electrochemical water splitting. Materials challenges and research scope. **4. HYDROGEN STORAGE**: Physical storage technologies, Materials storage: metal hydrides, metal alanates, amino borane, metal amides, amine metal borohydrides, chemical hydrogen storage, carbon materials, nanostructured adsorbents.
Suggested Books	• K. S. V. Santhanam, R. J. Press, Massoud J. Miri, A. V. Bailey, G. A. Takacs : *Introduction to Hydrogen Technology*: 2nd Edition : John Wiley and Sons Ltd : USA : 2017 : 9781119265573. • Bent Sorensen and Giuseppe Spazzafumo, *Hydrogen And Fuel Cells*, Acad Pr, 2018, ISNB: 9780081007082 • Mario Pagliaro and Athanasios G. Konstandopoulos, *Solar Hydrogen: Fuel of The Future,* RSC, 2012, ISBN: 781849731959 • Paulo Emilio Miranda, *Science and Engineering of Hydrogen-Based Energy Technologies*, Academic Press, 2018 ISBN: 9780128142516 • Kent Olsen, *Advanced Concepts of Hydrogen Storage Technology*, Clanrye International, 2015, ISNB: 9781632400178

1.	Course Code	**MM 416**
2.	Title of the Course	**Modeling and Simulation in Materials Engineering**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Introduction and Fundamentals: Multiscales Modeling and Simulation in Materials & Science Ab Initio Methods, Statistical Machines, Monte Carlo Simulation, Molecular Dynamics, Grrin continuum modeling. Computational micro- mechanics Multiscale coupling. Application of Multiscale Modeling: Modeling dislocation behavior, Phase field modeling, Modeling of grain growth and microstructure in polycrystalline materials, Modeling of structural materials.
8.	Suggested Books	**1.** R. Dierk, **Computational Materials Science**, Wiley VCH Verlag GmbH, 1998 **2.** Z. Xiao Guo (Ed), **Multiscale Materials Modelling: Fundamental and Applications,** Woodhead Publishing Limited, Cambridge, 2007 **3.** Z.H. Barber, **Introduction to Materials Modeling**, Maney Publishing, 2005.

1	Course Code	**MM 430/ MM 730**

1.	Course Code	**MM 428**
2.	Title of the Course	**Intelligent Materials**
3.	Credit Structure	L-T-P-Credits: 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	
7.	Course Syllabus	Composites, Smart materials and their properties, Piezoelectric, magneto structure, Shape memory materials, Electro Rhieological fluids, Optical fibers, actuation, sensing and control augmentation, distributed/discrete sensing and actuation, methods of analyses, finite elements, applications: Vibration suppression, shape control, sizing and optimization.
8.	Suggested Books	1. L. Meirovitch, **Dynamics and Control of Structures**, John Wiley & Sons Inc. New York, 1992. 2. M.V. Gandhi, B.S. Thompson, **Smart Materials and Structures** (2nd edition), Chapman & Hall, 1992. 3. H.S. Guran, H.S. Tzou, G.L. Anderson, M. Natori, **Structure Systems: Smart Structures, Devices and System** (Part 1), and **Materials and Structures** (Part 2), World Scientific Publications, 1998. 4. U. Gabbert, H.S. Tzou, **Smart Structures and Structuronic System**, Kluwer Academic Publishers, 2001. 5. H.T. Banks, R.C. Smith, and Y.W. Qang, **Smart Material structures: Modeling, Estimation and Control** (6th edition), John Wiley & Sons New York, 1997.

2	Title of the Course	**Two Dimensional Materials and Electronic Devices**
3	Credit Structure	L-T-P-Credits 2-1-0-3
4	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5	Pre-requisite, if any	Basic knowledge in nanomaterials fabrication, characterization, devices integration and electronic devices.
6	Scope of the Course	To gain fundamental knowledge about the world of 2-D materials. The course will develop an understanding on 2-D materials fabrication, classification, and characterization. It will deliver an idea, how 2-D materials can be applied in electronics devices and its importance and advantages.
7	Course Syllabus	Introduction to 2-D Materials. Stable 2-D layer: Theoretical Consideration to Experimental Demonstration. Overview of 2-D Materials: Graphene, Silicene, Germanene, Phosphorene, Stanene, Transition-Metal-Chalcogene, MX-enes etc. Graphene: Discovery, Structure, Its Derivatives and Applications. Fabrication and Characterization of Graphene and other 2-D Materials. Electronic Properties of 2-D materials: Band Structure, Mobility, Quantum Hall Effect etc. Surface Functionalization and Modification. Surface Controlled Electrical and Optical Properties of 2-D Materials. 2-D Materials in Electronic Devices, 2-D Transistors – State of The Art; Graphene MOSFET (GFET); GFET for Digital Electronics, 2-D Materials Based Transistors: RF Transistor; Multi-Gate FET, Inter-layer Tunnelling FET.
8	Suggested Books	1. M. Aliofkhazraei, and N. Ali, *Two-Dimensional Nanostructures,* CRC Press, 2012, ISBN:9781439866658 2. J.H. Warner, F. Schaffel, M. H. Rummeli and A. Bachmatiuk, *Graphene : Fundamentals and Emergent Applications*, Elsevier,2013, ISBN: 9780123945938 3. V. Skakalova, A. B. Kaiser, *Graphene: Properties, Preparation, Characterisation and Devices,* Woodhead Publishing, 2014, ISBN: 9780857095084 4. F. Iacopi, J. J. Boeckl and C. Jagadish; *2D Materials*, Academic Press, 2016, ISBN:9780128043370 5. Kolobov, Alexander V., Tominaga, Junji, *Two-Dimensional Transition-Metal Dichalcogenides* , Springer, 2016, ISBN: 9783319314501 6. M. Raghu, *Graphene Nanoelectronics: from Materials to Circuits*, Springer, 2012, ISBN: 9781461405481 7. M. Houssa, A. Dimoulas and A. Molle, *2D Materials for Nanoelectronics,* CRC Press , 2016, ISBN: 9781498704175

1.	Course Code	**MM 442/ MM 642**
2.	Title of the Course	**Quality Assurance in Metallurgy**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	To inculcate quality management and analytical industrial problem solving skills in our students so that readymade technical manpower will be available for industries.
7.	Course Syllabus	Inventory management; Colour code system; Heat number; Metallurgical parameters; Relevant materials testing standards (ASTM, ISO, DIN, etc.) for inclusion rating; C2R2S2, grain size and other specific customer requirement; Laboratory quality system (ISO17025, NADCAP, NABL accreditation); Process flow chart; Six sigma; 5S; PDCA, root cause analysis, Kaizen and other relevant lean manufacturing quality tools for continuous improvement in materials processing; Idea and talent management; various quality standard for quality control, such as ISO9000:2008; TS16949, etc.; Non-destructive testing; Introduction to Environmental management standards, such as ISO 14000 family; Statistical quality control tools; Total quality management (TQM); GATE review criteria; Process and product oriented research for sustainable development; Case studies and practical exposure to industries.
8.	Suggested Books	1. W. M. Fed,**Lean Manufacturing: Tools, Techniques, and How to Use Them,** 1st Edition, CRC Press Series on Resource management, 2000, ISBN: 978-1574442977. 2. ASTM International: **https://www.astm.org/Standard/standards-and-publications.html** 3. A. J. Duncan**, Quality Control and Industrial Statistics**, Richard D.Irwin, Inc,1974, ASIN: B01LQEKJ2M.

1.	Course Code	**MM 447/ MM 647**
2.	Title of the Course	**Metallurgical Thermodynamics and Phase Transformations**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	To develop critical thinking and analytical problem solving skills related to macroscopic thermodynamics and kinetics in Metallurgy and Materials Engineering.
7.	Course Syllabus	Introduction to metallurgical thermodynamics and concept of equilibrium; Clausius–Clapeyron equation; Phase diagram for unary system; Pressure-temperature-volume surface; Free energy of solution; Free energy–composition diagram; Evolution of Phase diagram; Phase rule and binary phase diagram; Fe-C equilibrium phase diagram; Introduction to ternary phase diagram; Free energy of intermediate phase; Metastable phase diagram; Miscibility gap in phase diagram; Kauzmann paradox and the glass transition; Free energy of undercooled liquid; Stability criteria for phase formation; Solid state phase transformations; Order of transformation; Thermodynamics of homogeneous and heterogeneous nucleation; Diffusion: Self-diffusion, Inter-diffusion, The Kirkendall effect, Capillarity-Driven diffusion, Stress-driven diffusion; Atomistic mechanisms of diffusion, Interphase layer Growth in inter-diffusion, Role of micro structure in diffusion: Short-circuits, Rate of reaction; Kinetics of phase changes; Kinetics in the diffusion-controlled regime, Sintering, Process of nucleation and growth; Gibbs-Thomson Effect; Grain-growth kinetics in two and three dimensions; Time-Temperature-Transformation diagrams; Continuous cooling transformation curves.
8.	Suggested Books	1. D. R. Gaskell and D. E. Laughlin, **Introduction to thermodynamics of materials,** Sixth Edition, CRC Press, 2017, ISBN-13: 978-1498757003. 2. D. A. Porter, and K. E. Eastering, *Phase Transformations in Metals and Alloys,*Chapman & Hall, London, New York, 1992, ISBN: 0442316380. 3. R. W. Balluffi, S. M. Allen, W. C. Carter, **Kinetics of Materials**, Wiley, New York, 2005, ISBN: 9780471246893. 4. D. V. Ragone, **Thermodynamics of Materials**, Vol 1-2, Wiley, New York, 1994, ISBN: 978-0-471-30885-0. 5. Bashforth, **Manufacture of Iron and Steel**. Vol I and II, Asia Publishing House, 1996, ISBN: 9781504122511.

1.	Course Code	**MM 448/ MM 648**
2.	Title of the Course	**Solidification and Phase Field Modeling**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Department of Metallurgy Engineering and Materials Science
5.	Pre-requisite, if any	None
6.	Scope of the Course	Solidification processing is considered as one the most important processing technique used by engineers to manufacture structural and functional components in automobile and electronic industries. More than 90% of all metallic materials used in daily human life are synthesized from the liquid state as their parent phase. This course is intended to make the students familiar with the science and technology of solidification processing of materials, undercooled metallic melts, as well as phase field modelling of microstructure development.
7.	Course Syllabus	Heat transfer in solidification, continuous and ingot casting processes, structure of castings and ingots, defects in casting, macro- and micro-segregation and homogenization, design of risering and gating in castings. Thermodynamics of solidification, nucleation and growth, Gibbs-Thomson effect, anisotropy and faceting, directional solidification-growth of single crystals. Alloy solidification, mathematical analysis of solute redistribution during solidification: Solidification at equilibrium and non-equilibrium condition. Scheil and Flemings solidification model, Stability of interface and constitutional undercooling, Mullins-Sekerka criterion, Cellular and dendrite growth. Physics of dendritic growth: Ivantsov's transport model and solution, Marginal stability hypothesis, Free dendritic theories: Lipton-Glicksman-Kurz (LGK) theory, Lipton-Kurz-Trivedi (LKT) theory, Microscopic solvability (MS) theory. primary and secondary dendrite arm spacing, Rayleigh instability. Solidification microstructures of multiphase alloys such as eutectic, peritectic and monotectic alloys, coupled growth and phase selection, rapid solidification processing, phase selection kinetics in undercooled metallic melt. Phase field modeling for microstructure evolution during solidification.
8.	Suggested Books	1. G. J. Davies, **Solidification and Casting**, Applied Science Publishers Ltd, London, 1973, ISBN: 0-853345562. 2. W. Kurz, D.J. Fisher, **Fundamental of Solidification**, Trans Tech Publications, Switzerland, 1992, ISBN: 0-878495223. 3. M.E. Glicksman, **Principles of Solidification**, Springer, New York, 2010, ISBN: 9781441973436. 4. J.A. Dantzig, M. Rappaz, **Solidification**, EPFL Press,

		Switzerland, 2016, ISBN: 9780849382383. 5. D. M. Herlach, D.M. Matson, **Solidification of Containerless Undercooled Melts**, Wiley-VCH, 2012, ISBN:9783527331222. 6. S. BulentBiner, **Programming Phase-Field Modeling**, Springer, 2017,ISBN: 9783319411941.

1	Course Code	**MM 449/ MM 649**
2	Title of the Course	**Advance Welding Technology**
3	Contact Hours	L-T-P-Credits 2-0-2-3
4	Name of the Concerned Department/School	Metallurgy Engineering and Materials Science
5	Pre–requisite, if any	None
6	Scope of the Course	In this course students learn briefly on joining of materials basics and extensively on advanced joining techniques, process selection and design of weld joint
7	Course Syllabus	Introduction to joining of materials, Advances in joining of materials Solid State Joining Processes (Pressure welding, friction welding, explosive welding, ultrasonic welding, diffusion bonding, resistance welding); Brazing and Soldering (Filler materials and fluxes, heating methods, wetability, joint design); Adhesive bonding (Types of adhesive, wetability, surface preparation, joint design) Fusion welding fundamentals, Fusion welding processes (Oxyacetylene torch welding, Manual metal arc welding, MIG and TIG welding, submerged arc welding, electron beam and laser welding), recent trends in fusion welding. Welding specific materials - Plain carbon, low alloy steels, stainless steels, copper and copper alloys, nickel and nickel alloys, aluminum and aluminum alloys (similar and dissimilar materials joining). Modern welding techniques (Pulsed TIG, Pulsed electron beam, Laser welding, plasma and friction stir welding); Welding defects; Quality Assurance of Welding Operations (Non-destructive testing, safety, measurement, control and recording); Process selection and joint deign with case studies
8	Suggested books	1. M. Robert, **Joining of Materials and Structures**, 1st Edition, Elsevier, 2004,**ISBN:** 9780750677578. 2. S. Kou, **Welding Metallurgy**, 2nd Edition, Wiley, 2002, ISBN: 9780471434917. 3. H. Granjon**, Fundamentals of Welding Metallurgy**, 1st Edition, Elsevier, 1991, ISBN: 9781855730199.

Course code	**MM 650/ MM 450**
Title of the course	**Ferrous and Non-Ferrous Alloys**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Metallurgy Engineering and Materials Science
Pre-requisite, if any	Fundamentals of materials science
Scope of the course	This course introduces students to the advanced alloys and develops literacy about the technologically important alloy-systems used in automotive, aerospace and nuclear industries. This course implicates the fundamental concepts in the metallurgy of the advanced alloys.
Course Syllabus	Ferrous alloys: Alloy Steels – General Introduction, Maraging Steels (Heat-treatment Cycle, Aging behavior), High-Strength Low-Alloy Steels (Role of Microalloying of Steels), Ultra-High Strength Steels (Role of Alloying Elements), Dual-Phase Steels, Stainless Steels (Fe-Cr-Ni System, Schaeffler Diagram, Precipitation of Carbides/Nitrides, Microstructural Aspects of Various Types of SS, Ni-free Duplex SS, Embrittlement Phenomena), Tool Steels (Secondary Hardening, Types of Carbides), TRIP-assisted Steels (Microstructural evolution, Stress induced transformation, Role of alloying elements, Factors affecting performance, Concept of &#948_-TRIP Steel), Bearing Steels (Metallurgical & Engineering Requirements of Steel, Microstructural Aspects, Microcracking, Spheroidise Annealing, Inclusions, Aerospace Bearings), IF Steels. Non-ferrous alloys: Nickel-Based Superalloys (Microstructural features, Role of Alloying Elements, Strengthening Mechanisms, Heat-Treatments, Dispersion-Hardened Superalloys), Titanium Alloys (Deformation Modes, Effect of Alloy Addition on Phase Diagrams, Alloy Classification, Phase Transformations, Microstructures, Hardening Mechanisms of Alfa- & Beta- Phases, Microstructure in Dependent of Processing, Basic Correlation between Microstructure & Mechanical Properties, Ti-based Intermetallic Compounds), Aluminum Alloys (Microstructures of Al-Si Alloys, Modified/Unmodified Al-Si Alloys, Aging Process in Al-4%Cu alloy), Brass, Bronze. Special alloys: Bulk Nanostructured Steels – the Latest Development in Steels, Mechanically Alloyed Metals, Shape Memory Alloys, Metallic-glass Forming Alloys, Nuclear Power Plant Alloys (Irradiation Damages in Microstructure, Irradiation Hardening, Concepts of ODS Steels).
Suggested Books	1. H. K. D. H. Bhadeshia, R. W. K. Honeycombe, ***Steels* , Microstructure and Properties**, Butterworth-Heinemann Publications, Elsevier, UK, 2006, ISBN, 9780750680844 2. R. E. Smallman, A. H. W. Ngan, ***Physical Metallurgy***

	and Advanced Materials, Elsevier, USA, 2007, ISBN, 9780750669061 3. G. Lutjering, J.C. Williams, ***Titanium***, Springer-Verlag, Berlin, 2003, ISBN, 9783540713975 4. R.C. Reed, ***The Superalloys, Fundamentals and Applications***, Cambridge University Press, UK, 2006, ISBN-13, 978-0521070119

1.	Course Code	**MM 451/ MM 651**
2.	Title of the Course	**Non-destructive Evaluation**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	Student will understand the basic principles of various methods used for nondestructive evaluation, fundamentals, and discontinuities in different product forms, importance of NDE, applications, and limitations of nondestructive testing (NDT) methods. Students will be able to cultivate in-depth understanding on the importance of NDT in the relevant industries.
7.	Course Syllabus	**Introduction**: Need for inspection, types of inspection system, Quality of inspection, Reliability of defect detection and benefits of NDE. **Visual Inspection**: Basic principles and applications, borescope; rigid chamber scopes; endoscope; videoscope; robotic crawlers. **Liquid Penetrant Inspection**: Physical principles, procedures of testing, penetrant testing materials, applications and limitations. **Magnetic Particle Testing**: Principle of MPT, Magnetization techniques, procedure used for testing a component, equipment used for MPT, applications and limitations. **Ultrasonic Testing**: Basic principles of sound beam, ultrasonic transducers, type of display, inspection methods, identification of defects, immersion testing, applications and limitations. **Acoustic Emission Testing (AET)**: Principles, technique, Instrumentation and applications. **Techniques used for Eddy Current Testing:** Basic principles, various probes, pulsed eddy current testing; low frequency eddy current testing; SQUID-based eddy current testing; and mechanical impedance analysis; Applications and limitations. **X-ray and Neutron Radiography**: Basic principles, electromagnetic radiation sources, effect of radiation in film, radiographic imaging, inspection techniques, applications and limitations. Shearography, Vibrothermography, Thermography, Laser Interferrometry, Acoustic microscopy, Microwave Testing: Working principles and applications. Case study; Statistical methods for quality control.

8.	Suggested Books	1. B. Raj, T. Jayakumar, M. Thavasimuthu, **Practical Non-destructive Testing**, 3rd Edition,Narosa, New Delhi, 2007, ISBN: 9788173197970. 2. ASM handbook committee,**Nondestructive Evaluation and Quality Control**,Metals Handbook, Vol. 17, ASM International, ISBN: 0871700077. 3. J. Prasad, C. G. Nair, **Nondestructive Test and Evaluation of Materials,** McGraw-Hill Education, 2008, ISBN: 9780070077461.

1.	Course Code	**MM 453/ MM 653**

1.	**Course Code**	**MM 452/ MM 652**
2.	**Title of the Course**	**Thermomechanical Processing**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Department of Metallurgy Engineering and Materials Science
5.	Pre-requisite, if any	None
6.	Scope of the Course	This course deals with advanced thermomechanical processing to understand the development of unique microstructure.
7	Course Syllabus	General Introduction, Microstructure and Properties, Plasticity, Work Hardening, Softening mechanisms, Deformation mechanism, Phase transformations, Textural developments during thermomechanical processing, Residual stress, Processing maps and constitutive Modelling, Forming techniques: Forging, Rolling, Deep drawing, Sheet metal forming, Defects in thermomechanical processing, Physical simulation of properties, Case studies: Aluminum alloys, Steels, Hexagonal alloys, High entropy alloys.
8.	Suggested Books	1. B. Verlinden, J. Driver, I. Samajdar, R. D. Doherty, Edited by R. W. Cahn, Thermo-Mechanical Processing of Metallic Materials, Elsevier, 2007,ISBN: 9780080444970 2. B.S. Altan, Severe Plastic Deformation: Towards Bulk Production of Nanostructured Materials, Nova Publishers, New York, 2006, ISBN: 1-59454-508-1. 3. M.J. Zehetbauer, R.Z. Valiev, Nanomaterials by Severe Plastic Deformation, Wiley-VCH, Germany, 2004, ISBN: 9783527604944. 4. A. Rosochowski, Severe Plastic Deformation Technology, Whittles Publishing, UK, 2017, ISBN: 9781849950916. 5. Y. T. Zhu, V. Varyukhin, Nanostructured Materials by High-Pressure Severe Plastic Deformation, Springer, Netherlands, 2006, ISBN-10: 1402039212. 6. T. C. Lowe, R. Z. Valiev, Investigations and Applications of Severe Plastic Deformation, Springer, Netherlands, 2000, ISBN: 9780792362814.

2.	Title of the Course	**Non-equilibrium Processing of Materials**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre-requisite, if any	None
6.	Scope of the Course	This course is intended to make the students familiar with the different non-equilibrium processing techniques and various novel materials and its possible applications.
7.	Course Syllabus	**Introduction:** Thermodynamics and kinetics of metastable phase formation. **Non-equilibrium processing methods (NEPM)**: Rapid solidification, Mechanical alloying, Laser processing, Thermal plasma processing, Spray forming, Ion-mixing, Physical vapor deposition, Chemical vapor deposition, Combustion synthesis. **Nanostructured materials:** Classification, preparation, structure, stability, properties, application and future direction. **Special alloys:** Introduction, properties, applications and future aspects. Case studies: Bulk amorphous alloys, Quasi-crystalline alloys, Shape memory alloys, Superalloys, Heusler alloys, High entropy alloys.
8.	Suggested Books	1. C. Suryanarayana, **Non-equilibrium Processing of Materials**, Elsevier, 1999, ISBN: 0080426972. 2. B.S. Murty, J.W. Yeh, S. Ranganathan, **High Entropy Alloys**, Elsevier, UK, 2014, ISBN: 9780128002513. 3. R. E. Smallman, A. H. W. Ngan, **Physical Metallurgy and Advanced Materials**, 7th Edition, Elsevier, 2007, ISBN: 9780080552866. 4. R.C. Reed, **The superalloys: fundamentals and applications**, Cambridge University Press, 2006, ISBN-13: 9780511245466. 5. Dimitris C. **Lagoudas**, **Shape Memory Alloys Modeling and Engineering Applications**, Springer, 2008, ISBN: 9780387476841.

1.	**Course Code**	**MM 454/ MM 654**
2.	**Title of the Course**	**Advanced Foundry Technology**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Department of Metallurgy Engineering and Materials Science
5.	Pre-requisite, if any	None
6.	Scope of the Course	This course introduces students to different foundry techniques, different alloy systems by casting routes, casting defects.
7	Course Syllabus	Introduction to Casting technology, Solidification analysis for metals and alloys, Technology of patternmaking, Study of molding sands and their testing methods, Technology of mould making and core making, Special sand moulding processes, Principles of gating design for castings, Principles of risering design for castings, Special casting methods, Melting furnaces, Melting and pouring practices for production of Cast Iron family, steel and non-ferrous metals and alloys, Fettling and Heat treatment of castings, Casting defect and its diagnostic methods.
8.	Suggested Books	1. R.W. Heine, C.R. Loper, P.C. Rosenthal, **Principles of Metal Casting**, McGraw Hill Education, New York, USA, 1976, ISBN: 9780070993488. 2. A. Ghosh, A.K. Mallik, **Manufacturing Science**, Affiliated East-West Press Pvt. Ltd., India, 2010, ISBN-10: 8176710636. 3. P.L. Jain, **Principles of Foundry Technology,** 5th Edition, Mcgraw Hill Education, 2009, ISBN: 9780070151291. 4. A.K. Chakrabarti, **Casting Technology and Cast Alloys**, PHI Learning Pvt. Ltd., 2005, ISBN: 9788120327795. 5. B. Ravi, **Metal Casting: Computer - Aided Design and Analysis**, Phi Learning Pvt. Ltd, 2010, ISBN: 9788120327269, 8120327268. 6. D. Kumar, S.K. Jain, **Foundry Technology**, Cbs Publisher, 2007, ISBN: 9788123902906. 7. P. Beeley, **Foundry Technology**, Butterworth-Heinemann, 2001, ISBN: 0750645679. 8. O.P. Khana, **Foundry Technology**, Dhanpat Rai Publications, 2011, ISBN: *ISBN*-10: 8189928341. 9. K.P. Sinha, D.B. Goel, **Foundry Technology**, Standard Publishers Distributors, 2006, ISBN: 8186308121. 10. G. Sutradhar, **Principles of Foundry Process Design**, New Age International Pvt. Ltd, 2010, ISBN 10: 8122434053.

1.	Course Code	**MM 457/ MM 657**
2.	Title of the Course	**Advances in Energy Storage Materials**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Department of Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	This course is designed for the students of science and engineering Departments to understand the use of nanomaterials in the advancement of energy storage devices. Potential of nanomaterials will be detailed for the significant enhancement in functionality of electrochemical devices. The basics of electrochemical devices and cutting edge research developments will be covered from various books, research reports, articles and review papers.
7.	Course Syllabus	Introduction to nanomaterials, Overview of the basic characteristic differences between nanomaterials and conventional materials, Overview of the types and architectures of nanomaterials with relevance to the applications in energy storage/conversion devices, Electrochemical interfaces at the nanoscale. **Characteristics and properties**: Effects of crystal structures, orientations, various dimensions, and aspect ratio at nano/micro scales, Morphological and structural stability during operation, Issues of diffusivity, Importance of chemical, physical and mechanical properties. **Devices**: Importance, working principles, characterization, and fabrication of advanced electrochemical energy storage and conversion devices like Electrochromic Smart windows, Supercapacitors, Li/Na-ion batteries, and fuel cells, etc. **Nanomaterials for devices**: Beneficial aspects of nanomaterials to improve device performance, Nanomaterials used and problems associated in electrochemical energy storage and conversion devices, Possible ways to overcome limitations, Potentials of nanostructures/nanomaterials for further significant enhancement in functionality. Present scenario and necessities of efforts on fabricating of nanomaterials for designing aforesaid applications.
8.	Suggested Books	1. E. R. Leite, **Nanostructured Materials for Electrochemical Energy Production and Storage**, Springer, 2009, ISBN: 978-0-387-49323-7. 2. B. E. Conway, **Electrochemical Supercapacitors Scientific Fundamentals and Technological Applications**, Springer, 1999, ISBN: 9781475730586. 3. D. Linden, T. B. Reddy, **Handbook of Batteries,** 3rd Edition,

		McGraw-Hill, 2002, ISBN-13: 9780071359788. 4. C. G. Granqvist**, Handbook of Inorganic Electrochromic Materials**, Elsevier, 1995, ISBN: 9780080532905.

Course code	**MM 474/ MM 674**
Title of the course	**Fluorescence Phenomenon**
Credit Structure	L - T - P - Credits 2-1-2-4
Name of the Concerned Department	Metallurgy Engineering and Materials Science
Pre-requisite, if any	NA
Scope of the course	The objective of course will be an asset to build up concept about phenomenon of fluorescence involved in development of materials. The course will illustrate the broad overview of various phenomenon and applications of fluorescence in materials science and engineering.
Course Syllabus	Introduction to fluorescent phenomenon, basic concepts and instrumental techniques involved in fluorescence, Time-domain lifetime measurements, Dynamics of solvent and spectral relaxation, Aggregation induced emission (AIE), Chelation induced fluorescence (CHEF), Quenching of fluorescence, Fluorescence resonance energy transfer (FRET), Fluorescence anisotropy, Intramolecular charge transfer (ICT), Twisted intramolecular charge transfer (TICT), Photoinduced electron transfer (PET), Effect of solvent and molecular conformation on emission, Time-resolved energy transfer and conformation distributions of biopolymers, protein fluorescence, fluorescence sensing, Nucleic acids fluorescence, live-cell imaging, applications of fluorescent phenomenon in disease detection. Laboratory Experiment: Demonstration of the fluorescence phenomenon in development of emissive materials.
Suggested Books	1. J. R. Lakowicz, ***Principles of Fluorescence Spectroscopy****, 3rd edition,* Springer Science + Bussines Media, New York, USA, 2006, 780387312781 2. J. R. Albani, ***Principles and Applications of Fluorescence Spectroscopy****,* Blackwell Publishing, Lowa, USA, 2007, 9781405138918 3. E. Wehry, ***Modern Fluorescence Spectroscopy****,* Plenum Press, New York and London, 1976, 9781468425833 4. O. S. Wolfbeis, *Fluorescence Spectroscopy,* New Methods and Applications : Springer-Verlag : Berlin, Heidelberg : 1993 : 9783642773747

1	Course Code	**MM 475/ MM 675**
2	Title of the Course	**Advanced Fracture Mechanics**
3	Contact Hours	L-T-P-Credits 2-1-0-3
4	Name of the Concerned Department/School	Metallurgy Engineering and Materials Science
5	Pre–requisite, if any	None
6	Scope of the Course	In this course students can learn about the fracture concepts, fracture mechanics basics, equations governing fracture and fracture mechanics, concept of fracture toughness and experimental measurement of fracture toughness. Advanced topics in fatigue of materials and creep.
7	Course Syllabus	Introduction to Fracture Mechanics, Theory of Elasticity and Plasticity, Mohr's circle, equivalent stress, stress tensors. Fracture, Theories of brittle and ductile fracture, Theoretical cohesive strength, strain energy release rate, Griffith theory, Stress intensity actor, relation between strain energy release rate and stress intensity factor, Ductile to brittle transition, instability in plastic deformation. Linear elastic fracture mechanics, elastic plastic fracture mechanics, fracture toughness and test methods, J-integral, R- Curve, CTOD. Fatigue of materials, basic terminology in fatigue, mechanism of fatigue, S-N curve, high cycle fatigue, Effect of mean stress on fatigue, good man diagram, low cycle fatigue, factors affecting fatigue of materials, fatigue crack growth, crack closure, thermal fatigue, fretting fatigue, corrosion fatigue, design to mitigate fatigue failure. Creep of materials, mechanisms of creep, creep curve, deformation mechanism maps, and basic equations governing creep. Creep-fatigue interaction, Damage tolerant design.
8	Suggested books	1. R. W. Hertzberg, R. P. Vinci, J. L. Hertzberg, **Deformation and Fracture Mechanics of Engineering Materials**, 5th Edition,Wiley,2012, ISBN-10: 0470527803. 2. G. E. Dieter, **Mechanical Metallurgy**, 3rd Edition,McGraw-Hill, 2017, ISBN: 0071004068. 3. T. L. Anderson, **Fracture Mechanics: Fundamentals and Applications**, 4th Edition, CRC Press, 2017, ISBN-10: 1498728138.

		4. R. J. Sanford, **Principles of Fracture Mechanics**, 1st Edition,Pearson, 2002, ISBN-10: 0130929921.

1	Course Code	**MM 477/ MM 677**
2	Title of the Course	**High Temperature Deformation of Materials**
3	Contact Hours	L-T-P-Credits 2-1-0-3
4	Name of the Concerned Department/School	Metallurgy Engineering and Materials Science
5	Pre–requisite, if any	None
6	Scope of the Course	This course provides basic understanding of d the various deformation mechanisms that take place under given stress and temperature.
7	Course Syllabus	Creep of materials. Creep curve, mechanisms of creep. structural changes during creep, equations governing creep of metals, stress rupture test. Creep resistance materials, super alloys, dispersion strengthening materials, refractory materials. Fatigue of materials, effect of temperature on fatigue behavior, high temperature fatigue, thermal fatigue, thermo mechanical fatigue. Creep fatigue interaction. Thermal barrier coatings. Deformation Mechanism Maps (Ashby and Langdon-Mohamed). Applications of Deformation Mechanism Maps [turbines, nuclear reactor components, metal forming and shaping, etc.
8	Suggested books	1. W. D. Callister, **Materials Science and Engineering: An Introduction**, 7th Edition, John Wiley & Sons, 2014, ISBN: 9781118324578. 2. J. S Zhang, **High Temperature Deformation and Fracture of Materials**, 1st Edition, Elsevier,2010, ISBN: 9780857090805. 3. M. A. Meyers, K. K. Chawla, **Mechanical Behavior of Materials**, Cambridge University Press, 1999, ISBN: 9780521866750. 4. G. E Dieter, **Mechanical Metallurgy**, 1st Edition, McGraw Hill Education, 1976, ISBN: 9780070168916.

1.	Course Code	**MM 479 / MM 679**
2.	Title of the Course	**Fundamentals and Engineering of Solar Energy Devices**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Department of Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	This course introduces various aspects of the solar energy devices to the students from science and engineering Departments. This course is intended to educate the students in basics, limitations, advantages, solar cell characteristics, design, fabrication, and applications of solar cells.
7.	Course Syllabus	**Fundamentals and basics concepts**:Working principle of solar cell, fundamental of photoelectric conversions (*charge excitation, conduction, separation, and collection*), Light absorption and reflections, Solar energy conversion (P*hotovoltaic, Solar thermal and photochemical*), Shockley–Queisser Limit (*Efficiency, Recombination time, AM1.5 radiation*), Generation and recombination of electron-hole pairs, recombination processes (*Radiative, Auger, Schokley-Read-Hall, direct/Langevin type, trap assisted, direct, interfacial, geminate, and non-geminate recombination*) and possible losses. **Characteristic:** Equivalent circuits of the solar cell, Physical aspects of efficiency, Irradiation and series/shunt resistances on the open-circuit voltage (*V_{OC}*) and short-circuit current (*I_{SC}*), Dark and illuminated characteristics, Dark current, Light generated current, Effects of shading, Significance of various parameters (O*ut-put parameter, FF, solar cell η, I_{SC}, V_{OC}, Quantum efficiency, Maximum power point operation*), Antireflections coating, Practical efficiency limit (P*arasitic resistance, Losses in I_{SC}, V_{OC}, and FF, Effects of temperature, Series and shunt resistance, high irradiance*), Theoretical Limits, Challenges, and New Ideas. **Solar Cell Devices**: Basic structure, modeling, advantages, disadvantages and challenges, Generations of solar cells, Si solar cell (*Single- and Poly- Crystalline, Amorphous, and Hybrid*), Thin film solar cells (*Amorphous silicon, Cd-Te, Cd-Se, CZTS, CIGS solar cells*), Grätzel& tandem cell(Metal-Oxide micro/nano-structures; *fabrication,Mechanism, Key efficiency parameters, Substrate effect, Examples of dyes for photosensitization, Electrolytes, Influence of additives on the performance,*), Heterojunction organic, Perovskite, Quantum dots and

		Hybrid solar cell (*types, materials used, compositions of components, processing, architectures, efficiency limits, stability issues, temperature effect*), Emerging new technologies. Over view of potential hazards, Solar energy storage/utilization (*Batteries, Supercapacitor, Display devices, Emitters, and Generators etc.*), Status and prospective of *PV technology*.
8.	Suggested Books	1. A.McEvoy, T.Markvart, L.Castaner, **Solar Cells: Materials, Manufacture and Operation,** 2nd Edition, Elsevier, 2013, ISBN: 9780080993799. 2. T. Soga, **Nanostructured Materials for Solar Energy Conversion**, Elsevier, 2006, ISBN: 9780444528445. 3. D. Yogi Goswami, **Principles of Solar Engineering,** 3rd Edition, CRC Press, 2015, ISBN: 9781466563780. 4. A. L. Fahrenbruch, R.Bube, **Fundamentals of Solar Cells**, Elsevier, 1983, ISBN: 9780323145381. 5. C. J. Chen, **Physics of Solar Energy,** John Wiley & Sons, Inc., 2011, ISBN: 9780470647806. 6. P.Wurfel, **Physics of Solar Cells: From Basic Principles to Advanced Concepts,** 2nd Edition, Wiley-VCH, 2005, ISBN:9783527408573. 7. L Fraas, L. Partain, **Solar Cells & Their Applications,** 2nd Edition, John Wiley & Sons, 2010, ISBN: 9780470446331. 8. M. A. Green, **Third Generation Photovoltaics: Advanced Solar Energy Conversion**, Springer, 2005, ISBN: 9783540265634.

Course code	**MM 481/ MM 681**
Title of the course	**High Pressure Materials Processing**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Metallurgy Engineering and Materials Science
Pre-requisite, if any	NA
Scope of the course	This course is designed for the students of science and engineering Departments to understand the use of High pressure for materials synthesis and properties studies under high pressure. This course provides new insight for basic, applied and industrial applications.
Course Syllabus	Introduction to High Pressure Materials Synthesis Technique and basic principles, Pressure effects in material synthesis and physics/science behind it, Comparison of solid-medium and gas-medium pressure techniques, Solid-medium ultra-high-pressure low-temperature O2 annealing, Gas-medium high-pressure synthesis. High Pressure Materials Synthesis Techniques: Encapsulation techniques, Shock-wave methods, Diamond-anvil cells, Cubic Anvil and Belt type. Synthesis of Novel Materials under high pressure: General features of high-pressure processes, calibration of parameters etc., High Pressure synthesis of Mechanical Materials and new layered structures, Polymers etc. Application of high-pressure techniques: magnetic materials, diamonds, gems, Wide band gap semiconductors, Electronic and Optical Materials, etc.
Suggested Books	1. R. S. Bradley, ***High Pressure Physics and Chemistry***, Academic Press, Cambridge, USA, 1963, 0121240029 2. K. D. Timmerheld, ***High-Pressure Science and Technology***, Springer, Berlin, Germany, 1979, 9780306400698 3. M. I. Eremets, ***High Pressure Experimental Methods***, Oxford University Press, United Kingdom, 1996, 9780198562696 4. R. V. Eldic and F. G. Kramer, ***High Pressure Chemistry, Synthetic, Mechanistic, and Supercritical Applications***, Wiley, New York, 2002, 9783527612635

1	Course Code	**MM 483/ MM 683**
2	Title of the Course	**Analysis and Modelling of Welding**
3	Contact Hours	L-T-P-Credits 2-0-2-3
4	Name of the Concerned Department/School	Metallurgy Engineering and Materials Science
5	Pre–requisite, if any	None
6	Scope of the Course	Welding is an important fabrication process in manufacturing industries. This course deals with the detailed analysis and modelling techniques that apply to the differentphenomena that take place during welding processes.
7	Course Syllabus	Introduction to fusion welding processes, Heat sources, Heat removal. Thermal modelling, Analytical solution to weld thermal field, Zones in a weldment, Phase change. Fluid flow in the weld pool, Fusion zone, Conduction mode and Keyhole mode. Introduction to micro-segregation, Solute redistribution, Microscale, Microstructure evolution. Solute transfer at Macroscale. Defects in fusion welds, Effects of dilution, Weld Cladding. Distortion in welding, Dissimilar welding, Solutions to Dissimilar welding. Numerical solutions to thermal field and fluid flow in welding.
8	Suggested books	1. S. Kou, **Welding Metallurgy**, 2nd Edition, John Wiley & Sons, 2002, ISBN: 9780471434917. 2. R. W. Messler, **Principles of Welding: Processes, Physics, Chemistry and Metallurgy**, Wiley-VCH, 1999, ISBN-13:978-0471253761. 3. J. F. Lancaster, **Metallurgy of Welding**, Abington Publishing, England, 1999, ISBN: 1855734281. 4. D. R. Gaskell, **An Introduction to Transport Phenomena in Materials Engineering**, 2nd Edition, Momentum Press, New York, 2013, ISBN-13: 978-6065-35-3. 5. S. V. Patankar, **Numerical Heat Transfer and Fluid Flow**, McGraw-Hill Book Company, New York,1980, ISBN: 0070487405.

1.	Course Code	**MM 485/ MM 685**
2.	Title of the Course	**Materials Degradation**
3.	Credit Structure	L-T-P-Credits 2-0-2-3
4.	Name of the Concerned Department	Metallurgy Engineering and Materials Science
5.	Pre–requisite, if any	None
6.	Scope of the Course	To start from the fundamentals and provide an integrated and up-to-date picture of degradation of engineering materials used in the current industry. This course will concentrate on the materials, forms of degradation and their mechanism that are most relevant to the largest number of current industrial applications.
7.	Course Syllabus	Introduction to materials degradation; Corrosion standards; Electrochemical corrosion of metallic materials; General corrosion; Localized corrosion; Introduction to electrochemical impedance spectroscopy (EIS); Metallurgical influenced corrosion; Mechanically assisted corrosion; Environmentally induced cracking; CO_2 corrosion of mild steel; materials degradation in nuclear power plant; Corrosion in automotive industry; Corrosion in aerospace industry; Corrosion in Aircraft industry; Corrosion in electronic industry; Degradation issues of concrete and polymer materials; Degradation issues in metallic implants; Electro-chemo-mechanical degradation of high-capacity battery electrode materials; Degradation of dental materials; Corrosion in the Brewery Industry; Biodetoriation of materials.
8.	Suggested Books	1. ASM committee,**ASM Handbook on Corrosion,**9th Edition, Vol 13, 1992, ISBN: 9780871707079. 2. J. R. David, **Corrosion: understanding the basics,** ASM international, Materials Park, Ohio, 2000,ISBN-10: 0824799178. 3. A. M. El-Sherik, **Trends in Oil and Gas Corrosion Research and Technologies,** Woodhead Publishing. 2017, ISBN: 9780081011058.

Course code	**MM 486/ MM 686**
Title of the course	**Applied Photoelectrochemistry**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Metallurgy Engineering and Materials Science
Pre-requisite, if any	Basic knowledge of Semiconductors, Optoelectronic Properties and Electrochemistry
Scope of the course	The course is designed to provide the fundamentals knowledge of Photoelectrochemistry and its application in solar light harvesting. The student would get comprehensive understanding on phenomenon's that are occurring at the interface of semiconductor and electrolyte. To introduce the nanostructure photoelectrode and their impact as well as recent advancement in semiconductor photoelectrodes.
Course Syllabus	1. Introduction: Electrochemistry and Electrochemical Cells, Electrodes: Anode and Cathode, Equilibrium Potential of Electrode Reactions, Cathodic and Anodic Reactions, Electrode Reactions in Electron Transfer. 2. Semiconductor Photoelectrodes: Electron Energy Bands of Semiconductors, Chemical Potential and Electrochemical Potential, Graphical Representation of Energy Levels, Theory of Junction Formation, Metal-Schottky Junction, Semiconductor– Electrolyte Junction, Flow of Carriers Across the Junction, Depth of Charge Separation at the Interface of n- and p-Type Semiconductors, Nature of Potential at the Interface, Width of the Space Charge Region, and Quasi-Fermi Levels (QFLs). Semiconductor–Electrolyte Junction Under Illumination: Open Circuit Potential, Photovoltage and Photocurrent, Photocurrent Conversion Efficiency. 3. Nanostructured Semiconductor Photoelectrodes: Band Bending in Nanostructures, Effect of Surface Area, Determination of Quasi-Fermi Level Positions, Surface States and Fermi Level Pinning, Surface Recombination, Charge Separation and Collection, Charge Compensation and Charge Trapping. 4. Photoelectrochemical Water Splitting: Concept of Solar Driven Water Splitting and Production of Chemical Fuels/Hydrogen. Prospective Materials for Solar Driven Water Splitting and Associated Challenges. The Advanced Materials Design: Harvesting of Wider Solar Spectrum, Effective Separation and Transportation of Photo Charge Carriers, Earth Abundant Elements based Nanostructures.

Suggested Books	1. Norio Sato, ***Electrochemistry at Metal and Semiconductor Electrodes***, Elsevier, The Netherlands, 2005, 0444828060 2. Yurii Pleskov, ***Semiconductor Photoelectrochemistry***, Springer, New York, USA, 2012, 9781468490800 3. Mary D Archer and Arthur J Nozik, ***Nanostructured and Photoelectrochemical Systems for Solar Photon Conversion***, World Scientific, London, 2008, 10 1860942555 4. R. Krol and M. Grätzel, ***Photoelectrochemical Hydrogen Production***, Springer, USA, 2011, 9781461413806

Course code	**MM 487/ MM 687**
Title of the course	**Advanced Battery Technologies**
Course Category	Institute Elective
Credit Structure	L - T - P - Credits 2 – 1 – 0 - 3
Name of the Concerned Department	Metallurgical Engineering and Materials Science
Pre-requisite, if any	Any basic course(s) on electrochemistry and crystal structure
Scope of the course (Objectives)	• Theoretical and practical aspects of secondary (rechargeable) batteries. • Emphasis on recent advances in Li-ion, Na-ion, solid-state, and alkali metal battery technologies.
Course Outcomes	Upon completion of the course, students are expected to: • have acquired knowledge of various cell chemistries, battery materials, and battery figures of merit. • apply the knowledge of key battery parameters to select the appropriate battery chemistry for target applications such as grid storage, electric vehicles, portable electronics, etc.
Course Content	• **Fundamentals of batteries:** *Basic battery terminologies; Historical development of alkali cells.* • **Alkali-ion batteries**: *Types of electrodes, electrolytes, and interfaces (SEI and CEI).* • **Ion transport dynamics across electrodes and electrolytes**. • **Characterization techniques for cell/batteries:** *CV; GCD (CCC, CVC, etc.); GITT; EIS.* • **Factors limiting battery performance:** *Importance of crystal structure, particle morphology, and active material loading.* • **Catastrophic battery failure & capacity fading mechanisms**: *Thermal runaway; the role of BMS.* • **Battery pack design**: *Role of impedance matching and appropriate cell configuration.* • **Issues with the current battery technologies**: *Safety; Sustainability; Technical challenges with fast charging.* • **Emerging battery technologies**: *Na-ion; All-solid-state; Li-S; Li-Air; Anode free batteries.*

Suggested Books	**Text Books:** 1. R. Korthauer : **Lithium-Ion Batteries - Basics and Applications** : Springer Berlin, Heidelberg : 2018 : **ISBN**- 9783662530696 2. K. P. Birker (editor) : **Modern Battery Engineering – A Comprehensive Introduction**, World Scientific Publishing Co. Pte. Ltd.: 2019 : **ISBN**- 9789811215988 **Reference Books:** 3. K. W. Beard (editor) : **Linden's Handbook of Batteries, 5th Edition**, McGraw-Hill : 2019 : **ISBN**- 9781260115925 *4.* P. Enge, N. Enge, and S. Zoepf : **Electric Vehicle Engineering**: McGraw-Hill : 2021 : **ISBN**- 9781260464078

Course code	**MM 688/ MM 488**
Title	**Electroceramics**
Credit Structure	L - T - P – Credits 2-1-0-3
Name of the Concerned Department	Metallurgy Engineering and Materials Science
Pre-requisite, if any	NA
Scope of the course	The course provides a comprehensive treatment of fundamental aspects of electroceramics and their applications.
Course Syllabus	A brief review of the structure of selected ceramic materials, Defects Equilibria, Diffusion Kinetics, Theory of Ionic Conduction, Applications of Ionic Conductors: Fuel Cells, Batteries, etc. Polarization in Static and Alternating Electric Fields, Clausius–Mossotti Relation, Linear & Nonlinear Dielectrics and their Applications: Capacitors, Sensors, Actuators, Data Storage Devices, Ferroelectric Random Access Memories (Fe-RAM), Magnetoelectric Coupling and Multiferroicity, Electroceramics Fabrication-Technology.
Suggested Books	1. W. D. Kingery, H. K. Bowen, and D. R. Uhlmann, ***Introduction to Ceramics***, 2nd Edition, Wiley India Pvt. Ltd., New Delhi, India, 2012, 978-8126539994 2. L. L. Hench and J. K. West, ***Principles of Electronic Ceramics***, Wiley-Interscience, New Jersey, United States, 1990, 978-0471618218 3. A. J. Moulson and J. M. Herbert, ***Electroceramics , Materials, Properties, Applications***, John Wiley & Sons, West Sussex, England, 2003, 978-0470864975 4. Anthony R. West, ***Solid State Chemistry and its Applications***,2nd Edition, Wiley, New Delhi, India, 2014, 978-1119942948 5. Nava Setter (editor), ***Electroceramic***-Based MEMS, Springer US, 2005, ISBN: 978-1441936042

Suggest edBooks	**Text Books:** 6. R. A. Swalin, Thermodynamics of Solids, Wiley-VCH; 1972,ISBN**:** 970471838548. 7. D. R. Gaskell, Introduction to Thermodynamics of Materials,CRC Press, 2008, ISBN: 9781439851500. **Reference Books:** 8. L. Darken and R. W. Gury, Physical Chemistry of Metals, CBSPublisher, 2002, ISBN**:** 9788123914794. 9. D.A. Porter and K.E. Easterling, Phase Transformation CRCPress, 2009, ISBN: 9781420062106. 10. D.A. Porter, K.E. Easterling, M. Sherif; Phase Transformationsin Metals and Alloys, CRC Press, 2009, ISBN: 9781439883570.

Syllabi
of
Chemical Engineering

Course code	**ChE 201**
Title of the course	**Chemical Engineering Thermodynamics**
Course Category	Core
Credit Structure	L - T - P - Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Course objective	The course aims to provide students with an understanding of the fundamental principles of Thermodynamics targeted towards Chemical and Biological Processes.
Course Outcomes	● Appreciate the relevance and importance of thermodynamic principles. ● Application of Thermodynamic principles to chemical and Biochemical processes.
Course Content	**Module 1: Basic Concepts of Thermodynamics** Laws of Thermodynamics. Carnot's theorem, Concept of Entropy. Applications of first law to close and open systems; Thermodynamic cycles, PVT relations; Equations of state, S-R-K equation, Peng-Robinson equation. **Module 2: Thermodynamic properties of ideal and real fluids** Thermodynamic potentials, Maxwell's relations, Gibbs free energy as generating function; Residual properties; Heat, and work interconversion devices **Module 3.: Gibbs energy change calculations** Ideal gas mixtures, Fugacity of species in gaseous, liquid and solid mixtures: Predictive activity coefficient models, Combined equation of state and Excess Gibbs Energy model **Module 4: Phase Equilibria** Phase rule; Dew and bubble-point calculations; Flash calculations; Property estimation using VLE; Partial molar Gibbs energy and Gibbs-Duhem Equation; Phase equilibria in a multi-component system, Regular solution theory, Wilson equation, UNIFAC method, Thermodynamic properties of Reacting mixtures and the Heat of Reaction. **Module 5: Bio-Process Thermodynamics** Application of thermodynamic principles to biological systems and bioprocesses; Gibb's free energy change in bio reactions - photosynthesis, glycolysis, citric acid cycle; Thermodynamic

	analysis of osmosis, dialysis, Donnan equilibrium; Thermodynamic analysis of industrial bioprocesses
Suggested Books	**Textbooks** 1) J. M. Smith, H. C. Van Ness, M. M. Abbott, M. T. Swihart, Chemical Engineering Thermodynamics, McGraw Hill (2019), ISBN-13:978-9353168490 2) Y. V. C. Rao, Chemical Engineering Thermodynamics, 2nd Edition, University Press (2001), ISBN-13: 978-8173710483 **Reference books** 3) M. Ozilgen, E. Sorguven, Bio thermodynamics – Principles and Applications, CRC Press (2016), ISBN -13: 978-1466586093 4) R. J. Elliot, C. T. Lira, Introductory Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall, Pearson (2012), ISBN-13: 978-0136068549

Suggested Course code	**ChE 203**
Title of the course	**Transport Phenomena**
Course Category	Core
Credit Structure	L - T - P – Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Objectives of the course	Understanding Mass, Momentum and Heat transfer in the context of Chemical Engineering Applications.
Course Outcomes	● Knowledge of fundamental principles underlying mass transfer, momentum transfer, and heat transfer. ● Apply transport phenomena concepts to design of chemical processes and equipment. ● Ability to formulate and solve mathematical models representing transport processes.
Course Content	**Module 1: Essential Mathematics and basic concepts** Vector and tensor analysis, Newton's law of viscosity, thermal conductivity and mechanism of energy transport, diffusivity and mechanism of mass transport, basic concept of classical momentum, heat, and mass transfer problems. **Module 2: Momentum Transport** Eulerian/Lagrangian motion, Reynolds transport theorem, Velocity distribution in laminar and turbulent flow, Fundamentals of boundary layer theory, Equations of continuity, Introduction to Navier - Stokes equation, Conservation of mechanical energy in fluids. **Module 3: Energy Transport** Temperature profiles in laminar and turbulent flow, Graetz problem with viscous dissipation, thermal boundary layer, conduction profile in solid under steady and unsteady conditions, equations of motion for free and forced convection. **Module 4: Mass Transfer** Basics of mass transport mechanism**,** shell balances of mass species diffusion under various driving forces, diffusion with chemical reaction, convective diffusion in dilute solutions, integral balances in momentum, heat, and mass transfer, concentration distributions in laminar flow; equation of continuity for a binary mixture and its application to convection-diffusion problems. concentration distributions under multiple variables. **Module 5: Bio-Thermo-Fluidics and Transport Processes** Fundamentals of momentum, heat, and mass transport as

	applied to biological systems; Rheology of Blood, Human body as a thermodynamic system, Fluid mechanical aspects of some diseases and organs.
Suggested Books	**Textbooks** 1) R.B. Bird, W. E. Steward, E. N. Lightfoot, Transport Phenomena, 2nd edition, John Wiley & Sons (2014), ISBN-13: 978-8126508082 2) J. L. Plawsky, Transport Phenomena Fundamentals, 4th edition, CRC Press (2020), ISBN-13: 978-1138080560 **Reference books** 3) P. A. Ramchandran, Advanced Transport Phenomena, Cambridge Univ Press (2014), ISBN-13: 978-0521762618 4) L.G. Leal, Advanced Transport Phenomena, Cambridge Univ Press (2007), ISBN-13: 978-0521849104

Suggested Course code	**ChE 205**
Title of the course	**Materials Science for Chemical Engineers**
Course Category	Elective
Credit Structure	L - T - P – Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Objectives of the course	The course aims to provide fundamentals of various classes of materials, microstructures, important properties, and their applications in various industries.
Course Outcomes	● Able to identify crystal structure and the important parameters. ● Knowledge of key differences among various classes of engineering materials. ● Understand the processing, structure, and properties relations of engineering materials.
Course Content	**Module 1**: Atomic bonding in solids and its influence on properties; Crystallography: Atomic Packing factor, Planar density, Linear density, Techniques for determining the crystal structure. Imperfections in crystalline solids and the characterization techniques **Module 2:** Gibbs phase rule, the transition from single to binary & multi-phase systems, Solidification principles: Nucleation and Kinetics, Solid Solution formation rules, a few important binary phase diagrams, Iron-Iron carbide phase diagrams, various classes of steels, Diffusion kinetics in materials **Module 3:** Mechanical properties of materials and the physics of deformation, strengthening mechanisms such as solid solution strengthening, Grain boundary strengthening, precipitation hardening, and failure in materials **Module 4:** Types, properties, and applications of polymeric, ceramic, and composite materials, Methods of fabrication of polymeric and composite materials. Viscoelastic properties, Kelvin-Voigt Model, Maxwell **Module 5:** Introduction to biomaterials, concept of biocompatibility, properties of biomaterials, bimetallic alloys, ceramic biomaterials, polymeric biomaterials.
Suggested Books	**Textbooks:** 1) W. D. Callister, Fundamentals of Materials Science and Engineering, John Wiley & Sons (2008), ISBN 13: 978-

	0470234631 2) M. Rubinstein, R. H. Colby, Polymer Physics, Oxford University Press, United Kingdom (2003), ISBN 13: 978-0-19-852059-7 **Reference Books:** 3) W. F. Smith, J. Hashemi, R. Prakash, Materials Science and Engineering, 4th Edition, McGraw Hill (2010), ISBN 13: 978-0073529240 4) Donald R. Askeland, Essentials of Materials Science and Engineering, 2nd edition, Wadsworth Publishing Co Inc. (2008), ISBN-13- 978-0495244462

Suggested Course code	**ChE 207**
Title of the course	**Chemical Process Calculations**
Course Category	Core
Credit Structure	L - T - P - Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Objectives the course	The course aims to provide students with an understanding of the fundamental principles of Material and Energy balances for Chemical and Biochemical Process Industries
Course Outcomes	● Basic knowledge of material and energy balances. ● Applications of behavior of Solid, liquid, and gas to chemical and biochemical plants.
Course Content	**Module 1: Introduction to Material Balance** Principles of material balance and its calculation, material balance equation, balances on single and multiple unit processes without reaction, material balances on non-reactive processes, material balances on non-reactive processes with recycle and bypass, material balances on reactive processes, Solving linear simultaneous algebraic equations for applications in material balance and computer-based calculations. **Module 2. Properties of Gases and Liquids** State equation of ideal gas and non-ideal gases and calculation, Vapor-liquid equilibrium: bubble point, dew point calculations, phase envelope diagrams, saturation and humidity, Psychometric chart and its use, problem-solving Process of phase change: Condensation, vaporization. **Module 3. Energy Balance on Chemical Process Units** Mechanical energy balance: basic understanding, enthalpy balance without reaction, energy balances with multiple inlet and outlet streams, energy balances on reactive systems, energy balance with standard heat of reaction, enthalpy balances for heat of solution, computer-based calculations for energy balance. **Module 4. Combustion Calculations** Characteristics of solid, liquid, and gaseous fuels, combustion reaction, stoichiometric principles to calculate the theoretical air-fuel ratio for complete combustion, energy balance in combustion processes, and combustion efficiency.

Suggested Books	**Textbooks** 1) D. M. Himmeblau, J. B. Riggs, Basic Principles and Calculations in Chemical Engineering, 4th Edition, Pearson (2012), ISBN-13- 978-0132346603 2) O. A. Hougen, K. M. Watson & R. A. Ragatz, Chemical Process Principles, Material and Energy Balances, Part I, John Wiley (2004), ISBN-13- 978-8123909530 **Reference books**. 3) G. V. Rekliatis, Introduction to Material and Energy Balances, John Wiley & Sons (1983), ISBN-13- 978-0471041313 4) R. M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes, 3rd Edition, John Wiley & Sons (2004), ISBN-13- 978-0471687573

Suggested Course code	**ChE 209**
Title of the course	**Introduction to Soft Matter and Polymers**
Course Category	Elective
Possible instructors	Prof. Gaurav, Prof. Kailasham
Credit Structure	L - T - P - Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Scope of the course	The course aims to provide students with an understanding of the forces governing the assembly of various soft materials such as synthetic polymers, proteins, colloids, gels, liquids, etc. along with their unique physicochemical properties
Learning Outcomes	• Demonstrate a thorough understanding of the assembly of soft materials such as colloids and polymers. • Understand the structure-property relationship for a variety of soft matter systems • Gain an appreciation for biological systems as living soft matter
Course Content	**Module 1: Fundamentals of Soft Matter** Everyday soft matter; Forces governing the assembly of soft matter; Experimental characterization techniques for soft matter; Thermodynamics and mechanical properties, such as viscoelasticity, of soft materials. **Module 2. Colloids** Types of colloids, Brownian motion, Intermolecular forces between colloids, sols, gels, food colloids. **Module 3. Polymers** Polymer chemistry; Thermodynamics of polymer solutions; Phase separation of polymer solutions; Polymer gels. **Module 4. Biological soft matter** Membranes, DNA, proteins. Protein folding and crystallization; Intrinsically disordered proteins and phase separation.
Suggested Books	**Textbooks** 1) I. W. Hamley, Introduction to soft matter, synthetic and biological self-assembling materials, Wiley, Germany (2007), ISBN13: 978-0470516102 2) M. Rubinstein & R. H. Colby, Polymer physics. Oxford University Press, United Kingdom (2003), ISBN: 978-0-19-852059-7 **Reference books**. 3) T. McLeish, Soft Matter, A Very Short Introduction, Oxford

	University Press, United Kingdom (2020), ISBN: 9780198807131 4) D. F. Evans, H. Wennerström, The Colloidal Domain, Where Physics, Chemistry, Biology, and Technology Meet, VCH Publishers Germany (1999), ISBN: 3-527-89525-6 5) K. Dill, S. Bromberg, Molecular Driving Forces, Statistical Thermodynamics in Biology, Chemistry, Physics, and Nanoscience., CRC Press, United States (2010), ISBN: 9781136672996

Course code	**ChE 211**
Title of the course	**Waste to Energy Conversion**
Course Category	Elective
Credit Structure	L - T - P - Credits 2 – 1 – 0 – 3
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Scope of the course	The course deals with the production of energy from different types of wastes through thermal, biological and chemical routes.
Learning Outcomes	• Fundamental knowledge and understanding of current thoughts and newer technology options along with their advances in the field of the utilization of different types of wastes for energy production. • Analyze case studies to understand the success and challenges of various Waste to Energy technology options.
Course Content	**Module 1: Introduction** The Principles of Waste Management and Waste Utilization. Waste Management Hierarchy and 3R Principle of Reduce, Reuse and Recycle. Waste as a Resource and Alternate Energy source. **Module 2. Waste Sources & Characterization** Waste production in different sectors such as domestic, industrial, agriculture, post-consumer, waste, etc. Classification of waste – agro-based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous), Characterization of waste for energy utilization, waste selection criteria. **Module 3. Technologies for Waste to Energy** Biochemical Conversion: Energy production from organic waste through anaerobic digestion and fermentation. Thermo-chemical conversion techniques: Combustion, Incineration and heat recovery, Pyrolysis, Gasification, and other newer technologies. **Module 4. Case Studies** Success/failures of waste to energy; Global Best Practices in Waste to Energy Production Distribution and use.
Suggested Books	**Textbooks** 1) M. J. Rogoff and F. Screve, "Waste-to-Energy, Technologies and Project Implementation", Elsevier Store. William Andrew (2019),

	ISBN-13- 978-0128160794 **Reference books**. 2) G. C. Young, Municipal Solid Waste to Energy Conversion Processes - Economic Technical and Renewable Comparisons, Economic, Technical, and Renewable Comparisons, John Wiley and Sons. (2010), ISBN-13- 978-0470539675 3) J. H. Harker and J. R. Backhusrt, "Fuel and Energy", Academic Press Inc. (1997), ISBN-13- 978-0123252500 4) M.M. EL-Halwagi, "Biogas Technology- Transfer and Diffusion", Elsevier Applied Science. (2014), ISBN-13- 978-9401084161

Course code	**ChE 251**
Title of the course	**Heat and Mass Transfer Lab**
Course Category	Core
Credit Structure	L - T - P - Credits 0 – 0 – 2 – 1
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Scope of the Lab	Introduce the students to the basics of heat and mass transfer
Learning Outcomes	• Understand the nuances in the experimental measurement in Heat and Mass transfer
Course Content	**List of representative experiments:** 1. Determine the unsteady state heat transfer by lumped capacitance. 2. Determine the heat transfer in the process of condensation and by free and forced convection. 3. Investigating the drying characteristics of a solid under forced draft condition 4. Examining the heat transfer in a Pin-Fin (by natural & forced convection) and the radiation heat transfer by the black body and the effect of hemisphere temperature on it 5. Evaluate the heat transfer through conduction in metal rods of different materials and Parallel flow/counter flow heat exchangers. 6. Demonstrate the super thermal conductivity of Heat pipe and compare its working with the best conductors. 7. Evaluate the critical flux in the Pool boiling apparatus using in-situ method 8. Operational principle of a Rotary dryer 9. Mass transfer operations in the water-cooling tower for different flow and thermodynamic conditions. 10. Dissolution characteristics of benzoic acid in water and aqueous solution of sodium hydroxide. 11. Adsorption in a packed bed for a solid-liquid system 12. Effect of temperature on the diffusion coefficient 13. Demineralization of water using two bed system

Suggested Books	Y. A. Cengel, A. J. Ghajar, Heat and Mass Transfer: Fundamentals and Applications, McGraw Hill; 6th Edition (2020), ISBN-13: 978-9390185283

Course code	**ChE 255**
Title of the course	**Materials Characterization lab**
Course Category	Core
Credit Structure	L - T - P - Credits 0 – 0 – 2 – 1
Name of the Concerned Department	Chemical Engineering
Pre-requisite, if any	None
Scope of the Lab	● Introduce the students to various mechanical, thermal and microstructure characterization techniques. ● Analysis of the data and establish a correlation between the structure and properties of various material systems
Learning Outcomes	● Evaluate the microstructure and mechanical properties of materials. ● Analyze the experimental data in terms of various empirical and phenomenological models. ● Able to design and conduct experiments to understand various properties of materials.
Course Content	**List of representative Experiments** (1) Determination of crystal structure of given metals using X-ray diffraction. (2) To determine the hardness of various materials (3) Determination of mechanical properties of different materials such as yield strength, elastic modulus, and strain hardening behavior. (4) To determine the microstructure of low, medium, and high-carbon steels (5) Determination of glass transition temperature of polymers and understanding the effect of rejuvenation. (6) Investigate the rheological properties of various polymers. (7) Determine the phase transformation temperature in steels and shape memory alloys. (8) Steady simple shear experiments to obtain the viscosity of polymer solutions. (9) Small Amplitude Oscillatory Shear (SAOS) experiments to measure storage and loss modulus of polymer solutions and blends.
Suggested Books	1) C. Suryanarayana, Experimental Techniques in Materials and Mechanics, CRC Press; 1st edition (2011) ISBN: 978-1439819043

Syllabi
of
Institute Elective Courses (IEC)

List of Institute Elective Courses (IEC)

(A) School of Basic Sciences:

1. IPH 471N/ PH 671N/ AA 471N/ AA 671N: Relativity and Cosmology (2-1-0-3)
2. IPH 474 / PH 674 / AA 474 / AA 674: Basics of Radio Astronomy (2-1-0-3)

(B) School of Engineering:

1. ICS 419/ CS 419/ CS 619 : Computer Vision (2-1-0-3)
2. IEE 431 / EE 431/ EE 631 : Organic Electronics (2-1-0-3)
3. IME 451 / ME 651 : Mechatronics System Design (2-1-0-3)

(C) School of Humanities and Social Sciences

1. IHS 402 : Twentieth Century World History: Critical Perspectives (2-1-0-3)
2. IHS 416 : French Language (2-1-0-3)
3. IHS 422 / HS 622 : Development Economics (2-1-0-3)
4. IHS 425 : Money and Banking (2-1-0-3)
5. IHS 443 / HS 643 : Contemporary Short Fiction (2-1-0-3)
6. IHS 444 : Literature of the Twentieth Century (2-1-0-3)
7. IHS 482 : Introduction to International Development and Area Studies (2-1-0-3)

(D) Inter-disciplinary Group of Biosciences and Bioengineering (BSBE)

1. IBSE 401 : Introduction to Cell and Molecular Biology (2-1-0-3)

(E) Center of Innovation, Incubation, Entrepreneurship and Industry Relations (CIIEIR)

1. IE 301/ IE 401/ IE 601 : Foundation for Entrepreneurship (2-0-2-3)

1	Course Code	**AA 471N/ AA 671N/ IPH 471N/ PH 671N**
2	Title of the Course	**Relativity and Cosmology**
3	Credit Structure	L-T- P- Credits
4	Name of the Department of Center	Astronomy, Astrophysics and Space Engineering
5	Pre–requisite, if any	
6	Scope of the Course	This course aims to introduce students to cosmology through an understanding of the General Theory of Relativity. Special emphasis will be placed on linear perturbation theory in the early universe, leading to the formation of the cosmic microwave background, as this illustrates basic undergraduate physics in the context of the frontiers of research in cosmology.
7	Course Syllabus	**1. Special Relativity:** Michaelson-Morley Experiment, Galilean vs. Lorentz transformations, Lorentz invariance, scalars in special relativity, relativistic dynamics, acceleration in special relativity **2. Cosmology:** Olber's paradox; difficulty with Newtonian cosmology; brief introduction to general theory of relativity, especially the line element; Schwarzschild metric, horizon, orbits, Hawking radiation; FRW metric as a consequence of cosmological principle; redshift, angular and luminosity distances; evolution of scale factor from Newtonian cosmology; density parameter; LCDM cosmology; flatness and horizon problems, basics of inflation theory; thermal history of the Universe, big bang nucleosynthesis; microwave background. **3. Structure formation:** Jeans instability in an expanding background; initial perturbation and anisotropies in CMBR, formation of dark matter halos, galaxy formation and star formation; millennium simulation; Sunyaev-Zeldovich effect; neutral hydrogen and other elements in the IGM, Lyman α forest and damped clouds; reionization, AGN/star-formation history of the universe; Gunn-Peterson effect.

8	Suggested Books	1. S. Dodelson, ***Modern Cosmology***, Academic Press, 2003, ISBN: 0-1221-9141-2. 2. S. Carroll, ***Spacetime and Geometry: An Introduction to General Relativity***, 2003, ISBN: 0-8053-8732-2. 3. J. A. Peacock, ***Cosmological Physics***, Cambridge University Press, 1998, ISBN: 9780521422703. 4. P. J. E. Peebles, ***Principles of Physical Cosmology***, Princeton University Press, 1993, ISBN: 0-6910-1933-9. 5. P. J. E. Peebles, ***Large-Scale Structure of the Universe***, Princeton University Press, 1980, ISBN: 0-6910-8240-5. 6. D. H. Lyth, & A. R. Liddle, ***The Primordial Density Perturbation***, Cambridge University Press, 2008, ISBN: 0-5218-2849-X. 7. S. Weinberg, ***Cosmology***, Oxford University Press, 2008, ISBN: 0-1985-2682-7. 8. R. Durrer, ***The Cosmic Microwave Background***, CUP 2008. 9. S. Weinberg, ***The First Three Minutes***, Basic Books, 1993, ISBN: 0-4650-2437-8. 10. Misner, C.W., Thorne, K.S., Wheeler, J.A., Princeton, 2017, ISBN: 978-0691177793 11. Hartle, J.B., ***Gravity: An introduction to Einstein's General Relativity***, Pearson, 2003, ISBN: 978-

1.	Course Code	**IPH 474 / PH 674 / AA 474 / AA 674**
2.	Title of the Course	**Basics of Radio Astronomy**
3.	Credit Structure	L-T- P-Credits 2-1-0-3
4.	Name of the Department	Physics
5.	Pre–requisite, if any	Basics of Electronics procedure of conducting experiments
6.	Scope of the Course	This course is intended to impart the hands-on Astronomy to students. It aims to introduce Radio Astronomy as well as basic instrumentation and Engineering in Astronomy. It also aims to introduce students to the basics of Extragalactic Astronomy and Cosmology.
7.	Course Syllabus	**Review of Electromagnetic theory:** Maxwell's equations and basics of electric and magnetic fields, Basic Electromagnetic Theory and radiation of electromagnetic waves, E & B Field Measurable quantities and Polarization. **Radio Universe and Antenna:** The Radio Universe and the Atmospheric Radio Window Brightness, Flux density and antenna fundamentals-I, Effects of the earth's atmosphere, Basics of Radiative Transfer, Antenna fundamentals–II, Antenna Fundamentals–III. **Radio Interferometry:** Introduction, Uses and Advantages, Essential Ingredients of an interferometer. **Radiometers:** from Voltages to Spectra, Galactic Astrophysics and observations. **Extragalactic Astrophysics:** Fundamentals, Galaxies, Clusters of Galaxies, A brief introduction to cosmology, Astrophysics with 21 cm emission. **Experiments:** 1. Measuring Beam Patterns – 4 sessions 2. Measuring telescope aperture efficiency – 2 sessions 3. Measuring the brightness of the sun and the moon – 2 sessions 4. Galactic Observations – 21 cm – 4 sessions 5. Extragalactic Observations – 21 cm – 6 sessions 6. Cosmological Comtinuum and spectral line observations – 4 sessions 7. Final Projects – 8-10 sessions
8.	Suggested Books	1. Ryden, Barbara, **Introduction to Cosmology**, Addison Wesley, 2003. ISBN: 0-8053-8912-1

1	Course Code	**ICS 419 / CS 419 / CS 619**
2	Title of the Course	**Computer Vision**
3	Credit Structure	L-T- P-Credits 2-1-0-3
4	Name of the Concerned Department	Computer Science and Engineering
5	Pre–requisite, if any	None
6	Scope of the course	Objective of this course is to understand and create artificial vision systems which can reliably extract information from images. Study of vision problems require the basic understanding of image formation, image representation, ways of analyzing the images and patterns present in them. This course aims at providing the knowledge at all these fronts.
7	Course Syllabus	**Digital Image Processing:** Fundamentals, Types of Image Processing, Image Acquisition Methods, Human Perception of Color and Images, Transformations: Orthogonal, Euclidean, Affine, Projective etc. **Low-level Image Processing:** Image Enhancement in Spatial Domain – Histogram Processing, Contrast Stretching, Log Transformation, Gamma Correction, Smoothing and Sharpening; Logical and Arithmetic Operations, Morphological Image Processing, Image Enhancement in Frequency Domain, Fourier Transform, Convolution and Filtering, Image Restoration. **Image Feature Extraction:** Edge detection – Canny, Sobel, Prewitt, LOG, DOG, Line detector: Hough Transform; Corner detectors – Harris and Hessian Affine; Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis – Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT. **Image Segmentation:** Edge Based Approaches to Segmentation, Region Growing, Texture Segmentation, Object Detection and Segmentation: Graph-cuts, Active Contours, Mean-Shift. **Object Recognition:** Structural Approaches, Model-based Approaches, Appearance and Shape-based Approaches, Probabilistic Paradigms. **Pattern Analysis:** Clustering: K-Means; Gaussian Mixture Model (GMM); Classification – Discriminant Function, Supervised, Semi-supervised, Unsupervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods. **Motion Analysis:** Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis. **Applications and Performance Measures:** CBIR, CBVR, Activity Recognition, Biometrics, Document processing, Super-resolution, Augmented Reality, Security and Surveillance, Performance Evaluation Measures.
8	Suggested	**Text Books**

	Books	1. Computer Vision: A Modern Approach, D. A. Forsyth and J. Ponce, Pearson Education, 2003. (693 pages), ISBN: 9780130851987. 2. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer-Verlag, 2011. (832 pages), ISBN: 978-1848829343. **Reference Books** 1. Digital Image Processing, Rafael C. Gonzalez and Richard E. Woods, Pearson Education, 2008. (976 Pages), ISBN: 9788131726952. 2. Pattern Classification, R.O. Duda, P.E. Hart and D.G. Stork, Wiley-Interscience, 2000. (654 pages), ISBN: 978-0471056690. 3. Multiple View Geometry in Computer Vision, Richard Hartley and Andrew Zisserman, Cambridge University Press, 2004. (668 pages), ISBN: 978-0521540513. 4. Introduction to Statistical Pattern Recognition, Keinosuke Fukunaga, Academic Press, 1990. (592 pages), ISBN: 978-0122698514.

1.	Course Code	**IEE 431 / EE 431/ EE 631**
2.	Title of the Course	**Organic Electronics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department/Discipline	Electrical Engineering
5.	Pre–requisite, if any	Basic Semiconductor Physics/ Basic electronics
6.	Scope of the course	
7.	Course Syllabus	Background towards molecular electronics, surfaces and interfaces, structures and organization. Introduction to Schrodinger equation, Hartree-Fock Theory, Density Functional Theory. Molecular Solids, π-conjugated polymers, one dimensional band structure of linear conjugated polymers, optical absorption and emission in conjugated oligomers/polymers. Device motivation for interface studies, Metal-semiconductor and Metal-Insulator-Semiconductor Interface. Charge transport in conjugated polymers. Hopping and Multiple trap and release model. Interface effects viz. Dipole, doping, band bending etc. in organic semiconductor devices. Materials and Interface Engineering in Organic Light Emitting Diodes (OLEDs). OLED materials and device architecture for full color displays and solid state lighting. Theory and operation principle of Organic Field Effect Transistors (OFETs). Interface Characterization, Threshold Voltage and subthreshold swing and charge carrier mobility in OFETs. Application of OFETs in Displays. Organic Photovoltaic Devices (OPDs) using Polymer-Fullerene Bulk heterojunction thin films. Interface effects and improvement in Polymer Solar Cells (PSCs) efficiency. Introduction to some other advanced concepts viz. Organic electrochromic materials and devices, multiphoton absorbing materials and devices and Nonvolatile Organic Thin Film Memory Device.
8.	Suggested Books	1. S. M. Sze, ***Physics of semiconductor devices***, John Wiley and Sons, 1981, ISBN: 0-471-05661-8 2. R. Kelsall, I. Hamley and M. Geoghegan, ***Nanoscale Science and Technology***, John Wiley and Sons Ltd, 2005, ISBN: 0-470-85086-8. 3. K. Morigaki, ***Physics of amorphous semiconductors***, Imperial College Press, 1999, ISBN: 981-02-1381-6. 4. G. Hadziioannou and G. Malliaras, ***Semiconducting Polymers: Chemistry, Physics and Engineering***, Wiley Interscience, 2007, ISBN: 978-3-527-31271-9. 5. **F. So, Organic Electronics: Materials Processing,**

		Devices and Applications, CRC Press, 2010, ISBN: 978-1-4200-7290-7. 6. **Conjugated Polymer Surfaces and Interfaces**, Cambridge University Press, 1996, ISBN: 0-521-47206-7.

1.	Course Code	**IME 451 / ME 651**
2.	Title of the Course	**Mechatronics System Design**
3.	Credit Structure	L-T-P-Credit 3-0-0-3
4.	Name of the Concerned Department/Discipline	Mechanical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	**Mechatronics System design:** Introduction to Mechatronics- Integrated design issues- Key elements and design processes- Physical system modelling - Electrical systems- Micro processor based controller and micro electronics- Mechanical translation and rotational systems-Electromechanical coupling- Fluid system **Actuating devices:** Direct current motor, Permanent magnet stepper motor, Mechanical actuation, Hydraulic and pneumatic power actuation devices, Linear and latching linear actuators, Rotatory actuators, Piezo electric actuators, Actuator parameters and characteristics. **Sensors and Transducers:** An introduction to sensors and transducers, sensors for motion and position, Force torque and tactile sensors, Flow sensors, Temperature sensing devices, Ultrasonic sensors, Range sensors, Active vibration control using magnetostructive transducers, Lasers and Opto-mechatronics based devices. **Software and Hardware components in Mechatronics systems:** Signals , system and controls, system representation, Signal conditioning and devices, PLC, system representation, linearization of nonlinear systems, Time delays and measurement of system performance, Elements of Data acquisition and control systems, real time interfacing. **MEMS and Microsystems:** Microsystems and miniaturization-lithography technique- Micro actuators- actuation using shape memory alloys, piezo electric crystals and electrostatic forces-micro valves and pumps- micro sensors- Overview on applications of Robotics in automobiles and other industries.
8.	Suggested Books	**Text books:** 1) W. Bolton, **Mechatronics**, Pearson publications (ISBN 978-81-3176253-3) 2) Devdas Shett, Richard A. Kolk, **Mechatronics System Design**, Brooks/Cole, Thomson learning(ISBN 0-534-95285-2). **Reference Books:** 1) J. Watton, **Fundamentals of Fluid power and control**, Cambridge university press (ISBN 9780521762502)

		2) A. M. Pawlak, **Sensor and Actuators in Mechatronics Design,** Taylor and Francis (ISBN-13:978-0-8493-9013-5) 3) Tai-Ran Hsu, **MEMS and Microsystems design and manufacture,** Tata McGraw-Hill(ISBN0-07-048709-X) 4) S. A. Campbell, **The Science and Engineering of microelectronic fabrication,** Oxford university press(ISBN 0-19-568144-4)

1.	**Course Code**	**IBSE 401**
2.	**Title of the Course**	**Introduction to Cell and Molecular Biology**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Biosciences and Bioengineering
5.	Pre–requisite, if any	None
6.	Scope of the Course	The course will give an overview of modern biology, in addition to fundamentals in the area of Cell and Molecular Biology.
7.	Course Syllabus	**Cell:** prokaryotes and eukaryotes, Evolution, Eukaryotic cell structure, the nucleus, **Chemistry of Bio-molecules:** Carbohydrates, proteins, nucleic acids, lipids, **Proteins:** amino acids, different levels of structure; structure-function relationship; folding and mis-folding. Separation techniques. Hemoglobin: portrait of a protein in action; co-operativity, **Enzymes:** basic concepts and kinetics, catalytic and regulatory strategies. **Metabolism:** basic concepts and design. Glycolysis and gluconeogenesis. TCA cycle. Oxidative phosphorylation. Photosynthesis. Integration of metabolism. **DNA and RNA:** Structure, properties, mutations, repair and diseases. **Flow of genetic information:** replication, transcription and translation, gene expression, introns-exons. Exploring genes and genomes. **Recombinant DNA technology**, sequences of genomes, manipulation of eukaryotic genes. **Omics:** Genomics, transcriptomics and proteomics.
8.	Suggested Books	**Text / Reference Books** **1.** J.M. Berg, J.L. Tymoczko, L. Stryer, **Biochemistry** (6th ed) W. H. Freeman, 2006. [ISBN-10: 0716730510 ISBN-13: 978-0716730514] **2.** D.J. Voet & J.G. Voet. **Fundamentals of Biochemistry: Life at the molecular level** (3rd ed) Wiley. 2008. [ISBN-10: 0470129301 | ISBN-13: 978-0470129302] **3.** H. Lodish et al., **Molecular Cell Biology**, (6th ed), W. H.

		Freeman, 2007. [ISBN-10: 0716776014 | ISBN-13: 978-0716776017]

1.	Course Code	**IHS 416**
2.	Title of the Course	**French Language**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department/School	HSS
5.	Pre-requisite, if any (for the student)	None
6.	Objectives of the course	This is the first part of level A1 in the French language to impart basic conversational and writing skills to the students. The learner will learn the basics of phonetics and grammar. At the end of the semester, the student will be able to introduce himself and talk about everyday life.
7.	Course Syllabus	**Grammar :** Introduction of conjugation of the verbs regular and irregular in basic present and future tenses, articles, possessive adjectives, three types of interrogation, negation, disjunctive pronouns, prepositions of situation in space, gender and number of nouns and adjectives etc. **Vocabulary: r**elated to oneself, hobbies and activities, date and time, figures, festival, lodging, orientation, festivals, etc **Oral Situation:** Self introduction, greetings and leave taking, express likes and dislikes, ask and understand simple questions. **Phonetic:** basics: rhythm of French language, syllables, “enchaînement”, introduction to mute e and “liaison”, phonemes **Reading Comprehension:** very short texts of information (maps, timetable, etc.), mails, personal diary and comprehension of chronology of events. **Writing exercises: f**illing a form, talking about oneself, small messages, etc. **Introduction to French Culture and civilization**
8.	Suggested Books and references	1. Tech French (Leçon 1 à 8) 2. Connexion 1 3. Alter Ego 1 4. French magazines 5. Web references http://www.francparler.org; http://www.ciep.fr; http://www.rfi.fr http://www.tv5.org; http://www.lepointdufle.net; h

Course code	**IE 301/ EE 401/ EE 601**
Title of the course	Foundation for Entrepreneurship
Credit Structure	L-T-P–Credits 2-0-2-3
Name of the Concerned Department/Center	Center of Innovation, Incubation, Entrepreneurship and Industry Relations (CIIEIR)
Pre-requisite, if any	NIL
Scope of the course	The main scope of this course is to develop innovation and entrepreneurship skills among students
Course Syllabus/Contents	● Becoming an entrepreneur: what is entrepreneurship, and how to get into the entrepreneurial mindset? Best practices and strategies. ● Storytelling, Design thinking and Visual communication: harnessing the power of stories for ideation, design thinking, and visual communication for brand building. ● How entrepreneurs identify business opportunities (case studies) ● What it takes to be an entrepreneur and the role of leadership. ● Entrepreneurial finance – Stages & sources of start-up financing ● Customer discovery and Customer value proposition ● Marketing and Go-to-market ● Business communication and pitching to investors: persuasive business communication to pitch ideas to prospective investors and develop an idea into an entrepreneurial business, marketing and communication, crisis communication competencies to avoid economic consequences and damage to a brand image ● Government initiatives: “Pradhan Mantri Mudra Yojana”, “Aatma Nirbhar Bharat”, “Digital India”, “Make in India” and “Start-Up India”. Case studies. ● Basics of IP for entrepreneurs and IP related special schemes for start-ups by GoI ● Opportunities in agribusiness-Input, Processing, Machineries and Output Industries ● Supply chain and Marketing management. ● Characteristics of entrepreneurial environment ● Opportunity identification & evaluation ● Innovation and entrepreneurship (Types of innovation) ● Basics of new venture creation ● New product development – Crossing the chasm (Concept of waste to wealth) ● Practical: Idea presentation, Business plan presentation, Guest lectures from successful entrepreneurs, eminent professors, industry experts, etc.
Suggested Books	1. Oxford Handbook on Business and the Natural Environment - Environment entrepreneurship, Edited by: Prof. Pratima

	Bansal and Andrew J. Hoffman, Nov 2011 ISBN: 9780199584451 Published online: Jan 2012 DOI: 10.1093/oxfordhb/9780199584451.001.0001 2. Newman, A; North-Samardzic, A, Bedarkar M and Brahmankar, Y: Entrepreneurship in India: Routledge: New York:2022: ISBN 978-0-367-49770-5 3. Drucker, Peter: Innovation and Entrepreneurship, Taylor and Francis, 2014: ISBN 10:1315747456 4. Chan, Mable: English for Business Communication, Routledge Applied English Language Introductions, Taylor and Francis, 2020: ISBN 10: 1138481688 5. Brown, Tim: Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation (Revised and updated edition), Harper Business, 2019, ISBN 10:0062856626 6. McGrath, Rita Gunther and Ian MacMillan: The Entrepreneurial Mindset: Strategies for Continuously Creating Opportunity in an Age of Uncertainty, Harvard University Press, 2000, ISBN 10: 0875848346

Syllabi of Courses of Minor Program in Humanities and Social Sciences (from AY 2014-15 onwards)

1.	Course Code	**HS 201**
2.	Title of the Course	**Understanding Philosophy**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Philosophy/HSS
5.	Pre–requisite, if any	None
6.	Scope of the course	
7.	Course Syllabus	1. Introduction: Knowing Anything Plato's Idol of the Cave The Value of Philosophy 2. Knowledge and Justification: Certainty & Uncertainty 3. Nature, Science and Philosophy - In search of a 'Method' 4. Brain-in-a-Vat - The Philosophy of Matrix 5. Ethics: Reason and Human Behavior
8.	Background Readings	1. A. F. Chalmers, **What is this thing Called Science?** (Indianapolis: Hackett Publishing Company Inc., 1972). 2. D. J. Soccio, **Archetypes of Wisdom:** An Introduction to Philosophy (Belmont: Wadsworth Cengage Learning, 2010). 3. E. Sober, Core Questions in Philosophy: **A text With Readings** (Prentice Hall Inc., 2008). 4. J. Ladyman, **Understanding Philosophy of Science** (London: Routledge, 2002). 5. J. J. Rousseau, **Essay Discourses on Arts and Sciences** 6. K. Jaspers, **Ways to Wisdom**: An Introduction to Philosophy (New Haven: Yale University Press, 1954). 7. T. Nagel, **What Does it All Mean**? A very Short Introduction to Philosophy? (Oxford: Oxford University Press, 1987). 8. T. Nagel, (Cambridge: Cambridge University Press, 1991).

1.	Course Code	**HS 203**
2	Title of the Course	**Psychology**
3.	Credit Structure	L-T-P-Credit 3-0-0-3
4.	Name of the Concerned Department	Psychology/ Humanities and Social Sciences
5.	Pre-requisite, if any	None
6.	Scope of the course	The course is designed to be a survey of the topics of psychology. In general, this course will provide an overview of the discipline. Upon completion of this course, students will be able to: 1. Define psychology and relate it to other allied fields and engineering. 2. Understand the application of scientific method and basic principles of psychology. 3. Have an idea of psychological tests. 4. Understand concepts related to how individuals process basic stimuli and the limitations of these abilities. 5. Identify and apply basic issues of psychology in workplaces.
7.	Course Syllabus	**Understanding Human Experience and Behavior:** Definition, Schools, Methods, Branches, Application of Psychology for Engineers. **Measuring Human Abilities:** Intelligence, Personal Testing. **The Individual Working Life:** Personality Definition, Approaches and Theories, Models of Memory, Information Processing, Attention, Learning, Thinking. Psychological Problem of Everyday Life: Stress and Coping, Psychological Disorders, Work & Mental Health. **Motivation:** The Concept and Theoretical Framework, Motivating People at Work, Attitude & Work Behavior, Leadership & Management.
8.	Suggested Books	**Textbooks:** 1. E. E. Smith, S. Nolen-Hoeksema, B. Fredrickson, G. Loftus, **Atkinson and Hilgard's Introduction to Psychology,** Wadsworth Publishing Company, 2009. 2. R. S. Feldman, **Understanding psychology** (9th Ed.), McGraw-Hill Higher Education, 2009. **Reference Readings:** 1. C.T. Morgan, R.A. King, J.R. Weiss, and J. Schopler, **Introduction to Psychology** (7th Ed.), Tata Mcgraw Hill Education, 2004. 2. J.S. Nevid, **Essentials of Psychology: Concepts and Applications** (3rd Ed.), Wadsworth Publishing Company,

		Cengage Learning, 2011. 3. B. Robert. **Social Psychology** (12^{th} Ed.), Pearson Education, 2009. 4. I. Rothmann, C. L. Cooper, **Organizational and Work Psychology: Topics in Applied Psychology,** Hodder Education, 2008. 5. M. W. Matlin. **Cognitive Psychology (**7^{th} Ed.), Wiley, 2009.

For 2009 batch as a special case the course HS-203 was offered as an Institute Elective Course with course code & title IHS 403 – Psychology-I.

1	Course Code	**HS 205**
2	Title of the Course	**Sociology**
3	Credit Structure	L-T-P-Credits 2-1-0-3
4	Name of the Department/School	Sociology/Humanities and Social Sciences
5	Prerequisite, if any	None
6	Scope of the Course	Main objective of this course is to provide an introductory overview of the major schools of sociological theory incorporating diverse perspectives and illustrations drawn from different cultural contexts. It introduces the concepts and ideas of important classical and modern sociologists by elaborating the theoretical systems which derive their fundamental tenets in the works of these authors.
7	Course Syllabus	**What is Sociology**: defining sociological theory; Speculative vs. grounded theory; macro vs. micro theory; theories and models. **Social interaction**: Communication, interpretation and understanding. **Types of Society:** pre-modern, agrarian, industrial, postindustrial. **Culture:** popular, elite, folk, consumer, pluralism, multiculturalism. **Systems theory**: models of system analysis; mechanistic model, organismic model, structural model, Talcott Parsons' system theory. **Socialization and Social control:** Conformity and deviance. **Social stratification:** caste, class, status, power, gender, ethnicity; social mobility, social inclusion and exclusion. **Theory of Anomie**- Durkheim, Merton, Parsons; **Alienation**- Marx, Fromm, Mills; Anomie of Affluence. **Symbolic Interactionism**: Charles H. Cooley, Mead; Blumer and the Chicago School; Kuhn and Iowa School. **Structuralism**
8	Suggested Books/ Articles	1. Jayram, N. 2000. Introductory Sociology. MacMillan Press, London. 2. Gupta, D. 1992. Social Stratification. OUP, New Delhi. 3. Wallace, R.A., Wolf, A. 1995. Contemporary sociological theory: continuing the classical tradition. Prentice Hall, New Jersey. 4. Srinivas, M. N. 1992. Social change in modern India. Orient Longman, Hyderabad. 5. Calhoun, C., Gerteis, J., Moody, J., Pfaff, S., Virk, I. (eds.). 2012. Contemporary sociological theory. Wiley-Blackwell, Oxford. 6. Giddens, A. 1995. Politics, sociology and social theory: encounters with classical and contemporary social thought. Stanford University Press, California.

1.	Course Code	**HS 206**
2.	Title of the Course	**Paradigms and Turning Points**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Interdisciplinary Course
5.	Pre–requisite, if any	None
6.	Scope of the Course	This course offers major historical paradigms that have shaped the world in many ways. By doing so the course attempts to educate students about great ideas from antiquity to the present, not in the chronological sense, but to bring to light deeper insights into their mutual contestations and collaborations. Through these ideas, students would be able to grasp the greatness and profundity of these contestations.
7.	Course Syllabus	1. Wisdom – *Notion* of *the Ideal* *Knowledge from Nowhere* *2.* Religion – *Understanding* the *Supernatural* *Idea of an Other World?* *3.* Science – Mapping the *Process: Evolution of Scientific Knowledge* *World as a Mechanical Clock* *The Structure of Scientific Revolutions* *4.* Romanticism – *The Aesthetic Mind* *The Brighter Side of Imagination* *5.* Politics – Forming the *Human World* *Understanding Humans and Human Societies* *Interplay of Ideologies* *6.*Technology – Creating the *alternate world* *Artificial Intelligence – Science Fiction* *7.* Moral – Meaning of the *Human* *The sense of Right and Wrong*
8.	Suggested Books	1. A. Pacey, **Technology in World Civilization: A Thousand Year History,** The MIT Press, Massachusetts, 1992, ISBN: 978-0262660723. 2. D. R. Headrick, **Technology: A World History.** Oxford University Press, Oxford, 2009, ISBN: 978-0195338218. 3. D. Chalmers, **Constructing the World,** Oxford University Press, Oxford, 2012, ASIN: B00DEKFIL4 4. G. E. R. Lloyd, **The Ideals of Inquiry: An Ancient History,** Oxford University Press, Oxford, 2014, ASIN: B00KU3BFQ0. 5. H. Brown, **Wisdom of Science: Its Relevance to Culture and**

		Religion, Cambridge University Press, Cambridge, 1986, ISBN: 978-0521314480. 6. H. Zinn, **The Politics of History,** The University of Illinois Press, Illinois, 1990, ISBN: 978-0252061226. 7. H. Smith, **The Illustrated World's Religions: A Guide to our Wisdom Traditions,** Harper Collins, New York, 1995, ISBN: 978-0060674403. 8. P. Kreeft, **Back to Virtue: Traditional Moral Wisdom for Modern Moral Confusion** Ignetius Books, ASIN: B00JIBDOTG. 9. L. G. Perdue, **Wisdom Literature: A Theological History,** John Knox Press, Westminister, 2007, ISBN: 978-0664229191. 10. M. Matousek, **Ethical Wisdom: The Search for a Moral Life,** Anchor Books, New York, 2012, ISBN: 978-0767930680 11. M. Ferber, **Romanticism: A Very Short Introduction,** Oxford University Press, 2010, ASIN: B005CU4TQ4 12. M. Kenneth, **Politics: A Very Short Introduction,** Oxford University Press, 2000, ISBN: 978-0192853882. 13. R. Tagore, **The Religion of Man,** Martino Fine Books, 2013 edition, ISBN: 978-1614274834. 14. S. Aurobindo, **The Human Cycle: The Psychology of Social Development,** Lotus Press, 2010, ASIN: B003VD24S4. 15. T. Kuhn, **The Structure of Scientific Revollutions,** University of Chicago Press, Chicago, 2012 [50th Anniversary Edition], ISBN: 978-0226458120. 16. T. Dixon, **Science and Religion: A Very Short Introduction,** Oxford University Press, Oxford, 2008, ASIN: B003N2P408.

1.	Course Code	**HS 207**
2.	Title of the Course	**French Language - I**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Linguistic/HSS
5.	Pre-requisite, if any	None
6.	Scope of the course	This is a basic level course in the French language to impart basic conversational and writing skills to the students. After completing this course, the learner can interact in a simple way. The course focuses on active student participation in conversational French as well as writing skills.
7.	Course Syllabus	**Grammar :** Conjugation of the verbs regular and irregular in Present, Past and Future tenses, The articles, The Interrogation, The Negation, The disjunctive pronouns etc. **Vocabulary:** Related to oneself, Places of the city and country, Hobbies and activities, Travels and transports, Food, Festival, Every day activities, Lodging, Orientation, etc. **Oral Situation:** Self Introduction, How to take leave, Express liking and disliking, Narrate the activities in past tense. **Phonetic:** Sound [ʒ] – [y]; Rhythm and linking of words ; Pronunciation difference of noun masculine , feminine and plural; Sounds [v] – [f]; Rhythm of groups « verbs + verbs » and negative sentences. Pronunciation difference in the sentences of present and past tense. **Reading Comprehension:** Symbols of road; Small articles of press and portrait of a person; Post cards of invitation, acceptation and refusal; Personal diary and comprehension of chronology of events. **Writing exercises:** Make correspondence, Small messages, post cards etc, acceptation and refusal; Express an experience in past tense, etc. **Introduction to French Culture and civilization**
8.	Suggested Books and references	1. Echo 1 of CLE International (Leçon 1 to Leçon 4) 2. Connexion 1 3. Alter Ego 1 4. French magazines 5. Web references http://www.francparler.org; http://www.ciep.fr; http://www.rfi.fr http://www.tv5.org; http://www.lepointdufle.net; http://www.dailymotion.com/group/374

		http://fr.youtube.com/user/campusfle

1.	Course Code	**HS 208**
2.	Title of the Course	**French Language - II**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Linguistic/HSS
5.	Pre-requisite, if any	**HS 207: French Language - I**
6.	Scope of the course	This is advanced course in French language to impart advanced conversational and writing skills to the students.
7.	Course Syllabus	**Grammar:** Conjugation of the verbs regular and irregular in Future tenses; The adjectives; The adverbs; The Prepositions, etc. **Vocabulary:** Travels and transports; Food; Festival, Every day activities, Lodging, Orientation, etc. **Oral Situation:** Give and ask an explanation, etc; Practical situations related to travel; Practical situations at hotel and restaurant; Ask the updates of someone Choose, buy and pay To get informed regarding the direction etc; Ask for the help. **Phonetic:** Sound [ɔ] [ɔ̃], Difference between sound [y] and [u], [b], [v] and [f], [s] and [z], Rhythm and intonation, Rhythm of negative sentences, Rhythm of reflexive verbs, Intonation of imperative sentences. **Reading comprehension:** Articles of Press, Extract of brochure touristic of Paris. **Writing exercises:** Narrate the circumstances of trip; Present oneself on internet site; Drafting of a brief document of information; Drafting of a card or a message. **French Culture and Civilization**
8.	Suggested Books and references	1. Echo 1 of CLE International (Leçon 5 to Leçon 8) 2. Connexion 1 3. Alter Ego 1 4. French magazines 5. Web references http://www.francparler.org; http://www.ciep.fr; http://www.rfi.fr http://www.tv5.org; http://www.lepointdufle.net; http://www.dailymotion.com/group/374 http://fr.youtube.com/user/campusfle

Course code	**HS 209**
Title of the course	**Intermediate Microeconomics**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned	Humanities & Social Sciences
Pre-requisite, if any	HS 108; Fundamentals of Economics
Scope of the course	This course aims to extend the students' knowledge of the basic microeconomics principles and provide insight into how economic models can help us think about important real-world phenomena.
Course Syllabus	1. Basic theory of consumer behaviour, production and costs, supply in a competitive market 2. Market power: monopoly and monopsony, imperfect competition 3. Factor markets: Pricing of factors of production and income distribution 4. General equilibrium and economic efficiency: General equilibrium analysis, efficiency in exchange and production 5. Asymmetric information: Adverse selection, moral hazard and principal- agent model 6. Externalities: Production and consumption externalities, solution to externalities problem and efficiency conditions in the presence of externalities
Suggested Books	• R. Pindyck and D. Rubinfeld : *Microeconomics* : Pearson : India : 2015 : 978-9332585096 • H. Varian : *Intermediate Microeconomics* : A Modern Approach (9th edition) : W.W. Norton & Company : New York : 2014 : 978-0393123975 • A. Goolsbee, S. Levitt, and C. Syverson : *Microeconomics (3rd edition)* : Worth Publishers : New York : 2019 : 978-0716759751 • J.M. Perloff: Microeconomics: Theory and Applications with

1.	Course Code	**HS 210**
2.	Title of the Course	**Indian Economy**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Economics/Humanities and Social Sciences
5.	Pre-requisite, if any	Fundamentals of Economics
6.	Scope of the course	This course examines the history and current state of economic landscape of India since independence. We plan to cover economic policies of the country post-independence focusing on agriculture, manufacturing, financial and trade sectors. The class discussions attempt to bring forth the implications of the policies on the economy and society at large. We aim to understand the present economic structure, status, reform experience, current issues, and likely future prospects of the Indian economy. The course begins with analysis of post-independence policies in view of the economic and social realities of the country. It is followed by the discussion on reform period across different sectors of the economy. It is expected that by the end of the course, the participants are aware of the evolution eras of India's economic structure and are able to provide an informed commentary on relevant topics.
7.	Course Syllabus	Post-independence evolution of the economic policies; Five year Plans and economic growth before 1990's and the need for reforms in 1991. Indian agricultural sector: land reforms, issues of food management and security Manufacturing sector: the changes made following the reform period in the Industrial policy, Competition Policy and Policy for Small and Medium Enterprises. Indian international trade, WTO and Indian currency. Issues of inflation, poverty and inequality. Introduction to Indian financial sector.
8.	Suggested Books	1. S. Acharya and R. Mohan.**India's Economy: Performances and Challenges**. New Delhi: Oxford University Press, 2010. *Selected chapters.* 2. U. Kapila. **Indian Economy: Performance and Policies** (14th Ed). New Delhi: Academic Foundation, 2014. 3. J. Dreze and A. Sen. **India: Development and Participation**

		(2nd Ed). New Delhi: Oxford University Press, 2002. *Selected chapters.* 4. J. Bhagwati and A. Panagariya. **India's Tryst with Destiny**. New Delhi: Collins Publishers, 2012. *Selected chapters.*

Course Code	**HS 211**
Title of the Course	**German Literature and Culture Studies**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department/ School	Humanities and Social Sciences
Prerequisite, if any (for the students)	None
Learning Objectives	To provide an introduction to literature and culture in contemporary Germany. To provide an overview of major literary works, music, films, art and culture in modern Germany.
Course Syllabus	**German Literature:** Historical overview of German literature in the following periods: 1789 to 1870: Period during and after the French Revolution. 1871 to 1918: Period after the foundation of second German Reich. 1919 to 1933: The Weimar Republic 1933 to 1945: The Third Reich. **Understanding German Culture:** The citizen and State in modern Germany German education system Music and Art in modern German culture German Cinema and its critique (Goodbye Lenin; Das Leben der Anderen; Das Boot, The Good German; Jacob the Liar)
Suggested Books	1. Beutin W., Ehlert K., Emmerich W., et al. (1993). *A history of German literature: from the beginnings to the present day.* Routledge.NY. 2. Watanabe-O' Kelly, H. (2008). *The Cambridge history of German literature.* Cambridge univ. press. NY. 3. Kolinsky, E., Wilfried van der Will. (1998). *The Cambridge companion to modern German culture.* Cambridge univ. Press. NY. 4. Gay, P. (2001). *The Weimar culture: the outsider as insider.* Norton paperback, NY. 5. Ward, J. (2001). *Weimar surfaces: urban visual culture in 1920s Germany.* University of California Press. LA.

Course code	**HS 212**
Title of the course	**History of India after Independence, 1947-2000**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course	This course explores the History of India after Independence (1947-2000). It is structured around the following questions: •How did the constitution evolve as a document of Indian sovereignty, and what are its basic features and provisions? •How was India linguistically reorganized into states after Independence? •What role have institutions such as the Supreme Court, the Houses of Parliament, and the Election Commission played to preserve and uphold democracy in India? •What has been the role of educational institutions, particularly the Indian Institutes of Technology, to nation building? •How have international events in Asia, North America, Europe, and Africa shaped independent India's foreign policy?
Course Syllabus	1. The Constitution and nationhood, 1947-56 (Evolution and basic features of the constitution, universal franchise and voting rights, linguistic reorganisation of states) 2. Nation building and Education, 1957-73 (Democratic institutions, development projects, role of the Indian Institutes of Technology in nation building) 3. Dissent and Consolidation, 1974-89 (JP Movement, the Emergency, Punjab crisis, Dravidian movement, Kerala, and West Bengal) 4. Local reforms and global aspirations, 1990-2000 (The rise of the middle class, agrarian and manufacturing reforms, contribution of technological institutes to the making of new global diasporas) 5. India's role in world affairs, 1950-2000 (Non-Alignment Policy, India as a member state of the United Nations, Policy towards the North Atlantic Treaty Organization and Europe, Asia and Africa)
Suggested Books	1. Chandra, B_ Mukherjee, A_ Mukherjee, M, ***India after Independence, 1947-2000,*** Penguin India, Delhi, 2000, ISBN-10:0140278255 2. Bassett, R, ***The Technological Indian,*** Harvard University Press, Cambridge, Massachusetts, 2016, ISBN-10:0674245970 3. Rothermund, D, ***India- The rise of an Asian giant,*** Yale University Press, London, 2009, ISBN-10:0300158274 4. Talbot, I, ***A History of Modern South Asia, Politics, States, Diasporas***, Yale University Press, London, 2016, ISBN:9780300216592

Course code	**HS 213**
Title of the course	**Cognitive Psychology**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course	The course is designed to provide an overview of how information is processed by the brain. This course will help engineering students to understand how the human brain and mind process information. Through the knowledge gained by this course, students will be able to develop their creative and critical thinking. They will also be able to apply this knowledge in creating and designing ergonomically efficient engineered devices, products, etc. that can be consumer efficient. The knowledge of social cognition will make learners able to understand that how people interact with each other, what are their needs, how people develop their cognition, how people develop their understanding of others. Also, it will make students able to communicate better with their clients, which will make them able to understand what people want, etc.
Course Syllabus	**Foundation of Cognitive Psychology:** • Introduction, Methods and Paradigms in Studying Cognitive Psychology, Mind and Brain **Basic Cognitive Processes:** • Perception: Introduction; Pattern Recognition, Theories; Processing involved: Top-Down and Bottom-Up Processing • Attention: Introduction; Types and Theories of Attentional Processes • Memory: Introduction and Overview; Short Term Memory/Working Memory, Long Term Memory, Memories of Everyday Life **Advanced Cognitive Processes:** • Language and Cognition: Language Structure, Phonology, Syntax, Semantics, Pragmatics • Thinking and Problem Solving: Nature of Problem Solving, Types of Problem, Approaches to Solve Problems, • Decision Making: Nature, Science of Decision Making, Phases of Decision Making **Social Cognition:** • Introduction, Social Facilitation, Social Loafing • Attitude: Nature and Meaning, Characteristics, Formation • Social Perception: Impression Formation and Attribution Process

Suggested Books	1. K. M. Galotti, ***Cognitive psychology in and out of the laboratory,*** Sage Publications, Minnesota, 2017, 9781506351568 2. R. J. Sternberg, & K. Sternberg, ***Cognitive Psychology***, Cengage Learning : Boston : 2011 : 9781111344764 3. E. E. Smith & S. M. Kosslyn, ***Cognitive Psychology***: ***Mind and Brain,*** Pearson Education, India, 2015, 9789332550452 4. M. W. Eysenck, & M. T. Keane, ***Cognitive Psychology : A Student_s Handbook,*** Psychology Press, New York, 2005 9781841693590

Course code	HS 214
Title of the course	**History of Indian Culture and Civilization**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course	**Overview:** This course is an introduction to Ancient, Medieval and Modern India, 2600 BC-AD 1947. **Objective:** The course covers a sizeable historical terrain to address a particular set of objectives. These are: 1. What do 'culture', and 'civilisation' mean in the Indian context? 2. When did Indian civilisation begin? What are its contents? 3. Can one historically locate Indian culture? 4. Was there a concept of India before the 19th century?
Course Syllabus	**Harrapan Civilisation (2600-1900 BC):** society and urban life **Vedic India (2000-1500 BC):** Vedic culture Varna and Jati **Cities and Society (600-300 BC):** Janapadas, Buddhism and Jainism **Ancient Empires (324 BC-AD 750):** Mauryan, Gupta and Chola Empires **State and Community in Medieval India (AD 750-1525):** North and South Indian kingdoms, Islam and its development in India, Vijayanagar **The transition to Early Modern India (AD 1526-1740):** Mughal Empire, Marathas **Modern India (AD 1757-1884):** East India Company, 1857 Mutiny, British Raj **Independence and partition (AD 1885-1947):** Early Congress and its opponents, Gandhi's campaigns, the Partition
Suggested Books	1. B Stein, ***A History of India,*** Wiley-Blackwell, Delhi, 2010, ISBN-10, 1405195096, ISBN-13 : 978-140 2. U Singh, ***A History of Ancient and Early Medieval India-From the Stone Age to the 12 century,*** Pearson Education India, Delhi, 2009, ISBN-10 : 8131716775 ISBN-13: 978-8131716779 3. S Sarkar, ***Modern India,*** Pearson Education India, Delhi, 2014, ISBN-10, 9332535744, ISBN-13, 978-9332535749

Course code	**HS 216**
Title of the course	**Introduction to Hindi Cinema**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course	This course is designed to introduce the students to the diversity of Hindi Cinema, from its beginnings to the present. The course will provide a background to the industrial landscape of Hindi cinema as well as trace thematic concerns and generic tendencies. The course will journey through the silent cinema of the early studio years, the coming of sound, the consolidation of the star system and the post-globalization cinema.
Course Syllabus	Silent Cinema, Historicals and Devotionals, Socials and Stunt Film, Bombay as the Site of Modernity, Crime, Music and the Modern Vamp, Angry Young Man Era, Documentary Tradition, B-Film Circuits, Globalization and Film Form, Bollywoodisation, The Multiplex
Suggested Books	1. M. Madhava Prasad, ***Ideology of the Hindi Film: A Historical Construction,*** Oxford University Press, New Delhi, 1998, 978-0195652956 2. V. Vitali, ***Hindi Action Cinema, Industries, Narratives, Bodies,*** Indiana University Press, Bloomington, 2010, 978-0253222220 3. B. Sarkar, ***Mourning the Nation, Indian Cinema in the Wake of Partition,*** Duke University Press, Durham, 2009, 978-0822344117 4. K. P. Jayasankar and A. Monteiro, ***A Fly in the Curry : Independent Documentary Film in India***, Sage, New Delhi, 2015, 978-9351505693

Course code	**HS 221**
Title of the course	**Fundamentals of Linguistics**
Course Category	Liberal Arts Minor; Institute Open Elective
Credit Structure	L - T - P - Credits 3 - 0 - 0 – 3 (3/2 = 1.5)
Name of the Concerned Department	English/Humanities and Social Sciences
Pre-requisite, if any	None
Course Objectives	• Foster comprehension of Linguistics as a scientific discipline • Explore the fundamental principles of linguistics and various levels of analysis. • Create an awareness of the structure and features of natural languages.
Course Outcomes	• Define the properties of human language • Explain Linguistics as a scientific study of language • Analyse data in various languages by using the tools and techniques of Linguistics
Course Content	• Theories of Linguistics (Prescriptive vs. Descriptive grammar, Behaviorism, Structuralism, Nativism, Generative linguistics) • Speech production (Organs of speech, speech production, speech sounds, place and manner of articulation) • Levels of linguistic analysis (Phonetics, phonology, morphology, syntax and semantics) • Applications of linguistics (Applied areas of linguistics)
Suggested Books (Text Books , Reference Books)	**Text Books** • N. Chomsky, **Aspects of the Theory of Syntax**, Vol. 11, MIT Press, 2014, ISBN: 9780262260503 • S.K. Verma and S. Krishnasamy, **Modern Linguistics-An Introduction**, Oxford University Press, 2002, ISBN: 0195623711 • G. Yule, **The Study of Language**, Cambridge University Press, 2010, ISBN: 9780521749220 **Reference Books** • M. Atkinson, I. Roca and D. Kibly, **Foundations of General Linguistics**, Routledge, 2015, ISBN: 9781138974579 • J. Cutting and K. Fordyce, **Pragmatics-A Resource Book for Students**, Routledge, 2020, ISBN: 9780367207250 • P. Roach, **English Phonetics and Phonology- A Practical Course**, Cambridge University Press, 1991, ISBN: 0521282527

Course code	**HS 223**
Title of the course	**Language Variation: Culture and Society**
Course Category	Liberal Arts Minor; Institute Open Elective
Credit Structure	L-T-P-Credits 3-0-0 -3 (3/2 = 1.5)
Name of the Concerned Department	English/Humanities and Social Sciences
Pre-requisite, if any	Fundamentals of Linguistics
Course Objectives	• This course analyses the relationship between language, society and culture. • It examines the interaction of language with society and the individual and how language establishes power, ethnicity, gender, and social identity. • Explore linguistic diversity in society and the methodology for sociolinguistic analysis of conversations.
Course Outcomes	• Learn social, cultural, and affective factors that influence language and communication. • Analyze conversations in natural languages and explain the characteristics of language use
Course Content	• Language, society and sociolinguistics • Dialect and Variety- language variations vs change • Variations in English- World English(es), Global English, Colonialism and English, Connecting language and Indian English(es) • Ethnolinguistics-language and culture, language shift • Language and identity- language, language choice, identity, language attitude, language and power, language and gender etc. • Language families and Policy in India

Suggested Books	**Textbooks** 1. P. Trudgill, **Sociolinguistic Variation and Change**, Edinburgh University Press, 2002, ISBN: 9780748615155 2. R. Mesthrie, J. Swann, A. Deumert and W.L. Leap, **Introducing Sociolinguistics**, Edinburgh University Press, 2009, ISBN: 9780748638444 **Reference Books** 3. M. Meyerhoff, **Introducing Sociolinguistics**, Routledge, 2018, ISBN: 9780429507922 4. S. Romaine, **Language in Society- An Introduction to Sociolinguistics**, Oxford University Press, 2000, ISBN: 0198731922

Course Code	**HS 224**
Title of the Course	**Contemporary Short Fiction**
Course Category	Liberal Arts Minor; Institute Open Elective
Credit Structure	L-T- P-Credits 3- 0- 0 - 3
Name of the Concerned Discipline/School	English/Humanities and Social Sciences
Pre–requisite, if any	None
Course Objectives	In this course students will: • Explore the historical and cultural contexts of contemporary short fiction. • Analyze the thematic concerns, narrative techniques, and stylistic innovations of contemporary short story writers.
Course Outcomes	• Analyze the thematic concerns, narrative techniques, and stylistic innovations of contemporary short story writers. • Explore the cultural, social, and political dimensions of contemporary short fiction.
Course Content	• Fundamentals of the short fiction genre (Postmodernism, Short Metafiction, Intertextuality, Fragmentation) • Science Fiction (Dystopias, Utopias, and Alternate Realities) • Narratives of Ecological Consciousness (Nature Writing, Environmental Concerns, and Eco-Criticism) • Electronic Literature (Digital storytelling)
Suggested Books	**Text Books** 1. M.H. Abrams, **Glossary of Literary Terms,** Wadsworth Publishing, 2011, ISBN: 9788131526354 2. K. Hayles, Electronic Literature- New Horizons for the Literary, Notre Dame Press, 2008, ISBN: 9780268030858 **Reference Books** 3. V. Singh, Ambiguity Machines and Other Stories, Small Beer Press, 2018, ISBN: 9781618731432 4. R. Vanita, The Shroud Stories-Premchand, Penguin Books, 2011, ISBN: 9780143415961

Suggested Course code	**HS 226**
Title of the course	**Sociology of Cinema**
Course Category	Liberal Arts Minor; Institute Open Elective
Credit Structure	L - T - P - Credits 2 - 1 - 0 - 3
Name of the Concerned Department	Sociology/Humanities and Social Sciences
Pre-requisite, if any	None
Course Objectives	• Introduction to the sociological intersections between cinema and society • Understanding Cinema vis-a-vis shifting historical landscape in post-independent India, and post-war US, Europe and Japan • Tracing key thematic and generic tendencies along major national events
Course Outcomes	• Assess economic and political undercurrents of cultural transformations in Cinema. • Analyse the role of technology in cinema's evolution and its overlap/competition with other media platforms (newspaper, radio and television) • Analyse the methods by which popular cinema has been designed to combine or segregate demographic clusters
Course Content	• How to study Cinema? - Textual analysis - Framing society as historical, economic and political context • Early Indian Sound Cinema, 1930s-40s - Devotional Films - Action Cinema • Classical Hollywood film language - Hollywood Lighting - Douglas Sirk's "women's weepies" • Post-War European Art cinema language - Jump Cut - Long Take • Post-War Japanese Horror films • Post-independence Hindi Melodramas, 1950s • Realist Representation • Indian New Wave Cinema • The Indian Documentary • Bollywood as a Culture Industry, post-liberalization • Multiplex Cinema, 2005 onwards

Suggested Books	**Text Books** 1. M.M. Prasad, **Ideology of the Hindi Film- A Historical Construction**, Oxford University Press, 1998, ISBN: 9780195652956 2. V. Vitali, **Hindi Action Cinema- Industries, Narratives, Bodies**, Indiana University Press, 2010, ISBN: 9780253222220 **Reference Books** 3. B. Sarkar, **Mourning the Nation- Indian Cinema in the Wake of Partition**, Duke University Press, 2009, ISBN: 9780822344117 4. K.P. Jayasankar and A. Monteiro, **A Fly in the Curry- Independent Documentary Film in India**, Sage, 2015, ISBN: 9789351505693

1.	Course Code	**HS 311**
2.	Title of the Course	**Life and Thought of Gandhi**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Philosophy/HSS
5.	Pre–requisite, if any	None
6	Scope of the course	The course focuses on the study of Gandhi's philosophy and life. The class will try to explore the man behind the legend, as well as explore his philosophy of *ahimsa*. The goal is to determine if his philosophy is relevant to our world and times.
7.	Course Syllabus	Major themes of the course: Introduction to the man and the Mahatma Principal Texts: Hind Swaraj, <u>An Autobiography</u> The practice and theory of Satyagraha Gandhi and the quest for Swaraj and Moksha Debates on Gandhi Critical Evaluation
8.	Suggested Books	1. S. Sharma and T. Suhrud, ***M.K. Gandhi's Hind Swaraj a critical edition,*** New Delhi: Orient Blackswan, 2010. 2. Parel, Anthony J. ***Gandhi: Hind Swaraj and Other Writings,*** Cambridge: Cambridge University Press. 1997. 3. B.R. Nanda, ***Gandhi and His Critics,*** New Delhi: Oxford University Press, 2010. 4. J. Brown, ***Gandhi: Prisoner of Hope,*** New Haven: Yale University Press, 1991. 5. Raghurama A Raju, ***Debating Gandhi,*** New Delhi: Oxford University Press, 2006. 6. C. Markovits, ***The Un-Gandhian Gandhi,*** New Delhi: Permanent Black, 2007. 7. R. Gandhi, ***The Good Boatman: A Portrait of Gandhi,*** New Delhi: Penguin,1995. 8. D. Hardiman, ***Gandhi in his Times and Ours*****:** ***The Global Legacy of His Ideas,*** New Delhi: Permanent Black, 2003. 9. L. Fischer, ***Life of Mahatma Gandhi,*** NewYork: Harpercollins, 1997. 10.B. Parekh, ***Gandhi: A Very Short Introduction*****,** New Delhi: Oxford University Press, 2001.

1.	Course Code	**HS 313**
2.	Title of the Course	**History of Early Cinema**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Philosophy/HSS
5.	Pre–requisite, if any	NIL
6.	Scope of the course	
7.	Course Syllabus	I. Cognition and Imagination Film and Knowledge - Film as Philosophy II. Philosophy of Motion Pictures Essence of Cinema: Perception, Illusion and Fantasy III. Film: Human Emotion - Meaning of Life IV. Film and Historical Imagination V. Film and Racism
8.	Suggested books	1. Bazin, Andre, **What is Cinema?** Vol 1, (New York: University of Californina Press, 2004). 2. Carroll, Noel, **The Philosophy of Motion Pictures** (Oxford: Wiley Blackwell, 2007). 3. Cavell, Stanley, **The World Viewed: Reflections on the Ontology of Film** (Harvard: Harvard University Press, 1979). 4. Currie, Gregory, **Image and Mind: Film**, Philosophy and Cognitive Science (Cambridge: Cambridge University Press, 2008). 5. McCuinn, Colin, **The Power of Movies: How Screen and Mind Interact** (Vintage Press, 2007). 6. Perrson, Per, **Understanding Cinema: The Psychological Theory of Moving Imagery** (Cambridge: Cambridge University Press, 2003) 7. Platinga, Carl & Greg M. Smith, **Passionate Views: Film**, Cognition and Emotion (Johns Hopkins University Press, 1999).

Course code	**HS 315**
Title of the course	**Sociology of Science and Technology**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	None
Scope of the course	The course is designed to provide the much needed exposure to students over interconnected domains of science, technology and society, by focusing on comprehensive and ever-changing relationship between technology and society. It also examines how cultural values/practices, public policies and political vision determine and at times be driving forces behind technological changes and vice versa
Course Syllabus	**Discourse of Science and Technology:** Nature of science and technology, Technology as an Idea, The structure of scientific revolution, Science and scientific community, Rhetoric of science and technology. **Technological change and Society:** Source and agents of technological change, Do machines make history? Technology and everyday life, The technological life world, Technology as shadow constitution, Technological change as social process. **Technology and Politics:** Intersection of culture, gender and technology, Feminization of work/workforce in the information age – politics, facts & artifacts, Technology as dominant force. **Technology and Ethics:** The rights and wrongs of science - case studies, Technology as a dominant social force, Technological momentum and determinism, Law and science/technology.
Suggested Books	1. M. Bridgstock, **Science, Technology and Society : An Introduction**, Cambridge University Press, Cambridge, 1998, 0521583209 2. A. Borgmann, ***Technology and the Character of Contemporary Life***, University of Chicago Press, Chicago, 1987, 9780226066295 3. K Thomas, ***The Structure of Scientific Revolutions***, Chicago, Univesity of Chicago Press, 1962 **Reference readings:** 4. Wenda K. Bauchspies, ***Science, Technology and Society***, A Sociological Approach, Blackwell Publishers, Boston, 2005, 0631232109 5. B. Latour, ***Laboratory Life: The Construction of Scientific Facts***, Princeton: Princeton University Press, 1986 6. Chalmers A.F., ***What is this thing called Science***, St Lucia, University of Queensland Press, 1999. 7. R Volti, ***Society and Technological Change***, (6th Edition) Newyork: Worth Publishers, 2008

	8. Deborah G. Johnson & Jameson M. Wetmore: *Technology and Society*: Building Our Sociotechnical Future: MIT Press: Cambridge: 2009 : 0262600730 9. S. Jasanoff, ***Science at the Bar: Law, Science and Technology in America***, Cambridge, Harvard University Press, 1995

Course code	**HS 321**
Title of the course	**History of Modern Indian Business**
Course Category	Open Elective/ Economics Minor
Credit Structure	L-T-P-Credit 2-1-0-3
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course (Objectives)	This course focuses on the role of Indian Business Communities in History from c. 1700 AD-2005 AD
Course Outcomes	• Evaluating the effects of colonialism on India's business environment in 1947. • Assessing the impact of the public sector on the growth of Indian business • Analysing the historical impact of Liberalization of the economy on Indian business
Course Content	• Indian Business Communities and merchants in History (1700-50) • The impact of colonial economic policies on independent India (1757-1947) • British businesses in India (1834-1940) • Indian Business and the Nationalist Movement (1890-1947) • How to build an economy: The challenges of 1947 on Indian Business climate. • The impact of the License Raj on Companies, firms and sectors (1960-90) • The impact of Liberalisation (1991-2005)
Suggested Books	**Text Books** • Tripathi, D., & Jumani, J. : The Oxford History of Contemporary Indian business : Oxford University Press : Delhi : 2017 : ISBN : 9780198082248, 019808224X **Reference Books/texts** • Habib, I., & Raychaudhuri T. : The Cambridge Economic History of India, Volume I : Orient Blackswan : Delhi : 1983 : ISBN : 9780521226929 • Kudaisa, M. : The Oxford India Anthology of Business History : Oxford University Press : Delhi : 2011 : ISBN-13 : 978-0198070191 ISBN-10 : 0198070195

1.	Course Code	**HS 323**
2.	Title of the Course	**International Economics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Economics/HSS
5.	Pre–requisite, if any	Introduction to Economics
6.	Scope of the course	
7.	Course Syllabus	Global trade in goods and services; Growth and trade; Basic theory of international trade; Empirical Tests of Trade Theories; International trade and technical change; Economics of import tariff; Non-tariff import barriers; Arguments for and against protection; Trade policies for development; Benefits and costs of the Globalization Process; Introduction to macroeconomics of an open economy and international Finance; World Trading System.
8.	Suggested Books	1. Salvatore, Dominick. **International Economics**. 8th Edition. Tata Mcgraw Hill. 2004. 2. Krugman, P.R. and M. Obstfeld. **International Economics: Theory and Policy**. 8th Edition. New York: Pearson. 2005.

Course code	**HS 325**
Title of the course	**Industrial Organization**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned	Humanities & Social Sciences
Pre-requisite, if any	None
Scope of the course	This course uses economic analysis to understand competition among firms in an industry and the evolution of its market structure. The focus is on firms' decision making and its consequences for market outcomes like prices, quantities, the type of products offered, and social welfare.
Course Syllabus	1. Theoretical background: Basic concepts of game theory, noncooperative game theory, normal, extensive, and repeated games 2. Different market structures of industries, markets for homogenous and differentiated goods and strategic interactions among the firms. Concentration, mergers, and entry barriers in industries 3. Pricing by firms in an industry, advertising, marketing, and pricing tactics 4. Technology and industry: Market structure, R&D, and patenting 5. Competition policy and industry: Need for policy, relation with
Suggested Books	• O. Shy : *Industrial Organization – Theory & Applications* : MIT Press : USA : 2000 : 9780262193665 • J. Tirole : *The Theory of Industrial Organisation* : MIT Press : USA : 1988 : 978-0262200714 • J. Church and R. Ware : *Industrial Organisation* : A Strategic Approach : McGraw-Hill : USA : 2000 : 0-256-20571 • P. Belleflamme and M Peitz: Industrial Organization: Markets and Strategies (2nd edition): Cambridge University Press: UK: 2015: 9781107687899

Course Code	**HS 327**
Title of the Course	**Mind, Action, and Technology**
Credit Structure	L-T-P-Credit 2-0-1-3
Name of the Concerned Department	Humanities and Social Sciences
Pre-requisite, if any (for the students)	None
Course Objective	This course will provide an overview of: 1. How does information enter our cognitive system? 2. How does information become incorporated into our cognitive structures? 3. How is information processed to allow us to complete complex tasks? 4. Cognitive development. 5. Advancements in human interaction with technology.
Course Syllabus	**Fundamental Issues Concerning Cognition:** Common View: Nature, Reality, and Existence. Generality and Normativity, A Priori Reasoning and Conceptual Analysis, the Importance of Empirically Informed Reflection. Artificial vs Animate/Natural Cognitive System: Understanding what an artificial system needs. Essential Elements of Cognitive Systems: Receptors, Motor Control, Cognitive Process (Interpretation, Action Control, Guidance the Allocation of Cognitive Resources, Memory). **Cognition and Nature** Extraneous to/Strangers to Nature, Instinct, Learned Aspects of Individuals. **Understanding the World/Real World and Cognition** Sensory Modalities, Sensory Processing vs. Sensory Integration, Perceptual Process and Unitization, Embodied Cognition, Distributed Cognition. Cognitive Development, Moral Development, Aging & Cognition, Altered State of Consciousness, Psychoactive Drugs, Cognitive Impairments, Music and Movement, Cognitive Evolution and Humans, Cognition, Science & Beyond. **Knowing Other's Mind** Not So Plasticity of Cognition, Social Learning, Stereotype, Communication, Culture and Cognition, Micro and Macro Cognition. Cognitive Plasticity: Cognitive Performance Plasticity, Factors

	Affecting CPP (Social Context, Physical Environment, Internal Factors), Measurement Approaches (Behavioral Reaction Norm), Implications. **The World and Its Real Mind** Representation and Computation, Relationship Between Humans and Machines, Artificial Intelligence, Cyber-Human System, Brain-Computer Interface, Human-Robot Interaction, Extended Reality, Assisted Reality, Build-Environment, Network-Enabled Systems, Trust, Safety, Security.
Suggested Books	1. D. Reisberg, **Cognition: Exploring the Science of the Mind,** W. W. Norton & Company, New York, 2018. ISBN: 978-0393877618. 2. H. L. Roitblat, H. S. Terrace, & T. G. Bever, **Animal Cognition,** Psychology Press, New York, 2014. ISBN: 13: 978-0-898-59334-1. 3. W. Sinnott-Armstrong, **Moral Psychology, Volume 2: The Cognitive Science of Morality: Intuition and Diversity**, The MIT Press, Cambridge, 2008, ISBN: 978-0-262-69357-8 4. D. Hofstadter, **Alan Turing: Life and Legacy of a Great Thinker,** Springer, Lausanne, 2013. 9783662056424.

Course code	HS 328
Title of the course	Philosophy and Film
Course Category	Liberal Arts Minor; Institute Open Elective
Credit Structure	L - T - P - Credits 3 - 0 - 0 -3
Name of the Concerned Department	Philosophy/Humanities and Social Sciences
Pre-requisite, if any	None
Course Objectives	• This course analyses the role of philosophy in cinema. • It focuses on the contributions of the discipline of philosophy to cinema.
Course Outcomes	• Identify the role of philosophical ideas in cinema • Analyse the philosophical relationship between cinema and imagination
Course Content	• Philosophy of Motion Pictures – *the Moving Image* • Essence of Cinema: Perception, Illusion, Fantasy, Reality • Fiction *vs.* Reality – Collapse of a distinction • Cinema: the world of make beliefs and interaction between reality and fiction • Genres of Cinema [Science Fiction, Historical Films, Political and War Cinema, and Motivation Films] • Science Fiction Cinema – Reclaiming the Human [About bringing humanity to human kind] • History goes to the movies [Critique of Representation of historical greatness in western cinema] • War Cinema – [critique of War as Spectacle – projection of war, good and bad] • Holocaust Film – [talks about the inhuman condition and the possibility of human evil]

Suggested Books	**Text Books** 1. R. Barsam and D. Monahan, Looking at Movies- An Introduction to Film, W.W. Norton & Company, 2016, ISBN:9780393885835 2. N. Carroll and J. Choi, Philosophy of Film & Motion Pictures- An Anthology, Wiley, 2005, ISBN: 9781405120265 Reference Books 3. J. Chapman, War and Film, Reakton Books, 2008, ISBN: 9781861893475 4. M. Hughes-Warrington, History Goes to the Movies- Studying History on Film, Routledge, 2016, ISBN: 9780415328289 5. R. Kavaney, From Alien to Matrix- Reading Science Fiction Film, I.B. Tauris, 2005, ISBN: 9781850438069

Course Code	**HS 330**
Title of the Course	**Graphic Literature**
Course Category	Liberal Arts Minor; Institute Open Elective
Credit Structure	L-T- P-2-1-0-3
Name of the Concerned Discipline/School	English/Humanities and Social Sciences
Pre–requisite, if any	None
Course Objectives	• Explore the history, theory, and practice of graphic literature as a distinct form of artistic and literary expression. • Analyze the conventions, techniques, and aesthetics of graphic storytelling across different genres, styles, and cultural contexts. • Investigate the cultural, social, and political dimensions of graphic narratives, including their role in shaping identities, ideologies, and public discourse.
Course Outcomes	• Develop a critical understanding of the conventions and techniques of graphic storytelling, including the use of images, text, and layout • Anaylse graphic narratives, examining their thematic content, visual symbolism, and narrative structures • Explore the cultural, social, and political significance of graphic literature, critically assessing its representation of diverse identities, experiences, and perspectives
Course Content	• History and Evolution of Graphic Literature (From Pioneers to Contemporary Storytellers) • Conventions and Techniques of Graphic Storytelling (Visual Grammar and Narrative Syntax) • Digital Graphic Narratives (Webcomics, Digital Graphic Narratives and New Platforms) • Comics Journalism (Documentary Graphic Narratives, Climate fiction, Visual Reporting) • Graphic Literature and Interdisciplinary Studies (Connections with Film, Literature, Visual Culture)

Suggested Books	Text Books 1. S. McCloud, **Understanding Comics**, Harper Perennial, 1993, ISBN: 9780060976255 Reference Books 2. A. Spiegelman, **Maus- A Survivors Tale**, Penguin Books, 1991, ISBN: 9780140173154 3. S. Vyam and S. Anand, **Bhimayana- Experiences of Untouchability**, Navayana, 2011, ISBN: 9788189059170 4. V. Ghosh, **Restorying Partition- Graphic Narratives from Pakistan, India and Bangladesh**, Yoda Press, 2013, ISBN: 9789382579014 5. M. Satrapi, **Persepolis-The Story of a Childhood**, Pantheon, 2004, ISBN: 9780375714573

1.	Course Code	**HS 341**
2.	Title of the Course	**Appreciating Indian English Literature**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	English/HSS
5.	Pre–requisite, if any	NIL
6.	Scope of the course	
7.	Course Syllabus	The Course will make an attempt at understanding the complex dynamics of the various socio-politico-cultural issues that lead to the marginalization of some sections in any given society. Though such deliberate marginalization is a universal malaise, this course will focus on the marginalized sections in the Indian context. The thrust here will be to try and understand how such oppressions, inequalities and marginalization are explored in the literatures of the very people who have been relegated to the margin through discriminations based on caste, gender, region, etc. The texts mentioned above are only indicative and other texts can be included depending on the directions that classroom discussions will take. The background readings will be helpful in familiarizing the students with some of the issues at hand and their complexities.
8.	Background Readings	1. Khair, Tabish. Babu Fictions: **Alienation in Contemporary Indian English Novels.** New Delhi: Oxford University Press. 2001. 2. Kumar, Raj. Dalit Personal Narratives: **Reading Caste, Nation and Identity.** Hyderabad: Orient Blackswan Pvt. Ltd. 2010. 3. Nubile, Clara. **The Danger of Gender**: **Caste, Class and Gender in Contemporary Indian Women's Writing**. New Delhi: Sarup Books Pvt. Ltd, 2008. 4. Swami, Indu, **Ed. Exploring North-East Indian Writings in English.** New Delhi: Sarup Book Publishers Pvt. Ltd, 2011. 5. Misra, Tilottama, ed. **The Oxford Anthology of Writings from North-East India (Fiction).** New Delhi: Oxford University Press, 2011. 6. Anand, Mulk Raj, ed. **An Anthology of Dalit Literature**. New Delhi: Gyan Publishing House, 1992. (selected Dalit writings)

		7. De Souza, Eunice and Pereira, Lindsay, Eds. Women's Voices: **Selections from Nineteenth and Early-Twentieth Century Indian Writing in English**. New Delhi: Oxford University Press, 2002. 8. Sarmila, Irom. **Fragrance of Peace**, New Delhi: Zubaan, 2010. 9. Hasan, Anjum. **Lunatic in My Head**. New Delhi: Penguin Books India, 2007. 10. Das, Narayan. **Writings and Speeches of Ambedkar**. New Delhi: Abd Publishers, 2009. 11. Rege, Sharmila, **Ed. Women Writing Caste: Testimonies of Dalit Women in Maharastra.** New Delhi: Zubaan Books, 2006.

1.	Course Code	**IHS 402**
2.	Title of the Course	**Twentieth Century World History: Critical Perspectives**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department/School	Philosophy/HSS
5.	Pre–requisite, if any	NIL
6.	Scope of the Course	No other century witnessed such a quantum leap in civilizational progress as the Twentieth century has. It has witnessed great wars, great revolutions and formation of several nations based on manifold ideological principles. This way we are obligated to know what took us beyond imagination, but also cannot overlook off-shoots of this great leap – which are in several ways hindrances to a better world. The Scope of the Course of the course is to bring to notice those 'amazing ideas' that makes century's history a unique in the book of story of humankind. Further, it puts before for though reflection several challenges that we are faced with to maintain peace and harmony among several races and cultures.
7.	Course Syllabus	Civilizations at the Crossroads – The Making of a Grand History War Among Nations The Cold War – Clash of Civilizations End of History Debate Post-Cold War World New Horizons of Peace and Conflict – Challenges to a Harmonious Universe – Drawbacks of International Law
8.	Suggested Books	1. C.S. Adams & J. H. Conrad, **Ideologies in Conflict: A Cold War Docu-Story** (iUniverse, 2001). 2. E.H. Carr, **What is Hitory?** 3. A.G. Frank, **The World System: Five Hundred Years or Five Thousand?** (Routledge, 1996). 4. F. Fukuyama, **The End of History and the Last Man** (Free Press, 2006). 5. C. Geertz, **The Interpretation of Cultures: Selected Essays** (New York: Basic Books, 1973). 6. M. Gilbert, **A History of the Twentieth Century: The Concise Edition of the Acclaimed World History** (William Marrow Paperbacks, 2002).

		7. S. Huntington, **The Clash of Civilizations and the Remaking of World Order** (Simon & Schuster, 2011). 8. I. Kant, **Perpetual Peace** (FQ Classics, 2007) 9. E. Schrecker, **Cold War Triumphalism: The Misuse of History After the Fall of Communism** (New Press, 2006). 10. M. Trachtenberg, **The Cold War and After: History, Theory and the Logic of International Politics** (Princeton: Princeton University Press, 2012)

Course Code	**HS 403**
Title of the course	**The West in Twentieth Century: Critical Perspectives**
Credit Structure	L-T-P-Credits 3-0-0-3
Name of the Concerned Discipline	Humanities and Social Sciences
Prerequisite, if any	NA
The Scope of the course	• The scope of this course is to bring to notice those 'amazing ideas' that makes the twentieth century's history a unique one in the story of human kind. • The objective of the course is to bring to your attention great challenges that made the century – to endure the consequences of ways of the past century; especially, in achieving a peaceful world order.
Course Syllabus	1. Twentieth Century: The Dawn of a new horizon [the rise of modern political states, new age, and new hope] 2. Political Revolution: The Socialist Experiment [gigantic efforts to replace equality with reckless freedom, by the spirit of "all humans are created equal"] 3. World War – I [First modern war - considered as "The Great War", a war to end all wars] 4. Inter-War Period – The Great Depression – The Rise of powerful nations [Rise of Germany, Hitler and the Third Reich – and related forms of Totalitarianism] 5. World War – II & Holocaust [Human moral failure never seen before – Race Wars] 6. The Cold War – The Ideological Age [Quantum leap forward, but without peace and integrity – Age of

	Extremes and Age of Violence, coming of Neo-Imperialism, Global Injustice] 7. Clash of Civilizations & The End of History [Fukuyama and Huntington – No Ideological War, No history and Rogues and Civilized Nations] 8. 9/11 – Myth or Reality [History repeats again, Violence and catastrophes continues challenging the beginning of a new millenium 9. History and the Guilt Paradigm – Forgiveness [To bring peace, do we need to forgive and forget the past? History, Crime and Guilt – a profound dilemma]
Suggested Books	Textbooks 1. Barkan, Elazar, & Alexander Karn, *Taking Wrongs Seriously: Apologies and Reconciliation*, Stanford: Stanford University Press: 2006: ISBN: 9780804752251 2. Bruckner, Pascal, *The Tyranny of the Guilt: Essays on Western Masochism*, Princeton: Princeton University Press: 2010: ISBN: 9780691154305 References 1. Cortright, David, *Peace: A History of Movements and Ideas*, Cambridge: Cambridge University Press: 2008: ISBN: 978-0-521-67000-5 2. Barett, Kevin, “9/11: Interpreting the Unspeakable: Myth or Reality” http://rl911truth.org/index.php/related-911-articles/58-barrett-kevin-interpreting-the-unspeakable-the-myth-of-911

Course code	**HS 410/ HS 610**
Title of the course	**Media Studies**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course	The emergence and proliferation of new/digital/web-based media over the last two decades compels us to establish, investigate and reconfigure the idea of what old and new media are and if they could be understood independent of one another. In this course, we will conceptualise Media Studies, exploring their historical and theoretical provenance. We shall assess how and why media aggregate, appropriate and comment upon other media, and how ways of seeing and listening are consolidated via other media. We will try to establish a dialogue across old and new media, sound- and image-based representation in media, and media as technology vis-à-vis media as infrastructure.
Course Syllabus	New vs Old Media_ Platform Economy/Capitalism and Algorithmic Governance_ Immediacy and Hypermediacy in Mediation_ Liveness in News Television and Public Scandals_ Media in terms of the history of Infrastructure_ Media and Modernization Theory_ Attention Economy (Capital, Attention and Cinema in Industrial Economies)_ Convergence Culture (Hardware vs Software convergence_ Post-Cinema Perspectives on the Future of Media.
Suggested Books	1. D. J. Bolter and R. Grusin, ***Remediation : Understanding New Media,*** MIT Press, Cambridge, 1999, 9780262522793 2. B. Larkin, ***Signal and Noise*: Media, Infrastructure,** Duke University Press : Durham, NC : 2008 : 9780822341086 3. J. Beller, ***The Cinematic Mode of Production : Attention Economy and the Society of Spectacle***, Dartmouth Press, New Hampshire, 2006, 9781584655831 4. S. Denson and J. Leyda, ***Post-Cinema : Theorizing 21st Century Film,*** Reframe Books, Falmer, 2016, 9780993199639

1	Course Code	**HS 412 / HS 612**
2	Title of the Course	**Contemporary Indian Thought**
3	Credit Structure	L-T-P-Credits 2-1-0-3
4	Name of the Concerned Department	Philosophy
5	Pre–requisite, if any	None
6	Scope of the Course	
7	Course Syllabus	Rabindranath Tagore, Swami Vivekananda, M.K. Gandhi, V.D. Savarkar, Sri Aurobindo, Krishnachandra Bhattacharyya, B.R.Ambedkar and Jawaharlal Nehru. (The course deals with key ideas of some of the contemporary Indian thinkers. The attempt will be to focus on important debates in contemporary Indian Philosophy)
8	Suggested Books	1. Bhattacharya, Sabyasachi. *The Mahatma and the Poet: letters and debates between Gandhi and Tagore, 1915-1941*. 1997. New Delhi: National Book Trust. 2. **Lal, B.K. *Contemporary Indian Philosophy.* 2010. Delhi: Motilal Banarasi Das.** 3. **Raghurama Raju A**, ***Debates in Indian Philosophy: Classical, Colonial and Contemporary*** **2007 New Delhi: Oxford University Press.** 4. **Raju P.T., *Structural Depths of Indian Thought.*1985 New Delhi: South Asian Publishers.** 5. Moolchand. *Nationalism and Internationalism of Gandhi, Nehru and Tagore.*1989.New Delhi: M.M. Publishers. 6. **Naravane, Vishwanath S.**, ***Modern Indian Thought,*** **Bombay: Asia Publishing House 1964.** 7. Nagaraj D.R. “Self-purification versus Self–respect” in Raghurama Raju. A (Ed) *Debating Gandhi.* 2006.New Delhi: Oxford University Press. 8. Nehru, Jawaharlal. *The Discovery of India.*1994. New York: Oxford University Press, Centenary Edition. 9. **Sharma, Chandradhar, *A Critical Survey of Indian Philosophy*,** **2000**, **Delhi**, **Motilal Banarasi Das.**

1.	Course Code	**HS 418/ HS 618**
2.	Title of the Course	**Sustainability Studies**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Humanities and Social Sciences
5.	Pre–requisite, if any	None
6.	Course Objective	The course introduces and details the concepts in sustainability from the social sciences and basic sciences perspectives. It will include definitions, theories, historical developments, applications and case study references. The course will also include a module on Eco-criticism in literature, theoretical discourses and examples from contemporary literature.
7.	Course Syllabus	Introduction to sustainability, Climate change, biosphere, physical resources: water, pollution, and minerals, resource economics Systems Dynamics, models in natural sciences Sustainable energy systems, Problem solving: metrics, and tools; Agro-food systems, renewable resources: water fish and forests, Non-renewable resources: oil Sustainable infrastructure Eco-criticism including eco-feminism and deconstruction of rhetoric of environment studies. Definition of eco-critical theory and practice, observing the more recent influence of interdisciplinary, ecological perspectives in criticism and theory (the emergence of 'eco-criticism') and considering their implications for the interpretation of literature and the creation of writing, environmental foundations of the global economy, Narratives of development in postcolonial writing
8.	Text Books	1. Theis and Tomkin (Ed.) 2011. Sustainability: Comprehensive. Foundation University of Illinois Open Source Text Book Initiative. ID: 1741effd-9cda-4b2b-a91e-003e6f587263@43.5 2. Bert J.M. de Vries2012 Sustainability Science Cambridge University Press, ISBN 9780521184700 3. Mulligan, M. 2015. An Introduction to Sustainability: Environmental, Social and Personal Perspectives. Routledge Publications ISBN 9780415706438 4. Newton A.C. and Cantarello E. 2014 An Introduction to the Green Economy: Science Systems and Sustainability. Routledge Publications. ISBN 978 0415 711609 5. Ed. CheryllGlotfelty and Harold Fromm. 1996. *The Ecocriticism Reader.* University of Georgia Press

		6. AmitavGhosh 2010. *The Glass Palace* Harper Collins 7. Mahashweta Devi. 2008. *Imaginary Maps.* Routledge 8. Westling, Louise. “Literature and Ecology” (75-90). *Teaching Ecocriticism and Green Cultural Studies.* Ed. by Greg Garrard. 9. Timothy Clark, *The Cambridge Introduction to Literature and the Environment*

Course code	**HS 421/ HS 621**
Title of the course	**Historiography and Historical Methods**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department/School	Humanities & Social Sciences
Pre-requisite, if any	NA
The scope of the course	This course is a systematic exploration of approaches to research in history and how the discipline has been influenced by other subjects in the humanities and social sciences. 1. How is research in history done? 2. How is the historian's construction of the past any different from the public perception of a historical event? 3. Is interdisciplinarity in history possible? 4. What is the relationship between history, the humanities, and social sciences?
Course Syllabus	1. **Introduction to History** 2. **Kinds of History** (global, cultural, social, economic, military, history of art) 3. **Historical Knowledge** (standards, quality, reliability, frameworks) 4. **Historical Theory** (historical truth, power, limits of objectivity, the challenge of postmodernism) 5. **Sources** (written texts, paintings, epigraphy, numismatics) 6. **Public History** (the ownership of the past, moral judgements and multiple audiences) 7. **Periodisation** (Historical time, dividing the past, events and descriptions) 8. **History and other disciplines** (Sociology, Philosophy, Anthropology and Literature)
Suggested Books	1. Jordanova, L: ***History in Practice***: Bloomsbury Academic: London: 2005: ISBN: 0340663316 2. Evans, R: ***In Defense of History***: W W Norton & Company: London: 2000: ISBN-10: 0393319598 3. Appadurai, A: ***The social life of things***: Commodities in cultural perspective: Cambridge University Press: New Delhi: 1986: ISBN 978-0-521-35726-5 4. Hobsbawm, E: ***On History***: Little, Brown Book Group: London: 1998: ISBN-10: 0349110506

1.	Course Code	**IHS 422 / HS 622**
2.	Title of the Course	**Development Economics**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department/School	Economics/HSS
5.	Pre–requisite, if any	None
6.	Scope of the Course	This course offers a broader understanding of economic transformation of developing countries. It discusses issues in per capita income, economic growth, inequality, poverty, population. It also aims at analyzing land, labour and insurance sector. At the macro level the course will orient students about political economy of international trade, monetary policy and international relations from developing country perspective.
7.	Course Syllabus	Trends in international development; Basic features of underdeveloped countries/ LDCs; Development indices, Growth and development theories, Dual economy models, Domestic resources and foreign resources and economic development, Industrialization, protection and trade policies, Strategy towards foreign capital external finances; Strategy towards imports /export balance of payments; Balanced / unbalanced growth approach; Sectoral strategy; population, poverty, employment, migration, Some recent contributions to development theory; Trade and development, The global strategy: new international economic order (NIEO); The policy of structural adjustment, environment and development.
8.	Suggested Books	1. S. Ghatak, **Introduction to Development Economics,** Routledge Publication. 2003. 4th edition. 2. D. Ray. **Development Economics,** Princeton University Press. 1998. 3. G. Meier, and J. Stiglitz, **Frontiers of Development Economics,** Oxford University Press, 2001. **Reference Readings:** 1. A. Sen, **Development as Freedom,** Oxford University Press, 1999. 2. P. Draper, P. Alves, R. Sally (editors), **The political Economy of Trade Reform in Emerging Markets: Crisis or Opportunity?"** Edward Elgar Publishing, 2009. 3. R. Capello, and Nijkamp, **Handbook of Regional Growth**

		and Development Theories, Edward Elgar Publishing, 2009. 4. O. Galor, **Inequality and Economic Development: the Modern Perspective,** Edward Elgar Publishing, 2009. 5. D. Williams, **International Development and Global Politics: History, Theory and Practice,** Routledge Publication, 2011. 6. Y. Hayami, and Godo, **Development Economics: From the Poverty to the Wealth of Nations,** Oxford University Press, 2005.

1.	Course Code	**HS 424/ HS 624**
2.	Title of the Course	**Econometrics-I**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Economics
5.	Pre–requisite, if any	Research Methods in Social Sciences; Basic Statistics
6.	Scope of the Course	This aim of the course is to cover basic econometrics with focus on regression modeling and the problems encountered in dealing with cross-section and time series data.
7.	Course Syllabus	Methodology of econometrics; Regression analysis; Assumptions of the classical linear regression Models; Two variable regression analyses; Multiple regression analyses; Heteroscedasticity; Autocorrelation and Multicollinearity; Dummy variable regression models; Model Selection; Time Series Econometrics (introduction); Panel data regression models (introduction).
8.	Suggested Books	1. D.N. Gujarati, Basic Econometrics, The McGraw-Hill Companies. 2005. 2. G.S. Maddala, Introduction to Econometrics, (3rd edition) Wiley, 2001. 3. J.M. Wooldridge, Introductory Econometrics: A Modern Approach, South Western, 2009.

1.	Course Code	**IHS 425**
2.	Title of the Course	**Money and Banking**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department/School	Economics/HSS
5.	Scope of the Course	Give an overview of role of money, financial markets, financial institutions, conduct of monetary policy, monetary transmission mechanism, and the relationships between monetary policy and asset returns.
6	Pre–requisite, if any	None
7.	Course Syllabus	**Introduction:** Why study money, banking and financial markets; Definition of money, banking and financial system. **Financial Markets**: Understanding interest rates; Behavior of interest rates; Risk and term structure of interest rate; Stock Market. **Financial Institutions**: Economic analysis of financial structure; Management of financial institutions; Financial regulation; Financial crises. **Central Bank**: Central Bank, The Conduct of Monetary Policy, The Money Supply Process; Tools of Monetary Policy **Monetary Theory:** Demand for Money; Aggregate demand and
8.	Suggested Books	**Text Book** **1.** Mishkin, F. S. The Economics of Money, Banking and Financial Markets (10th edition) Pearson (ISBN-10: 0-13-247918-4) **Reference Books** **2.** Walsh, Carl E. Monetary Theory and Policy, 3rd edition. The MIT Press, 2010. (ISBN-10: 0262013770) **3.** Handa, Jagdish. Monetary Economics, 2nd Edition. Routledge, 2008. (ISBN-10: 0415772109) **4.** Romer, David. Advanced Macroeconomics. 4th edition. McGraw-Hill Education, 2011. (ISBN-10: 0073511374) **5.** Cecchetti, S. and K. Schoenholtz, Money, Banking and Financial Markets, 3rd Edition, McGraw Hill, 2011. (ISBN-10: 007337590X) **6.** Money and Banking: Select Research Papers by the

1.	Course Code	**HS 426**
2.	Title of the Course	**Economics of Innovation**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department	Economics/Humanities and Social Sciences
5.	Pre-requisite, if any	Fundamentals of Economics
6.	Scope of the course	The rapid innovation in the modern knowledge-based economy has increased the rate of production of information and contributed to the decline in the cost of producing it. Innovation as a harbinger of growth is also the prime focus of policy makers. Thus, policy makers are devising intellectual property rights and alternative mechanisms for creating incentives for innovation. This course will introduce the students to the basic concepts like public goods and externalities. The participants will learn about the innovation systems, incentive mechanisms like intellectual property, the relationship of IP to technology transfer, and private/public funding.
7.	Course Syllabus	Basic concepts like public goods, externalities, different types of innovation like drastic vs non-drastic innovation; disruptive innovation. Innovation and economic development. Technological innovation and the theory of firm; Innovation as an evolutionary process. Policy for innovation: intellectual property rights. University research and public-private interaction. Geography of innovation. Markets for technology and issues related to technology transfer. Financing R&D. Innovation in clusters. Diffusion of technology.
8.	Suggested Books	1. S. Scotchmer. **Innovation and Incentives**. Cambridge MA: MIT Press, 2004. 2. B. Hall and N. Rosenberg. **Handbook of Economics of Innovation**. Netherland: Elsevier, 2010. *Selected chapters.* 3. W. D. Nordhus. **Invention, Growth, and Welfare: A Theoretical Treatment of Technological Change**. Cambridge, MA: MIT Press, 1969. 4. J. E. Stiglitz. “Knowledge as a Global Public Good.” In **Global Public Goods: International Cooperation in the 21st Century**, edited by I. Kaul, I. Grunberg, and M.A. Stern. New York: Oxford University Press, 1999. 5. G. Rosegger. **The Economics of Production and**

		Innovation: An Industrial Perspective. Oxford: Butterworth Heinemann Limited, 1996. 6. A. Arora, A. Fosfuri and A. Gambardella. **Markets for Technology**. Cambridge, MA: MIT Press, 2002. 7. A. S. Rao, M. Gulati, T. Sarkar, R. Singh, K.L. Kala, S. Gargav, and A. Khanna. **Promoting Innovation in Clusters**. New Delhi: Foundation for MSME Clusters, 2013. 8. J. Watal. **Intellectual Property Rights in the WTO and Developing Countries**. New Delhi: Oxford University Press, 2001.

Course code	**HS 642/ HS 442**
Title of the course	**Language and Mind**
Credit Structure	L - T - P – Credits 2-1-0-3
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course	The course aims to build interest of students in the field of language and mind. Language is considered to be the most accessible output of the working of the mind and raises some very important questions for a phenomenon unique to human beings. The course addresses some fundamental questions including how language is represented in our minds, how children acquire language so quickly and effortlessly, the connection between language and thought among others.
Course Syllabus	**Nature of Language:** Language as an object of scientific study, essential components of Language, Standard and non-standard languages, basic universal features in phonological, morphological and syntactic systems of language. **Biological Foundations:** Is Language unique to humans?, Animals learning language, Nature versus Nurture Debate for Language, Language Acquisition Device, Poverty of Stimulus, Principles and Parameters, Critical Period Hypothesis, Case Studies of Feral Children and language savants, Linguistic Relativism. **Language in the Brain:** Language in the human brain, contra-lateralization, and language centres in the brain, aphasia and its types, specific language impairment, brain plasticity, fundamental differences between first and second language acquisition, sign language.
Suggested Books	1. J. F. Kess, ***Psycholinguistics : Psychology, Linguistics, and the Study of Natural Language***, John Benjamins Publishing, Amsterdam, The Netherlands, 1992, 9789027235848 2. N. Chomsky, ***Lectures on Government and Binding,*** Mouton De Gruyter, Holland, 1981, 9783110141313 3. S. D. Krashen, **Second Language acquisition and Second Language Learning,** Pergamon Press Inc, Oxford, 1981, 0080253385 4. J. Aitchison, ***The Articulate Mammal : An Introduction to Psycholinguistics***, Routledge, New York, 2008, 0415420164

1.	Course Code	**IHS 443 / HS 643**
2.	Title of the Course	**Contemporary Short Fiction**
3.	Credit Structure	L-T- P-Credits 3-0-0-3
4.	Name of the Concerned Department/School	English/HSS
5.	Pre–requisite, if any	NIL
6.	Scope of the Courses of the course	This course aims to familiarize students with the genre of the short story, a form of writing that has been around ever since human beings began to write the stories. Students will learn to understand the features of the short story and read selected short works written in the 20th century from different cultures across the world. Translations of stories in different languages will allow students to recognize the various modes of crafting and narrating short stories across the world. Examples of novellas or the ‘long’ short story will also be discussed.
7.	Course Syllabus	Discussion of short stories, history of the short story, introduction to prominent short story authors from different cultures and their writings, identify and describe the different features of the genre, story and plot structure, critical writing in the genre, comparison of structure and form with other genres of literature.
8.	Suggested Books	1. D. Halpern (edited), **The Art of the Story: An International Anthology of Contemporary Short Stories**, Penguin 2000. 2. N. Chimamanda Ngozi and J. Lahiri (Edited), **The Global Anthology of Short Stories**, New Internationalist Publishing, May 2009. (Selected 10-12 stories from both these collections) **Background Readings:** 1. M H Abrams. **Glossary of Literary terms,** Wadsworth Publishing, 2011. 2. Selected electronic articles that I will provide links to or copies from time to time.

1.	Course Code	**IHS 444**
2.	Title of the Course	**Literature of the Twentieth Century**
3.	Credit Structure	L-T-P-Credits 3-0-0-3
4.	Name of the Concerned Department/ School	English/HSS
5.	Pre–requisite, if any	NIL
6.	Scope of the course	The Course will focus on selected writings and excerpts from the authors mentioned in the syllabus. The list is indicative and could include other writers depending on the directions that classroom discussions will take. The primary genres will be the Short Story, Non Fiction and Poetry. The course will survey the major themes and ideas that predominate in the literature of the twentieth century from across the globe and will include background readings that throw light on the socio cultural milieu and political context in which these works get published.
7.	Course Syllabus	James Joyce, Virginia Woolf, T.S. Eliot, Premchand, Samuel Beckett, Albert Camus, Franz Kafka, J.D. Salinger, R.K. Narayan, Gabriel Garcia Marquez, Chinua Achebe, Knut Hamsun, V.S. Naipaul, Jorges Luis Borges, Alice Walker, Yukio Mishima, Mikhail Sholokhov, Orhan Pamuk, Amitav Ghosh, Zakaria Tamer, J.M. Coetzee, Thomas Pynchon, Umberto Eco, Italo Calvino, Mario Vargas Llosa, Ravindra Nath Tagore.
8.	Suggested Books	1. Brown, Nicholas. **Utopian Generations: The Political Horizon of Twentieth-Century Literature.** Princeton: Princeton Univ Press, 2005. 2. Clifford, James. **The Predicament of Culture: Twentieth-Century Ethnography,** Literature, and Art. Cambridge: Harvard Univ Press, 1988. 3. Clifford, James. Routes: **Travel and Translation in the Late Twentieth Century.** Cambridge: Harvard Univ Press, 1997. 4. Heise, Thomas. **Urban Underworlds: A Geography of Twentieth-Century American Literature and Culture. New Brunswick:** Rutgers Univ Press, 2011. 5. Johnson, David. **The Popular and the Canonical: Debating Twentieth-Century Literature 1940-2000.**

		London: Routledge, 2005. 6. North, Michael. **The Dialect of Modernism: Race, Language, and Twentieth-Century Literature**. New York: Oxford Univ Press, 1994. 7. Wyatt, David. **Secret Histories: Reading Twentieth-Century American Literature**. Baltimore: Johns Hopkins Univ Press, 2010.

Course code	**HS 445/ HS 645**
Title of the course	**Advanced Discourse Studies**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course	**Scope:** This course is designed to focus on discourse analytic approaches to research in education and related areas of inquiry. The course has been conceived to provide insights through an interdisciplinary lens and caters to traditions that range from interactional sociolinguistics to conversation analysis and critical discourse analysis. **Learning Objectives:** The course is intended for doctoral students who would like to learn about discourse analysis for an advanced understanding of their own set of research data. To develop interest and appreciation for theories of talk-in-interaction and conversation analysis as methods in the practice of research. Familiarity with research based on interactions deploying discourse analytic approaches.
Course Syllabus	**Theoretical framework of discourse studies** Theories and methods of discourse, ethnography, discourse as a cultural practice. **Methods of discourse analysis** Transcription, complexities involved in analysing written and spoken language, text and discourse, ethical treatment of data, conversational sequence, interaction and power structure. **Analysing discourse using Conversation Analysis as a tool** Analysis of multiple set of interactions including classroom exchanges using conversation analysis as a method.
Suggested Books/ References	1. Foucault, M. (1972). ***The Archaeology of knowledge***. New York: Pantheon Books. 2. Garfinkel, H. (1967). ***Studies in ethnomethodology***. Englewood Cliffs, NJ: Prentice Hall. 3. Goffman, E. (1959). ***The presentation of self in everyday life***. New York: Anchor Books, Doubleday. 4. Goffman, E. (1981). ***"Footing" in Forms of talk***. Philadelphia: University of Pennsylvania Press. 5. Goodwin, C. (1981). ***Conversational organization: Interaction between speakers and hearers***. New York: Academic Press. 6. Gumperz, J. J. (1982). ***Discourse strategies.*** Cambridge: Cambridge University Press. 7. Labov, W., & Fanshel, D. (1977). ***Therapeutic discourse: Psychotherapy as conversation.*** New York: Academic Press. 8. Malone, M. J. (1997). ***Worlds of talk: The presentation of self in everyday conversation***. Cambridge: Polity Press. 9. Sacks, H. (1992). ***Lectures on conversation*****.** (Vol. I-II). Oxford:

	Blackwell. 10. van Dijk, T. A. (Ed.). (1997a). ***Discourse as social interaction***. London: Sage.

Course code	**HS 446**
Title of the course	**Music and Literary Modernism**
Credit Structure	L - T - P - Credits 2- 1- 0- 3
Name of the Concerned Department	Humanities & Social Sciences
Pre-requisite, if any	NA
Scope of the course	Music and literature are integrally connected. 'All art,' wrote English literary and art critic Walter Pater, 'constantly aspires to the condition of music.' This interdisciplinary course examines the critical role of music in the works of 20th-century writers such as T.S. Eliot, James Joyce, Ezra Pound, Virginia Woolf, and Marcel Proust. Collectively, their works are representative of a new literary form- modernism. Modernist literature was as influenced by music as music was by literature. Thus the relationship between modernism and music is a reciprocal one. In exploring the specific points of reciprocity where music and literature influence each other, this course highlights the importance of reading texts aurally by drawing attention to the role of music in a text; and, how in turn, music shapes literature.
Course Syllabus	• **Introduction and significance of modernist literature**: The course explores why modernist literature continues to be important in the contemporary culture. • **Influence of music on modernist literature:** Selected works of writers such as T.S. Eliot, Ezra Pound, James Joyce, Mina Loy, James Weldon Johnson, Stéphane Mallarmé, Marcel Proust, Gertrude Stein, John Cage, Wallace Stevens, and Virginia Woolf will be paired with and read alongside touchstones of modern music. • **The influence of modernism on critical theory:** The readings of the above authors will be supported by critical commentaries on the relationship between sound and word. The critics include Walter Pater, Wilhelm Fürtwangler, Ezra Pound, T.S. Eliot, George Bernard Shaw, Roland Barthes, Arnold Schönberg, Northrop Frye, Henry Cowell, and Luigi Russolo. • **The reciprocal influence of modernist literature on music**: The importance of literary art for composers such as George Antheil, Olivier Messiaen, Pierre Boulez, and The Beatles will be discussed. Which were the literary sources that influenced their music? How did their music inspire the literature of the period? The trends articulated during the modernist period will be explored through the emergence of blues poetry and jazz poetry and how they got reformed in the work of avant-garde writers and composers throughout the 20th century. These explorations will show how the binary categories of 'music' and 'literature' dissolve- while music attempts to be like literature, poetry and fiction begin to sound more and more like music.

Suggested Books	1. Brown, Calvin S.: ***Music and Literature. A Comparison of the Arts***: University of Georgia Press: Athens: 1948: ISBN-10:1406739162 2. Albright, Daniel: ***Untwisting the Serpent*: *Modernism in Music, Literature, and Other Arts***: University of Chicago Press: Chicago: 2000: ISBN-13:9780226012544 3. Bucknell, Brad: ***Literary Modernism and Musical Aesthetics***: Cambridge University Press: Cambridge: 2010: ISBN-13: 9780521155083 4. Ripple, Gabriele: ***Handbook of Intermediality*: *Literature - Image - Sound - Music***: De Gruyter: Boston: 2015: ISBN-13: 9783110308365

Course code	**HS 448/ 648**
Title of the course	**Indian Cinema: Nation, Region and Technology**
Course Category	Institute Open Elective
Credit Structure	L - T - P - Credits 2 - 1- 0 - 3
Concerned Department	Sociology/Humanities and Social Sciences
Pre-requisite, if any	None
Course Objectives	• The course will address the diversity of Indian film productions, beginning with the regional production centers of undivided/British India – Lahore, Calcutta, Madras and Bombay. • It will analyze the wealth of co-productions, remakes and adaptations across Indian film industries to understand how forms and themes have traveled across.
Course Outcomes	• Identify region-specific themes and genres in Indian film history • Assess the cultural history of adaptations, remakes, cinematic crossovers
Course Content	• Pre-Partition Film (Studios) • Cultural Translations across film Industries - Co-productions - Remakes - Adaptations • Thematic Overlaps in Representation - Rural-Urban Migration - Middle-Class Family - Desires and Commodity Fetish (Fashion, Travel etc.) • Key Representations in Art Cinema - Poverty in urban slums - Exploitation in the countryside - Police Brutality • Subtitling vs Dubbing • Globalization of Film Form • Over-the-Top (OTT) Platforms - Films vs Long-form storytelling - Rise of Regional film industries • Visual Effects (VFX) in Period Films

Suggested Books	**Textbook:** 1. Vebhuti Duggal, Bindu Menon and Spandan Bhattacharya (eds): Film Studies: An Introduction: Worldview Publications: Delhi & Kolkata: 2022: 9789382267515. 2. Sudhir Mahadevan: A Very Old Machine: The Many Origins of the Cinema in India: State University of New York Press: Albany: 2015: 9781438458298. **Reference Books:** 1. M. Madhava Prasad: *Cine-Politics* : Film Stars and Political Significance in South India: Orient Blackswan: Hyderabad: 2014: 978-8125053569 2. Rajani Mazumdar: *Bombay Cinema: An Archive of the City*: University of Minnesota Press: Minneapolis: 2007: 978- 0-816649426. 3. S. V. Srinivas: *Politics as Performance: A Social history of Telugu Cinema*: Permanent Black: Ranikhet: 2013: 977-8178243726. 4. Hrishikesh Ingle: *Marathi Cinema, Cultural Space, and Liminality.* Oxford University Press: New Delhi: 2022: 9780192859785.

Course Code	**HS 455/ HS 655**
Title of the Course	**Digital Humanities**
Credit Structure	(L-T-P)-Credits 2-0-2-3
Name of the Concerned Department	Humanities and Social Sciences
Pre-requisite, if any	NIL
Course Objective	Scope of the Course 1. Explain the broad spectrum and perspective of Digital Humanities (DH) 2. Introduce the necessary tools and techniques to understand various DH research projects 3. Critically discuss DH projects 4. Explain DH in various disciplines. 5. Plan, Evaluate, and Develop a DH research project
Course Syllabus	***Introduction and History of DH***: Intersection of digital technology and humanities disciplines; the history of humanities computing ***Analysis of DH Projects, Platforms, and Tools****:* Text and Document; Digital Tools; Digitization, OCR, Text Analysis ***Digital Environments***: Copyright, Digital Rights, ***Visual Cultures***: Images as visual cultures, Subject-Object debate; Power and Knowledge; Visual Cultures and Critical theory; Mapping-Geo spatial Humanities; role of place and space in cultural visibility; digital heritage, Digital Knowledge Spaces ***Archive and Its Evolution***: Introducing, Archive in historical time, politics and poetics of archiving, archive in the digital age ***Databases***: Types of Databases, repositories and their making Authorship, Open Access, Building Open Access Ecosystems, Open Access India, Databases across Indian languages. **Laboratory:** Disciplinary Presentations, Digital Humanities Project Critiques, and Final Project
Suggested Books	**Text Books:** 1. Eileen Gardiner, Ronald G. Musto (2015), The Digital Humanities: A Primer for Students and Scholars, Cambridge University Press. ISBN 9781139003865 2. Eve, Martin (2019) Close Reading with Computers Paperback ISBN: 9781503609365 Ebook ISBN: 9781503609372 3. Maya Dodd and Nidhi Kalra Edited (2020) Digital Humanities in India: Pedagogy, Publishing and Practices ISBN 9780367347932 4. Gold, Matthew K. (2012), Debates in the Digital Humanities, University of Minnesota Press SBN 978-0-8166-7795-5 **Reference Books:** 1. Hockey, Susan. (2000), Electronic Texts in the Humanities: Principles and Practice, Oxford University Press. ISBN-13:

	9780198711940 2. Schreibman, S., Siemens, R., Unsworth, J. (2004), Companion to Digital Humanities, Oxford: Blackwell. Print ISBN:9781405103213 |Online ISBN:978047099987

Course code	**HS 481/ HS 681**
Title of the course	**Language, Mind and Society**
Course Category	Institute Elective
Credit Structure	L-T- P-Credits 3-0-0-3
Name of the Concerned Department	Humanities and Social Sciences
Pre-requisite, if any	Nil
Scope of the` course (Objectives)	This course examines language as a social practice, focusing on how it is represented in our minds. The course addresses fundamental questions on language acquisition and language as a social practice. Students are introduced to key concepts, theories, and methods in linguistics
Course Outcomes	● Analyze language as a special purpose cognitive ability and understand the underlying mental computation of natural languages. ● Identify the differences in language use that manifests themselves in society at different social and linguistic levels
Course Content	• Language- as an object of scientific study: Universal features of language, • Language and Mind: Language as a species-specific species uniform faculty, Behaviorism, Biological foundations of language Generative Linguistics Language centres in the brain and brain plasticity Language acquisition vs language learning • Language and Society Sociolinguistics, Language variation and change Language, identity and ideology Language, culture, and intercultural communication. Sociolinguistic phenomena **(**Multilingualism, *Lingua franca* , Language contact, Language evolution, Pidgins and creoles, Language endangerment and death) • India as a linguistic area (Language families and coexistence)
Suggested Books	Textbooks:

	• Chomsky, N.: *Language and Mind*: Cambridge University Press: Cambridge: 2006: 9781139448901 • Nikolas Coupland: Style: Language variation and identity: Cambridge University Press: Cambridge: 2007: 9781403944146. • Peter Trudgill: Sociolinguistic variation and change: Edinburgh University Press: Edinburgh: 2002: 9780748615155 • William Labov. Principles of linguistic change, vol. 3: Cognitive and cultural factors: John Wiley & Sons: UK: 2011: 9781405112154 Reference Books • Coupland, N.: *Style: Language variation and identity*: Cambridge University Press: Cambridge: 2007: 9781403944146. • Florian Coulmas: The handbook of sociolinguistics: Blackwell Publishing: USA: 2017: 9780631211938 • Miriam Meyerhoff: Introducing sociolinguistics: Routledge: London: 2018:9780429507922 • Nikolas Coupland and Adam Jaworski: The new sociolinguistic reader: Palgrove Macmillan: New York: 2009: 9781403944146 • Suzanne Romaine: Language in society: An introduction to sociolinguistics: OUP: Oxford: 2000: 0198731922 • William Labov: Principles of linguistic change, Vol. 1: internal factors: John Wiley & Sons: UK: 1994: 9780631179146 • William Labov. Principles of linguistic change, vol. 2social factors: John Wiley & Sons: UK: 2011: 9780631179153

1	Course Code	**IHS 482**
2	Title of the Course	**Introduction to International Development and Area Studies**
3	Credit Structure	L-T-P-Credits 2-1-0-3
4	Name of the Concerned Department/ School	Sociology / Humanities and Social Sciences
5	Prerequisite, if any	None
6	Scope of the Course	To provide an introduction to development theory and practice from an interdisciplinary perspective and of the history of development; To explain the principal theories underlying past and present approaches to international development, problematize the Euro-centric/Western-centric nature of much of the debates and critically discuss the role of different actors and institutions. In the first part of the course the focus of the lectures will be on acquiring basic concepts and theories of international development. In the second part of the course the focus will be on applying this knowledge to present-day development problems.
7	Course Syllabus	**Definitions of Development**: Legacies of the Colonial era. International development in the post-war era: Decolonization, restructuring and economic growth. **Invention of 'Development**'- President Truman's Point Four and Underdevelopment. **Modernization** and Rostow's stages of economic growth, Criticizing Modernization. **Dependency** theories of Development, Neo-Marxism in USA and Latin America, Works of Raul Prebisch, Celso Furtado, Paul Baran, A.G. Frank. **Institutionalist development theory**- Gunnar Myrdal. Role of market, Neo-liberalism and people-centred development. **Post-development.** **Alternatives to development**; Amartya Sen's 'development as freedom'. Millennium Development Goals (MDGs) and their social, economic, political and environmental consequences for people in India.
8	Suggested Books	**Text Books:** 1. Greig, A., D. Hulme and M. Turner. Challenging Global Inequality: Development Theory and practice in the 21st Century. Palgrave-MacMillan. NY, 2007. 2. Rist, G. 2008. The History of Development: from western origins to global faith. Zed Books, London. **References:**

		1. Roberts, J.T., Hite, A. (eds.). 2000. From Modernization to Globalization. Blackwell Publications, London.

Minor Program

in

Biosciences and Biomedical Engineering (BSBE)

(from AY 2014-15 onwards)

1.	Course Code	**BSE 201**
2.	Title of the Course	**Biophysics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Department	Biosciences and Biomedical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the Course	This course will introduce students with the physical laws that govern biology. It will also focus on various physical techniques used in biology and medicine for characterization and diagnosis.
7.	Course Syllabus	Introduction to macroscopic and microscopic aspect of matter. Schrödinger equation, H-atom, chemical bonds. Quantitative discussion of Entropy, free energy, partition function, diffusion and rate equations. Basic principles of spectroscopy, particularly electronic, vibrational, rotational and magnetic resonance. Applications of spectroscopy techniques to understand biological, and medical systems. The physical basis of diffusive processes in biology and biochemistry. Optical microscopy fundamentals, visible and UV light absorption, fluorescence and phosphorescence, quasielastic light scattering. Biological networks, and chaos in biological systems.
8.	Suggested Books	**Text / Reference Books** 1. Philip Nelson, Biological Physics, 2007, First edition. [ISBN-10: 0716798972 | ISBN-13: 978-0716798972] 2. William Bialik, Biophysics: Searching for Principles, 2012. [ISBN-10: 0691138915 | ISBN-13: 978-0691138916] 3. Jack Tuszynski, Michal Kurzynski, Introduction to Molecular Biophysics. [ISBN-10: 0849300398 | ISBN-13: 978-0849300394] CRC Series in Pure and Applied Physics 4. James G. Fujimoto and Daniel Farkas, Biomedical optical imaging, 1st edition. [ISBN-10: 0195150449]

1.	Course Code	**BSE 202**
2.	Title of the Course	**Biomedical Technologies**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Biosciences and Biomedical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the Course	This course will focus on the basic working principles of common medical instruments that are routinely used in clinics. It will also discuss basic design considerations of biomedical instrumentation.
7.	Course Syllabus	Electrocardiography system: Electrocardiograph, ECG machines, instrumentation amplifier, ECG traces, faults and maintenance. Electroencephalography system: Overview, EEG electrodes, introduction to filters, EMG and related studies. Blood pressure measurement: Heart mechanics and blood pressure basics, non-invasive and invasive methods, Pacemakers: Pacing basics, external and internal pacemakers, defibrillators. Ventilators and respirators. Lasers and their applications in medicine and biology. Medical Imaging: X-rays, MRI, PET, mammography, ultrasound and other developing technologies.
8.	Suggested Books	**Text / Reference Books** 1. J. Carr and J. Brown, Introduction to Biomedical Equipment and Technology, 4th edition. [ISBN-10: 0130104922 | ISBN-13: 978-0130104922] 2. R. Aston, Principles of Biomedical Instrumentation and Measurement, 1st edition. [ISBN-10: 0675209439 | ISBN-13: 978-0675209434] 3. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Bio-Medical Instrumentation and Measurements, 2nd edition, Pearson Education. [ISBN-10: 0130764485 | ISBN-13:

		978-0130764485] 4. John G. Webster, Medical Instrumentation: Application and Design, 4th edition, Wiley, New York. [ISBN-10: 0471676004 | ISBN-13: 978-0471676003]

1.	Course Code	**BSE 301**
2.	Title of the Course	**Introduction to Molecular Biology**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Department	Biosciences and Biomedical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the Course	This course will give an overview of modern biology, in addition to fundamentals in the area of Molecular Biology.
7.	Course Syllabus	Macromolecules and Cells, Nucleus, Cell Cycle. **DNA the unit of life:** Structure, Properties, Mutations, Repair and Diseases. Flow of genetic information: Replication of DNA and its repair, **RNA:** the ribonucleic acid, Structure, Properties, Transcription of RNA and its modification, Gene expression, Introns-exons. Exploring genes and genomes. **Translation:** Genetic Code, Protein synthesis, Function and structure of Proteins. Recombinant DNA technology, sequences of genomes, manipulation of eukaryotic genes. **Omics:** Genomics, transcriptomics and proteomics.
8.	Suggested Books	**Text / Reference Books** 1. Robert F., Weaver, Molecular Biology, 4th ed., McGraw-Hill, 2003. [ISBN-10: 0071275487 | ISBN-13: 978-0071275484] 2. Lodish H., et al., Molecular Cell Biology. 6th ed., Freeman, W.H., 2007. [ISBN-10: 0716776014 | ISBN-13: 978-0716776017] 3. Alberts et al., Molecular Biology of the Cell, 4th ed., Garland Publishing, Inc., 2002. 4. Tropp B.E., Molecular Biology: Genes to Proteins, 3rd ed., Jones & Bartlett Publishers, 2007 [ISBN-10: 0763709166 ISBN-13: 978-0763709167

1.	Course Code	**BSE 402**
2.	Title of the Course	**Cancer Diagnosis and Therapy**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Department	Bioscience and Biomedical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the Course	The purpose of this course is to provide an introduction to cancer and modern diagnostic methods available to detect cancer at an earlier stage. The diagnostic methods will include invasive and non-invasive methods.
7.	Course Syllabus	**Introduction** Definition, Benign Tumors Vs. Malignant Tumors, Types of Cancer, Common Symptoms, Molecular Hallmarks of Cancer – Growth Signal Autonomy, Evasion of Growth Inhibitory Signals, Evasion of Apoptosis (Programmed Cell Death), Unlimited Replicative Potential, Angiogenesis (Formation of New Blood Vessels), Invasion and Metastasis, Molecular Basis of Cancer - Cancer Genes (Oncogenes and Tumor Suppressor Genes), Carcinogenesis – A Multistep Process, Evidences for Multistage Models of Carcinogenesis **Diagnostic Methods and Therapy** **Cancer Screening and Treatment Modalities:** Screening - Definition, Principles, Evaluating Screening Tests, Developing and evaluating a Cancer Screening Programme, Different Kind of Screening Tests, Screening for Specific Types of Cancer, Genetic Counselling; Treatment – Essential Terms, Surgery, Radiation, Chemotherapy, Biological Therapy, Hormone Therapy, Transplantation, Targeted Therapies, Gene Therapy, Other Treatment Methods (Cryosurgery, Laser Therapy, Photodynamic Therapy, Hyperthermia), Cancer Clinical Trials

8.	Suggested Books	**Text Books** 1. R. A. Weinberg, **The Biology of Cancer**, Garlan Science, **2012**, ISBN-10: 0815340761 2. R. Hesketh, **Introduction to Cancer Biology**, Cambridge University Press, **2013**, *ISBN*-10: 1107601487 3. V. T. DeVita, T. S. Lawrence, S. A. Rosenberg, **Cancer: Principles and Practice of Oncology, 9th Edition**, Lippincott Williams and Wilkins, **2011**, ISBN-10: 1451105452 **Reference Books** 1. S. Heim, F. Mitelman, **Cancer Cytogenetics,** 3rd Edition, Willy-Blackwell, **2011**, ISBN-10: 0470181796 2. L. Pecorino, **Molecular Biology of Cancer: Mechanisms, Targets and Therapeutics**, Oxford University Press, **2008**, ISBN-10: 0199211485 3. **American Cancer Society**, http://www.cancer.org. 4. **National Cancer Institute**, http://www.cancer.gov.

1.	Course Code	**BSE 404 / BSE 604**
2.	Title of the Course	**Biomedical Imaging**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Concerned Department	Biosciences and Biomedical Engineering
5.	Pre–requisite, if any	None
6.	Scope of the Course	This course will give a comprehensive introduction to the fundamental and major aspects of biomedical imaging systems used currently. The fundamental physics and engineering of each imaging modality will be discussed.
7.	Course Syllabus	Radiation and interaction with matter, principle of diagnostic biomedical optical imaging. Radiation dosimetry, risk and protection. Radiography, mammography and fluoroscopy. Principle of ultrasound imaging and current status. Image analysis, image processing, image reconstruction theory, computed tomography system. Magnetic Resonance Imaging (MRI): principle of nuclear magnetic resonance, MR imaging, functional MR imaging, application of MR imaging. Single Photon Emission Computed Tomography (SPECT) principle, Positron Emission Tomography (PET).
8.	Suggested Books	**Text / Reference Books** 1. J. T. Bushberg et al, The essential physics of medical imaging, 2nd edition. [ISBN-10: 0683301187 | ISBN-13: 978-0683301182] 2. Richard R. Carlton, Principle of radiographic imaging: An art and a science. [ISBN-10: 1439058725 | ISBN-13: 978-1439058725] 3. James G. Fujimoto and Daniel Farkas, Biomedical optical imaging, 1st edition. [ISBN-10: 0195150449] 4. Andrew G. Webb, Introduction to biomedical imaging, 1st edition. [ISBN-10: 0471237663 | ISBN-13: 978-0471237662]

1.	**Course Code**	**BSE 405/ BSE 605**
2.	**Title of the Course**	**Molecular Biophysics**
3.	Credit Structure	L-T-P-C 2-1-0-3
4.	Name of the Concerned Department	Biosciences and Biomedical Engineering
5.	Pre–requisite, if any	Open to all graduates, with the prior permission of course instructor.
6.	Scope of the Course	This course is designed to teach the basics of Physics, sufficient for BSBE graduate students. The fundamental physics of Biological phenomena will be discussed. It will also prepare students to learn and apply biophysical approaches to understand biochemical, biotechnological and medical problems.
7.	Course Syllabus	Review of calculus and its application in biology. Introduction to thermodynamics and role in biology. Discussion about various stages of evolution. Single cell machinery to multi-cellular organs. Structure of biomolecules. Elements of building blocks for macromolecules. Weaker interatomic interactions. Hydrogen bond and hydrophobic interactions. Amphiphilic molecular behavior in aqueous environments. Introduction to X-ray crystallography. Structures and physics of amino acids and proteins. Conformational transitions of proteins (folding and unfolding of proteins), Ramachandran plot. Physics of nucleic acid, membranes and membrane physics. Modeling membranes as elastic materials. Dynamics of biomolecules: diffusion, vibrations versus conformational transitions. Interaction of biomolecules with electromagnetic radiation. General characteristic of a cell. Cytoskeletal organizations and constituents molecules and their mechanism. Ion channels and ion pumps, osmotic pressure of cells. Cellular energetics: chloroplast and mitochondria. Cells as thermodynamic machines. Active transport. Review of fundamentals of electricity and magnetism. Bioelectricity, heart dynamics, anatomy of nerve cells, conducting properties of neurons. Structure and function of synapse.
8.	Suggested Books	**Text / Reference Books** 1. P. Nelson, **Biological Physics**, (Updated edition), W. H. Freeman, New York, December 16, 2013. [ISBN-10: 0716798972 | ISBN-13: 978-0716798972] 2. W. Bialik, **Biophysics: Searching for Principles**, Princeton University Press, October 28, 2012. [ISBN-10: 0691138915 | ISBN-13: 978-0691138916] 3. J. Tuszynski, and M. Kurzynski, **Introduction to Molecular**

		Biophysics, (First edition), CRC Press, New York, February 26, 2003. [ISBN-10: 0849300398 | ISBN-13: 978-0849300394] CRC Series in Pure and Applied Physics 4. C. R. Cantor and P. R. Schimmel, **Biophysical Chemistry, Part I: The conformation of biological macromolecules** (Their Biophysical Chemistry), (First edition), W. H. Freeman, New York, March 15, 1980. [ISBN-10: 0716711885 | ISBN-13: 978-0716711889] 5. C. R. Cantor and P. R. Schimmel, **Biophysical Chemistry, Part 2: Techniques for the study of biological structure and function**, (First edition), W. H. Freeman, New York, April 15, 1980. [ISBN-10: 0716711907 | ISBN-13: 978-0716711902] 6. C. R. Cantor and P. R. Schimmel, **Biophysical Chemistry, Part 3: The behavior of biological macromolecules**, (First edition), W. H. Freeman, New York, June 15, 1980. [ISBN-10: 0716711923 | ISBN-13: 978-0716711926]

Course code	**BSE 413/ BSE 613**
Title of the course	**Omics Technologies**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Biosciences and Biomedical Engineering
Pre-requisite, if any	NA
Scope of the course	This course is designed for the students with the background in biology, chemistry and computer science. This course will emphasize at molecular level changes through the studies of Genomics, Transcriptomics, Proteomics, Metabolomics, Glycomics and Lipidomics. The goal of this course is to explain the details of modern OMICS technologies and their applications which control structure, function, and dynamics of organisms.
Course Syllabus	OMICS: Introduction of omics, types of omics, methods to study, experimental approaches, bioinformatics algorithm. Genomics: Gene, Genome and their genomics, Status of genomics project, genome annotation, genome database, Prediction for transcription factor binding sites, Bioinformatic analysis for miRNA target and motif search, Single nucleotide polymorphisms (SNP) in bio-medical research. Transcriptomics: Principle and applications of experimental techniques: micro-arrays, Expressed Sequence Tag (EST), Serial analysis of gene expression (SAGE), tissue arrays. Data analysis and normalization through bioinformatics methods. Publicly available micro-arrays expression data. Proteomics: Principle and applications of proteomics technologies: 2D-electrophoresis, MALDI-TOF mass spectrometry, yeast 2-hybrid system. Protein-protein interactions, Protein-DNA interaction, Protein-RNA interaction. Computational prediction of interactions, protein databases. Metabolomics: Principles and applications of technologies in metabolomics: High-performance liquid chromatography (HPLC), Gas Chromatography, Mass Spectrometry, Nuclear Magnetic Resonance. Metabolic pathways resources, Metabolic health, and complications. Glycomics and Lipidomics: Principles and applications. Instrumentation and arrays to understand these structural changes in leaving organism.
Suggested Books	1. C. Simo, A. Cifuentes, V. Garcia-Canas, ***Fundamentals of Advanced Omics Technologies***, From Genes to Metabolites, Elsevier, United States of America, 2008, 978-0-44462-651-6 2. D. Barh, K. Blum, M.A. Madigan, ***OMICS:*** **Biomedical Perspectives and Applications**, CRC Press, United States of America, 2017, 978-1-43985-008-4 3. B. Mayer, ***Bioinformatics for OMICS Data***, Springer, United States of America , 2011 , 978-1-61779-027-0 4. E.C. Soo, J.P.M. Hui, ***Metabolomics in Glycomics***, Springer, United States of America, 2009, 978-1-60761-453-1

Course code	**BSE 417/ BSE 617**
Title of the course	**Biomolecular Modeling**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Biosciences and Biomedical Engineering
Pre-requisite, if any	NA
Scope of the course	This course is designed for the students with the background in biology, chemistry, physics, or computer science and who are interested in learning biomolecular modeling. The goal of the course is to introduce the principles of biomolecular modeling and to develop practical skills for using existing modeling software.
Course Syllabus	Elements of thermodynamics and statistical mechanics: laws of thermodynamics, entropy, ensembles in statistical mechanics: microcanonical, canonical, and grandcanonical ensembles, Partition function, Maxwell-Boltzmann distribution, Phase space. Introduction to stochastic phenomena: Gaussian noise, Brownian motion, diffusion (Fokker-Planck equation), Euler algorithm for Brownian motion. Molecular Mechanics: introduction, Morse potential, Harmonic Oscillator Model for molecules, Energy due to stretch, bend, stretch-bend, torsional strain, van der Waals and Dipole-Dipole interactions. Types of Force fields: AMBER, CHARMM, GROMOS, OPLS, Merck Molecular Force Field, Consistent Force Field, MM2, MM3, and MM4 force fields, force field optimizations. Potential Energy Surface:- Convergence Criteria, Optimization Criteria, Unidirectional Search, Finding Minimum Point, Gradient based Methods-Steepest Descent and Conjugate Gradient Methods Molecular Dynamics Simulations: Introduction, Newtonian dynamics, Integrators- Leapfrog and Verlet algorithm, Thermostats and barostats, Implicit and explicit solvation models, periodic boundary conditions, Ewald's summation for electrostatistics, radial distribution functions, pair correlation function. Biased sampling: umbrella sampling and steered MD simulations. Free energy calculations: molecular recognitions, protein-drug interactions, Molecular Mechanics-Poisson-Boltzmann (Generalized Born) Surface Area (MMPBSA/MMGBSA), Free Energy Perturbation, Thermodynamic Integration (TI).
Suggested Books	1. R. Leach, **Molecular Modeling, Principles and Applications**, Pearson Education, India, 2009 and 978-8131728604 2. Frenkel, B. Smit, **Understanding Molecular Simulation, From Algorithms to Applications**, Academic Press, USA, 2001 and 978-0122673511

	3. K. I. Ramachandra, G. Deepa, K. Namboori, **Computational Chemistry and Molecular Modeling-Principles and Applications**, Springer, New York, 2010 and 978-3642095986 4. T. Schlick, **Molecular Modeling and Simulation-An interdisciplinary Guide**, Springer, New York, 2010 and 978-1441963505

Course Code	**BSE 619/ BSE 419**
Title of the Course	**Renewable Energy Technologies**
Credit Structure	L-T-P- Credits 2-1-0-3
Name of the Concerned Department	Biosciences and Biomedical Engineering (to be cross listed with other engineering Departments especially Mechanical, Electrical and Civil Engineering)
Pre-requisite, if any	NA
Scope of the Course	This course will provide an overview of fundamentals and applications of renewable energy technologies. Current and emerging applications, challenges and potential solutions for various technical, economic and resource constraints for the technologies will be discussed. The course will cover renewable energy technologies such as Solar, wind, biofuels, geothermal and wave energy technologies with a special emphasis on solar and biofuel technologies.
Course Syllabus	***Overview of energy scenario:*** Introduction to energy sources, available renewable energy technologies, systems analysis and sustainability. ***Renewable energy technologies:*** Solar photovoltaics, solar thermal technologies, wind power, technologies for bioethanol from sugarcane, starch and lignocellulosic based feedstocks, biodiesel from oil seeds, algae, hydro and geothermal energy sources ***Systems Analysis:*** Introduction to process modeling and economic analysis, life cycle analysis using GREET, application of renewable technologies around the world with a special emphasis on their applicability to India. ***Summary:*** State of the art and future outlook.
Suggested Books	Recommended texts: 1. David J.C. MacKay, ***Sustainable Energy-Without the hot air***. UIT Cambridge, 2008, ISBN 978-0-9544529-3-3, This book can be freely downloaded from: 2. M. Kanoglu, Y. Cengel and J. Cimbala, ***Fundamentals and Applications of Renewable Energy***, McGraw-Hill Education, 2019, ISBN-13: 978-1260455304 3. B. Sorensen, ***Renewable Energy: Physics, Engineering, Environmental Impacts, Economics and Planning***, 4th edition, Academic Press. 2010, ISBN-13: 978-0123750259 4. O. Jolliet, M. Saade-Sbeih, S. Shaked, A. Jolliet, P. Crettaz, ***Environmental Life Cycle Assessment****,* CRC Press, Taylor and Francis, 2015, ISBN: 9781439887660 - CAT# K14053 Relevant journal articles will be provided for some of the lectures.

Course Code	**BSE 442/ BSE 642**
Title of the Course	**Fundamentals of Neuroscience**
Course Category	**Elective**
Credit Structure	L-T-P-Credits, 2-1-0-3
Name of the Concerned Department	Biosciences and Biomedical Engineering
Pre–requisite, if any	Nil
Course objectives	• Comprehend the fundamental principles of neuroscience and their implications in brain function and behavior. • Explore the pathophysiology of neurogenetic diseases and their impact on neurological functions.
Course outcomes	• This course provides a strong foundation for understanding the organization and structural intricacies of the brain. • Students will acquire knowledge of various neurological processes, such as memory formation and sensory processing.
Course Syllabus	**Brain structure:** Brain Organisation, Structure of Cerebellum and Basal Ganglia, Blood Brain Barrier. Histology of Brain Sections (Coronal/sagittal) – Normal vs. Diseased. **Learning and memory:** Theories of memory, Classification, short-term and long-term storage of memory, Retrieval, Memory consolidation, anterograde and retrograde amnesia, Different types of plasticity, Cell & molecular basis of learning and memory, Neural oscillations basis of learning and memory. Modelling of synaptic potentials. **Sensation and Sensory Processing:** The Somatic Sensory System: Touch and Proprioception; Pain; Vision – The Eye and Central Visual Pathways. The Auditory System ;Olfactory System; Gustatory System **Neuroendocrinology:** Function of hypothalamus, pituitary, circumventricular organs, Hypophysiotropic hormones; Feedback loops; Pineal gland & neuroendocrine regulation of biological rhythms. **Brain metabolism:** Brain metabolism of carbohydrate, lipids & amino acids, Metabolism of neurotransmitters. Neuro-glial interaction, Effect of malnutrition on brain metabolism. **Neurogenetic diseases:** Autosomal (recessive and dominant) and X-linked neurological diseases –neurodegenerative diseases, and molecular pathology. Metabolic defects causing neurological diseases. Complex genetic diseases, gene environment interactions, Pathogenetic of migraine, epilepsy, autism and schizophrenia.

Suggested Books	**Text Books:** [1] Eric R. Kandel, John D. Koester, Sarah H. Mack, Steven A. Siegelbaum. **Principles of Neural Science, VI Edition**: McGraw-hill New York; 2021. ISBN: 1259642232 [2] Larry Squire, Darwin Berg, Floyd E. Bloom, Sascha du Lac, Anirvan Ghosh, Nicholas C. Spitzer. **Fundamental Neuroscience, IV Edition,** Elsevier Science; 2012. ISBN: 9780123858702 **Reference Books:** [1] Bear MF, Connors BW, Paradiso MA. **Neuroscience: Exploring The Brain, Enhanced Edition** Wolters Kluwer; 2020. ISBN: 1284211282 [2] Nicholls JG, Martin AR, Fuchs PA, Brown DA, Diamond ME, Weisblat DA. **From Neuron to Brain, VI Edition:** Sinauer; 2015. ISBN: 9781605354392 [3] Garrett B, Hough G. **Brain & Behavior: An Introduction to Behavioral Neuroscience:** SAGE Publications; 2021. ISBN: 9781544373485

Course Code	**BSE 443 / BSE 443**
Title of the Course	Applied Biomechanics
Course Category	Elective
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Biosciences and Biomedical Engineering
Pre–requisite, if any	Nil
Course Objective	This course will describe biomechanics of human body including the study of human motion and design of assistive biomedical devices for rehabilitation and augmentation.
Course Outcomes	● Students will know tissue mechanics and measurement techniques for tissue physical properties. ● Learn about different types of human movement. ● Learn about design principles for prosthetics, assistive and rehabilitation devices.
Course Syllabus	**Tissue mechanics:** Electrochemical signaling and excitation contraction in different cells; Components of convective tissue; Structure, functions and mechanical properties of different tissue types; Mathematical models of tissue structure and properties; Measurement methods for tissue mechanical properties. **Human body motion:** Neuromusculoskeletal system; Interactions between nerves, muscles and the skeleton; Muscles coordination; Vision-motion coordination; Kinematics and musculature; Forces, torques, and equilibrium, motion in one plane and levers in 2D and 3D for human body joints; Defining body orientation; Mechanics of different human motions; Acceleration and collisions of the human body; Motion capture and gait analysis systems; Vision tracking systems; Wearable motion analysis systems. **Prosthesis design:** Principles of prosthesis and exoskeleton design; Bar and links mechanisms; Compliant mechanisms; Sensors and actuators in assistive devices; Computer aided analysis of artificial joints and limbs; Mathematical modeling of artificial joints and limbs motion; Modeling of multi-joint systems and system chains – forward and inverse kinematics; Feedback control design in prosthesis.
Suggested Books	**Textbooks:** 1. David A Winter, **Biomechanics and motor control of human movement**. John Wiley & Sons, 2009. [ISBN - 9780470398180] 2. Susan J. Hall, **Basic Biomechanics**, 9th Edition, McGraw Hill, 2022 [ISBN13: 9781264169665] 3. William Craelius, **Prosthetic Designs for Restoring Human Limb Function**, 2022, Springer Cham [ISBN: 9783030310769]

	Reference Books: 4. Irving P. Herman, **Physics of the Human Body**, Springer Cham, 2nd Edition, 2016. [ISBN: 9783319239309]

Course code	**BSE 444/ BSE 644**
Title of the course	**Biomedical Signal and Image Processing**
Course Category	Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Bioscience and Biomedical Engineering
Prerequisite, if any	None
Course Objectives	• This course is designed to cover digital signal and image processing techniques, with a focus on problems associated with biomedical engineering. • It covers the implementation of signal and image processing algorithms and offers a hands-on learning experience.
Course Outcomes	• It provides a strong foundation for those interested in pursuing careers in biomedical signal and image processing. • Students will be able to choose and implement signal and image processing algorithms for processing biomedical data.
Course Content	Introduction to Probability Density Functions (PDFs) and their estimation in biomedical signals and images. Correlation and coherence analysis. Frequentist and Bayesian statistics for biomedical signal and image data. Deterministic and random signals in human electrophysiology. Theory and application of convolution, Fourier analysis in biomedical signals. Estimation of signal properties in the time domain and artifact identification in EEG, EMG, and ECG. Common medical image compression, segmentation, and registration techniques. Standard biomedical signal and image features and their analysis. Discussion of image enhancement techniques, filtering methods, and morphological operations in the context of medical images. 2D Discrete Fourier analysis and filtering techniques for the medical images. Medical image formation. Common medical imaging artifacts. Design of filters, spectral and time-frequency analysis of human physiological signals.
Suggested Books	**Text Books:** 1) AV Oppenheim and RW Shafer, "Discrete-time Signal Processing", Pearson Education India, 3rd ed, 2014. ISBN 978-9332535039. 2) N Kayvan and S Robert, “Biomedical Signal and Image Processing”, Taylor & Francis, CRC Press, 2012. ISBN

	978-1439870334 3) D C Reddy, “Biomedical Signal Processing: Principles and Techniques”, Tata McGraw-Hill Publishing Co. Ltd, 2005. ISBN 978-0070583887. **Reference Books:** 4) R.B. Pachori, “Time-frequency analysis techniques and their applications”, CRC Press, 2023, ISBN: 9781032392974. 5) Richard Newbold, “Practical Applications in Digital Signal Processing”, Prentice Hall, 2012. ISBN 978-0133038385. 6) RC Gonzalez and RE Woods, “Digital Image Processing”, Pearson India Ltd, 2011. ISBN 978-9353062989

Syllabi of Courses

of

Minor Program in Chemistry

(from AY 2014-15)

1.	Course Code	**CH 201**
2.	Title of the Course	**Molecules that Change the World**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Department	Chemistry
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	The purpose of this course is to describe the molecules have had a dramatic impact on society in sustenance and maintenance of life on planet earth. This course will expound our knowledge of Nature's most intriguing molecules and man's ability to discover, modify and use them to our advantage that was not formerly envisioned. The lectures will touch upon fascinating tales about molecules and their presence in, among many items, foods, perfumes, dyes, textiles, vitamins, nutritional supplements, pesticides, insecticides, and above all, medicines.
7.	Course Syllabus	Introduction, Atomic theory and total Synthesis; Importance of the life saving molecules, mode of action and their applications-Urea, Acetic acid, Glucose, Aspirin, Camphor, Tropinone, Haemin, Morphine, Steroids, Strychnine, Pencillin, Longifolene, Prostaglandins, Vitamin B12, Erythronolide B and A, Monensin, Avermectin, Amphotericin, Ginkgolide, Cyclosporin, FK 506, and Rapamycin, Calcheamicin, Palytoxin, Taxol, Mevacor, Zaragozic Acid, and the CP Molecules, Brevetoxin B, Ecteinascidin 743, Epothilones, Resiniferatoxin, Vancomycin, Quinine and Thiostrepton.
8.	Suggested Books	**Text Books** 1. K. C. Nicolau, T. Montagnon, **Molecules that Changed the World**, **2008**, ISBN: 978-3-527-30983-2. **References** 1.Online Journals: http://www.pubs.acs.org; www.rsc.org; http://www.elsevier.com, http://onlinelibrary.wiley.com/journal

1.	Course Code	**CH 202**
2.	Title of the Course	**Applications of Transition Metals and Lanthanides**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Department	Chemistry
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	This course provides basic knowledge of various topics in inorganic chemistry, particularly related to coordination chemistry of transition metals and lanthanides.
7.	Course Syllabus	**Properties of Transition Metals and Lanthanides** General properties of Transition metals, magnetic behaviour, L-S and J-J coupling. General properties of lanthanide elements, Lanthanide contraction. Occurrence and principles of separation of lanthanides. **Applications of Transition Metals and Lanthanides** Properties of Transition metals and Lanthanides, generation of new age materials, metal-organic frameworks (MOF), application in gas storage, gas separation, sensors, catalysis, magnetism and drug delivery.
8.	Suggested Books	**Text Books** 1) D. F. Shriver, P. W. Atkins, **Inorganic Chemistry**, Oxford University Press, **2006**, ISBN 978-0-199-23617-6. 2) L. R. MacGillivray, **Metal-Organic Frameworks: Design and Applications**, John Wiley & Sons, **2010**, ISBN 978-0-470-19556-7. 3) D. Farrusseng, **Metal-Organic Frameworks: Applications from Catalysis to Gas Storage**, Wiley-VCH, **2011**, ISBN 978-3-527-32870-3. 4) A. G. Sharp, **Inorganic Chemistry**, 3rd Edition, Pearson Education Ltd., **2009**, ISBN 978-81-317-0699-0. **Reference Book** 1) M. Schröder, **Functional Metal-Organic Frameworks: Gas Storage, Separation and Catalysis**, Springer, **2010**, ISBN 978-3-642-14612-1.

1.	Course Code	**CH 301**
2.	Title of the Course	**Functional Materials**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Department	Chemistry
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	The development of functional materials for various applications has been a key focus area. Specially, with the development of materials in the nanometer level, the application of materials for various applications have increased manifold. This course will give the basics of synthesis and design of the functional materials from chemistry point of view.
7.	Course Syllabus	Introduction of chemical functionalities at the molecular level. Relevant chemical reactions. Basic concepts of surface and colloid chemistry emphasizing the physical and chemical aspects of surfaces important for applications in colloids, catalysis, microelectronics and biocompatibility, surfactants and micelles, self-assembled monolayers, synthesis and properties of metallic, semiconducting and magnetic nanoparticles. carbon nanoparticles: graphene oxide and carbon nanotubes, applications in environmental studies, water purification, catalytic converter, solar cell materials, Liquid crystals, conducting polymers, nanomaterials as contrast agents for biomedical applications, sensor applications. Molecular nanomachines. Basics of Instrumentation techniques: electron microscopy, force microscopy and X-ray diffraction, Inorganic porous materials and metal-organic frameworks.
8.	Suggested Books	**Text Books** 1. T. Pradeep, **Nano: The Essentials**, Tata McGraw-Hill New Delhi, **2007**, ISBN: 978-0-07-061788-9. 2. G. A. Ozin, A. C. Arsenault, L. Cademartiri, **Nanochemistry A Chemical Approach to Nanomaterials**, RSC Publishing, **2009**, ISBN: 978-1-84755-895-4. **References** 1. Online Journals: http://www.pubs.acs.org; www.rsc.org; http://www.elsevier.com, http://onlinelibrary.wiley.com/journal

1.	Course Code	**CH 402**
2.	Title of the Course	**Chemistry in Industry**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Department	Chemistry
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	Industrial Chemistry is the branch of chemistry which studies physical and chemical processes applied for the transformation of raw materials into products that are of benefit to mankind. The goal of this undergraduate course is to equip students with high skills and knowledge in those industrial subjects which link engineering, chemical processing, economics and industrial management.
7.	Course Syllabus	1. **Fuels: Solid, Liquid and Gaseous fuels** (a) **Solid:** Origin of coal, analysis of coal, high and low temperature carbonization of coal (b) **Liquid:** Petroleum and petrochemicals: petroleum hydrocarbons-classification. Chemicals structure, crude oil, naptha, kerosene, diesel, lube oil, separation of crude oil, (distillation-atmospheric and vacuum), cracking, octane number, cetane number, flash point. (c) **Gaseous:** Natural gas, LPG, coal gas, producer gas, water gas. 2. **Some important industrial products (manufacture and application):** (a) **Polymers:** PVC, polyethylene, bakelite, nylon-66, terylene, natural rubber, buna and neoprene rubber, vulcanization of rubber. (b) **Detergents:** Dodecylbenzene sulphonates etc (c) **Pesticides:** DDT, BHC etc (d) **Dyes and Pigments:** Methyl orange, phenolphthalein, mercurochrome, ultramarine, zinc-white, litho phone, carbon black etc (e) **Fertilizers:** Superphosphate of lime, urea, ammonium sulphate etc (f) **Ceramics**: Glass (g) **Cement** 3. **Oils, fats, and waxes:** Types oil, fat and waxes, analysis of oils, saponification, recovery of glycerin, hydrogenation of oils, determination of adulteration in edible oils.
8.	Suggested Books	**Text Books** 1. **Davis & Berner Handbook of Industrial Chemistry, Vol. 1,** CBS Publishers, New Delhi, **2004**, ISBN: 9788123910567. 2. M. Ali, Bassam Ali, **Handbook of Industrial Chemistry: Organic Chemicals,** McGraw-Hill Handbooks, 1st Edition, 2004, ISBN: 978-0071410373 3. **Reigel Handbook of Industrial Chemistry and Biotechnology,**

		11th Edition, Springer Verlag, Editor, J. A. Kent, **2007**, ISBN: 9780387278421 4. George T. Austin, **Shreve's Chemical Process Industries,** 5th Edition, McGraw-Hill International, Singapore, **1984.** **References** Online Journals: http://www.pubs.acs.org; www.rsc.org; http://www.elsevier.com, http://onlinelibrary.wiley.com/journal

1.	Course Code	**CH 404**
2.	Title of the Course	**Chemical Physics**
3.	Credit Structure	L-T-P-Credits 2-1-0-3
4.	Name of the Department	Chemistry
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	The goal of this course is to understand chemical structures and reactions from the first principles, specifically in looking for answers to questions such as: How do chemical reactions really take place? Can we understand chemical reactions from first principles? What is the step-by-step process that occurs during solvation?
7.	Course Syllabus	Probing the structure and dynamics of: ions, molecules/bio-molecules, clusters, free radicals, nanoparticles. Understanding: intermolecular forces, hydrogen bonding, electron transfer, intra/inter molecular charge transfer, multipole moments, concept of polarizability, basic idea on polarity of a solvent, the formation and dissolution of chemical bonds, the basic idea on transition state theory, thermodynamics aspect of transition state theory, basic idea of diffusion and its applications, thermodynamic view of diffusion, molecular collisions.
8.	Suggested Books	**Text Books** 1. J. L. McHale, **Molecular Spectroscopy,** 1st Edn., Prentice-Hall, Inc: New Jersey, **1999**, ISBN: 978-0132290630 2. M. R. Wright, **Fundamental Chemical Kinetics,** Harwood Publishing, **1999,** ISBN: 978-1898563600 3. D. A. McQuarrie, J. D. Simons, **Physical Chemistry** 1st Edn., Viva Books Private Limited, New Delhi, **1998**, ISBN 0935702997 **Reference Books** 1. K. J. Laidler, **Chemical Kinetics,** TMH Publishing Company Limited, **1988**, ISBN 9788131709726 2. D. Chandler, **Introduction to Modern Statistical Mechanics**, Oxford University Press **1987**, ISBN 0195042778 3. C. N. Banwell, E. M. McCash, **Fundamentals of Molecular Spectroscopy,** 4th Edn., Tata McGraw-Hill Publishing Company Ltd., New Delhi, **1994**, ISBN: 978-007-128-221-5

1.	Course Code	**CH 406**
2.	Title of the Course	**Nuclear Science**
3.	Credit Structure	L-T-P-Credit 2-1-0-3
4.	Name of the Department	Nuclear Chemistry
5.	Pre–requisite, if any	Nil
6.	Scope of the Course	This course provides basic knowledge of radiochemistry, nuclear structure, nuclear forces and applications
7.	Course Syllabus	**Nuclear Properties:** Nuclear Mass, terminology, binding energy per nucleon, nuclear size and shape **Radioactive decay:** Decay equation, decay equilibrium, branching decay, natural radioactivity, dating **Radiotracers:** Different mode of synthesis, applications, Isotope dilution analysis **Nuclear force and nuclear structure** **Nuclear reactions**: Energetic, reaction type; Nuclear fission and fusion.
8.	Suggested Books	**Text Books** 1. W. Loveland, D. J. Morrissey and G. T. Seaborg, **Modern Nuclear Chemistry**, John Wiley & Sons, **2006**, ISBN 13 978-0-471-11532-8 2. G. R. Choppin, J. Rydberg, J-O, Liljenzin and C. Ekberg, **Radiochemistry & Nuclear Chemistry,** 4th Edn., Elsevier, ISBN 978-0-12-405897-2 3. J. V. Kratz, K. H. Leiser, **Nuclear and Radiochemistry Fundamentals and Applications, 2013**, Wiley-VCH, ISBN 978-3-527-32901-4

Syllabi of Courses

of

Astronomy, Astrophysics and Space Engineering

(from AY 2016-17 onwards)

1	**Course Code**	**AA 201**
2	**Title of the Course**	**An Introduction to Astronomy**
3	Credit Structure	L-T-P-Credits 2-1-0-3
4	Name of the Department/Centre	Astronomy, Astrophysics and Space Engineering
5	Prerequisite, if any	None
6	Scope of the course	To provide an introduction to Astronomy for second-year B.Tech. students. This would become the second course in the Minor in Astronomy, the first being first-year Electrodynamics
7	Course Syllabus	**Introduction, Distances & Measurement systems** Typical physical scales/conditions in astrophysics; order of magnitude estimation; astronomical observations: electromagnetic, earth vs space based observations, atmospheric transmission; co-ordinate systems; luminosity/magnitude scale, electromagnetic wavebands; distance measurement **Telescopes:** radio, infrared, optical, X-ray, gamma ray; collecting area, diffraction limit, atmospheric seeing; optics, aperture synthesis, spectroscopy (prisms and gratings). **Fundamentals of radiation:** specific intensity, energy density, opacity, black body distribution **Stars & Stellar structure/evolution:** Solar spectrum, luminosity; nuclear fusion; Thomson scattering, hydrostatic equilibrium, gas/radiation pressure; order of magnitude estimates, main sequence; HR diagram **Galactic & Extragalactic Astronomy:** Types of galaxies, Milkyway components:; 21 cm line, rotation curve, dark matter; Jeans instability and star formation, interstellar medium; cosmic rays. Galactic dynamics Active Galaxies; Extragalactic distance scale, classification of clusters, ICM, virial theorem
8	Suggested Books	1. Rai Chaudhuri, A., Astrophysics for Physicists, Cambridge University Press, 2010. ISBN 978-0521815536 2. Carroll B. W. & Ostlie, D. A.: An introduction to Modern Astrophysics, Pearson Education-Addison Wesley, 2007. ISBN 978-0805304022 3. Shu, F., The Physical Universe, Universal Science Books, 1982. ISBN 978-0935702057 4. Harwit, M., Astrophysical Concepts, 3rd ed, Springer-verlag, 2006. ISBN 978-0387329437 5. Maoz, D., Astrophysics in a nutshell, Princeton University Press, 2006. ISBN 978-0387329437 6. Padmanabhan, T., Invitation to Astrophyiscs, World Scientific, 2006. ISBN 978-9812566874 7. 7. Acheson, Elementary Fluid Dynamics, Oxford University

1.	Course Code	**AA 202N**
2.	Title of the Course	**Astronomical Techniques**
3.	Credit Structure	L-T- P- Credits 2-1-
4.	Name of the Department / Centre	Center of Astronomy
5.	Pre–requisite, if any	None
6.	Scope of the course	To provide a working knowledge of astronomical techniques
7.	Course Syllabus	**1. Introduction:** Radio observations, physical mechanisms generating emission, Multi-waveband observations **2. Receiver and Signal Processing Theory:** Probability Density, Expectation Values, Ergodicity, Auto-correlation and power spectrum, linear systems, Filters, digitization and sampling, square law detectors, and other signal processing, understanding of noise concepts, Noise, statistics, estimation and uncertainties, discussion of flux, surface brightness, Antenna Temperature. Direct Detection and Heterodyne systems; the importance of phase in interferometry, amplifiers, specifically low-noise; mixers and filters. **3. Fourier Transform and Related Topics:** Basics, and physical meaning; properties; coherence (mutual and self; phase-space picture); uncorrelatedness versus incoherence; uses of Fourier transforms; discrete & continuous versions; resolution versus sampling; aliasing (discretization and cyclicity); bandwidth and information content & its rate of change; Nyquist criteria (for real and complex sampling); Fourier synthesis and analysis; symmetries; physical examples (e.g. Fourier pairs relevant to astronomy/physical optics); auto-correlation function & power spectrum; Structure function (and its relation with other functions); convolution versus correlation (including physical meaning); convolution theorem; filtering; impulse-response/point-spread function; sidelobes & window functions; interpolation; digitization and loss of information; Matched filtering and optimum detection/estimation; Fourier versus Laplace transforms. **4. Imaging principles:** resolution, aperture synthesis, methods of

8.	Suggested Books	1. Bracewell, R.N., ***The Fourier Transform and Its Applications***, McGraw Hill. ASIN, B0006BMAD8 2. Brigham, N.O., ***Fast Fourier Transform and Its Applications***, Pearson, 1988, ISBN: 978-0133075052 3. Roy, A.E. and Clarke, D., Astronomy Principles and Practice, CRC Press, 4th edition, 2003. ISBN 978-0750309172 4. Kitchin, C.R.: Astrophysical Techniques, CRC Press, 6th edition, 2013. ISBN 978-1466513761 5. Knoll, G.F.: Radiation Detection and Measurement, Wiley, 2010. ISBN 978-0470131480 6. Hamaker et al. (A & A Suppl. Ser., 117, 1996): Understanding Radio Polarimetry 6. Jaap Tinbergen: Astronomical Polarimetry, Cambridge University Press, 2005. ISBN 78-0521018586 7. J. D. Krauss: Radio Astronomy, Cygnus-Quasar Books, 2ed, 1986. ISBN 978-1882484003 8. H. Bradt: Astronomy Methods Cambridge Univ. Press

Course code	**AA 204**
Title of the course	**Introduction to Space Exploration**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Astronomy, Astrophysics and Space Engineering
Prerequisite, if any	None
Scope of the course	To provide introductory concepts of space science and exploration
Course Syllabus	**Sun and the solar system**: Overview of Sun and Heliosphere; Solar wind plasma and Coronal Mass Ejection. Asteroid belts; **Solar interaction with solar system bodies**: Planetary magnetism; Planetary magnetic fields and observations; Solar interactions with planets and comets, **Earth and Atmosphere**: Remote Sensing from Space; Vertical structure of the Atmosphere and circulations; Chemistry and dynamics of Ionosphere; Ongoing and future missions. **Planetary Science**: Overview of planetary characteristics; Planetary system; Gas planets; Planetary satellites; Planetary atmosphere. **Fundamentals of Satellites**: Basics of rockets and satellite launching; Overview of satellite communications and satellite orbit, orbit principles, basics of space flightorbital mechanics, Spacecraft payloads **Spacecraft-environment interactions**: Spacecraft charging in low Earth orbit and geostationary orbit; Radiation damage effects; Background effects and their minimisation; Penetrating radiation; South Atlantic Anomaly **Space Explorations**: Overview of national and international space agencies; Space policies; Historical overview of space exploration missions; International Space Station; Human Interaction in Space, Astronautics. **Exoplanets and Astrobiology**: Exoplanets; Basic technique to detect exoplanets; Habitable zones; Search for Extraterrestrial Intelligence
Suggested Books	1. B. A. Campbell, S. W. McCandless, Jr.: ***Introduction to Space Sciences and Spacecraft Applications***, Gulf Professional Publishing, 1996, ISBN-978-0-88415-411-2 2. Kivelson M G & Russel C T, ***Introduction to Space Physics***, Cambridge Univ. Press, Cambridge, 1995, ISBN-10, 0521457149 3. Spohn T, Breuer D & Johnson T V, ***Encyclopedia of the Solar System***, 3rd edition, Elsevier, 2014, ISBN: 978-0-12-415845-0 4. 4. G. Joseph and C Jeganathan, ***Fundamentals of Remote***

	Sensing, Third Edition, Universities Press Pvt. Ltd., Hyderabad, India. 2018. ISBN 978-93-86235-46-6. 606

Course code	**AA 301**
Title of the course	**High Energy Astronomy**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Astronomy
Pre-requisite, if any	NA
Scope of the course	Providing an introduction to astrophysical processes.
Course Syllabus	**Radiative Processes:** Covariant formulation of classical electrodynamics. Radiation from accelerated charges. Cyclotron and synchrotron radiation. Bremsstrahlung. Thomson and Compton scattering. Plasma effects. Atomic and molecular spectra. Transition rates and selection rules. Opacity calculations. Line formation in stellar atmospheres. Fundamentals of radiative transfer, synchrotron radiation, Compton scattering, spectral line transfer, gas heating and cooling and topics in atomic and molecular spectroscopy are discussed within the framework of astrophysical sources and problems. Applications will include the interstellar and intergalactic media, neutron stars, active galactic nuclei, and exoplanetary systems. **Application to Accretion Physics:** Accretion in binary systems, effect on binary evolution_ Accretion physics: The origin of viscosity, time-scales and stability, thin and thick disks,_ Nova and Type Ia SN, ultra compact binaries_ Supermassive Black Holes (BHs): Introduction to Active Galactic Nuclei (AGN), radio sources, quasars, synchrotron radiation, minimum energy, supermassive BHs_ Jets: relativistic effects, radiation. **Photon interaction with matter:** detection of high energy radiation (X-ray and Gamma ray)_ Gamma Ray Bursts: Simple models
Suggested Books	1. H Bradt, ***Astrophysics Porcesses***, Cambridge University Press, : Cambridge, UK : 2008 : 978-1107677241 2. G B Rybicki, A P Lightman, ***Radiative Processes in Astrophysics,*** Wiley, Weinheim, Germany, 1985, 978-0471827597 3. G Ghisellini, ***Radiative Processes in High Energy Astrophysics***, Springer, Heidelberg, Germany, 2013, 978-3319006116 4. Shapiro, S. and Teukolsky, S. ***Black Holes***, White Dwarfs and Neutron Stars, 1983 5. J. Frank, A king & D. Raine: ***Accretion Power in Astrophysics***, 2002 6. Fulvio Melia: ***High Energy Astrophysics***, 2009 7. J. Krolik: Active Galactic Nuclei, 199 8. W.H.G. Lewin, & M. Van del Klis (eds), ***Compact Stellar X-ray Sources***, 2006 9. M S Longair, ***High Energy Astrophysics,*** Cambridge

	University Press, Cambridge, UK, 2011, 978-0521756181

Course Code	**AA 303**
Title of the course	**IoT for Space Applications**
Credit Structure	L – T – P – Credits 2 – 1 – 0 – 3
Prerequisite if any	None
Name of Department	Astronomy, Astrophysics and Space Engineering
Scope of the course	Enabling students to implement IoT in Space Applications
Course Syllabus	1. Introduction to IoT in Space: Applications of IoT in space – communications between satellite and ground, sensors and sensor control in space, onboard data storage and analysis on a satellite, onboard signal processing for space applications, IoT framework for Space Applications 2. Space Communications: Protocols, receiving signals from satellites using a Software Defined Radio (SDR), Detecting satellites, Downlink from and Uplink to satellites with a receiver-transmitter 3. Onboard data analysis: Using a low-power device for frontend analysis of data for communications, transmitter-receiver in radio, Using an energy-efficient sensor controller in space 4. Using an array of sensors through IoT for space/atmospheric measurements: Rain Gauge, Humidity, Temperature and Pressure sensing Onboard analysis of sensor data, Simultaneous IoT control of sensors and transmitter-receiver, Sensor array / Transceiver as space communications and sensing solution 5. IoT Framework towards Space Applications Analysis: Analysis of data from Smart Space Sensors - Classification and Regression; Linear, Polynomial Regression; Logistic Regression; Clustering; Optimization techniques; Machine Learning techniques for onboard Space IoT data analysis
Suggested Books	1. Collins, Getz, Pu and Wyglinski; ***Software Defined Radio for Engineers***; Artech House; 2018; ISBN: 978-1-63081-457-1 2. Stewart, Barlee, Atkinson and Crockett; ***Software Defined Radio using MATLAB, Simulink and the RTL-SDR***; Strathclyde Academia Publishers; 2015; ISBN: 978-0992978723 3. S. Monk; ***Programming the Raspberry Pi***, Second Edition: Getting Started with Python; McGraw-Hill Education; 2015; ISBN: 978-1259587405 4. A. Maheshwari; ***Big Data***; McGraw-Hill; 2019; ISBN: 978-9353167950 5. S. Monk; ***Programming Arduino: Getting Started with Sketches***; McGraw-Hill; 2016; ISBN: 978-1259641633 6. J. Grus; ***Data Science From Scratch***: First Principles with Python; O'Reilly; 2019; ISBN: 978-9352138326

Course code	**AA 403 / AA 603**
Title of the course	**Space Engineering Systems**
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Department	Astronomy, Astrophysics and Space Engineering
Prerequisite, if any	None
Scope of the course	Students will familiarize with the key features of communication electronics, the space environment and how it affects electronics, how to design for the thermal environment in space, the effects of the radiation environment on electronics and what types of electronics might be used in the future.
Course Syllabus	**Qualifying systems for space:** Total ionizing dose (TID), Single event effects (SEEs), Radiation shielding, Mitigation of SEEs (hardware,software) Electronic, Electrical and Electromechanical - Definition, Screening/testing and reliability, Radiation Hardness Assurance Materials, Thermal modelling of spacecraft, Temperature requirements Thermal cycling and testing, Standards (ECSS), Radiation design margins **Spacecraft-Space Environment Interactions:** Radiation environments, Thermal environment, Launch environment, Other environments (space debris, atomic oxygen, low energy plasma, spacecraft charging, arcing), Radiation effects **Payload Design:** Payload requirements, Payload components and their characteristics - antennas, Low Noise Amplifiers (LNAs), microwave filters, channel and power amplifiers, power combiners, FPGAs for space, Onboard processing, Payload Configuration management **Satellite Systems Engineering:** System development methodology, Analog and Digital processor architecture, Transponder / Transceiver gain control, linearity, multipexing, filters, wideband systems Uplink and Downlink power control, beam pointing, modulation and demodulation, individual and block upconverters and downconverters **Space Operations:** Tracking, Telemetry and Command (TT&C), Satellite Network architectures, In-orbit monitors and testing, Earth Stations - Classes and Design, Terrestrial Network Interfaces - Plesiochronous Digital Hierarchy (PDH) and Synchronous Digital Hierarchy (SDH). The future - Use of COTs, Miniaturisation

Suggested Books	2. Cruise, A. M., **Principles of space instrument design**, Cambridge University Press, Cambridge, 2006, ISBN: 052102594x, 0521451647 3. **An Introduction to Space Instrumentation**, Edited by K. Oyama and C. Z. Cheng, Terrapub, 2003, ISBN 978-4-88704-160-8 4. Elbert, B.R., **Introduction to Satellite Communication**, Artech House, 2008, ISBN: 978-1-59693-210-4 5. Fortescue, Peter W.; Stark, John; Swinerd, Graham, **Spacecraft systems engineering,** Wiley, Hoboken, N.J., 2011, ISBN: 047075012X, 9780470750124

Course Code	**AA 404 / AA 604**
Title of the Course	**Spacecraft and Payload Attitude Dynamics, Control and Pointing**
Credit Structure	L-T- P-C 2-1-0-3
Name of the Department / Centre	Astronomy, Astrophysics and Space Engineering
Pre-requisites (if any)	
Course Syllabus	Three-axis Spacecraft Attitude dynamics; quaternions and other representations. Multi-body spacecraft with articulated antennas, sensors, and solar arrays. Design of spacecraft controllers with reaction wheels, magnets, single- and double-gimbaled control moment gyros as actuators. Three-axis large angle manoeuvres. Payload controllers for acquiring, precision pointing, and high-accuracy tracking of landmarks and moving objects of interests for remote sensing and communication. Pointing error budget. Image motion compensation to remove image blur. Solar array controllers for tracking the Sun using micro-stepper motors. Flexible spacecraft dynamics and control. Dynamics and control of spinning spacecraft: stability, precession and nutation. Control of spin-axis attitude during ΔV-firing for changing orbits; active nutation control; dual-spin stabilization; Rhumb-line manoeuvre. Dynamics and precision pointing of bias momentum spacecraft: stability**;** control using two momentum wheels and a reaction wheel. Reaction jet attitude control and nonlinear controllers: pulse-width-pulse-frequency
Suggested Books	1.Hughes, P.C., Spacecraft Attitude Dynamics, John Wiley,1986, ISBN: 9780486439259 2.Sidi, M.J., Spacecraft Dynamics and Control, Cambridge University Press, 1997, ISBN: 9780521787802 3.Agrawal, B., Design of Geosynchronous Spacecraft, Prentice Hall, 1986, ISBN: 9780132001144 4.Bryson, A.E., Control of Spacecraft and Aircraft, Princeton University Press, 1994, ISBN: 9780691087825 5.Wie, B., Space Vehicle Dynamics and Control, AIAA Education Series, 1998, ISBN: 9781563479533 6.Markley, F.,L., Fundamentals of Spacecraft Attitude Determination and Control, Springer – 2014, ISBN: 9781493908011

Course code	**AA 405/ AA 605**
Title of the course	**Detectors and sensors for space observations**
Credit Structure	L - T - P – Credits 2-0-2-3
Name of the Concerned Department	Astronomy, Astrophysics and Space Engineering
Prerequisite, if any	None
Scope of the course	Observational techniques and detectors for space telescopes and missions, design, working principle, and operation.
Course Syllabus	**Spacecraft as Observation platforms:** space environment, space effects from Earth's surface, in situ measurements, Noise and Uncertainty. **Attitude and Position sensing, Communication**: sun sensors, earth sensors, star sensors, magnetometers, attitude control, Communication **Detectors for E and B field Measurements in Space:** Spacecraft charging in low Earth orbit and geostationary orbit. Radiation damage effects. Background effects and their minimization. Plasma influx, penetrating radiation, sunlight. Direction of Arrival. **Detectors for Imaging:** Various interaction of radiations with matter for detection purposes, Solid State Detectors, MKIDs (Microwave Kinetic Inductance Detectors), Super Conducting Tunnel Junction Devices (STJs), CCD, SSD (Silicon Strips Detectors), and G-APD, Radiometry, cooling, photoconductors, bolometers, coherent detectors, polarimeters, magnetometers, and electric field sensors, readout, amplifiers, current collectors, future X-ray interferometers **Non-Imaging Detectors:** Laser Interferometer, Incoherent detectors, photodiodes, photoemission detectors, photomultipliers, Channeltrons, microchannel plates, ionization detectors, scintillator detectors, calorimeters **Detectors for Spectroscopy:** Gratings, γ-ray, X-ray, α-particle, neutron, Mossbauer spectrometers. Visible light & dust particle spectroscopic measurement techniques. **In-situ plasma measurements:** Requirements; Energy and mass analysis for charged species from 1eV to 1MeV. Neutral mass spectrometers. **Techniques and Applications of Hyperspectral Sensor:** Elements of Hyperspectral Sensing, Imaging System Design, Hyperspectral Target Detection **Augmented Systems:** Focusing optics, collimators, CAMs **Applications**: Various applications in Astronomy, Atmospheric measurements, Planetary analysis, Radar, Space sciences

Suggested Books	1. K. Oyama and C. Z. Cheng, ***An Introduction to Space Instrumentation***, Terrapub, 2013, ISBN: 978-4-88704-160-8 2. H. Bradt, ***Astronomy Methods***, Cambridge University Press, 2003, ISBN: 9780511802188 3. P. Léna, D. Rouan, F. Lebrun, F. Mignard, D. Pelat, ***Observational Astrophysics***, Springer-Verlag, Berlin, Heidelberg, 2012, ISBN: 978-3-662-51733-8 4. 4. C.R. Kitchin, ***Astrophysical Techniques***, 6 ed., CRC Press, 2013, ISBN: 978-1-4665-1115-6

Course code	**AA 407/ AA 607**
Title of the course	**Remote sensing for Atmospheric and Space Sciences**
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Astronomy, astrophysics and space engineering
Prerequisite, if any	None
Scope of the course	Fundamental concepts of system, sensors and information retrieval techniques for remote sensing system and its application in space and atmospheric science
Course Syllabus	**History and development** of remote sensing technique, Recent trends and state-of-art in optical and microwave remote sensing techniques **Sources of energy in remote sensing**: Active and Passive Radiation, Electromagnetic Radiation -Reflectance, Transmission, Absorption, Thermal Emissions, Wave interaction with atmosphere, Atmospheric windows, Spectral reflectance; **Remote sensing data acquisition platforms**: Characteristics of different types of remote sensing platforms; Sensors for active and passive remote sensing- spatial, spectral and radiometric resolution; **Remote sensing data:** Characteristics, Atmospheric, radiometric and geometric Corrections, Basic principles of visual interpretation of passive remote sensing images, Image processing and feature identification, Case studies with Landsat and Sentinel satellite images for classification of objects. **Microwave Remote Sensing**: Advantages and challenges, Passive microwave remote sensors and operation principle, Basic concepts of radar remote sensing- resolution, range and angular measurements, microwave scattering, imaging radar technique and data interpretation. **Radar remote sensing systems** –Clear air and ST/MST radar for atmospheric studies, Synthetic Aperture Radar for planetary studies, Doppler weather radar, Coherent and incoherent radar for ionospheric studies **Applications and Satellite Missions:** Atmospheric and planetary remote sensing satellites -TRMM/GPM, Cloudsat, NISAR, CALIPSO, MODIS, Megha-tropique, GOES. Applications in Weather monitoring (Temperature, Humidity, Wind, Cloud, Rain, lightning), Ionosphere and change detection, Data exploration using BHUVAN, Google Earth map and NASA Earth Explorer.

Suggested Books	1. W.G. Rees : Physical Principles Of Remote Sensing : Cambridge University Press : Cambridge : 2001 : 978-0521181167 2. J.R Jensen : Remote Sensing Of Environment : An Earth Resource Perspective : Pearson Education India : New Delhi : 2013 : 978-9332518940 3. F. T. Ulaby, R. K. Moore, A. K. fung : Microwave Remote Sensing, Active and Passive : Vol I, Fundamentals and Radiometry : Artech House Publishers : _ : 1981 : 978-0890061909 4. F. T. Ulaby, R. K. Moore, A. K. fung : Microwave Remote Sensing, Active and Passive : Vol II, Radar Remote Sensing and Surface Scattering : Artech House Publishers : _ : 1986 : 978-0201107609

Course code	**AA 410/ AA 610**
Title of the course	**Spatial Informatics**
Credit Structure	L - T - P – Credits 2-0-2-3
Name of the Discipline	Astronomy, Astrophysics and Space Engineering
Prerequisite, if any	None
Scope of the course	This course introduces the fundamental concepts of Geographic Information Science (GIS), geospatial data processing and spatial statistics. The course would also lab-based tutorials on spatial data handling and processing using open-source tools/software.
Course Syllabus	GIS, spatial data concepts, map reference systems. Spatial data - sources, models, structures, analysis, and interpolation. Terrain modeling, visualization, data quality, spatial decision support systems, Open GIS standards, GIS applications and advances Spatial Statistics; Basic Concepts of Statistics; Variogram; Semi-Variogram; Fitting Variogram Models, Validation; Applications of Variograms; Interpolation using Spatial Models; Spatial Prediction and Kriging – Ordinary Kriging, Multivariate Kriging, Vornoi diagrams; Analysis of Space-Time Geostatistical Data; Application of Spatial Statistics in Remote Sensing. **Practicals:** Spatial statistics using Python/Matlab, Geospatial data processing and manipulation using open source (*QGIS*) tools and Python libraries (*GDAL, GeoPandas, Shapely)*. Scalable analytics and geospatial data handling using Python libraries (*DASK and XArray*). Introduction to Google Earth Engine and its applications.
Suggested Books	**Text books:** *1.* K. Chang**, Introduction to Geographic Information Systems**, Fourth edition (Indian edition), McGraw Hill Education (2017). ISBN-13: 978-0070658981 2. P.A. Burrough and R. A. McDonnell, **Principles of Geographical Information Systems**, Oxford University Press (2006). ISBN-13: 978-0199228621 **Reference books:** 1. O. Schabenberger, & C.A. Gotway, **An introduction to applied geostatistics**. Oxford university press. (2017). ISBN: 9781315275086 2. N. Cressie, (1993). **Statistics for Spatial Data** (Revised Ed.). John Wiley & Sons, Inc. Chiles, J. P. and Delfiner, P. (1999). ISBN-13: 9780471002550

	3. C.P. Lo, and Yeung, Albert K.W., **Concepts and Techniques of Geographic Information Systems**, Prentice Hall (2002). ISBN-13 : 978-0131495029 4. I. H. Sarah, Cornelius and S. Carver, **An Introduction to Geographical Information Systems**. 3rd Edition, Pearson Education. New Delhi (2006). ISBN-13 : 978-027372259

Course code	**AA 411 / AA 611**
Title of the course	**Advanced Optics**
Course Category	Core
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Astronomy, Astrophysics and Space Engineering
Pre-requisite, if any	None
Scope of the course (Objectives)	Theoretical and technical concepts behind optical systems
Course Outcomes	This course will help students develop skills in the design/development of solutions and real-life optics related problem analysis. This course will further give students engineering knowledge related to optical and laser systems.
Course Content	1. Geometrical Optics & Ray Tracing : Optical system design, raytracing, spot-size diagram and MTF. Optical aberrations, tolerancing and optical design optimisation. 2. Wave Optics : Concepts of wavefront and phase, complex representation of electromagnetic wave, image formation and spatial resolution, optical path and spatial coherence, monochromaticity and temporal coherence. Interference and diffraction, Fourier Optics. concept of spatial filtering, amplitude and phase filters in spatial frequency domain, image processing. Shack-Hartman wave-front sensor, Zernike decomposition, wavefront correction, deformable optics. 3. Polarization : Stokes parameter, birefringence, Faraday rotation, Jones matrix, Berry phase and Panchratan sphere 4. Laser Interferometry : Two beam (Michelson) and multi-beam (Fabry-Perot), interferometers, Fizeau and white light interferometry, principles of phase shifting techniques and phase un-wrapping. Standard Quantum Limits (SQL) of interferometers and sub-SQL

	measurements. Scanning white light interferometer (SWLI), Doppler velocimetry and Velocity Interferometer System for Any Reflector (VISAR). Stellar interferrometry, Synthetic aperture optical telescope 5. Optical systems : Applications, Waveguides, Holographic systems etc., adaptive optics Typical list of experiments: • Using Michelson's interferometer determine the wavelength of an unknown source. • White light interferometry with Michelson's interferometer. • Using Michelson's interferometer determine the thickness of a thin glass plate or a thin film. • Use a Fabry-Perot interferometer to study Zeeman effect. • Verify Malus law. • Wavefront sensor
Suggested Books	**Textbook:** 1. Ajoy Ghatak, 'Optics', McGraw Hill, India, 2020, 978-9390113590 **Reference books:** 1. Eugene Hecht, 'Optics', Pearson, 2017, 978-0133977226 2. R. S. Longhurst, 'Geometrical and Physical Optics', Orient Blackswan, 1986, 9788125016236 3. Ajoy Ghatak, K Thyagarajan, "Introduction to FiberOptics", Cambridge University Press, 1998, 978-0521571203 4. Born and Wolf, 'Principles of Optics', Cambridge University Press, 1999, 978-0521642224

Course code	**AA 412/ AA 612**
Title of the course	**Microwave Remote Sensing**
Credit Structure	L - T - P – Credits 2-1-0-3
Name of the Discipline	Astronomy, Astrophysics and Space Engineering
Prerequisite, if any	None
Scope of the course	This course introduces the advanced topics in microwave remote sensing for Earth Observation and space sciences. The course is aimed at training students to utilize the microwave and Synthetic Aperture Radar data for various applications including ecosystems, solid earth, disaster mapping, agriculture and planetary remote sensing.
Course Syllabus	Introduction to active and passive microwave remote sensing. Advanced active and passive systems. Doppler Weather radar (Clear air / precipitation), scatterometer, altimeter- Principle and operations Synthetic Aperture Radar (SAR) data processing and image classification, SAR Interferometry - raw data processing, registration, coherence, phase unwrapping, geo-coding Differential SAR interferometry, permanent scatterer interferometry, Polarimetric SAR Interferometry. Radar polarimetry - measurement of the backscattering matrix, polarimetric scattering vectors, covariance matrix, scattering mechanism interpretation Active microwave data for Digital Elevation Model (DEM) generation, change mapping in geo-sciences, passive microwave data for global soil moisture, snow cover mapping, global temperature monitoring, disaster mapping using SAR data, case studies
Suggested Books	**Text Books:** 1. I.H. Woodhouse, (2015). **Introduction to Microwave Remote Sensing** (1st ed.). CRC Press. DOI: 10.1201/9781315272573. ISBN-13: 9780415271233 2. F. T. Ulaby, R. K. Moore, and A. K. Fung, **Microwave Remote Sensing: Active and Passive,** *Vol 1*. Artech House, 1981. ISBN-13: 978-0890061909 Reference books: 3. J. R. Jensen, **Remote Sensing of the Environment: An earth resource perspective**, Second edition, January 2013, Pearson

	Education India. ISBN-13: 9789332518940 4. J. C. Curlander and R. N. McDonough, **Synthetic Aperture Radar: Systems and Signal Processing**, April 1992. Wiley. ISBN-13: 9780471857709 5. F.M. Henderson, A.J. Lewis, **Manual of Remote Sensing - Principles and Applications of Imaging Radar**, Volume 2, Third Edition, 1998. ISBN-13: 978-0471294061 6. J.S. Lee, and E. Pottier, **Polarimetric Radar Imaging: From Basics to Applications**, CRC Press; 2nd Edition, 2020. ISBN-13: 978-1466585393

1. Course Code	**AA 472N / AA 672N**
2. Title of the Course	**Galactic and Extragalactic Astronomy**
3. Credit Structure	L-T- P-Credits 2-1-0-3
4. Name of the Department /	Astronomy, Astrophysics and Space Engineering
5. Pre–requisite, if	
6. Scope of the	
7. Course Syllabus	**Types of galaxies:** spirals, ellipticals and irregulars, Hubble pitchfork classification. Milkyway components: gas, stars, magnetic field and cosmic rays; satellites; 21 cm line, rotation curve, dark matter; Jeans instability and star formation, Phases and components of interstellar medium; HII regions; Radiative transfer, optical depth, Free-free emission, Scattering from dust, Optical depth, cosmic rays. **Galactic dynamics:** orbits in axisymmetric potentials, epicyclic limit; Oort's A & B constants, local differential rotation, collisionless Boltzmann equation, Jean's equations, Distribution Functions DFs, isothermal models gas in galaxies. **Evolution of Galaxies:** starbursts, galaxy formation models; color-magnitude diagram for galaxies; initial mass function; **Active Galaxies:** observations of active galaxies and quasars, unified model, radio lobes and jets; relativistic apparent superluminal motion, Doppler boosting, blazars; properties of accretion flows around supermassive black holes; M-σ relation for central black holes; Sgr A*, the Galactic center black hole. **Extragalactic distance scales**: classification of clusters, the local group,
8. Suggested Books	1. Mo, H.; van den Bosch, F.; White, S, ***Galaxy Formation and Evolution***, Cambridge University Press, 2010. ISBN 978-0-521-85793-2. 2. Schneider, P., ***Extragalactic Astronomy and Cosmology: An Introduction***, Springer 2006. ISBN 978-3-540-33174-2. 3. Phillipps, S., ***The Structure and Evolution of Galaxies***, John Wiley & Sons, Ltd, 2005; ISBN 978-0-470-85507-X. 4. Longir, Malcolm S., ***Galaxy Formation***, Springer, 2008. ISBN 5. James Binney, Scott Tremane, ***Galactic Dynamics***, Princeton University Press; Second edition (January 27, 2008), ISBN: 978-0691130279 6. Sparke, L.; Gallagher, J., ***Galaxies in the Universe: An Introduction*** (2nd Edition), Cambridge University Press, 2007. ISBN 978-0-521-67186-6

1.	Course Code	**AA 476/ AA 676**
2.	Title of the Course	**Satellite Based Navigation Systems**
3.	Credit Structure	L-T-P-Credit 2-1-0-3
4.	Name of the Concerned Department	Center of Astronomy
5.	Pre–requisite	None
6.	Scope of the course	This is a contemporary course on GPS-Aided Geostationary Augmented Navigation (GAGAN) and Navigation with Indian Constellation (NAVIC) satellite-based navigation systems of the country and how they will be used for navigation of land, air and space vehicles.
7.	Course Syllabus	Review of satellite-based navigations: GPS (Global Positioning System), IRNSS (Indian Regional Navigation Satellites System). GPS measurements and error sources; Code phase and carrier phase measurements. Ionospheric and tropospheric delay models; receiver clock error model; User range error; Combining code and carrier phase measurements – carrier-aided smoothing. Differential GPS, local-area DGPS, relative positioning; wide-area DGPS; Indian navigation system GAGAN (Geostationary Augmented GPS Aided navigation). Position, velocity and time estimation with pseudorange and pseudorange rate measurements. Precise positioning with carrier phase, with integer ambiguity resolution using code measurements and dual- and three-frequency measurements; LAMBDA method. Differential GPS-aided INS for flight vehicles: Code and carrier double-differencing, triple-differencing. Integration of differenced observables with inertial navigation (INS); GPS-Aided INS for precise aircraft landing. Tightly coupled GPS/INS integration for missiles and launch vehicle navigation. Absolute and relative navigation with GRAPHIC technique for satellites rendezvous. Unmanned Aerial Vehicle (UAV) and Micro Air Vehicle (MAV) navigation. Spinning sounding rocket navigation. Submarine navigation
8.	Suggested Books	1. Brown and Hwang, **Introduction to Random Signals and Applied Kalman Filtering**, John Wiley, 2012, 4th edition, ISBN : 0470609699 2. Rogers, R.M., **Applied Mathematics in Integrated Navigation Systems**, 3rd Ed., AIAA Education Series, 2007, ISBN : 1563479273 3. Farrell, J.L., **GNSS Aided Navigation and Tracking**, American Literary Press, 2007, ISBN : 1561679798 4. Farrell, J. A., **Aided Navigation: GPS with High Rate Sensors**, McGraw Hill, 2008, ISBN : 0071493298 5. Farrell, J.A. and Barth, M., **The Global Positioning System and Inertial Navigation**, McGraw-Hill, 1999,

		ISBN : 007022045X 6. Misra, P., and Enge, P., **GPS – Signals, Measurements and Performance**, Second Edition, Ganga-Jamuna Press, 2006, ISBN: 0970954425

Course code	**AA 478/ AA 678**
Title of the course	**Space Weather**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Astronomy
Pre-requisite, if any	NA
Scope of the course	This course gives an overview of the space weather systems involving the Sun, Heliosphere, Magnetosphere and Ionosphere.
Course Syllabus	1. Introduction – Definition of Space Weather(Sun, Heliosphere, Magnetosphere, Ionosphere) 2. Solar interior, solar magnetism, structure of solar atmosphere 3. Solar Activity: Flares, Coronal Mass Ejections and Solar Energetic Particles, Solar Wind Formation and Acceleration, Heliospheric Structure 4. Magnetospheric structure, magnetospheric storms and substorms , Geomagnetic Storms– Geomagnetic Variations, Geomagnetic Activity Indices, Geomagnetic Storms 5. Ionosphere – Description of the ionospheric layers, anomalous features of the F-region, ionospheric irregularities, short-term and long-term behavior of the ionospheric layers, sporadic-E, ionospheric models. 6. Space WeatherMeasurement Systems–Ionospheric Sounding Systems, Radar, Transionospheric Propagation Systems, GPS. 7. Space Weather Effects on Telecommunication Systems – outline of ionospheric effects, integrated propagation effects – refraction, phase and group path variation, Doppler shift, Faraday rotation, absorption, differential effects – scintillations, mitigation scheme.
Suggested Books	1. Gerd W. Prolss, ***Physics of the Earth_s Space Environment -An Introduction,*** Springer Publications, Heidelberg, 2004, ISBN-10 : 3540214267 2. MG Kivelson and CT Russel, ***Introduction to Space Physics,*** Cambridge Univ. Press, Cambridge, 1995, ISBN-10, 0521457149 3. M.Kallenrode, ***Space Physics : An Introduction to Plasma and Particles in the Heliosphere and Magnetosphere***, Springer Publications, Heidelberg, 2004, ISBN, 3-540-20617-5 4. M. Moldwin, ***An Introduction to Space Weather,*** Cambridge Univ. Press, Cambridge, 2008, ISBN 9780511801365

Course code	**AA 681/ AA 481**
Title of the course	**Introduction to Climate and Climate Change**
Course Category	Core
Credit Structure	L - T - P - Credits 2-0-0-2
Name of the Concerned Department	AASE
Pre-requisite, if any	Nil
Scope of the course (Objectives)	Introduce the concepts and connections among atmosphere, ocean, and climate. The course also gives an idea about the energy transfer, stability and circulations present in the atmosphere and oceans and the causal relationship to climate change.
Course Outcomes	Students will learn about the physics and mathematics of atmosphere and oceans, and their role in climate in order to analyse and model the climate change implications.
Course Content	Module 1: Climate system and its components, Structure of the atmosphere and physical properties, Energy balance, hydrological and carbon cycles, Stability and waves. Module 2: The general circulation of the atmosphere, Ocean and its circulation, Climate and climate variability.
Suggested Books	**Textbook:** • John Marshall and R. Alan Plumb : Atmosphere, Ocean and Climate Dynamics-An Introductory Text : Academic Press : 2007 : 9780125586917 **Reference Book:** • Roger G. Barry and Richard J Chorley : Atmosphere, Weather and Climate : Routledge (9th edition) : 2017 : 9781138294073

Course Code	**AA 203 / PH 203**
Title of the Course	**Classical Mechanics**
Course Category	Core
Credit Structure	L-T-P-Credits (2-1-0-3)
Name of the Department	Physics
Pre–requisite, if any	None
Objectives of the course	This course provides basic knowledge of classical physics
Course Outcomes	Students should be able to • Solve problems using the Lagrange method • Apply Lorentz transformations, understand 4-vector analyses and relativistic kinematics, and use Lagrange and Hamiltonian formulations for relativistic particles. • Develop problem-solving skills in classical and relativistic mechanics.
Course Syllabus	• System of particles, Center of mass, equation of motion of the CM, conservation of linear and angular momentum, conservation of energy, variable mass systems. Elastic and inelastic collisions. • Central Force: uniformly rotating frame, centrifugal and Coriolis forces, Motion under a central force, Kepler's laws, Gravitational Law and field, Conservative and non-conservative forces. • Introduction to Lagrangian mechanics, Mechanics of Rigid Body: Rigid body motion, fixed axis rotations orthogonal transformations and rotations (finite and infinitesimal); Euler's theorem, Euler's angles; moments of Inertia tensor, parallel and perpendicular axes theorem, Principal moments and axes; Euler's equation; Small Oscillations, normal modes, and frequencies. • Special Theory of Relativity: Lorentz transformations; 4-vectors, 4-dimensional velocity, and acceleration; 4-momentum and 4-force; Covariant equations of motion; Relativistic kinematics (decay and elastic scattering); Lagrangian and Hamiltonian of a relativistic particle. • General properties of matter: Introduction to Elasticity, Surface Tension and Viscosity

Suggested Books	Textbooks: 1. Goldstein, Poole, Safko, *Classical Mechanics*, Pearson, (2017), ISBN: 978-0201657029 2. N. Rana and P. Jog, *Classical Mechanics*, Mcgraw Hill, (2017), ISBN: 978-0074603154 Reference Books: 3. Kleppner and Kolenkow, *An Introduction to Mechanics*, Cambridge Univ. Press, (2013), ISBN: 978-0521198110 4. K. C. Gupta, *Classical Mechanics of Particles and Rigid Bodies*, New Age Education, (2018) ISBN: 978-9386649782 5. D. Morin, *Introduction to Classical Mechanics*, Cambridge Univ. Press, (2009), ISBN: 978-0521185028

Course code	**AA 205 / PH 205**
Title of the course	**Electronic Devices and Circuits - I**
Course Category	**Core**
Credit Structure	**L - T - P – Credits (2-1-0-3)**
Name of Dept.	**Astronomy, Astrophysics and Space Engineering**
Prerequisite, if any	None
Objectives of the course	The students will gain foundational knowledge of analogue electronics.
Course Outcome	• Acquire knowledge of basic analog electronics. • Gain skills to design basic electronic circuits.
Course Syllabus	**Module - 1** Basics of semiconductor devices and their characterization: diodes, transistors, BJT, FET, MOSFET, etc. **Module - 2** Small signal analysis in electrical circuits: Estimation of voltage gain, input/output resistance, Miller's theorem, high-frequency transistor model. **Module - 3** Amplifiers and their applications: Single-stage and two-stage amplifier, Differential amplifiers, Operational amplifiers. **Module - 4** Oscillators: Basics of oscillators, phase shifter, multi-vibrators, timers.
Suggested Books	Textbooks: 1. A. Malvino and D. Bates, *Electronics Principles*, McGraw Hill Education, 7th Ed., (2017), ISBN : 978-0070634244 2. A. S. Sedra and K. C. Smith, *Microelectronic Circuits,* Oxford University Press, (2017), ISBN: 978-0199476299 Reference Books: 3. Gray, Hurst, Lewis, and Meyer, *Analysis and Design of Analog Integrated Circuits,* Wiley (2009) ISBN: 978-8126521487 4. R. Gayakwad, *Op-amps and Linear Integrated Circuits*, Pearson, (2021) ISBN: 978-9353949037 5. B. Razavi, *Fundamentals of Microelectronics*, Wiley, (2017), ISBN: 978-8126571352 6. R. L. Boylestad, *Electronic Devices and Circuits Theory*, Pearson (2021) ISBN: 978-9332542600

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	AA 206 / PH 206
Title of the course	Electronic Devices and Circuits – II
Course Category	Core
Credit Structure	L - T - P – Credits (2-1-0-3)
Name of the Department	Astronomy, Astrophysics and Space Engineering
Pre-requisite, if any	None
Objectives of the course	The students will develop a basic understanding of digital electronics principles
Course Outcomes	Students will learn about digital electronics and will able to solve related problems in the domain of engineering.
Course Content	**Module -1** **Number System and Codes:** Decimal, Binary, Octal and Hexadecimal number systems and arithmetic, base conversions. Representation of signed and unsigned numbers, addition, subtraction by 2's complement method, and multiplication. **Module -2** **Logic Gates and Boolean algebra:** Truth Tables of OR, AND, NOT, NOR, NAND, XOR, XNOR, Universal Gates, Basic postulates and fundamental theorems of Boolean algebra. **Module -3** **Combinational Logic Analysis, Design and Arithmetic Circuits:** Standard representation of logic functions, Binary Addition. Half and Full Adder. Half and Full Subtractor, 4-bit binary Adder/Subtractor, counters and registers. **Module -4** **Signal Conditioning and D-A and A-D Conversion:** A-D and D-A conversion, sampling and reconstruction of signal, Nyquist sampling, Fourier transform, Fast Fourier Transform.
Suggested Books	Textbooks: 1. D. P. Leech and A. P. Malvino, *Digital Principles and Applications*, Tata McGraw Hill, 8th ed., (2014) ISBN: 978-9339203405. 2. A. S. Sedra, K. C. Smith, *Microelectronic Circuits*, Oxford University Press, (2017), ISBN: 978-0199476299 Reference books: 3. J. G. Proakis and D. G. Manolakis, *Digital Signal Processing: Principle, Algorithms and Applications*, 4th ed., Pearson Education, (2007), ISBN:

	978-8131710005. 4. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, *Signals & systems*, Pearson Education, 2nd ed., (2015) ISBN: 9332550239. 5. J. Millman and C. Halkias, *Integrated Electronics: Analog and Digital Circuits and Systems*, McGraw-Hill, 2nd ed., (1972), ISBN: 9780070151420.

Course Code	**AA 207 / PH 207**
Title of the course	Wave Phenomenon and Optics
Course Category	Core
Credit Structure	L-T-P-Credits (2-1-0-3)
Name of Dept.	Astronomy, Astrophysics and Space Engineering
Prerequisite, if any	None
Objectives of the course	The students will be introduced to the basics of waves and oscillations, including optics and lasers.
Course Outcome	● The students will learn to solve for motions in different oscillatory systems ● The students will understand the concepts of optics and compare the outcomes in different optical systems
Course Syllabus	**Module 1:** • Oscillations: Harmonic motion (simple, damped, critical). Driven oscillation, resonance. Oscillations of two-particle systems and modes. Oscillations of n particle systems. Oscillation modes. Longitudinal and transverse oscillations. • Waves: Equations of motion, standing waves and travelling waves. Harmonics and their superpositions. Fourier analysis and Fourier coefficients. Doppler effect. **Module 2:** • Geometrical Optics: Fermat's Principle, Refraction, Thick Lens and Lens Combination, Matrix Method, Aberrations, Optical Instruments: Telescopes and Microscopes. • Wave Optics: Electromagnetic Spectrum, Huygen's Principle, Interference: Young's Experiment, Fresnel's Biprism, Newton's Rings, Interferometers: Michelson and Fabry-Perot; Coherence: Temporal and Spatial; Diffraction: Fresnel and Fraunhofer, Single and Double Slit, Circular aperture, Grating, Resolving power. • Polarization, LASER and Holography: Brewster's Law, Birefringence, Dichroism, Babinet's Compensator, Polarimeters, Optical Activity. Coherence, LASER, spontaneous and stimulated emission, Gaussian wave and its diffraction. Holography.

Suggested Books:	Textbooks: 1. A. P. French, *Vibrations and Wave*, CRC Press; 1st edition, (2017), ISBN: 978-1138414082 2. A. Ghatak, *Optics*, MacGraw Hill, (2020), ISBN: 978- 9390113590 [Module 2] Reference Books: 3. F. S. Crawford, *Waves*, MacGraw Hill Education, (2017), ISBN: 978-0070702172 4. N. Bajaj, *The physics of waves and oscillations*, McGraw Hill, (2017), ISBN: 978-0074516102 5. F. Jenkins and H. White, *Fundamentals of Optics*, McGraw Hill Education; 4th edition, (2017), ISBN: 978-1259002298 6. M. Born and E. Wolf, *Principles of Optics*, Cambridge Univ. Press, (2019), ISBN: 978-1108477437

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	AA 208 / PH 208
Title of the course	Electrodynamics
Course Category	Core
Credit Structure	L-T-P–Credits (2-0-0-2)
Name of Dept.	Astronomy, Astrophysics and Space Engineering
Prerequisite, if any	None
Objectives of the course	The students will be introduced to electromagnetism
Course Outcome	Develop understanding of basic electrodynamics and its applications in the domain of engineering.
Course Syllabus	• Review of Electrostatics and Magnetostatics. Time-Varying Fields and Maxwell's Equations: Faraday's law for Electromagnetic induction, Displacement current, Integral and differential forms of Maxwell's equations, and Motional Electromotive forces. Boundary Value Problems, multipole expansion. • Electromagnetic Waves: Derivation of Wave Equation, Coulomb and Lorentz gauges; Plane waves in free space and in a homogenous material. non-conducting and conducting media; reflection and transmission at normal and oblique incidences, Skin effect, Poynting theorem. Polarization. • Lorentz Invariance of Maxwell's Equation, Radiation by moving charges, retarded potentials. Dipole antenna radiation, Introduction to waveguides.
Suggested Books	Textbooks: 1. D. J. Griffiths, *Introduction to Electrodynamics*, Cambridge University Press, (2020), ISBN: 978-1108822909 2. H. C. Verma, *Classical Electromagnetism*, Bharati Bhawan, (2022), ISBN-10:9388704827 Reference Books: 3. M. N. O. Sadiku, *Elements of Electromagnetics*, Oxford University Publication, (2014), ISBN-0199321388 4. W. Hayt, *Engineering Electromagnetics*, McGraw Hill Education, (2012), ISBN-9339203275 5. J. D. Jackson, *Classical Electrodynamics*, 3rd edition, Wiley, (2007), ISBN-10: 9788126510948

**This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	**AA 209 / PH 209**
Title of the course	**Fundamental Concepts for Solid State Engineering**
Course Category	**Core**
Credit structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisites	None
Objectives of the course	This course provides a multidisciplinary introduction to fundamental concepts of solid state physics, encompassing topics ranging from crystals, reciprocal lattices to structural, elastic, thermal, optical and electronic properties of materials. This course will build the foundation for applications of solids in various fields of applied physics and engineering branches.
Course Outcomes	● Develop an understanding of the core concepts of solid-state physics and understand their implications in various applications/branches of engineering. ● Application of fundamental concepts in solid state physics to solve relevant conceptual and numerical problems.

Course Syllabus	• Introduction: Periodic array of atoms, Symmetry operations, Point Groups in general, Index system for crystal planes, Lattices in 1–, 2– and 3-D Bravais Lattices. • Reciprocal lattice: Diffraction of waves by crystals, Scattered Wave Amplitude, Brillouin zones, Wigner–Seitz Cells, Fourier analysis of the Basis. • Elastic Properties of Crystals and Crystal Binding. • Crystal Vibrations: mono-atomic lattice, diatomic lattice, quantization of elastic waves, phonon-dispersions. Thermal properties of Crystals: Phonon density of states, Heat capacity, thermal expansion, thermal conductivity. • Electrons in Crystals: Review of Free electron model, Periodic potential, Born–von Karman boundary conditions, Bloch's theorem, Electronic band structure, single electron energy state, degenerate electron levels, Consequences of the nearly free electron model, Fermi surface. • Electronic properties of Materials: Construction of Fermi surfaces, Reduced Zone Scheme, Periodic Zone Scheme, Reflectance and Absorption, Intrinsic and Extrinsic semiconductors, Effective mass and mobility of carriers, Hall Effect, Semiconducting junctions, Metal-semiconductor contacts – Schottky barriers, Ohmic contacts, Brief introduction to semiconductor device fabrication. • Structural Defects: Point defects, Dislocations, Microcracks, Stacking faults, Grain boundaries.
Suggested Books:	Textbooks: 1. C. Kittel, *Introduction to Solid State Physics* (7th Edition), John Wiley & Sons, (2019) ISBN: 9788126578436. 2. A. J. Dekker, *Solid State Physics*, MacMillan India Ltd. (2008) ISBN: 978-0333918333 Reference Books: 3. R. E. Hummel, *Electronic Properties of Materials: An introduction for Engineers*, Springer-Verlag, (1985), ISBN: 978-0387156316 4. M. Ali Omar, *Elementary Solid-State Physics: Principles and Applications* (1st Edition), Pearson Education, (2002) ISBN: 978-8177583779 5. Ashcroft and Mermin, *Solid State Physics*, Thomson Press (India) Ltd. (2021), ISBN:9780030839931

Course code	**AA 210 / PH 210**
Title of the course	**Fundamentals of Quantum Mechanics**
Course Category	Core
Credit structure	L-T-P-Credits (2-1-0-3)
Name of the department	Physics
Prerequisites	None
Objectives of the course	The students will be introduced to the basics of quantum mechanics
Course Outcomes	Students will be able to • Demonstrate a thorough understanding of the foundational principles of quantum physics • Analyze and solve the Schrödinger equation for various scenarios • Apply quantum mechanical principles to understand and explain several phenomena related to hydrogen atom, atomic nuclei and radioactivity.
Course Syllabus	• Review of Introductory Quantum Physics • Calculation of expectation values, Kets, Bras and operators, Base kets and matrix representations, Measurements, observables and the uncertainty relations, change of basis, position, momentum and translation, wave functions in position and momentum space. • Quantum dynamics: Time evolution and the Schrodinger equation, The Schrodinger versus the Heisenberg picture, Schrödinger equation, and its solution for one, two, and three-dimensional boxes. Solution of Schrödinger equation for the one-dimensional harmonic oscillator. Reflection and transmission at a step potential, Pauli exclusion principle. • WKB approximation, Tunneling through a barrier, Structure of the atomic nucleus, mass, and binding energy. Hydrogen atom, Radioactivity and its applications. Laws of radioactive decay.
Suggested Books	Textbooks: 1. D. J. Griffiths and D. F. Schroeter, *Introduction to Quantum Mechanics*, Cambridge University Press, (2018), ISBN: 978-1107189638 2. R. Shankar, *Principles of Quantum Mechanics*, Springer, (2011), ISBN: 978-0306447907 Reference books: 3. P. M. Mathews and K. Venkatesan, *A Textbook of Quantum Mechanics*, Springer, (2017), ISBN: 978-0070146174 4. J. Townsend, *A Modern Approach to Quantum Mechanics*, University Science Books, (2010) ISBN:978-1891389788. 5. A. Das, *Quantum Mechanics: A Modern Introduction*, CRC Press; 1st edition, (1986) ISBN: 978-2881240539

Suggested Course code	**AA 211**
Title of the course	The Blue Planet: Introduction to Earth System Sciences
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Astronomy, Astrophysics and Space Engineering
Pre-requisite, if any	None
Scope of the course (Objectives)	The purpose of this course is to provide with an understanding of how the Earth and its different components works and how it affects the Earth's inhabitants
Course Outcomes	● Students will understand the important processes that occur on Earth ● They will critically analyze human impacts on and interactions with the environment. ● They will conduct scientific experiments and in-situ data collection to validate the observations
Course Content	Theory: ● Introduction to Earth system - review of history of evolution of Earth, plate tectonics, volcanoes and earthquakes. ● Hydrosphere, Atmosphere and Biosphere - Equation of fluid motion for non-rotating and rotating fluid, global ocean and ground water, Earth's dynamic atmosphere, ecosystems and biomes. ● The Changing Earth - land-use land-cover, human induced changes and their impacts on our surroundings, Change detection techniques. Lab: Relevant lab experiments which includes: ● Cloud formation on adiabatic expansion; Measurement of relative humidity with a psychrometer ● Reading and interpretation of weather charts ● Seismograph and its measurements ● Canopy cover mapping with hemispherical photography ● Field survey of different land-use land-cover ● In-situ measurement of different parameters (e.g. temperature, humidity, radiance (photometer), soil moisture, etc) ● Pollution measurement from field survey

	● Observing Earth and its components from air and space (drone and satellites)
Suggested Books	**Text Book:** 1. Brian J. Skinner and Barbara W. Murck, The Blue Planet: An Introduction to Earth System Science, 3rd Edition: 2011: ISBN: 978-0-471-23643-6 **Reference Books:** 2. Lutgens and Edward J. Tarbuck, Foundations of Earth Science, 9th Edition, 2021, ISBN: 9780135851562 3. A.P. Trujillo and H.V. Thurman, Essentials of Oceanography,12th Edition: 2016 Pearson: ISBN: 978-0134891521

Course Code	**AA 212 / PH 212**
Course Title	**Thermal Physics**
Course Category	Core
Credit Structure	L-T-P-Credits (2 -1-0-3)
Name of the Dept.	Physics
Pre-requisite if any	None
Objectives of the course	This course introduces the basic concepts of heat and thermodynamics
Course Outcomes	Student will be • Able to understand Kinetic theory of gases and apply the theory to gain insights into specific heat and transport phenomena in gases • Grasp and effectively apply the Laws of Thermodynamics to understand the principle of heat engines, phase transitions etc.
Course Syllabus	• **Kinetic Theory of Gases:** Ideal gas, Distribution of velocities, Mean, RMS and Most Probable Speeds, Degrees of Freedom, Law of Equipartition of Energy (statement only), Specific heats of Gases, Mean Free Path. Collision Probability, Transport phenomena (viscosity, thermal conductivity and diffusion), Real Gases, Virial equation, Boyle temperature, Van der Waal's Equation of State, Comparison with Experimental P-V Curves. • **Laws of Thermodynamics:** Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, Internal Energy and First Law of Thermodynamics, Isothermal and Adiabatic Processes, Second Law of Thermodynamics, Reversible and Irreversible process with examples, Carnot's Cycle, Carnot engine & efficiency, Carnot's Theorem, Heat engines, Concept of Entropy, Clausius Theorem and Clausius Inequality, Principle of Increase of Entropy, Third Law of Thermodynamics. • **Thermodynamic potentials:** Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy, their Definitions, Properties and Applications, First and second order Phase Transitions, Clausius-Clapeyron Equation, Maxwell's Thermodynamic Relations, Joule-Kelvin coefficient, Joule-Thomson Effect. • **Non-equilibrium Thermodynamics**: Entropy production, Kinetic coefficients, Proof of Onsager reciprocal relations, Thermoelectricity
Suggested Books	Textbooks: 1. M. W. Zemansky, R. Dittman, *Heat and Thermodynamics*, McGraw-Hill, (1996) ISBN: 978-0070170599 2. D. V. Schroeder, *An Introduction to Thermal Physics,* Oxford University Press, (2021) ISBN: 978-0192895547 Reference books: 3. S. J. Blundell and K. M. Blundell, *Concepts in Thermal Physics*, Oxford

	University Press, (2009), ISBN: 978-0199562107 4. F. Reif, *Fundamentals of Statistical and Thermal Physics,* Waveland Press, (2010) ISBN: 978-1577666127 5. P. K. Nag, *Engineering Thermodynamics,* McGraw Hill Education, (2021) ISBN: 978-9352606429

Course code	**AA 214**
Title of the course	Stellar and Planetary Science
Course Category	Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of Dept.	Astronomy, Astrophysics and Space Engineering
Prerequisite, if any	None
Scope of the course	The course aims to provide a physical picture of how stars and planets form and evolve both within our Solar System and beyond.
Course Outcome	● Demonstrate the role of basic physical processes in the formation of stars and planets. ● Identify the different observational characteristics and detection techniques of stars and planets.
Course Syllabus	**Module 1 - Stellar science**: Star formation - Spherical collapse model, Stellar Structure and HR diagram, concepts of Hydrostatic equilibrium and energy generation and transfer, Stellar evolution - Main sequence/ giants/ supergiants, Our Sun, Binary stars and Mass Transfer Binaries, star clusters, Stellar feedback **Module 2 - Planetary science :** Overview of Solar system, Planetary atmospheres, Planetary surfaces, Planet formation and migration - Minimum mass solar nebula, Core Accretion, Gravitational Instability, Type I and Type II Migration, Exoplanetary detection - Radial Velocity, Transit Method, Microlensing, Habitable zones, planetary satellites and tidal effects.
Suggested Books	**Text Books:** 1. S. W. Stahler and F. Palla, The Formation of Stars, Wiley–VCH, 2004; ISBN:9783527405596 [Module 1] 2. Jack Lissauer and Imke de Pater, Fundamental Planetary Science, Cambridge University Press, 2019, ISBN 9781108411981 [Module 2] **Reference Books:** 3. L. Hartmann; Accretion Processes in Star Formation; Cambridge University Press, 2009; ISBN 978-0511552090 4. Dina Prialnik, An introduction to the theory of stellar structure and evolution, Cambridge University Press; 2010; ISBN : 978-0521866040 5. Scott Tremaine; Dynamics of Planetary Systems; Princeton University Press; 2023; ISBN 978-0691207124 6. Sara Seager; Exoplanets; University of Arizona Press; 2011; ISBN 978-0816529452

Suggested Course code	**AA 216**
Title of the course	Flight mechanics and classical control
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Astronomy, Astrophysics and Space Engineering
Pre-requisite, if any	None
Scope of the course (Objectives)	The purpose of this course is to teach performance, static and dynamic stability, and classical feedback control of the spacecraft
Course Outcomes	• Students will be able to understand the mechanism of spacecraft flight • They will be able to compute rigid body dynamics • They will understand how the control systems are used in spacecrafts
Course Content	**Module 1:** **Flight mechanics**: Review of Newtonian mechanics; Generalized coordinates, constraints, virtual work; Lagrange's equation; Dynamics of rigid bodies in three dimensions; Euler angles; Euler's equations of motion for rigid bodies, Gyrodynamics, equations of motion for UAVs. **Module 2:** **Classical contro**l: Linear feedback control systems, frequency and time domain analysis, I/O relationships, transfer function ,stability criteria, Bode diagrams, Root locus method, Analysis of simple problems using software
Suggested Books	**Text Books:** 1. John David Anderson, Introduction to Flight, McGraw-Hill Higher Education, 9th Edition, 2022, ISBN: 9781260226744 [Module I] 2. N.S. Nise, Control Systems Engineering, John Wiley &

	Sons, India Edition, 2018, ISBN: 978-8126571833 [Module II] **Reference Book** 3. B.C. Kuo, Automatic, Control Systems, Prentice Hall India, 9th edition, 2014, ISBN: 978812655233

Course code	**AA 251 / PH 251**
Title of the course	**Engineering Physics Lab - I**
Credit structure	L-T-P-Credits (0-0-3-1.5)
Course Category	Core
Name of the Dept.	Physics
Pre-requisite if any	None
Objectives of the course	Students will get exposure to several experiments based on various advanced concepts of Physics.
Course Outcomes	• Learn to accurately collect, analyze and interpret data to understand the underlying physical principles/concepts. • Experimental verification of fundamental concepts in Classical Physics, Waves and Optics and Solid State engineering • Evaluate the errors and statistical deviations associated with the experimental results
Course Syllabus	A representative list of experiments will be performed by students: **Classical physics** • Moment of inertia of flywheel • Measurement of Young's modulus • Verification of Bernoulli's theorem • Constant volume and pressure air thermometer • Determination of Planck's constant • Millikan oil drop experiment • Helmholtz coil & measurement of Faraday's number **Waves and Optics** • Michelson interferometer • Verification of Brewster's law • Determination of specific rotation of sugar solution by using Laurent's Half Shade Polarimeter. **Solid State Engineering** • Nature of semiconductor band-gap of a powdered semiconductor using Diffuse Reflectance Spectroscopy. • Demonstration of X-ray diffraction in crystalline solids • Determination of Heat Capacity using Differential Scanning Calorimetry.
Suggested Books	Reference Books: 1. W. F. Smith, *Experimental Physics: Principles and Practice for the laboratory*, CRC Press, (2020), ISBN: 978-1498778473

	2. L. Lyons, *A practical guide to data analysis for physical science students***,** Cambridge Univ. Press, (1991), ISBN: 978-0415481519

Course Code	**AA 252 / PH 252**
Title of the Course	**Scientific Computing Lab**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (0-0-2-1)**
Name of the department	**Physics**
Pre–requisite, if any	None
Objectives of the course	To familiarize students with Object-Oriented Programming language, data structures, and their application in Physics-specific problems.
Course outcomes	Student will be able to learn to apply computational techniques for Physics problems using a model programming language in vogue
Course Syllabus	• Introduction to Object-Oriented Programming (OOP), using a model language such as Python. • Object types, numbers, strings, lists, arrays, dictionaries, tuples, files, I/O handling. Statements and syntax, expressions, loops, iterations. • Basic functions, arguments, recursive functions, modules, module packages. Introduction to class and OOP, Error & exceptions handling. • Data structure and data handling. Efficient array handling using standard libraries. Scientific computing and problem solving, Integrating Fortran/C++ code with Python, as a model language. • Application of the model language to solve Physics problems
Suggested Books	Textbook: 1. A. K. Gupta, *Scientific Computing in Python*, Techno World Publishers, (2021) ISBN: 978-81-949567-6-1 Reference Books: 2. M. Lutz, *Learning Python: Powerful Object-Oriented Programming (5th edition)*, Cambridge University Press; (1989), ISBN: 978-1449355739 3. A. K. Gupta, *Python Computing: Fundamentals and Applications,* Techno World, (2023), ISBN: 978-93-92145-55-1

Course code	**AA 255 / PH 255**
Title of the course	**Electronic Devices and Circuits Lab - I**
Course Category	Core
Credit Structure	L-T-P-Credits (0-0-3-1.5)
Name of Dept.	Astronomy, Astrophysics and Space Engineering
Prerequisite, if any	None
Objectives of the course	The students will acquire foundational knowledge and skills in analog electronics experimentation
Course Outcome	• Acquire hands-on experience in the domain of analog electronics. • Learn how to implement electronic circuits.
Course Syllabus	• Diode and its applications; I-V characteristics, Clipping Circuits. • Diode as – Voltage Doublers, Rectified Differentiator, Precision Rectifier, reverse-bias capacitance. • To measure the minority carrier lifetime in a semiconductor photodiode. • Transistor and Op-Amp characteristics - amplification, Op-Amp as summer, Integrator, Differentiator. • Zener Diode - rectification, DC power supply. • Characterization of basic and cascade current mirror circuits (with BJT and MOSFET). • Design of single-stage and differential amplifiers. • 555 Timers - timer and oscillator functions.
Suggested Books	Reference Books: 1. J. Millman, A. Grabel, *Microelectronics,* Tata McGraw-Hill (2017), ISBN: 978-0074637364 2. S. Sedra K. C. Smith: *Microelectronic Circuits,* OUP, (2017), ISBN: 978-0199476299 3. Razavi, *Fundamentals of Microelectronics,* Wiley, (2017) ISBN: 978-8126571352

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	**AA 256 / PH 256**
Title of the course	**Electronic Devices and Circuits Lab - II**
Course Category	Core
Credit Structure	L - T - P – Credits (0-0-3-1.5)
Name of the Department	Astronomy, Astrophysics and Space Engineering
Pre-requisite, if any	None
Objectives of the course	The students will engage in hands-on digital electronics experiments.
Course Outcomes	● Acquire hand-on experience in digital electronics. ● Implement digital components to solve electronics problems.
Course Content	A representative list of experiments will be performed by students: • Introduction to Logic Circuits: To gain familiarity with digital integrated circuits by setting up simple logic circuits. • Combinational Logic Circuits: Use of TTL adder, multiplexer and decoder. • Sequential building blocks • Digital to Analog and Analog to Digital Conversion • Sampling and Reconstruction of Continuous-Time Signals and Interpolation with Decimation. • Implementation of a (4 X 4) multiplier using registers and a down counter. • MOSFET inverting amplifiers and first-order circuits • Introduction to VHDL and FPGA • Electronics Project
Suggested Books	Reference Books 1. Wakerly, *Digital Design: Principles And Practices*, Pearson India; 4th edition (2008) ISBN: 978-9332508125 2. S. Salivahanan, S. Arivazhagan, *Digital circuits and design*, Oxford University Press; Fifth edition, (2018), ISBN: 978-0199488681 3. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, McGraw-Hill, 4th edition, (2017), ISBN: 978-9352601943 4. J. Millman, A. *Grabel, Microelectronics*, McGraw Hill Education, 2nd edition, (2017), ISBN: 978-0074637364

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Syllabi of Open Elective Courses

of

Department of Mathematics

Course code	**MA 405/ MA 605**
Title of the course	**Differential Equations in Population Dynamics**
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department/ Centre	Mathematics
Prerequisite, if any	Differential Equations and Numerical Methods
Scope of the course	The objective of the course is to present differential equation models arising in population dynamics, physical, mechanical and chemical systems, etc. The course will give an opportunity to apply several mathematical theories, methodologies and computational techniques of differential equations in the aforementioned areas. Current research advances in the field of modelling will also be discussed. After completing the course, students are expected to start research work in advanced topics.
Course Syllabus	**Introduction:** Mathematical models: Necessity, advantages and limitations; Brief history of population models, Different tools and modeling frameworks, Birth and death processes in population models. **Ordinary differential equations:** The Multhus, Verhulst, Lotka-Volterra, Rosenzweiz-MacArthur and Hestings-Powell models, Routh-Hurwitz criteria, Mean population density in cyclic and chaotic dynamics, Population harvesting, Resilience in Ecology, Hydra effects, Population genetic models, FitzHugh-Nagumo model. **Partial differential equations:** Fisher equation, Turing instability, Pattern formation, Spatiotemporal chaos, Reaction-diffusion in Ecological and Chemical systems, Diffusion in delayed predator-prey systems. **Delay differential equations:** Discrete and distributed delays in population dynamics, Hopfbifurcation and stability switching, Delayed harvesting in Nicholson blowflies model, Delayed dispersal in patchy environment, Mackey-Glass equation. **Impulsive differential equations:** Fixed-time and variable-time impulses, Impulses in biological control theory and epidemic models. **Applications of softwares:** Several measures will be quantified in all the models using computer simulations, and graphical representations will be provided to interpret the system dynamics.
Suggested Books	1. J. D. Murray, ***Mathematical Biology: I. An Introduction***, Springer, 2002: ISBN 978-0- 387-95223-9. 2. R. K. Upadhyay, S. R. K. Iyengar, ***Spatial Dynamics and Pattern Formation in Biological Populations***, Chapman and Hall/CRC, 2021: ISBN 9780367555504. 3. K. Gopalsamy, ***Stability and Oscillations in Delay Differential Equations of Population Dynamics***, Springer, 1992: ISBN 978-0-7923-1594-0.

	4. V. Lakshmikantham, D. D. Bainov, P. S. Simeonov, ***Theory of Impulsive Differential Equations***, World scientific, 1989: ISBN 978-9971-5-0970-5.

Course code	**MA 450/ MA 650**
Title of the course	**Mathematical Theory of Waves**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Multivariable Calculus, Differential Equations
Scope of the course	To expose the students to the basic ideas that underline linear wave motion. To derive important mathematical tools to deal with problems of wave theory.To consider simple examples of linear waves on strings, sound waves and water waves. To develop the mathematical models of waves and to ultimately apply those models to understand the elastic waves, sound waves and light waves.
Course Syllabus	• Introduction to waves and Review of the wave equation; • Traveling and standing waves; Waves on strings;Waves in membranes; Longitudinal waves in bars and springs;Waves in liquids; Sound waves: Plane, cylindrical and spherical sound waves;Waves associated with theconservation laws; Electric waves; • General considerations on waves: Doppler effect, beats, amplitude modulation, group velocity, motion of wave packets, dispersion, Kirchhoff's solution, Fresnel's principal, Fraunhofer diffraction theory; Wave propagation in an inhomogeneous media; • Characteristics of nonlinear waves: general effect of nonlinearity, wave-fronts bounding a constant state, Riemann invariants, Piston problem, Discontinues solutions and shock waves, Wave localization phenomena. • **Free vibration, forced harmonic vibration and resonance.** • Some special waves: Seismic waves, Traffic waves, Water waves.
Suggested Books	1. R. Knobel, *An Introduction to the Mathematical Theory of Waves,* American Mathematical Society, 2000, ISBN: 0-8218-2039-7. 2. C.A. Coulson and Alan Jeffrey, *Waves: A mathematical approach to the common types of wave motion*, Longman Group Limited, London, 1977, ISBN: 0-582-44954-5 3. G.B. Whitham,*Linear and Nonlinear Waves*, Pure and Applied Mathematics, Wiley, 1999,ISBN: 0-471-35942. 4. Sir J. Lighthill, *Waves in Fluids*,Cambridge Mathematical Library, CUP, 2001, ISBN: 0-521-01045. 5. J. Billingham & A.C. King, *Wave Motion*, Cambridge Texts in Applied Mathematics, CUP, 2001,ISBN: 0-521-634504

Course code	**MA 452/ MA 652**
Title of the course	**Theory of Transforms**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Calculus, Complex Variable, Differential Equations
Scope of the course	This course provides a working knowledge of analytical methods required in pure and applied mathematics, physics and engineering. It also gives a systematic exposition of the basic properties of various integral transforms and their applications to the solution of initial and boundary value problems in mathematical physics, engineering, and applied mathematics.
Course Syllabus	Fourier Series, Riemann-Lebesgue Lemma, Gibbs Phenomenon, Fourier Sine and Cosine Series, Fourier Transform, Fourier Integral Theorem, Convolution and Parseval_s Theorem, Applications to Partial Differential Equations. Laplace Transform: definition and properties, Complex Inversion, Convolution Theorem, Heaviside's Expansion Theorem, Bromwich Contour Integral, Applications to Initial and Boundary Value Problems. Fundamental Theorem of the Discrete Fourier Transform, Cyclical Convolution, and Parseval's Theorem. Z Transform: definition and examples, Basic Operational Properties of Z Transforms, Inverse Z Transform and Examples, Applications of Z Transforms to Finite Difference Equations and Summation of Infinite Series.
Suggested Books	1. L. Debnath, D. Bhatta, ***Integral transforms and their applications,*** Chapman & Hall/CRC, New York, 2006, 1584885750 2. R. J. Beerends, H. G. ter Morsche, J. C. van den Berg, E. M. van de Vrie, ***Fourier and Laplace Transforms,*** Cambridge University Press, New York, 2003, 0521534410 3. A. Pinkus, S. Zafrany, ***Fourier Series and Integral Transforms,*** Cambridge University Press, New York, 1997, 0521597714 4. U. Graf, ***Applied Laplace Transforms and Z-Transforms for Scientists and Engineers***, Birkhauser Verlag, Basel, Switzerland, 2004 : 3034895933

Course code	MA 454/ MA 654
Title of the course	**Mathematical Modeling and Simulations**
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Differential Equations, Linear Algebra
Scope of the course	The Mathematical model plays a significant role providing a quantitative framework for understanding and solving many real-life problems under certain conditions. Most of the mathematical models have been like individual works of art that reflected the personal characteristics and scientific views of the modeler. At the end of the course, students should be exposed to fundamental knowledge of implementing the models in real-world situations. They will get the bright idea about constructing or selecting the appropriate model, identify the problem, Analytically or numerically computing the solution and test the validity of models. This course provides an introduction to modeling through in-depth discussion of a series of real examples.
Course Syllabus	**Introduction to Mathematical Modeling:** Characteristics, Classifications, Tools, Techniques, Deterministic and stochastic models, Modeling approaches, Compartmental models, Introduction to Discrete Models and Continuous Models, Dynamical systems and its mathematical models. **Models from systems of natural sciences:** Population models for a single species (discrete and continuous-time models), Modeling of population dynamics of two interacting species, Analytical Tool: Kolmogorov Theorem, Linear Stability Analysis, Lotka-Volterra Model, Variation of the Classical LV Model, Leslie-Gower Model, Prey-Predator Model, Arms Race Model, Holling-Tanner Model, Modified HT Model, Applications of Lyapunov functions. **Modeling of Atmospheric, Mining and Engineering systems:** Spatial Models Using Partial Differential Equations, Modeling with Stochastic Differential Equations, Models of Heating and Cooling, Models for traffic flow, Model for detecting land mines, Models in Mechanical Systems, Models in Electronic systems, Models for vehicle dynamics, Kicked Harmonic oscillator, Modeling the ventilation system of a mine. MATLAB/MATHEMATICA programs to study the dynamics of the developed model systems.
Suggested Books	1. B. Barnes, G. R. Fulford, ***Mathematical Modeling with Case Studies,*** CRC PRESS, Taylor & Francis, London, New York,

	2009, 13, 978-1-4200-8348-4 2. Edward A. Bender, ***An Introduction to Mathematical Modeling***: John Wiley & Sons, United States of America, 1978, 0-471-02951-3 3. R. K. Upadhyay, S. R. K. Iyengar, ***Introduction to Mathematical Modeling and Chaotic Dynamics,*** CRC Press Taylor & Francis, London, New York, 2014, 13: 978-1-4398-9887-1 4. S. Banerjee, ***Mathematical Modeling,*** Models, Analysis and Applications, CRC Press, Taylor & Francis, London, New York, 2014, 13: 978-1-4822-2916-5

Syllabi
of
B. Tech. in Mathematics and Computing
(From AY 2023-24 onwards)

Department Core in Semester-III

Course Code	**MA 205**
Title of the Course	**Complex Analysis**
Course Category	Institute Core
Credit Structure	L-T- P-Credits 3-1-0-2 (half semester)
Name of the Concerned Department	Mathematics
Pre-requisite, if any	None
Objective of the Course	This is a foundation course on complex analysis for UG students.
Course Outcomes	Students will understand the concepts, like analytic functions, harmonic functions, Cauchy's theorem, residue formula and their applications.
Course Syllabus	• Definitions and properties of analytic functions. • Cauchy-Riemann equations, harmonic functions. • Power series and their properties. Elementary functions. • Cauchy's theorem and its applications, Taylor series and Laurent expansion. • Residues and Cauchy's residue formula, Evaluation of improper integrals.
Suggested Books	Text Books: 1. E. Kreyszig, ***Advanced Engineering Mathematics***, John Wiley & Sons, 2020, ISBN: 9781119455929. 2. R.V. Churchill and J.W. Brown, ***Complex Variables and Applications***, McGraw-Hill Inc. New York, 2014, ISBN: 9780073383170. Reference Books: 3. J.M. Howie, ***Complex Analysis***, Springer-Verlag, Berlin, 2012, ISBN: 9781447100270. 4. M.J. Ablowitz and A.S. Fokas, ***Complex Variables: Introduction and Applications***, Cambridge University Press, 2008, ISBN: 9787506291804.

Course Code	**MA 207**
Title of the Course	**Differential Equations-II**
Course Category	Institute Core
Credit Structure	L-T- P-Credits 3-1-0-2 (half semester)
Name of the Concerned Department	Mathematics
Pre-requisite, if any	None
Objective of the Course	This is a foundation course on differential equations for UG students.
Course Outcomes	• Students will be trained to solve various types of higher ordinary differential equations and partial differential equations. • Students will also be exposed to the real-life applications of Laplace, wave, and heat equations.
Course Syllabus	• Review of power series and series solutions of ODEs. • Regular singular points, method of Frobenius, Bessel equation and Bessel function. • Legendre equation and Legendre Polynomials. • Strum-Liouville problems, Fourier series. • Classification of linear second order PDEs in two variables, D'Alembert solution to the wave equations, Laplace, Wave, and Heat equations with applications.
Suggested Books	Text Books: 1. E. Kreyszig, ***Advanced Engineering Mathematics***, John Wiley & Sons, 2020, ISBN: 9781119455929. 2. W.E. Boyce and R. Diprima, ***Elementary Differential Equations***, John Wiley & Sons, 2022, ISBN: 9781119820512. Reference Books: 3. R.V. Churchill and J.W. Brown, ***Fourier Series and Boundary Value Problems***, McGraw-Hill Inc., 2019, ISBN: 9787560381251. 4. G. Simmons, ***Differential Equations with Applications and Historical Notes*****,** Taylor & Francis, 2017, ISBN: 9781498702591.

Suggested Course Code	**MA 209**
Title of the Course	**Foundations of Mathematical Analysis**
Course Category	Department Core
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge of calculus and linear algebra
Objective of the Course	Students will have fundamental knowledge and problem-solving skills in analysis in metric space and convergence criteria in sequences and series of functions.
Course Outcomes	• Students will have knowledge of different topologies on Euclidean spaces. • They will have an understanding of the space of continuous functions.
Course Content	• Review of calculus and highlights of its applications • Introduction to metric space, Finite-dimensional normed space ($R^n, \|\|.\|\|_p$) as l_p^n with l_p-norms, real word implication of l_p norms, illustration of unit balls in l_p^n, Finite-dimensional inner product space • Topology on l_p^n: Uniform continuity, convergence and completeness in l_p^n, properties of compact sets in l_p^n, Extreme Value Theorem and approximation result for closest point, Intermediate Value Theorem on a connected subset of l_p^n, Cantor set • *p*-norm on C[0,1], sequence, series and their convergence in C[0,1], Weierstrass theorem, topological properties of C[0,1], Nowhere differentiable function
Suggested Books	Text Books: 1. N. L. Carothers, ***Real Analysis***, Cambridge University Press, 2009, ISBN: 0521497566.

	2. W. Rudin, ***Principles of Mathematical Analysis***, McGrawHill, 1983, ISBN: 0-07-054235-X. Reference Books: 3. K. R. Davidson and A. P. Donsig, ***Real Analysis with Real Applications***, Prentice Hall, 2002, ISBN: 978-0-387-98097-3. 4. T. M. Apostol, ***Calculus: Volumes 1 and 2***, Wiley Eastern, 1980, ISBN: 978-0-471-00005-1. 5. T. M. Apostol, ***Mathematical Analysis***, Narosa Publishers, 2002, ISBN: 9788185015668. 6. S. Kumaresan, ***Topology of Metric Spaces***, Narosa Publishers, 2011, ISBN: 978-8184870589.

Course Code	**MA 215**
Title of the Course	**Probability and Statistics**
Course Category	Department Core
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Nil
Objective of the Course	This is a foundation course on probability and statistics for UG students.
Course Outcomes	● understand the techniques of data collection, analysis, and interpretation, enabling them to make informed decisions in diverse fields, ● learn a solid foundation in probability and statistics, empowering them to analyze data, and draw meaningful conclusions.
Course Content	• **Descriptive Statistics:** Data collection techniques, organizing and presenting data, frequency distributions, measures of central tendency, variation, skewness, and kurtosis. • **Probability and Random Variable:** Axiomatic definition of probability, conditional probability and Bayes rule, random variables, cumulative distribution function, and its properties, histogram density estimation and bootstrap, discrete random variables, probability mass function, continuous random variables, probability density function, functions of random variables, expectation and moment of a random variable, moment generating function, probability integral transform. • **Probability Distributions:** Bernoulli, binomial, geometric, negative binomial, hypergeometric, Poisson, exponential, gamma, Weibull, beta, Cauchy, normal. • **Random Vectors:** Joint distributions, marginal and conditional distributions, independence of random variables, covariance and correlation. • **Inequalities and Limit Theorems:** Markov's inequality, Chebyshev's inequality, Jensen's inequality, convergence in probability and convergence in distribution, weak law of large numbers and central limit theorem.

Suggested Books	Text Books: 1. S. M. Ross, ***Introductory Statistics***, Academic Press, USA, 2017, ISBN: 978-0-12-804317-2. 2. D. C. Montgomery and G. C. Runger, ***Applied Statistics and Probability for Engineers*****,** Wiley, 2016, ISBN: 978-8126562947. Reference Books: 3. S. M. Ross, ***Introduction to Probability and Statistics for Engineers and Scientists***, Academic Press, 2004, ISBN: 9780123704832. 4. J. A. Rice, ***Mathematical Statistics and Data Analysis***, Duxbury Press, 2006, ISBN: 0-534-39942-8. 5. I. R. Miller, J.E. Freund, R. Johnson, ***Probability and Statistics for Engineers***, Prentice-Hall (I) Ltd, India, 2011, ISBN: 9788177581843.

Suggested Course code	**MA 211 / CS 201**
Title of the course	**Discrete Mathematical Structures**
Course category	Department Core
Credit Structure	L - T - P – Credits 2-1-0-3
Name of the Concerned Department	Mathematics / Computer Science and Engineering
Pre-requisite, if any	Basic courses on mathematics
Objective of the Course	This course will introduce the basic concepts of discrete mathematics and its applications.
Course Outcome	● Students will learn about discrete mathematical structures like sets, relations, functions, groups, graphs, etc. ● They will also learn about proof techniques and how to apply them to prove lemmas, theorems, etc.
Course Syllabus	● Elementary counting techniques ● Propositions and predicates, proofs and proof techniques. ● Sets, relations and functions, cardinality ● Posets and lattices: Dilworth`s theorem, inversion and distributive lattices ● Graph theory basics: paths, cycles, trees, connectivity ● Group theory: Lagrange`s theorem, homomorphisms, applications
Suggested Books	Textbooks: 1. K. H. Rosen, ***Discrete Mathematics and Its Applications***, Mc Graw Hill, 2019, ISBN: 9781259676512 Reference books: 2. R. P Grimaldi, ***Discrete and Combinatorial Mathematics***, Pearson, 2017, ISBN: 9788177584240

Suggested Course code	**MA 213/ CS 203**
Title of the course	**Data Structures and Algorithms**
Course Category	Department Core
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Mathematics / Computer Science and Engineering
Pre-requisite, if any	Computer Programming
Objective of the Course	• This Course is designed to provide an introduction to the theory and practice of different data structures. • This course will also provide familiarity with the algorithms for those data structures.
Course Outcomes	Students will learn the uses of data structures to make efficient algorithms
Course Syllabus	• Introduction to data structures, Abstract data types, Analysis of algorithms, Introduction to complexity analysis and measures. • Arrays – operations and addressing, Linked list (singly, doubly, and circular), Stack ADT and its applications in expression evaluation and recursion, Queue ADT and its variants such as circular queues and double-ended queues. Hashing and hash tables, Recursion. • Tree ADT, Binary trees – properties and traversals, Binary search trees, Height balanced trees -- AVL trees, Binary heaps, and priority queues. • Graph ADT, Graph representation, Graph traversal – breadth-first search, depth-first search, and topological ordering, Connected components, cut-vertices, 2-connected components • Algorithms and data structures for sorting and searching, Order statistics.
Suggested Books	Textbooks: 1. S. Sahni, ***Data structures, algorithms, and applications in C++***, McGraw-Hill, 1998, ISBN: 978-0929306322 2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms***, (3rd Edition), Prentice Hall, 2009. ISBN: 978-81-203-4007-7

	Reference Books: 3. D. E. Knuth, ***The Art of Computer Programming: Fundamental Algorithms***, Vol. 1 (3rd Edition, 1997) and Vol 3, (2nd Edition, 1998), Addison-Wesley Professional. ISBN: 978-0137935109 4. M.T. Goodrich, R. Tamassia, and D. Mount, ***Data Structures and Algorithms in C++***, 2^{nd} Edition, Wiley, ISBN: 978-0-470-38327-8

Suggested Course code	**MA 253/ CS 253**
Title of the course	**Data Structures and Algorithms Lab**
Course Category	Department Core
Credit Structure	L - T - P - Credits 0-0-3-1.5
Name of the Concerned Department	Mathematics/Computer Science and Engineering
Pre-requisite, if any	Computer Programming
Objective of the Course	This Course is designed to provide ● an introduction to the theory and practice of different data structures ● familiarity with the algorithms for those data structures
Course Outcomes	Students will learn uses of data structures to make efficient algorithms.
Course Syllabus	● Implementation of array, linked list, stack, and queue ● Implementation of tree and graph data structure ● Implementation of sorting and searching, ● Implementation of Hash and hash tables and order statistics.
Suggested Books	Textbooks: 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms***, (3rd Edition), Prentice Hall, 2009. ISBN: 978-81-203-4007-7 Reference Books: 2. D. E. Knuth, ***The Art of Computer Programming: Fundamental Algorithms***, Vol. 1 (3rd Edition, 1997) and Vol 3, (2nd Edition, 1998), Addison-Wesley Professional. ISBN: 978-0137935109 3. M.T. Goodrich, R. Tamassia, and D. Mount, ***Data Structures and Algorithms in C++***, 2nd Edition, Wiley. ISBN: 978-0-470-38327-8

Course Code	**MA 204N**
Title of the Course	**Numerical Methods**
Course Category	Institute Core
Credit Structure	L-T- P-Credits 2-0-2-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	None
Objective of the Course	This is a foundation course on numerical methods for UG students.
Course Outcomes	Students will be trained to evaluate integration and differentiation, and to solve numerically system of linear equations and differential equations.
Course Syllabus	• Interpolation by polynomials, divided differences, error of the interpolating polynomial. • Solution of a system of linear equations, Cholesky's method, Gauss-Seidel methods, partial pivoting, row echelon form, norms, ill-conditioning. Eigen-value problem, power method. • Solution of a nonlinear equation, bisection and secant methods, Newton's method, rate of convergence, solution of a system of nonlinear equations. • Numerical integration, composite rules, error formulae. • Numerical solution of ordinary differential equations, Euler and Runge-Kutta methods, multi-step methods, predictor-corrector methods, order of convergence. • Finite difference methods, numerical solutions of elliptic, parabolic, and hyperbolic partial differential equations.
Suggested Books	Text Books: 1. S. S. Sastry, ***Introductory Methods of Numerical Analysis*,** PHI Learning, ISBN-978-81-203-4592-8, 2012. 2. E. Kreyszig, ***Advanced Engineering Mathematics***, John Wiley & Sons, 2020, ISBN: 9781119455929. 3. S. D. Conte and Carle de Boor, ***Elementary Numerical Analysis - An Algorithmic Approach***, SIAM, 2018, ISBN: 9781611975208 Reference Books: 4. B. Bradie, ***A Friendly Introduction to Numerical Analysis,*** Pearson Prentice Hall, 2007, ISBN: 8131709426. 5. W. Cheney, D. Kincaid, ***Numerical Mathematics and Computing***, Cengage Learning, 2020, ISBN: 9780357670842. 6. D. Watkinson, ***Fundamentals of Matrix Computations***, Wiley Inter Science, 2010, ISBN: 9780470528334.

Course Code	**MA 202**
Title of the Course	**Multivariate Calculus and Measure Theory**
Course Category	Department Core
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge of calculus and linear algebra
Objective of the Course	First part of this course introduces basic concepts and results related to continuity and differentiability in the finite dimensional setting. The second part introduces concepts related to Lebesgue integral and some of their important properties.
Course Outcomes	The student is able to generalize all the results and techniques learned in the first year calculus course and their applications.
Course Content	• Functions of several variables - Continuity and differential calculus for functions from R^n to R^m Jacobian matrix, Mean Value Theorem, higher order derivatives, Taylor series for function from R^n to *R*, inverse function theorem, implicit function theorem. • Lebesgue measure and integral - sigma-algebra of sets, measure space, Lebesgue measure, measurable functions, Lebesgue integral, Fatou's lemma, dominated convergence theorem, monotone convergence theorem, *Lp* spaces.

Suggested Books	Text Books: 1. T. M. Apostol, ***Mathematical Analysis***, Narosa Publishers, 2002, ISBN: 978-8185015668. 2. R. G. Bartle, ***The Elements of Integration and Lebesgue Measure**,* Wiley, 1995, ISBN: 0471042226. Reference Books: 3. W. Rudin, ***Principles of Mathematical Analysis**,* McGraw Hill, 1983, ISBN: 0-07-054235-X. 4. M. Capinski and E. Kopp, ***Measure, Integral and Probability***, Springer, 2007, ISBN: 9781852337810. 5. G. de Barra, ***Measure Theory and Integration***, New Age International, 1981, ISBN: 9788122435023.

Course Code	**MA 206**
Title of the Course	**Mathematical Logic and Theory of Computation**
Course Category	Department Core
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Discrete mathematical structures
Objective of the Course	At the end of the course, students should be exposed to fundamental knowledge in mathematical Logic and theory of computations.
Course Outcomes	● Exhibit a strong foundation in formal computation, mathematical logic, formal reasoning, and formal semantics. ● Distinguish various computing languages, and effectively engage in logical argumentation, discussion, and communication of essential logic concepts in the context of computer science.
Course Content	• **Propositional Logic:** Language of propositional logic, Tautological consequence • **First Order Logic:** A language for arithmetic, First order languages, Examples of first-order languages for some mathematical structures, Tarski's definition of truth. • **Automata and Language Theory:** Finite automata, Regular expressions, Push-down automata, Context-free grammars, Pumping lemmas. • **Computability Theory:** Turing machines, Church-Turing thesis, Decidability, Halting problem, Reducibility.
Suggested Books	Text Books: 1. H. R. Lewis and C. H. Papadimitriou, ***Elements of Theory of Computation***, Prentice-Hall, 2nd Edition, Englewood, New Jersey, 1997, ISBN: 0-13-26247&-8. 2. R. E. Hodel, ***An Introduction to Mathematical Logic***, PWS Publishing Company, Boston, 1995, ISBN: 9780534944407. Reference Books: 3. J. Hopcroft, R. Motwani, and J. Ullman, *I**ntroduction to Automata Theory, Language, and Computation***, Pearson

	Education, 2nd Edition, 2001. ISBN:0201441241. 4. M. Sipser, ***Introduction to the Theory of Computation***, Cengage India Private Limited, 3rd Edition, 2014, ISBN: 8131771865.

Suggested Course code	**MA 208 /CS 204**
Title of the Course	**Design and Analysis of Algorithms**
Course Category	Department Core
Credit Structure	L - T - P - Credits: 2-1-0-3
Name of the Concerned Discipline	Mathematics/Computer Science and Engineering
Pre-requisite, if any	Knowledge of Data Structures and Algorithms
Objective of the Course	This is an introductory course in the field of computer algorithms.
Course Outcomes	At the end of the course, students will know the basics of ∉ algorithm analysis, ∉ algorithm design, and ∉ different problem classes.
Course Syllabus	• **Algorithm Analysis:** Time and Space Complexity; Computational Tractability (Best, Average & Worst Cases), Asymptotic Bounds (Lower, Upper & Tight Bounds). • **Algorithm Design**: Divide and Conquer; Greedy, Dynamic Programming, Branch and Bound. • **Problem Classes:** Reducibility and Intractability, P, NP, PSPACE, NP-Complete, and NP-Hard.
Suggested Books	Textbooks: 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms*** (Eastern Economy Edition), 3rd Edition, PHI Learning Pvt. Ltd. (Originally MIT Press), 2010. ISBN: 978-8120340077 Reference books: 2. J. Kleinberg and E. Tardos, ***Algorithm Design***, 2nd Edition, Pearson Education, 2022. ISBN: 978-0132131087

Suggested Course code	**MA 254/CS 254**
Title of the Course	**Design and Analysis of Algorithms Laboratory**
Course Category	Department Core
Credit Structure	L - T - P - Credits: 0-0-3-1.5
Name of the Concerned Discipline	Mathematics/Computer Science and Engineering
Pre-requisite, if any	Knowledge of Data Structures and Algorithms
Objective of the Course	This is an introductory course in the field of computer algorithms.
Course Outcomes	At the end of the course, students will know the basics of ∉ algorithm analysis and design ∉ different problem classes.
Course Syllabus	● Runtime analysis of different sorting algorithms and linked lists in best-case, worst-case, and average-case. ● Implementation and analysis of algorithms based upon the following design techniques: ○ Divide and Conquer Strategy (Closest Pair of Points, Integer Multiplication, Matrix Multiplication, Fast Fourier Transform etc.). ○ Greedy Strategy (Interval Partitioning, Dijkstra's Algorithm, Minimum Spanning Tree etc.). ● Dynamic Programming Strategy (Weighted Interval Scheduling, Sequence Alignment, Bellman-Ford Algorithm etc.).
Suggested Books	Textbooks: 1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms*** (Eastern Economy Edition), 3rd Edition, PHI Learning Pvt. Ltd. (Originally MIT Press), 2010. ISBN: 978-8120340077 Reference books: 2. J. Kleinberg and E. Tardos, ***Algorithm Design***, 2nd Edition, Pearson Education, 2022. ISBN: 978-0132131087

Course Code	**MA 301**
Title of the Course	**Matrix Computations**
Course Category	Department Core
Credit Structure	L-T- P-Credits 2-0-2-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge of calculus and linear algebra
Objective of the Course	This course is aimed at understanding the theoretical and computational aspects of important algorithms and techniques of scientific computing.
Course Outcomes	• To solve application problems involving matrix computation algorithms and understanding the relationships between the computational effort and the accuracy of these algorithms. • Knowledge of effect of errors in computations.
Course Syllabus	• Review of basic linear algebra, minimal polynomials, Cayley-Hamilton Theorem, triangulation, diagonalization, Invariant subspace, Rational canonical form, Jordan canonical form. • Linear least-squares problems: Rotation and reflections, QR factorization, Gram-Schmidt orthogonalization, SVD and Moore-Penrose pseudoinverse, low-rank approximation by SVD, solution of least-squares problems by normal equation, QR method. Eigenvalue problems: Eigenvalues and eigenvectors, Schur theorem, Inner product space, spectral theorems for Hermitian and normal matrices, power and inverse power methods, QR algorithm for eigenvalue problems. Iterative methods for linear systems: SOR, and CG methods.

Suggested Books	Text Books: 1. D. S. Watkins, ***Fundamentals of Matrix Computations***, Wiley, 2010, ISBN: 9780470528334. 2. G. Strang, ***Linear Algebra and Its Applications***, Academic Press, 2006, ISBN: 978-8131501726. 3. C. T. Kelley, ***Iterative Methods for Linear and Nonlinear Equations***, SIAM, 1995, ISBN: 9780898713527. Reference Books: 4. G. H. Golub, C. F. Van Loan, ***Matrix Computations***, The Johns Hopkins University Press, 2013, ISBN: 9781421407944. 5. L. N. Trefethen, D. Bau, ***Numerical Linear Algebra***, SIAM, 1997, ISBN: 9780898713619. 6. J. W. Demmel, ***Applied Numerical Linear Algebra***, SIAM, 1997, ISBN: 9780898713893.

Course Code	**MA 305**
Title of the Course	**Data Science**
Course Category	Department Core
Credit Structure	L-T- P-Credits 2-0-2-3
Name of the Concerned Department	Mathematics
Prerequisite, if any	Basics of linear algebra, probability and statistics
Objective of the Course	This is a foundation course on data science for UG students.
Course Outcomes	The students will understand the fundamental concepts of data science, supervised/unsupervised learning and their applications to industrial problems.
Course Syllabus	• Concept of data science, data editing, missing data and logical operators, data management with repeats, sorting, ordering, and lists, statistical functions for handling data through graphics, programming and illustration with examples. • Overview of concepts: Bias/variance, overfitting and train/test splits of data, confusion matrix, accuracy metrics, receiver operator characteristics (ROC) curve, unbalanced datasets, types of machine learning-supervised (regression and classification), unsupervised (clustering), classification and regression algorithms - K-Nearest neighbors, support vector machines (SVM) for classification and regression problems, kernel based SVM and their generalization ability. • Principal component analysis in high dimension - rank and covariance estimation, graph, networks and clustering, k-means and spectral clustering, introduction to diffusion maps of point clouds and relationship to spectral clustering, semi-supervised learning - introduction. • Data science applications such as weather forecasting, stock market prediction, credit card fraud detection, object recognition, real time sentiment analysis, disease diagnosis, etc.

Suggested Books	Text Books: 1. A. Blum, J. Hopcroft, and R. Kannan, ***Foundations of Data Science***, Cambridge University Press, 2020, ISBN: 9781108485067. 2. J. A. Rice, ***Mathematical Statistics and Data Analysis*****,** Cengage, Boston, 2013, ISBN: 9788131519547. Reference Books: 3. S. Marsland, ***Machine Learning-An Algorithmic Perspective***, CRC Press, Taylor & Francis, Boca Raton, 2015, ISBN: 9781138583405. 4. M. P. Deisenroth, A. A. Faisal, and C. S. Ong, ***Mathematics for Machine Learning****,* Cambridge University Press, 2020, ISBN: 9781108455145. 5. T. T. Soong, ***Fundamentals of Probability and Statistics for Engineers***, John Wiley & Sons, 2004, ISBN: 0470868147. 6. P. Teetor, ***R Cookbook,*** O'Reilly Media, Inc., 2011, ISBN: 9780596809157.

Suggested Course code	**MA 307 / CS 307**
Title of the Course	**Optimization Algorithms and Techniques**
Course Category	Department Core
Credit Structure	L-T-P-Credits 2–1–0-3
Name of the Concerned Discipline	Mathematics/Computer Science & Engineering
Pre-requisite, if any	Knowledge of Data Structures and Algorithms
Objective of the Course	This is an introductory course in the field of mathematical optimization.
Course Outcomes	At the end of the course, students will know ● The Basics of Optimization, ● Unconstrained and Constrained Optimization, and ● Linear and Quadratic Programming.
Course Syllabus	● **Introduction to Optimization and Math Foundation:** Type of Problems, Examples, Formulations, Applications, Notations, and Convexity. ● **Unconstrained Optimization**: Necessary and Sufficient conditions for a Minima; Linear Search and Trust Region Methods; Multi-dimensional Minimization - Steepest descent, Newton, Gauss Newton, Quasi Newton; One-Dimensional minimization - Dichotomous, Quadratic & Cubic Interpolation. ● **Constrained Optimization:** Conversion to Unconstrained, Lagrange Multipliers, Necessary and Sufficient Conditions for Minima (KKT), and Duality. ● **Linear Programming**: Necessary and Sufficient Conditions for a Minima for a Linear Program, Derivation and Implementation of Simplex, Starting Simplex, and Interior-Point Methods.
Suggested Books	Textbooks: 1. J. Nocedal and S. J. Wright, ***Numerical Optimization***, 1st Edition, Springer, 2006. ISBN: 781493937110 Reference books: 2. A. Antoniou and W.-S.g Lu, ***Practical Optimization: Algorithms and Engineering Applications***, 2nd Edition, Springer, 2021. ISBN: 9781071608432

Course Code	**MA 303/ CS 303**
Title of the Course	**Operating Systems**
Course Category	Department Core
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics / Computer Science and Engineering
Pre-requisite, if any	NIL
Objective of the Course	This course will introduce the basic components of operating systems and functionalities.
Course Outcomes	Understanding basic functionalities of operating system for efficient performance of the processes
Course Syllabus	• **Introduction:** Overview of important features of computer architectures for OS operation; Service and system performance • **Multiprogramming:** Concurrency and parallelism; Processes and threads; Process synchronization; Process deadlocks • **Memory management:** Paging; Segmentation; Virtual memory • **File systems**: File operations. File protection • **Case Studies:** Case studies of contemporary operating systems
Suggested Books	Text books: 1. A. Silberschatz, P.B. Galvin, and G. Gagne, ***Operating System Principles***, 7th edition, John Wiley, 2005, ISBN: 9788126509621. Reference books: 2. A. Silberschatz, P.B. Galvin, and G. Gagne, ***Operating System Concepts***, 9th edition, Wiley, 2018, ISBN: 9781118063330. 3. W. Stallings, ***Operating Systems: Internals and Design Principles***, 5th edition, Pearson Education, 2005, ISBN: 9780134670959.

Suggested Course code	**MA 313 / CS 313**
Title of the course	**Computer Networks**
Course Category	Department Core
Credit Structure	L - T - P - Credits 2-0-2-3
Name of the Concerned Department	Mathematics / Computer Science and Engineering
Pre-requisite if any	Knowledge of data structures and algorithms, programming skills in C/C++/python
Objective of the Course	This course will introduce computer networking protocols and performance analysis of networks.
Course outcome	Understanding the basic functionalities of computer networks
Course Syllabus	● Network Architecture and protocols. History of networking–Circuit switching and packet switching. Network performance metrics–Throughput and delay ● Application layer–HTTP, DNS, CDN, SMTP, P2P etc., ● Transport layer–UDP and TCP, Reliability and congestion control in TCP. ● Socket programming, Introduction to Network Layer. Routing protocols. Interdomain routing–BGP ● Link layer and physical layer, Performance analysis of networks. Router Architecture, Resource allocation, and QoS, Network simulation version 3 (NS3). ● Introduction to next-generation networks. ● Practical components: ○ Experimental study of application protocols such as HTTP, FTP, SMTP, using network packet sniffers and analyzers ○ Socket programming - Small exercises in socket programming in C/C++/Java. ○ Experiments with packet sniffers to study the TCP protocol. ○ Introduction to ns3 (network simulator) and small simulation exercises to study TCP behavior under different scenarios. ○ Setting up a small IP network in ns3 ○ Experiments with ns3 to study Ethernet and 802.11 wireless LAN. ○ Programming with pcap

Suggested Books	Textbooks: 1. J. Kurose and K. Ross, ***Computer Networking, A Top-Down Approach***, Pearson Education, 8th Ed. 2022. ISBN: 978-9356061316 Reference books: 2. L. Peterson and B. Davie, ***Computer Networks, A Systems Approach***, Morgan Kaufmann Publishers Inc, 6th ed. 2021, ISBN: 978-0128182000 3. W. R. Stevens, ***Unix Network Programming: The Sockets Networking API***, Pearson Education, 3rd ed. 2017, ISBN: 978-9332549746 4. Bertsekas and Gallager, ***Data Networks***, Pearson Education 2nd ed., 2015. ISBN:978-9332550476

Course Code	**MA 357/ CS 357N**
Title of the Course	**Optimization Algorithms and Techniques Lab**
Course Category	Department Core
Credit Structure	L-T- P-Credits 0-0-2-1
Name of the Concerned Department	Mathematics/Computer Science and Engineering
Pre-requisite, if any	Knowledge of Data Structures and Algorithms
Objective of the Course	This is an introductory course in the field of mathematical optimization.
Course Outcomes	At the end of the course, students will know ● The Basics of Optimization, ● Unconstrained and Constrained Optimization, and ● Linear and Quadratic Programming.
Course Syllabus	• Understanding of Matlab/ Scilab via implementation of Newton's method for solving non-linear system of equations as well as numerical integration. • Analyzing convexity of functions numerically. • Implementation and analysis of Multi-dimensional Unconstrained Optimization algorithms (Steepest Descent, Newton, Gauss-Newton, Quasi-Newton, Conjugate Gradients etc.). • Implementation and analysis of One-dimensional Unconstrained Optimization algorithms (Dichotomous, Quadratic Interpolation, Cubic Interpolation etc.). • Implementation and analysis of Simplex and Interior Point Methods for Linear Program. • Implementation and analysis of Sequential Quadratic Program for solving general Constrained Optimization problem.
Suggested Books	Textbooks: 1. J. Nocedal and S. J. Wright, ***Numerical Optimization***, 1st Edition, Springer, 2006. ISBN: 78-1-4939-3711-0 Reference books: 2. A. Antoniou and W.-S.g Lu, ***Practical Optimization: Algorithms and Engineering Applications***, 2nd Edition, Springer, 2021. ISBN: 978-1-0716-0843-2

Course Code	**MA 353/ CS 353N**
Title of the Course	**Operating Systems Lab**
Course Category	Department Core
Credit Structure	L-T- P-Credits 0-0-2-1
Name of the Concerned Department	Mathematics / Computer Science and Engineering
Pre-requisite, if any	NIL
Objective of the Course	This course will introduce the basic components of operating systems and functionalities.
Course Outcomes	Understanding basic functionalities of operating system for efficient performance of the processes
Course Syllabus	● **OS Programming prerequisites:** Familiarities with IPC facilities, IPC identifiers, IPC keys, Message queues and their internal and user data structures, System calls related to IPC, Semaphore and Shared memory. ● **CPU scheduling:** Simulation programs for long-term, short-term and medium term schedulers, Simulation for the maintenance of various scheduling queues such as ready, I/O, blocked etc., Implementations of different scheduling algorithms such as FCFS, SJF, Priority scheduling (preemptive and non-preemptive), Round robin, multilevel feedback queue scheduling and their performance evaluations. ● **Concurrent Processing and Concurrency Control:** Simulation of updating processe PCBs with shared memory, Implementation of interprocess communication using simulated semaphore through (i) shared memory, (ii) synchronized producer-consumer problem, (ii) Pipes and message passing (asynchronous and synchronous). Concurrence control with pipes socket for iterative and concurrent servers ● **File Systems Implementation:** creating, removing, accessing, protecting and error handling of EXT2 FS, Registering the virtual file system in Kernel, accessing superblock information.
Suggested Books	Textbooks: 1. A. Silberschatz, P.B. Galvin, and G. Gagne, ***Operating System Principles***, 7th edition, John Wiley, 2005. ISBN: 9788126509621 Reference books: 2. A. Silberschatz, P.B. Galvin, and G. Gagne, ***Operating System Concepts***, 9th edition, Wiley, 2018. ISBN: 978-1-

	118-06333-0 3. W. Stallings, ***Operating Systems: Internals and Design Principles***, 5th edition, Pearson Education, 2005. ISBN: 978-0-13-467095-9

Course Code	**MA 302**
Title of the Course	**Statistical Inference**
Course Category	Department Core
Credit Structure	L-T- P-Credits 2-0-2-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Probability and Statistics
Objective of the Course	This course aims to describe the methods of estimation and testing of hypotheses. The course will help to apply statistical methodologies in data science and other fields of study.
Course Outcomes	● Understanding the estimation theory and testing of statistical hypotheses and applying these techniques to real-life problems.
Course Syllabus	• Review of random variables and associated probability distributions, sampling distributions, order statistics, distribution of order statistics. • **Principles of Data Reduction:** Sufficient statistics, minimal sufficiency, Fisher's factorization theorem, ancillary statistics, completeness. • **Point and Interval Estimation:** Concept of estimation, unbiased estimation, uniformly minimum variance unbiased estimator, Rao-Blackwell and Lehmann-Scheffe theorems and their applications, Cramer-Rao inequality, method of moments, method of maximum likelihood estimation, confidence intervals for mean, difference of means, and proportions, Bayesian estimation. • **Testing of Hypothesis:** Elements of testing of hypothesis, the most powerful test, uniformly most powerful test, tests for one sample and two sample problems for normal populations, tests for proportions.
Suggested Books	Text Books: 1. G. Casella and R. L. Berger, ***Statistical Inference***, Cengage Learning, Delhi. (Duxbury Advanced Series), 2002, ISBN: 9788131503942. 2. V. K. Rohatgi and A. K. Md. E. Saleh, ***An Introduction to Probability and Statistics***, Wiley, 2001, ISBN: 9788126519262. Reference Books:

	3. J. A. Rice, ***Mathematical Statistics and Data Analysis***, Duxbury Press, 2006, ISBN: 0534399428. 4. R. V. Hogg, J. McKean, and A. T. Craig, ***Introduction to Mathematical Statistics***, Pearson Education, 2019, ISBN: 9789332519114.

Course Code	**MA 306**
Title of the Course	**Monte-Carlo Simulation**
Course Category	Department Core
Credit Structure	L-T- P-Credits 2-0-2-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge of calculus, probability and statistics
Objective of the Course	This course supply all the basic tools and theory for understanding the Monte-Carlo simulation and demonstrate its applications in mathematics and finance.
Course Outcomes	• The student will learn how to generate random numbers and its usage in Monte-Carlo simulation. • The students will be able to evaluate integrals, finding roots, maximum-likelihood estimation using Monte-Carlo simulation.
Course Content	• Uniform random number generation, apparent randomness of pseudo-random number generators, generating random numbers from nonuniform continuous distributions, generating random numbers from discrete distributions. • Random samples associated with Markov chains, variance reduction for one-dimensional Monte-Carlo integration, errors in numerical integration. • Theory of low-discrepancy sequences, finding a root, maximization of functions, maximum-likelihood estimation, estimating derivatives, the score function estimator.

Suggested Books	Text Books: 1. G. S. Fishman, ***Monte Carlo Concepts, Algorithms, and Applications***, Springer, 1996, ISBN: 9780387945279. 2. I. T. Dimov, ***Monte Carlo Methods for Applied Scientists***, World Scientific, 2008, ISBN: 9789812779892. Reference Books: 3. C. Robert, G. Casella, ***Monte Carlo Statistical Methods,*** Springer, 2013, ISBN: 9781475730715. 4. W. Wang, ***Monte Carlo Simulation with Applications to Finance***, Chapman and Hall/CRC, 2019, ISBN: 9780367381356. 5. D. L. McLeish, ***Monte Carlo Simulation and Finance***, Wiley, 2005, ISBN: 9780471677789.

Course Code	**MA 308**
Title of the Course	**Techniques in Parallel Computing**
Course Category	Department Core
Credit Structure	L-T- P-Credits 0-1-2-2
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge of linear algebra
Objective of the Course	To demonstrate the parallel computing techniques to solve mathematical problems.
Course Outcomes	Understanding major benefits and limitations of parallel computing.
Course Content	• Concept of parallelism, scope of parallel computing, sources of overhead in parallel programs. • Performance metrics for parallel systems, scalability of parallel systems, asymptotic analysis of parallel programs, matrix-vector multiplication, matrix-matrix multiplication. • Solving a system of linear equations, sequential search algorithms, search overhead factor, parallel depth-first search, parallel best-first search.
Suggested Books	Text Books: 1. A. Grama, A. Gupta, G. Karypis, and V. Kumar, ***Introduction to Parallel Computing***, Addison Wesley, 2003, ISBN: 0201648652. 2. M. J. Quinn, ***Parallel Computing: Theory and Practice***, Tata McGraw Hill, 2002, ISBN: 9780070512948. Reference Books: 3. W. P. Petersen, and P. Arbenz, ***Introduction to Parallel Computing***, Oxford Texts in Applied and Engineering Mathematics, 2004, ISBN: 019 8515766. 4. P. S. Pacheco, ***An Introduction to Parallel Programming***, Morgan Kaufmann, 2011, ISBN**:** 9780123742605. 5. D. B. Kirk and W. W. Hwu, ***Programming Massively Parallel Processors: A Hands-on Approach*****,** Morgan Kaufmann, 2016, ISBN: 9780128119860.

Course Code	**MA 304/ CS 304N**
Title of the Course	**Computational Intelligence**
Course Category	Department Core
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics / Computer Science and Engineering
Pre-requisite, if any	Computer Programming, Data structure, and Design and Analysis of Algorithm
Objective of the Course	Basics of machine learning techniques
Course Outcomes	Understanding of machine learning techniques and implementation
Course Syllabus	● **Introduction:** Overview, Basics of Problem solving as an Artificial Intelligence problem, Computational Intelligence, Applications. Intelligent Search techniques, Knowledge representation, ● **Methodologies:** Computational intelligence methodologies; Learning, adaptation: Artificial neural networks: feed-forward, recurrent and multi-layer architectures; Supervised and unsupervised learning; Characteristics: adaptability, fault tolerance, generalization; limitations of neuro-computing. ● **Different learning algorithms:** Perceptron, Back propagation, Hopefield, Kohenen networks. Uncertainty treatment: Fuzzy sets - Basic Definition; Fuzzy-set- theoretic Operations – Member Function Formulation and Parameterization – Fuzzy Rules and Fuzzy Reasoning, Fuzzy If-Then Rules Hybrid computational learning : Fuzzy Neural Networks and Evolutionary Algorithms ● **Detailed Discussion from Example Domains:** Industry, Language, Medicine, Verification, Vision, Knowledge Based Systems etc.
Suggested Books	Textbooks: 1. S. Russell and P. Norvig, ***Artificial Intelligence: A Modern Approach***, Pearson, 2010. ISBN: 978-0136042594 2. E. Rich and K. Knight, ***Artificial Intelligence***, McGraw Hill Education, 2017. ISBN: 978-0070087705 Reference books: 3. J.S.R.J ang, C.T. Sun and E. Mizutani, ***Neuro-Fuzzy and Soft Computing***, Prentice Hall of India and Pearson Education, 2004. ISBN: 978-9332549883 4. D.E. Goldberg, ***Genetic Algorithms: Search,***

	Optimization and Machine Learning, Addison Wesley, 1989. ISBN: 9781584883883 5. S. Rajasekaran and G.A.V. Pai, ***Neural Networks, Fuzzy Logic and Genetic Algorithms***, Prentice Hall, 2003. ISBN: 9788120321861 6. R. Eberhart, P. Simpson and R. Dobbins, ***Computational Intelligence - PC Tools***, AP Professional, 1996. ISBN: 978-0122286308

Course Code	**MA 354/ CS 354N**
Title of the Course	**Computational Intelligence Lab**
Course Category	Department Core
Credit Structure	L-T- P-Credits 0-0-3-1.5
Name of the Concerned Department	Mathematics/ Computer Science and Engineering
Pre-requisite, if any	Computer Programming, Data structure, Discrete Structure, Design and Analysis of Algorithm
Objective of the Course	Basics of machine learning techniques
Course Outcomes	Understanding of machine learning techniques and implementation
Course Syllabus	• **AI programming:** Prolog, LISP, Experiments to support the associated theory course that demonstrate the different applications of Neural, fuzzy, evolutionary and hybrid model; • **Implementation:** Minor project based on real life applications such as Functional approximation; Time-series prediction; Pattern recognition; Data compression; Control applications, Optimization etc.
Suggested Books	Textbooks: 1. S. Russell and P. Norvig, ***Artificial Intelligence: A Modern Approach***, Prentice Hall Series in AI, 1995. ISBN: 978-9332543515 2. E. Rich and K. Knight, ***Artificial Intelligence***, Tata McGraw Hill, 1992. ISBN: 978-0-07-067816-3 Reference books: 3. J.S.R.J ang, C.T. Sun and E. Mizutani, ***Neuro-Fuzzy and Soft Computing***, Prentice Hall and Pearson Education, 2004. ISBN: 978-9332549883 4. D.E. Goldberg, ***Genetic Algorithms: Search, Optimization and Machine Learning***, Addison Wesley, 1989. ISBN: 9781584883883 5. S. Rajasekaran and G.A.V. Pai, ***Neural Networks, Fuzzy Logic and Genetic Algorithms***, Prentice Hall, 2003. ISBN: 9788120321861 6. R. Eberhart, P. Simpson and R. Dobbins, ***Computational Intelligence - PC Tools***, AP Professional, 1996. ISBN: 978-0122286308

Suggested Course code	**MA 217**
Title of the course	**Linear Programming**
Course Category	Department Elective
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basics linear algebra and coordinate geometry
Objective of the Course	This course aims to develop basic understanding of linear programming problems.
Course Outcomes	Students will learn basics of linear programming, solution methods, essence of duality and applications
Course Syllabus	• Introduction to linear programming, formulating a linear program, feasibility and optimality, solution space, some practical examples on feasibility, optimality and sensitivity. • Graphically solving linear programming problems (LPP) with two variables, canonical and standard form of LPP, formalizing the graphical method, problems with alternate optimal solutions, no solutions, and unbounded feasible regions. • Simplex method: Computational procedure, use of artificial variables, Big M method, applications of simplex algorithm. • Duality: Primal-dual pair, formulating a dual problem, duality theorems, complementary slackness theorem. • Solving linear programming with MATLAB/R, applications to industrial problems.
Suggested Books	Text Books: 1. H. A. Taha, ***Operations Research: An Introduction***, Pearson Education, 2022, ISBN: 9780137625819. 2. S. Bazaraa, J. J. Jarvis and H. D. Sherali, ***Linear Programming and Network Flows***, Wiley, 2011, ISBN: 9781118211328. Reference Books: 3. N. S. Kambo, ***Mathematical Programming Techniques***, Revised Edition, Affiliated East-West Press, 2008, ISBN: 9788185336473. 4. G. Murty, ***Linear Programming***, Wiley, 1983, ISBN: 9780471892496.

Suggested Course code	**MA 219**
Title of the course	**Introduction to Dynamical Systems**
Course Category	Department Elective
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic calculus and ordinary differential equations
Objective of the Course	This course introduces relevant tools and techniques used in analysing dynamic equations applied to modelling real-world problems.
Course Outcomes	● Formulating models of electrophysiology, chemical reactions, dynamics of the human heart, etc. ● Analyzing slow-fast dynamics and implement it for the population models.
Course Syllabus	● Introduction to linear and nonlinear autonomous systems, complete solutions, flows, blow-up, equilibrium and local stability, asymptotic stability, quasi-stability, exponential stability, Hartman-Grobman theorem. ● Oscillation theory, weakly perturbed linear oscillators, multiple time scale analysis, relaxation oscillations and multiple limit cycles, Stuart–Landau oscillator networks. ● Introduction to monotone dynamical systems, Metzler matrices, Kamke's condition, Ji-Fa's theorem, Smillie's theorem, dynamics of cooperative and competitive systems, application to the Ribosome flow model and electrophysiology. ● Numerical simulations and applications: Modelling electric circuits, enzyme kinetics, chemical oscillators and the Belousov-Zabitinsky reaction, population models, dynamics of neurons and human heart.
Suggested Books	Text Books: 1. R. C. Hilborn, ***Chaos and Nonlinear Dynamics***, Oxford University Press, 2000, ISBN: 978-0198507239. 2. H. L. Smith, ***Monotone Dynamical Systems: An Introduction to the Theory of Competitive Cooperative Systems***, American Mathematical Society, 2008, ISBN: 978-0821844878. Reference Books: 3. S. H. Strogatz, ***Nonlinear Dynamics and Chaos***, Westview Press, 2015, ISBN: 978-0-8133-4910-7.

	4. D. W. Jordon, P. Smith, ***Nonlinear Ordinary Differential Equations: An Introduction for Scientists and Engineers***, Oxford University Press, 2007, ISBN: 978-0199208258.

Course Code	**MA 210**
Title of the Course	**Elementary Number Theory and Algebra**
Course Category	Department Elective
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge of linear algebra
Objective of the Course	To expose the students to the basic ideas of algebra. At the end of the course, students should be exposed to fundamental knowledge and problem-solving skills in number theory and groups.
Course Outcomes	Making students familiar with groups, ring and fields which will help them in cryptography and coding theory.
Course Content	• **Number theory:** Integers, divisibility in integers, GCD, LCM, Bezout's identity, modular arithmetic, Chinese remainder theorem, Fermat's little theorem, Euler Phi-function. • **Group theory:** Cyclic, dihedral, symmetric, matrix groups, normal subgroups and quotient groups, conjugacy classes, isomorphism theorems, group automorphisms, symmetric group and alternating group, class equations, Cauchy's theorem (without proof), rings, integral domains, ideals, quotient rings, prime and maximal ideals, ring homomorphisms, polynomial rings, factorization in polynomial rings, fields, characteristic of a field, field extensions.
Suggested Books	Text Books: 1. N. Herstein, ***Topics in Algebra***, John Wiley & Sons, 2005, ISBN: 997151253X. 2. D. Burton, ***Elementary Number Theory***, McGraw Hill Education, 2017, ISBN: 9355325126. Reference Books: 3. D. S. Dummit and R.M. Foote, ***Abstract Algebra***, John Wiley & Sons, 2003, ISBN: 812651776X. 4. M. Artin, ***Algebra***, Prentice Hall of India, 1999, ISBN: 8184956754. 5. I. Niven, H. S. Zuckerman, and H. L. Montgomery, ***An***

	Introduction to the Theory of Numbers, John Wiley & Sons, 1991, ISBN: 9788126518111.

Course Code	**MA 212**
Title of the Course	**Regression Analysis**
Course Category	Department Elective
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Probability and Statistics
Objective of the Course	Understanding of data modelling and forecasting concepts. It has several applications in the fields of machine learning and data science.
Course Outcomes	● understand and apply regression techniques to model and analyse the relationship between variables, ● interpret the coefficients of regression models, and predict the new observations.
Course Syllabus	● Simple Linear Regression: Least-squares and maximum likelihood estimation of the parameters, hypothesis testing on the slope and intercept, interval estimation, prediction of new observations, coefficient of determination, regression through the origin. ● Multiple Linear Regression: Estimation of the model parameters, hypothesis testing, confidence intervals, prediction of new observations. ● Model Adequacy Checking: Residual analysis, methods for scaling residuals, residual plots, detection and treatment of outliers, lack of fit of the regression model. ● Model Inadequacies Corrections: Variance-stabilizing transformations, transformations to linearize the model, box–cox method, generalized and weighted least squares. ● Multicollinearity, variance inflation factors, ridge regression, variable selection and model building, logistic regression models, Poisson regression.

Suggested Books	Text Books: 1. D. C. Montgomery, E. A. Peck, G. G. Vining, ***Introduction to Linear Regression Analysis***, Wiley, India, 2012, ISBN: 978-0470542811. 2. M. H. Kutner, C. J. Nachtsheim, J. Neter, W. Li, ***Applied Linear Statistical Models***, McGraw-Hill, Irwin, 2005, ISBN: 0-07-238688-6. Reference Books: 3. N. R. Draper, H. Smith, ***Applied Regression Analysis***, Wiley, 1998, ISBN: 978-0471170822.

Course Code	**MA 309**
Title of the Course	**Numerical Methods for Partial Differential Equations**
Course Category	Department Elective
Credit Structure	L-T- P-Credits 2-0-2-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge of differential equations
Objective of the Course	The course will introduce some numerical techniques for solving partial differential equations that are used for modelling many practical problems and the theories behind them.
Course Outcomes	Students will be able to choose suitable methods to solve different types of differential equations numerically.
Course Syllabus	• Finite difference method: Explicit and implicit schemes; consistency, stability and convergence, maximum principle, Lax's equivalence theorem; FTCS, ADI methods, Lax-Wendroff method, upwind scheme, CFL conditions. • Finite element method: Variational methods, method of weighted residuals, finite element analysis of one- and two-dimensional problems. • Finite volume schemes, conservation properties, multigrid methods and boundary integral methods. • Recent progresses on numerical PDEs arising in the applicable field will be discussed and demonstrated through computations.
Suggested Books	Text Books: 1. P. Knabner, L. Angermann, ***Numerical Methods for Elliptic and Parabolic Partial Differential Equations***, Springer, 2003, ISBN: 038795449X. 2. G. D. Smith, ***Numerical Solutions of Partial Differential Equations**,* Calrendorn Press, 1985, ISBN: 9780198596509. Reference Books: 3. G. F. Pinder, ***Numerical Methods for Solving Partial Differential Equations: A Comprehensive Introduction for Scientists and Engineers***, 2018, John Wiley and Sons, Inc, ISBN: 9781119316114. 4. M. S. Gockenbach, *P**artial Differential Equations***

	Analytical and Numerical Methods, SIAM, 2002, ISBN: 0898715180. 5. M. M. Hafez, J. J. Chattot, ***Innovative Methods for Numerical Solutions of Partial Differential Equations***, World Scientific, 2002, ISBN: 9810248105. 6. R. J. LeVeque, ***Finite Volume Methods for Hyperbolic Problems***, Cambridge University Press, 2002, ISBN: 9780521009249.

Course Code	**MA 311**
Title of the Course	**Statistical Distribution Theory**
Course Category	Department Elective
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Probability and Statistics
Objective of the Course	This course deals with multivariate distributions and their applications. The concept of copula function will be introduced for measuring the dependence between multivariate random variables.
Course Outcomes	● understanding the multivariate probability distributions. ● apply statistical techniques involving two or more dependent variables using copula functions.
Course Syllabus	● Review of standard univariate distributions, distribution of function of random variable, Jacobians of transformation technique, random sample generation from univariate distributions. ● Bivariate distributions, conditional distributions, conditional expectation and variance, independence of random variables, covariance, Pearson and Spearman correlations, distributions of functions of random variables, including sums, means, products and ratios, convolution technique. ● Bivariate and multivariate normal distributions and their properties, bivariate exponential distribution and their properties, copula function and their applications, and construction of bivariate distributions using copula functions.
Suggested Books	Text Books: 1. V. K. Rohatgi and A. K. Md. E. Saleh, ***An Introduction to Probability and Statistics***, Wiley, 2001, ISBN: 9788126519262. 2. G. Casella and R. L. Berger, ***Statistical Inference***, Cengage Learning, (Duxbury Advanced Series), 2002, ISBN: 9788131503942. Reference Books:

	3. J. A. Rice, ***Mathematical Statistics and Data Analysis***. Duxbury Press, 2006, ISBN: 0534399428. 4. R. V. Hogg, J. McKean, and A. T. Craig, ***Introduction to Mathematical Statistics***, Pearson Education, 2019, ISBN: 9789332519114. 5. R. B. Nelsen, ***An Introduction to Copulas***, Springer, 2006, ISBN: 9780387286594.

Course Code	**MA 310**
Title of the Course	**Algorithmic Techniques and Applications of Data Science**
Course Category	Department Elective
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Mathematics / Computer Science and Engineering
Pre-requisite, if any	Linear Algebra, Probability and Statistics, Discrete Mathematics
Objective of the Course	This course will provide fundamentals of algorithmic techniques of data science and presents different applications wherein such techniques are applied.
Course Outcomes	The students will learn the fundamental principles of data science and the mathematical foundations related to high dimensional space, SVD, random walks, etc.
Course Syllabus	• **High Dimensional Space**: Law of large numbers, geometry of high himensions, properties of unit ball, generating points, uniformly at random from a ball, Gaussians in high dimension, random projection and Johnson-Lindenstrauss lemma. • **Singular Value Decomposition (SVD)**: SVD applications to discrete optimization problems. • **Random Walks and Markov Chain**: Stationary distribution, Markov Chain Monte Carlo, Metropolis Hasting algorithm, areas and volumes, convergence of random walks on undirected graphs, random walks in Euclidean space. • **Foundations of Machine Learning**: Perceptron algorithm, kernel functions, generalizing new data, overfitting and uniform convergence, online learning, strong and weak learning, stochastic gradient descent. • **Algorithms for Massive Data Problems**: Streaming, sketching, sampling. • **Advanced Topics in Data Science**: Clustering techniques, linear

	methods for regression and classification, basis expansion and regularization, kernel smoothing methods, model assessment and selection, model inference and averaging, additive models, logistic regression, trees and related methods, boosting and additive trees, decision trees, random forests, neural networks, recurrent neural networks (RNNs).
Suggested Books	Text Books: 1. T. Hastie, R. Tibshirani and J. Friedman, ***Elements of Statistical Learning***, Springer, 2013, ISBN: 9781489905185. 2. A. Blum, J. Hopcroft and R. Kannan**,** ***Foundations of Data Science*****,** Cambridge University Press, 2020, ISBN: 9781108485067. Reference Books: 3. C. C. Aggarwal and C. K. Reddy, ***Data Clustering, Algorithms and Applications.***, Chapman and Hall, CRC Press, 2013, ISBN: 9781466558229. 4. M. J. Kearns and U. Vazirani, ***An Introduction to Computational Learning Theory***, The MIT Press, 1994, ISBN: 9780262111935.

<table>
<tr><td>Course Code</td><td>MA 314</td></tr>
<tr><td>Title of the Course</td><td>Random Matrices</td></tr>
<tr><td>Course Category</td><td>Department Elective</td></tr>
<tr><td>Credit Structure</td><td>L-T- P-Credits
2-1-0-3</td></tr>
<tr><td>Name of the Concerned Discipline</td><td>Mathematics</td></tr>
<tr><td>Pre-requisite, if any</td><td>Basic knowledge of calculus and linear algebra</td></tr>
<tr><td>Objective of the Course</td><td>This course introduces random matrices and their applications.</td></tr>
<tr><td>Course Outcomes</td><td>Students will learn how the different ensembles of random matrices are defined and their applications in various fields including data science, mathematical Finance, etc.</td></tr>
<tr><td>Course Syllabus</td><td>
Random matrices in science and applications: Random matrices in statistics, physics, telecommunications, numerical analysis, community detection in networks
Norms of random matrices: Norm of a random symmetric matrix, norms of rectangular matrices, the moment method, Gaussian processes, Sudakov-Fernique inequality
Sample covariance matrices: Concentration inequalities and moment inequalities for the sample covariance matrices, spectral projectors, principal component analysis
Gaussian ensembles of random matrices: Gaussian Unitary Ensemble (GUE), Gaussian Orthogonal ensemble (GOE), Wishart ensemble, eigenvalues density, eigenvectors, determinantal structure, spectral statistics, Wigner-Dyson-Gaudin-Mehta conjecture
Random vectors in high dimension: Multivariate Gaussian distribution, distribution of norm of random vector, dimensionality reduction, Johnson- Lindenstrauss lemma
</td></tr>
<tr><td>Suggested Books</td><td>Text Books:
G. Anderson, A. Guionnet and O. Zeitouni, An Introduction to Random Matrices, Cambridge University Press, 2010, ISBN: 9780521194525.
M. L. Mehta, Random Matrices, Academic Press, 2004, ISBN: 9780120884094.
Reference Books:<ol start="3">
T. Tao, Topics in Random Matrix Theory, AMS, 2023, ISBN: 9781470474591.
</td></tr>
</table>

	4. Z. Bai and J. W. Silverstein, ***Spectral Analysis of Large Dimensional Random Matrices***, Springer, 2010, ISBN: 9781441906601.

Course Code	**MA 452/ MA 652**
Title of the Course	**Theory of Transforms**
Course Category	Department Elective
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge of calculus, complex variable, differential equations
Objective of the Course	This course explores properties of integral transforms, applying them to solve initial and boundary value problems arise from mathematical modelling.
Course Outcomes	Understanding the concept of various transform techniques and their applications.
Course Syllabus	• Fourier series, Riemann-Lebesgue lemma, Gibbs phenomenon, Fourier sine and cosine series, Fourier transform, Fourier integral theorem, convolution and Parseval's theorem, applications to partial differential equations. • Laplace transform: Definition and properties, complex inversion, convolution theorem, Heaviside's expansion theorem, Bromwich contour integral, applications to initial and boundary value problems. • Fundamental theorem of the discrete Fourier transform, cyclical convolution, and Parseval's theorem. • Z-transform: Definition and examples, basic operational properties of Z-transforms, inverse Z-transform and examples, applications of Z-transforms to finite difference equations and summation of infinite series.

Suggested Books	Text Books: 1. R. J. Beerends, H. G. ter Morsche, J. C. van den Berg, E. M. van de Vrie, ***Fourier and Laplace Transforms,*** Cambridge University Press, 2003, ISBN: 0521534410. 2. U. Graf, ***Applied Laplace Transforms and Z-Transforms for Scientists and Engineers,*** Birkhauser Verlag, Basel, 2004, ISBN: 3034895933. Reference Books: 3. L. Debnath, D. Bhatta, ***Integral Transforms and their Applications,*** Chapman & Hall/CRC, 2006, ISBN: 1584885750. 4. G. B. Folland, ***Fourier Analysis and its Applications,*** American Mathematical Society, Providence, 2009, ISBN: 9780821847909. 5. A. Pinkus, S. Zafrany, ***Fourier Series and Integral Transforms***, Cambridge University Press, 1997, ISBN: 0521597714.

Course Code	**MA 407/ MA 607**
Title of the Course	**Nonlinear Dynamics and Computations**
Course Category	Department Elective
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Linear Algebra and Ordinary Differential Equations
Objective of the Course	Understand the qualitative behaviours of autonomous systems and discrete maps, and write independent algorithms and coding in exploring complex dynamics numerically.
Course Outcomes	● Learning the idea of global stability with Lyapunov function. ● Generating Arnold tongue and shrimp structures using numerical simulation.
Course Syllabus	● Introduction to dynamical systems, flows, phase space analysis, stable and unstable manifolds, Hartman-Grobman theorem, Lyapunov function and stability. ● Transcritical, saddle-node, pitch-fork, and Hopf-bifurcations, limit cycles, index theory, Poincare-Bendixson theorem, homoclinic and heteroclinic orbits, nonlinear centers. ● Lorenz system, Rössler attractor, Chua's circuit, Kuramoto oscillator. ● Difference equations, periodic orbits, period-doubling, Feigenbaum constant, period-bubbling, quasi-periodic, chaos, Lyapunov exponents, Sharkovskii's theorem, synchronization, shadowing lemma, routes to chaos, Ruelle-Takens embedding theorem, reconstructing an attractor, Smale horseshoe, the renormalization idea, Neimark-Sacker bifurcation, Henon map. ● Bifurcations in 2D parameter plane: Isoperiodic diagram, Arnold tongue, shrimp-shaped structure, spiral structure. ● Numerical simulations: Plotting orbits, phase portrait, bifurcation diagrams, Lyapunov exponents, organized structures, etc. using computer programming.
Suggested Books	Text Books: 1. S. H. Strogatz, ***Nonlinear Dynamics and Chaos***, Westview Press, 2015, ISBN: 9780813349107. 2. K. T. Alligood, T. D. Sauer and J. A. Yorke, ***Chaos: An Introduction to Dynamical Systems***, Springer, 1996, ISBN: 9780387224923. Reference Books: 3. M. W. Hirsch, S. Smale and R. L. Devaney, *Differential* ***Equations, Dynamical Systems, and an Introduction to Chaos***, Academic Press, 2012, ISBN:

	9780123820105. 4. S. Lynch, ***Dynamical Systems with Applications using MATLAB***, Springer, 2014, ISBN: 9783319068206.

Course Code	**MA 454 / MA 654**
Title of the Course	**Mathematical Modeling and Simulations**
Course Category	Department Elective
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge of differential equations and linear algebra
Objective of the Course	The Mathematical model plays a significant role providing a quantitative framework for understanding and solving many real-life problems under certain conditions.
Course Outcomes	• Students should be exposed to fundamental knowledge of implementing the models in real-world situations. • They will get the bright idea about constructing or selecting the appropriate model, identify the problem, analytically or numerically computing the solution and test the validity of models.
Course Syllabus	• **Introduction to mathematical modeling**: Characteristics, classifications, tools, techniques, deterministic and stochastic models, modeling approaches, compartmental models, introduction to discrete models and continuous models, dynamical systems and its mathematical models. • **Models from systems of natural sciences**: Population models for a single species (discrete and continuous-time models), modeling of population dynamics of two interacting species, analytical tool: Kolmogorov Theorem, linear stability snalysis, Lotka-Volterra model, variation of the classical LV model, Leslie-Gower model, prey-predator model, arms race model, Holling-Tanner model, modified HT model, applications of Lyapunov functions. • **Modeling of atmospheric, mining and engineering systems**: Spatial models using partial differential equations, modeling with stochastic differential equations, models of heating and cooling, models for traffic flow, model for detecting land mines, models in mechanical systems, models in electronic systems, models for vehicle dynamics, kicked harmonic oscillator, modeling the ventilation system of a mine. • MATLAB/MATHEMATICA programs to study the dynamics of the developed model systems
Suggested Books	Text Books: 1. B. Barnes, G. R. Fulford, ***Mathematical Modeling with Case Studies***, CRC PRESS, Taylor & Francis, 2009, ISBN: 9781420083484.

	2. S. Banerjee, ***Mathematical Modeling, Models, Analysis and Applications***, CRC Press, Taylor & Francis, London, 2014, ISBN: 9781482229165. Reference Books: 3. E. A. Bender, ***An Introduction to Mathematical Modeling***, Dover Publications, 2012, ISBN: 9780486137124. 4. R. K. Upadhyay, S. R. K. Iyengar, ***Introduction to Mathematical Modeling and Chaotic Dynamics***, CRC Press Taylor & Francis, London, 2014, ISBN: 9781439898871.

Course Code	**MA 405/ MA 605**
Title of the Course	**Differential Equations in Population Dynamics**
Course Category	Department Elective
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic concepts of differential equations and numerical methods
Objective of the Course	Theory and computational techniques of differential equations will be applied in population dynamics.
Course Outcomes	• To know some well celebrated models in population dynamics. • exploring some ecological phenomenon such as the paradox of enrichment, ecological resilience, hydra effects, etc.
Course Syllabus	• **Introduction**: Mathematical models: necessity, advantages and limitations; brief history of population models, different tools and modeling frameworks, birth and death processes in population models. • **Ordinary differential equations**: The Multhus, Verhulst, Lotka-Volterra, Rosenzweiz-MacArthur and Hestings-Powell models, Routh-Hurwitz criteria, mean population density in cyclic and chaotic dynamics, population harvesting, resilience in ecology, hydra effects, population genetic models, FitzHugh-Nagumo model. • **Partial differential equations**: Fisher's equation, Turing instability, pattern formation, spatiotemporal chaos, reaction-diffusion in ecological and chemical systems, diffusion in delayed predator-prey systems. • **Delay differential equations**: Discrete and distributed delays in population dynamics, Hopf-bifurcation and stability switching, delayed harvesting in Nicholson blowflies model, delayed dispersal in patchy environment, Mackey-Glass equation. • **Impulsive differential equations**: Fixed-time and variable-time impulses, impulses in biological control theory and epidemic models. • **Computer simulations**: Several measures will be quantified in all the models using numerical methods, and different software will be implemented to interpret the system dynamics graphically.
Suggested Books	Text Books: 1. J. D. Murray, ***Mathematical Biology: I. An Introduction***, Springer, 2002, ISBN: 9780387952239. 2. R. K. Upadhyay, S. R. K. Iyengar, ***Spatial Dynamics and Pattern Formation in Biological Populations***, Chapman

	and Hall/CRC, 2021, ISBN: 9780367555504. Reference Books: 3. K. Gopalsamy, ***Stability and Oscillations in Delay Differential Equations of Population Dynamics***, Springer, 1992, ISBN: 9780792315940. 4. V. Lakshmikantham, D. D. Bainov, P. S. Simeonov, ***Theory of Impulsive Differential Equations***, World Scientific, 1989, ISBN: 9789971509705.

Course Code	**MA 402**
Title of the Course	**Industrial Statistics**
Course Category	Department Elective
Credit Structure	L-T-P-Credits 2-0-2-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Probability and Statistics
Objective of the Course	Understanding the concepts of quality control and system reliability techniques.
Course Outcomes	Techniques to apply these concepts in industrial problems such as pharma, automotive industry, etc.
Course Syllabus	• **Statistical Quality Control:** Product quality, need for quality control, the basic concept of process control, process capability and product control, theory of control charts, operation and uses of control charts, probability limits, specification limits, tolerance limits, 3-sigma limits, and warning limits, control charts for variables and attributes, modified control charts, acceptance sampling plans for attributes inspection, single and double sampling plans and their properties, and plans for inspection by variables for one-sided and two-sided specification. • **Reliability Theory:** Reliability concepts and measures, components and systems, coherent systems, reliability of coherent systems, life distributions, reliability function, hazard rate, mean residual life and mean time to failure, notions of ageing: IFR, IFRA, DMRL, NBU, and NBUE classes and their duals, reliability modellings in series/parallel systems and k-out-of-n systems.
Suggested Books	Text Books: 1. D. C. Montgomery, ***Introduction to Statistical Quality Control***, Seventh edition, Wiley, 2019, ISBN: 9781119399308. 2. J. Navarro, ***Introduction to System Reliability Theory***, Springer, 2022, ISBN: 9783030869526. Reference Books: 3. A. J. Duncan, ***Quality Control and Industrial Statistics***, Irwin, Homewood, 1986, ISBN: 9780256035353. 4. C. D. Lai, and M. Xie, ***Stochastic Ageing and Dependence for Reliability***. Springer, 2006, ISBN: 0387297421.

Course Code	**MA 404**
Title of the Course	**Foundation of Approximation Theory**
Course Category	Department Elective
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite if any	Basic knowledge of calculus, linear algebra
Objective of the Course	This course introduces the basic terms and techniques of approximation theory.
Course Outcomes	Students would be able to understand the concept of approximations of functions by polynomials and trigonometric functions.
Course Syllabus	• **Density theorems:** Approximation of periodic function, Weierstrass Theorem, Stone-Weierstrass Theorem. • **Linear Chebyshev approximation:** Approximation in normed linear space, linear Chebyshev approximation of vector-valued functions, Chebyshev polynomials, strong uniqueness and continuity of metric projection, discrete best approximation, approximation by algebraic polynomials. • **Best approximation in normed linear spaces:** Approximative properties of sets, characterization and duality, continuity of metric projections.
Suggested Books	Text Books: 1. H. N. Mhaskar and D. V. Pai, ***Fundamentals of Approximation Theory***, *CRC Press*, 2007, ISBN: 0849309395. 2. M. J. D. Powell, ***Approximation Theory and Methods***, Cambridge University Press, 1981, ISBN: 0521224721. Reference Books: 3. K. G. Steffens, ***The History of Approximation Theory: From Euler to Bernstein***, Birkhauser, Boston, 2006, ISBN: 0817643532.

Course Code	**MA 406**
Title of the Course	**Graph Theory**
Course Category	Department Elective
Credit Structure	L-T-P- Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge of linear algebra
Objective of the Course	This course explores the theoretical development of graph theory and mathematical models based on it.
Course Outcomes	• Solving problems arising from computer science using graphs and trees. • Adapt and demonstrate state-of-the-art algorithms to real-life situations.
Course Syllabus	• Graphs and graph models, graph terminology and special types of graphs, path problems, incidence matrix, adjacency matrix, degree sequence of graphs, graph isomorphism, trees and its characterizations, spanning trees, algorithms for minimum weighted spanning trees, matching, perfect matching, augmenting path, bipartite matching, Hall marriage theorem, matching in general graphs, Tutte's theorem, Min-Max theorems, Konig-Egervary theorem. • Eulerian tour and seven bridges problem, Hamiltonian cycles and travelling salesman problem, necessary conditions for Hamiltonian graphs, sufficient conditions for Hamiltonian graphs, vertex coloring, edge coloring, Brook's theorem, network flows, max-flow min-cut theorem, Ford-Fulkerson algorithm, planar graphs, Euler's Formula, Kuratowski theorem, four color theorem.
Suggested Books	Text Books: 1. D. B. West, ***Introduction to Graph Theory***, Pearson Education, 2015, ISBN: 0130144002. 2. J. A. Bondy, U. S. R. Murty, ***Graph Theory with Applications***, Elsevier Science Publishing Co., Inc., 1984, ISBN: 0444194517. Reference Books: 3. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms***, MIT press, 2009, ISBN: 026204630X 4. R. Diestel, ***Graph Theory***, Springer, 2006, ISBN: 3540261834.

	5. A. M. Gibbons, ***Algorithmic Graph Theory***, Cambridge University Press, 1985, ISBN: 0521288819.

Course Code	**MA 408**
Title of the Course	**Mathematical Theory of Waves**
Course Category	Department Elective
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Differential Equations
Objective of the Course	To expose the students to the basic ideas that underline linear/non-linear wave motion. To derive important mathematical tools to deal with problems of wave theory. To consider simple examples of linear waves on strings, sound waves and water waves.
Course Outcomes	Upon completion of this course, students will know some of the most interesting wave phenomena that have physical significance, while at the same time, they will also be introduced to some of the deeper mathematical issues that are pertaining to wave motion.
Course Syllabus	• Introduction to waves: Classification, terminology, mathematical representation of waves. • One-dimensional waves in solids and fluids: Waves in a string (free and forced vibrations), waves in a rod, steady-state waves, reflection and transmission of waves, water waves: Surface gravity waves, internal waves, sinusoidal waves on deep water, ripples, wave patterns, Fourier analysis of dispersive systems. • Two-dimensional and three-dimensional waves: Basics of elasticity, waves in finite, infinite and semi-infinite media, waves in inhomogeneous media, motion of wave packets, dispersion and attenuation, phase velocity, group velocity. • Non-linear waves: General effect of nonlinearity, non-linear Schrodinger equation, Riemann invariants, Piston problem, discontinues solutions and shock waves, wave localization phenomena.

Suggested Books	Text Books: 1. C. A. Coulson and Alan Jeffrey, ***Waves: A Mathematical Approach to the Common Types of Wave Motion,*** Longman Group Limited, 1977, ISBN: 9780582449541. 2. G. B. Whitham, ***Linear and Nonlinear Waves,*** Pure and Applied Mathematics, Wiley-Interscience, 1999, ISBN: 9780471359425. Reference Books: 3. R. Knobel, ***An Introduction to the Mathematical Theory of Waves***, American Mathematical Society, 2000, ISBN: 9780821820391. 4. J. Lighthill, ***Waves in Fluids,*** Cambridge Mathematical Library, Cambridge, 2001, ISBN: 9780521010450.

Course Code	**MA 414**
Title of the Course	**Time Series Analysis**
Course Category	Department Elective
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Probability and Statistics
Objective of the Course	To introduce various techniques for modelling and forecasting the time series data.
Course Outcomes	• Understand the concepts of time series models and their applications in various fields, • Apply these models and techniques to real-life problems such as finance and stock analysis, sales and demand forecasting, weather forecasting etc.
Course Syllabus	• Components of time series, tests for randomness, trend and seasonality, estimation/elimination of trend and seasonality, mathematical formulation of time series, weak stationary, stationary up to order m. • Auto-covariance and auto-correlation functions of stationary time series and its properties, linear stationary processes and their time-domain properties-AR, MA, ARMA, seasonal, non-seasonal and mixed models, ARIMA models, invertibility of linear stationary processes. • Parameter estimation of AR, MA, and ARMA models-least square approach, estimation based on Yule-Walker for AR, ML approach for AR, MA and ARMA models, asymptotic distribution of MLE, best linear predictor and partial auto-correlation function (PACF), model-identification with ACF and PACF, model order estimation techniques-AIC, AICC, BIC, etc.

Suggested Books	Text Books: 1. P. J. Brockwell and R. A. Davis, ***Introduction to Time Series and Forecasting***, Springer, 2002, ISBN: 9781493970865. 2. C. Chatfield and H. Xing, ***The Analysis of Time Series - An Introduction with R***, Chapman and Hall/CRC Press, 2019, ISBN: 9781138066137. Reference Books: 3. R. H. Shumway, D. S. Stoffer, ***Time Series Analysis and Its Applications with R Examples***, Springer, 2016, ISBN: 9783319524511. 4. G. E. P. Box, G. Jenkins, and G. Reinsel, ***Time Series Analysis-Forecasting and Control***, Prentice-Hall International, Inc., 1994, ISBN: 0130607746.

Course Code	**MA 416**
Title of the Course	**Integral Equations**
Course Category	Department Elective
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Mathematics
Pre-requisite, if any	Basic knowledge in calculus and differential equations
Objective of the Course	The course introduces the classification of integral equations, fundamental mathematical ideas and techniques that lie at the core of the integral equation approach of problem solving.
Course Outcomes	• understand the concepts of Volterra and Fredholm integral equations • apply appropriate integral equation to solve initial and boundary value problems
Course Syllabus	• Basic concepts, Volterra integral equations, relationship between linear differential equations and Volterra equations, resolvent kernel, method of successive approximations, convolution type equations, Volterra equation of the first kind, Abel's integral equation. • Fredholm integral equations, Fredholm equations of the second kind, the method of Fredholm determinants, iterated kernels, integral equations with degenerate kernels, eigenvalues and eigen functions of a Fredholm alternative, construction of Green's function for BVP. • Weakly singular integral equations, Cauchy singular integral equations, hypersingular integral equations. • Bernstein polynomials, properties and its use in solving integral equations.

Suggested Books	Text Books: 1. F. G. Tricomi, ***Integral Equations***, Dover Publications Inc, 1985, ISBN: 9780486648286. 2. N. I. Muskhelishvili, ***Singular Integral Equations: Boundary Problems of Functions Theory and Their Applications to Mathematical Physics***, Springer, 2011, ISBN: 9789400999961. Reference Books: 3. D. Porter and D. S. G. Stirling, ***Integral Equations: A Practical Treatment, from Spectral Theory to Applications***, Cambridge University Press, 2012, ISBN: 9781139172028. 4. R. P. Kanwal, ***Linear Integral Equations: Theory & Technique***, Birkhäuser, 2013, ISBN: 9781461460121.

Syllabi of Open Elective Courses

of

Centre for Advanced Electronics (CAE)

Course code	**CAE 601/ CAE 401**
Title of the course	Advanced Microwave & Optical Devices
Credit Structure	L - T - P - Credits 2-1-0-3
Name of the Concerned Department	Centre for Advanced Electronics
Pre-requisite, if any	Not Applicable
Scope of the course	This course is designed for the UG and PG students with the background in Electronics, Electrical Engineering, Physics and Material Science. This course will emphasize on the fundamentals of microwave and optical devices and their multidisciplinary applications. The course aims to explain basics, advances and technology of high frequency devices & components.
Course Syllabus	**Introduction to Microwave Engineering & Photonics**: Elements of electromagnetic field theory; Wave propagation in microwave and optical waveguides. **Microwave and High Frequency Devices**: Microwave waveguides & components; Tunnel diode, High frequency transistors – HBTs, HEMTs; Charge coupled devices. Transferred electron devices, Avalanche transit time devices; Microwave generation; Monolithic microwave integrated circuits. **Advanced Optical Devices:** Advanced optical waveguides and cavities, LIDAR, semiconductor optoelectronics, Optical switches, Cavity opto-mechanics. **Elements of Microwave Photonics:** Microwave photonic links, Radio over fibre; Photonic generation of microwave signals.
Suggested Books	1. Microwave devices and circuits, S. Y. Liao, Pearson, ISBN No. 8177583530 2. Chuang, Physics of Optoelectronic Devices, Wiley (2008), ISBN 9780470293195 3. Solid state electronic devices, by Bannerjee & Streetman, Prentice Hall, ISBN: 9789332555082 4. Microwave photonics, Jianping Yao, Wiley, ISBN: 9780470905371

Syllabi of Courses

of

Center for Electric Vehicles and Intelligent Transport Systems (CEVITS)

Course code	**EV 401/ EV 601**
Title of the course	**Vehicle Dynamics**
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned Department	Mechanical Engineering
Pre-requisite, if any	NA
Scope of the course	This course is designed for students from diverse engineering fields of study. This course shall cover fundamental approaches for vehicle dynamics modelling as well as study of important dynamic systems of the automotive systems including vehicle handling performance.
Course Syllabus	**Mechanisms, kinematics and balancing:** Introduction. **Introduction to vehicle dynamics:** History of motor vehicle age; Fundamental approach for modelling: lumped mass, vehicle and earth fixed coordinate systems; and Dynamic axle loads. **Acceleration and braking analysis:** Characteristics of conventional vehicle engines; Power train and different elements in it; Automatic transmissions; Selection of gear ratios; and Traction-limited acceleration. Basic equations; Braking forces; Tire-road friction; Requirement for braking performance; Brake proportioning; Anti-lock brake systems; Braking efficiency; Rear wheel lock-up; and Pedal force analysis. **Road loads and ride:** Aerodynamics: Mechanics of air flow and pressure distribution on vehicle, aerodynamic forces and aids, and different forces and moments; Rolling resistance; and Total road loads. Excitation sources; Vehicle response; and Perception of ride. **Steady state cornering:** Low-speed turning; High-speed cornering; Suspension effects on cornering; and Measurement of understeer gradient. **Suspensions:** Solid axles; Independent suspensions; Anti-squat and anti-pitch suspension geometries; Anti-drive suspension geometry; Roll center analysis; and Active analysis. **Steering systems:** Axis systems; Steering linkages; Steering geometry error; Front wheel geometry; Steering system forces and moments; Steering models; Effect of front-wheel drive; and Four-wheel steer. **Rollover:** Quasi-static rollover of rigid and suspended vehicles; Transient rollover; and Rollover accidents. **Tires:** Tire construction; Size and load rating; Terminology and axis system; Forces and moments acting on tire; Free rolling tire; Rolling resistance; Tire under braking, driving and cornering conditions; Combined cornering and braking/driving; Physical tire models; Camber thrust; Aligning moment; Conicity and ply steer; Durability forces; and Tire transient behavior and vibrations.

	Vehicle handling performance: Criteria for good handling; Single-track vehicle modeling; Steady and non-steady state analysis; and Graphical assessment methods.
Suggested Books	1. J.J. Uicker, G.R. Pennock, and J.E. Shigley, **Theory of Machines and Mechanisms**, Oxford University Press, New York, 2014, ISBN 978-0199454167 2. D.H. Myszka, **Machines and Mechanisms: Applied Kinematic Analysis**, Pearson, 2011, ISBN 978-0132157803 3. T.D. Gillespie, **Fundamentals of Vehicle Dynamics**, SAE International, 1992, ISBN 978-1560911999 4. J.P. Pauwelussen, **Essentials of Vehicle Dynamics**, Butterworth-Heinemann, 2014, ISBN 978-0081000366 5. R. N. Jazar, **Vehicle Dynamics: Theory and Application**, Springer, Boston, 2008, ISBN 978-0-387-74243-4

Course code	**EV 402/ EV 602**
Title of the course	**Vehicular Communication Systems**
Credit Structure	L-T-P–Credits 2-1-0-3
Name of the Concerned School/ Department/ Centre	Center for Electric Vehicles and Intelligent Transport Systems
Pre-requisite, if any	Basic knowledge of signal processing.
Scope of the course	This course will provide fundamentals of vehicular communications, networks, and advanced network security techniques specific to vehicular networks.
Course Syllabus	**Vehicular Communications:** Basics of Communication Systems in the context of vehicular communications, Vehicle-to-Everything (V2X), Vehicle-to-Infrastructure (V2I), Infrastructure-to-Vehicle (I2V), Vehicle-to-Vehicle (V2V), Infrastructure-to-Infrastructure (I2I) communications and architectures, Intelligent transportation systems, Standards for wireless access in vehicular environments (IEEE 802.11p), Vehicular Channel characterization and basic modelling. **Vehicular Networks:** Manually driving vehicular networks, Automated driving vehicular networks, Routing protocols. **Communication Security in EV Charging Systems:** EV Charging Security Requirements and Security Risks, Communication Security: Confidentiality and Message Integrity in Local Controllers, Non Repudiation, Firmware Integrity and Access Control in Local Controller and Authentication Terminal, Authentication Mechanisms, and Signature Schemes in Vehicular Networks, Cryptographic Communication protocols in EV Systems, Variants of security events and logging of security events in local controllers and authentication terminals.
Suggested Books	1. C. Sommer and F. Dressler, ***Vehicular Networking***, Cambridge University Press, 2014, ISBN: 9781107046719 2. X. Cheng, R. Zhang, and L. Yang, ***5G Enabled Vehicular Communications and Networking***, Springer publication, 2019, ISBN: 9783030021764 3. D. Stinson, ***Cryptography: Theory and Practice***, Chapman and Hall, CRC, 2006, ISBN: 9781138197015

Course Code	**EV 407/ EV 607**
Title of the Course	**Energy Storage in Electric Vehicle**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Metallurgy Engineering and Materials Science
Pre–requisite, if any	None
Scope of the Course	This course is designed for the students of science and engineering Departments to understand the use of energy storage materials in electrical vehicles. The basics of energy storage performance and cutting edge research developments will be covered from various books, research reports, articles and review papers.
Course Syllabus	**Battery Technology**: Introduction to common battery terminologies, Overview of the development of battery technology, Electrochemical energy storage mechanism in LIBs, Intercalation, conversion, and alloys type electrodes, Factors limiting the energy; power densities and cyclability of LIBs, Cell form factors (cylindrical, prismatic, and pouch), Capacity fading and battery failure mechanisms, Case study of commercially available LIBs, Emerging trends and beyond Li-ion battery technologies for EVs. **Battery Management System:** Introduction to BMS, charging discharging process, BMS requirements, Battery state of charge and state of health estimation, thermal management of battery. **Supercapacitor Technology**: Introduction to supercapacitor, Types and energy storage mechanism of SCs, Advances in supercapacitor, EDLC for transportation applications, Analysis and evaluation of EDLC, Thermal analysis and ageing in EDLC, Battery-Supercapacitor hybridization for large vehicles, Case studies, Emerging trends in supercapacitor. **Fuel Cell Technology**: Introduction to Fuel Cell, Types of Fuel Cell, Fuel cell thermo-chemistry and materials
Suggested Books	5. Edson R. Leite, **Nanostructured Materials for Electrochemical Energy Production and Storage**, Springer, 2009, ISBN 978-0-387-49323-7 6. Rui Xiong, Weixiang Shen, **Advanced Battery Management Technologies for Electric Vehicles**, Wiley, 2019, ISBN 9781119481645 7. B. E. Conway, **Electrochemical Supercapacitors Scientific Fundamentals and Technological Applications**, Springer, 1999, ISBN 978-1-4757-3058-6 8. Devid Linden and Thomas B. Reddy, **Handbook of Batteries, 3rd Edition**, McGraw-Hill, 2002, ISBN 9780071359788 9. C. G. Granqvist**, Handbook of Inorganic Electrochromic Materials**, Elservier, 1995, eBook ISBN: 9780080532905

Syllabi of Courses

of

Centre for Rural Development and Technology (CRDT)

1.	Course Code	**RDT 201**
2.	Title of the Course	**Immersion for Rural Technology Development**
3.	Credit Structure	L-T-P-Credits 1-0-2-2
4.	Name of the Concerned Department	Centre for Rural Development and Technology
5.	Pre-requisite if any	Nil
6.	Course Objective	Scope of the Course: The student will learn methods to understand the landscape of the rural areas. Through extensive field visits they will be able to identify different kinds of challenges faced by the communities.
7.	Course Syllabus	**Module-I**: Basic project management for rural development; Primary and secondary data collection methods, Qualitative and Quantitative Analytical methods; Documentation and reporting techniques/ methods for the field-based projects. Participatory Rural Appraisal; Effective Communication, Interview Methods; Governance System, 73rd Amendment of Constitution, Observation and Assimilation **Module II**: Field Work: Field survey in the rural area and data gathering preparation of questionnaire, identification of problems and prospects, data compilation and analysis, preparing field reports. **Module-III**: Assimilating and writing Project reports; Narrative and writing of the project report. Field Based Projects in agriculture, health care, water conservation, housing, automation/mechanization/engineering and other areas relevant to the rural domains.
	Suggested Books	**Textbooks:** **1.** A. Bryman, **Social Research Methods**, Oxford University Press, 2016, ISBN 9780199689453 0199689458 **2.** R. K. Yin, **Case Study Research: Design and Methods**,SAGE Publications, 2009. 3. S. Taylor, R. Bogdan, M. DeVault, **Introduction to Qualitative Research Methods: A Guidebook and Resource,** John Wiley & Sons, 2015, ISBN: 978-1-118-76721-4

Course Code	**RDT 301**
Title of the Course	**Design Thinking for Rural Applications**
Credit Structure	L-T-P-Credit 1-1-2-3
Name of the Concerned Department	Centre for Rural Development and Technology
Pre-requisite, if any	NIL
Course Objective	Scope of the Course: Classroom component and Field work towards the overall process of technology-based product development for rural community.
Course Syllabus	• <u>Rural Community requirements</u>: Data gathering and analysis for rural community indicators, determinants, and challenges; Concept testing through field survey and stakeholder experiences of rural community; Analysis of existing products and product market fit; Minimum Viable Product; Case studies on technologies implemented in rural communities • Government schemes supporting rural technology development and transfer; Self-help group and co-operative society for major technological interventions • <u>Product Conception and Prototype Development for Rural Community</u>: Design methodology and design philosophy; Establishing product function; Concept Generation and evaluation; Embodiment design; Value Engineering; Product conception; Prototype development • <u>Product Development and Assessment for Rural Community</u>: Product development ; Field testing; Scaling up; Packaging; Cost estimate of business case study • <u>Implementation of New Technology in Rural Community</u>: Technology transfer; Product marketing; Technology impact assessment; Field application of developed prototype/product and stakeholder feedback
Suggested Books	**Text Books** 1. K. Singh, K. **“Rural development: principles, policies and management”** 2009, SAGE Publications India, ISBN10: 9789351509981 2. J. P. Shukla, (Ed.).. **“Technologies for sustainable rural development: having potential of socio-economic upliftment (TSRD–2014) (Vol. 1)”** 2014, Allied Publications India . ISBN-978818424862-3 3. R. Chambers **“Rural Development: Putting the last first”,** 1983, Routlege-Taylor and Francis group. ISBN 9780367474560. 4. K. T. Ulrich and D. S. Eppinger, **”Product Design and Development”**, 2007 Tata McGraw Hill, ISBN10: 1260043657 **Reference Books** 5. A. F. McCalla, & W. S. Ayres, **“Rural development: From vision to action.”** 1997, The World Bank.

	6. M. J. Campbell, & M.J. Campbell (Eds.), **“New technology and rural development: the social impact”**, 1990, Routledge, ISBN 041500911-1 7. K. Otto and K. Wood, **“Product design”**, 2013,Pearson, ISBN-10: 0131742795

Syllabi of Courses

of

Department of Physics

Course Code	**PH 203 / AA 203**
Title of the Course	**Classical Mechanics**
Course Category	Core
Credit Structure	L-T-P-Credits (2-1-0-3)
Name of the Department	Physics
Pre–requisite, if any	None
Objectives of the course	This course provides basic knowledge of classical physics
Course Outcomes	Students should be able to • Solve problems using the Lagrange method • Apply Lorentz transformations, understand 4-vector analyses and relativistic kinematics, and use Lagrange and Hamiltonian formulations for relativistic particles. • Develop problem-solving skills in classical and relativistic mechanics.
Course Syllabus	• System of particles, Center of mass, equation of motion of the CM, conservation of linear and angular momentum, conservation of energy, variable mass systems. Elastic and inelastic collisions. • Central Force: uniformly rotating frame, centrifugal and Coriolis forces, Motion under a central force, Kepler’s laws, Gravitational Law and field, Conservative and non-conservative forces. • Introduction to Lagrangian mechanics, Mechanics of Rigid Body: Rigid body motion, fixed axis rotations orthogonal transformations and rotations (finite and infinitesimal); Euler's theorem, Euler's angles; moments of Inertia tensor, parallel and perpendicular axes theorem, Principal moments and axes; Euler's equation; Small Oscillations, normal modes, and frequencies. • Special Theory of Relativity: Lorentz transformations; 4-vectors, 4-dimensional velocity, and acceleration; 4-momentum and 4-force; Covariant equations of motion; Relativistic kinematics (decay and elastic scattering); Lagrangian and Hamiltonian of a relativistic particle. • General properties of matter: Introduction to Elasticity, Surface Tension and Viscosity

Suggested Books	Textbooks: 6. Goldstein, Poole, Safko, *Classical Mechanics*, Pearson, (2017), ISBN: 978-0201657029 7. N. Rana and P. Jog, *Classical Mechanics*, Mcgraw Hill, (2017), ISBN: 978-0074603154 Reference Books: 8. Kleppner and Kolenkow, *An Introduction to Mechanics*, Cambridge Univ. Press, (2013), ISBN: 978-0521198110 9. K. C. Gupta, *Classical Mechanics of Particles and Rigid Bodies*, New Age Education, (2018) ISBN: 978-9386649782 10. D. Morin, *Introduction to Classical Mechanics*, Cambridge Univ. Press, (2009), ISBN: 978-0521185028

Course Code	PH 207 / AA207
Title of the course	Wave Phenomenon and Optics
Course Category	**Core**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of Dept.	**Astronomy, Astrophysics and Space Engineering**
Prerequisite, if any	None
Objectives of the course	The students will be introduced to the basics of waves and oscillations, including optics and lasers.
Course Outcome	● The students will learn to solve for motions in different oscillatory systems ● The students will understand the concepts of optics and compare the outcomes in different optical systems
Course Syllabus	**Module 1:** • Oscillations: Harmonic motion (simple, damped, critical). Driven oscillation, resonance. Oscillations of two-particle systems and modes. Oscillations of n particle systems. Oscillation modes. Longitudinal and transverse oscillations. • Waves: Equations of motion, standing waves and travelling waves. Harmonics and their superpositions. Fourier analysis and Fourier coefficients. Doppler effect. **Module 2:** • Geometrical Optics: Fermat's Principle, Refraction, Thick Lens and Lens Combination, Matrix Method, Aberrations, Optical Instruments: Telescopes and Microscopes. • Wave Optics: Electromagnetic Spectrum, Huygen's Principle, Interference: Young's Experiment, Fresnel's Biprism, Newton's Rings, Interferometers: Michelson and Fabry-Perot; Coherence: Temporal and Spatial; Diffraction: Fresnel and Fraunhofer, Single and Double Slit, Circular aperture, Grating, Resolving power. • Polarization, LASER and Holography: Brewster's Law, Birefringence, Dichroism, Babinet's Compensator, Polarimeters, Optical Activity. Coherence, LASER, spontaneous and stimulated emission, Gaussian wave and its diffraction. Holography.

Suggested Books:	Textbooks: 7. A. P. French, *Vibrations and Wave*, CRC Press; 1st edition, (2017), ISBN: 978-1138414082 8. A. Ghatak, *Optics*, MacGraw Hill, (2020), ISBN: 978- 9390113590 [Module 2] Reference Books: 9. F. S. Crawford, *Waves*, MacGraw Hill Education, (2017), ISBN: 978-0070702172 10. N. Bajaj, *The physics of waves and oscillations*, McGraw Hill, (2017), ISBN: 978-0074516102 11. F. Jenkins and H. White, *Fundamentals of Optics*, McGraw Hill Education; 4th edition, (2017), ISBN: 978-1259002298 12. M. Born and E. Wolf, *Principles of Optics*, Cambridge Univ. Press, (2019), ISBN: 978-1108477437

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	**AA 205 / PH 205**
Title of the course	**Electronic Devices and Circuits - I**
Course Category	Core
Credit Structure	**L - T - P – Credits (2-1-0-3)**
Name of Dept.	**Astronomy, Astrophysics and Space Engineering**
Prerequisite, if any	None
Objectives of the course	The students will gain foundational knowledge of analogue electronics.
Course Outcome	• Acquire knowledge of basic analog electronics. • Gain skills to design basic electronic circuits.
Course Syllabus	**Module - 1** Basics of semiconductor devices and their characterization: diodes, transistors, BJT, FET, MOSFET, etc. **Module - 2** Small signal analysis in electrical circuits: Estimation of voltage gain, input/output resistance, Miller's theorem, high-frequency transistor model. **Module - 3** Amplifiers and their applications: Single-stage and two-stage amplifier, Differential amplifiers, Operational amplifiers. **Module - 4** Oscillators: Basics of oscillators, phase shifter, multi-vibrators, timers.
Suggested Books	Textbooks: 7. A. Malvino and D. Bates, *Electronics Principles*, McGraw Hill Education, 7th Ed., (2017), ISBN : 978-0070634244 8. A. S. Sedra and K. C. Smith, *Microelectronic Circuits,* Oxford University Press, (2017), ISBN: 978-0199476299 Reference Books: 9. Gray, Hurst, Lewis, and Meyer, *Analysis and Design of Analog Integrated Circuits,* Wiley (2009) ISBN: 978-8126521487 10. R. Gayakwad, *Op-amps and Linear Integrated Circuits*, Pearson, (2021) ISBN: 978-9353949037 11. B. Razavi, *Fundamentals of Microelectronics*, Wiley, (2017), ISBN: 978-8126571352 12. R. L. Boylestad, *Electronic Devices and Circuits Theory*, Pearson (2021) ISBN: 978-9332542600

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	**PH 209 / AA 209**
Title of the course	**Fundamental Concepts for Solid State Engineering**
Course Category	**Core**
Credit structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisites	None
Objectives of the course	This course provides a multidisciplinary introduction to fundamental concepts of solid state physics, encompassing topics ranging from crystals, reciprocal lattices to structural, elastic, thermal, optical and electronic properties of materials. This course will build the foundation for applications of solids in various fields of applied physics and engineering branches.
Course Outcomes	● Develop an understanding of the core concepts of solid-state physics and understand their implications in various applications/branches of engineering. ● Application of fundamental concepts in solid state physics to solve relevant conceptual and numerical problems.
Course Syllabus	• Introduction: Periodic array of atoms, Symmetry operations, Point Groups in general, Index system for crystal planes, Lattices in 1–, 2– and 3-D Bravais Lattices. • Reciprocal lattice: Diffraction of waves by crystals, Scattered Wave Amplitude, Brillouin zones, Wigner–Seitz Cells, Fourier analysis of the Basis. • Elastic Properties of Crystals and Crystal Binding. • Crystal Vibrations: mono-atomic lattice, diatomic lattice, quantization of elastic waves, phonon-dispersions. Thermal properties of Crystals: Phonon density of states, Heat capacity, thermal expansion, thermal conductivity. • Electrons in Crystals: Review of Free electron model, Periodic potential, Born–von Karman boundary conditions, Bloch's theorem, Electronic band structure, single electron energy state, degenerate electron levels, Consequences of the nearly free electron model, Fermi surface. • Electronic properties of Materials: Construction of Fermi surfaces, Reduced Zone Scheme, Periodic Zone Scheme, Reflectance and Absorption, Intrinsic and Extrinsic semiconductors, Effective mass and mobility of carriers, Hall Effect, Semiconducting junctions, Metal-semiconductor contacts – Schottky barriers, Ohmic contacts, Brief introduction to semiconductor device fabrication. • Structural Defects: Point defects, Dislocations, Microcracks, Stacking faults, Grain boundaries.

Suggested Books:	Textbooks: 6. C. Kittel, *Introduction to Solid State Physics* (7th Edition), John Wiley & Sons, (2019) ISBN: 9788126578436. 7. A. J. Dekker, *Solid State Physics*, MacMillan India Ltd. (2008) ISBN: 978-0333918333 Reference Books: 8. R. E. Hummel, *Electronic Properties of Materials: An introduction for Engineers*, Springer-Verlag, (1985), ISBN: 978-0387156316 9. M. Ali Omar, *Elementary Solid-State Physics: Principles and Applications* (1st Edition), Pearson Education, (2002) ISBN: 978-8177583779 10. Ashcroft and Mermin, *Solid State Physics*, Thomson Press (India) Ltd. (2021), ISBN:9780030839931

<table>
<tr><td>Course code</td><td>PH 251 / AA 251</td></tr>
<tr><td>Title of the course</td><td>Engineering Physics Lab - I</td></tr>
<tr><td>Credit structure</td><td>L-T-P-Credits (0-0-3-1.5)</td></tr>
<tr><td>Course Category</td><td>Core</td></tr>
<tr><td>Name of the Dept.</td><td>Physics</td></tr>
<tr><td>Pre-requisite if any</td><td>None</td></tr>
<tr><td>Objectives of the course</td><td>Students will get exposure to several experiments based on various advanced concepts of Physics.</td></tr>
<tr><td>Course Outcomes</td><td>Learn to accurately collect, analyze and interpret data to understand the underlying physical principles/concepts.
Experimental verification of fundamental concepts in Classical Physics, Waves and Optics and Solid State engineering
Evaluate the errors and statistical deviations associated with the experimental results</td></tr>
<tr><td>Course Syllabus</td><td>A representative list of experiments will be performed by students:

Classical physics
Moment of inertia of flywheel
Measurement of Young’s modulus
Verification of Bernoulli’s theorem
Constant volume and pressure air thermometer
Determination of Planck’s constant
Millikan oil drop experiment
Helmholtz coil & measurement of Faraday’s number
Waves and Optics
Michelson interferometer
Verification of Brewster’s law
Determination of specific rotation of sugar solution by using Laurent’s Half Shade Polarimeter.
Solid State Engineering
Nature of semiconductor band-gap of a powdered semiconductor using Diffuse Reflectance Spectroscopy.
Demonstration of X-ray diffraction in crystalline solids
Determination of Heat Capacity using Differential Scanning Calorimetry.</td></tr>
<tr><td>Suggested Books</td><td>Reference Books:
3. W. F. Smith, Experimental Physics: Principles and Practice for the laboratory, CRC Press, (2020), ISBN: 978-1498778473
4. L. Lyons, A practical guide to data analysis for physical science</td></tr>
</table>

	students, Cambridge Univ. Press, (1991), ISBN: 978-0415481519

Course code	**PH 255 / AA 255**
Title of the course	**Electronic Devices and Circuits Lab - I**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (0-0-3-1.5)**
Name of Dept.	**Astronomy, Astrophysics and Space Engineering**
Prerequisite, if any	None
Objectives of the course	The students will acquire foundational knowledge and skills in analog electronics experimentation
Course Outcome	• Acquire hands-on experience in the domain of analog electronics. • Learn how to implement electronic circuits.
Course Syllabus	• Diode and its applications; I-V characteristics, Clipping Circuits. • Diode as – Voltage Doublers, Rectified Differentiator, Precision Rectifier, reverse-bias capacitance. • To measure the minority carrier lifetime in a semiconductor photodiode. • Transistor and Op-Amp characteristics - amplification, Op-Amp as summer, Integrator, Differentiator. • Zener Diode - rectification, DC power supply. • Characterization of basic and cascade current mirror circuits (with BJT and MOSFET). • Design of single-stage and differential amplifiers. • 555 Timers - timer and oscillator functions.
Suggested Books	Reference Books: 4. J. Millman, A. Grabel, *Microelectronics,* Tata McGraw-Hill (2017), ISBN: 978-0074637364 5. S. Sedra K. C. Smith: *Microelectronic Circuits,* OUP, (2017), ISBN: 978-0199476299 6. Razavi, *Fundamentals of Microelectronics,* Wiley, (2017) ISBN: 978-8126571352

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course Code	**PH 211**
Title of the Course	**Fundamentals of Vacuum Science and Technology**
Course Category	**Department Elective**
Credit Structure	**L-T- P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	NIL
Objectives of the course	This course provides a framework to understand fundamentals of Vacuum Science ranging from basic physics concepts, measurement techniques, to different vacuum pumps to equip students with essential theoretical and practical knowledge for applications in fields requiring high to ultra-high vacuum environments such as Applied Physics (material science, semiconductors, space research) and other branches of engineering including electrical, chemical and space engineering etc.
Course Outcome	• To develop a comprehensive understanding of the fundamental concepts in vacuum science, vacuum generation and vacuum measurement techniques. • Students will be able to apply mathematical concepts and techniques to solve problems related to vacuum generation and measurement.
Course Syllabus	• **Revision of some fundamental concepts:** Revisiting Kinetic theory of gases and fundamentals of mean free path and its correlation with the pressure temperature etc., Distribution functions for molecular gases and concept of pressure with the molecular density, viscosity of gases and its correlation with flow/conductance of the gas, Relation of conductance/impedance of a gas with the volume and vacuum line, concepts of different types of gas lines, elbows, tubes, and its effect on the molecular flow. • **Generation of Vacuum:** Introduction to mechanical vacuum pumps including oil sealed rotary pump, Roots Pump, molecular drag pump etc., Oil pumps including diffusion pump, Ion pumps: E-vapor ion pumps, Sputter ion pumps, Titanium sublimation pump (Chemical cleanup (oxidation etc.) and sublimation pumps, Turbo molecular pumps, Electrical cleanup and ion pumps, Cryopumps including cryo-sorption pumps, Getter pumps. • **Measurements of Vacuum:** Concept and working principle for measurement of pressure in general, different types of pressure gauges for low to high vacuum including electrical and mechanical gauges, Mc-Leod manometer, Thermal conductivity

	gauges, Pressure and flow gauges for high to ultrahigh vacuum, Hot cathode ionization gauges, Cold cathode ionization gauges. • **Operation of High-vacuum gauges:** Concept of rough, high, and ultra-high vacuum with respect to the molecular density, Vacuum measuring units and vacuum ranges.
Suggested books	Textbooks: 1. V. V. Rao, T.B. Ghosh, K.L. Chopra, *Vacuum Science and Technology*, Allied Publishers, New Delhi (2008) ISBN: 9788170237631 2. D. Hoffman, B. Singh, J. H. Thomas III, *Handbook of Vacuum Science and Technology,* Elsevier Science (1997) ISBN: 9780080533759 Reference Books: 3. T. A. Delchar, *Vacuum Physics and Techniques: 6*, Chapman and Hall (1993) ISBN: 9780412465901 4. A. Roth, *Vacuum Technology,* Elsevier Science B.V., North Holland (1990) ISBN: 978-0444860279 5. J. Yarwood, *High Vacuum Techniques*, Chapman and Hall, London, (1967), ISBN: 978-0412025204

Course Code	**PH 213**
Title of the Course	**Detector Physics**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (1-1-2-3)**
Name of the department	**Physics**
Pre–requisites	None
Objectives of the course	To familiarize students in the frontiers of detectors used in high energy experiments
Course outcomes	Student will able to understand • Working principle of basic detectors • Energy loss mechanisms of different charge and neutral particles in medium • General characteristics of detectors
Course Syllabus	• Interaction of Radiation with Matter: Energy loss of heavy charge particle, Energy loss of electron and positron, Interaction of Photons. • General Characteristics of Detectors: Energy Resolution, Detector Response, Detector Efficiency, Response Time and Dead Time. • Basic Detectors: Cloud and Bubble Chambers, Gaseous Ionization Detectors, Scintillation Detector and Photomultiplier tubes, Semiconductor Detectors, Electromagnetic and Hadronic calorimeter, Time of Flight Detector, Transition Radiation Detector, Example of Hermetic Detectors. • Experiments related to different radiation detectors and their characteristics.
Suggested Books	Textbooks: 1. W. R. Leo, *Techniques for Nuclear and Particle Physics Experiments* (2^{nd} Edition), Narosa Publishing. (1994) ISBN: 978-3540572800 2. G. F. Knoll, *Radiation Detection and Measurement (4th edition),* John-Wiley and Sons., (2010) ISBN**:** 978-0470131480 Reference Books: 3. T. Ferbel, *Experimental Techniques in High Energy, Nuclear and Particle Physics* (2^{nd} Edition), World Scientific Publishing, (1991) ISBN-13: 978-9810208677 4. S. S. Kapoor and V. S. Ramamoorthy, *Nuclear Radiation Detectors* (2^{nd} edition), New Age International, (2022) ISBN-13: 978-9395161084

Course code	**PH 210 / AA 210**
Title of the course	**Fundamentals of Quantum Mechanics**
Course Category	**Core**
Credit structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisites	None
Objectives of the course	The students will be introduced to the basics of quantum mechanics
Course Outcomes	Students will be able to • Demonstrate a thorough understanding of the foundational principles of quantum physics • Analyze and solve the Schrödinger equation for various scenarios • Apply quantum mechanical principles to understand and explain several phenomena related to hydrogen atom, atomic nuclei and radioactivity.
Course Syllabus	• Review of Introductory Quantum Physics • Calculation of expectation values, Kets, Bras and operators, Base kets and matrix representations, Measurements, observables and the uncertainty relations, change of basis, position, momentum and translation, wave functions in position and momentum space. • Quantum dynamics: Time evolution and the Schrodinger equation, The Schrodinger versus the Heisenberg picture, Schrödinger equation, and its solution for one, two, and three-dimensional boxes. Solution of Schrödinger equation for the one-dimensional harmonic oscillator. Reflection and transmission at a step potential, Pauli exclusion principle. • WKB approximation, Tunneling through a barrier, Structure of the atomic nucleus, mass, and binding energy. Hydrogen atom, Radioactivity and its applications. Laws of radioactive decay.
Suggested Books	Textbooks: 6. D. J. Griffiths and D. F. Schroeter, *Introduction to Quantum Mechanics*, Cambridge University Press, (2018), ISBN: 978-1107189638 7. R. Shankar, *Principles of Quantum Mechanics*, Springer, (2011), ISBN: 978-0306447907 Reference books: 8. P. M. Mathews and K. Venkatesan, *A Textbook of Quantum Mechanics*, Springer, (2017), ISBN: 978-0070146174

	9. J. Townsend, *A Modern Approach to Quantum Mechanics*, University Science Books, (2010) ISBN:978-1891389788. 10. A. Das, *Quantum Mechanics: A Modern Introduction*, CRC Press; 1st edition, (1986) ISBN: 978-2881240539

<table>
<tr><td>Course Code</td><td>PH 212 / AA 212</td></tr>
<tr><td>Course Title</td><td>Thermal Physics</td></tr>
<tr><td>Course Category</td><td>Core</td></tr>
<tr><td>Credit Structure</td><td>L-T-P-Credits (2 -1-0-3)</td></tr>
<tr><td>Name of the Dept.</td><td>Physics</td></tr>
<tr><td>Pre-requisite if any</td><td>None</td></tr>
<tr><td>Objectives of the course</td><td>This course introduces the basic concepts of heat and thermodynamics</td></tr>
<tr><td>Course Outcomes</td><td>Student will be
Able to understand Kinetic theory of gases and apply the theory to gain insights into specific heat and transport phenomena in gases
Grasp and effectively apply the Laws of Thermodynamics to understand the principle of heat engines, phase transitions etc.</td></tr>
<tr><td>Course Syllabus</td><td>Kinetic Theory of Gases: Ideal gas, Distribution of velocities, Mean, RMS and Most Probable Speeds, Degrees of Freedom, Law of Equipartition of Energy (statement only), Specific heats of Gases, Mean Free Path. Collision Probability, Transport phenomena (viscosity, thermal conductivity and diffusion), Real Gases, Virial equation, Boyle temperature, Van der Waal’s Equation of State, Comparison with Experimental P-V Curves.
Laws of Thermodynamics: Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, Internal Energy and First Law of Thermodynamics, Isothermal and Adiabatic Processes, Second Law of Thermodynamics, Reversible and Irreversible process with examples, Carnot’s Cycle, Carnot engine & efficiency, Carnot’s Theorem, Heat engines, Concept of Entropy, Clausius Theorem and Clausius Inequality, Principle of Increase of Entropy, Third Law of Thermodynamics.
Thermodynamic potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb’s Free Energy, their Definitions, Properties and Applications, First and second order Phase Transitions, Clausius-Clapeyron Equation, Maxwell’s Thermodynamic Relations, Joule-Kelvin coefficient, Joule- Thomson Effect.
Non-equilibrium Thermodynamics: Entropy production, Kinetic coefficients, Proof of Onsager reciprocal relations, Thermoelectricity</td></tr>
<tr><td>Suggested Books</td><td>Textbooks:
M. W. Zemansky, R. Dittman, Heat and Thermodynamics, McGraw-Hill, (1996) ISBN: 978-0070170599
D. V. Schroeder, An Introduction to Thermal Physics, Oxford University Press, (2021) ISBN: 978-0192895547</td></tr>
</table>

	Reference books: 3. S. J. Blundell and K. M. Blundell, *Concepts in Thermal Physics*, Oxford University Press, (2009), ISBN: 978-0199562107 4. F. Reif, *Fundamentals of Statistical and Thermal Physics,* Waveland Press, (2010) ISBN: 978-1577666127 5. P. K. Nag, *Engineering Thermodynamics,* McGraw Hill Education, (2021) ISBN: 978-9352606429

Course code	**AA 206 / PH 206**
Title of the course	**Electronic Devices and Circuits – II**
Course Category	**Core**
Credit Structure	**L - T - P – Credits (2-1-0-3)**
Name of the Department	**Astronomy, Astrophysics and Space Engineering**
Pre-requisite, if any	None
Objectives of the course	The students will develop a basic understanding of digital electronics principles
Course Outcomes	Students will learn about digital electronics and will able to solve related problems in the domain of engineering.
Course Content	**Module -1** **Number System and Codes:** Decimal, Binary, Octal and Hexadecimal number systems and arithmetic, base conversions. Representation of signed and unsigned numbers, addition, subtraction by 2's complement method, and multiplication. **Module -2** **Logic Gates and Boolean algebra:** Truth Tables of OR, AND, NOT, NOR, NAND, XOR, XNOR, Universal Gates, Basic postulates and fundamental theorems of Boolean algebra. **Module -3** **Combinational Logic Analysis, Design and Arithmetic Circuits:** Standard representation of logic functions, Binary Addition. Half and Full Adder. Half and Full Subtractor, 4-bit binary Adder/Subtractor, counters and registers. **Module -4** **Signal Conditioning and D-A and A-D Conversion:** A-D and D-A conversion, sampling and reconstruction of signal, Nyquist sampling, Fourier transform, Fast Fourier Transform.
Suggested Books	Textbooks: 6. D. P. Leech and A. P. Malvino, *Digital Principles and Applications*, Tata McGraw Hill, 8th ed., (2014) ISBN: 978-9339203405. 7. A. S. Sedra, K. C. Smith, *Microelectronic Circuits*, Oxford University Press, (2017), ISBN: 978-0199476299 Reference books: 8. J. G. Proakis and D. G. Manolakis, *Digital Signal Processing: Principle, Algorithms and Applications*, 4th ed., Pearson Education,

	(2007), ISBN: 978-8131710005. 9. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, *Signals & systems*, Pearson Education, 2nd ed., (2015) ISBN: 9332550239. 10. J. Millman and C. Halkias, *Integrated Electronics: Analog and Digital Circuits and Systems*, McGraw-Hill, 2nd ed., (1972), ISBN: 9780070151420.

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	**AA 208 / PH 208**
Title of the course	**Electrodynamics**
Course Category	**Core**
Credit Structure	**L-T-P–Credits (2-0-0-2)**
Name of Dept.	**Astronomy, Astrophysics and Space Engineering**
Prerequisite, if any	None
Objectives of the course	The students will be introduced to electromagnetism
Course Outcome	Develop understanding of basic electrodynamics and its applications in the domain of engineering.
Course Syllabus	• Review of Electrostatics and Magnetostatics. Time-Varying Fields and Maxwell's Equations: Faraday's law for Electromagnetic induction, Displacement current, Integral and differential forms of Maxwell's equations, and Motional Electromotive forces. Boundary Value Problems, multipole expansion. • Electromagnetic Waves: Derivation of Wave Equation, Coulomb and Lorentz gauges; Plane waves in free space and in a homogenous material. non-conducting and conducting media; reflection and transmission at normal and oblique incidences, Skin effect, Poynting theorem. Polarization. • Lorentz Invariance of Maxwell's Equation, Radiation by moving charges, retarded potentials. Dipole antenna radiation, Introduction to waveguides.
Suggested Books	Textbooks: 6. D. J. Griffiths, *Introduction to Electrodynamics*, Cambridge University Press, (2020), ISBN: 978-1108822909 7. H. C. Verma, *Classical Electromagnetism*, Bharati Bhawan, (2022), ISBN-10:9388704827 Reference Books: 8. M. N. O. Sadiku, *Elements of Electromagnetics*, Oxford University Publication, (2014), ISBN-0199321388 9. W. Hayt, *Engineering Electromagnetics*, McGraw Hill Education, (2012), ISBN-9339203275 10. J. D. Jackson, *Classical Electrodynamics*, 3rd edition, Wiley, (2007), ISBN-10: 9788126510948

**This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	**AA 256 / PH 256**
Title of the course	**Electronic Devices and Circuits Lab - II**
Course Category	**Core**
Credit Structure	**L - T - P – Credits (0-0-3-1.5)**
Name of the Department	**Astronomy, Astrophysics and Space Engineering**
Pre-requisite, if any	None
Objectives of the course	The students will engage in hands-on digital electronics experiments.
Course Outcomes	● Acquire hand-on experience in digital electronics. ● Implement digital components to solve electronics problems.
Course Content	A representative list of experiments will be performed by students: • Introduction to Logic Circuits: To gain familiarity with digital integrated circuits by setting up simple logic circuits. • Combinational Logic Circuits: Use of TTL adder, multiplexer and decoder. • Sequential building blocks • Digital to Analog and Analog to Digital Conversion • Sampling and Reconstruction of Continuous-Time Signals and Interpolation with Decimation. • Implementation of a (4 X 4) multiplier using registers and a down counter. • MOSFET inverting amplifiers and first-order circuits • Introduction to VHDL and FPGA • Electronics Project
Suggested Books	Reference Books 5. Wakerly, *Digital Design: Principles And Practices*, Pearson India; 4th edition (2008) ISBN: 978-9332508125 6. S. Salivahanan, S. Arivazhagan, *Digital circuits and design*, Oxford University Press; Fifth edition, (2018), ISBN: 978-0199488681 7. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, McGraw-Hill, 4th edition, (2017), ISBN: 978-9352601943 8. J. Millman, A. *Grabel, Microelectronics*, McGraw Hill Education, 2nd edition, (2017), ISBN: 978-0074637364

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course Code	**PH 252 / AA 252**
Title of the Course	**Scientific Computing Lab**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (0-0-2-1)**
Name of the department	**Physics**
Pre–requisite, if any	None
Objectives of the course	To familiarize students with Object-Oriented Programming language, data structures, and their application in Physics-specific problems.
Course outcomes	Student will be able to learn to apply computational techniques for Physics problems using a model programming language in vogue
Course Syllabus	• Introduction to Object-Oriented Programming (OOP), using a model language such as Python. • Object types, numbers, strings, lists, arrays, dictionaries, tuples, files, I/O handling. Statements and syntax, expressions, loops, iterations. • Basic functions, arguments, recursive functions, modules, module packages. Introduction to class and OOP, Error & exceptions handling. • Data structure and data handling. Efficient array handling using standard libraries. Scientific computing and problem solving, Integrating Fortran/C++ code with Python, as a model language. • Application of the model language to solve Physics problems
Suggested Books	Textbook: 4. A. K. Gupta, *Scientific Computing in Python*, Techno World Publishers, (2021) ISBN: 978-81-949567-6-1 Reference Books: 5. M. Lutz, *Learning Python: Powerful Object-Oriented Programming (5th edition)*, Cambridge University Press; (1989), ISBN: 978-1449355739 6. A. K. Gupta, *Python Computing: Fundamentals and Applications,* Techno World, (2023), ISBN: 978-93-92145-55-1

Course Code	**PH 214**
Title of the Course	**Classical Field Theory**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Basic classical mechanics, Lagrange formalism
Objectives of the course	Exposing the students to certain advanced concepts in Classical Mechanics.
Course outcomes	The students will learn • To describe the dynamics of continuous systems using Lagrangian formalism. Potential applications include but are not limited to description of propagation of waves in an elastic medium. • To make a natural precursor to Quantum Field Theory.
Course Syllabus	• **Introduction to Lagrangian density and fields:** Transition from discrete to continuous mechanical systems, Wave propagation, Concept of field and Lagrangian density, Euler-Lagrange equation for fields. • **Symmetries and conservation laws:** External and Internal symmetries, Conserved currents, Stress-energy tensor, Gauge transformations in classical field theory. • **Hamiltonian density:** Momentum density, Functional derivatives, Hamiltonian density, Poisson bracket in terms of functional derivatives, Fourier expansion of fields and Creation and Annihilation operators. • **Examples of classical field theories:** Schrodinger field, Scalar field theories (Klein-Gordon, Sine-Gordon, and Higgs field theories), Dirac field theory, Vector field theories, Electrodynamics as an example of a massless vector field theory, Proca Lagrangian and massive vector fields.
Suggested Books	Textbook: 1. H. Goldstein, C. P. Poole and J. L. Safko, *Classical Mechanics (3rd edition)*, Addison Wesley, (2001), ISBN: 978-0-201-65702-9 Reference books: 2. D. Morin, *Introduction to Classical Mechanics*, Cambridge Univ. Press, (2009), ISBN: 978-0521185028

	3. L. D. Landau, E. M. Lifshitz, *Course of Theoretical Physics - Vol. 2 (4th edition)*, Elsevier, (1987), ISBN: 978-0750627689 4. J. R. Taylor, *Classical Mechanics*, University Science Books, (2004), ISBN: 978-1891389207

Course Code	**PH 215**
Course Title	**Geometrical Methods in Physics**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the Department	Physics
Pre-requisite, if any	Calculus
Scope of the course	Introducing students to some geometrical concepts used in Physics. This is primarily aimed at students who are inclined towards mathematical aspects of physics and will require geometrical concepts in their study.
Expected outcome	Students should learn some geometric techniques which are useful in theoretical and applied physics such as high energy physics and condensed matter physics
Course Syllabus	**Curves:** Plane and Space curves; Parametrization; Osculating plane; Curvature, torsion and Frenet frame **Extrinsic Geometry of Surfaces:** Parametrization; Tangent plane; Regular surfaces; Orientability; First and second fundamental forms; Normal and Principal curvature; Gaussian and Mean curvature; Gauss-Codazzi equation; Theorem Egregium **Intrinsic Geometry of Surfaces:** Covariant derivative of vector field; Parallel transport; Geodesics; Gauss Bonnet theorem; Application to Plane, Spherical and hyperbolic geometry **Topological Ideas:** Notion of topological spaces; Closed, compact and connected spaces; Topological invariants; Notion of homology and homotopy; Examples from 2D surfaces; Concept and examples of Minkowski functional; Use of softwares such as SnapPy, PolyTop etc. to study the topology and geometry of surfaces **Differential forms in Physics:** Definition of differential forms, sums and products of differential forms; Exterior derivative; Integration of differential forms; Example from electromagnetism **Asymptotic Methods:** Method of stationary phase; Method of steepest descents; Uniform asymptotic expansions; Asymptotic expansion of multiple integrals
Suggested References	**Textbooks:** 1. Bernard Schutz, *Geometrical Methods of Mathematical Physics*, Cambridge University Press (1999), ISBN: 9780521298872 2. M Nakahara, *Geometry, Topology and Physics* (2nd edition), Taylor and Francis (2003). ISBN: 9780750306065 **Reference books:**

	3. John McCleary, *Geometry from a differentiable viewpoint*, Cambridge University Press (1994). ISBN: 9780521133111 4. Norman Bleistein, Richard A. Handelsman, *Asymptotic expansions of integrals*, Dover Publication (1986), ISBN: 9780486650821 5. Thomas F. Banchoff, Stephen Lovett, *Differential Geometry of Curves and Surfaces* (3rd edition), CRC Press (2023). ISBN: 9781032047782 6. Richard Courant, Fritz John, *Introduction to Calculus and Analysis*, Volume II (4th edition), Springer (2005), ISBN: 9781461389606

Course Code	**PH 216**
Course Title	**Accelerator Physics**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the Department	**Physics**
Pre-requisites	Basic Electromagnetic theory
Objectives of the course	To familiarize students in accelerator physics
Course Outcomes	Student will be able to understand: ● Different aspects of Linear accelerator, cyclotron, synchrotron ● Applications of accelerators
Course Syllabus	• Introduction to accelerators: History of accelerators. Basic principle of DC and Radio Frequency (RF) accelerators. Accelerators in India. Application of accelerators in basic research, medicine, industry. • Linear Accelerator: Principle of Linear accelerator, Principle of Radiofrequency Quadrupole (RFQ). • Cyclotron: Basic principle of cyclotron, Synchrocyclotron, Betatron tunes • Synchrotron and Radiation Source: Basic principle of Synchrotron, Electron and ion Synchrotron, Synchrotron radiation source, Total radiated power, Properties of Synchrotron radiation, Insertion devices. • Concepts of van de Graff, Cyclotron and Linear Accelerator (LINAC), Synchrocyclotron, Radio Frequency (RF) field and particle acceleration, Storage Ring, • Colliders and Fixed target Experiments, Luminosity, Cross-sections, concept of event triggering
Suggested References	Textbook: 1. M.S. Livingston and J.B. Blewett, *Particle Accelerators*, McGraw-Hill Inc, US (1962), ISBN: 978-0070381407 2. H. Wiedemann, *Particle Accelerator Physics*, Fourth Edition, Springer (2015). ISBN: 978-1013270468 Reference Book: 3. K. Wille *The Physics of Particle Accelerators: An Introduction*, Clarendon Press, (2001), ISBN: 978-0198505495 4. S. Humphries, *Principles of Charged Particle Acceleration*, J. Wiley (1986), ISBN: 978-0486498188 5. J. J. Livingood, *Principles of Cyclic Particle Accelerators*, Van Nostrand, NJ (1961), ISBN: 978-0442048228

Course Code	**PH 218**
Course Title	**Introduction to General Relativity**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	Physics
Pre-requisites, if any	Classical Mechanics
Scope of the course	This course is an introductory course to the theory of general relativity, their various applications and classical tests.
Course Outcomes	The student will be able to understand any gravitational set up and perform calculations related to various measurements or effects related to them.
Course Syllabus	Review of Special Theory of Relativity: Covariant formalism Metric tensor; One forms; Tensors of general rank; Energy momentum tensor, Perfect fluids; Conservation laws General coordinate transformations; Tangent manifold; Derivative of general tensors; Christoffel symbols Manifolds; Covariant derivatives and connection; Parallel transport; Geodesics; Riemann, Ricci and Einstein tensors; Weak field limit; Killing vectors; Einstein equations; Linearized equations; gravitational waves Gravitational redshift; Schwarzschild metric; Particle motion; Light bending
Suggested references	**Textbooks:** 1. B. Schutz, *A first course in general relativity* (2nd edition), Cambridge University Press (2009), ISBN: 9780521887052 2. S. Carlip, *General relativity: A concise introduction*, Oxford Univ. Press (2019), ISBN: 9780198822165 **Reference books:** 3. J. Hartle, *Gravity*, Pearson Education (2014), ISBN: 9789332535084 4. Christian Boehmer, *Introduction to general relativity and cosmology*, World Scientific (2016), ISBN: 9781786341181

	S. P. Puri, *General theory of relativity*, Pearson education (2013), ISBN:9788131795682 5. S. Carroll, *Spacetime and Geometry*, Cambridge Univ. Press (2019) ISBN:978-1108488396

Course Code	**PH 301**
Title of the Course	**Nuclear Science and Engineering**
Course Category	**Core**
Credit Structure	**L-T- P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Nil
Objectives of the course	To introduce students with the concepts and important developments in our understanding of nucleus and elementary particles and their interactions.
Course Outcomes	● Familiarity with different nuclear models and properties of Nucleus ● Learn the working principle of different kinds of detectors and their applications. ● Exposure to different elementary particles
Course Syllabus	• **Nuclear Properties through experiments:** Rutherford scattering, Basic nuclear properties: size, shape, charge distribution, spin and parity; Binding energy, Nature of the nuclear force, form of nucleon-nucleon potential; Charge- independence and charge-symmetry of nuclear forces; Deuteron problem • **Nuclear Models:** Liquid drop model, semi-empirical mass formula; Electric and magnetic moments; Fermi gas model of nucleus; nuclear shell model; Collective model • **Radioactivity:** Radioactive decays, Gamow model, Fermi theory and Selection rules, Electromagnetic transitions in nuclei multipole radiation • **Fission and Fusion:** Fission Reactors, Fission explosives, Controlled Fusion reactor. • **Detectors and Accelerators:** Gas filled counters, Scintillation detectors, Semiconductor detectors, Linear Accelerator (LINAC), Cyclotron and synchrotron accelerators, Mass spectroscopy with accelerators, Accelerators in medical science. • **Elementary Particles:** Classification of fundamental forces; Elementary particles (quarks, baryons, mesons, leptons); quark model; Symmetries and Conservation laws; Spin and parity assignments, isospin, strangeness, Gell-Mann-Nishijima formula; C, P, and T invariance and applications of symmetry arguments to particle reactions, parity non-conservation in weak interaction
Suggested Books	Textbooks: 1. K. S. Krane, *Introductory Nuclear Physics*, Wiley, (2022) ISBN: 978-9354640834 2. B. R. Martin *Nuclear and Particle Physics: An Introduction*, Wiley, (2009), ISBN: 978-0470742754 Reference Books: 3. W. S. C. Williams, *Nuclear and Particle Physics*, Oxford University Press, USA, (1991) ISBN: 978-0198520467 4. A. Das and T. Ferbel, *Introduction to Nuclear and Particle Physics*, World Scientific Publishing Company, (2003) ISBN: 978-9812387448

	5. D. Griffiths, *Introduction to Elementary Particles*, Wiley-vch Verlag Gmbh, (2008), ISBN: 978-3527406012

Course code	**PH 303**
Title of the course	**Quantum Mechanics**
Course Category	**Core**
Credit structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisites	Non-relativistic quantum mechanics
Objectives of the course	The students will be introduced to more concepts and some important applications of quantum mechanics
Course Outcomes	Students will be able to: ● Apply internal symmetry concepts to various problems. ● Apply various standard techniques to a variety of quantum problems.
Course syllabus	• Stern-Gerlach experiment, Dirac notation for state vectors. • **Quantum dynamics**: Time evolution and the Schrodinger equation, • **Theory of angular momentum**: Rotation and angular momentum commutation relations, spin ½ systems and finite rotations, SO(3), SU(2) and Euler rotations, Eigenvalues and eigenstates of angular momentum, Orbital angular momentum, addition of angular momenta, Wigner-Eckart theorem, Tensor operators. • **Approximation methods**: Time independent perturbation theory (Non degenerate case), Time-independent perturbation theory (The dependent case), hydrogen like atoms (Fine structure and Zeeman effect), Variational methods, Time dependent potentials (The interaction picture), Fermi's Golden Rule; Selection rules; Time dependent perturbation theory, Energy shift and decay width • **Identical particles:** Pauli's exclusion principle, spin-statistics connection
Suggested Books	Textbooks: 1. J. J. Sakurai and J. Napolitano, *Modern Quantum Mechanics* (3rd edition), Cambridge University Press, (2020) ISBN: 978-1108473224. 2. R. Shankar, *Principles of Quantum Mechanics*, Springer, (2011), ISBN: 978-0306447907 Reference Books: 3. J. S. Townsend, *A Modern Approach to Quantum Mechanics*, University Science Books, (2012), ISBN:978-1891389788. 4. L. Landau and L. Liftshitz, *Quantum mechanics - Vol. 3* (3rd edition), Butterworth-Heinemann, (1981) ISBN: 978-0750635394. 5. C. Cohen-Tannoudji, B. Diu and F. Laloë, *Quantum Mechanics Vol. 2*, Wiley-VCH, (2019), ISBN: 978-3527345540

Course Code	**PH 305**
Title of the Course	**Advanced Classical Mechanics**
Course Category	**Core**
Credit Structure	**L-T-P-Credits 2-1-0-3 (3/2 = 1.5) Half semester course**
Name of the department	**Department of Physics**
Pre–requisite, if any	Fundamental classical mechanics with Langrangian Formulation
Objectives of the course	This course provides advanced concepts and techniques in classical mechanics and special theory of relativity
Course Outcomes	● To solve classical problems using Hamiltonian's principle ● Learn different aspects of Canonical Transformation ● Know basics of fluid mechanics
Course Syllabus	• **Hamilton's Principle**: Calculus of variations; Hamilton's principle; Legendre transformation and Hamilton's canonical equations; Canonical equations from a variational principle; Principle of least action. Noether's theorem and conservation of charges. • **Canonical transformations**: Generating functions; example of canonical transformations; group property; Integral variants of Poincare; Lagrange and Poisson brackets; Infinitesimal canonical transformations; Conservation theorem in Poisson bracket formalism; Jacobi's identity; Angular momentum Poisson bracket relations Hamilton-Jacobi theory: The Hamilton Jacobi equation for Hamilton's principal function; The harmonic oscillator problem; Hamilton's characteristics; Action angle variables. • **Fluid Mechanics**: Kinematics of moving fluids, equation of continuity, Euler's equation, Bernoulli's theorem • **Nonlinear Dynamics:** Introduction, maps and flows, stability, phase space, fixed point analysis, logistic maps, chaos.
Suggested Books	Textbooks: 1. H. Goldstein, C. P. Poole and J. L. Safko, *Classical Mechanics (3rd edition)*, Addison Wesley, (2001), ISBN: 978-0201657029 2. J. R. Taylor, *Classical Mechanics*, Uni. Science Books, (2005), ISBN: 978-1891389221 Reference Books: 3. L. D. Landau, E. M. Lifshitz, *Course of Theoretical Physics - Vol. 1 (3rd edition)*, Butterworth-Heinermann, (1976), ISBN: 978-0750628969 4. J. B. Marion and S. T. Thornton, *Classical Dynamics of Particles and Systems (4th edition)*, Holt Rinehart & Winston, (1995), ISBN: 978-0030973024 5. E. C. G. Sudarshan, *Classical Dynamics: A Modern Perspective (1st edition)*, John Wiley & Sons, (1974), ISBN: 978-9814730013

Course Code	**PH 307**
Course Title	**Topics in Mathematical Physics**
Course Category	**Core**
Credit Structure	**L - T - P – Credits 2-1-0-3 (3/2=1.5) Half semester course**
Name of the department	**Physics**
Pre-requisite, if any	Fundamental knowledge of Differential equations and Linear Algebra
Objectives of the course	This course introduces some physics specific advanced concepts of mathematics
Course Outcomes	● Be conversant in group theory, special functions and tensors and apply these concepts in various problems.
Course Syllabus	• **Introductory Group theory**: Abelian and non-Abelian groups, discrete and continuous groups, reducible and irreducible representations, generators and Lie algebra, applications of Lie groups. • **Special functions and applications**: Legendre, Bessel, Laguerre, Hermite, Chebyshev, Hypergeometric Functions, Spherical Harmonics. • **Tensors and their applications**: Introduction to Tensors, Covariant derivative, tensor transformations and applications to geometry.
Suggested Books	Textbooks: 1. G. B. Arfken and H. J. Weber, *Mathematical Methods for Physicists* (6th edition), Academic Press, (2005), ISBN: 978-9381269558 2. K. F. Riley, M.P. Hobson and S.J. Bence, *Mathematical Methods for Physics and Engineering: A Comprehensive Guide* (3rd edition), Cambridge University Press, (2006) ISBN: 978-0521679718 Reference Books: 3. S. Hassani, *Mathematical Physics: A modern introduction to its foundations*, Springer-Verlag, (1999), ISBN: 978-0387985794 4. M. L. Boas, *Mathematical Methods in the Physical Sciences (3rd edition),* John Wiley & Sons, (2005), ISBN: 978-0471198260 5. E. Kreyszig, *Advanced Engineering Mathematics (8th edition)*, John Wiley & Sons, (2006), ISBN: 978-8126508273

Course Code	**PH 309**
Title of the Course	**Simulation Methods and Analysis**
Course Category	**Core**
Credit Structure	**L-T-P-C (2-0-2-3)**
Name of the department	**Physics**
Pre–requisite, if any	Programming Language (Fortran/C/C++/Python)
Objectives of the course	The students will learn about various computing techniques used to understand physical phenomena in various systems.
Course Outcomes	Students should be able to write their own program to apply physics principles and study processes in a diverse range of settings.
Course Syllabus	• **Statistical Analysis:** Basics of Probability and Statistics, Bayes theorem, Probability distributions, Characteristic function, Central limit theorem, error propagation, Test statistic, Type I and II errors, sampling of data, Statistical tests: Goodness of fit, statistical fitting and parameter estimation, p-value and significance, interval estimations. • **Monte Carlo (MC) Techniques:** Random number generators, sampling, importance sampling, integration, biased/unbiased Monte Carlo, Metropolis algorithm, Markov chain Monte Carlo, quantum Monte Carlo, kinetic Monte Carlo, convergence and central limit theorem, various application of Monte Carlo methods • **Classical Molecular Dynamics (CMD):** Classical force fields, Different algorithms for integrating Newton's equation of motion, stability of various solvers, pressure and temperature coupling, MD in NPT and NVT ensembles, application of CMD in condensed matter and biological systems, Application in drug discovery.
Suggested Books	Textbooks: 1. M. H. Kalos and P. A. Whitlock, *Monte Carlo Methods (2nd Edition)*, Wiley-VCH , (2008), ISBN : 978-3527407606 2. D. Frenkel, *Understanding Molecular Simulation: From Algorithms to Applications*, Academic Press, New York, (2001), ISBN : 978-0122673511 3. G. Cowan, *Statistical Data Analysis*, Oxford Science Publications, (1998), ISBN: 978-0198501558 Reference Books: 4. M. P. Allen, D. J. Tildesley, *Computer Simulation of Liquids (2nd Edition)*, Oxford University Press, (2017) ISBN 978-0-19-880320-1 5. D. Sholl, J. A. Steckel, *Density Functional Theory: A Practical Introduction*, Wiley-Interscience, (2009) ISBN: 978-0470373170

Course Code	**PH 351**
Title of the Course	**Engineering Physics Lab - II**
Course Category	**Core**
Credit Structure	**L-T- P-Credits (0-0-3-1.5)**
Name of the department	**Physics**
Pre–requisite, if any	Nil
Objectives of the course	To enhance experimental skills and concepts in physics by giving students exposure to a variety of different experiments
Course Outcomes	The students will be able to • Develop essential experimental skills by conducting a variety of physics experiments in the laboratory, • Experimental verification of concepts in Fundamental Physics, Nuclear Physics, Non-linear dynamics • Evaluate the errors and statistical deviations associated with the experimental results
Course Syllabus	A representative list of experiments will be performed by students. **Fundamental Physics:** o Thermal expansion of solids o Cauchy's dispersion relations o Stefan's constant (Black body radiation) o Uncertainty principle using single slit diffraction o Dielectric constant of liquids **Nuclear Physics:** o Gamma-ray detection using the Geiger-Muller counter o Rutherford Scattering Experiment o Muon lifetime determination using a scintillator detector **Non-linear Dynamics:** o Chaos (Chua circuit) o FeigenBaum Circuit
Suggested books	Reference Books: 1. W. F. Smith, *Experimental Physics: Principles and Practice for the laboratory*, CRC Press, (2020), ISBN: 978-1498778473 2. L. Lyons, *A practical guide to data analysis for physical science students*, Cambridge Univ. Press, (1991), ISBN: 978-0415481519

Course Code	**PH 311**
Title of the Course	**Physics of Semiconductor Devices**
Course category	**Department Elective**
Credit Structure	**L-T- P-Credits (3-0-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Fundamental concepts in Solid State Physics
Objectives of the course	This course will discuss about the basics of semiconductor materials and their device physics
Course Outcome	• Basic understanding of semiconductor materials and their applications. • Understanding of various types of semiconductor devices.
Course Syllabus	• **Semiconductor Fundamentals**: General Material Properties, Crystal Structure, Crystal Growth, Carrier Modelling, Semiconductor Models, Intrinsic and Extrinsic Semiconductor, Carrier Properties, State and Carrier Distribution, Equilibrium, Carrier Concentrations, Carrier Action: Drift, Diffusion, Recombinations-Generation, Equations of State. • **Basics of Device Fabrication and p-n Junction**: Fabrication Process, Device Fabrication Examples, p-n Junction: p-n Junction Electrostatics, I-V Characteristics, Junction Breakdown Mechanisms, Homo- and Hetero-Junctions. • **Metal-Semiconductor Contacts**: Schottky Barrier Diodes, Current Transport in Schottky Diodes, I-V Characteristics, Ohmic Contacts. • **MOS Structure**: Ideal MOS Structure, Energy Band Diagrams under Accumulation, Depletion, and Inversion Conditions, C-V Characteristics, MOSFET, basics about the operation of a MOSFET, I-V relationships of a MOSFET. • **Optoelectronic Devices**: Basics of Solar Cells, Light-Emitting Diodes, Lasers, and Photodetectors.
Suggested Books	Textbooks: 1. S. M. Sze, *Physics of Semiconductor Devices*, 3rd edition, Wiley, (2008) ISBN: 9788126517022 2. D. A. Neamen, *Semiconductor Physics and Devices*, 3rd edition, Tata Mcgraw Hill, (2017) ISBN: 978-007-0529-05-1 Reference Books: 3. R. F. Pierret *Semiconductor Device Fundamentals* 1st edition, Pearson, (2006) ISBN 978-8177589771 4. J. W. Orton, *The Story of Semiconductors*, Oxford University Press, (2008), ISBN: 9780191565441

Course Code	**PH 313**
Title of the Course	**Quantum Transport Theory and Simulations**
Course Category	**Elective**
Credit Structure	L-T- P-Credits (2-0-2-3)
Name of the Department	Physics
Pre–requisite, if any	Linear algebra and ordinary differential equations, Python Programming, Fundamental Quantum Mechanics
Objectives of the course	This course will introduce the key concepts of quantum transport in nanoscale/mesoscale electronic devices
Course Outcome	• Analyze quantum effects and phenomena applicable in a given nano-electronic device. • Acquire an overview of the present status of the field of nanophysics/quantum technologies.
Course Syllabus	• **Boltzmann Transport Equation**: Time-Relaxation Approximation, Linearized Approximation, Numerical solutions by discretization and Monte-Carlo simulations, Semiclassical transport and its Quantum corrections (with 3 Lab classes) • **Transport in nano-structures**: Distribution functions, Density of states, Ballistic conductors, Landauer Buttiker formula, Quantized conductance, Single-particle Green's functions formulation, Self-energies, Spin-polarized transport (with 3 Lab classes) • **Quantum transport Phenomena**: Quantum Hall effect, Weak-localization, Universal conductance fluctuations, Aharonov-Bohm effect, Spin-Orbit coupling • **Advanced formalism**: Correlation functions , Non-equilibrium density matrix: Simulations, Inflow and outflow, Inelastic flow, Coulomb blockade/Kondo resonance, Simulations of Non-equilibrium Green's function (NEGF) formalism and its application to nanowire transport (with 6 Lab classes)
Suggested Books:	Textbooks: 1. S. Datta, *Lessons from Nanoelectronics: A New Perspective on Transport*, Worlds Scientific, Singapore, (2018), ISBN: 978-981-4335-28-7 2. S. Datta, *Quantum Transport: Atom to Transistor*, Cambridge Press, (2005), ISBN: 9781139164313 Reference Books: 3. M. Lundstrom, *Fundamentals of Carrier Transport*, Cambridge Press, (2000), ISBN-13. 978-0521631341 4. J. H. Davies, *The Physics of Low-Dimensional Semiconductors*, Cambridge Press, (2006), ISBN: 0-521-48148-1. 5. D. Frenkel, *Understanding Molecular Simulation: From Algorithms to Applications*, Academic Press, New York, (2001), ISBN-13 : 978-0122673511

Course Code	**PH 315**
Title of the Course	**Advanced Quantum Mechanics**
Course Category	**Department Elective**
Credit Structure	**L - T - P - Credits (2-1-0-3)**
Name of the Department	**Physics**
Pre-requisite, if any	Basics of Quantum Mechanics and Mathematical Physics
Objectives of the course	Exposing the students to various advanced aspects of Quantum Mechanics.
Course Outcomes	• The students will learn several advanced concepts in Quantum Mechanics, which have important applications in atomic and nuclear physics research.
Course Syllabus	• **Scattering theory:** Formal theory of scattering in Quantum Mechanics, Lippman-Schwinger equation, Scattering amplitude and differential cross-section, Born approximation, Application for Coulomb scattering, Partial wave analysis, Phase shift and scattering length, Scattering resonances and Breit-Wigner shape, Form factors and their applications. • **Symmetries in Quantum Mechanics:** Symmetry and degeneracy in Quantum Mechanics, Discrete symmetries, Parity transformation, Time reversal and need for anti-unitary operators. • **Relativistic Quantum Mechanics:** Relativistic Hamiltonian and Klein-Gordon equation, Negative energy solutions, Dirac equation, gamma matrices and their properties, spin and helicity, Dirac bilinears, Covariance of Dirac equation, Weyl spinors, Charge conjugation and Majorana equation.
Suggested Books	Textbooks: 1. J. J. Sakurai and J. Napolitano, *Modern Quantum Mechanics*, Third Edition, Cambridge University Press, (2020), ISBN: 9781108587280 2. J. D. Bjorken and S. D. Drell, *Relativistic Quantum Mechanics*, First Edition, Primis, (2008), ISBN: 978-0072320022 Reference Books: 3. W. Greiner and B. Muller, *Quantum Mechanics (Symmetries),* Second Edition, Springer, (1994), ISBN: 978-3-642-57976-9 4. J. J. Sakurai, *Advanced Quantum Mechanics*, Pearson, (1967) ISBN: 978-0201067101 5. R. Shankar, *Principles of Quantum Mechanics*, Second Edition, Springer (2011) ISBN: 978-0306447907

Course Code	**PH 317**
Title of the Course	**Data Analysis in High Energy Physics**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisite, if any	Nil
Objectives of the course	To familiarize students in relativistic kinematics and data analysis of High Energy Physics.
Course Outcomes	The student will know various technical concepts used to describe motion of relativistic particles
Course Syllabus	• **Review of special theory of relativity:** Lorentz Transformations, concept of four vectors, proper time, natural units, transformation from laboratory to center of momentum frame, concepts of rapidity, pseudo rapidity, decay kinematics, Lorentz Invariants, Two and three body decay processes, phase space. • **Analysis Framework:** Review of Object-oriented programming C++ and Python, Analysis Framework: ROOT- CERN, 1D, 2D, 3D Histograms, Graphs, Fitting, Physics with three and four vectors, Tree: concept of reading and writing data in columnar • Review of Statistical analysis • **Monte Carlo Techniques:** Generation of Toy Monte Carlo Sample, Unbinned Maximum Likelihood Fit • **Machine learning applications in High Energy Physics data:** Enhancement of signal to noise ratio, identification of electron and photon accelerator Physics clusters in electromagnetic calorimeter through image processing.
Suggested Books	Textbooks: 1. P. R. Bevington and D. K. Robinson, *Data Reduction and Error Analysis for the Physical Sciences*, McGraw-Hill, (2002), ISBN-10: 0072472278 2. R. Hagedorn, J. D. Jackson, D. Pines, *Relativistic Kinematics: A Guide to The Kinematic Problems of High Energy Physics*, Literary Licensing LLC, (2012), ISBN: 978-1258264369 Reference Books: 3. G. Cowan, *Statistical Data Analysis*, Oxford Science Publications, (1998), ISBN: 978-0198501558 4. J. R. Taylor, *An Introduction to Error Analysis The Study of Uncertainties in Physical Measurements (2nd edition)*, University Science Books, (1997) ISBN: 9780935702750 5. Richard Fernow, *Introduction to Experimental Particle Physics*, Cambridge University Press, (1989) ISBN: 0521379407

Course Code	**PH 302**
Title of the course	**Cooperative Phenomena in Solids**
Course Category	**Core**
Credit structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisites	Basic Knowledge of Quantum Mechanics and Electricity & Magnetism
Objectives of the course	This course aims to provide an in-depth introduction to collective phenomena in solids as well as their applications
Course Outcomes	Students will develop an understanding of the fundamentals of various exotic properties displayed by solids.
Course syllabus	• **Fermi Surfaces and Metals:** Construction of Fermi Surfaces, Calculation of Energy Bands, De Haas-Van Alphen effect and Shubnikov–De Haas Oscillations, Landau levels. • **Spontaneous Coherence in Matter:** Superconductivity, Phonon-Mediated Cooper Pairing Mechanism, brief introduction to BCS theory, Flux quantization, Single particle tunneling, Type–I, Type–II superconductors, D.C and A.C Josephson effect; Introduction to Bose–Einstein Condensation and Superfluidity. • **Magnetism:** Para- and Ferro- magnetism, Ising Model, Magnetic Structures, Langevin theory of diamagnetism, Pauli Paramagnetism, Quantum mechanical considerations – Ferromagnetism, Domain wall energy, GMR in multilayers. • **Quasiparticles in Condensed Matter Physics:** Introduction to Plasmons, Polaritons and Polarons: Dielectric function of Electron gas, Mott Metal–Insulator Transition, Electron–electron interaction, Electron–Phonon interaction • **Optical processes in solids:** Complex dielectric function and refractive index of solids, Optical Reflectance, Absorption, Kramer-Kronig Relations, Excitons, Band-gap determination from optical spectra, Band – Band transitions, Band gap renormalization, Impurity levels – shallow and deep states, Optoelectronic devices • **Dielectrics and Ferroelectrics:** Dielectric constant and Polarizability, Structural Phase transitions, Ferroelectric Crystals, Displacive Transitions and theory of ferroelectric phase transition, Antiferroelectricity, Ferroelectric domains, Piezoelectric effect and other applications of ferroelectrics.
Suggested Books	Textbooks: 1. C. Kittel*, Introduction to Solid State Physics* (India Edition), Wiley India, (2019) ISBN: 9788126578436. 2. Ashcroft and Mermin, *Solid State Physics*, Thomson Press (India) Ltd. (2021), ISBN: 9780030839931 Reference Books: 3. D. W. Snoke, *Solid State Physics Essential Concepts*, Cambridge University Press, (2008) ISBN: 9781107191983 4. A. J. Dekker, *Solid State Physics*, MacMillan India Ltd. (2008),

	ISBN : 978-0333918333 5. M. A. Omar, *Elementary Solid-State Physics: Principles and Applications* (1st Edition), Pearson Education, (2002), ISBN: 978-8177583779

Course Code	**PH 304**
Title of the Course	**Fundamentals of Statistical Mechanics**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Basic knowledge of thermal physics
Objectives of the course	This course imparts analytic techniques in classical and quantum statistical mechanics
Course Outcomes	● The students should get well versed with partition function and various related concepts. ● They should be able to differentiate between various regimes of validity and properties of quantum and classical ensemble of particles
Course Syllabus	• **Formulation of thermodynamics using generalized coordinates:** Thermodynamic laws and potentials, approach to equilibrium and stability analysis, Gibbs-Duhem relation, generalized Maxwell's equations. • **Statistical tools:** Probability theory, random variables, moments and cumulants, probability distributions, Wick's theorem, sums of random variables and the central limit theorem, Illustrative applications in: Rules for large numbers, Information theory and Shannon entropy. • **Kinetic theory of gasses:** Concept of phase space, Liouville's theorem, Boltzmann equation. • **Classical statistical mechanics:** Micro-canonical ensemble, two-level systems, ideal gas, mixing entropy and Gibbs paradox, canonical ensemble, Gibbs canonical ensemble, grand canonical ensemble, limitations of classical statistical mechanics and thermal wavelength. • **Interacting particles:** Cluster expansion, van der Waals equation and Virial coefficients, introduction to mean-field theory. • **Quantum statistical mechanics:** Quantum macrostates and density matrices, Liouville's theorem using density matrix. • **Ideal quantum gases:** Identical particles, canonical and grand canonical formulations, non-relativistic gas, degenerate Fermi and Bose gases, superfluidity of Helium.
Suggested Books	Textbooks: 1. M. Kardar, *Statistical Physics of Particles*, Cambridge University Press. (2007) ISBN: 978-0521873420. 2. R. K. Pathria and P. D. Beale, *Statistical Mechanics* (4th edition), Academic Press, Elsevier. (2021) ISBN: 978-9351073970. Reference Books:

	3. K. Huang, *Statistical Mechanics* (2nd edition), John Wiley & sons. (2021) ISBN: 978-9354247736. 4. J. P. Sethna, *Statistical mechanics: entropy, order parameters, and complexity* (2nd edition), Oxford University Press. (2006) ISBN: 978-0198865254. 5. D. Chandler, *Introduction to Modern Statistical Physics*, Oxford University Press. (1987) ISBN: 978-0195042771.

Course Code	**PH 306**
Title of the Course	**Atomic and Molecular Spectroscopy**
Course Category	**Core**
Credit Structure	**L-T- P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Basic Knowledge of Quantum Mechanics and Mathematics.
Objectives of the course	To make the students to understand the physics of atomic and molecular structure and spectra, which are essential in terms of knowledge development in basic science and its applications.
Course Outcomes	Students will be able to ● Develop a solid foundation in atomic and molecular physics, preparing students for advanced study or careers in physics, chemistry, or related fields. ● Acquire problem-solving skills specific to atomic and molecular systems, enhancing analytical thinking and application of theoretical concepts to practical scenarios.
Course Syllabus	• **Fundamentals of spectroscopy:** Principles and instrumentation. • **Review of atomic structure of Hydrogen:** Atomic structure of two electron system, Many electron atoms; Central field approximation, Fine and Hyperfine structure: The interaction Hamiltonian, Selection rules, Effect of external magnetic field. • **Many-electron atom:** Central field approximation Slater determinant, L-S and j-j coupling, Equivalent and nonequivalent electrons, Energy levels and spectra, Spectroscopic terms, Hund's rule, Landé interval rule, Alkali spectra. • **Molecular Electronic States:** Concept of molecular potential, Separation of electronic and nuclear wavefunctions, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Electronic angular momenta, The LCAO approach, States for hydrogen molecular ion, Coulomb, Exchange and Overlap integral, Symmetries of electronic wavefunctions, pi and sigma bond; • **Rotation and Vibration of Molecules:** Centrifugal distortion, Symmetric top molecules, Molecular vibrations: Harmonic oscillator and the anharmonic oscillator approximation, Morse potential, Molecular rotation/vibration and microwave/infrared spectroscopy. • **Spectra of Diatomic Molecules**: Transition matrix elements, Vibration-rotation spectra, Electronic transitions, Franck-Condon principle, Dissociation energy of molecules, Raman transitions and Raman spectra, Vibration of Polyatomic Molecules: Application of Group Theory.
Suggested Books	Textbooks: 1. B. H. Bransden and C. J. Joachain, *Physics of Atoms and*

	Molecules, Pearson Education Limited, Second edition (2003), ISBN: 978-0582356924 2. C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, McGraw-Hill College (1994), ISBN: 978-9352601738 Reference Books: 3. D. C. Harris, M. D. Bertolucci, *Symmetry and Spectroscopy – An Introduction to Vibrational and Electronic Spectroscopy*, Oxford University Press, USA, Dover publications (1989), ISBN: 978-0486661445 4. J. M. Hollas, *Modern Spectroscopy*, Wiley (2004), ISBN: 978-0470844168 5. G. M. Barrow, Introduction to Molecular Spectroscopy, McGraw-Hill, (1962), ISBN: 978-0070038707

Course Code	**PH 352**
Title of the Course	**Solid State Physics Lab**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (0-0-3-1.5)**
Name of the department	**Physics**
Pre–requisite, if any	None
Objectives of the course	Students will gain exposure to experimental and theoretical aspects of Solids State Physics
Course Outcomes	The students will be able to • Relate the concepts or phenomena learnt in solid state physics to physical systems via experimental learning. • Operation of different advanced instruments, handling of the data analysis and evaluation of the errors and statistical deviations associated with the experimental results.
Course Syllabus	A representative list of experiments will be performed by students: **Optical processes in solids** • Demonstration of Photoluminescence in solids **Structural and morphological studies on solids:** • Understanding the concept of grain boundary and grain-size in polycrystalline solids using force/electron microscopy **Optoelectronic devices:** • IV- Characteristics of a silicon solar cell • Temperature-dependent Hall effect • Characterization of Light Emitting Diode **Dielectric/Magnetic measurement on Solids:** • Measurement of Magnetoresistance of Bismuth • Magnetic hysteresis loop tracer • Study of dielectric constant and Curie temperature of ferroelectric ceramics • Magnetic susceptibility of paramagnetic substance using Gouy's method • Frequency dependence of dielectric constant **Computational Assignments:** • Computational design of 2D layer materials • Theoretical design principle of bulk materials. • The equilibrium geometry, electronic structure and thermodynamic potential computations.
Suggested books	Reference Book: 1. M. I. Pergament, *Methods of experimental physics*, CRC Press, 2019, ISBN: 978-0367866426

Course Code	**PH 356**
Title of the Course	**Spectroscopy Lab**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (0-0-3-1.5)**
Name of the department	**Physics**
Pre–requisite, if any	None
Objectives of the course	Students will gain practical exposure to the field of spectroscopy through experiments
Course Outcomes	The students will be able to • Carry out advanced experiments in Atomic and Molecular Spectroscopy. • Understand the utilization of various energy ranges of the *EM*-radiation in detecting the various atomic and molecular processes.
Course Syllabus	A representative list of experiments will be performed by students: • Demonstration of Electron Spin Resonance effect • Demonstration of Zeeman effect • Fine structure of Sodium • Demonstration of NMR effect • Study of thermoluminescence of F centers • Demonstration of Raman effect • Understanding molecular vibrations using FTIR • Determination of valance state of atoms using X-ray Absorption Spectroscopy
Suggested books	Reference Book: 1. M. I. Pergament, *Methods of experimental physics*, CRC Press, (2019), ISBN: 978-0367866426

Course Code	**PH 312**
Title of the Course	**Solar Photovoltaics: Fundamentals, Technologies and Applications**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Fundamental concepts around semiconductors and devices
Objectives of the course	This course will discuss the applied physics of solar energy conversion
Course Outcomes	Students will develop a thorough understanding of ● the fundamental concepts of semiconductor physics, the working principles and characterization of photovoltaic devices, and different generations of photovoltaic technologies. ● Students will be proficient in applying mathematical concepts and techniques to solve problems related to semiconductor physics and photovoltaic devices.
Course Syllabus	• **Fundamental concepts in semiconductor physics:** p and n-type semiconductors, doping and carrier concentration, diffusion and drift of carriers, continuity equation, P-N junction and its properties, *I-V* characteristics of a p-n junction under dark • **Working principle of a photovoltaic device and its characterization:** p-n junction as a solar cell, I-V characteristics of a p-n junction under illumination (concepts of Voc, Jsc, FF, Eff), parameters affecting the photovoltaic device performance (absorption coefficient, carrier mobilities, carrier diffusion lengths, carrier-generation/recombination mechanisms and rates, traps states etc.), Shockley-Queisser limit on the performance of a single junction solar cell, • Solar spectrum and Air Mass, Solar simulators and spectral mismatch, Characterization techniques for PV devices: EQE, LBIC etc. • **Different Generations of photovoltaic devices and their fabrication:** A brief history of Photovoltaic devices, single crystal, polycrystalline and amorphous Silicon solar cells, Thin film solar cells- CIGS, CdTe solar cells, Emerging PV technologies: Organic, DSSC, Hybrid perovskite, Quantum Dot solar cells. Overcoming SQ limit using multijunction solar cells. • **Current status of PV technologies:** Lab cells vs Modules, Fabrication of Modules and issues surrounding their operation. • **Advanced Applications of PV technologies:** Solar to hydrogen, Solar thermal approaches etc.
Suggested books	Textbooks: 1. J. Nelson, *The Physics of Solar Cells*, Imperial College Press (2003), ISBN: 978-1860943492

	2. P. Wurfel, *Physics of Solar Cells: From Basic Principles to Advanced Concepts* Wiley-VCH, (2009) ISBN: 978-3527413126 Reference books: 3. S. M. Sze and Kwok. K. Ng, *Physics of Semiconductor Devices*, Wiley, (2008), ISBN: 978-8126517022 4. R. F. Pierret *Semiconductor Device Fundamentals* 1st edition, Pearson, (2006) ISBN 978-8177589771

Course Code	**PH 314**
Title of the Course	**Introduction to Quantum Field Theory**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Relativistic Quantum Mechanics, General theory of relativity
Objectives of the course	The students will learn unified framework and techniques of relativistic field theory.
Course Outcomes	The students will be able to calculate amplitudes and probabilities of a variety of physical processes.
Course Syllabus	• **Canonical quantization:** Canonical quantization of free and interacting fields, relativistic normalization, S-Matrix, Dyson's formula, Wick's theorem. • **Feynman Diagrams:** Introduction to Feynman diagrams, Connected and amputated diagrams, Decay rates and scattering cross section, Vacuum bubbles, From Green's functions to S-matrices. • **Quantization of fermions:** Spinors, Dirac equation, Chiral spinors, Fermion quantization, Feynman rules for fermions, Scattering involving fermions. • **Quantum Electrodynamics:** Quantization of the electromagnetic field and its coupling to matter, Charged scalars, Feynman rules for QED, Scattering in QED.
Suggested Books	Textbooks: 1. M. Peskin and a D. Schroeder, *An Introduction to Quantum Field Theory*, Addison-Wesley, (1995) ISBN: 9780201503975 2. A. Lahiri and P. B. Pal, *A First Book of Quantum Field Theory*, Narosa, (2007), ISBN: 978-8173196546 Reference books: 3. M. D. Schwartz, *Quantum Field Theory and the Standard Model*, Cambridge University Press, (2013), ISBN: 978-1107034730 4. A. Zee, *Quantum Field Theory in a Nutshell*, 2nd Edition, Levant Books, (2012), ISBN: 9789380663425 5. M. Maggiore, *A Modern Introduction to Quantum Field Theory*, Oxford University Press, (2004), ISBN : 978-0198520740

Course Code	**PH 316**
Title of the Course	**Group Theory in Particle Physics**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Mathematical Physics
Objectives of the course	The students will be introduced use of symmetry in the context of Particle Physics
Course Outcomes	The students will learn how to use Group Theory to construct mathematical models describing fundamental physics.
Course Syllabus	**Review of Group theory:** constructing multiplication tables, direct product, homomorphism, isomorphism, permutation group, invariant subgroup, simple group, continuous groups, rotation group and Lie algebra, SO(3), SU(2) and SU(3), general properties of SU(N). **Applications for Particle Physics:** • SU(3) of flavor, isospin as a subgroup, U and V spins, roots and weights, hadron multiplets, Gell-Mann Okubo mass formula, Young tableaux. • Lorentz group, connection with spin, Dirac, Majorana and Weyl spinors. • Nonabelian gauge theory, SU(2)xU(1) --> U(1) breaking. • Accidental symmetries of the Standard Model, Baryon and Lepton number conservation, Custodial symmetry. • Grand Unification and SU(5), from SU(5) to SO(10). • Applications of groups in flavor model building, Froggatt- Nielsen mechanism.
Suggested Books	Textbooks: 1. A. Zee, *Group Theory in a Nutshell for Physicists*, Princeton Univ. Press, (2016) ISBN: 978-0691162690 2. Georgi, *Lie algebras in Particle Physics*, Sarat, 2nd Edition, (2009) ISBN: 978-8190806428 Reference Books: 3. J. Schwichtenberg, *Physics from Symmetry*, Second Edition, Springer. (2017) ISBN: 9783319192017 4. P. B. Pal, *A Physicist's Introduction to Algebraic Structures*, First Edition, Cambridge University Press. (2019) ISBN: 9781108729116 5. A. Das, *Lie groups and Lie algebras for Physicists*, Hindustan Book Agency, (2014), ISBN: 978-9380250632

Course Code	**PH 318**
Title of the Course	**Introduction to String Theory**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Relativistic Quantum Mechanics, General Theory of Relativity
Objectives of the course	The students will be introduced to the basic frameworks of string theory
Course Outcomes	The students will gain understanding and outlook of various research topics in string theory
Course Syllabus	• Introduction to strings, Problems with quantizing gravity and comparison with other approaches, Notion of Effective Field Theory. • String dynamics. Nambu-Goto and Polyakov action, Various gauge choices, Worldsheet conformal field theory, Bosonic strings in 26 dimensions. • Types of string theory, Spectrum of string theory. • Introducing fermions, Supersymmetric strings in 10 dimensions. • D-branes, Higher form gauge fields, Introduction to M-theory. • Applications of string theory in many body physics, quantum information theory and low-energy effective field theory.
Suggested Books	Textbooks: 1. B. Zwiebach, *A first course in string theory*, Cambridge University Press, (2nd Ed.), (2009) ISBN- 978-0521880329 2. K. Becker, M. Becker, J. Schwarz, *String Theory and M-Theory: A Modern Introduction* Cambridge University Press, (1st Ed.), (2006) ISBN- 978-0521860697 Reference Book: 3. E. Kiritsis, *String Theory in a Nutshell*, Princeton University Press, 2nd Edition, (2007), ISBN : 978-0691155791

Course Code	**PH 320**
Title of the Course	**Physics of the Early Universe and Dark Matter**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Introductory general theory of relativity, Knowledge of the Standard Model of Particle physics.
Objectives of the course	Applications of the Standard Model of Particle Physics in cosmology, followed by introduction to dark matter and its importance
Course Outcomes	• It will enable students to work in the interface of cosmology and particle physics. • Familiarity with on-going research on dark matter with an exposure to the particle nature of dark matter
Course Syllabus	• Homogeneous Isotropic Universe, Robertson-Walker metric, redshift and luminosity distance, Friedmann equations, time evolution of the Universe, thermodynamics in the expanding Universe, Primordial nucleosynthesis, Photon decoupling, CMB power spectrum, Neutrino freeze-out, • Cosmological model with dark matter and dark energy, phase transitions in the early universe, generation of baryon asymmetry, aspects of Inflation. Application of the Standard Model of particle physics and physics beyond it in cosmology. • Experimental evidence of dark matter, Direct and indirect searches, Particle nature of dark matter, Hot and cold thermal relics, Various candidates: WIMPs, axions, etc.
Suggested Books	Textbooks: 1. V. A Rubakov, D. S. Gorbunov, *Introduction To The Theory Of The Early Universe*: *Hot Big Bang Theory*, WS Professional; Second edition, (2011) ISBN: 978-9813209886 2. S. Profumo, *An Introduction to Particle Dark Matter*, World Scientific, (2017) ISBN:978-1786340016 Reference Books 3. S. Weinberg, *The First Three Minutes: A Modern View Of The Origin Of The Universe*, Basic Books, (2022), ISBN: 978-0465024377 4. E. Kolb and M. Turner, *The Early Universe*, Taylor & Francis, (1994) ISBN: 978-1138329904 5. S. Dodelson and F. Schmidt, *Modern Cosmology*, Academic Press Inc; 2nd edition, (2020), ISBN: 978-0128159484

Course Code	**PH 308 / PH 408**
Title of the Course	**Experimental and Theoretical Aspects of Heavy Ion Collisions**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Relativistic Kinematics, Nuclear Physics
Objectives of the course	Students will understand theoretical and experimental aspects of understanding quark gluon plasma
Course Outcomes	Students will learn: ● Different models of QGP ● Space Time evolution of heavy ion collision ● Different experimental Facilities ● Signatures of QGP
Course Syllabus	• Introduction to Heavy ion collisions and quark gluon plasma • **Review of Relativistic kinematics**: Lorentz transformation: frequently used reference frames, four vector notation, rapidity and pseudo-rapidity variables, light cone variables, collision and decay, relativistic invariants • **Thermodynamics**: Relativistic gas (hadrons, quarks and gluons) and its statistical and thermodynamical properties, MIT Bag model, Hagedron gas, phase diagram of QCD, criteria for formation of QGP in the laboratory • **Collision dynamics**: different stages of space-time evolution like pre-equilibrium, formation of • QGP, chemical and thermal equilibria, freeze-out and particle production; Bjorken's model for energy density; • **Experiments**: a general overview of past, present and future experimental facilities dedicated to search for QGP, data analysis technique, extraction of 4 momentum, control variables (centrality, root(s), system size) • **Signals of QGP:** Global Observable: Multiplicity, ET, Ef, (pseudo) Rapidity, Pt distributions: explanations of various regions and connections with particle production mechanism; Correlations and fluctuations; Collective flow: radial, directed, elliptic and higher order flow harmonics extraction and interpretations; Heavy quark and quarkonia suppression, strangeness enhancement, jet quenching and electromagnetic signals (photon and di-lepton).
Suggested Books	Textbooks: 1. C. Y. Wong, *Introduction to High-Energy Heavy-Ion Collisions*, World Scientific, (1994), ISBN: 978-9810202644 2. A. K. Chaudhuri, *A Short Course on Relativistic Heavy Ion Collisions*, IOP Publishing, (2014), ISBN: 978-0-750-31061-1l Reference Books:

	3. S. Sarkar, H. Satz, B. Sinha, *The Physics of the Quark-Gluon Plasma: Introductory Lecture*, Springer, (2010), ISBN: 978-3642261923 4. R. Fernow, *Introduction to Experimental Particle Physics*, Cambridge University Press, (2010), ISBN:978-0521379403 5. B. Sinha, S. Pal, S. Raha, *Quark-Gluon Plasma*, Springer-Verlag, (2012) ISBN: 978-3540519843

Course Code	**PH 322**
Title of the Course	**Introduction to Quantum Information and Computation**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-0-2-3)**
Name of the department	Physics
Pre–requisite, if any	Basics of Quantum Mechanics, Linear algebra
Objectives of the course	To understand the basics of quantum information and computation and solve problems.
Course Outcomes	Students will develop an understanding on basics of quantum information, quantum entanglement, quantum computation, and quantum communication protocols.
Course Syllabus	• **Preliminaries:** Overview of classical information, computation, and complexity classes. • **States and operators:** Axioms of quantum mechanics; Qubit systems; Concept of mixed states – density operators. • **Composite systems:** Entanglement in pure states; Local operation and classical communication; Entanglement in mixed states; Peres-Horodecki criterion of severability. • **Measurement and operations:** Orthogonal (higher rank) and generalized (POVM) measurements; Quantum operations, noise, and channels. • **Quantum gates and circuits for computation:** single and multi-qubit gates; universal gates; basic quantum circuit diagrams. • **Entropy and information:** Shannon entropy, Basic properties of entropy, Von Neumann entropy, Strong subadditivity. • **Quantum communication:** No-cloning theorem, Quantum teleportation, Quantum dense coding.
Suggested Books	Textbook: 1. M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information: 10th Anniversary Edition*, Cambridge University Press, Cambridge, (2010). ISBN: 978-1107002173. Reference books: 2. D. Bruss (Editor), G. Leuchs (Editor), *Quantum Information: From Foundations to Quantum Technology Applications (2nd edition)*, Wiley-VCH, Germany, (2019) ISBN: 978-3527413539. 3. M. Wilde, *Quantum information theory*, Cambridge University Press, Cambridge, (2013) ISBN: 978-1107034259.

Course Code	**PH 402 / PH 616**
Title of the Course	**Principles and Applications of Optical Spectroscopy**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-0-2-3)**
Name of the department	**Physics**
Pre–requisite, if any	Laser Physics course and Engineering Electromagnetics, Fundamental Quantum Mechanics
Objectives of the course	Students will learn the principles of different optical spectroscopic techniques and the applications of these techniques in investigations of optical, optoelectronic and vibrational properties of materials. The students will be introduced to the optoelectronic parts of various spectroscopic techniques.
Course Outcome	• Modern tool usage: Develop skills to use optoelectronics and spectroscopic techniques. • Engineering knowledge: Develop understanding of working of optoelectronics. • Life-long learning: Develop an aptitude for research on optoelectronic materials and devices.
Course Syllabus	• Light and matter interactions, Basic principles of optics • Working principles of optoelectronics for spectroscopy: Applications of lasers in spectroscopy, Linear and nonlinear optics, Modulators, Photodetectors, Polarizers, Gratings, Birefringent, and Waveguides. • Spectroscopic techniques, physical parameters and their significance, and applications: Atomic spectra, Rotational spectroscopy, Vibrational spectroscopy, Electronic spectroscopy, Ultraviolet visible spectroscopy, Raman and micro-Raman spectroscopy, Fourier Transformed Infrared Spectroscopy, Steady state and time-resolved Photoluminescence Spectroscopy, Ultrafast Optical Spectroscopy. • Experiments: Based on the abovementioned spectroscopic techniques
Suggested books	Textbooks: 1. J. Wilson, J. Hawkes, *Optoelectronics: An Introduction*, 3rd Ed., Prentice Hall Europe, (1998), ISBN: 978-0136384953 2. H. Kuzmany, *Solid-State Spectroscopy 2nd Ed*.: Springer (2009), ISBN: 978-3540639138 Reference books: 3. M. F. Vitha, *Spectroscopy: Principles and Instrumentation,* Wiley, (2019), ISBN:978-1-119-43664-5 4. S. S. Jha, *Perspectives in optoelectronics,* World Scientific (1995), ISBN: 978-9810220228 5. S. Agnello, *Spectroscopy for Materials Characterization,* John Wiley & Sons, (2021) ISBN: 9781119697329