Indian Institute of Technology Indore

Curriculum and
Courses of Study
for
Bachelor of Technology in “Engineering Physics”

October 2025

[After incorporating decisions of 57th meeting of the Senate held on October 17, 2025]

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

Section-A (CSE+CE+MEMS+CH+EP)				**Section-B (EE+ME+MC+SSE)**			
Semester-I	**Autumn Semester**			**Semester-I**	**Autumn Semester**		
Course Code	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**	**Course Code**	**Course Title**	**Weekly Contact Hours (L-T-P)**	**Credits**
EE 101	Basic Electrical Engineering	1-1-0	2	EE 101	Basic Electrical Engineering	1-1-0	2
ME 101	Engineering Mechanics	2-0-0	2	ME 101	Engineering Mechanics	2-0-0	2
PH 107	Basics of Physics	2-1-0	3	CH 105	Chemistry	3-0-0	3
PH 157	Physics Lab- I	0-0-2	1	CH 155	Chemistry Lab	0-0-2	1
MA 101N	Calculus-I (half Semester)	3-1-0 (=4/2)	2	MA 101N	Calculus-I (half Semester)	3-1-0 (=4/2)	2
MA 103N	Calculus-II (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 109	Language and Composition	2-0-0	2
HS XXX	Flexible Elective (HSS)	1-0-0	1	HS XXX	Flexible Elective (HSS)	1-0-0	1
IC 152	Makerspace	1-0-6	4	CS 103	Computer Programming	2-0-0	2
CS 103	Computer Programming	2-0-0	2	IC 151	Computer Programming Lab	0-0-3	1.5
IC 151	Computer Programming Lab	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	**14-3-11**	**22.5**		**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

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

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	Total	**14-3-2**	**18**

NO 102	National Sports Organization (NSO)	0-0-0	P/NP
	Total	**14-4-8**	**22**

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

Semester III

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

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

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

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PH 2XX	Department Elective II	x-x-x	3
ZZ 2XX	Institute Elective I	x-x-x	3
	Total		**22.5/ 25.5**

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

Semester V

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

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

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

ZZ 3XX	Institute Elective III	x-x-x	3
		Total	**22/ 25**

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

Semester VII

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

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

List of the Elective Courses for BTech in Engineering Physics:

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

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

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

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

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

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

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

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

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

PH 314 : Introduction to Quantum Field Theory (2-1-0-3)

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

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

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

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

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

PH 408 / PH 608: Experimental and Theoretical Aspects of Heavy Ion Collisions (2-1-0-3)

PH 412/PH 612 : Dualities in field theory and gravity (2-1-0-3)

PH 432/PH 632 : Group Theory in Particle Physics (2-1-0-3)

PH 440/PH 640 : Introduction to String Theory (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	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
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 Psychology	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 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 HS 205: Sociology HS 221 Fundamentals of	AA 201: Introduction to Astronomy

				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 Courses
of
Department of Physics

Course Code	**PH 203 / AA 203**
Title of the Course	**Classical Mechanics**
Course Category	Core
Credit Structure	L-T-P-Credits (2-1-0-3)
Name of the Department	Physics
Pre–requisite, if any	None
Objectives of the course	This course provides basic knowledge of classical physics
Course Outcomes	Students should be able to • Solve problems using the Lagrange method • Apply Lorentz transformations, understand 4-vector analyses and relativistic kinematics, and use Lagrange and Hamiltonian formulations for relativistic particles. • Develop problem-solving skills in classical and relativistic mechanics.
Course Syllabus	• System of particles, Center of mass, equation of motion of the CM, conservation of linear and angular momentum, conservation of energy, variable mass systems. Elastic and inelastic collisions. • Central Force: uniformly rotating frame, centrifugal and Coriolis forces, Motion under a central force, Kepler's laws, Gravitational Law and field, Conservative and non-conservative forces. • Introduction to Lagrangian mechanics, Mechanics of Rigid Body: Rigid body motion, fixed axis rotations orthogonal transformations and rotations (finite and infinitesimal); Euler's theorem, Euler's angles; moments of Inertia tensor, parallel and perpendicular axes theorem, Principal moments and axes; Euler's equation; Small Oscillations, normal modes, and frequencies. • Special Theory of Relativity: Lorentz transformations; 4-vectors, 4-dimensional velocity, and acceleration; 4-momentum and 4-force; Covariant equations of motion; Relativistic kinematics (decay and elastic scattering); Lagrangian and Hamiltonian of a relativistic particle. • General properties of matter: Introduction to Elasticity, Surface Tension and Viscosity

Suggested Books	Textbooks: 1. Goldstein, Poole, Safko, *Classical Mechanics*, Pearson, (2017), ISBN: 978-0201657029 2. N. Rana and P. Jog, *Classical Mechanics*, Mcgraw Hill, (2017), ISBN: 978-0074603154 Reference Books: 3. Kleppner and Kolenkow, *An Introduction to Mechanics*, Cambridge Univ. Press, (2013), ISBN: 978-0521198110 4. K. C. Gupta, *Classical Mechanics of Particles and Rigid Bodies*, New Age Education, (2018) ISBN: 978-9386649782 5. D. Morin, *Introduction to Classical Mechanics*, Cambridge Univ. Press, (2009), ISBN: 978-0521185028

Course Code	PH 207 / AA207
Title of the course	Wave Phenomenon and Optics
Course Category	**Core**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of Dept.	**Astronomy, Astrophysics and Space Engineering**
Prerequisite, if any	None
Objectives of the course	The students will be introduced to the basics of waves and oscillations, including optics and lasers.
Course Outcome	• The students will learn to solve for motions in different oscillatory systems • The students will understand the concepts of optics and compare the outcomes in different optical systems
Course Syllabus	**Module 1:** • Oscillations: Harmonic motion (simple, damped, critical). Driven oscillation, resonance. Oscillations of two-particle systems and modes. Oscillations of n particle systems. Oscillation modes. Longitudinal and transverse oscillations. • Waves: Equations of motion, standing waves and travelling waves. Harmonics and their superpositions. Fourier analysis and Fourier coefficients. Doppler effect. **Module 2:** • Geometrical Optics: Fermat's Principle, Refraction, Thick Lens and Lens Combination, Matrix Method, Aberrations, Optical Instruments: Telescopes and Microscopes. • Wave Optics: Electromagnetic Spectrum, Huygen's Principle, Interference: Young's Experiment, Fresnel's Biprism, Newton's Rings, Interferometers: Michelson and Fabry-Perot; Coherence: Temporal and Spatial; Diffraction: Fresnel and Fraunhofer, Single and Double Slit, Circular aperture, Grating, Resolving power. • Polarization, LASER and Holography: Brewster's Law, Birefringence, Dichroism, Babinet's Compensator, Polarimeters, Optical Activity. Coherence, LASER, spontaneous and stimulated emission, Gaussian wave and its diffraction. Holography.

Suggested Books:	Textbooks: 1. A. P. French, *Vibrations and Wave*, CRC Press; 1st edition, (2017), ISBN: 978-1138414082 2. A. Ghatak, *Optics*, MacGraw Hill, (2020), ISBN: 978- 9390113590 [Module 2] Reference Books: 3. F. S. Crawford, *Waves*, MacGraw Hill Education, (2017), ISBN: 978-0070702172 4. N. Bajaj, *The physics of waves and oscillations*, McGraw Hill, (2017), ISBN: 978-0074516102 5. F. Jenkins and H. White, *Fundamentals of Optics*, McGraw Hill Education; 4th edition, (2017), ISBN: 978-1259002298 6. M. Born and E. Wolf, *Principles of Optics*, Cambridge Univ. Press, (2019), ISBN: 978-1108477437

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	**PH 205 /AA 205**
Title of the course	**Electronic Devices and Circuits - I**
Course Category	Core
Credit Structure	**L - T - P – Credits (2-1-0-3)**
Name of Dept.	**Astronomy, Astrophysics and Space Engineering**
Prerequisite, if any	None
Objectives of the course	The students will gain foundational knowledge of analogue electronics.
Course Outcome	• Acquire knowledge of basic analog electronics. • Gain skills to design basic electronic circuits.
Course Syllabus	**Module - 1** Basics of semiconductor devices and their characterization: diodes, transistors, BJT, FET, MOSFET, etc. **Module - 2** Small signal analysis in electrical circuits: Estimation of voltage gain, input/output resistance, Miller's theorem, high-frequency transistor model. **Module - 3** Amplifiers and their applications: Single-stage and two-stage amplifier, Differential amplifiers, Operational amplifiers. **Module - 4** Oscillators: Basics of oscillators, phase shifter, multi-vibrators, timers.
Suggested Books	Textbooks: 1. A. Malvino and D. Bates, *Electronics Principles*, McGraw Hill Education, 7th Ed., (2017), ISBN : 978-0070634244 2. A. S. Sedra and K. C. Smith, *Microelectronic Circuits,* Oxford University Press, (2017), ISBN: 978-0199476299 Reference Books: 3. Gray, Hurst, Lewis, and Meyer, *Analysis and Design of Analog Integrated Circuits,* Wiley (2009) ISBN: 978-8126521487 4. R. Gayakwad, *Op-amps and Linear Integrated Circuits*, Pearson, (2021) ISBN: 978-9353949037 5. B. Razavi, *Fundamentals of Microelectronics*, Wiley, (2017), ISBN: 978-8126571352 6. R. L. Boylestad, *Electronic Devices and Circuits Theory*, Pearson (2021) ISBN: 978-9332542600

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	**PH 209 / AA 209**
Title of the course	**Fundamental Concepts for Solid State Engineering**
Course Category	**Core**
Credit structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisites	None
Objectives of the course	This course provides a multidisciplinary introduction to fundamental concepts of solid state physics, encompassing topics ranging from crystals, reciprocal lattices to structural, elastic, thermal, optical and electronic properties of materials. This course will build the foundation for applications of solids in various fields of applied physics and engineering branches.
Course Outcomes	• Develop an understanding of the core concepts of solid-state physics and understand their implications in various applications/branches of engineering. • Application of fundamental concepts in solid state physics to solve relevant conceptual and numerical problems.

Course Syllabus	• Introduction: Periodic array of atoms, Symmetry operations, Point Groups in general, Index system for crystal planes, Lattices in 1–, 2– and 3-D Bravais Lattices. • Reciprocal lattice: Diffraction of waves by crystals, Scattered Wave Amplitude, Brillouin zones, Wigner–Seitz Cells, Fourier analysis of the Basis. • Elastic Properties of Crystals and Crystal Binding. • Crystal Vibrations: mono-atomic lattice, diatomic lattice, quantization of elastic waves, phonon-dispersions. Thermal properties of Crystals: Phonon density of states, Heat capacity, thermal expansion, thermal conductivity. • Electrons in Crystals: Review of Free electron model, Periodic potential, Born–von Karman boundary conditions, Bloch's theorem, Electronic band structure, single electron energy state, degenerate electron levels, Consequences of the nearly free electron model, Fermi surface. • Electronic properties of Materials: Construction of Fermi surfaces, Reduced Zone Scheme, Periodic Zone Scheme, Reflectance and Absorption, Intrinsic and Extrinsic semiconductors, Effective mass and mobility of carriers, Hall Effect, Semiconducting junctions, Metal-semiconductor contacts – Schottky barriers, Ohmic contacts, Brief introduction to semiconductor device fabrication. • Structural Defects: Point defects, Dislocations, Microcracks, Stacking faults, Grain boundaries.
Suggested Books:	Textbooks: 1. C. Kittel, *Introduction to Solid State Physics* (7th Edition), John Wiley & Sons, (2019) ISBN: 9788126578436. 2. A. J. Dekker, *Solid State Physics*, MacMillan India Ltd. (2008) ISBN: 978-0333918333 Reference Books: 3. R. E. Hummel, *Electronic Properties of Materials: An introduction for Engineers*, Springer-Verlag, (1985), ISBN: 978-0387156316 4. M. Ali Omar, *Elementary Solid-State Physics: Principles and Applications* (1st Edition), Pearson Education, (2002) ISBN: 978-8177583779 5. Ashcroft and Mermin, *Solid State Physics*, Thomson Press (India) Ltd. (2021), ISBN:9780030839931

Course code	**PH 210 / AA 210**
Title of the course	**Fundamentals of Quantum Mechanics**
Course Category	**Core**
Credit structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisites	None
Objectives of the course	The students will be introduced to the basics of quantum mechanics
Course Outcomes	Students will be able to • Demonstrate a thorough understanding of the foundational principles of quantum physics • Analyze and solve the Schrödinger equation for various scenarios • Apply quantum mechanical principles to understand and explain several phenomena related to hydrogen atom, atomic nuclei and radioactivity.
Course Syllabus	• Review of Introductory Quantum Physics • Calculation of expectation values, Kets, Bras and operators, Base kets and matrix representations, Measurements, observables and the uncertainty relations, change of basis, position, momentum and translation, wave functions in position and momentum space. • Quantum dynamics: Time evolution and the Schrodinger equation, The Schrodinger versus the Heisenberg picture, Schrödinger equation, and its solution for one, two, and three-dimensional boxes. Solution of Schrödinger equation for the one-dimensional harmonic oscillator. Reflection and transmission at a step potential, Pauli exclusion principle. • WKB approximation, Tunneling through a barrier, Structure of the atomic nucleus, mass, and binding energy. Hydrogen atom, Radioactivity and its applications. Laws of radioactive decay.
Suggested Books	Textbooks: 1. D. J. Griffiths and D. F. Schroeter, *Introduction to Quantum Mechanics*, Cambridge University Press, (2018), ISBN: 978-1107189638 2. R. Shankar, *Principles of Quantum Mechanics*, Springer, (2011), ISBN: 978-0306447907 Reference books: 3. P. M. Mathews and K. Venkatesan, *A Textbook of Quantum Mechanics*, Springer, (2017), ISBN: 978-0070146174

	4. J. Townsend, *A Modern Approach to Quantum Mechanics*, University Science Books, (2010) ISBN:978-1891389788. 5. A. Das, *Quantum Mechanics: A Modern Introduction*, CRC Press; 1st edition, (1986) ISBN: 978-2881240539

Course Code	**PH 211**
Title of the Course	**Fundamentals of Vacuum Science and Technology**
Course Category	**Department Elective**
Credit Structure	**L-T- P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	NIL
Objectives of the course	This course provides a framework to understand fundamentals of Vacuum Science ranging from basic physics concepts, measurement techniques, to different vacuum pumps to equip students with essential theoretical and practical knowledge for applications in fields requiring high to ultra-high vacuum environments such as Applied Physics (material science, semiconductors, space research) and other branches of engineering including electrical, chemical and space engineering etc.
Course Outcome	• To develop a comprehensive understanding of the fundamental concepts in vacuum science, vacuum generation and vacuum measurement techniques. • Students will be able to apply mathematical concepts and techniques to solve problems related to vacuum generation and measurement.
Course Syllabus	• **Revision of some fundamental concepts:** Revisiting Kinetic theory of gases and fundamentals of mean free path and its correlation with the pressure temperature etc., Distribution functions for molecular gases and concept of pressure with the molecular density, viscosity of gases and its correlation with flow/conductance of the gas, Relation of conductance/impedance of a gas with the volume and vacuum line, concepts of different types of gas lines, elbows, tubes, and its effect on the molecular flow. • **Generation of Vacuum:** Introduction to mechanical vacuum pumps including oil sealed rotary pump, Roots Pump, molecular drag pump etc., Oil pumps including diffusion pump, Ion pumps: E-vapor ion pumps, Sputter ion pumps, Titanium sublimation pump (Chemical cleanup (oxidation etc.) and sublimation pumps, Turbo molecular pumps, Electrical cleanup and ion pumps, Cryopumps including cryo-sorption pumps, Getter pumps. • **Measurements of Vacuum:** Concept and working principle for measurement of pressure in general, different types of pressure gauges for low to high vacuum including electrical and mechanical gauges, Mc-Leod manometer, Thermal

	conductivity gauges, Pressure and flow gauges for high to ultrahigh vacuum, Hot cathode ionization gauges, Cold cathode ionization gauges. • **Operation of High-vacuum gauges:** Concept of rough, high, and ultra-high vacuum with respect to the molecular density, Vacuum measuring units and vacuum ranges.
Suggested books	Textbooks: 1. V. V. Rao, T.B. Ghosh, K.L. Chopra, *Vacuum Science and Technology*, Allied Publishers, New Delhi (2008) ISBN: 9788170237631 2. D. Hoffman, B. Singh, J. H. Thomas III, *Handbook of Vacuum Science and Technology,* Elsevier Science (1997) ISBN: 9780080533759 Reference Books: 3. T. A. Delchar, *Vacuum Physics and Techniques: 6*, Chapman and Hall (1993) ISBN: 9780412465901 4. A. Roth, *Vacuum Technology,* Elsevier Science B.V., North Holland (1990) ISBN: 978-0444860279 5. J. Yarwood, *High Vacuum Techniques*, Chapman and Hall, London, (1967), ISBN: 978-0412025204

Course Code	**PH 212 / AA 212**
Course Title	**Thermal Physics**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (2 -1-0-3)**
Name of the Dept.	**Physics**
Pre-requisite if any	None
Objectives of the course	This course introduces the basic concepts of heat and thermodynamics
Course Outcomes	Student will be • Able to understand Kinetic theory of gases and apply the theory to gain insights into specific heat and transport phenomena in gases • Grasp and effectively apply the Laws of Thermodynamics to understand the principle of heat engines, phase transitions etc.
Course Syllabus	• **Kinetic Theory of Gases:** Ideal gas, Distribution of velocities, Mean, RMS and Most Probable Speeds, Degrees of Freedom, Law of Equipartition of Energy (statement only), Specific heats of Gases, Mean Free Path. Collision Probability, Transport phenomena (viscosity, thermal conductivity and diffusion), Real Gases, Virial equation, Boyle temperature, Van der Waal's Equation of State, Comparison with Experimental P-V Curves. • **Laws of Thermodynamics:** Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, Internal Energy and First Law of Thermodynamics, Isothermal and Adiabatic Processes, Second Law of Thermodynamics, Reversible and Irreversible process with examples, Carnot's Cycle, Carnot engine & efficiency, Carnot's Theorem, Heat engines, Concept of Entropy, Clausius Theorem and Clausius Inequality, Principle of Increase of Entropy, Third Law of Thermodynamics. • **Thermodynamic potentials:** Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy, their Definitions, Properties and Applications, First and second order Phase Transitions, Clausius-Clapeyron Equation, Maxwell's Thermodynamic Relations, Joule-Kelvin coefficient, Joule- Thomson Effect. • **Non-equilibrium Thermodynamics**: Entropy production, Kinetic coefficients, Proof of Onsager reciprocal relations, Thermoelectricity
Suggested Books	Textbooks: 1. M. W. Zemansky, R. Dittman, *Heat and Thermodynamics*, McGraw-Hill, (1996) ISBN: 978-0070170599 2. D. V. Schroeder, *An Introduction to Thermal Physics,* Oxford

	University Press, (2021) ISBN: 978-0192895547 Reference books: 3. S. J. Blundell and K. M. Blundell, *Concepts in Thermal Physics*, Oxford University Press, (2009), ISBN: 978-0199562107 4. F. Reif, *Fundamentals of Statistical and Thermal Physics,* Waveland Press, (2010) ISBN: 978-1577666127 5. P. K. Nag, *Engineering Thermodynamics,* McGraw Hill Education, (2021) ISBN: 978-9352606429

Course Code	**PH 213**
Title of the Course	**Detector Physics**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (1-1-2-3)**
Name of the department	**Physics**
Pre–requisites	None
Objectives of the course	To familiarize students in the frontiers of detectors used in high energy experiments
Course outcomes	Student will able to understand • Working principle of basic detectors • Energy loss mechanisms of different charge and neutral particles in medium • General characteristics of detectors
Course Syllabus	• Interaction of Radiation with Matter: Energy loss of heavy charge particle, Energy loss of electron and positron, Interaction of Photons. • General Characteristics of Detectors: Energy Resolution, Detector Response, Detector Efficiency, Response Time and Dead Time. • Basic Detectors: Cloud and Bubble Chambers, Gaseous Ionization Detectors, Scintillation Detector and Photomultiplier tubes, Semiconductor Detectors, Electromagnetic and Hadronic calorimeter, Time of Flight Detector, Transition Radiation Detector, Example of Hermetic Detectors. • Experiments related to different radiation detectors and their characteristics.
Suggested Books	Textbooks: 1. W. R. Leo, *Techniques for Nuclear and Particle Physics Experiments* (2nd Edition), Narosa Publishing. (1994) ISBN: 978-3540572800 2. G. F. Knoll, *Radiation Detection and Measurement (4th edition),* John-Wiley and Sons., (2010) ISBN: 978-0470131480 Reference Books: 3. T. Ferbel, *Experimental Techniques in High Energy, Nuclear and Particle Physics* (2nd Edition), World Scientific Publishing, (1991) ISBN-13: 978-9810208677 4. S. S. Kapoor and V. S. Ramamoorthy, *Nuclear Radiation Detectors*

	(2nd edition), New Age International, (2022) ISBN-13: 978-9395161084

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Course code	**PH 206 / AA 206**
Title of the course	**Electronic Devices and Circuits – II**
Course Category	**Core**
Credit Structure	**L - T - P – Credits (2-1-0-3)**
Name of the Department	**Astronomy, Astrophysics and Space Engineering**
Pre-requisite, if any	None
Objectives of the course	The students will develop a basic understanding of digital electronics principles
Course Outcomes	Students will learn about digital electronics and will able to solve related problems in the domain of engineering.
Course Content	**Module -1** **Number System and Codes:** Decimal, Binary, Octal and Hexadecimal number systems and arithmetic, base conversions. Representation of signed and unsigned numbers, addition, subtraction by 2's complement method, and multiplication. **Module -2** **Logic Gates and Boolean algebra:** Truth Tables of OR, AND, NOT, NOR, NAND, XOR, XNOR, Universal Gates, Basic postulates and fundamental theorems of Boolean algebra. **Module -3** **Combinational Logic Analysis, Design and Arithmetic Circuits:** Standard representation of logic functions, Binary Addition. Half and Full Adder. Half and Full Subtractor, 4-bit binary Adder/Subtractor, counters and registers. **Module -4** **Signal Conditioning and D-A and A-D Conversion:** A-D and D-A conversion, sampling and reconstruction of signal, Nyquist sampling, Fourier transform, Fast Fourier Transform.
Suggested Books	Textbooks: 1. D. P. Leech and A. P. Malvino, *Digital Principles and Applications*, Tata McGraw Hill, 8th ed., (2014) ISBN: 978-9339203405. 2. A. S. Sedra, K. C. Smith, *Microelectronic Circuits*, Oxford University Press, (2017), ISBN: 978-0199476299 Reference books: 3. J. G. Proakis and D. G. Manolakis, *Digital Signal Processing: Principle, Algorithms and Applications*, 4th ed., Pearson Education, (2007), ISBN: 978-8131710005.

	4. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, *Signals & systems*, Pearson Education, 2nd ed., (2015) ISBN: 9332550239. 5. J. Millman and C. Halkias, *Integrated Electronics: Analog and Digital Circuits and Systems*, McGraw-Hill, 2nd ed., (1972), ISBN: 9780070151420.

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	**AA 208 / PH 208**
Title of the course	**Electrodynamics**
Course Category	**Core**
Credit Structure	**L-T-P–Credits (2-0-0-2)**
Name of Dept.	**Astronomy, Astrophysics and Space Engineering**
Prerequisite, if any	None
Objectives of the course	The students will be introduced to electromagnetism
Course Outcome	Develop understanding of basic electrodynamics and its applications in the domain of engineering.
Course Syllabus	• Review of Electrostatics and Magnetostatics. Time-Varying Fields and Maxwell's Equations: Faraday's law for Electromagnetic induction, Displacement current, Integral and differential forms of Maxwell's equations, and Motional Electromotive forces. Boundary Value Problems, multipole expansion. • Electromagnetic Waves: Derivation of Wave Equation, Coulomb and Lorentz gauges; Plane waves in free space and in a homogenous material. non-conducting and conducting media; reflection and transmission at normal and oblique incidences, Skin effect, Poynting theorem. Polarization. • Lorentz Invariance of Maxwell's Equation, Radiation by moving charges, retarded potentials. Dipole antenna radiation, Introduction to waveguides.
Suggested Books	Textbooks: 1. D. J. Griffiths, *Introduction to Electrodynamics*, Cambridge University Press, (2020), ISBN: 978-1108822909 2. H. C. Verma, *Classical Electromagnetism*, Bharati Bhawan, (2022), ISBN-10:9388704827 Reference Books: 3. M. N. O. Sadiku, *Elements of Electromagnetics*, Oxford University Publication, (2014), ISBN-0199321388 4. W. Hayt, *Engineering Electromagnetics*, McGraw Hill Education, (2012), ISBN-9339203275 5. J. D. Jackson, *Classical Electrodynamics*, 3rd edition, Wiley, (2007), ISBN-10: 9788126510948

**This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course Code	**PH 214**
Title of the Course	**Classical Field Theory**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Basic classical mechanics, Lagrange formalism
Objectives of the course	Exposing the students to certain advanced concepts in Classical Mechanics.
Course outcomes	The students will learn • To describe the dynamics of continuous systems using Lagrangian formalism. Potential applications include but are not limited to description of propagation of waves in an elastic medium. • To make a natural precursor to Quantum Field Theory.
Course Syllabus	• **Introduction to Lagrangian density and fields:** Transition from discrete to continuous mechanical systems, Wave propagation, Concept of field and Lagrangian density, Euler-Lagrange equation for fields. • **Symmetries and conservation laws:** External and Internal symmetries, Conserved currents, Stress-energy tensor, Gauge transformations in classical field theory. • **Hamiltonian density:** Momentum density, Functional derivatives, Hamiltonian density, Poisson bracket in terms of functional derivatives, Fourier expansion of fields and Creation and Annihilation operators. • **Examples of classical field theories:** Schrodinger field, Scalar field theories (Klein-Gordon, Sine-Gordon, and Higgs field theories), Dirac field theory, Vector field theories, Electrodynamics as an example of a massless vector field theory, Proca Lagrangian and massive vector fields.
Suggested Books	Textbook: 1. H. Goldstein, C. P. Poole and J. L. Safko, *Classical Mechanics (3rd edition)*, Addison Wesley, (2001), ISBN: 978-0-201-65702-9

	Reference books: 2. D. Morin, *Introduction to Classical Mechanics*, Cambridge Univ. Press, (2009), ISBN: 978-0521185028 3. L. D. Landau, E. M. Lifshitz, *Course of Theoretical Physics - Vol. 2 (4th edition)*, Elsevier, (1987), ISBN: 978-0750627689 4. J. R. Taylor, *Classical Mechanics*, University Science Books, (2004), ISBN: 978-1891389207

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Course Code	**PH 215**
Course Title	**Geometrical Methods in Physics**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the Department	Physics
Pre-requisite, if any	Calculus
Scope of the course	Introducing students to some geometrical concepts used in Physics. This is primarily aimed at students who are inclined towards mathematical aspects of physics and will require geometrical concepts in their study.
Expected outcome	Students should learn some geometric techniques which are useful in theoretical and applied physics such as high energy physics and condensed matter physics
Course Syllabus	**Curves:** Plane and Space curves; Parametrization; Osculating plane; Curvature, torsion and Frenet frame **Extrinsic Geometry of Surfaces:** Parametrization; Tangent plane; Regular surfaces; Orientability; First and second fundamental forms; Normal and Principal curvature; Gaussian and Mean curvature; Gauss-Codazzi equation; Theorem Egregium **Intrinsic Geometry of Surfaces:** Covariant derivative of vector field; Parallel transport; Geodesics; Gauss Bonnet theorem; Application to Plane, Spherical and hyperbolic geometry **Topological Ideas:** Notion of topological spaces; Closed, compact and connected spaces; Topological invariants; Notion of homology and homotopy; Examples from 2D surfaces; Concept and examples of Minkowski functional; Use of softwares such as SnapPy, PolyTop etc. to study the topology and geometry of surfaces **Differential forms in Physics:** Definition of differential forms, sums and products of differential forms; Exterior derivative; Integration of differential forms; Example from electromagnetism **Asymptotic Methods:** Method of stationary phase; Method of steepest descents; Uniform asymptotic expansions; Asymptotic expansion of multiple integrals
Suggested References	**Textbooks:** 1. Bernard Schutz, *Geometrical Methods of Mathematical Physics*, Cambridge University Press (1999), ISBN: 9780521298872 2. M Nakahara, *Geometry, Topology and Physics* (2nd edition),

	Taylor and Francis (2003). ISBN: 9780750306065 **Reference books:** 3. John McCleary, *Geometry from a differentiable viewpoint*, Cambridge University Press (1994). ISBN: 9780521133111 4. Norman Bleistein, Richard A. Handelsman, *Asymptotic expansions of integrals*, Dover Publication (1986), ISBN: 9780486650821 5. Thomas F. Banchoff, Stephen Lovett, *Differential Geometry of Curves and Surfaces* (3rd edition), CRC Press (2023). ISBN: 9781032047782 6. Richard Courant, Fritz John, *Introduction to Calculus and Analysis*, Volume II (4th edition), Springer (2005), ISBN: 9781461389606

Course Code	**PH 216**
Course Title	**Accelerator Physics**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the Department	**Physics**
Pre-requisites	Basic Electromagnetic theory
Objectives of the course	To familiarize students in accelerator physics
Course Outcomes	Student will be able to understand: ● Different aspects of Linear accelerator, cyclotron, synchrotron ● Applications of accelerators
Course Syllabus	• Introduction to accelerators: History of accelerators. Basic principle of DC and Radio Frequency (RF) accelerators. Accelerators in India. Application of accelerators in basic research, medicine, industry. • Linear Accelerator: Principle of Linear accelerator, Principle of Radiofrequency Quadrupole (RFQ). • Cyclotron: Basic principle of cyclotron, Synchrocyclotron, Betatron tunes • Synchrotron and Radiation Source: Basic principle of Synchrotron, Electron and ion Synchrotron, Synchrotron radiation source, Total radiated power, Properties of Synchrotron radiation, Insertion devices. • Concepts of van de Graff, Cyclotron and Linear Accelerator (LINAC), Synchrocyclotron, Radio Frequency (RF) field and particle acceleration, Storage Ring, • Colliders and Fixed target Experiments, Luminosity, Cross-sections, concept of event triggering
Suggested References	Textbook: 1. M.S. Livingston and J.B. Blewett, *Particle Accelerators*, McGraw-Hill Inc, US (1962), ISBN: 978-0070381407 2. H. Wiedemann, *Particle Accelerator Physics*, Fourth Edition, Springer (2015). ISBN: 978-1013270468 Reference Book: 3. K. Wille *The Physics of Particle Accelerators: An Introduction*, Clarendon Press, (2001), ISBN: 978-0198505495 4. S. Humphries, *Principles of Charged Particle Acceleration*, J. Wiley

	(1986), ISBN: 978-0486498188 5. J. J. Livingood, *Principles of Cyclic Particle Accelerators*, Van Nostrand, NJ (1961), ISBN: 978-0442048228

Course Code	**PH 218**
Course Title	**Introduction to General Relativity**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	Physics
Pre-requisites, if any	Classical Mechanics
Scope of the course	This course is an introductory course to the theory of general relativity, their various applications and classical tests.
Course Outcomes	The student will be able to understand any gravitational set up and perform calculations related to various measurements or effects related to them.
Course Syllabus	Review of Special Theory of Relativity: Covariant formalism Metric tensor; One forms; Tensors of general rank; Energy momentum tensor, Perfect fluids; Conservation laws General coordinate transformations; Tangent manifold; Derivative of general tensors; Christoffel symbols Manifolds; Covariant derivatives and connection; Parallel transport; Geodesics; Riemann, Ricci and Einstein tensors; Weak field limit; Killing vectors; Einstein equations; Linearized equations; gravitational waves Gravitational redshift; Schwarzschild metric; Particle motion; Light bending
Suggested references	**Textbooks:** 1. B. Schutz, *A first course in general relativity* (2nd edition), Cambridge University Press (2009), ISBN: 9780521887052 2. S. Carlip, *General relativity: A concise introduction*, Oxford Univ. Press (2019), ISBN: 9780198822165 **Reference books:** 3. J. Hartle, *Gravity*, Pearson Education (2014), ISBN: 9789332535084 4. Christian Boehmer, *Introduction to general relativity and cosmology*, WorldScientific (2016), ISBN: 9781786341181

	S. P. Puri, *General theory of relativity*, Pearson education (2013), ISBN:9788131795682 5. S. Carroll, *Spacetime and Geometry*, Cambridge Univ. Press (2019) ISBN:978-1108488396

Course code	**PH 251 / AA 251**
Title of the course	**Engineering Physics Lab - I**
Credit structure	**L-T-P-Credits (0-0-3-1.5)**
Course Category	**Core**
Name of the Dept.	**Physics**
Pre-requisite if any	None
Objectives of the course	Students will get exposure to several experiments based on various advanced concepts of Physics.
Course Outcomes	• Learn to accurately collect, analyze and interpret data to understand the underlying physical principles/concepts. • Experimental verification of fundamental concepts in Classical Physics, Waves and Optics and Solid State engineering • Evaluate the errors and statistical deviations associated with the experimental results
Course Syllabus	A representative list of experiments will be performed by students: **Classical physics** • Moment of inertia of flywheel • Measurement of Young's modulus • Verification of Bernoulli's theorem • Constant volume and pressure air thermometer • Determination of Planck's constant • Millikan oil drop experiment • Helmholtz coil & measurement of Faraday's number **Waves and Optics** • Michelson interferometer • Verification of Brewster's law • Determination of specific rotation of sugar solution by using Laurent's Half Shade Polarimeter. **Solid State Engineering** • Nature of semiconductor band-gap of a powdered semiconductor using Diffuse Reflectance Spectroscopy. • Demonstration of X-ray diffraction in crystalline solids • Determination of Heat Capacity using Differential Scanning Calorimetry.
Suggested Books	Reference Books: 1. W. F. Smith, *Experimental Physics: Principles and Practice for the laboratory*, CRC Press, (2020), ISBN: 978-1498778473

	2. L. Lyons, *A practical guide to data analysis for physical science students*, Cambridge Univ. Press, (1991), ISBN: 978-0415481519

Course Code	**PH 252 / AA 252**
Title of the Course	**Scientific Computing Lab**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (0-0-2-1)**
Name of the department	**Physics**
Pre–requisite, if any	None
Objectives of the course	To familiarize students with Object-Oriented Programming language, data structures, and their application in Physics-specific problems.
Course outcomes	Student will be able to learn to apply computational techniques for Physics problems using a model programming language in vogue
Course Syllabus	• Introduction to Object-Oriented Programming (OOP), using a model language such as Python. • Object types, numbers, strings, lists, arrays, dictionaries, tuples, files, I/O handling. Statements and syntax, expressions, loops, iterations. • Basic functions, arguments, recursive functions, modules, module packages. Introduction to class and OOP, Error & exceptions handling. • Data structure and data handling. Efficient array handling using standard libraries. Scientific computing and problem solving, Integrating Fortran/C++ code with Python, as a model language. • Application of the model language to solve Physics problems
Suggested Books	Textbook: 1. A. K. Gupta, *Scientific Computing in Python*, Techno World Publishers, (2021) ISBN: 978-81-949567-6-1 Reference Books: 2. M. Lutz, *Learning Python: Powerful Object-Oriented Programming (5th edition)*, Cambridge University Press; (1989), ISBN: 978-1449355739 3. A. K. Gupta, *Python Computing: Fundamentals and Applications,* Techno World, (2023), ISBN: 978-93-92145-55-1

Course code	**PH 255 / AA 255**
Title of the course	**Electronic Devices and Circuits Lab - I**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (0-0-3-1.5)**
Name of Dept.	**Astronomy, Astrophysics and Space Engineering**
Prerequisite, if any	None
Objectives of the course	The students will acquire foundational knowledge and skills in analog electronics experimentation
Course Outcome	• Acquire hands-on experience in the domain of analog electronics. • Learn how to implement electronic circuits.
Course Syllabus	• Diode and its applications; I-V characteristics, Clipping Circuits. • Diode as – Voltage Doublers, Rectified Differentiator, Precision Rectifier, reverse-bias capacitance. • To measure the minority carrier lifetime in a semiconductor photodiode. • Transistor and Op-Amp characteristics - amplification, Op-Amp as summer, Integrator, Differentiator. • Zener Diode - rectification, DC power supply. • Characterization of basic and cascade current mirror circuits (with BJT and MOSFET). • Design of single-stage and differential amplifiers. • 555 Timers - timer and oscillator functions.
Suggested Books	Reference Books: 1. J. Millman, A. Grabel, *Microelectronics,* Tata McGraw-Hill (2017), ISBN: 978-0074637364 2. S. Sedra K. C. Smith: *Microelectronic Circuits,* OUP, (2017), ISBN: 978-0199476299 3. Razavi, *Fundamentals of Microelectronics,* Wiley, (2017) ISBN: 978-8126571352

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course code	**PH 256/ AA 256**
Title of the course	**Electronic Devices and Circuits Lab - II**
Course Category	**Core**
Credit Structure	**L - T - P – Credits (0-0-3-1.5)**
Name of the Department	**Astronomy, Astrophysics and Space Engineering**
Pre-requisite, if any	None
Objectives of the course	The students will engage in hands-on digital electronics experiments.
Course Outcomes	• Acquire hand-on experience in digital electronics. • Implement digital components to solve electronics problems.
Course Content	A representative list of experiments will be performed by students: • Introduction to Logic Circuits: To gain familiarity with digital integrated circuits by setting up simple logic circuits. • Combinational Logic Circuits: Use of TTL adder, multiplexer and decoder. • Sequential building blocks • Digital to Analog and Analog to Digital Conversion • Sampling and Reconstruction of Continuous-Time Signals and Interpolation with Decimation. • Implementation of a (4 X 4) multiplier using registers and a down counter. • MOSFET inverting amplifiers and first-order circuits • Introduction to VHDL and FPGA • Electronics Project
Suggested Books	Reference Books 1. Wakerly, *Digital Design: Principles And Practices*, Pearson India; 4th edition (2008) ISBN: 978-9332508125 2. S. Salivahanan, S. Arivazhagan, *Digital circuits and design*, Oxford University Press; Fifth edition, (2018), ISBN: 978-0199488681 3. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, McGraw-Hill, 4th edition, (2017), ISBN: 978-9352601943 4. J. Millman, A. *Grabel, Microelectronics*, McGraw Hill Education, 2nd edition, (2017), ISBN: 978-0074637364

** This course will be taught by instructors of Department of Astronomy, Astrophysics and Space Engineering

Course Code	**PH 301**
Title of the Course	**Nuclear Science and Engineering**
Course Category	**Core**
Credit Structure	**L-T- P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Nil
Objectives of the course	To introduce students with the concepts and important developments in our understanding of nucleus and elementary particles and their interactions.
Course Outcomes	• Familiarity with different nuclear models and properties of Nucleus • Learn the working principle of different kinds of detectors and their applications. • Exposure to different elementary particles
Course Syllabus	• **Nuclear Properties through experiments:** Rutherford scattering, Basic nuclear properties: size, shape, charge distribution, spin and parity; Binding energy, Nature of the nuclear force, form of nucleon-nucleon potential; Charge-independence and charge-symmetry of nuclear forces; Deuteron problem • **Nuclear Models:** Liquid drop model, semi-empirical mass formula; Electric and magnetic moments; Fermi gas model of nucleus; nuclear shell model; Collective model • **Radioactivity:** Radioactive decays, Gamow model, Fermi theory and Selection rules, Electromagnetic transitions in nuclei multipole radiation • **Fission and Fusion:** Fission Reactors, Fission explosives, Controlled Fusion reactor. • **Detectors and Accelerators:** Gas filled counters, Scintillation detectors, Semiconductor detectors, Linear Accelerator (LINAC), Cyclotron and synchrotron accelerators, Mass spectroscopy with accelerators, Accelerators in medical science. • **Elementary Particles:** Classification of fundamental forces; Elementary particles (quarks, baryons, mesons, leptons); quark model; Symmetries and Conservation laws; Spin and parity assignments, isospin, strangeness, Gell-Mann-Nishijima formula; C, P, and T invariance and applications of symmetry arguments to particle reactions, parity non-conservation in weak interaction
Suggested Books	Textbooks: 1. K. S. Krane, *Introductory Nuclear Physics*, Wiley, (2022) ISBN: 978-9354640834 2. B. R. Martin *Nuclear and Particle Physics: An Introduction*, Wiley, (2009), ISBN: 978-0470742754

	Reference Books: 3. W. S. C. Williams, *Nuclear and Particle Physics*, Oxford University Press, USA, (1991) ISBN: 978-0198520467 4. A. Das and T. Ferbel, *Introduction to Nuclear and Particle Physics*, World Scientific Publishing Company, (2003) ISBN: 978-9812387448 5. D. Griffiths, *Introduction to Elementary Particles*, Wiley-vch Verlag Gmbh, (2008), ISBN: 978-3527406012

Course Code	**PH 302**
Title of the course	**Cooperative Phenomena in Solids**
Course Category	**Core**
Credit structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisites	Basic Knowledge of Quantum Mechanics and Electricity & Magnetism
Objectives of the course	This course aims to provide an in-depth introduction to collective phenomena in solids as well as their applications
Course Outcomes	Students will develop an understanding of the fundamentals of various exotic properties displayed by solids.
Course syllabus	• **Fermi Surfaces and Metals:** Construction of Fermi Surfaces, Calculation of Energy Bands, De Haas-Van Alphen effect and Shubnikov–De Haas Oscillations, Landau levels. • **Spontaneous Coherence in Matter:** Superconductivity, Phonon-Mediated Cooper Pairing Mechanism, brief introduction to BCS theory, Flux quantization, Single particle tunneling, Type–I, Type–II superconductors, D.C and A.C Josephson effect; Introduction to Bose–Einstein Condensation and Superfluidity. • **Magnetism:** Para- and Ferro- magnetism, Ising Model, Magnetic Structures, Langevin theory of diamagnetism, Pauli Paramagnetism, Quantum mechanical considerations – Ferromagnetism, Domain wall energy, GMR in multilayers. • **Quasiparticles in Condensed Matter Physics:** Introduction to Plasmons, Polaritons and Polarons: Dielectric function of Electron gas, Mott Metal–Insulator Transition, Electron–electron interaction, Electron–Phonon interaction • **Optical processes in solids:** Complex dielectric function and refractive index of solids, Optical Reflectance, Absorption, Kramer-Kronig Relations, Excitons, Band-gap determination from optical spectra, Band – Band transitions, Band gap renormalization, Impurity levels – shallow and deep states, Optoelectronic devices • **Dielectrics and Ferroelectrics:** Dielectric constant and Polarizability, Structural Phase transitions, Ferroelectric Crystals, Displacive Transitions and theory of ferroelectric phase transition, Antiferroelectricity, Ferroelectric domains, Piezoelectric effect and other applications of ferroelectrics.
Suggested Books	Textbooks: 1. C. Kittel, *Introduction to Solid State Physics* (India Edition), Wiley India, (2019) ISBN: 9788126578436. 2. Ashcroft and Mermin, *Solid State Physics*, Thomson Press (India)

	Ltd. (2021), ISBN: 9780030839931 Reference Books: 3. D. W. Snoke, *Solid State Physics Essential Concepts*, Cambridge University Press, (2008) ISBN: 9781107191983 4. A. J. Dekker, *Solid State Physics*, MacMillan India Ltd. (2008), ISBN : 978-0333918333 5. M. A. Omar, *Elementary Solid-State Physics: Principles and Applications* (1st Edition), Pearson Education, (2002), ISBN: 978-8177583779

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Course code	**PH 303**
Title of the course	**Quantum Mechanics**
Course Category	**Core**
Credit structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisites	Non-relativistic quantum mechanics
Objectives of the course	The students will be introduced to more concepts and some important applications of quantum mechanics
Course Outcomes	Students will be able to: ● Apply internal symmetry concepts to various problems. ● Apply various standard techniques to a variety of quantum problems.
Course syllabus	• Stern-Gerlach experiment, Dirac notation for state vectors. • **Quantum dynamics**: Time evolution and the Schrodinger equation, • **Theory of angular momentum**: Rotation and angular momentum commutation relations, spin ½ systems and finite rotations, SO(3), SU(2) and Euler rotations, Eigenvalues and eigenstates of angular momentum, Orbital angular momentum, addition of angular momenta, Wigner-Eckart theorem, Tensor operators. • **Approximation methods**: Time independent perturbation theory (Non degenerate case), Time-independent perturbation theory (The dependent case), hydrogen like atoms (Fine structure and Zeeman effect), Variational methods, Time dependent potentials (The interaction picture), Fermi's Golden Rule; Selection rules; Time dependent perturbation theory, Energy shift and decay width • **Identical particles:** Pauli's exclusion principle, spin-statistics connection
Suggested Books	Textbooks: 1. J. J. Sakurai and J. Napolitano, *Modern Quantum Mechanics* (3rd edition), Cambridge University Press, (2020) ISBN: 978-1108473224. 2. R. Shankar, *Principles of Quantum Mechanics*, Springer, (2011), ISBN: 978-0306447907 Reference Books: 3. J. S. Townsend, *A Modern Approach to Quantum Mechanics*, University Science Books, (2012), ISBN:978-1891389788. 4. L. Landau and L. Liftshitz, *Quantum mechanics - Vol. 3* (3rd edition), Butterworth-Heinemann, (1981) ISBN: 978-0750635394. 5. C. Cohen-Tannoudji, B. Diu and F. Laloë, *Quantum Mechanics Vol. 2*, Wiley-VCH, (2019), ISBN: 978-3527345540

Course Code	**PH 304**
Title of the Course	**Fundamentals of Statistical Mechanics**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Basic knowledge of thermal physics
Objectives of the course	This course imparts analytic techniques in classical and quantum statistical mechanics
Course Outcomes	● The students should get well versed with partition function and various related concepts. ● They should be able to differentiate between various regimes of validity and properties of quantum and classical ensemble of particles
Course Syllabus	• **Formulation of thermodynamics using generalized coordinates:** Thermodynamic laws and potentials, approach to equilibrium and stability analysis, Gibbs-Duhem relation, generalized Maxwell's equations. • **Statistical tools:** Probability theory, random variables, moments and cumulants, probability distributions, Wick's theorem, sums of random variables and the central limit theorem, Illustrative applications in: Rules for large numbers, Information theory and Shannon entropy. • **Kinetic theory of gasses:** Concept of phase space, Liouville's theorem, Boltzmann equation. • **Classical statistical mechanics:** Micro-canonical ensemble, two-level systems, ideal gas, mixing entropy and Gibbs paradox, canonical ensemble, Gibbs canonical ensemble, grand canonical ensemble, limitations of classical statistical mechanics and thermal wavelength. • **Interacting particles:** Cluster expansion, van der Waals equation and Virial coefficients, introduction to mean-field theory. • **Quantum statistical mechanics:** Quantum macrostates and density matrices, Liouville's theorem using density matrix. • **Ideal quantum gases:** Identical particles, canonical and grand canonical formulations, non-relativistic gas, degenerate Fermi and Bose gases, superfluidity of Helium.
Suggested Books	Textbooks: 1. M. Kardar, *Statistical Physics of Particles*, Cambridge University Press. (2007) ISBN: 978-0521873420. 2. R. K. Pathria and P. D. Beale, *Statistical Mechanics* (4th edition), Academic Press, Elsevier. (2021) ISBN: 978-9351073970.

	Reference Books: 3. K. Huang, *Statistical Mechanics* (2nd edition), John Wiley & sons. (2021) ISBN: 978-9354247736. 4. J. P. Sethna, *Statistical mechanics: entropy, order parameters, and complexity* (2nd edition), Oxford University Press. (2006) ISBN: 978-0198865254. 5. D. Chandler, *Introduction to Modern Statistical Physics*, Oxford University Press. (1987) ISBN: 978-0195042771.

Course Code	**PH 305**
Title of the Course	**Advanced Classical Mechanics**
Course Category	**Core**
Credit Structure	**L-T-P-Credits 2-1-0-3 (3/2 = 1.5) Half semester course**
Name of the department	**Department of Physics**
Pre–requisite, if any	Fundamental classical mechanics with Langrangian Formulation
Objectives of the course	This course provides advanced concepts and techniques in classical mechanics and special theory of relativity
Course Outcomes	● To solve classical problems using Hamiltonian's principle ● Learn different aspects of Canonical Transformation ● Know basics of fluid mechanics
Course Syllabus	• **Hamilton's Principle**: Calculus of variations; Hamilton's principle; Legendre transformation and Hamilton's canonical equations; Canonical equations from a variational principle; Principle of least action. Noether's theorem and conservation of charges. • **Canonical transformations**: Generating functions; example of canonical transformations; group property; Integral variants of Poincare; Lagrange and Poisson brackets; Infinitesimal canonical transformations; Conservation theorem in Poisson bracket formalism; Jacobi's identity; Angular momentum Poisson bracket relations Hamilton-Jacobi theory: The Hamilton Jacobi equation for Hamilton's principal function; The harmonic oscillator problem; Hamilton's characteristics; Action angle variables. • **Fluid Mechanics**: Kinematics of moving fluids, equation of continuity, Euler's equation, Bernoulli's theorem • **Nonlinear Dynamics:** Introduction, maps and flows, stability, phase space, fixed point analysis, logistic maps, chaos.

Course Code	**PH 306**
Title of the Course	**Atomic and Molecular Spectroscopy**
Course Category	**Core**
Credit Structure	**L-T- P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Basic Knowledge of Quantum Mechanics and Mathematics.
Objectives of the course	To make the students to understand the physics of atomic and molecular structure and spectra, which are essential in terms of knowledge development in basic science and its applications.
Course Outcomes	Students will be able to ● Develop a solid foundation in atomic and molecular physics, preparing students for advanced study or careers in physics, chemistry, or related fields. ● Acquire problem-solving skills specific to atomic and molecular systems, enhancing analytical thinking and application of theoretical concepts to practical scenarios.
Course Syllabus	• **Fundamentals of spectroscopy:** Principles and instrumentation. • **Review of atomic structure of Hydrogen:** Atomic structure of two electron system, Many electron atoms; Central field approximation, Fine and Hyperfine structure: The interaction Hamiltonian, Selection rules, Effect of external magnetic field. • **Many-electron atom:** Central field approximation Slater determinant, L-S and j-j coupling, Equivalent and nonequivalent electrons, Energy levels and spectra, Spectroscopic terms, Hund's rule, Landé interval rule, Alkali spectra. • **Molecular Electronic States:** Concept of molecular potential, Separation of electronic and nuclear wavefunctions, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Electronic angular momenta, The LCAO approach, States for hydrogen molecular ion, Coulomb, Exchange and Overlap integral, Symmetries of electronic wavefunctions, pi and sigma bond; • **Rotation and Vibration of Molecules:** Centrifugal distortion, Symmetric top molecules, Molecular vibrations: Harmonic oscillator and the anharmonic oscillator approximation, Morse potential, Molecular rotation/vibration and microwave/infrared spectroscopy. • **Spectra of Diatomic Molecules**: Transition matrix elements, Vibration-rotation spectra, Electronic transitions, Franck-Condon principle, Dissociation energy of molecules, Raman

	transitions and Raman spectra, Vibration of Polyatomic Molecules: Application of Group Theory.
Suggested Books	Textbooks: 1. B. H. Bransden and C. J. Joachain, *Physics of Atoms and Molecules*, Pearson Education Limited, Second edition (2003), ISBN: 978-0582356924 2. C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, McGraw-Hill College (1994), ISBN: 978-9352601738 Reference Books: 3. D. C. Harris, M. D. Bertolucci, *Symmetry and Spectroscopy – An Introduction to Vibrational and Electronic Spectroscopy*, Oxford University Press, USA, Dover publications (1989), ISBN: 978-0486661445 4. J. M. Hollas, *Modern Spectroscopy*, Wiley (2004), ISBN: 978-0470844168 5. G. M. Barrow, Introduction to Molecular Spectroscopy, McGraw-Hill, (1962), ISBN: 978-0070038707

Course Code	**PH 307**
Course Title	**Topics in Mathematical Physics**
Course Category	**Core**
Credit Structure	**L - T - P – Credits 2-1-0-3 (3/2=1.5) Half semester course**
Name of the department	**Physics**
Pre-requisite, if any	Fundamental knowledge of Differential equations and Linear Algebra
Objectives of the course	This course introduces some physics specific advanced concepts of mathematics
Course Outcomes	● Be conversant in group theory, special functions and tensors and apply these concepts in various problems.
Course Syllabus	• **Introductory Group theory**: Abelian and non-Abelian groups, discrete and continuous groups, reducible and irreducible representations, generators and Lie algebra, applications of Lie groups. • **Special functions and applications**: Legendre, Bessel, Laguerre, Hermite, Chebyshev, Hypergeometric Functions, Spherical Harmonics. • **Tensors and their applications**: Introduction to Tensors, Covariant derivative, tensor transformations and applications to geometry.
Suggested Books	Textbooks: 1. G. B. Arfken and H. J. Weber, *Mathematical Methods for Physicists* (6th edition), Academic Press, (2005), ISBN: 978-9381269558 2. K. F. Riley, M.P. Hobson and S.J. Bence, *Mathematical Methods for Physics and Engineering: A Comprehensive Guide* (3rd edition), Cambridge University Press, (2006) ISBN: 978-0521679718 Reference Books: 3. S. Hassani, *Mathematical Physics: A modern introduction to its foundations*, Springer-Verlag, (1999), ISBN: 978-0387985794 4. M. L. Boas, *Mathematical Methods in the Physical Sciences (3rd edition),* John Wiley & Sons, (2005), ISBN: 978-0471198260 5. E. Kreyszig, *Advanced Engineering Mathematics (8th edition)*, John Wiley & Sons, (2006), ISBN: 978-8126508273

Course Code	**PH 309**
Title of the Course	**Simulation Methods and Analysis**
Course Category	**Core**
Credit Structure	**L-T-P-C (2-0-2-3)**
Name of the department	**Physics**
Pre–requisite, if any	Programming Language (Fortran/C/C++/Python)
Objectives of the course	The students will learn about various computing techniques used to understand physical phenomena in various systems.
Course Outcomes	Students should be able to write their own program to apply physics principles and study processes in a diverse range of settings.
Course Syllabus	• **Statistical Analysis:** Basics of Probability and Statistics, Bayes theorem, Probability distributions, Characteristic function, Central limit theorem, error propagation, Test statistic, Type I and II errors, sampling of data, Statistical tests: Goodness of fit, statistical fitting and parameter estimation, p-value and significance, interval estimations. • **Monte Carlo (MC) Techniques:** Random number generators, sampling, importance sampling, integration, biased/unbiased Monte Carlo, Metropolis algorithm, Markov chain Monte Carlo, quantum Monte Carlo, kinetic Monte Carlo, convergence and central limit theorem, various application of Monte Carlo methods • **Classical Molecular Dynamics (CMD):** Classical force fields, Different algorithms for integrating Newton's equation of motion, stability of various solvers, pressure and temperature coupling, MD in NPT and NVT ensembles, application of CMD in condensed matter and biological systems, Application in drug discovery.
Suggested Books	Textbooks: 1. M. H. Kalos and P. A. Whitlock, *Monte Carlo Methods (2nd Edition)*, Wiley-VCH , (2008), ISBN : 978-3527407606 2. D. Frenkel, *Understanding Molecular Simulation: From Algorithms to Applications*, Academic Press, New York, (2001), ISBN : 978-0122673511 3. G. Cowan, *Statistical Data Analysis*, Oxford Science Publications, (1998), ISBN: 978-0198501558 Reference Books: 4. M. P. Allen, D. J. Tildesley, *Computer Simulation of Liquids (2nd Edition)*, Oxford University Press, (2017) ISBN 978-0-19-880320-1 5. D. Sholl, J. A. Steckel, *Density Functional Theory: A Practical Introduction*, Wiley-Interscience, (2009) ISBN: 978-0470373170

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Course Code	**PH 311**
Title of the Course	**Physics of Semiconductor Devices**
Course category	**Department Elective**
Credit Structure	**L-T- P-Credits (3-0-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Fundamental concepts in Solid State Physics
Objectives of the course	This course will discuss about the basics of semiconductor materials and their device physics
Course Outcome	• Basic understanding of semiconductor materials and their applications. • Understanding of various types of semiconductor devices.
Course Syllabus	• **Semiconductor Fundamentals**: General Material Properties, Crystal Structure, Crystal Growth, Carrier Modelling, Semiconductor Models, Intrinsic and Extrinsic Semiconductor, Carrier Properties, State and Carrier Distribution, Equilibrium, Carrier Concentrations, Carrier Action: Drift, Diffusion, Recombinations-Generation, Equations of State. • **Basics of Device Fabrication and p-n Junction**: Fabrication Process, Device Fabrication Examples, p-n Junction: p-n Junction Electrostatics, I-V Characteristics, Junction Breakdown Mechanisms, Homo- and Hetero-Junctions. • **Metal-Semiconductor Contacts**: Schottky Barrier Diodes, Current Transport in Schottky Diodes, I-V Characteristics, Ohmic Contacts. • **MOS Structure**: Ideal MOS Structure, Energy Band Diagrams under Accumulation, Depletion, and Inversion Conditions, C-V Characteristics, MOSFET, basics about the operation of a MOSFET, I-V relationships of a MOSFET. • **Optoelectronic Devices**: Basics of Solar Cells, Light-Emitting Diodes, Lasers, and Photodetectors.
Suggested Books	Textbooks: 1. S. M. Sze, *Physics of Semiconductor Devices*, 3rd edition, Wiley, (2008) ISBN: 9788126517022 2. D. A. Neamen, *Semiconductor Physics and Devices*, 3rd edition, Tata Mcgraw Hill, (2017) ISBN: 978-007-0529-05-1 Reference Books: 3. R. F. Pierret *Semiconductor Device Fundamentals* 1st edition, Pearson, (2006) ISBN 978-8177589771 4. J. W. Orton, *The Story of Semiconductors*, Oxford University Press, (2008), ISBN: 9780191565441

Course Code	**PH 312**
Title of the Course	**Solar Photovoltaics: Fundamentals, Technologies and Applications**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Fundamental concepts around semiconductors and devices
Objectives of the course	This course will discuss the applied physics of solar energy conversion
Course Outcomes	Students will develop a thorough understanding of ● the fundamental concepts of semiconductor physics, the working principles and characterization of photovoltaic devices, and different generations of photovoltaic technologies. ● Students will be proficient in applying mathematical concepts and techniques to solve problems related to semiconductor physics and photovoltaic devices.
Course Syllabus	• **Fundamental concepts in semiconductor physics:** p and n-type semiconductors, doping and carrier concentration, diffusion and drift of carriers, continuity equation, P-N junction and its properties, *I-V* characteristics of a p-n junction under dark • **Working principle of a photovoltaic device and its characterization:** p-n junction as a solar cell, I-V characteristics of a p-n junction under illumination (concepts of Voc, Jsc, FF, Eff), parameters affecting the photovoltaic device performance (absorption coefficient, carrier mobilities, carrier diffusion lengths, carrier-generation/recombination mechanisms and rates, traps states etc.), Shockley-Queisser limit on the performance of a single junction solar cell, • Solar spectrum and Air Mass, Solar simulators and spectral mismatch, Characterization techniques for PV devices: EQE, LBIC etc. • **Different Generations of photovoltaic devices and their fabrication:** A brief history of Photovoltaic devices, single crystal, polycrystalline and amorphous Silicon solar cells, Thin film solar cells- CIGS, CdTe solar cells, Emerging PV technologies: Organic, DSSC, Hybrid perovskite, Quantum Dot solar cells. Overcoming SQ limit using multijunction solar cells. • **Current status of PV technologies:** Lab cells vs Modules, Fabrication of Modules and issues surrounding their operation. • **Advanced Applications of PV technologies:** Solar to hydrogen,

	Solar thermal approaches etc.
Suggested books	Textbooks: 1. J. Nelson, *The Physics of Solar Cells*, Imperial College Press (2003), ISBN: 978-1860943492 2. P. Wurfel, *Physics of Solar Cells: From Basic Principles to Advanced Concepts* Wiley-VCH, (2009) ISBN: 978-3527413126 Reference books: 3. S. M. Sze and Kwok. K. Ng, *Physics of Semiconductor Devices*, Wiley, (2008), ISBN: 978-8126517022 4. R. F. Pierret *Semiconductor Device Fundamentals* 1st edition, Pearson, (2006) ISBN 978-8177589771

Course Code	**PH 313**
Title of the Course	**Quantum Transport Theory and Simulations**
Course Category	**Elective**
Credit Structure	L-T- P-Credits (2-0-2-3)
Name of the Department	Physics
Pre–requisite, if any	Linear algebra and ordinary differential equations, Python Programming, Fundamental Quantum Mechanics
Objectives of the course	This course will introduce the key concepts of quantum transport in nanoscale/mesoscale electronic devices
Course Outcome	• Analyze quantum effects and phenomena applicable in a given nano-electronic device. • Acquire an overview of the present status of the field of nanophysics/quantum technologies.
Course Syllabus	• **Boltzmann Transport Equation**: Time-Relaxation Approximation, Linearized Approximation, Numerical solutions by discretization and Monte-Carlo simulations, Semiclassical transport and its Quantum corrections (with 3 Lab classes) • **Transport in nano-structures**: Distribution functions, Density of states, Ballistic conductors, Landauer Buttiker formula, Quantized conductance, Single-particle Green's functions formulation, Self-energies, Spin-polarized transport (with 3 Lab classes) • **Quantum transport Phenomena**: Quantum Hall effect, Weak-localization, Universal conductance fluctuations, Aharonov-Bohm effect, Spin-Orbit coupling • **Advanced formalism**: Correlation functions , Non-equilibrium density matrix: Simulations, Inflow and outflow, Inelastic flow, Coulomb blockade/Kondo resonance, Simulations of Non-equilibrium Green's function (NEGF) formalism and its application to nanowire transport (with 6 Lab classes)
Suggested Books:	Textbooks: 1. S. Datta, *Lessons from Nanoelectronics: A New Perspective on Transport*, Worlds Scientific, Singapore, (2018), ISBN: 978-981-4335-28-7 2. S. Datta, *Quantum Transport: Atom to Transistor*, Cambridge Press, (2005), ISBN: 9781139164313 Reference Books: 3. M. Lundstrom, *Fundamentals of Carrier Transport*, Cambridge Press, (2000), ISBN-13. 978-0521631341 4. J. H. Davies, *The Physics of Low-Dimensional Semiconductors*, Cambridge Press, (2006), ISBN: 0-521-48148-1. 5. D. Frenkel, *Understanding Molecular Simulation: From Algorithms*

	to Applications, Academic Press, New York, (2001), ISBN-13 : 978-0122673511

Course Code	**PH 314**
Title of the Course	**Introduction to Quantum Field Theory**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Relativistic Quantum Mechanics, General theory of relativity
Objectives of the course	The students will learn unified framework and techniques of relativistic field theory.
Course Outcomes	The students will be able to calculate amplitudes and probabilities of a variety of physical processes.
Course Syllabus	• **Canonical quantization:** Canonical quantization of free and interacting fields, relativistic normalization, S-Matrix, Dyson's formula, Wick's theorem. • **Feynman Diagrams:** Introduction to Feynman diagrams, Connected and amputated diagrams, Decay rates and scattering cross section, Vacuum bubbles, From Green's functions to S-matrices. • **Quantization of fermions:** Spinors, Dirac equation, Chiral spinors, Fermion quantization, Feynman rules for fermions, Scattering involving fermions. • **Quantum Electrodynamics:** Quantization of the electromagnetic field and its coupling to matter, Charged scalars, Feynman rules for QED, Scattering in QED.
Suggested Books	Textbooks: 1. M. Peskin and a D. Schroeder, *An Introduction to Quantum Field Theory*, Addison-Wesley, (1995) ISBN: 9780201503975 2. A. Lahiri and P. B. Pal, *A First Book of Quantum Field Theory*, Narosa, (2007), ISBN: 978-8173196546 Reference books: 3. M. D. Schwartz, *Quantum Field Theory and the Standard Model*, Cambridge University Press, (2013), ISBN: 978-1107034730 4. A. Zee, *Quantum Field Theory in a Nutshell*, 2nd Edition, Levant Books, (2012), ISBN: 9789380663425 5. M. Maggiore, *A Modern Introduction to Quantum Field Theory*, Oxford University Press, (2004), ISBN : 978-0198520740

Course Code	**PH 315**
Title of the Course	**Advanced Quantum Mechanics**
Course Category	**Department Elective**
Credit Structure	**L - T - P - Credits (2-1-0-3)**
Name of the Department	**Physics**
Pre-requisite, if any	Basics of Quantum Mechanics and Mathematical Physics
Objectives of the course	Exposing the students to various advanced aspects of Quantum Mechanics.
Course Outcomes	• The students will learn several advanced concepts in Quantum Mechanics, which have important applications in atomic and nuclear physics research.
Course Syllabus	• **Scattering theory:** Formal theory of scattering in Quantum Mechanics, Lippman-Schwinger equation, Scattering amplitude and differential cross-section, Born approximation, Application for Coulomb scattering, Partial wave analysis, Phase shift and scattering length, Scattering resonances and Breit-Wigner shape, Form factors and their applications. • **Symmetries in Quantum Mechanics:** Symmetry and degeneracy in Quantum Mechanics, Discrete symmetries, Parity transformation, Time reversal and need for anti-unitary operators. • **Relativistic Quantum Mechanics:** Relativistic Hamiltonian and Klein-Gordon equation, Negative energy solutions, Dirac equation, gamma matrices and their properties, spin and helicity, Dirac bilinears, Covariance of Dirac equation, Weyl spinors, Charge conjugation and Majorana equation.
Suggested Books	Textbooks: 1. J. J. Sakurai and J. Napolitano, *Modern Quantum Mechanics*, Third Edition, Cambridge University Press, (2020), ISBN: 9781108587280 2. J. D. Bjorken and S. D. Drell, *Relativistic Quantum Mechanics*, First Edition, Primis, (2008), ISBN: 978-0072320022 Reference Books: 3. W. Greiner and B. Muller, *Quantum Mechanics (Symmetries)*, Second Edition, Springer, (1994), ISBN: 978-3-642-57976-9 4. J. J. Sakurai, *Advanced Quantum Mechanics*, Pearson, (1967) ISBN: 978-0201067101 5. R. Shankar, *Principles of Quantum Mechanics*, Second Edition, Springer (2011) ISBN: 978-0306447907

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Course Code	**PH 317**
Title of the Course	**Data Analysis in High Energy Physics**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Prerequisite, if any	Nil
Objectives of the course	To familiarize students in relativistic kinematics and data analysis of High Energy Physics.
Course Outcomes	The student will know various technical concepts used to describe motion of relativistic particles
Course Syllabus	• **Review of special theory of relativity:** Lorentz Transformations, concept of four vectors, proper time, natural units, transformation from laboratory to center of momentum frame, concepts of rapidity, pseudo rapidity, decay kinematics, Lorentz Invariants, Two and three body decay processes, phase space. • **Analysis Framework:** Review of Object-oriented programming C++ and Python, Analysis Framework: ROOT- CERN, 1D, 2D, 3D Histograms, Graphs, Fitting, Physics with three and four vectors, Tree: concept of reading and writing data in columnar • Review of Statistical analysis • **Monte Carlo Techniques:** Generation of Toy Monte Carlo Sample, Unbinned Maximum Likelihood Fit • **Machine learning applications in High Energy Physics data:** Enhancement of signal to noise ratio, identification of electron and photon accelerator Physics clusters in electromagnetic calorimeter through image processing.
Suggested Books	Textbooks: 1. P. R. Bevington and D. K. Robinson, *Data Reduction and Error Analysis for the Physical Sciences*, McGraw-Hill, (2002), ISBN-10: 0072472278 2. R. Hagedorn, J. D. Jackson, D. Pines, *Relativistic Kinematics: A Guide to The Kinematic Problems of High Energy Physics*, Literary Licensing LLC, (2012), ISBN: 978-1258264369 Reference Books: 3. G. Cowan, *Statistical Data Analysis*, Oxford Science Publications, (1998), ISBN: 978-0198501558 4. J. R. Taylor, *An Introduction to Error Analysis The Study of Uncertainties in Physical Measurements (2nd edition)*, University Science Books, (1997) ISBN: 9780935702750 5. Richard Fernow, *Introduction to Experimental Particle Physics*, Cambridge University Press, (1989) ISBN: 0521379407

Course Code	**PH 318**
Title of the Course	**Introduction to String Theory**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Relativistic Quantum Mechanics, General Theory of Relativity
Objectives of the course	The students will be introduced to the basic frameworks of string theory
Course Outcomes	The students will gain understanding and outlook of various research topics in string theory
Course Syllabus	• Introduction to strings, Problems with quantizing gravity and comparison with other approaches, Notion of Effective Field Theory. • String dynamics. Nambu-Goto and Polyakov action, Various gauge choices, Worldsheet conformal field theory, Bosonic strings in 26 dimensions. • Types of string theory, Spectrum of string theory. • Introducing fermions, Supersymmetric strings in 10 dimensions. • D-branes, Higher form gauge fields, Introduction to M-theory. • Applications of string theory in many body physics, quantum information theory and low-energy effective field theory.
Suggested Books	Textbooks: 1. B. Zwiebach, *A first course in string theory*, Cambridge University Press, (2nd Ed.), (2009) ISBN- 978-0521880329 2. K. Becker, M. Becker, J. Schwarz, *String Theory and M-Theory: A Modern Introduction* Cambridge University Press, (1st Ed.), (2006) ISBN- 978-0521860697 Reference Book: 3. E. Kiritsis, *String Theory in a Nutshell*, Princeton University Press, 2nd Edition, (2007), ISBN : 978-0691155791

Course Code	**PH 320**
Title of the Course	**Physics of the Early Universe and Dark Matter**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Introductory general theory of relativity, Knowledge of the Standard Model of Particle physics.
Objectives of the course	Applications of the Standard Model of Particle Physics in cosmology, followed by introduction to dark matter and its importance
Course Outcomes	• It will enable students to work in the interface of cosmology and particle physics. • Familiarity with on-going research on dark matter with an exposure to the particle nature of dark matter
Course Syllabus	• Homogeneous Isotropic Universe, Robertson-Walker metric, redshift and luminosity distance, Friedmann equations, time evolution of the Universe, thermodynamics in the expanding Universe, Primordial nucleosynthesis, Photon decoupling, CMB power spectrum, Neutrino freeze-out, • Cosmological model with dark matter and dark energy, phase transitions in the early universe, generation of baryon asymmetry, aspects of Inflation. Application of the Standard Model of particle physics and physics beyond it in cosmology. • Experimental evidence of dark matter, Direct and indirect searches, Particle nature of dark matter, Hot and cold thermal relics, Various candidates: WIMPs, axions, etc.
Suggested Books	Textbooks: 1. V. A Rubakov, D. S. Gorbunov, *Introduction To The Theory Of The Early Universe*: *Hot Big Bang Theory*, WS Professional; Second edition, (2011) ISBN: 978-9813209886 2. S. Profumo, *An Introduction to Particle Dark Matter*, World Scientific, (2017) ISBN:978-1786340016 Reference Books 3. S. Weinberg, *The First Three Minutes: A Modern View Of The Origin Of The Universe*, Basic Books, (2022), ISBN: 978-0465024377 4. E. Kolb and M. Turner, *The Early Universe*, Taylor & Francis, (1994) ISBN: 978-1138329904 5. S. Dodelson and F. Schmidt, *Modern Cosmology*, Academic Press Inc; 2nd edition, (2020), ISBN: 978-0128159484

Course Code	**PH 322**
Title of the Course	**Introduction to Quantum Information and Computation**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-0-2-3)**
Name of the department	Physics
Pre–requisite, if any	Basics of Quantum Mechanics, Linear algebra
Objectives of the course	To understand the basics of quantum information and computation and solve problems.
Course Outcomes	Students will develop an understanding on basics of quantum information, quantum entanglement, quantum computation, and quantum communication protocols.
Course Syllabus	• **Preliminaries:** Overview of classical information, computation, and complexity classes. • **States and operators:** Axioms of quantum mechanics; Qubit systems; Concept of mixed states – density operators. • **Composite systems:** Entanglement in pure states; Local operation and classical communication; Entanglement in mixed states; Peres-Horodecki criterion of severability. • **Measurement and operations:** Orthogonal (higher rank) and generalized (POVM) measurements; Quantum operations, noise, and channels. • **Quantum gates and circuits for computation:** single and multi-qubit gates; universal gates; basic quantum circuit diagrams. • **Entropy and information:** Shannon entropy, Basic properties of entropy, Von Neumann entropy, Strong subadditivity. • **Quantum communication:** No-cloning theorem, Quantum teleportation, Quantum dense coding.
Suggested Books	Textbook: 1. M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information: 10th Anniversary Edition*, Cambridge University Press, Cambridge, (2010). ISBN: 978-1107002173. Reference books: 2. D. Bruss (Editor), G. Leuchs (Editor), *Quantum Information: From Foundations to Quantum Technology Applications (2nd edition)*, Wiley-VCH, Germany, (2019) ISBN: 978-3527413539. 3. M. Wilde, *Quantum information theory*, Cambridge University Press, Cambridge, (2013) ISBN: 978-1107034259.

Course Code	**PH 351**
Title of the Course	**Engineering Physics Lab - II**
Course Category	**Core**
Credit Structure	**L-T- P-Credits (0-0-3-1.5)**
Name of the department	**Physics**
Pre–requisite, if any	Nil
Objectives of the course	To enhance experimental skills and concepts in physics by giving students exposure to a variety of different experiments
Course Outcomes	The students will be able to • Develop essential experimental skills by conducting a variety of physics experiments in the laboratory, • Experimental verification of concepts in Fundamental Physics, Nuclear Physics, Non-linear dynamics • Evaluate the errors and statistical deviations associated with the experimental results
Course Syllabus	A representative list of experiments will be performed by students. **Fundamental Physics:** ○ Thermal expansion of solids ○ Cauchy's dispersion relations ○ Stefan's constant (Black body radiation) ○ Uncertainty principle using single slit diffraction ○ Dielectric constant of liquids **Nuclear Physics:** ○ Gamma-ray detection using the Geiger-Muller counter ○ Rutherford Scattering Experiment ○ Muon lifetime determination using a scintillator detector **Non-linear Dynamics:** ○ Chaos (Chua circuit) ○ FeigenBaum Circuit
Suggested books	Reference Books: 1. W. F. Smith, *Experimental Physics: Principles and Practice for the laboratory*, CRC Press, (2020), ISBN: 978-1498778473 2. L. Lyons, *A practical guide to data analysis for physical science students*, Cambridge Univ. Press, (1991), ISBN: 978-0415481519

Course Code	**PH 352**
Title of the Course	**Solid State Physics Lab**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (0-0-3-1.5)**
Name of the department	**Physics**
Pre–requisite, if any	None
Objectives of the course	Students will gain exposure to experimental and theoretical aspects of Solids State Physics
Course Outcomes	The students will be able to • Relate the concepts or phenomena learnt in solid state physics to physical systems via experimental learning. • Operation of different advanced instruments, handling of the data analysis and evaluation of the errors and statistical deviations associated with the experimental results.
Course Syllabus	A representative list of experiments will be performed by students: **Optical processes in solids** • Demonstration of Photoluminescence in solids **Structural and morphological studies on solids:** • Understanding the concept of grain boundary and grain-size in polycrystalline solids using force/electron microscopy **Optoelectronic devices:** • IV- Characteristics of a silicon solar cell • Temperature-dependent Hall effect • Characterization of Light Emitting Diode **Dielectric/Magnetic measurement on Solids:** • Measurement of Magnetoresistance of Bismuth • Magnetic hysteresis loop tracer • Study of dielectric constant and Curie temperature of ferroelectric ceramics • Magnetic susceptibility of paramagnetic substance using Gouy's method • Frequency dependence of dielectric constant **Computational Assignments:** • Computational design of 2D layer materials • Theoretical design principle of bulk materials. • The equilibrium geometry, electronic structure and thermodynamic potential computations.
Suggested books	Reference Book: 1. M. I. Pergament, *Methods of experimental physics*, CRC Press, 2019, ISBN: 978-0367866426

Course Code	**PH 356**
Title of the Course	**Spectroscopy Lab**
Course Category	**Core**
Credit Structure	**L-T-P-Credits (0-0-3-1.5)**
Name of the department	**Physics**
Pre–requisite, if any	None
Objectives of the course	Students will gain practical exposure to the field of spectroscopy through experiments
Course Outcomes	The students will be able to • Carry out advanced experiments in Atomic and Molecular Spectroscopy. • Understand the utilization of various energy ranges of the *EM*-radiation in detecting the various atomic and molecular processes.
Course Syllabus	A representative list of experiments will be performed by students: • Demonstration of Electron Spin Resonance effect • Demonstration of Zeeman effect • Fine structure of Sodium • Demonstration of NMR effect • Study of thermoluminescence of F centers • Demonstration of Raman effect • Understanding molecular vibrations using FTIR • Determination of valance state of atoms using X-ray Absorption Spectroscopy
Suggested books	Reference Book: 1. M. I. Pergament, *Methods of experimental physics*, CRC Press, (2019), ISBN: 978-0367866426

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Course Code	**PH 402 / PH 616**
Title of the Course	**Principles and Applications of Optical Spectroscopy**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-0-2-3)**
Name of the department	**Physics**
Pre–requisite, if any	Laser Physics course and Engineering Electromagnetics, Fundamental Quantum Mechanics
Objectives of the course	Students will learn the principles of different optical spectroscopic techniques and the applications of these techniques in investigations of optical, optoelectronic and vibrational properties of materials. The students will be introduced to the optoelectronic parts of various spectroscopic techniques.
Course Outcome	• Modern tool usage: Develop skills to use optoelectronics and spectroscopic techniques. • Engineering knowledge: Develop understanding of working of optoelectronics. • Life-long learning: Develop an aptitude for research on optoelectronic materials and devices.
Course Syllabus	• Light and matter interactions, Basic principles of optics • Working principles of optoelectronics for spectroscopy: Applications of lasers in spectroscopy, Linear and nonlinear optics, Modulators, Photodetectors, Polarizers, Gratings, Birefringent, and Waveguides. • Spectroscopic techniques, physical parameters and their significance, and applications: Atomic spectra, Rotational spectroscopy, Vibrational spectroscopy, Electronic spectroscopy, Ultraviolet visible spectroscopy, Raman and micro-Raman spectroscopy, Fourier Transformed Infrared Spectroscopy, Steady state and time-resolved Photoluminescence Spectroscopy, Ultrafast Optical Spectroscopy. • Experiments: Based on the abovementioned spectroscopic techniques
Suggested books	Textbooks: 1. J. Wilson, J. Hawkes, *Optoelectronics: An Introduction*, 3rd Ed., Prentice Hall Europe, (1998), ISBN: 978-0136384953 2. H. Kuzmany, *Solid-State Spectroscopy 2nd Ed.*: Springer (2009), ISBN: 978-3540639138 Reference books: 3. M. F. Vitha, *Spectroscopy: Principles and Instrumentation,* Wiley, (2019), ISBN:978-1-119-43664-5 4. S. S. Jha, *Perspectives in optoelectronics,* World Scientific (1995),

	ISBN: 978-9810220228 5. S. Agnello, *Spectroscopy for Materials Characterization,* John Wiley & Sons, (2021) ISBN: 9781119697329

Course Code	**PH 408 / PH 608**
Title of the Course	**Experimental and Theoretical Aspects of Heavy Ion Collisions**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite	Relativistic Kinematics, Nuclear Physics
Objectives of the course	Students will understand theoretical and experimental aspects of understanding quark gluon plasma
Course Outcomes	Students will learn: • Different models of QGP • Space Time evolution of heavy ion collision • Different experimental Facilities • Signatures of QGP
Course Syllabus	• Introduction to Heavy ion collisions and quark gluon plasma • **Review of Relativistic kinematics**: Lorentz transformation: frequently used reference frames, four vector notation, rapidity and pseudo-rapidity variables, light cone variables, collision and decay, relativistic invariants • **Thermodynamics**: Relativistic gas (hadrons, quarks and gluons) and its statistical and thermodynamical properties, MIT Bag model, Hagedron gas, phase diagram of QCD, criteria for formation of QGP in the laboratory • **Collision dynamics**: different stages of space-time evolution like pre-equilibrium, formation of • QGP, chemical and thermal equilibria, freeze-out and particle production; Bjorken's model for energy density; • **Experiments**: a general overview of past, present and future experimental facilities dedicated to search for QGP, data analysis technique, extraction of 4 momentum, control variables (centrality, root(s), system size) • **Signals of QGP:** Global Observable: Multiplicity, ET, Ef, (pseudo) Rapidity, Pt distributions: explanations of various regions and connections with particle production mechanism; Correlations and fluctuations; Collective flow: radial, directed, elliptic and higher order flow harmonics extraction and interpretations; Heavy quark and quarkonia suppression, strangeness enhancement, jet quenching and electromagnetic signals (photon and di-lepton).

Suggested Books	Textbooks: 1. C. Y. Wong, *Introduction to High-Energy Heavy-Ion Collisions*, World Scientific, (1994), ISBN: 978-9810202644 A. K. Chaudhuri, *A Short Course on Relativistic Heavy Ion Collisions*, IOP Publishing, (2014), ISBN: 978-0-750-31061-1l Reference Books: S. Sarkar, H. Satz, B. Sinha, *The Physics of the Quark-Gluon Plasma: Introductory Lecture*, Springer, (2010), ISBN: 978-3642261923 R. Fernow, *Introduction to Experimental Particle Physics*, Cambridge University Press, (2010), ISBN:978-0521379403 B. Sinha, S. Pal, S. Raha, *Quark-Gluon Plasma*, Springer-Verlag, (2012) ISBN: 978-3540519843

Course code	**PH 612 / PH 412**
Title of the course	**Dualities in field theory and gravity**
Credit structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre-requisites	Some basic understandings of Theoretical Particle Physics, and Relativity and Cosmology.
Objectives of the course	
Course outcome	String theory provides a deep connection between Einstein's gravity and a theory of quantum fields excluding gravity. This goes by the name of holographic or gauge/gravity or AdS/CFT duality. This course aims to introduce students to the forefront of this exciting research field, tying together seemingly unconnected subjects such as black holes, condensed matter physics, quantum information theory etc., and clarifies the nature of quantum gravity.
Course syllabus	• **Introduction**: Gravity vs all other interactions, black holes and black hole thermodynamics, holographic principle, Bekenstein bound, QCD in the large *N* limit, D-brane solutions and (super) gravity, introduction to Anti- de Sitter (AdS) spacetime. • **Conformal Field Theory (CFT)**: Conformal symmetries, primary operators, radial quantization, operator product expansion (OPE). • **Duality conjecture and dictionary**: General aspects of the duality, generalizations, correlation functions of local operators, Wilson loops. • **Holographic renormalization group**: Holographic renormalizations, Hamilton-Jacobi approach, holographic Wilsonian renormalization group approach. • **Insights to many-body systems**: Transports, hydrodynamics, quarkgluon plasma, interpretation of phase transitions in AdS. • **Applications to quantum information**: Entanglement structure, quantum error correction, computational complexity and related unfolding topics. • **Outlooks and open questions**: Checks of the duality,

	black hole information paradox, structure of quantum gravity.
Suggested books	Textbooks: M. Ammon and J. Erdmenger, Gauge/Gravity duality: Foundations and Applications, Cambridge University Press, 2015, ISBN: 978- 1107010345 H. Nastase, Introduction to the AdS/CFT correspondence, Cambridge University Press, 2015, ISBN: 978-1107085855 References: Aharony et al. Large N field theories, string theory and gravity. ArXiv: 9905111 [hep-th], D'Hoker et al. Supersymmetric gauge theories and the AdS/CFT correspondence (TASI 2001 lecture notes). ArXiv: 0201253 [hep-th] J. Penedones. TASI lectures on AdS/CFT. ArXiv: 1608.04948[hep-th]

Course Code	**PH 432 / PH 632**
Title of the Course	**Group Theory in Particle Physics**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**

Name of the department	**Physics**
Pre–requisite, if any	Mathematical Physics
Objectives of the course	The students will be introduced use of symmetry in the context of Particle Physics
Course Outcomes	The students will learn how to use Group Theory to construct mathematical models describing fundamental physics.
Course Syllabus	**Review of Group theory:** constructing multiplication tables, direct product, homomorphism, isomorphism, permutation group, invariant subgroup, simple group, continuous groups, rotation group and Lie algebra, SO(3), SU(2) and SU(3), general properties of SU(N). **Applications for Particle Physics:** • SU(3) of flavor, isospin as a subgroup, U and V spins, roots and weights, hadron multiplets, Gell-Mann Okubo mass formula, Young tableaux. • Lorentz group, connection with spin, Dirac, Majorana and Weyl spinors. • Nonabelian gauge theory, SU(2)xU(1) --> U(1) breaking. • Accidental symmetries of the Standard Model, Baryon and Lepton number conservation, Custodial symmetry. • Grand Unification and SU(5), from SU(5) to SO(10). • Applications of groups in flavor model building, Froggatt- Nielsen mechanism.
Suggested Books	Textbooks: 1. A. Zee, *Group Theory in a Nutshell for Physicists*, Princeton Univ. Press, (2016) ISBN: 978-0691162690 2. Georgi, *Lie algebras in Particle Physics*, Sarat, 2nd Edition, (2009) ISBN: 978-8190806428 Reference Books: 3. J. Schwichtenberg, *Physics from Symmetry*, Second Edition, Springer. (2017) ISBN: 9783319192017 4. P. B. Pal, *A Physicist's Introduction to Algebraic Structures*, First Edition, Cambridge University Press. (2019) ISBN: 9781108729116 5. A. Das, *Lie groups and Lie algebras for Physicists*, Hindustan Book Agency, (2014), ISBN: 978-9380250632

Course Code	**PH 440 /PH 640**

Title of the Course	**Introduction to String Theory**
Course Category	**Department Elective**
Credit Structure	**L-T-P-Credits (2-1-0-3)**
Name of the department	**Physics**
Pre–requisite, if any	Relativistic Quantum Mechanics, General Theory of Relativity
Objectives of the course	The students will be introduced to the basic frameworks of string theory
Course Outcomes	The students will gain understanding and outlook of various research topics in string theory
Course Syllabus	• Introduction to strings, Problems with quantizing gravity and comparison with other approaches, Notion of Effective Field Theory. • String dynamics. Nambu-Goto and Polyakov action, Various gauge choices, Worldsheet conformal field theory, Bosonic strings in 26 dimensions. • Types of string theory, Spectrum of string theory. • Introducing fermions, Supersymmetric strings in 10 dimensions. • D-branes, Higher form gauge fields, Introduction to M-theory. • Applications of string theory in many body physics, quantum information theory and low-energy effective field theory.
Suggested Books	Textbooks: B. Zwiebach, *A first course in string theory*, Cambridge University Press, (2nd Ed.), (2009) ISBN- 978-0521880329 K. Becker, M. Becker, J. Schwarz, *String Theory and M-Theory: A Modern Introduction* Cambridge University Press, (1st Ed.), (2006) ISBN- 978-0521860697 Reference Book: 1. E. Kiritsis, String Theory in a Nutshell, Princeton University Press, 2nd Edition, (2007), ISBN : 978-0691155791

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