Indian Institute of Technology Indore

Curriculum and Courses of Study for Bachelor of Technology: Electrical Engineering

November 2025

[After incorporating decisions of the 58th meeting of the Senate held on November 26, 2025]

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

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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

Curriculum of 2st year of BTech in CSE, EE and ME (for AY 2010-11)

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)				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**	**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	MA 106	Linear Algebra and Ordinary Differential Equations-I	3-1-0	4
PH 104	Physics-II (Electricity and Magnetism)	2-1-0	3	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	HS 108	Fundamentals of Economics	3-0-0	3
EE 104	Basic Electrical and Electronics Engineering	2-1-0	3	EE 104	Basic Electrical and Electronics Engineering	2-1-0	3
ME 104	Basic Mechanical Engineering	3-0-0	3	ME 106	Basic Mechanical Engineering	2-1-0	3
PH 154	Physics Lab	0-0-3	1.5	PH 156	Physics Lab	0-0-3	1.5
EE 154	Basic Electrical and Electronics Engineering Lab	0-0-2	1	EE 154	Basic Electrical and Electronics Engineering Lab	0-0-2	1
ME 154	Basic Manufacturing Techniques	2-0-2	3	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	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**		**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	0-0-2	1	IC 151	Computer Programming Lab	0-0-3	1.5

	Lab						
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 (Electrical Engineering)

Semester III

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 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
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
IC 211	Experimental Engineering Lab	0-0-3	1.5
	Total	**13/12-4/5-6**	**20**

Curriculum of 2nd Year B. Tech. (EE) [From AY 2014-15 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
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
IC 211	Experimental Engineering Lab	0-0-3	1.5
	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)				**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**	**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
EE 202	Signals and Systems	3-1-0	4	EE 202	Signals and Systems	3-1-0	4
EE 204	Analog Circuits	3-0-0	3	EE 204	Analog Circuits	2-1-0	3
EE 206	Electrical Machines and Power Electronics	3-0-0	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	Basic 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)				**Curriculum of 3rdYear 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 xxx	HSS Course	3-0-0	3	ZZXXX HS XXX	Course-III for Minor Program * HSS Elective (for 2012 batch only)	X-X-X X-X-X	3 3
EE 301	Microprocessors	3-0-0	3	EE 301N	Microprocessors and Digital Systems Design	2-1-0	3
EE 303	Probability and Random Processes	2-1-0	3	EE 303	Probability and Random Processes	2-1-0	3
EE 305	Electromagnetic Waves	3-0-0	3	EE 305	Electromagnetic Waves	2-1-0	3
EE 307	Communication Systems	3-0-0	3	EE 307	Communication Systems	2-1-0	3
EE 309	Electrical Measurements and Instrumentation	3-0-0	3	EE 309	Electrical Measurements and Instrumentation	2-1-0	3
				EE 311	VLSI Systems and Technology	2-1-0	3
EE 351	Microprocessors Lab	0-0-3	1.5	EE 351N	Microprocessors and Digital Systems Design Lab	0-0-3	1.5
	Total	**17-1-3**	**19.5**		**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	2 – 1 - 0	3

	Design		
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 353	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	Environmental Studies: Social Aspects (Half Semester course)	3-0-0	1.5	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	ES 302	Environmental Studies: Scientific and Engineering Aspects (Half Semester course)	3-0-0	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

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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 352	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.	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				

						6. Last Date of Submission of Grades: 2nd week of Dec.		
		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 XXX	Course-V for Minor project/field study/white paper/domain comprehension (Seminar)/Lab course	x-x-x	2
ZZ 493N	B. Tech Project (BTP)	0-0-32	16
ZZ 495 ZZ XXX	Internship **OR** Professional/ Societal-Connect basket course	x-x-x	1.5
	Total		**17.5/19.5**

Semester VIII

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 2019-20]			
Course Code	**Course Title**	**Weekly L-T-P**	**Credits**		**Course Code**	**Course Title**	**Weekly L-T-P**	**Credits**
EE xxx	Department Elective – II	x-x-x	3		ZZ xxx	Elective-I	x-x-x	3
EE xxx	Department Elective - III	x-x-x	3		ZZ xxx	Elective-II	x-x-x	3
EE xxx	Department Elective - IV	x-x-x	3		ZZ xxx	Elective-III	x-x-x	3
EE xxx	Department Elective - IV	x-x-x	3		ZZ xxx	Elective-IV (or Course-IV for Minor Program *)	x-x-x	3
XX xxx	Institute Elective – II	x-x-x	3		ZZ xxx	Elective-V (or Course-V for Minor	x-x-x	3

EE 492	B. Tech. Project (Stage 2)	0-0-12	6
		Total	**21**

	Program *)		
	Total		**15**
Curriculum of 4th 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 218 : Synchronous and Special Electrical Machines (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 318 : Statistical and Experimental Design Methods for Signal Processing (2-1-0-3)

EE 401/ EE 601 : Power Electronics

EE 409/EE 609 : Power System Modelling (2-1-0-1.5)

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 449/EE 649 : Power System Stability (2-1-0-1.5)

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 456 /EE 656 : Deregulated Power Systems (2-1-0-1.5)

EE 463/663 : Design of Electric Motors (2-1-0-1.5)

EE 459/EE 659 : Linear Systems Theory (2-1-0-1.5)

EE 460/EE 660 : Microgrids and Distributed Generation (2-1-0-1.5)

EE 464 /EE 664 : Optimal and Adaptive Control (2-1-0-1.5)

EE 466/EE 666 : Electromagnetic Interference and Compatibility (2-1-0-1.5)

EE 468/EE 668 : Game Theory and Mechanism Design (2-1-0-3)

EE 470/ EE 670 : Brain Signal Processing (2-1-0-3)

EE 472/ EE 672 : Human-Centric Multimedia Quality Analysis(2-1-0-3)

EE 467/667 : Cyber Resiliency in Smart Grid (2-1-0-1.5)

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

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

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	AA 301: High Energy Astronomy

			HS 315: Sociology of Science and 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	CH 301: Functional	HS 311: Life and Thought of Gandhi	AA 301: High Energy

	Molecular Biology	Materials	HS 313: History of Early Cinema HS 315: Sociology of Science and Technology HS 323: International Economics HS 341: Appreciating Indian English Literature	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	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	AA 201: Introduction to Astronomy

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 213: Cognitive Psychology 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	HS 418/ 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 HS 431: Innovation and Intellectual Property Rights	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 HS 446: Music and Literary Modernism HS 481/ HS 681: Language, Mind and Society	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	AA 201: Introduction to Astronomy

				HS 205: Sociology HS 221 Fundamentals of Linguistics HS 223 Language Variation: Culture and Society	
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 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
5th : 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
6TH : Minor 4			HS 325: Industrial Organization	HS 315: Sociology of Science and Technology HS 328 Philosophy and Film HS 330 Graphic Literature	

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
Electrical Engineering Courses

Course Code	**ES 302** [from AY 2010-11 onwards]
Title of the Course	**Environnemental Studies: Scientific and Engineering Aspects**
Credit Structure	L-T-P-Credits 3-0-0-1.5 **(Half Semester Course)**
Name of the Concerned Department	Multi-disciplinary
Pre–requisite, if any	None
Scope of the course	
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.
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	**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 202**
Title of the Course	**Signals and Systems**
Credit Structure	L-T-P-Credits 3-1-0-4
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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
Suggested Books	1. R.F. Ziemer, W.H. Tranter, and D.R. Fannin, **Signals and Systems: Continuous and Discrete** (4^{th} 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.

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 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 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**, 3th 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 205**
Title of the Course	**Introduction to Electrical Systems**
Credit Structure	L-T-P-Credits 3-1-0-4
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

Course Code	**EE 206**
Title of the Course	**Electrical Machines and Power Electronics**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

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 Outcomes	Introduction to the construction and working principles of various Electrical Machines
Scope of the course	• Foundation for Electrical Machines and three-phase systems • Analysis of the various types of Electrical machines
Course Syllabus	• 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 208**
Title of the Course	**Digital Systems**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.)
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.

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 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 212**
Title of the course	**Basic 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 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 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 218**
Title of the course	**Synchronous and Special Electrical Machines**
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 understanding of Electrical machines
Scope of the course (Objectives)	• Understanding the operational characteristics, construction, performance, and control of synchronous machines. • Insights of special machines: Switched reluctance machines, BLDC (brushless DC) machines, Synchronous reluctance machines, Permanent magnet Synchronous machines, and Stepper motors.
Course Outcomes	1. Analysis, working principles, and basic control ideas of synchronous and special machines. 2. Design and performance analysis of machines for specific applications. 3. Model and simulate machine performance using modern software tools.
Course Content	**Part 1: Synchronous Machines:** Construction, types, and operating principles: **Module - 1: Synchronous Generators:** Armature and field excitation windings, model with standard parameters, equivalent circuit, phasor diagrams, voltage regulation, power-angle characteristics, the effect of change of excitation, short circuit transient analysis of synchronous generator, parallel operation, a synchronous generator connected to infinite bus system. **Module - 2: Synchronous Motors:** Starting, hunting, damper windings, control methods. **Part 2: Special Machines:** Basic operation, construction and working principles, speed - torque characteristics, converter circuits and control:

	Module - 3: Reluctance Machines: with winding details, inductance relations and equivalent circuits. **Module - 4: Permanent Magnet (PM) Machines:** BLDC machines, PM synchronous machines (PMSM) and Stepper motors.
Suggested Books	**Text Books:** 1. I. J. Nagrath, and D. P. Kothari**, Electric Machines**, 5th edition, Tata McGraw Hill, India, 2017, ISBN: 935260640X. 2. S. J. Chapman, **Electric Machinery Fundamentals,** 4th edition, McGraw Hill Education, 2017, ISBN: 978-0071070522. 3. J. P. Desai, **Special Electrical Machinery,** 1st edition, Wiley-Scrivener, 2024, ISBN: 978-1394193615. **Reference Books:** 4. P. C. Krause, **Analysis of Electric Machinery and Drive Systems,** 3rd edition, Wiley-IEEE Press, 2013, ISBN: 978-1118024294. 5. R. Krishnan, **Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications,** 1st edition, CRC Press, 2001, ISBN: 978-0849308383. 6. K. Venkataratnam, **Special Electrical Machines,** 1st edition, Universities Press, 2008, ISBN: 978-8173716317.

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 book** 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 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 253**
Title of the Course	**Electronic Devices Lab**
Credit Structure	L-T-P-Credits 0-0-3-1.5
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
Suggested Books	Same as the associated theory course on Electronic Devices

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 Book** 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 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 256**
Title of the Course	**Electrical Machines Lab**
Credit Structure	L-T-P-Credits 0- 0-4-2
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
Suggested Books	Same as the associated theory course EE 206

Course Code	**EE 258**
Title of the Course	**Digital Systems Lab**
Credit Structure	L-T-P-Credits 0-0-3-1.5
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
Suggested Books	Same as the associated theory course EE 208: Digital Systems

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 301**
Title of the Course	**Microprocessors**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	Digital Systems Course
Scope of the course	
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.
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.

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 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 303**
Title of the Course	**Probability and Random Processes**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

Course Code	**EE 304/CS 404**
Title of the Course	**Digital Signal Processing**
Credit Structure	L-T-P-Credits 3-1-0-4
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	Signals and Systems Course
Scope of the course	
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.
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.

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 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

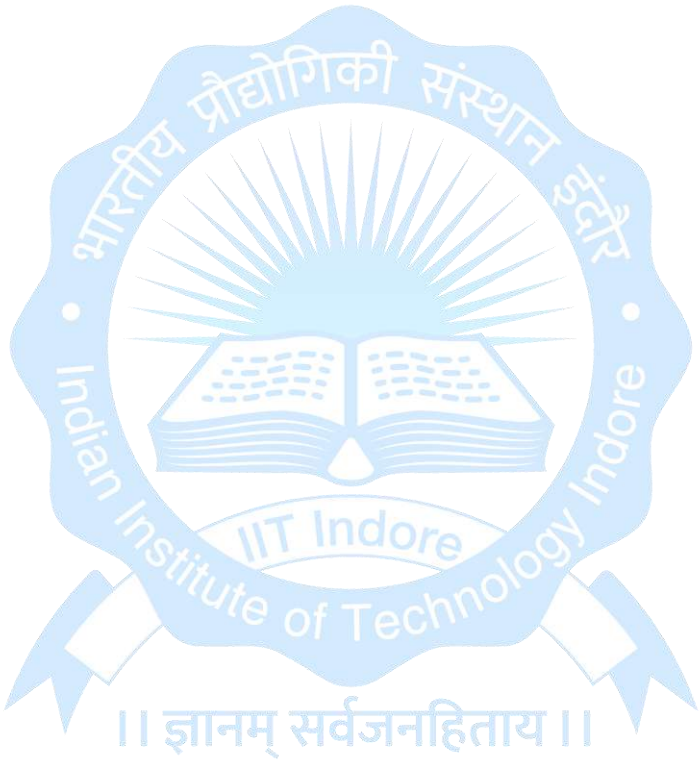
	Reference Books 3. J. G. Proakis, **Digital Communications**, 4th edition, McGraw Hill, 2000. ISBN: 978-0071181839.

Course Code	**EE 307**
Title of the Course	**Communication Systems**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

Course Code	**EE 308**
Title of the Course	**Power Systems**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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
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.

Course Code	**EE 309**
Title of the Course	**Electrical Measurements and Instrumentation**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.


भारतीय प्रौद्योगिकी संस्थान इंदौर
Indian Institute of Technology Indore
IIT Indore
।। ज्ञानम् सर्वजनहिताय ।।

Course code	**EE 310**
Title of the course	**VLSI Systems and Technology**
Course Category	Core
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.)

	The list of tentative experiments for the practical component is provided below: RTL Based • Design and Simulation of Basic Logic Gates. • Design of 4-bit Arithmetic Circuits. • Design of Data Routing Circuits. • Sequential Elements – Latches and Flip-Flops. • Shift Register and Counter Design. • Finite State Machine and ALU Design. • CMOS based • I–V Characteristics of NMOS and PMOS Transistors. • CMOS Inverter Design, Simulation, and Layout (Schematic to GDSII). • Design and Simulation of Combinational Logic Circuits. • Sequential Circuits – Latches and Flip-Flops. • SRAM Memory Cell Design and Analysis. Each of the experiments will be accompanied with assignments.
Suggested Books	**Text Books** 1. N. H. E. Weste and D. M. Harris, **CMOS VLSI Design: A Circuit and Systems Perspective**, 4th edition, Pearson, Addison-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 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 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 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** 1. M. Shahidehpour and M. Alomoush, **Restructured Electrical Power Systems: Operation, Trading and Volatility**, CRC Press, 2001, ISBN: 9781138582330. 2. L. Philipson and H. L. Willis, **Understanding Electric Utilities and Deregulation**, CRC Press,

	2005, 2nd edition, ISBN: 978-0824727734. 3. S. A. Khaparde and A. R. Abhyankar, **Restructured Power System**, Alpha Science International Ltd, 2015, ISBN: 978-1842653111. **Reference Books** 4. K. Bhattachrya, M. Bollen and J. Daalder, **Operation of Restructured Power Systems**, Springer, 2001, 1st edition, ISBN: 978-1461355670. 5. L. L. Lai, **Power System Restructuring and Deregulation**, Wiley, 2001, ISBN: 47149500X.

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 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** 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. C. A. Balanis, **Antenna Theory: Analysis and Design**, John Wiley and Sons, 2005, ISBN: 978-0471667827. **Reference Books** 4. S. Y. Liao, **Microwave devices and circuits**, Pearson, ISBN: 8177583530. 5. D. K. Misra, **Radio-frequency and Microwave Communication Circuits**, 2nd edition, John Wiley and Sons, 2004, ISBN: 9780471478737.

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 318**
Title of the course	**Statistical and Experimental Design Methods 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	None
Course Objectives	The course aims to introduce students to statistical reasoning, data analysis techniques, and the principles of experimental design with problems involving signals and images. The objectives are to: ● Familiarize students with the nature, structure, and variability of signal and image data. ● Develop an understanding of statistical methods for data summarization, inference, and modeling. ● Enable students to design experiments and to analyze and interpret results with statistical rigor.
Course Outcomes	On successful completion of the course, students will be able to: ● Represent, visualize, and summarize datasets using appropriate statistical and computational tools. ● Apply hypothesis testing, regression, and ANOVA methods to analyze and interpret different types of data. ● Design statistically sound experiments and draw rigorous, evidence-based conclusions from the results.
Course Content	**Review of Statistics and Probability** ● Introduction to various applications of statistical and experimental design methods in signal processing, including sensor data, biomedical signals, images, simulation outputs, experimental measurements, survey data ● Data formats, metadata, sampling rates ● Measurement error, variability, reproducibility ● Role of statistics in engineering research ● Data summarization and visualization ● Revision of basic probability concepts **Statistical Inference and Hypothesis Testing** ● Sampling methods and sampling error ● Point & interval estimation (confidence intervals for mean/proportion)

	● Hypothesis testing: z-test, t-test, chi-square test ● Type I/II errors, p-values, power of test ● ANOVA (one-way and two-way), F-test, post-hoc comparisons ● Multiple comparisons correction (Bonferroni, FDR) ● Correlation and covariance between variables **Experiment Design, Advanced Topics, and Applications** ● Principles of experimental design: randomization, replication, blocking ● Randomized Block, Latin Square, and 2^n Factorial Designs ● Interaction effects and two-way ANOVA in designed experiments ● Introduction to non-parametric tests (Wilcoxon, Kruskal-Wallis) ● Introduction to Survival Analysis (Kaplan-Meier curves) ● Applications of statistical methods and experimental design methods for signals and images such as ECG, EEG, MRI, Ultrasound. Short, guided tutorials and assignments using computational tools and software packages to utilize the statistical techniques learnt in each of the modules for analyzing different data types.
Suggested Books	**Text Books** 1. D. C. Montgomery, Design and Analysis of Experiments, Wiley; ISBN: 9781119492443. 2. W. W. Daniel, and C.L. Cross, Biostatistics: A Foundation for Analysis in the Health Sciences, Wiley, 2018; ISBN: 9781119496571. 3. Jay L. Devore, Probability and Statistics for Engineering and the Sciences, Cengage India Pvt. Ltd.; ISBN: 9789353506247. **Reference Books** 4. R.E. Walpole, R.H. Myers, S.L. Myers and K. Ye, Probability and Statistics for Engineers and Scientists, Pearson Education, ISBN: 9788119896646. 5. S. K. Yadav, S. Singh and R. Gupta, Biomedical Statistics: A Beginner's Guide, Springer Verlag, ISBN: 9789813292963.

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** 2. L. Kleinrock, **Queueing Systems, Volume I: Theory: 1**, 1st Edition, Wiley-Interscience, 1975, ISBN: 9780471491101. 3. D. Bertsekas, and R. Gallager, **Data networks,** 2nd Edition**,** Prentice Hall India Learning Private Limited, 1992, ISBN: 978-8120307803. **Reference Books** 4. S.K. Bose, **An introduction to queueing systems**, 1st Edition, Springer Science and Business Media, 2002, ISBN: 978-1-4615-0001-8. 5. J.F. Shortle. J. M. Thompson, D. Gross., and C.M. Harris **Fundamentals of queueing theory,** 2018, John Wiley and Sons, ISBN: 9781118943526. 6. 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 351**
Title of the Course	**Microprocessors Lab**
Credit Structure	L-T-P-Credits 0- 0-3-1.5
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
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.
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
Suggested Books	Same as the associated theory course EE 301: Microprocessors

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

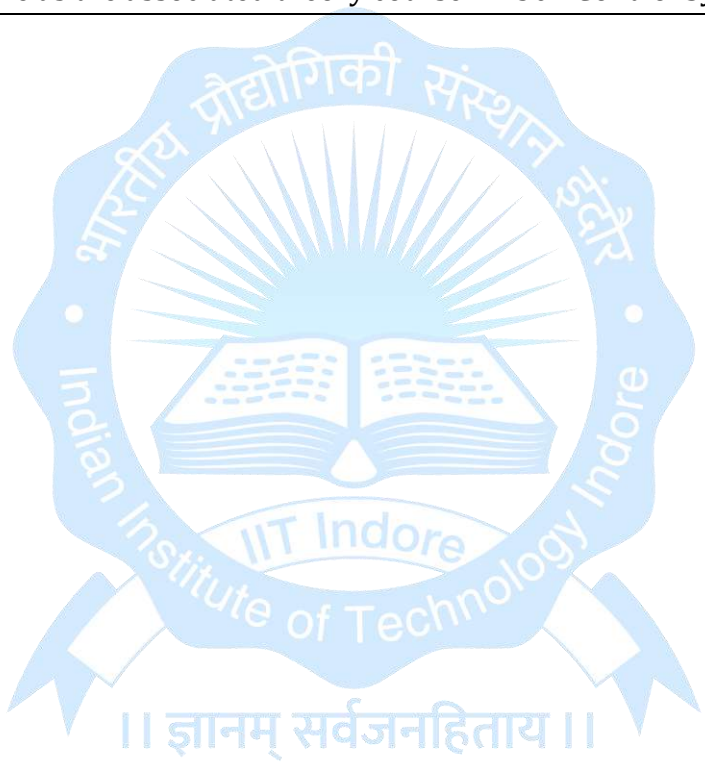
	prototypes. • Interconnection On-chip Buses: basic architecture, topologies, arbitration and protocols, Bus standards like AMBA. Network-onchip: Architecture-topologies-switching strategies - routing algorithms - flow control. • SOC implementation Study of processor IP, Memory IP, wrapper Design - Real-time operating system (RTOS), Peripheral interface and components, High-density FPGAs - EDA tools used for SOC design. SoC testing.
Suggested Books	**Text Books** 6. 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. 7. M. J. Flynn, W. Luk, **Computer system Design: System-onChip**, Wiley-India, 2011, ISBN: 978-0-470-64336-5. 8. S. Pasricha, N. Dutt, **On Chip Communication Architectures: System on Chip Interconnect**, Morgan Kaufmann Publishers.1st edition, 2008, ISBN-13: 9780123738929. **Reference Books** 9. W. H. Wolf, **Computers as Components: Principles of Embedded Computing System Design**, Elsevier, 2008, 2nd edition, ISBN:9780080886213. 10. P. Schaumont, **A Practical Introduction to Hardware/Software Co-design**, Springer, 2012. 2nd edition, ISBN:9781461437369. 11. W. Wolf, **Modern VLSI Design: IP Based Design**, Prentice-Hall India, 4th edition, 2009, ISBN: 978-0137145003.

Course code	**EE 353**
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 352**
Title of the Course	**Control Systems Lab**
Credit Structure	L-T-P-Credits 0-0-3-1.5
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	
Scope of the course	
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
Suggested Books	Same as the associated theory course EE 302 Control Systems



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 356**
Title of the Course	**Communications Lab**
Credit Structure	L-T-P-Credits 0-0-3-1.5
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
Suggested Books	Same as the associated theory course EE 306: Digital Communications

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**, 4th edition, McGraw Hill, 2000. ISBN: 978-0071181839. 4. B. P. Lathi and Zhi Ding, **Modern Digital and Analog Communication Systems** [International 4th edition, Oxford University Press, 2011, ISBN: 978-0198073802.

Course Code	**EE 401** [from AY 2010-11 to 2014-15] **EE 311** [from AY 2014-15 onwards]
Title of the Course	**VLSI Systems and Design**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

Course Code	**EE 601**
Title of the Course	**Power Electronics**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Discipline	Electrical Engineering
Pre–requisite, if any	Power electronics at UG level
Scope of the Course	
Course Syllabus	Power Switches: BJT, MOSFET, IGBT, SCR and GTO characteristics, control and protection. Electromagnetic components: Design of Inductor and Transformers. Review of Line Commutated Converters. Switched Mode Rectifiers: Circuits and Techniques. DC-DC converters: steady state analysis and dynamic modeling of DC-DC converters. Voltage Source Inverters: Single Phase Inverters, Three Phase Inverters, Multilevel Inverters, PWM strategies for Inverters. Current Source Inverters: Single phase and three phase circuit configuration. Overview of modeling and simulation of power electronic converters
Suggested Books	1. N. Mohan, T.M. Undeland & W.P. Robbins, **Power Electronics: Converter**, **Applications & Design**, John Wiley & Sons, 2007. 2. Umanand L, **Power Electronics: Essentials and Applications**, Wiley India, 2009. 3. Erickson, R.W. and Maksimovic, D., **Fundamentals of Power Electronics**, 2nd Edition, Kluwer Academic Publishers, 2002. 4. Patil M.B., Ramanarayanan V., Ranganathan, V.T., **Simulation of Power Electronic Circuits**, Narosa Publishers, 2009

Course Code	**EE 603**
Title of the Course	**Optimization Techniques**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Discipline	Electrical Engineering
Pre–requisite, if any	Nil
Scope of the Course	The objective of this course is to introduce the various types of optimization problems., their solution techniques and applications in signal processing and communications.
Course Syllabus	Fundamental concepts in optimization, optimality conditions for constrained and unconstrained problems., duality theory, various algorithms for single variable as well as multivariable unconstrained optimization problems., constrained optimization algorithms, linear programming, integer programming, geometric programming and introduction to evolutionary algorithms.
Suggested Books	1. S.S. Rao, **Engineering optimization: theory and practice** (3rd edition), John Wiley and Sons, 2009, ISBN: 978-0471550341. 2. K. Deb, **Optimization for engineering Design: algorithms and examples**, Prentice Hall India Learning Pvt. Ltd. New Delhi, 2009, ISBN: 978-8120309432. 3. A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, **Engineering Optimization: methods and applications** (2nd edition), Wiley India Pvt. Ltd., 2006, ISBN: 978-0471558149.

Course Code	**EE 403** [from AY 2010-11 to 2014-15]
Title of the Course	**Digital Systems Design**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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
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.

Course code	EE 409/ EE 609
Title of the course	**Power System Modelling**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3 (Half semester, Credits: 3/2 = **1.5**)
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basics of Power Systems
Course Objectives	• Introduces the basics of power system modelling, focusing on synchronous generators, high-power converters, transmission lines, and loads. • Students will learn to mathematically represent and analyse these components in power systems.
Course Outcomes	• Analysis and modelling of power system components. • Development and evaluation of mathematical models for power system components in different operating conditions. • Model and simulate power system components using modern software tools for detailed performance analysis.
Course Content	**Module-1: Traditional Power Systems** **Synchronous Machine:** Rotor positioned dependent model, DQ-transformation, model with standard parameters, Synchronous generator connected to infinite bus system. **Excitation and Prime Mover Systems:** Physical characteristics and models, control system components, excitation system controller, prime mover controller. **Transmission Lines and Loads:** Physical characteristics of transmission line, Type of transmission line models, Load models. **Model-2: Converter Dominated Power Systems** **High Power Converters:** Multi-level converters, control loops of converter. **Transmission Lines:** Distributed cable/lines model, frequency dependent cable/lines, AC/DC grid model.
Suggested Books	**Textbooks:** **1.** P. Kundur, ***Power System Stability and Control***. 1st edition, McGraw Hill Inc, 1995, ISBN-13: 9780070635199. **2.** P. Sauer & M. A. Pai, ***Power System Dynamics & Stability***. 1st

	edition, Prentice Hall, 1997, ISBN: 0136788300. **Reference Books:** 3. A. Iravani, R. Yazdani, ***Voltage-Sourced Converters in Power Systems***. 1st edition, Wiley-IEEE Press, 2010, ISBN: 9780470521564. 4. D. V. Hertem, O. G. Bellmunt and J. Liang, ***HVDC Grids for Offshore and Super grid of the Future***. 1st edition, Wiley-IEEE Press, 2016, ISBN: 9781118859155.

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 411**
Title of the Course	**Communication Systems Theory**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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
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.

Course Code	**EE 412/ EE 612**
Title of the Course	**Digital Communication Systems**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

Course Code	**EE 413**
Title of the Course	**Discrete Data and Digital Control**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	EE 302: Control Systems
Scope of the course	
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.
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.

Course Code	**EE 414**
Title of the Course	**Special Semiconductor Devices**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

Course Code	**EE 415**
Title of the Course	**Electronic Instrumentation**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

Course Code	**EE 416**
Title of the Course	**Industrial Instrumentation**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

Course Code	**EE 417**
Title of the Course	**Analog Filters**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

Course Code	**EE 418**
Title of the Course	**Control Systems Design**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	Control Systems
Scope of the course	
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.
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.

Course Code	**EE 419/ EE 619**
Title of the Course	**Biomedical Optics**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	Fundamentals of Electromagnetic wave theory and optics.
Scope of the course	
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.
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.

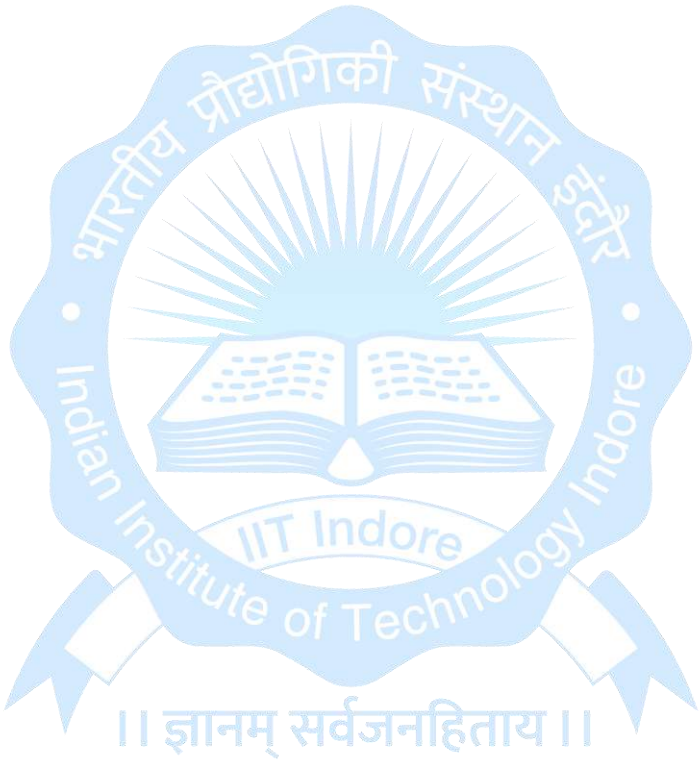
Course Code	**EE 420/ EE 220**

Title of the Course	**IC Fabrication Technology**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	
Scope of the Course	
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.
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)

Course Code	**EE 421 / 621**
Title of the Course	**MOS Devices & Modeling**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	Knowledge of basic physics of diodes, BJTs, FETs, MOS structure. Semiconductors, Junctions and MOSFET
Scope of the Course	
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.

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.



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
• Scope of the Course	• To develop the concepts of designing circuits associated with signal processing methods.
• Course Syllabus	• Understanding the fundamentals of MOS logic design. • Skills in simulation of combinational and sequential MOS logic and memories.
Suggested Books •	• 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.
	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 424/ EE 724**
Title of the Course	**Advanced Micro-processes and Nanotechnology**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering Department
Pre–requisite, if any	A course on semiconductor device physics, MOSFETs and VLSI
Scope of the Course	
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.
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.

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. • 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
Suggested Books	**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.

Course code	**EE 427**
Title of the course	**Physics of Semiconductor Devices**
Credit structure	L-T-P-Credits 2-1-0-3
Name of the concerned Department	Electrical Engineering
Pre-requisite, if any	Electronic devices
Scope of the course	
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.
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.

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 429/ EE 629**
Title of the Course	**Nanotechnology and Nanoelectronics**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	
Scope of the Course	
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
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)

Course Code	**EE 430/ EE 630**
Title of the Course	**Analog CMOS IC Design**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Department	Electrical
Pre–requisite, if any	Knowledge of MOSFET device operation, physics and technology.
Scope of the Course	
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.
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).

Course Code	**EE 431/ IEE 431/ EE 631**
Title of the Course	**Organic Electronics**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department/Discipline	Electrical Engineering
Pre–requisite, if any	Basic Semiconductor Physics/ Basic electronics
Scope of the course	
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.
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.

Course Code	**EE 432/ EE 632**
Title of the Course	**Optoelectronics**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	
Scope of the Course	
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.
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)

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 435 /EE 635**
Title of the course	**VLSI Technology**
Credit structure	L-T-P-C 2-1-0-3
Name of the concerned Department	Electrical Engineering
Pre-requisite (if any)	None
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.
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.
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).

Course Code	**EE 436**
Title of the Course	**Microwave and Satellite Communication**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	Electromagnetic Waves
Scope of the course	
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.
Suggested Books	1. R.E. Collin, **Foundations of Microwave Engineering**, (2nd edition) McGraw Hill, 1992. 2. D.M. Pozar, **Microwave Engineering**, John Wiley, 1996. 3. Pratt and Bostian, **Satellite Communication**, John Wiley International 1986.

Course Code	**EE 438**
Title of the Course	**Computer Control and Automation of Power Systems**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
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.

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 441/ EE 641**
Title of the Course	**Advanced Signal Processing**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	Signals and Systems
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.
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.
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 643**
Title of the Course	**Detection and Estimation Theory**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Discipline	Electrical Engineering
Pre–requisite, if any	Concepts of probability theory
Scope of the Course	To get familiar with statistical inference techniques for Detection and Estimation of data or signals.
Course Syllabus	**Review of Probability Theory:** Selected concepts of probability theory, random variables and stochastic processes. **Binary Decisions: Single Observation:** Maximum-likelihood decision criterion, Neyman-Pearson criterion, probability-of-error criterion, Bayes risk criterion, and min-max criterion. **Multiple Observations:** Vector observations, general Gaussian problem, waveform observations and additive Gaussian noise. **Multiple Decisions:** Bayes risk, minimum probability of error decision rule, Gaussian case, erasure decision problems. **Composite and Nonparametric Decision Theory:** Composite decisions, sign test, Wilcoxon test. **Classical Estimation Theory:** Random parameter estimation, Bayes cost method, relationship of estimators, non-random parameter estimation, CRLB, linear minimum variance and least-squares methods, multiple parameter estimation. **State Estimation:** Problem statement, Kalman filter, miscellaneous estimation techniques.
Suggested Books	1. J. L. Melsa and D. L. Cohn, **Decision and Estimation Theory**, McGraw-Hill Inc, 1978, ISBN: 978-0070414686. 2. H. L. Van Trees, **"Detection, Estimation and**

	Modulation Theory (Part I), John Wiley & Sons, 2001, ISBN: 978-0471095170. 3. S. M. Kay, **Fundamentals of Statistical Signal Processing - Estimation Theory (Vol. 1)**, Prentice-Hall, Inc., 1993, ISBN: 978-0133457117. 4. H. V. Poor, **An Introduction to Signal Detection and Estimation**, (2nd edition), Springer, 2010, ISBN: 978-1441928375.

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: 978-0471290483. **Reference Books** 3. R. Bose**, Information Theory, Coding and Cryptogr** Tata McGraw Hill Education Pvt. Ltd., 2007, ISBN: 0070151512. 4. K. Sayood, **Introduction to Data Compression**, 3rd ed Morgan Kaufmann; 2012, ISBN: 978-0124157965. 5. S. Gravano, **Introduction to Error Control Codes**, O University Press, 2001, ISBN: 978-0198562313.

Course Code	**EE 642**
Title of the Course	**Wireless Communication**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Discipline	Electrical Engineering
Pre–requisite, if any	Concepts of probability theory and communications.
Scope of the Course	To familiarize with the concepts of wireless communications and cellular systems.
Course Syllabus	**Wireless Channels:** Modelling of wireless channels, stochastic characterization and discrete-time representation, Jakes Model, Autocorrelation. **Diversity:** Realizing diversity over time, frequency, and space, code design for wireless channels, Rayleigh/ Ricean fading channels, diversity modelling for Wireless Communications, performance improvement with diversity. **Information Theory of Wireless Channels:** Entropy and mutual information, capacity of the Gaussian channel and of parallel Gaussian channels, capacity of fading channels: ergodic capacity and outage capacity, high versus low SNR regime, waterfilling capacity. **Multiple-Input Multiple-Output (MIMO) Wireless Systems:** Capacity of MIMO wireless systems; MIMO-OFDM, MIMO spatial multiplexing, space-time coding and MIMO diversity. **Cellular Communications:** Multiuser systems, multiple access and inference management, CDMA and FDMA schemes, multi-user diversity, cooperative diversity. **3G and 4G standards:** GSM, GPRS, WCDMA, LTE, WiMAX.
Suggested Books	1. D. Tse and P. Viswanath, **Fundamentals of wireless communication**, Cambridge University Press, 2005 ISBN: 978-0521845274. 2. T. S. Rappaport, **Wireless communications (**2nd edition**)**, Prentice Hall, 2002, ISBN: 978-0130422323. 3. G. L. Stuber, **Principles of Mobile Communication** (3rd

	edition), Springer International Ltd., 2011, ISBN: **978-1461403630**. 4. A. Goldsmith, **Wireless Communications**, Cambridge University Press, 2007, ISBN: 978-0521837163.

Course Code	**EE 644**
Title of the Course	**Image Processing**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Discipline	Electrical Engineering
Pre–requisite, if any	Basic knowledge of signals and systems.
Scope of the Course	The main goal of this course is to provide an overview of the concepts and algorithms for image processing.
Course Syllabus	Linearity and space-invariant property. Point spread function, image transforms and properties, sampling and quantization, 2-D systems. Image coding, image representation models, image enhancement, equalization and filtering Image restoration and reconstruction, Wiener filtering using transforms, image compression Image analysis, Spatial and transform based features, edge detection techniques, AR models and region representation, multiresoultion analysis (MRA) based techniques, segmentation and classification.
Suggested Books	1. A. K. Jain, **Fundamentals of Digital Image Processing**, Prentice Hall, 1988, ISBN: 978-0133361650. 2. R.C. Gonzalez and R.E. Woods; **Digital Image Processing**, (3/e), 2007, ISBN: 978-0131687288.

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 449/ EE 649
Title of the course	**Power System Stability**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3 (Half semester, Credits: 3/2 = **1.5**)
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basics of Power Systems
Course Objectives	• Introduces the power system stability, focusing on classification of stability, converter induced stability, analysis technique and corresponding the mitigation technique. • Students will learn to mathematically represent and analyse the components of power systems and their impact on stability.
Course Outcomes	• Analyse and model power system components, including synchronous generators, high-power converters, transmission lines, and loads, to assess their impact on system stability. • Use modern software tools to model, simulate, and analyse power system stability, enabling the identification and application of effective mitigation techniques.
Course Content	**Module-1: Traditional Power Systems** **Introduction to Power System Stability:** Classification of power system stability, concept of equilibrium, small and large disturbance stability, issues in modeling: slow and fast transients, stiff systems, modal analysis in linear system, analysis using numerical integration techniques. **Stability Issues in Interconnected Power Systems:** Single machine infinite bus system, multi-machine system, frequency stability, voltage stability, concept of load sharing, torsional oscillations. **Module-2: Converter Dominated Power Systems** **High Power Converters:** Multi-level converters, control loops of converter, converter induced stability issue. **Power System Stability Analysis Tools:** Small signal analysis program, Transient stability program, EMTP programs.
Suggested Books	**Textbooks:** 1. P. Kundur, ***Power System Stability and Control***. 1st edition, McGraw Hill Inc, 1995, ISBN-13: 9780070635199. 2. P. Sauer & M. A. Pai, ***Power System Dynamics & Stability***. 1st edition, Prentice Hall, 1997, ISBN: 0136788300.

	Reference Books: 3. A. Iravani, R. Yazdani, ***Voltage-Sourced Converters in Power Systems***. 1st edition, Wiley-IEEE Press, 2010, ISBN: 9780470521564. 4. D. V. Hertem, O. G. Bellmunt and J. Liang, ***HVDC Grids for Offshore and Super grid of the Future***. 1st edition, Wiley-IEEE Press, 2016, ISBN: 9781118859155.

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 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.

Course Code	**EE 453** [from AY 2010-11 to 2014-15]
Title of the Course	**Digital Systems Design Lab**
Credit Structure	L-T-P-Credits 0 -0-3-1.5
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	None
Scope of the course	
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.
Suggested Books	Same as the associated theory course EE 403: Digital Systems Design.

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 456/ EE 656
Title of the Course	**Deregulated Power Systems**
Course Category	Departmental Elective
Credit Structure	L-T-P-Credits 2-1-0-3 (Half semester, Credits: 3/2 = **1.5**)
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	Basics of Power Systems
Course Objectives	To provide a comprehensive understanding of various challenges in deregulated power systems and possible ways of handling them
Course Outcomes	• Understanding various operational issues in deregulated power systems • Knowledge of Indian power market and its operation.
Course Content	**Module-1:** Introduction: benefits of introducing competition in power industry, possible market entities, various types of contracts, types of electricity markets, experiences of different countries in deregulation **Module-2:** Operational Issues: Available Transfer Capability (ATC), different types of ATC, different methods of determining ATC, congestion management, different methods of congestion management, ancillary services **Module-3:** Indian Power Market: availability-based tariff, open access issues, power exchanges, renewable energy policies, renewable purchase obligations
Suggested Books	**Text Books** 1. M. Shahidehpour and M. Alomoush, ***Restructured Electrical Power Systems: Operation, Trading and Volatility***. CRC Press, 2001, ISBN: 9781138582330. 2. L. Philipson and H. L. Willis, ***Understanding Electric Utilities and Deregulation***. CRC Press,2005, 2nd edition, ISBN: 9780824727734. 3. S. A. Khaparde and A. R. Abhyankar, ***Restructured Power System***. Alpha Science International Ltd, 2015, ISBN: 9781842653111. **Reference Books**

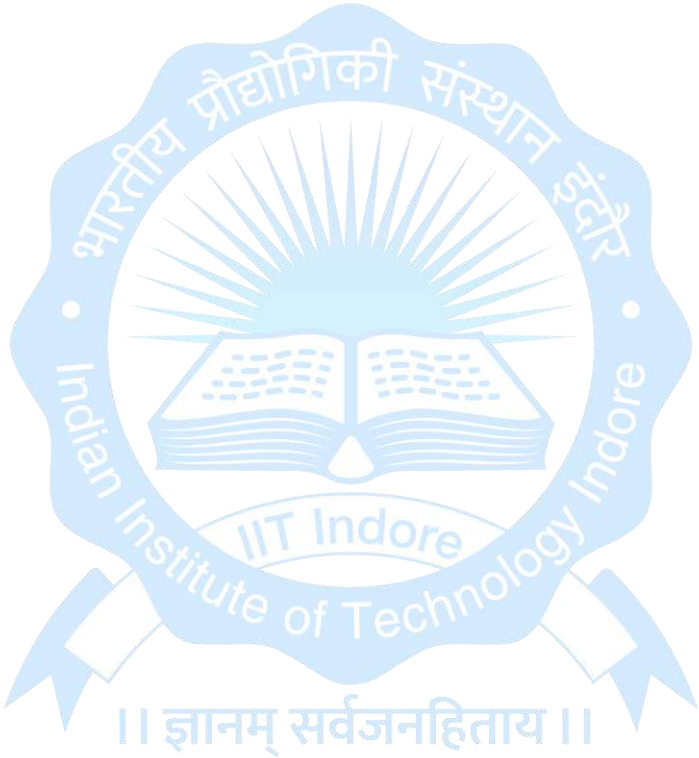
	4. K. Bhattachrya, M. Bollen and J. Daalder, ***Operation of Restructured Power Systems***. Springer, 2001, 1st edition, ISBN: 9781461355670. 5. L. L. Lai, ***Power System Restructuring and Deregulation***. Wiley, 2001, ISBN: 47149500X.

Course code	EE 4XX/ EE 6XX
Title of the course	**Design of Electric Motors**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3 (Half semester, Credits: 3/2 = **1.5**)
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basics of Electrical Machines and Electromagnetics
Course Objectives	• To understand the importance of electric motor design, including design principles, sizing equations, and density relations for various machines. • To analyze the role of design in determining machine output, torque/speed ratings, efficiency, and power density. • Understanding the concepts of thermal modelling for electric machines to ensure optimal performance and reliability.
Course Outcomes	• Generalized design concepts to analyze and design induction machines, special machines, and other electrical machines. • Design and performance analysis of machines for specific applications. • Concepts of thermal modelling of electrical motors
Course Content	**Module 1: Generalized Theory for Design of Electrical Machines** Design factors, standards, electric and magnetic loadings, volume, power density, types of windings, stator core, rotor core, etc. **Module 2: Induction Motor Design** Main dimensions with D^2L Product, design of stator and rotor cores, slot selection, winding analysis, power loss, efficiency, phase resistance, inductance, torque, speed, and realization of the complete machine datasheet. **Module 3: Design of Special Machines (SRM/BLDC/Syn-SRM)** Sizing equations, design of stator and rotor cores, machine parameters, and efficiency calculations. **Module 4: Thermal Design of Electrical Machines** Thermal issues, limits, heat transfer techniques, cooling methods and design, and thermal equivalent circuits.
Suggested Books	**Text books**

	1. T. A. Lipo, ***Introduction to AC Machine Design.*** 1st edition, Wiley-IEEE Press, 2017, **ISBN: 9781119352167.** 2. J. Pyrhonen, T. Jokinen, V. Hrabovcova, ***Design of Rotating Electrical Machines.*** 2nd Edition, John Wiley & Sons Ltd, 2013, ISBN: 9781118581575. **Reference Books** 3. R. Krishnan, ***Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications*****,** 1st edition, CRC Press, 2001, ISBN: 9780849308383. 4. I. Boldea, L. Tutelea, ***Reluctance Electric Machines: Design and Control***, 1st Edition, CRC Press, 2019, ISBN: 9781498782333

Course code	EE 459/659
Title of the Course	**Linear Systems Theory**
Course Category	Departmental Elective
Credit Structure	L – T – P – Credits 2-1-0-3 (Half semester, Credits: 3/2 = **1.5**)
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	• Basics of Control Systems • Basics of Signals and Systems
Course Objectives	This course provides a mathematically rigorous introduction to fundamental concepts in the field of linear systems theory. This course will cover concepts of linear systems, stability, controllability, observability, state feedback and observers design and serve as a necessary foundation for further study in systems and control.
Course Outcomes	• Acquiring a profound comprehension of state-space representation for linear systems and its practical applications. • Analyze stability, reachability, controllability, and observability of state-space models. • To gain expertise in the design of feedback controllers.
Course Content	**Module-1: State-Space Representation, Controllability and Observability:** State-space linear systems, Solutions to LTI systems and LTV systems, Reachability and controllability, Observability, Standard forms for uncontrollable and unobservable systems, Kalman's decomposition theorem. **Module-2: Stability and Realization Theory:** Equilibrium points and stability analysis (Lyapunov, Input-output stability, Routh-Hurwitz criterion), Relations between: State-Space & Input–output descriptions, Poles-zeros & eigenvalues; Minimal realizations. **Module-3: State Feedback and State Observers:** Linear state feedback, Eigenvalue assignment, Linear Quadratic Regulator (LQR)/LQG optimal control, Linear state observers, Full-order observers, Reduced-order observers, Optimal state estimation, Observer-based dynamic controllers.
Suggested Books	**Text Books:** 1. J. P. Hespanha, ***Linear Systems Theory***. Princeton university press, 2018, 2nd edition, ISBN 9780691179575. 2. P. J. Antsaklis, A. N. Michel, ***A Linear Systems Primer***, Birkhäuser Boston Inc, 2007, ISBN 9780817644604.

	Reference Books: 3. K. J. Astrom, R. M. Murray, ***Feedback Systems: An Introduction for Scientists and Engineers***. Princeton university press, 2020, ISBN 9780691193984. 4. T. Kailath, ***Linear Systems***. Prentice Hall International, 1998, ISBN 978-0-135369616. 5. C. T. Chen, ***Linear System Theory and Design***. Oxford University Press, 2013, 3rd edition, ISBN 9780199959570.



Course code	EE 460/ 660
Title of the course	**Microgrids and Distributed Generation**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3 (Half semester, Credits: 3/2 = **1.5**)
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basics of Power Electronics and Power Systems
Course Objectives	Impart the applications of power electronics to renewable energy integration and address the challenges in control and protection of these systems.
Course Outcomes	• Exposure to the challenges in renewable energy integration and state of the art solutions for the same • Understanding the control and energy management of microgrids using power electronics
Course Content	**Module 1: Microgrid Concept with Architectures** Concept of microgrids and distributed generation, Types and architectures of microgrids – AC, DC and hybrid, Communication requirements in microgrids **Module 2: Microgrid Modelling with Distributed Generations (DG)** Modelling of renewable energy conversion systems, Energy Storage: grid level and distributed, Ancillary services - DG Multi-functional capabilities, Virtual inertia in Microgrids **Module 3: Microgrid Control Aspects** Microgrid control architectures: Centralized, decentralized and distributed control, Converter control: Approaches and challenges, Control Strategies for multiple converters: Frequency and voltage droop control, Power sharing and stability analysis and examples in AC, DC and hybrid systems.
Suggested Books	**Text Books** 1. A. Keyhani, ***Design of Smart Power Grid Renewable Energy Systems.*** 3rd edn., Wiley-IEEE Press, 2020, ISBN: 9781119573210. 2. N. Hatziargyriou, ***Microgrids: Architectures and Control***. Wiley-IEEE Press, 2014, ISBN: 9781118720646. 3. N. Jenkins, J. Ekanayake and G. Strbac, ***Distributed Generation.*** IET Publications, 2009, ISBN: 9780863419584.

	Reference Books 4. H. Bevrani, B. François, and T. Ise. ***Microgrid Dynamics and Control***. John Wiley and Sons, 2017, ISBN: 9781119263692. 5. A. K. Pandey, S. Padmanaban, S. L. Tripathi, V. Patel, and V. Patel, ***Microgrid: Design, Optimization, and Applications*****.** CRC Press, 2024, ISBN: 9781032565767.

Course code	EE 463/ EE 663
Title of the course	**Design of Electric Motors**
Course Category	Departmental Elective
Credit Structure	L - T - P - Credits 2-1-0-3 (Half semester, Credits: 3/2 = **1.5**)
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basics of Electrical Machines and Electromagnetics
Course Objectives	• To understand the importance of electric motor design, including design principles, sizing equations, and density relations for various machines. • To analyze the role of design in determining machine output, torque/speed ratings, efficiency, and power density. • Understanding the concepts of thermal modelling for electric machines to ensure optimal performance and reliability.
Course Outcomes	• Generalized design concepts to analyze and design induction machines, special machines, and other electrical machines. • Design and performance analysis of machines for specific applications. • Concepts of thermal modelling of electrical motors
Course Content	**Module 1: Generalized Theory for Design of Electrical Machines** Design factors, standards, electric and magnetic loadings, volume, power density, types of windings, stator core, rotor core, etc. **Module 2: Induction Motor Design** Main dimensions with D^2L Product, design of stator and rotor cores, slot selection, winding analysis, power loss, efficiency, phase resistance, inductance, torque, speed, and realization of the complete machine datasheet. **Module 3: Design of Special Machines (SRM/BLDC/Syn-SRM)** Sizing equations, design of stator and rotor cores, machine parameters, and efficiency calculations. **Module 4: Thermal Design of Electrical Machines** Thermal issues, limits, heat transfer techniques, cooling methods and design, and thermal equivalent circuits.
Suggested Books	**Text books**

	5. T. A. Lipo, ***Introduction to AC Machine Design.*** 1st edition, Wiley-IEEE Press, 2017, **ISBN: 9781119352167.** 6. J. Pyrhonen, T. Jokinen, V. Hrabovcova, ***Design of Rotating Electrical Machines.*** 2nd Edition, John Wiley & Sons Ltd, 2013, ISBN: 9781118581575. **Reference Books** 7. R. Krishnan, ***Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications*****,** 1st edition, CRC Press, 2001, ISBN: 9780849308383. 8. I. Boldea, L. Tutelea, ***Reluctance Electric Machines: Design and Control***, 1st Edition, CRC Press, 2019, ISBN: 9781498782333

Course code	EE 464/ 664
Title of the Course	**Optimal and Adaptive Control**
Course Category	Departmental Elective
Credit Structure	L – T – P – Credits 2-1-0-3 (Half semester, Credits: 3/2 = **1.5**)
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	• Basics of Control Systems • Basics of Linear Systems Theory
Course Objectives	This course provides a mathematically rigorous introduction to fundamental concepts in the field of Optimal Control. This course will cover concepts of calculus of variations, Pontryagin's maximum principle, Hamilton-Jacobi-Bellman equation, Dynamic programming, LQR problems, and Model Predictive Controller.
Course Outcomes	• Learn to formulate and solve optimal control problems, including dynamic programming and the Hamilton-Jacobi-Bellman equation. • To have deep understanding of calculus of variation, Pontryagin's maximum principle and capable of addressing minimum control effort and minimum time problems.
Course Content	**Module-1: Optimization Techniques and Optimal Control Fundamentals:** Nonlinear optimization, Optimal control problems, Performance measures for the optimal control problem, Properties of optimal control solutions. **Module-2: Dynamic Programming and the Principle of Optimality:** Dynamic programming, Hamilton-Jacobi-Bellman (HJB) Equation and continuous linear regulator problems. **Module-3: Variational Methods in Optimal Control:** Functionals of a single and several independent functions, Constrained optimal control and constrained extrema, Pontryagin's maximum principle, Necessary conditions for optimality, Minimum control effort problems, Minimum time problem, Bang-bang control and applications.
Suggested Books	**Text Books:** 1. D. E. Kirk, ***Optimal Control Theory: An Introduction***. Dover Publications Inc., 2004, ISBN: 9780486434841. 2. B. P. Dimitri, ***Dynamic Programming and Optimal Control***. Vol. 1 and 2, Athena Scientific, 2007. ISBN: 9781886529083.

	Reference Books: 3. D. Liberzon, ***Calculus of Variations and Optimal Control Theory***. Princeton University Press, 2012, ISBN 978-0-691-15187-8. 4. A. Bryson and Y. C. Ho, ***Applied Optimal Control: Optimization, Estimation, and Control***. Taylor & Francis, 1975, ISBN: 9780891162285. 5. B. Anderson and J. Moore, ***Linear Optimal Control***. Prentice Hall, 1971, ISBN: 9780135368701. 6. T. Vincent and W. Grantham, ***Nonlinear and Optimal Control Systems***. Wiley, 1997, ISBN: 9780471042358.

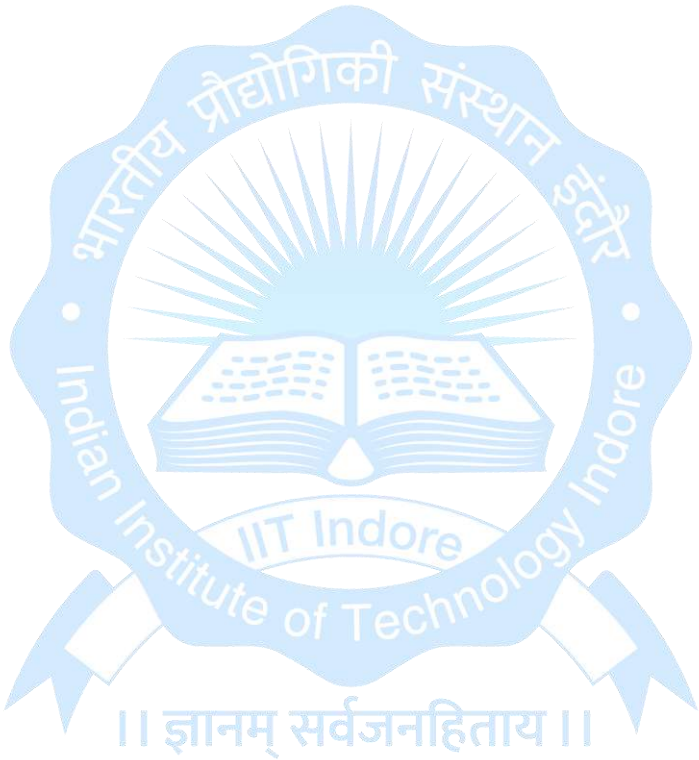
Course code	EE 466/ 666
Title of the course	**Electromagnetic Interference and Compatibility**
Course Category	Departmental Elective
Credit Structure	L – T – P – Credits 2-1-0-3 (Half semester, Credits: 3/2 = **1.5**)
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Basic knowledge of Power Electronics and Electromagnetic Theory
Course Objectives	The objective of this course is to familiarize the students with the concepts and techniques of various EMI sources, their measurements, and EMC designs
Course Outcomes	• To acquire knowledge about various types of EMIs and their sources • To analyze various method for suppression of EMI and determination of shielding effectiveness • To design and analyze circuits for EMC
Course Content	**Module – 1: Introduction to Electromagnetic Interference and Electromagnetic Compatibility (EMI-EMC):** Sources of EMI / EMC, Electromagnetic environment, History, Concepts, Practical experiences and concerns, EMI-EMC engineering applications **Module – 2: EMI from Various Sources:** Electromagnetic emissions, Noise from relays and switches, Non-linearities in circuits, Passive intermodulation, Cross talk in transmission lines, Transients in power supply lines, Open area test sites and measurements **Module – 3: EMI Measurement Techniques:** Fundamental considerations, EMI Shielding effectiveness test, Open field test, Transverse electromagnetic (TEM) cell for immunity test, Shielded chamber, EMI test receivers, EMI test wave simulators, EMI coupling networks, Electrostatic discharge (ESD), Electrical surges, Feedthrough capacitors, Antennas, Current probes. **Module – 4: EMI Mitigation Techniques:** Working principle of Shielding, Apertures and shielding effectiveness, Principle of Grounding, EMI suppression cables, EMC connectors, EMC gaskets, National / International EMI-EMC standards.

Suggested Books	**Text books:** 7. V. P. Kodali, ***Engineering Electromagnetic Compatibility- Principles, Measurements, and Technologies***. 1st Edition, IEEE Press, 1996, ISBN: 9780780311176. 8. C. R. Paul, ***Introduction to Electromagnetic Compatibility***. 2nd Edition, John Wiley & Sons, 2010, ISBN: 9788126528752. **Reference books:** 9. L. A. Kumar, and Y. U. Maheswari, ***Electromagnetic Interference and Electromagnetic Compatibility- Principles, Design, Simulation, and Applications***. 1st Edition, CRC Press, 2023, ISBN: 9781032419763. 10. P. S. Crovetti, ***Electromagnetic Interference and Compatibility.*** 1st Edition, MDPI AG, 2021, ISBN: 9783036505008.

Course Code	EE 467/667
Title of the Course	**Cyber Resiliency in Smart Grid**
Course Category	Departmental Elective
Credit Structure	L-T-P-Credits 2-1-0-3 (Half semester, Credits: 3/2 = **1.5**)
Name of the Concerned Department	Electrical Engineering
Pre–requisite, if any	-
Course Objectives	This course aims to introduce the smart grid concept, various cyber-vulnerable areas in smart grid, and ways to achieve cyber-resilient grid.
Course Outcomes	• Understanding the concept of smart grid and various cyber security issues. • Realizing the impact of cyber-attack on smart grid and learning different methods to mitigate their impact.
Course Content	**Module – 1: Introduction to Smart grid** Definition, conventional vs smart grid, necessity and advantages of smart grid, various smart grid domains and enablers of smart grid. **Module - 2: Cyber Security** Need of cyber security, history of cyber-attacks in power sector, security in information technology (confidentiality, integrity, availability) vs security in operational technology (availability, integrity, confidentiality) systems, cyber security vs cyber resiliency, types of cyber-attack and its possibility at different layers **Module – 3: Cyber Resilient Grid** Impact of different cyber-attacks on smart grid, detection of cyber-attacks and mitigating their impact.
Suggested Books	**Text Books** 1. M. S Thomas and J. D. McDonald, ***Power System Scada and Smart Grids.*** CRC Press, 2015, ISBN: 9781482226744. **Reference Books** 2. C. C. Liu, S. McArthur and S. J. Lee, ***Smart Grid Handbook.*** Wiley, 2016, ISBN: 9781118755488. 3. A. Sreejith, and K. S. Swarup, ***Cyber-Security for Smart Grid Control.*** Springer, 2024, ISBN: 9789819713011.

Course Code	**EE 468/EE 668**
Title of the Course	**Game Theory and Mechanism Design**
Credit Structure	2-1-0-3
Course Type	Elective
Name of Department	Electrical Engineering
Pre-requisite, if any	Background in Optimization may be helpful
Course Objectives	● Introduce mathematical modeling of games ● Familiarity with solution strategies, their existence and complexities
Course Outcomes	● Formulate problems in distributed systems using game theory ● Identify the type of game ● Apply state-of-the art solution strategies to solve games ● Design mechanisms or policies with desirable properties
Course Syllabus	**Introduction to Game Theory: Static Games** Motivating examples: Spectrum Auctions, Matching Markets, Sponsored Search Auctions, Crowdsourcing applications, Social network analysis. Mathematical modeling of games and their classification, Strategic-form games, Iterated strict dominance, Elimination method, Nash Equilibrium, Pure-strategy and mixed strategies, Existence, multiple Nash equilibria and pareto optimality, Complexity of finding Nash Equilibrium. **Dynamic and Bayesian Games** Extensive-form representation of games, multi-stage game, Subgame perfect equilibrium, Stackelberg competition, Incomplete Information and Bayesian games. **Bargaining, Repeated and Cooperative Games** Bargaining game of Alternating offers, Nash Bargaining Solution, Repeated games: Infinite vs Finite Repeated games, Nash Folk Theorems. Cooperative games: The Core and Shapley Value. **Mechanism Design and Algorithmic Game theory** Basics of mechanism design, first and second price auctions, Myerson's lemma, VCG auctions, Regret and no-regret algorithms.

Suggested Textbooks	Textbooks: 1. D. Fudenberg, and J. Tirole. **Game theory**, 1st Edition, MIT press, 1991, ISBN: 9780262061414 2. M. J. Osborne, and Ariel Rubinstein. **A course in game theory**, 1st Edition, MIT press, 1994, ISBN: 9780262650403 Reference Books: 1. Y. Narahari. **Game theory and mechanism design**. 4th Edition. World Scientific, 2014, ISBN: 9789814525046 2. N. Nisan, T. Roughgarden, E. Tardos,V. V. Vazirani, **Algorithmic Game Theory**, 1st Edition, Cambridge University Press, 2007, ISBN: 9780511800481



Course code	**EE 470/ EE 670**
Title of the course	**Brain Signal Processing**
Course Category	Departmental Elective
Credit Structure	L-T-P-Credits 2-1-0-3
Pre-requisite, if any	Basic knowledge of signal analysis
Course Objectives	• Introduce the physiological origins, acquisition, and analysis of brain signals with emphasis on EEG. • Develop skills in signal processing and machine learning for clinical and brain-computer interface applications. • Provide an overview of other neuroimaging modalities (MEG, fNIRS, fMRI) and their integration with EEG.
Course Outcomes	On successful completion of the course, students will be able to: • Explain the generation, characteristics, and measurement principles of key brain signals and compare major neuroimaging modalities. • Apply advanced signal processing and machine learning techniques for preprocessing, analysis, and interpretation of brain signals. • Analyze functional connectivity and perform source localization in brain networks for clinical and BCI applications.
Course Content	**Neuroanatomy and Fundamentals of Brain Signals** • Overview of brain structure and functional neuroanatomy • Basics of neuronal activities and action potentials • Introduction to brain signal modalities: EEG, MEG, fNIRS, fMRI - principles and comparisons • EEG generation, rhythms, and recording techniques • Physiological, developmental, and pathological brain signal patterns **Modelling and Signal Processing of Brain Signals** • Physiological and mathematical modelling of brain signal generation • Nonlinearity, nonstationarity, and signal segmentation • Signal transforms: Fourier, Wavelet, Hilbert-Huang • Empirical Mode Decomposition and advanced statistical modelling • EEG signal decomposition and source separation: blind source separation, independent component analysis (ICA) **Event-Related Potential (ERP) and Source Localization** • ERP generation, detection, and classification (e.g., P300) • ERP applications in cognitive assessment and BCI • Brain source localization: head models, forward/inverse problems • Machine learning approaches to EEG/MEG source localization **Brain Connectivity and Machine Learning** • Brain connectivity measures: coherency, phase-based indices, graph representation • Feature extraction and dimensionality reduction • Classification and clustering methods for brain signal analysis **Brain-Computer Interfaces, Multimodal Integration, and Clinical Applications**

	• Fundamentals of BCI and key brain signal components • Signal processing challenges, performance evaluation, and advanced BCI applications (multiclass, hybrid, neurotechnology) • Joint analysis and fusion of EEG with fNIRS, MEG, or fMRI • Clinical and cognitive applications: seizure detection/prediction, sleep analysis, mental-fatigue and emotion recognition • Brain signals as biomarkers for neurological and psychiatric disorders **Short, guided tutorials using computational tools and software packages to demonstrate:** • Basic data I/O and preprocessing of brain signals • Artifact removal • Time-frequency analysis • ERP analysis • Connectivity estimation • Machine learning classification • Brain source localization
Suggested Books	**Text Books** 1. S. Sanei and J. A. Chambers, *EEG Signal Processing and Machine Learning*, John Wiley & Sons; ISBN: 1119386942. 2. M. A. Jatoi and N. Kamel, *Brain Source Localization Using EEG Signal Analysis*, CRC Press; ISBN: 9781498799348. **Reference Books** 1. M. X. Cohen, *Analyzing Neural Time Series Data: Theory and Practice*, The MIT Press; ISBN: 9780262019873. 2. S. J. Luck, *An Introduction to the Event-Related Potential Technique*, The MIT Press; ISBN: 0262525852. 3. R. M. Rangayyan, *Biomedical Signal Analysis*, IEEE Press/Wiley, 3rd edition, 2024; ISBN: 978119825852.

Course code	**EE 472/ EE 672**
Title of the course	**Human-Centric Multimedia Quality Analysis**
Course Category	Elective
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Department	Electrical Engineering
Pre-requisite, if any	Signals and Systems, Probability and random processes
Scope of the Course (Objectives)	• Covers human quality assessment methodologies for multimedia content. • Introduces automatic perceptual prediction models for visual and audio media. • Builds theoretical understanding of perceptual quality mechanisms. • Develops practical skills in designing and evaluating quality assessment systems.
Course Outcomes	• Covers psychophysical and subjective evaluation methods used in human quality assessment of multimedia content. • Introduces data-driven and learning-based perceptual prediction models for visual and auditory media analysis. • Builds a theoretical foundation on human visual and auditory perception mechanisms relevant to quality modeling. • Develops hands-on expertise in implementing, training, and validating perceptual quality assessment systems.
Course Content	**Introduction to human visual system** Perception- Human eye characteristics, Projection of image, Binocular vision and depth perception, Color and brightness processing. **Visual quality analysis** 2D and 3D, VR and AR multimedia perception and differences. Visual quality corruption- storage, compression, degradation issues. **Human assessment studies** Procedure of ITU-R recommendations and physical conditions, Psychovisual analysis, Understanding of effect of multiple quality attributes during multimedia processing. **Mathematical analysis** Conventional mathematical computations- MAE, MSE, PSNR, correlation.

	Marginal and joint statistical modeling of quality attributes, Quality of experience issues and quality map computation. Introduction to deep learning architectures and Autoencoders. Applications of quality assessment and Display technologies.
Suggested Books	**Text Books** 1. Zhou Wang and Alan C. Bovik, Modern Image Quality Assessment, Morgan & Claypool Publishers, 2006. ISBN-13: 978-1598290226 2. Deng, Chenwei, Lin Ma, Weisi Lin, and King Ngi Ngan, Visual Signal Quality Assessment, Springer International Publishers, 2015. ISBN: 978-3-319-10368-6. 3. Chang Wen Chen, Periklis Chatzimisios, Tasos Dagiuklas, Luigi Atzori, Multimedia Quality of Experience (QoE): Current Status and Future Requirements, Wiley-Blackwell, 2016. ISBN: 978-1-118-48391-6. **Reference Books** 1. H. R. Wu and K. R. Rao, Digital Video Image Quality and Perceptual Coding, 1st ed., Taylor & Francis, 2005, ISBN-13: 978-0824727772.

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 701**
Title of the Course	**Time-Frequency Analysis**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Discipline	Electrical Engineering
Pre–requisite, if any	Basic knowledge of Fourier analysis
Scope of the Course	Many signals exhibit frequency characteristics that change over time. Examples include such as speech, marine mammal sounds, heart rate, electroencephalogram, machine vibrations, sonar, radar, and communication signals. Understanding these changes is important because they are often indicative of the underlying processes that generated the signal. Time-frequency analysis, also called time-varying spectral analysis, is a technique for studying the time-dependent spectral changes in a signal.
Course Syllabus	Basics of Fourier Analysis, Spectral Theory, Fundamentals of Time-Frequency Analysis, Instantaneous Frequency and Instantaneous Bandwidth, Gabor Transform, The Short-Time Fourier Transform/Spectrogram, Time-Frequency Localization, Continuous Wavelet Transform/ Scalogram, Multiresolution Analysis, Quadratic Time-Frequency Transform, Wigner-Ville Distribution, Signal Processing Applications, Image Processing Applications.
Suggested Books	1. S. Mallat, **A Wavelet Tour of Signal Processing** (3rd edition), Academic Press, 2008, ISBN: 978-0123743701. 2. Leon Cohen, **Time-Frequency Analysis**, Prentice Hall; 1994, ISBN: 978-0135945322. 3. B. Boashash, **Time-Frequency Signal Analysis and Processing: A Comprehensive Reference**, Elsevier Science, 2003, ISBN-13: 978-0080443355. 4. R. M. Rao and A. S. Bopardikar, **Wavelet Transforms: Introduction to Theory & Applications**, Prentice Hall, 1998, ISBN-13: 978-0201634631.

Course Code	**EE 740**
Title of the Course	**Speech Signal Processing**
Credit Structure	L-T-P-Credits 2-1-0-3
Name of the Concerned Discipline	Discipline of Electrical Engineering
Pre–requisite, if any	Signals and Systems, Digital Signal Processing
Scope of the Course	The main objective of this course to provide concepts for speech signal analysis, synthesis recognition etc.
Course Syllabus	**Signal processing tools:** Digital filters, Fourier series, Fourier transform, DFT, FFT, short term Fourier transform (STFT), continuous wavelet transform, discrete wavelet transform **Speech acquisition and digitization** **Speech analysis and parameter extraction:** Short time analysis, frames and windows, time-domain analysis: energy, zero-crossings, statistic parameters, autocorrelation, frequency-domain analysis: spectra and spectrograms, cepstral analysis, linear prediction analysis, pitch and formant estimation, static and dynamic features **Speech signal synthesis** **Speech coding** **Speech enhancement**
Suggested Books	1. J.R. Deller, J.G. Proakis, J.H.L. Hansen, **Discrete-Time Processing of Speech Signals**, Wiley-IEEE Press, 1999, ISBN 978-0780353862. 2. T. F. Quatieri, **Discrete-Time Speech Signal Processing: Principles and Practice**, Prentice Hall, 2001, ISBN 978-0132429429. 3. L. R. Rabiner, R. W. Schafer, **Digital Processing of Speech Signals**, Prentice Hall, 1978, ISBN 978-0132136037.

Course Code	**EE 742**
Title of the Course	**MIMO Wireless Communications**
Credit Structure	L-T- P-Credits 2-1-0-3
Name of the Concerned Discipline	Electrical Engineering
Pre–requisite, if any	Concepts of random variable and communication theory.
Scope of the Course	To understand the concepts of space time coding, spative diversity and multiplexing involved by deploying multiple antenna at the transmitters and receiver.
Course Syllabus	**Review of Matrix Algebra:** Trace, Frobenius norm, positive definite matrix, singular value decomposition, vectorization, Kronecker product. **MIMO System and Channel Models:** Frequency-flat and frequency-selective MIMO channel, Matrix formulations. **MIMO Information Theory:** Entropy and mutual information, capacity of MIMO channel, MIMO capacity with and without transmit CSI, ergodic channel capacity, outage capacity. **Receive Diversity:** SIMO receivers, flat and frequency-selective channels, linear processing and MRC, orthogonal frequency division multiplexing (OFDM). **Transmit Diversity and Space-Time Coding:** Optimal beamforming with transmit CSI, beamforming for MISO systems, achieving transmit diversity, space-time coding concepts. **Linear Space-Time Block Codes:** A general framework for Linear STBC, spatial multiplexing, orthogonal space-time block codes, error performance analysis, mutual information properties, diversity-multiplexing tradeoff analysis. **Applications:** Multiuser MIMO, Collaborative MIMO, MIMO in WiFi and WiMAX, Large MIMO systems.
Suggested Books	1. E. G. Larsson and P. Stoica, **"Space-Time Block Coding for Wireless Communications"**, Cambridge University Press, USA, 2008, ISBN: 978-0521065337. 2. A. Paulraj, R. Nabar, and D. Gore, **"Introduction to Space-Time Wireless Communications"**, Cambridge University Press, USA, 2008, ISBN: 978-0521065931.

	3. E. Biglieri, R. Calderbank, A. Constantinides, A. Goldsmith, A. Paulraj, **"MIMO Wireless Communications"**, Cambridge University Press, USA, 2010, ISBN 978-0521137096. 4. D. Tse and P. Vishwanath, "**Fundamentals of Wireless Communication**, Cambridge University Press, 2005, ISBN: 978-0521845274.