B.Tech. Program from the Dept. of Physics

B.Tech. in Engineering Physics

Program Learning Objectives:	Program Learning Outcomes:
Program Goal 1: To nurture young engineers with a strong foundation in science and engineering for producing highly skilled engineers and scientists.	**Program Learning Outcome 1a:** Developing skills to apply strong knowledge of mathematics, science, engineering fundamentals. **Program Learning Outcome 1b:** To use research-based knowledge and research methodologies for developing cutting edge technology and for solving complex engineering problems.
Program Goal 2: Enhancement of problem-solving skills and independent thinking through a research oriented curriculum to conduct research or contribute to technology development projects, either individually or as a team leader.	**Program Learning Outcome 2a:** Develop highly skilled engineers who can contribute to the solution of technical and engineering problems that are based on broad principles of physics. **Program Learning Outcome 2b:** Ability to participate as members and project leaders on multidisciplinary teams in diverse workplaces and communities. Be able to communicate effectively in oral and written form.
Program Goal 3: To provide career opportunities in rapidly-advancing scientific and technical areas, R&D establishments, Modern cutting edge technologies, higher degree, Academia/Industry and etc .	**Program Learning Outcome 3a:** To practice and inculcate an ability of utilizing scientific knowledge and engineering design for developing technology for public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. **Program Learning Outcome 3b:** Be able to demonstrate an understanding of professional and ethical responsibility.

Sl. No.	Subject Code	SEMESTER III	L	T	P	C
1.	EP2101	Quantum Physics	3	1	0	4
2.	EP2102	Optics and Lasers	3	0	3	4.5
3.	EP2103	Classical dynamics: discrete and continuum systems	3	1	0	4
4.	EP2104	Thermal physics with engineering applications	3	1	0	4
5.	HS21XX	HSS Elective – I	3	0	0	3
Total Credit			**15**	**3**	**3**	**19.5**

Sl. No.	Subject Code	SEMESTER IV	L	T	P	C
1.	EP2201	Introduction to Nuclear and Particle Physics	2	1	0	3
2.	EP2202	Mathematical Methods for Engineers	3	1	0	4
3.	EP2203	Electromagnetism	3	1	0	4
4.	EP2204	Introductory Statistical Mechanics	2	1	0	3
5.	EP2205	Analog Electronics	2	0	3	3.5
6.	XX22PQ	IDE – I	3	0	0	3
Total Credit			**15**	**4**	**3**	**20.5**

Sl. No.	Subject Code	SEMESTER V	L	T	P	C
1.	EP3101	Computational Techniques	2	0	3	3.5
2.	EP3102	Data Science for Physicists	1	1	3	3.5
3.	EP3103	Digital Electronics and Microprocessors	2	0	3	3.5
4.	EP3104	Solid State Physics	3	1	2	5
5.	EP3105	Instrumentation Techniques	2	0	2	3
6.	XX31PQ	IDE – II	3	0	0	3
Total Credit			**13**	**2**	**13**	**21.5**

Sl. No.	Subject Code	SEMESTER VI	L	T	P	C
1.	EP3201	Nonlinear Dynamics	2	1	0	3
2.	EP3202	Interfacing and data analysis	1	0	4	3
3.	EP3203	Atomic and Molecular Physics	3	1	2	5
4.	EP3204	Soft Condensed Matter Physics	3	0	0	3
5.	PH32XX	DE – I	3	0	0	3
6.	PH32XX	DE – II	3	0	0	3
Total Credit			**15**	**2**	**6**	**20**

Sl. No.	Subject Code	SEMESTER VII	L	T	P	C
1.	EP4105	Quantum Technology Laboratory	1	0	3	2.5
2.	PH41XX	DE-III	3	0	0	3
3.	HS41XX	HSS Elective – II	3	0	0	3
4.	XX41PQ	IDE – III	3	0	0	3
5.	PH4198	Summer Internship*	0	0	12	3
6.	PH4199	Project – I	0	0	12	6
Total Credit			**10**	**0**	**27**	**20.5**

*** For specific cases of internship after VIth Semester, the performance evaluation would be made on joining the VIIth Semester and graded accordingly in the VIIth Semester:**

Note:
a) (i) Summer internship (*) period of at least 60 days' (8 weeks) duration begins in the intervening vacation between Semester VI and VII that may be done in industry / R&D / Academic Institutions including IIT Patna. The evaluation would comprise **combined grading based on host supervisor evaluation, project internship report after plagiarism check and seminar presentation at the Department (DAPC to coordinate)** with equal weightage of each of the three components stated herein.

a) (ii) Further, on return from internship, students will be evaluated for internship work through combined grading based on host supervisor evaluation, project internship report after plagiarism check, and presentation evaluation by the parent department with equal weightage of each component.

b) (i) In the VIIth semester, students can opt for a semester long internship on recommendation of the DAPC and approval of the Competent Authority.

b) (ii) On approval of semester long internship, at the maximum two courses (properly mapped/aligned syllabus) at par with institute electives may be opted from NPTEL and / or SWAYAM and the other two more should be done at the institute through course overloading in any other semester (either before or after the internship) and/or during following summer semester.

b) (iii) The candidates opting two courses from NPTEL and / or SWAYAM would be required to appear in the examination at the Institute as scheduled in the Academic Calendar.

Sl. No.	Subject Code	SEMESTER VIII	L	T	P	C
1.	PH42XX*	DE-IV	3	0	0	3
2.	PH42XX	DE-V	3	0	0	3
3.	PH42XX	DE-VI	3	0	0	3
4.	PH42XX	DE-VII	3	0	0	3
5.	PH4299	Project – II	0	0	16	8
Total Credit			**12**	**0**	**16**	**20**
Grand Total Credit (Semester I to VIII)			**168**			

* Valid only for the course PH4206 since this is common to M. Sc. and Engineering Physics

ELECTIVE GROUPS

Sl. No.	Course Code	Departmental Elective – I	L	T	P	C
1.	PH3201	Engineering Optics	3	0	0	3
2.	PH3202	Cryogenic Engineering	3	0	0	3
3.	PH3203	Advanced Quantum Mechanics	3	0	0	3
4.	PH3204	Power Sources for Electric Vehicles	3	1	0	4
5.	PH3205	Engineering Electromagnetics	3	0	0	3

Sl. No.	Course Code	Departmental Elective – II	L	T	P	C
1.	PH3206	Laser Physics	3	0	0	3
2.	PH3207	Advanced Mathematical Methods	2	1	0	3
3.	PH3208	Electron Microscopy	3	0	0	3
4.	PH3209	Quantum Computation	2	1	0	3
5.	PH3210	Device Modeling and Design	2	1	0	3

Sl. No.	Course Code	Departmental Elective – III	L	T	P	C
1.	PH4106	Science and Technology of Nanomaterials	3	0	0	3
2.	PH4107	Optical Quantum Communication	3	0	0	3
3.	PH4108	Photovoltaics: Concepts and Applications	3	0	0	3
4.	PH4109	Electronic Devices and Circuits	3	0	0	3

Sl. No.	Course Code	Departmental Elective – IV	L	T	P	C
1.	PH4205	Quantum Mechanics - II	2	1	0	3
2.	PH4206	Thin Film Technology	3	0	0	3
3.	PH4209	Solar Energy and Photovoltaics	3	0	0	3
4.	PH4210	Modeling Complex Systems	3	0	0	3
5.	PH4211	AC Network Analysis	3	0	0	3

Sl. No.	Course Code	Departmental Elective – V	L	T	P	C
1.	PH4212	X-ray and Applications	3	0	0	3
2.	PH4213	Materials Engineering	3	0	0	3
3.	PH4214	Superconducting Qubits: Fundamentals and Operation	3	0	0	3
4.	PH4215	Analytical Techniques	3	0	0	3

Sl. No.	Course Code	Departmental Elective – VI	L	T	P	C
1.	PH4216	Computational Methods for Classical and Quantum Physics	3	0	0	3
2.	PH4217	LASER Technology	3	0	0	3
3.	PH4218	Atomtronics & Quantum Technology	3	0	0	3
4.	PH4219	Nanoscale Devices	3	0	0	3

Sl. No.	Course Code	Departmental Elective – VII	L	T	P	C
1.	PH4220	Medical Physics and Applications	3	0	0	3
2.	PH4221	Emerging Technologies in Photonics	3	0	0	3
3.	PH4222	Micro Nano Fabrication	3	0	0	3
4.	PH4223	Nanogenerators and Application in Self-powered System	3	0	0	3

Interdisciplinary Electives (Available to students of B. Tech. other than Dept. of Physics)

Sl. No.	Subject Code	Subject	L	T	P	C
		IDE-I				
1.	PH2201	Fundamentals of Electromagnetism	3	0	0	3
2.	PH2202	Waves and Particles	3	0	0	3
3.	PH2203	Fuel Cell Fundamentals	3	0	0	3
		IDE-II				
1.	PH3101	Energy Materials Processing	3	0	0	3
2.	PH3102	Mechanics in Physics	3	0	0	3
		IDE-III				
1.	PH4110	Photovoltaics and Fuel Cell Technology	3	0	0	3

Minor Options from the Dept. of Physics

1. Minor in Physics

Sl. No.	Subject Code	Subject	L	T	P	C
1.	EP2101	Quantum Physics	3	1	0	4
2.	EP2203	Electromagnetism	3	1	0	4
3.	EP3104	Solid State Physics	3	1	2	5
4. Minor-IV (Any One)						
i.	PH3201	Engineering Optics	3	0	0	3
ii.	PH3206	Laser Physics	3	0	0	3
iii.	PH3210	Device Modeling and Design	2	1	0	3
5. Minor-V (Any One)						
i.	PH4106	Science and Technology of Nanomaterials	3	0	0	3
ii.	PH4107	Optical Quantum Communication	3	0	0	3
iii.	PH4108	Photovoltaics: Concepts and Applications	3	0	0	3

Total Credits : 19

2. Minor in Nanoscience

Sl. No.	Subject Code	Subject	L	T	P	C
1.	EP2101	Quantum Physics	3	1	0	4
2.	EP2203	Electromagnetism	3	1	0	4
3.	EP3105	Instrumentation Techniques	2	0	2	3
4.	PH3208	Electron Microscopy	3	0	0	3
5.	PH4206	Thin Film Technology	3	0	0	3

Total Credits : 17

1. **Minor in Optics**

Sl. No.	Subject Code	Subject	L	T	P	C
1.	EP2102	Optics and Lasers	3	0	3	4.5
2.	EP2203	Electromagnetism	3	1	0	4
3.	EP3105	Instrumentation Techniques	2	0	2	3
4.	PH3201	Engineering Optics	3	0	0	3
5.	PH4221	Emerging Technologies in Photonics	3	0	0	3

Total Credits : 17.5

2. **Minor in Energy Storage Technology**

Brief outline: Emergent issues of global significance comprising fast depleting fossil fuels reserve, carbon foot print, visible climate change, temperature rise and melting of glaciers causing sea level rise are interrelated. These challenging issue are threatening sustainable growth and even survival of the planet earth.

To exercise an effective control well in time, therefore, requires "zero emission" culture and effective implementation of clean and green energy alternatives without any loss of time. This requirement has put pressing demand for development of newer clean energy technology on R&D institutions, its commercialization on industry, creation of talent pool in the area under demand by academic institutions and better industry-academia tie up in this emergent area. A positive signal has already become visible with faster adoption of electric vehicles (EVs) on road that is likely to emerge as a multiplicative technology market in near future.

Keeping this realistic fact in mind, the department of Physics has come up with a minor program in *"Energy Storage Technology"* with following course structure:

Sl. No.	Subject Code	Subject	L	T	P	C
1.	PH2101	Energy Storage Fundamentals	3	0	0	3
2.	PH2203	Fuel Cell Fundamentals	3	0	0	3
3.	PH3101	Energy Materials Processing	3	0	0	3
4.	PH3204	Power Sources for Electric Vehicles	3	1	0	4
5.	PH4108	Photovoltaics: Concepts and Applications	3	0	0	3

Total Credits : 16

Minor in Quantum Technology

Sl. No.	Subject Code	Subject	L	T	P	C
1.	EP2101	Quantum Physics	3	1	0	4
2.	EP2204	Introductory Statistical Mechanics	2	1	0	3
3.	EP3101	Computational Techniques	2	0	3	3.5
4.	PH3209	Quantum Computation	2	1	0	3
5.	PH4107	Optical Quantum Communication	3	0	0	3

Total Credits: 16.5

Sl. No.	Subject Code	SEMESTER I	L	T	P	C
1.	MA1101	Calculus and Linear Algebra	3	1	0	4.0
2.	CS1101	Foundations of Programming	3	0	3	4.5
3.	PH1101/PH1201	Physics	3	1	3	5.5
4.	CE1101/CE1201	Engineering Graphics	1	0	3	2.5
5.	EE1101/EE1201	Electrical Sciences	3	0	3	4.5
6.	HS1101	English for Professionals	2	0	1	2.5
TOTAL			**15**	**2**	**13**	**23.5**

Course Number	MA1101
Course Credit (L-T-P-C)	3-1-0-4
Course Title	Calculus and Linear Algebra
Learning Mode	Lectures and Tutorials
Learning Objectives	To provide the essential knowledge of basic tools of Differential Calculus, Integral Calculus, Vector spaces and Matrix Algebra.
Course Description	This course provides a foundation for Calculus and Linear Algebra. Topics related to properties of single and two variable functions along with their applications will be discussed. In addition fundamentals of linear algebra and matrix theory with applications will also be discussed.
Course Content	**Differential Calculus (12 Lectures)**: Limit and continuity of one variable function (including ε-δ definition). Limit, continuity and differentiability of functions of two variables, Tangent plane and normal, Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers. **Integral Calculus (10 Lectures)**: Riemann integral for one variable functions, Double and Triple integrals, Change of order of integration. Change of variables, Applications of Multiple integrals such as surface area and volume. **Vector Spaces (12 Lectures)**: Vector spaces (over the field of real numbers), subspaces, spanning set, linear independence, basis and dimension. Linear transformations, range and null space, rank-nullity theorem, matrix of a linear transformation. **Matrix Algebra (8 Lectures)**: Elementary operations and their use in getting the rank, inverse of a matrix and solution of linear simultaneous equations, Orthogonal, symmetric, skew-symmetric, Hermitian, skew-Hermitian, normal and unitary matrices and their elementary properties, Eigenvalues and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix.
Learning Outcome	Students completing this course will be able to: 1. Understand various properties of functions such as limit, continuity and differentiability. 2. Learn about integrations in various dimension and their applications. 3. learn about the concept of basis and dimension of a vector space. 4. define Linear Transformations and compute the domain, range, kernel, rank, and nullity of a linear transformation. 5. compute the inverse of an invertible matrix. 6. solve the system of linear equations. 7. Apply linear algebra concepts to model, solve, and analyze real-world problems.
Assessment Method	Quiz /Assignment/ MSE / ESE
Suggested Readings:	**Textbooks:** 1. Thomas, G. B., Hass, J., Heil, C. and Weir M. D., "Thomas' Calculus", 14th Ed., Pearson Education, 2018 2. Kreyszig, E., "Advanced Engineering Mathematics", 10th Ed., Wiley India Pvt. Ltd, 2015 **Reference Books:** 1. Jain, R. K. and Iyenger, S. R. K., "Advanced Engineering Mathematics", 5th Ed., Narosa Publishing House, 2017 2. Axler, S., "Linear Algebra Done Right", 3rd Ed., Springer Nature, 2015 3. Strang, G., "Linear Algebra and Its Applications" 4th Ed., Cengage India Private Limited, 2005

Course Number	CS1101
Course Credit	3-0-3-4.5
Course Title	**Foundations of Programming**
Learning Mode	Offline
Learning Objectives	• To understand the fundamental concepts of programming • To develop the basic problem-solving skills by designing algorithms and implementing them. • To learn about various data types, control statements, functions, arrays, pointers, and file handling. • To achieve proficiency in debugging and testing a C program
Course Description	This introductory course provides a solid foundation in programming principles and techniques. Designed for students with little to no prior programming experience, it covers fundamental concepts such as variables, data types, control structures, functions, and basic data structures. Students will learn to write, debug, and execute programs using a high-level programming language. Emphasis is placed on developing problem-solving skills, logical thinking, and the ability to write clear and efficient code. By the end of the course, students will be equipped with the essential skills needed to pursue more advanced studies in computer science and software development.
Course Outline	Introduction and Programming basics, Expressions Control and Iterative statements, Functions, Arrays, Recursion vs. Iteration Pointers, 2D-Array with pointers, Structures, String, Dynamic memory allocation, File handling, Contemporary programming languages, and applications **Practical component**: Lab to be conducted on a 3-hour slot weekly. It will be conducted with the theory course so the topics for problems given in the lab are already initiated in the theory class.
Learning Outcome	• Understanding of Basic Syntax and Structure in C language • Proficiency in Data Types, Operators, and Control Structures • Function Implementation and learn to use them appropriately • Efficient Use of Arrays and Strings • Pointer Utilization • Ability to perform dynamic memory allocation and deallocation using malloc (), calloc (), realloc (), and free () functions. • Structured data management with structures and unions • Exposure of file Handling • Learning debugging and error Handling
Assessment Method	Internal (Quiz/Assignment/Project), Mid-Term, End-Term
Suggested Readings:	• Knuth, Donald E. The art of computer programming, volume 4A: combinatorial algorithms, part 1. Pearson Education India, 2011. • P.J. Deitel and H.M. Deitel, C How To Program, Pearson Education (7th Edition) • Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice−Hall • A. Kelley and I. Pohl, A Book on C, Pearson Education (4th Edition) • K. N. King, C PROGRAMMING A Modern Approach, W. W. Norton & Company

Course Number	**PH1101/PH1201**
Course Credit	3-1-3-5.5
Course Title	Physics
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with Program Goals 1 and 2
Course Description	This course deals with fundamentals in Classical mechanics, Waves and Oscillations and Quantum Mechanics. As a prerequisite, the mathematical preliminaries such as coordinate systems, vector calculus etc will be discussed in the beginning.
Course Outline	Orthogonal coordinate systems (Plane polar, Spherical, Cylindrical), concept of generalised coordinates, generalised velocity and phase space for a mechanical system, Introduction to vector operators, Gradient, divergence, curl and Laplacian in different co-ordinate systems. Central force problem and its applications. Rigid body rotation, vector nature of angular velocity, Finding the principal axes, Euler's equations; Gyroscopic motion and its application; Accelerated frame of reference, Fictitious forces. Potential energy and concept of equilibrium, Lennard-Jones and double-well potentials, Small oscillations, Harmonic oscillator, damped and forced oscillations, resonance and its different examples, oscillator states in phase space, coupled oscillations, normal modes, longitudinal and transverse waves, wave equation, plane waves, examples two- and three-dimensional waves. Michelson-Morley experiment, Lorentz transformation, Postulates of special theory of relativity, Time dilation and length contraction, Applications of special theory of relativity. **List of Experiments** Experiments in Broad Day light: Decay of Current in A Capacitive Circuit, Q-Factor of an LCR Circuit, Use of Hall probe for magnetic field measurement ‘g’ by different pendulums Surface Tension of Water by Method of Capillary Ascent (Marangoni effect) Normal modes (double pendulum; two pendulums connected by light spring; spring mass system) Speed of Sound in Air (design of experiments) Experiments in Darkroom:

	Speed of Light in Glass, Determination of e/m, Interference of Light: Newton’s Ring, Determination of Planck’s constant by Photoelectric Effect, Diffraction of light using single slit, grating and a thin wire (design of experiments)
Learning Outcome	Complies with PLO 1a, 2a, 3a The lab part of this course trains by practical laboratory sessions: 1. Skill development. 2. Students get know the basics of measurement by instrument, accuracy & precision of data, data analysis skill and error handling. Students get to know how various laws of classical and quantum physics plays important role in shaping and explaining various natural phenomena.
Assessment Method	Quiz, Assignments and Exams
Suggested Readings:	**Textbooks:** 1. Engineering Mechanics, M. K. Harbola, 2nd ed., Cengage, 2012 2. D. Kleppner and R. J. Kolenkow, An introduction to Mechanics, Tata McGraw-Hill, New Delhi, 2000. 3. I. G. Main, Oscillations and Waves 4. H. G. Pain, The Physics of Vibrations and Waves, 1968 5. Frank S. Crawford, Berkeley Physics Course Vol 3: Waves and Oscillations, McGraw Hill, 1966. **References:** 1. R. P. Feynman, R. B. Leighton and M. Sands, The Feynman Lecture in Physics, Vol I, Narosa Publishing House, New Delhi, 2009. 2. David Morin, Introduction to Classical Mechanics, Cambridge University Press, NY, 2007. 3. P. C. Deshmukh, Foundations of Classical Mechanics, Cambridge University Press, 2019

Course code	**CE1101/CE1201**
Course Credit (L-T-P-C)	1-0-3-2.5
Course Title	**Engineering Graphics**
Learning Mode	Lectures and Practical
Learning Objectives	Complies with PLO-1a 1. The course on engineering drawing is designed to introduce the fundamentals of technical drawing as an important form of conveying information. 2. Apply principles of engineering visualization and projection theory to prepare engineering drawings, using conventional and modern drawing tools. 3. Practice drawing orthographic projections, isometric views, and sectional views, of simple and combined solids in different orientations.
Course Description	This course will introduce drawing as a tool to represent a complex three-dimensional object on two-dimensional paper through methods of projections. The course explains the use of different drafting tools and the importance of conventions for uniformity and standardization of the interpretation of the drawings.
Course Outline	Fundamental of engineering drawing, line types, dimensioning, and scales. Conic sections: ellipse, parabola, hyperbola; cycloidal curves. Principle of projection, method of projection, orthographic projection, plane of projection, first angle of projection, Projection of points, lines, planes and solids. Section of solids: Sectional views of simple solids- prism, pyramid, cylinder, cone, sphere; the true shape of the section. Methods of development, development of surfaces. Isometric projections: construction of isometric view of solids and combination of solids from orthographic projections. Introduction to AutoCad and solving isometric problems.
Learning Outcome	After attending this course, the following outcomes are expected: a) The student will understand the basic concepts of engineering drawing. b) The student will be able to use basic drafting tools, drawing instruments, and sheets. c) The student will be able to represent three-dimensional simple and combined solid objects on two-dimensional paper. d) The student will be able to visualize and interpret the orientation of simple and combine solid objects.
Assessment Method	Laboratory Assignments (30%), Mid-semester examination (25%) and End-semester examination (45%).
Suggested Readings:	**Textbooks:** 1. N.D. Bhatt, Engineering Drawing, Charotar Publishing House. 2. Agrawal & Agrawal, Engineering Drawing, McGraw Hill. 3. Jolhe, Engineering Drawing. **References:** 1. Engineering Drawing and Design by David Madsen

Course Number	EE1101/EE1201
Course Credit	3-0-3-4.5
Course Title	Electrical Sciences
Learning Mode	Lectures and Experiments
Learning Objectives	Complies with Program goals 1, 2 and 3
Course Description	The course is designed to meet the requirements of all B. Tech programmes. The course aims at giving an overview of the entire electrical engineering domain from the concepts of circuits, devices, digital systems and magnetic circuits.
Course Outline	Circuit Analysis Techniques, Circuit elements, Simple RL and RC Circuits, Kirchoff's law, Nodal Analysis, Mesh Analysis, Linearity and Superposition, Source Transformations, Thevenin's and Norton's Theorems, Time Domain Response of RC, RL and RLC circuits, Sinusoidal Forcing Function, Phasor Relationship for R, L and C, Impedance and Admittance, Instantaneous power, Real, reactive power and power factor. Semiconductor Diode, Zener Diode, Rectifier Circuits, Clipper, Clamper, UJT, Bipolar Junction Transistors, MOSFET, Transistor Biasing, Transistor Small Signal Analysis, Transistor Amplifier and their types, Operational Amplifiers, Op-amp Equivalent Circuit, Practical Op-amp Circuits, Power Opamp, DC Offset, Constant Gain Multiplier, Voltage Summing, Voltage Buffer, Controlled Sources, Instrumentation Amplifier, Active Filters and Oscillators. Number Systems, Logic Gates, Boolean Theorem, Algebraic Simplification, K-map, Combinatorial Circuits, Encoder, Decoder, Combinatorial Circuit Design, Introduction to Sequential Circuits. Magnetic Circuits, Mutually Coupled Circuits, Transformers, Equivalent Circuit and Performance, Analysis of Three-Phase Circuits, Power measurement in three phase system, Electromechanical Energy Conversion, Introduction to Rotating Machines (DC and AC Machines). Laboratory: Experiments to verify Circuit Theorems; Experiments using diodes and bipolar junction transistor (BJT): design and analysis of half -wave and full-wave rectifiers, clipping and clamping circuits and Zener diode characteristics and its regulators, BJT characteristics (CE, CB and CC) and BJT amplifiers; Experiment on MOSFET characteristics (CS, CG, and CD), parameter extraction and amplifier; Experiments using operational amplifiers (op-amps): summing amplifier, comparator, precision rectifier, Astable and Monostable Multivibrators and oscillators; Experiments using logic gates: combinational circuits such as staircase switch, majority detector, equality detector, multiplexer and demultiplexer; Experiments using flip-flops: sequential circuits such as non-overlapping pulse generator, ripple counter, synchronous counter, pulse counter and numerical display; Power Measurement by two Wattmeter method; Open and Short Circuit Tests of Transformer.
Learning Outcomes	Complies with PLO 1a, 2a and 3a
Assessment Method	Quiz, Assignments and Exams
Suggested Readings:	**Texts/References** 1. C. K. Alexander, M. N. O. Sadiku, Fundamentals of Electric Circuits, 3rd Edition, McGraw-Hill, 2008. 2. W. H. Hayt and J. E. Kemmerly, Engineering Circuit Analysis, McGraw-Hill, 1993. 3. R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 6th Edition, PHI, 2001. 4. M. M. Mano, M. D. Ciletti, Digital Design, 4th Edition, Pearson Education, 2008. 5. Floyd, Jain, Digital Fundamentals, 8th Edition, Pearson.

	6. David V. Kerns, Jr. J. David Irwin, Essentials of Electrical and Computer Engineering, Pearson, 2004. 7. Donald A Neamen, Electronic Circuits; analysis and Design, 3rd Edition, Tata McGraw-Hill Publishing Company Limited. 8. Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, 5th Edition, Oxford University Press, 2004. 9. A. E. Fitzgerald, C. Kingsley Jr., S. D. Umans, Electric Machinery, 6th Edition, Tata McGraw-Hill, 2003. 10. D. P. Kothari, I. J. Nagrath, Electric Machines, 3rd Edition, McGraw-Hill, 2004. 11. Del Toro, Vincent. "Principles of electrical engineering." (No Title) (1972).

Course Number	HS1101
Course Credit	L-T-P-W: 2-0-1-2.5
Course Title	English for Professionals
Learning Mode	Offline
Learning Objectives	This course aims to help the students **(a)** attain proficiency in written English through the construction of grammatically correct sentences, utilization of subject-verb agreement principles, mastery of various tenses, and effective deployment of active and passive voice to ensure coherent and impactful written expression; **(b)** enhance oral communication skills by honing public speaking abilities, acquiring strategies to deliver persuasive presentations, and cultivating a polished telephone etiquette, enabling confident and articulate verbal communication; **(c)** foster active listening capabilities by recognizing different types of listening, and applying proven methods and strategies to improve active listening skills; **(d)** strengthen reading skills, including comprehension, interpretation, and critical analysis, to grasp diverse written materials and derive meaning from various types of texts encountered in academic and professional contexts; **(e)** develop adeptness in written communication for business purposes, encompassing the understanding of essential writing elements, mastery of appropriate writing styles thereby enhancing prospects for successful job interviews and subsequent professional endeavors.
Course Description	This academic course on communication skills aims to equip students with fluency in spoken and written English for effective expression in both academic and professional settings. By focusing on essential communication principles and providing practical experiences, students develop clarity, precision, and confidence in their communication. Through interactive discussions and exercises, students enhance critical thinking and adaptability in diverse contexts. Upon completion, students will excel in formal presentations, group discussions, and persuasive writing, enhancing their overall communication proficiency.
Course Outline	**Unit I:** Introduction to professional communication – LSRW - Phonetics and phonology Sounds in English Language – production and articulation – rhythm and intonation – connected speech - Basic Grammar and Advanced Vocabulary Sounds in English Language – production and articulation – rhythm and intonation – connected speech – persuading and negotiating – brevity and clarity in language. Unit II: Characteristics of Technical Communication: Types of communication and forms of communication - Formal and informal communication Verbal and non-Verbal Communication – Communication barriers and remedies Intercultural communication – neutral language Unit III: Comprehension and Composition – summarization, precis writing Business Letter Writing CV/ Resume – E-Communication Unit IV: Statement of Purpose, Writing Project Reports, Writing research proposal, writing abstracts, developing presentations, interviews – combating nervousness Tutorial: Listening Exercises, Speaking Practice (GDs, and Presentations), and Writing Practice Learning Outcome • Attain proficiency in written English, enabling the construction of grammatically correct sentences and coherent written expression through the use of appropriate grammar, tenses, and voice. • Enhance oral communication skills, including public speaking, persuasive presentation, and polished telephone etiquette, fostering confident and articulate verbal expression. • Cultivate active listening abilities, recognizing different listening types, overcoming obstacles, and employing strategies for attentive and effective communication.

	• Develop proficient written communication skills for business purposes, demonstrating understanding of essential writing elements, appropriate styles, and the creation of reports, notices, agendas, and minutes that effectively convey information.
Assessment Method	Class test + Quiz = 20%; Mid-semester = 25%; Assignment = 15%; End semester = 40%
Suggested Readings:	1. Balzotti, Jon. Technical Communication: A Design-Centric Approach. Routledge, 2022. 2. Kaul, Asha, Business Communication. PHI Learning Pvt. Ltd. 2009 3. Laplante, Phillip A. Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals. CRC Press, 2018. 4. Lawson, Celeste, et al. Communication Skills for Business Professionals, Second Edition. CUP, 2019. 5. Sharon Gerson and Steven Gerson. Technical Writing: Process and Product (8th Edition), London: Longman, 2013 6. Rentz, Kathryn, Marie E. Flatley & Paula Lentz. Lesikar's Business Communication Connecting in a Digital world, McGraw-Hill, Irwin.2012 7. Allan & Barbara Pease. The Definitive Book of Body Language, New York, Bantam,2004 8. Jones, Daniel. The Pronunciation of English, New Delhi, Universal Book Stall.2010 9. Savage, Alice. Effective Academic Writing. OUP. 2014 10. Swan and Alter. Oxford English grammar course. OUP. 201

Sl. No.	Subject Code	SEMESTER II	L	T	P	C
1.	MA1201	Probability Theory and Ordinary Differential Equations	3	1	0	4
2.	CS1201	Data Structure	3	0	3	4.5
3.	CH1201/CH1101	Chemistry	3	1	3	5.5
4.	ME1201/ME1101	Mechanical Fabrication	0	0	3	1.5
5.	ME1202/ME1102	Engineering Mechanics	3	1	0	4
6.	IK1201	Indian Knowledge System (IKS)	3	0	0	3
TOTAL			**15**	**3**	**9**	**22.5**

Course Number	MA1201
Course Credit (L-T-P-C)	3-1-0-4
Course Title	Probability Theory and Ordinary Differential Equations
Learning Mode	Lectures and Tutorials
Learning Objectives	To introduce the basic concepts of probability, statistics, and Differential equations.
Course Description	This course aims to cover basic concepts of probability, statistics and ordinary differential equations. In particular, popular distributions, random sampling, various estimators and hypothesis testing will be discussed. Students will also get exposure to the linear ordinary differential equations and their solution techniques.
Course Content	**Probability (12 Lectures)**: Random variables and their probability distributions, Cumulative distribution functions, Expectation and Variance, probability inequalities, Binomial, Poisson, Geometric, negative binomial distributions, Uniform, Exponential, beta, Gamma, Normal and lognormal distributions. **Statistics (10 Lectures)**: Random sampling, sampling distributions, Parameter estimation, Point estimation, unbiased estimators, maximum likelihood estimation, Confidence intervals for normal mean, Simple and composite hypothesis, Type I and Type II errors, Hypothesis testing for normal mean. **Ordinary Differential Equations (20 Lectures)**: First order ordinary differential equations, exactness and integrating factors, Picard's iteration, Ordinary linear differential equations of n-th order, solutions of homogeneous and non-homogeneous equations (Method of variation of parameters). Systems of ordinary differential equations, Power series methods for solutions of ordinary differential equations. Legendre equation and Legendre polynomials, Bessel equation and Bessel functions.
Learning Outcome	Students will get exposure and understanding of: 1. Random variables and their probability distributions 2. Understand popular distributions and their properties 3. Sampling, estimation and hypothesis testing 4. Solution of ordinary differential equations 5. Solution of system of ordinary differential equations 6. Special functions arising as power series solutions of ordinary differential equations
Assessment Method	Quiz /Assignment/ MSE / ESE
Suggested Readings:	**Text Books:** 1. Hogg, R. V., Mckean, J. and Craig, A. T., “Introduction to Mathematical Statistics”, 8th Ed., Pearson Education India, 2021 2. S.M. Ross “An introduction to Probability Models, Academic Press INC, 11th edition. 3. Miller, I. and Miller, M., “John E. Freund's Mathematical Statistics with Applications”, 8th Ed., Pearson Education India, 2013 4. S. L. Ross, Differential equations, 3rd Edition, Wiley, 1984 5. W. E. Boyce and R. C. Di Prima, Elementary Differential equations and Boundary Value Problems, 7th Edition, Wiley, 2001.

Course Number	CS1201
Course Credit	3-0-3-4.5
Course Title	**Data Structure**
Learning Mode	Offline
Learning Objectives	• Understand the principles and concepts of data structures and their importance in computer science. • Learn to implement various data structures and understand how different algorithms works. • Develop problem-solving skills by applying appropriate data structures to different computational problems. • Achieving proficiency in designing efficient algorithms.
Course Description	This course provides a comprehensive study of data structures and their applications in computer science. It focuses on the implementation, analysis, and use of various data structures such as arrays, linked lists, stacks, queues, trees, and graphs. Through theoretical concepts and practical programming exercises, this course aims to develop problem-solving and algorithmic thinking skills essential for advanced topics in computer science and software development.
Course Outline	• Introduction to Data Structure, • Time and space requirements, Asymptotic notations • Abstraction and Abstract data types • Linear Data Structure: stack, queue, list, and linked structure • Unfolding the recursion • Tree, Binary Tree, traversal • Search and Sorting, • Graph, traversal, MST, Shortest distance • Balanced Tree **Practical component**: Lab to be conducted on a 3-hour slot weekly. It will be conducted with the theory course so the topics for problems given in the lab are already initiated in the theory class.
Learning Outcome	• Understand Data Structure Fundamentals • Implement Basic Data Structures using a programming language • Analyse and Apply Algorithms • Design and Analyse Tree Structures • Understand the usage of graph and its related algorithms • Design and Implement Sorting and Searching Algorithms • Debug and Optimize Code
Assessment Method	Internal (Quiz/Assignment/Project), Mid-Term, End-Term
Suggested Readings:	• Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, Data Structures and Algorithms, Published by Addison-Wesley • Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein., Introduction to Algorithms, • Mark Allen Weiss, Data Structures and Algorithm Analysis in Java • Robert Sedgewick and Kevin Wayne, Algorithms • Narasimha Karumanchi, Data Structures and Algorithms Made Easy

Course Number	**CH1201/CH1101**
Course Credit	3-1-3-5.5
Course Title	Chemistry
Learning Mode	Offline
Learning Objectives	The course aims to lay a foundation for all three branches of chemistry, viz. Organic, Inorganic, and Physical Chemistry. The course aims to nurture knowledge to appreciate the interface of chemistry with other science and Engineering branches by combining theoretical concepts and experimental studies.
Course Description	This course introduces basic organic chemistry, inorganic chemistry and Physical chemistry to understand fundamental laws that governs various reactions, reaction rates, equilibrium, and their applications in daily life through relevant experimentation.
Course Outline	**Module 1:** Thermodynamics: The fundamental definition and concept, the zeroth and first law. Work, heat, energy and enthalpies. Second law: entropy, free energy and chemical potential. Change of Phase. Third law. Chemical equilibrium. Conductance of solutions, Kohlrausch's law-ionic mobilities, Basic Electrochemistry. **Module 2:** Coordination chemistry: Crystal field theory and consequences color, magnetism, J.T distortion. Bioinorganic chemistry: Trace elements in biology, heme and non-heme oxygen carriers, haemoglobin and myoglobin; Organometallic chemistry. **Module 3:** Stereo and regio-chemistry of organic compounds, conformational analysis and conformers, Molecules devoid of point chirality (allenes and biphenyls); Significance of chirality in living systems, organic photochemistry, Modern techniques in structural elucidation of compounds (UV–Vis, IR, NMR). **Module 4 (Lab Component):** Experiments based on redox and complexometric titrations; synthesis and characterization of inorganic complexes and nanomaterials; synthesis and characterization of organic compounds; experiments based on chromatography; experiments based on pH and conductivity measurement; experiment related to chemical kinetics and spectroscopy.
Learning Outcome	Students will be able to 1**.** identify organic and inorganic molecules and relate them to daily life applications through experiments. 2. understand important hypothesis, laws and their derivations to intercept physical phenomenon of chemical reactions and apply them in hands-on experiments. 3. understand the importance of organic and inorganic molecules in our body and environment. 4. know important analytical techniques to intercept chemical entity. 5. approach organic and inorganic synthesis as a skillset for drug manufacturing, calculate limiting reagents and yields, use various analytical tools to characterize organic compounds, interpret and ascertain data related to Physical chemistry aspects and know laboratory safety measures, risk factors and scientific report writing skills.
Assessment Method	**Theory**: 20% Quiz and assignment, 30% Mid sem and 50% End semester exams for theory part (4 credits). **Lab**: 60% lab report, lab performance and assignment, 20% End semester exam for practical part, 20% viva/quiz (1.5 credits). **Overall Weightage**: Theory (70%), Lab (30%).
Suggested Readings:	**Text books:** 1. Vogel's Qualitative Inorganic Analysis, G. Svehla, 7^{th} Edition, Revised, Prentice Hall, 1996. 2. A. J. Elias, S. S. Manoharan and H. Raj, "Experiments in General Chemistry", Universities Press (India) Pvt. Ltd., 1997.

	3. A. J. Elias, A Collection of Interesting General Chemistry Experiments, revised edition, Universities Press (India) Pvt. Ltd., 2007. 4. F. Albert Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, Advanced Inorganic Chemistry - 6^{th} Edition New Delhi: Wiley India, 2008. 5. K. Mukkanti, Practical Engineering Chemistry, B.S. Publications, Hyderabad, 2009. 6. Shriver and Atkins inorganic chemistry / Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller, Fraser Armstrong-5^{th} Edition – Oxford: UOP. 2012. 7. Atkins' Physical Chemistry, Peter Atkins, Julio de Paula, James Keeler, Oxford University Press, 11^{th} Edition 2017. 8. K. L. Kapoor, A Textbook of Physical Chemistry, Vol: 1, 2 (6^{th} Edition, 2019), Vol: 3 (5^{th} Edition, 2020) MaGraw Hill. 9. G. R. Chatwal, S. K. Anand, Instrumental Methods of Chemical Analysis, 5^{th} Edition, Himalaya Publications, 2023.

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8
CLO-1	X	X	X	X	X	X	X	X
CLO-2	X	X		X	X			
CLO-3	X	X	X	X		X	X	
CLO-4	X	X		X	X	X	X	X
CLO-5			X	X	X			X

Course Number	**ME1201/ME1101**
Course Credit	0-0-3-1.5
Course Title	Mechanical Fabrication
Learning Mode	Fabrication work – hands on fabrication work in Workshop
Learning Objectives	Complies with PLOs 3-4. • This course aims to develop the concepts and skills of various mechanical fabrication methods. • Fabrication of metallic and non-metallic components, fabrication using bulk and sheet metals, subtractive and additive manufacturing methods, and assemble the parts
Course Description	This course is designed to fulfil the need of hand on experience about various approaches (conventional and CNC, subtractive and additive) of mechanical fabrication approaches. Prerequisite: NIL
Course Outline	The jobs for various shops should be planned such that they are the parts of an assembled item. The student groups will fabricate different parts in various shops which will involve some amount of their creativeness/input particularly in design and/or planning. Various components as required for the assembled part can be made using the following shops: **Sheet Metal Working:** Development, sheet cutting and fabrication of designated job using sheet metal (ferrous/nonferrous); Joining of required portions by soldering, in case part is desired to be made leak proof. **Pattern Making and Foundry:** Making of suitable pattern (wood); making of sand mould, melting of non-ferrous metal/alloy (Al or Al alloys), pouring, solidification. Observation/identification of various defects appeared on the component. **Joining:** Butt/lap/corner joint job fabrication as required of low carbon steel plates; weld quality inspection by dye-penetration test (non-destructive testing approach)of the component made. Demonstration of semi-automatic Gas Metal Arc welding (GMAW). **Conventional machining:** Operations on lathe and vertical milling to fabricate the required component. The fabrication of the component should cover various lathe operations like straight turning, facing, thread cutting, parting off etc., and operations using indexing mechanism on vertical milling. **CNC centre:** Fundamentals of CNC programming using G and M code; setting and operations of job using CNC lathe or milling, tool reference, work reference, tool offset, tool radius compensation to fabricate the component with a designed profile on Al/Al-alloy plate. **3D printing (Fused Filament Fabrication): (2 weeks)** Create the model, select appropriate slicing and path for fabrication of a 3D job by layer deposition (additive manufacturing approach) using polymeric material. Demonstration on pattern fabrication using 3D printing.
Learning Outcome	• This course would enable the students to develop the concept of design, fabrication (subtractive and additive) for various engineering applications**.** Fabrication of components and assemble them. • The practical skill and hands on experience for various fabrication methods from bulk, sheet metal using conventional as well as CNC machines.
Assessment Method	Fabrication of components in each of the shops required for assembly of the given part; submission of reports for each shop, and quiz assessment.
Suggested Readings:	1. Hajra Choudhury, HazraChoudhary and Nirjhar Roy, 2007, Elements of Workshop Technology, vol. I,Mediapromoters and Publishers Pvt. Ltd.

	2. W A J Chapman, Workshop Technology, 1998, Part -1, 1st South Asian Edition, Viva Book Pvt Ltd. 3. P.N. Rao, 2009, Manufacturing Technology, Vol.1, 3rd Ed., Tata McGraw Hill Publishing Company. 4. M.Adithan, B.S. Pabla, 2012, CNC machines, New Age International Publishers

Course Number	**ME1202/ ME1102**
Course Number	Engineering Mechanics
L-T-P-C	3-1-0-4
Pre-requisites	Nil
Semester	Spring
Learning Mode	Lectures
Learning Objectives	Complies with PLOs 1, 4 • The objective of this first course in mechanics is to enable engineering students to analyze basic mechanics problems and apply vector-based approach to solve them.
Course Outline	1. **Rigid body statics**: Equivalent force system. Equations of equilibrium, Free body diagram, Reaction, Static indeterminacy. 2. **Structures**: 2D truss, Method of joints, Method of section. Beam, Frame, types of loading and supports, axial force, Bending moment, Shear force and Torque Diagrams for a member. 3. **Friction**: Dry friction (static and kinetic), wedge friction, disk friction (thrust bearing), belt friction, square threaded screw, journal bearings, Wheel friction, Rolling resistance. 4. **Centroid and Moment of Inertia** 5. **Introduction to stress and strain**: Definition of Stress, Normal and shear Stress. Relation between stress and strain, Cauchy formula. **Stress in an axially loaded member and stress due to torsion in axisymmetric section**
Learning Outcomes:	Following learning outcomes are expected after going through this course. • Learn and apply general mathematical and computer skills to solve basic mechanics problems. • Apply the vector-based approach to solve mechanics problems.
Assessment Method	Mid semester examination, End semester examination, Class test/Quiz, Tutorials
Suggested Readings:	**Reference Books** 1. H. Shames, Engineering Mechanics: Statics and dynamics, 4th Ed, PHI, 2002. 2. F. P. Beer and E. R. Johnston, Vector Mechanics for Engineers, Vol I - Statics, 3rd Ed, Tata McGraw Hill, 2000. 3. J. L. Meriam and L. G. Kraige, Engineering Mechanics, Vol I - Statics, 5th Ed, John Wiley, 2002. 4. E.P. Popov, Engineering Mechanics of Solids, 2nd Ed, PHI, 1998. F. P. Beer and E. R. Johnston, J.T. Dewolf, and D.F. Mazurek, Mechanics of Materials, 6th Ed, McGraw Hill Education (India) Pvt. Ltd., 2012.

Sl. No.	Subject Code	SEMESTER III	L	T	P	C
1.	EP2101	Quantum Physics	3	1	0	4
2.	EP2102	Optics and Lasers	3	0	3	4.5
3.	EP2103	Classical dynamics: discrete and continuum systems	3	1	0	4
4.	EP2104	Thermal physics with engineering applications	3	1	0	4
5.	HS21XX	HSS Elective – I	3	0	0	3
Total Credit			**15**	**3**	**3**	**19.5**

Course Number	**EP2101**
Course Credit	3-1-0-4
Course Title	Quantum Physics
Learning Mode	Lectures, Tutorials and Assignments
Learning Objectives	Complies with Program Goals 1,2 and 3
Course Description	Fundamental structure of the subject is explicated through theorems, postulates and models. Several well-known discoveries in quantum mechanics are detailed. It also includes a variety of applications to various physical systems (both 1D and 3D) which are not adequately explained by classical theory. Some modern relevant applications are mentioned too.
Course Outline	Emphasis on both early and modern experiments (Black body radiation, photoelectric effect, Compton effect, Stern-Gerlach, Frank-Hertz, Davisson-Germer, Wave-packet propagation, Quantum Hall effect, Dirac-Kapitza effect, Raman-Nath scattering, etc.). Postulates of quantum mechanics, Observables, uncertainty principle, Schrödinger Equation, stationary states, orthonormality, expectation values, application to 1-D problems: Free particle, Particle in a box and finite square well, Quantum tunneling and applications, Harmonic oscillator, Delta-Function Potential, orbital and spin angular momentum, Hydrogen atom, electrons in 1D periodic lattice and origin of bands. Engineering applications: devices based on quantum principles such as tunnel diode, single electron transistor, MRI and NMR, SEM, TEM and SPM.
Learning Outcome	Complies with PLO 1a, 1b, 2a and 3a
Assessment Method	Assignments, Quizzes, Seminar, Mid-semester examination, End-semester examination
Suggested Readings:	**Textbooks:** **1.** A. Beiser, Concepts of Modern Physics, Tata McGraw Hill, 2020 **2.** Eisberg and Resnick 3. Introduction to Quantum Mechanics (2nd edn) by D. J. Griffiths, Prentice Hall (2004). **Reference books**: 1. Quantum Mechanics, Powell and Craseman 1. Mastering quantum mechanics, Barton Zwiebach, MIT Press, 2022

Course Number	**EP2102**
Course Credit	3-0-3-4.5
Course Title	Optics & Lasers
Learning Mode	Lectures and Assignments
Learning Objectives	Complies with Program Goals 1,2 and 3
Course Description	This course deals with fundamentals in Optics and Lasers. Students will learn about principles of LASERs, different types of Lasers, applications of Lasers in different engineering domains besides developing strong fundamentals in Optics
Course Outline	Review of basic optics: Polarization, Reflection and refraction of plane waves. Diffraction: diffraction by circular aperture, Gaussian beams. Interference: two beam interference-Mach-Zehnder interferometer and multiple beam interference-Fabry-Perot interferometer. Monochromatic aberrations. Fourier optics, Holography. The Einstein coefficients, Spontaneous and stimulated emission, Optical amplification and population inversion. Laser rate equations, three level and four level systems; Optical Resonators: resonator stability; modes of a spherical mirror resonator, mode selection; Q-switching and mode locking in lasers. Properties of laser radiation and some laser systems: Ruby, He-Ne, CO2, Semiconductor lasers. Some important applications of lasers, Fiber optics communication, Lasers in Industry, Lasers in medicine, Lidar. The list of experiments is as follows: 1. External Cavity Diode Laser: Assembly and Characteristics 2. Michelson Interferometer 3. Haidinger fringes for measuring thickness of the film 4. Diffraction using gratings 5. Polarization of Light 6. Optical fiber characteristics 7. Spatial Light Modulator(SLM) for generation of Optical Angular Momentum (OAM) 8. Recording and reconstruction of Hologram 9. Saturation Absorption Spectroscopy: Observation of Hyperfine Splitting 10. Demonstration of Faraday rotation principle 11. TE and TM propagation modes in a Wave guide 12. Generation of Second Harmonics inside a Non-linear crystal 13. Demonstration of Pulse shaping 14. Experiment on Q-Switching 15. Optical tweezers for trapping of dielectric particles Polarizing optical microscope
Learning Outcome	Complies with PLO 1a, 1b, 2a and 3a
Assessment Method	Quiz, Assignments and Exams
Suggested Readings:	**Textbooks:** 1. R. S. Longhurst, Geometrical and Physical Optics, 3rd ed., Orient Longman, 1986. 2. E. Hecht, Optics, 4th ed., Pearson Education, 2004. 3. M. Born and E. Wolf, Principles of Optics, 7th ed., Cambridge University Press, 1999. 4. William T. Silfvast, Laser Fundamentals, 2nd ed., Cambridge University Press, 2004. 5. K. Thyagarajan and A. K. Ghatak, Lasers: Theory and Applications, Macmillan, 2008.

Course Number	**EP2103**
Course Credit (L-T-P-C)	3-1-0-4
Course Title	Classical dynamics: discrete and continuum systems
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with Program Goals 1, 2a and 3
Course Description	Formulate mechanics problem with Lagrangian, Hamiltonian, Calculus and Jacobi methods. Solve central force motion, rigid body dynamics, relativistic problems with learned expertise.**TO BE CHANGED
Course Content	Constraints, D' Alembert's Principle and Lagrange's Equation, Hamilton's Principle, The Hamilton Equation of Motion, Symmetry and Conservation Review of two body central force problem, Noether's Theorem, Conserved quantities including Laplace-Runge-Lenz Vector, Scattering in a Central Force field, Scattering cross-section, Rutherford scattering. Introduction to continuum mechanics: 1. Basics of tensor algebra. 2. Fluid mechanics: Euler equations, potential flow, incompressible fluids, momentum and energy fluxes, circulations, internal waves, gravity waves, viscous fluids, Navier-Stokes equation, laminar flows, stream and string lines, rotating fluids, oscillatory motion in fluids, laminar boundary layers. 3. Elasticity – Concept of stress and strain, Linear elastic materials, Hooke's law, boundary value problems in 2D, Flexure of elastic beams, introduction to thermo-elasticity and photo-elasticity.
Learning Outcome	Complies with PLO 1, 2(a) and 3
Assessment Method	Assignments, Quizzes, Presentation, Mid-semester examination and End-semester examination
Suggested Readings:	**Textbooks:** 1. Classical Mechanics - J. R. Taylor, University Science Books, 2005. 2. Classical Dynamics, D. T. Greenwood, Dover, 1997 3. Fluid Mechanics, P. K. Kundu, I. M. Cohen and R. David 4. Elasticity: Theory, Applications and Numerics, M. H. Saad **References:** 5. Classical Mechanics, L. D. Landau and E. M. Lifshitz, Course on Theoretical Physics, Vol.1, 3rd Edition, Butterworth-Heinemann. 6. Classical Mechanics - H. Goldstein, C. P. Poole and J. Safko; Pearson Education (2011). 7. Theory of Elasticity, L. D. Landau and E. M. Lifshitz 8. Fluid Mechanics, L. D. Landau and E. M. Lifshitz 9. Classical Mechanics, N.C. Rana and P. S. Joag, McGraw Hill Education Pvt Ltd. (2001). 10. Introduction to Dynamics, I. Percival and D. Richards, Cambridge University Press, 1983. 11. Special Relativity - A.P. French; CRC Press(2017). 12. Introduction to Fluid Mechanics and Fluid Machines, S. K. Som, G. Biswas, S. Chakraborty, McGraw Hill, 2017 13. Vijay Gupta and Santosh Gupta, Fluid Mechanics and its Applications, New Age, 2015

Course Number	**EP2104**
Course Credit	3-1-0-4
Course Title	Thermal physics with engineering applications
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with 1 and 2
Course Description	This course provides student's fundamentals of Thermal Physics towards Engineering applications. This course deals with many engineering applications like heat engines, Refrigeration systems, Thermal Power plant, Gas Turbines, Phase transitions etc.
Course Outline	Kinetic Theory of Gases, Maxwell-Boltzmann distribution, effusion, collision, equation of state, ideal gas, Equipartition of energy, real gas; Thermal Diffusion Equation; Laws of Thermodynamics, Temperature, Internal Energy, specific heat, Entropy; Carnot engine, Various thermodynamic cycles; Thermodynamic potentials, Path and State Functions, Gibb's-Duhem relations, Maxwell Relations; Clausius-Clapeyron Equation; Chemical Potential, Chemical Equilibrium, Phase Diagram, Gibb's Phase Rule, Phase Transitions, Stable and Metastable States, Phase Co-existence, Maxwell's Construction; Various modes of heat transfer; Saha-Ionization; Speed of Sound in Fluids, Shock Waves, Rankine-Hugoniot Conditions. Engineering applications -Heat Engines, Joule-Thompson effect and applications to cryogenics, Refrigerators, Heating-Ventilation and Air-conditioning (HVAC), Exergy analysis of engineering systems, Information Theory.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3(a)
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination
Suggested Readings:	**Textbooks:** 1. Stephen J. Blundell and Katherine M. Blundell, Concepts in Thermal Physics, 3rd Ed, Oxford University Press, 2014. 2. R. H. Dittman and M. W. Zemansky, Heat and Thermodynamics, McGraw-Hill College; Subsequent Ed, 1996. 3. M. A. Boles, Y. A. Cengel, M. Kanoglu, Thermodynamics: An Engineering Approach 4. Finn's Thermal Physics, Andrew Rex 5. Thermal Physics, C. Kittel, H. Kroemer, W. H. Freeman, 2nd ed., 2012 **References:** 1. M. N. Saha and B. N. Srivastava, Treatise on Heat, 3rd Edition, The Indian Press, Allahabad, 1950. 2. R.Baierlein, Thermal Physics, Cambridge University Press, 2005.

Sl. No.	Subject Code	SEMESTER IV	L	T	P	C
1.	EP2201	Introduction to Nuclear and Particle Physics	2	1	0	3
2.	EP2202	Mathematical Methods for Engineers	3	1	0	4
3.	EP2203	Electromagnetism	3	1	0	4
4.	EP2204	Introductory Statistical Mechanics	2	1	0	3
5.	EP2205	Analog Electronics	2	0	3	3.5
6.	XX22PQ	IDE – I	3	0	0	3
Total Credit			**15**	**4**	**3**	**20.5**

Course Number	**EP2201**
Course Credit	2-1-0-3
Course Title	Introduction to Nuclear and Particle Physics
Learning Mode	Class lectures, tutorials, assignments, discussions.
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	This is an introductory course of Nuclear and Particle Physics. The course covers tools (accelerators, detectors), nuclear properties, nuclear forces, nuclear models, radioactive decay and nuclear reactions. Fundamentals of particle interactions and forces, symmetries and conservation laws will be discussed. Topics will be taught with key experiments.
Course Outline	**Nuclear properties:** mass, radius, spin, parity, binding energy; **Nuclear models:** liquid drop model, semi-empirical mass formula, nuclear shell model - validity and limitations, magic numbers; **Nature of the nuclear force:** form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces; **Radioactive decay:** radioactive decay law, elementary ideas of alpha, beta and gamma decays and their selection rules; **Nuclear reactions:** reaction mechanism, Fission and fusion, compound nuclei and direct reactions. **Particle Phenomenology:** Fundamental interactions; Elementary particles and their quantum numbers; Gellmann-Nishijima formula, Quark model, baryons and mesons; C, P, and T invariance, Conservation laws and particle reactions. **Introduction to nuclear detector technology and particle accelerators.**
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination.
Suggested Readings:	**<u>Text Books:</u>** 1. D. Griffiths, Introduction to Elementary Particles, Wiley (2008) 2. Kenneth S. Krane, Introductory Nuclear Physics, Wiley (2008) 3. A. Das,T. Ferbel, Introduction to Nuclear and Particle Physics, World Scientific (2003) 4. S.N. Ghoshal, Nuclear Physics, S Chand (1994) **<u>Reference Books:</u>** 1. Martin B. and Shaw G. P., Particle Physics, Wiley. 2. Detectors for Particle Radiation, Konrad Kleinknecht, Cambridge. 3. Techniques for Nuclear and Particle Physics Experiments: A How-To Approach, William R. Leo, Springer. 4. Roy R. and Nigam B. P., *Nuclear Physics: Theory and Experiment*, New Age. 5. J. Lilley, Nuclear Physics, Wiley (2006) 6. Hughes I. S., *Elementary Particles*,Cambridge. 7. D. H. Perkins, Introduction to High Energy Physics, 4th edition, Cambridge (2000). 8. Halzen F. and Martin Alan D., Quarks and Leptons, Wiley India edition. 9. Mittal V. K., Verma R. C., Gupta S.C., *Introduction To Nuclear And Particle Physics*, Prentice-Hall of India Pvt. Ltd.

Course Number	**EP2202**
Course Credit	3-1-0-4
Course Title	Mathematical Methods for Engineers
Learning Mode	Class lectures, tutorials, assignments, discussions.
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	This course will train students in mathematical methods required for various engineering applications.
Course Outline	Vector Space: Gram-Schmidt Orthonormalization, Self-adjoint operators, completeness of Eigen functions, Complex analysis: - Basic review, Cauchy's integral theorem, Classification of singularities, Residue theorem. Contour integration and examples. Analytic continuation. Multiple-valued functions, branch points and branch cut integration. Conformal mapping, Physical Applications (fluid flow, electrostatics, heat flow etc.), Polynomials and Special Functions: Legendre, Hermite, Laguerre, Chebyshev, Jacobi, Bessel, Neumann, Hankel; Green's function: 1,2,3 dimensional problems (Laplace, wave, heat equations etc.), Integral Transforms, Basic Introduction to Tensors and engineering applications.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination.
Suggested Readings:	**Text Books:** 1. G. B. Arfken and H. J. Weber, Mathematical methods for physicists, Elsevier; 7th Ed, 2012. 2. J. Brown and R. Churchill, Complex Variables and Applications, McGraw Hill Education, 8th Ed, 2017. 3. V. Balakrishnan, Mathematical Physics with Applications, Problems and Solutions, Ane Books, 1stEd, 2017. **Reference books:** 1. L. A. Pipes and L. R. Harvill, Applied Mathematics for Engineers and Physicists, Dover Publications Inc., 3rd rev. Ed, 2014. 2. I. S. Gradshteyn and I. M. Ryzhik, Tables of Integrals, Series and Products, Edited by A. Jeffrey and D.Zwillinger, Academic Press is an imprint of Elsevier 7th Ed, 2007. 3. Abramowitz and Stegun, Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables, United States Department of Commerce, National Institute of Standards and Technology (NBS), 1964. 4. E. Kreyszig, Advanced Engineering Mathematics, Wiley India 10th Ed, 2011. 5. M. L. Boas, Mathematical Methods in the Physical Sciences, Wiley, 3rd Ed, 2005. Charlie and Harper, Introduction to Mathematical Physics, Prentice Hall India, 1978.

Course Number	**EP2203**
Course Credit	3–1–0–4
Course Title	Electromagnetism
Learning Mode	Class lectures, tutorials, assignments, discussions.
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	This course gives an introduction to fundamentals of electromagnetic theory. Students will learn electrostatics, electrodynamics and electromagnetic waves in medium and its applications
Course Outline	Electrostatics and Magnetostatics, Displacement current and Maxwell's equations, Maxwell's equation in matter, Boundary conditions, Conservation principles in EM theory (energy and momentum), Poynting's theorem, Electromagnetic (EM) wave equation for E and B in vacuum, Monochromatic plane waves, Energy and momentum in EM waves, Propagation of EM waves in linear media, Reflection and transmission of EM waves at conducting and non-conducting media; Skin effect, Frequency dependence of permittivity; Wave guides: EM waves between two conducting planes, TM, TE and TEM waves and their transmission.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination.
Suggested Readings:	**<u>Text Books:</u>** 1. D. J. Griffiths, Introduction to Electrodynamics, Third Edition, Pearson Education Inc., 2006. 2. J. D. Ryder, Networks, Lines and Fields, Second Edition, Prentice Hall of India, 2002.

Course Number	**EP2204**
Course Credit (L-T-P-C)	2-1-0-3
Course Title	Introductory Statistical Mechanics
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	Equips the students with the techniques in Statistical Physics and allows them to apply these techniques to wide variety of problems in Physics
Course Content	Random walk, motivation for Statistical Mechanics; Phase space; Postulates of Statistical Physics; Ergodicity; Microcanonical, canonical and grand-canonical ensembles approach with examples; Partition functions, examples; real gases; Ising model; Quantum statistics: Bosonic and Fermionic gases; Bose-Einstein Condensation; Phases and phase transitions, Ehrenfest criteria, order-parameters, liquid Helium as example; Shannon entropy and other entropy measures, applications in information science
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination
Suggested Readings:	**Textbooks:** 1. R. K. Pathria and Paul D. Beale, Statistical Mechanics (Elsevier, 4th Edition, 2021). 2. D. Chandler, Introduction to Modern Statistical Physics (Oxford University Press, 1987). 3. W. Krauth, Statistical Mechanics: Algorithms and Computations (Oxford Masters Series in Physics, 2006). **References:** 1. F. Mandl, Statistical Physics (Wiley-Blackwell, ELBS Edition, 1988). 2. F.Reif, Fundamentals of Statistical and Thermal Physics (Berkeley Physics Course - Vol.5., 2017). 3. M.Pilschke and B.Bergerson, Equilibrium Statistical Physics, (World Scientific, 1994). 4. B. P. Agarwal ad M. Eisner, Statistical Mechanics, (Wiley Eastern Limited, 1988). 5. K.Huang, Introduction to Statistical Physics (Chapman and Hall/CRC, 2nd Edition, 2009). 6. D. Chowdhury, D. Stauffer, Principles of Equilibrium Statistical Mechanics, Wiley-Vch, 2000

Course Number	**EP2205**
Course Credit	2-0-3-3.5
Course Title	Analog Electronics
Learning Mode	Lectures and Laboratory
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	The course covers various devices and components used in analog electronics. The device operation, behaviour and technological framework required for the fabrication of these devices is also discussed. In the laboratory, the students will receive hands-on training on designing circuits to measure the current-voltage characteristics of these devices. Also, at the end, designing and making circuit in a PCB is also performed.
Course Outline	Lecture: p-n junction diode, Zener diode, Schottky diode, photovoltaic cell, photodiode, tunnel diode, unijunction transistor, bipolar junction transistor, junction field effect transistor, metal oxide semiconductor field effect transistor and insulated gate bipolar transistor Device fabrication, introduction to cleanroom processes including wafer cleaning, deposition, lithography, diffusion, etching and bonding Laboratory: I – V characteristics of: Zener diode and its voltage regulation, Schottky diode, Tunnel diode, Solar cell, Silicon controlled rectifier, Unijunction transistor, BJT in CE, CB and CC mode of operation, JFET, MOSFET, both for enhancement and depletion mode, IGBT; Soldering semiconductor devices on PCB for making a circuit
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Lecture: Mid Semester, Quizzes, Assignments and End Semester Exam Laboratory: Laboratory report and End Semester Examination
Suggested Readings:	1. B. G. Streetman and S. Banerjee, Solid State electronic devices, 6th Ed, PHI, 2006. 2. Adel S. Sedra and Kenneth C. Smith, Microelectronic Circuits, Oxford University Press, 6th Edition, 2009 3. Robert L. Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory, Prentice Hall, 7th Edition. 4. Jacob Millman and Christos C. Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, Tata McGraw Hill, 2008 5. D. A. Neamen, Semiconductor physics and devices, 4th Ed, McGrawHill, 2012. 6. S. M. Sze and Kwok Ng, Physics of Semiconductor Devices, 3rd Ed, Wiley, 2006. 7. U. K. Mishra and J. Singh, Semiconductor Device Physics and Design, Springer, 2008. 8. B. Ghosh, Advanced Practical Physics, Volume – II, Sreedhar Publishers, 6th Edition, 2015

Sl. No.	Subject Code	SEMESTER V	L	T	P	C
1.	EP3101	Computational Techniques	2	0	3	3.5
2.	EP3102	Data Science for Physicists	1	1	3	3.5
3.	EP3103	Digital Electronics and Microprocessors	2	0	3	3.5
4.	EP3104	Solid State Physics	3	1	2	5
5.	EP3105	Instrumentation Techniques	2	0	2	3
6.	XX31PQ	IDE – II	3	0	0	3
Total Credit			**13**	**2**	**13**	**21.5**

Course Number	**EP3101**
Course Credit	2–0–3–3.5
Course Title	Computational Techniques
Learning Mode	Class lectures, tutorials, assignments, discussions.
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	This course will train students in various numerical methods and techniques required for solving various physics and engineering problems numerically
Course Outline	Preliminaries of Computing; Roots of Non Linear Equations and solution of system of Linear Equations:- Fixed-point iteration, Bisection, Secant, Regula-Falsi method, Newton Raphson method, Gauss Elimination method by pivoting, Gauss – Jordan method, Gauss – Seidel method, Relaxation method, Convergence of iteration methods, LU and Cholesky decomposition. Interpolation and approximations:-Lagrange and Newton interpolation, Spline interpolation, Rational approximations, Curve fitting: Least square method, Numerical Integration:-Newton-Cote's rule, Gaussian quadrature, Monte-Carlo technique, Numerical Solution of Ordinary a Differential Equations:-Taylor series method, Runge-Kutta methods.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Assignments, Quizzes, lab, Mid-semester examination and End-semester examination
Suggested Readings:	**Text Books:** 1. W. H. Press, S. A. Teukolsky, W T. Vetterling and B. P. Flannery, Numerical Recipes in C: The Art of Scientific Programming, 2nd Ed, Cambridge University Press, 1997 2. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education India; 7 Ed, 2007. 3. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI learning Pvt. Ltd., 5th Ed, 2012. 4. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Edition, New Age International (P) Ltd., 2014. **Reference Books:** 1. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, Wiley, 2005. 2. B. S. Grewal, Higher Engineering Mathematics, 43rd Edition, Khanna Publishers, 2014. 3. Y. Kanetkar, Let us C, 13th edition, BPB publication 2013. 4. Programming in ANSI C, Tata McGraw-Hill Education, 2008. 5. Programming with C (Schaum's Outlines Series), McGraw Hill Education (India) Private Limited; 3rdEd, 2010.

Course Number	**EP3102**
Course credit(L-T-P-C)	1-1-3-3.5
Course title	Data Science for Physicists
Learning mode	Offline
Learning objectives	• An introduction to data science career path for physicists. • Understanding the basics of machine learning and ML model building. • Exposition to popular python-based environments like Jupyter, Kaggle which are used industry-wide for AI/ML or data science applications. • Using state-of-the-art libraries like pandas and sklearn to preprocess the data, apply ML models, validate, and test predictions. • Hands-on experience through real-world projects.
Course description	Data science is increasingly becoming an essential skill for physicists. While there are numerous courses and programs on data science offered across various media, these are almost invariably targeted at computer science graduates and industry professionals. This course is designed to bridge this gap by introducing essential data science techniques from the perspective of applications in physics research and prepare learners for advanced courses in ML/AI/Data science.
Course content	Programming environments for data science: local python development environment like Jupyter, cloud based python notebook and data science platforms like Kaggle, basics of various open-source libraries for data science applications (like numpy, pandas), file versioning using github. The what and why of machine learning, mathematical basis of ML – setting up a problem, example of linear and polynomial regression; statistical learning theory – bias, variance, model complexity; cost function, gradient descent, basics of supervised and unsupervised learning, regression with multiple variables, feature normalization, basics of neural networks, building first ML model – handling data for training, testing, and validation, types of models, using scikit-learn library, ML pipelines; data science techniques – pandas, data cleaning, data visualization. Hands-on project – detection of gravitational waves – introduction to gravitational waves, Fourier transform, noise, GW signal analysis, data fitting.
Pre-requisites	• Linear algebra, matrices, vector algebra • Basic familiarity with programming in Python
Learning outcomes	Upon successful completion of this course, students will be able to: • write intermediate-level programs in Python, define functions, import and use libraries. • Work on projects in Jupyter environment, and collaborate on group projects on platforms like Kaggle, and github. • Understand the fundamental concepts of machine learning and theoretical understanding of how ML models are developed. • Understand and manipulate data for training, validating, and testing predictions of ML models. • Use various python libraries like scikit-learn, pandas, numpy, etc. to create ML pipelines that take in given data and generate predictions. • Get exposure to real-world usage of data science techniques in trending research areas.
Assessment method	Project, Assignments, Quiz, Mid-semster examination, End-semester examination

Suggested Readings:	
Textbooks:	• Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007 • Introduction to Machine Learning Edition 2, by Ethem Alpaydin • Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997.
References:	• A high-bias, low-variance introduction to Machine Learning for physicists, Pankaj Mehta, Marin Bukov, Ching-Hao Wang, Alexandre G.R. Day, Clint Richardson, Charles K. Fisher, David J. Schwab, 2019, Phys. Rep. 810, 1. • John Hopcroft, Ravindran Kannan, Foundations of Data Science, 2014. • I. Goodfellow, Y. Bengio, A. Courville. Deep Learning. MIT Press, 2016. • Machine learning & artificial intelligence in the quantum domain, Vedran Dunjko, Hans J. Briegel, arXiv:1709.02779 • Andrew Ng's lectures on machine learning, Coursera, https://www.coursera.org/learn/machine-learning-course/

Course Number	**EP3103**
Course Credit (L-T-P-C)	2-0-3-3.5
Course Title	Digital Electronics and Microprocessors
Learning Mode	Lectures and Practical
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	This course aims providing a detailed overview and hands-on study of Digital Electronics and Microprocessors, which are important in modern day electronic devices and circuits
Course Content	Moving and Storing Digital Information, Digital IC Signal Levels, Digital Logic, Basic Gates, Universal Logic Gates; Combinational Logic Circuits, Boolean Laws and Theorems, Sum-of-Products Method, Truth Table to Karnaugh Map, Karnaugh Simplifications, Product-of-sums Simplification, Quine-McClusky Method; Data-Processing Circuits, Multiplexers, Demultiplexers, Decoders and Encoders, Parity Generators and Checkers; Comparator, Read-only Memory, Programmable Array Logic, HDL Implementation of Data Processing Circuits; Binary, octal and hexadecimal number systems, ASCII, Excess-3 Gray Codes; Error Detection and Correction; Arithmetic Circuits, Complement Representation; Clocks and Timing Circuits, TTL Clock, Schmitt Trigger; Timer-Astable, Monostable, Monostables with Input Logic; Flip-Flops, RS, gated, edge-triggered, D, JK and Master-slave versions; Analysis of Sequential Circuits; Registers, Serial In-serial Out, Serial In-parallel Out, Parallel In-serial Out, Parallel In-parallel Out, Universal Shift Register; Counters, Asynchronous and Synchronous Counters, Decade Counters, Counter Design using HDL; Design of Synchronous and Asynchronous Sequential Circuits; State Transition Diagram and Table; Implementation using Read Only Memory; Algorithmic State Machine, State Reduction Technique; D/A and A/D Conversion, ROM, PROM, EPROM, RAM; TTL Parameters, TTL-to-CMOS and CMOS-to-TTL Interfaces; Multiplexing Displays, Frequency Counters; Microprocessor-compatible A/D Converters, Execution of lnstructions, Macro and Micro Operations; BCD Codes, IEEE Standards; Block diagram of a microprocessor, architecture of 8086, pin diagram, register organization, pipelining, physical address generation; Basics of assembly language programming, assembler, linker, debugger, machine language instruction format; use of opcode sheet, pseudocode and microprocessor programming, elementary operations. About 8 to 10 laboratory experiments based on above syllabus will be performed.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination
Suggested readings	**Textbooks:** 1. Digital Principles and Applications (7/e), Donald P. Leach, Tata McGraw Hill (2011). 2. Microprocessor Architecture, Programming and Applications with the 8085 (6/e), Ramesh Gaonkar, PRI (2013). **References**: 1. Mastering Digital Electronics, Hubert Henry Ward, APress (2024). 2. Microprocessors and Microcontrollers, 3. N. Senthil Kumar, M. Saravanan, S. Jeevananthan (2/e), Oxford University Press (2018).

Course Number	**EP3104**
Course Credit	3-1-2-5
Course Title	Solid State Physics
Learning Mode	Class lectures, tutorials, assignments, discussions
Learning Objectives	Complies with program goal 1,2 and 3.
Course Description	This course deals with basic theory of solids which are important to understand the vast range of real solids, with an emphasis on its structure and physical properties. This includes topics that are entirely based on classical methods, and also those which demand a detailed quantum treatment. The concepts of statistical mechanics, thermodynamics and mathematical methods are inherently present in this course due to its interdisciplinary approach. The course includes theories of metals, insulators, and semiconductors. Electrical, mechanical, thermal, magnetic and superconducting properties are discussed with detailed analysis.
Course Outline	Crystal physics: Symmetry operations; Bravais lattices; Point and space groups; Miller indices and reciprocal lattice; Structure determination; diffraction; X-ray, electron and neutron; Crystal binding; Defects in crystals; Point and line defects. Lattice vibration and thermal properties: linear lattice; acoustic and optical modes; dispersion relation; density of states; phonons and quantization; Brillouin zones; Specific heat (Einstein and Debye models) and thermal conductivity of metals and insulators. Electronic properties: Free electron theory of metals; electrons in a periodic potential; Bloch equation; Kronig-Penny model; band theory; Nearly free electron and tight-binding model, Motion of electrons in applied electric and magnetic fields. Semiconductor physics: concept of holes, carrier concentration in intrinsic and extrinsic semiconductors, effective mass and mobility. Magnetic properties: Dia-, para- and ferro-magnetism. Superconductivity: General properties of superconductors, Meissner effect; London equations; coherence length; type-I and type-II superconductors. The list of experiments: 1. Phase transition of Barrium Titanate with temperature 2. Magnetic susceptibility of a paramagnetic salt using Quinck's Tube method 3. Magnetic hysteresis loop 4. Scanning tunneling microscopy of HOPG surface 5. Nuclear magnetic resonance 6. Electron spin resonance 7. X-ray diffraction 8. UV-Visible absorption spectra of molecules 9. Fluorescence and phosphorescence spectra of molecules 10. Determination of size of nanoparticle using scanning electron microscope 11. Electric hysteresis loop 12. Magnetoresistance

	13. Determination of bandgap of a semiconductor 14. Piezoelectric effect 15. Verification of Weidemann-Franz law 16. Thermoelectric effect
Learning Outcome	Complies with PLO 1a, 1b, 3
Assessment Method	Tutorials & assignments + mid-semester exam + end-semester exam
Suggested Readings:	**Textbooks:** 1. C. Kittel, Introduction to Solid State Physics, Wiley India (2009). 2. M. A. Omar, Elementary Solid State Physics, Addison-Wesley (2009). **References:** 1. J. Dekker, Solid State Physics, Macmillan (2009). 2. N. W. Ashcroft and N. D. Mermin, Solid State Physics, HBC Publ. (1976). 3. H. P. Myers, Introduction to Solid State Physics, Taylor and Francis (1997). 4. Richard Zallen, The Physics of Amorphous Solids, John Wiley and Sons Inc.,(1983)

Course Number	**EP3105**
Course Credit	2-0-2-3
Course Title	Instrumentation Techniques
Learning Mode	Class lectures, laboratory demonstration and hands on sessions
Learning Objectives	Complies with program goal 1,2 and 3.
Course Description	A sound knowledge of instrumentation is key to a well-rounded training of an engineer. This course introduces the students to fundamental aspects of the 'systems design approach' which will come handy when they want to apply it in development of various systems. The course deals with aspects of signal processing, control, data acquisition and power management. Issues in handling massive data in the form of images and image processing will also be taught.
Course Outline	Fundamentals of system design Signals processing, Control and Data acquisition: Principles of sensors, transducers, and measurement techniques; Signal processing; Theory of feedback control, stability analysis, and controller design; A/D and D/A, Design Data acquisition, virtual instrumentation; Case studies related to signal processing and control aspects for different systems including advanced analytical instruments, thin film coating units and space applications Power systems: Different types of power supplies; transformers; signal conditioning; estimation of power requirements Vacuum systems: Vacuum production techniques, operation for rotary, diffusion, turbo molecular, and cryo-vacuum pumps; Measurement of vacuum, different gauges and their working; Designing Vacuum Systems: Mechanical and thermal design considerations; Pump throughput estimation; Case studies for vacuum systems in different instruments; accelerators, superconducting magnets, food preservation systems, electron microscopes, thin film coating technology CMOS and CCD camera, coupling light in systems, crucial issue with data handling for large image sizes Lab component: Use of Simulink™/Simscape in signal processing and control; Designing chambers using Solidwork™ and Comsol™ Multiphysics; Signal transduction; Signal conditioning; Controller deployment using Arduino; Generating vacuum using different pumps; Use of different gauges to measure vacuum; Image and video acquisition; processing of images
Learning Outcome	Complies with PLO 1a, 1b, 3
Assessment Method	mid-semester exam, end-semester exam
Suggested Readings:	**Books:** 1. Instrumentation: Devices and Systems, C. Rangan, G. Sarma, V. S. V. Mani, 2nd ed. McGraw Hill Education, 2017 2. Instrumentation for Engineers, J. D. Turner, Springer (reprint), 2020 3. Vacuum Technology, A. Roth, North-Holland, 3rd ed., 2007. **References:** 1. Vacuum Science & Technology- V. V. Rao, K. L. Chopra and T. B. Ghosh, Allied Publishers Pvt. Ltd., 2012 2. A user's guide to vacuum technology, J. F. O'Hanlon, Wiley-Interscience, 2nd ed., 2003.

	3. Handbook of vacuum science and technology, D. M. Hoffman, Bawa Singh, J. H. Thomas-III (Eds)., Elsevier, 1998.

Sl. No.	Subject Code	SEMESTER VI	L	T	P	C
1.	EP3201	Nonlinear Dynamics	2	1	0	3
2.	EP3202	Interfacing and data analysis	1	0	4	3
3.	EP3203	Atomic and Molecular Physics	3	1	2	5
4.	EP3204	Soft Condensed Matter Physics	3	0	0	3
5.	PH32XX	DE – I	3	0	0	3
6.	PH32XX	DE – II	3	0	0	3
Total Credit			**15**	**2**	**6**	**20**

Course Number	**EP3201**
Course Credit (L-T-P-C)	2-1-0-3
Course Title	Nonlinear Dynamics
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	This course will help to understand the concept and method of theory of dynamical system as well as its application to physics, chemistry and biology. It will describe nonlinear phenomena in physical systems by using a minimum background in physics and mathematics.
Course Content	Role of nonlinearity in physical systems. Dynamical systems: Flow systems, iterated maps in 1D and hybrid systems, fixed points, their stability analysis and classifications, physical examples including nonlinear planar pendulum with and without damping. Flows in two dimensions: limit cycles, Poincare-Benedixon theorem, driven oscillators with damping, bifurcations in one and two dimensions, Hopf bifurcation. Chaos and various routes to chaos: period doubling, intermittency and quasi-periodic routes, Lyapunov exponents, self-similarity and fractal objects. Fractal dimensions, Lorentz system and its fixed points and stability. Cantor set, logistic map, computer based problems relevant to engineering and biology.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3(a)
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination
Suggested Readings:	**Textbooks:** **1.** S. H. Strogatz, Nonlinear Dynamics & Chaos, CRC Press, 2018. **2.** Nonlinear Ordinary Differential Equations, D. W. Jordan and P. Smith **References:** 1. Chaos and Nonlinear Dynamics: an Introduction for Scientists and Engineers, R.C. Hillborn 2. R. H. Enns and G. C. McGuire, Nonlinear Physics with Mathematica for Scientists and Engineers, Birkhäuser, Boston, 2001.

Course Number	**EP3202**
Course Credit	1-0-4-3
Course Title	Interfacing and Data analysis
Learning Mode	Lecture and Lab
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	The course teaches (a) how to control and communicate remotely through interfacing and (b) perform a(multiple) measurement(s) by using Labview. It will also introduce different ways of communications like GPIB, RS-232 etc. Various ways to display and analyze data will also be covered.
Course Outline	Overview of GUI software based data acquisition and analysis platforms, Programming basics; Front panel; block diagram; data flow Programming Structures: for/while loops; shift resistor; case structures; sequence structures Graphs and charts: Arrays; Clusters Serial ports (RS232) and GPIB (IEEE 488.1) Communication; Background and working principle; communication with instruments; instrument drivers; Property nodes; strings; file I/O; data acquisition and visualization Data analysis: Gaussian and Poisson distribution; Error analysis; Regression; Bayesian parameter estimation and hypothesis testing; The maximum-entropy approach; Linear and nonlinear model fitting; Time-series analysis
Learning Outcome	Complies with PLO 1(a),1(b), 2(a) and 3a
Assessment Method	Day to Day experimental assessment and viva End term examination
Suggested Readings:	1. Getting Started with Labview, NI Instruments 2. Labview user manual by NI Instruments 3. Bevington, Philip R. and D. Keith Robinson, Data Reduction and Error Analysis for the 4. Physical Sciences, 3rd edition, McGraw-Hill, New York, 2003. 5. Meyer, Stuart L., Data Analysis for Scientists and Engineers, John Wiley and Sons, Inc., New York, 1975. 6. Young, Hugh D., Statistical Treatment of Experimental Data, McGraw-Hill Book Company, Inc., New York, 1962. 7. Bayesian Logical Data Analysis for the Physical Sciences: A Comparative Approach with Mathematica Support (Links to an external site.), by Phil Gregory (Cambridge University Press). 8. A Student's Guide To Python for Physical Modeling (Links to an external site.), by Jesse M. Kinder and Philip Nelson (Princeton University Press).

Course Number	**EP3203**
Course Credit (L-T-P-C)	3-1-2-5
Course Title	Atomic and Molecular Physics
Learning Mode	Lectures & Tutorials
Learning Objectives	Complies with program goals 1. 2 and 3
Course Description	This course provides engineering students building strong fundamentals in Atomic Physics and Molecular physics. Also this course introduces methods and models which are very essential to pursue research in advanced theoretical, experimental physics and engineering applications.
Course Outline	Time independent and time-dependent perturbation theory, interaction of one electron atoms with electromagnetic radiation, Transition rates, The dipole approximation, Selection rules, Spectrum of one electron atoms, Line intensities and the life time of the excited states, Line shapes and widths, Fine structure and Hyperfine structure, The Lamb Shift, Zeeman and Stark effect. Many electron atoms: Variational method, Hartree- Fock method and the SCF, Central field approximation, L-S coupling and j-j coupling, Molecular structure, Born-Oppenheimer approximation, Electronic structure of diatomic molecule, Electronic, Rotational, Vibrational and Vibration-Rotation Spectra of diatomic molecules. The list of experiments: 1. Frank Hertz experiment 2. Verification of Stefan-Boltzman law 3. Determination of Rydberg constant from Hydrogen spectra 4. Blackbody spectra 5. X-ray spectra of tungsten at various accelerating potentials 6. Scattering of alpha particle by a thin gold foil: Rutherford Scattering, 7. Auger effect 8. Compton effect 9. Stern-Gerlach experiment 10. Normal and Anomalous Zeeman effect 11. Stark effect 12. Fine structure 13. Hyperfine structure
Learning Outcome	Complies with PLO 1a. 1b, 2a and 3a
Assessment Method	Assignments, Quizzes, Mid-semester examination, End-semester examination
Suggested Readings:	
Textbooks:	• B.H. Bransden and C.J. Joachain, Physics of Atoms and Molecules, Longman Scientific and Technical, 1983. • Gordon W and F. Drake, Springer Handbook of Atomic, Molecular, and Optical Physics, Springer, 2006. • W. Demtroder, Atoms, Molecules and Photons, Springer, 2010. • H. Haken and H.C. Wolf, Physics of Atoms and Quanta, Springer, 2005. • H. E. White, Introduction to Atomic Spectra,McGraw Hill, 2019 • G. K. Woodgate, Elementary Atomic Structure, 2nd Ed., ClerentonPress, Oxford, 2002 • M. Karplus and R. N. Porter, Atoms and Molecules: An Introduction for Students of Physical Chemistry
References:	• Ira N. Levine, Quantum Chemistry, 6th Edition, PHI Learning Private Limited, New Delhi, 2009. • John P. Lowe and Kirk A. Peterson, Quantum Chemistry, 3rd Edition, Academic Press, 2009. • Peter Atkins and Ronald Friedman, 4thEdition, Oxford Univ. Press, 2012.

	• Collin N. Banwell and Elain M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4thEdition, Tata McGraw Hills, 2008.

Course Number	**EP3204**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Soft Condensed Matter Physics
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with Program Goals 1, 2a and 3
Course Description	Create understanding diffusion in soft matter, colloids, and polymers. Learn expertise for biologically relevant polymers, different self-assemblies, and impact of varied interfaces. Acquire understanding of liquid crystals and various experimental techniques for characterizing soft matter.
Course Content	*Introduction to Soft Matter: Overview of soft matter, entropy in disordered systems; forces, energies, length scale and time scales in soft matter Diffusion processes: Fick's laws, Diffusion Equation, Random walks, Brownian motion, Langevin and Fokker-Plank equations* *Colloids:* Colloidal particle in a liquid (Stoke's law and Brownian motion), forces between colloidal particles (Van der Waals, electrostatic double layer, steric, depletion interaction), stability and phase behaviour of colloids. Polymers: Basic concepts, types of polymers, molecular weights, determination of molecular weights. Crystallization *Self-Assemblies and Interface Science:* Self-assembled phases in solutions of amphiphilic molecules, spherical micelles and critical micelle concentration, reverse micelles, bilayers and vesicles, Langmuir monolayers; complex phases in surfactant solutions and microemulsions. *Liquid Crystals:* Types of liquid crystals, characteristics and identification of liquid crystal phases, nematic/isotropic transition, rigidity and elastic constants of a nematic liquid crystal. *Biological Soft Matter:* DNA (structure, condensation, noncanonical structures), RNA (structure, folding, crystallization), proteins (structure, folding, crystallization). Applications of soft matter physics.
Learning Outcome	Complies with PLO 1, 2a and 3
Assessment Method	Assignments, Quizzes, Presentation, Mid-semester examination and End-semester examination
Suggested Readings:	***Textbooks:*** 1. *Soft condensed matter by R. A. L. Jones, Oxford University Press* 2. *Biological Physics by P. Nelson* 3. *Polymer Physics by Tanaka Fumihiko, Cambridge University Press* ***References:*** 4. *Liquid Crystals: Nature delicate phase of matter by P. J. Collings, Princeton University Press* 5. Ian W. Hamley, Introduction to Soft Matter: Synthetic and Biological Self-Assembling Materials, John Wiley & Sons. 6. Thomas A. Witten and Philip A. Pincus, Structured Fluids: Polymers, Colloids and Surfactants, Oxford University Press. 7. Scaling Concepts in Polymer Physics, P. G. de Gennes

Sl. No.	Course Code	Departmental Elective – I	L	T	P	C
1.	PH3201	Engineering Optics	3	0	0	3
2.	PH3202	Cryogenic Engineering	3	0	0	3
3.	PH3203	Advanced Quantum Mechanics	3	0	0	3
4.	PH3204	Power Sources for Electric Vehicles	3	1	0	4
5.	PH3205	Engineering Electromagnetics	3	0	0	3

Course Number	**PH3201**
Course Credit	3-0-0-3
Course Title	Engineering Optics
Learning Mode	Lectures and Assignments
Learning Objectives	Complies with Program Goals 1,2 and 3
Course Description	This course introduces students various optical systems, optical devices needed for various engineering applications in the field of Optics and modern cutting edge technology
Course Outline	**Lens systems:** Basics and concepts of lens design, some lens systems. **Optical components:** Reflective, refractive and diffractive systems; Mirrors, prisms, gratings, filters, polarizing components. **Interferometric systems:** Two beam, multiple beam, shearing, scatter fringe and polarization interferometers. **Vision Optics:** Eye and vision, colorimetry basics. **Optical sources:** Incandescent, fluorescent, discharge lamps, Light emitting diode. **Optical detectors:** Photographic emulsion, thermal detectors, photodiodes, photomultiplier tubes, detector arrays, Charge-coupled device, CMOS. **Optical Systems:** Telescopes, microscopes (bright field, dark field, confocal, phase contrast, digital holographic), projection systems, interferometers, spectrometers. **Display devices:** Cathode ray tube, Liquid crystal display, Liquid crystals on silicon, Digital light processing, Digital micro-mirror device, Gas plasma, LED display, Organic led displays (OLED). **Consumer devices:** Optical disc drives: CD, DVD; laser printer, photocopier, cameras, image intensifiers.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination
Suggested Readings:	**Text Books:** 1. R. S. Longhurst, *Geometrical and Physical Optics*, 3rd ed., Orient Longman, 1988. 2. R. E. Fischer, B. Tadic-Galeb, and P. R. Yoder, *Optical System Design*, 2nd ed., SPIE Press, 2008. **Reference Books:** 1. W. J. Smith, *Modern Optical Engineering*, 3rd ed., McGraw Hill, 2000. 2. K. Iizuka, *Engineering Optics*, Springer, 2008. 3. B. H. Walker, *Optical Engineering Fundamentals*, SPIE Press, 1995.

Course Number	**PH3202**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Cryogenic Engineering
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	Equips the students with the techniques in Cryogenic Engineering and allows them to apply these techniques in both research and industrial scenarios
Course Content	Introduction to cryogenic engineering and its scope; components of a typical cryogenic systems; physical properties of cryogenic fluids such as nitrogen, helium and hydrogen including their extraction, purification, regeneration, safe storage and transfer; sensors at cryogenic temperatures; cryogenic heat transfer; cryocooler systems for refrigeration and liquefaction; elements of cryogenic system design and instrumentation; low heat leak structural supports, thermal mass considerations, thermal insulation systems, liquefaction/refrigeration of cryogens; Stirling, Claude and related cycles, recovery and storage, cryogenic heat exchangers, instrumentation for cryogenics including compressors, pumps, expansion engines and turbine mechanisms; safety features in cryogenic systems; design considerations for cryogenic systems for applications including CCR, MRI, NMR, accelerators, adiabatic demagnetization and dilution refrigerators, and cryogenic engines.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(b) and 3
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination
Suggested Readings:	**Textbooks:** **1.** Randall Barron, *Cryogenic Systems*, 2nd Edition (1985). 2. Thomas M. Flynn, *Cryogenic Engineering*, New York, NY: Marcel Dekker USA, 2nd Edition (2005). **References:** 1. Zuyu Zhao and Chao Wang, *Cryogenic Engineering and Technologies*, CRC Press, Taylor and Francis USA (2020). 2. Frank Pobell, *Matters and Methods at Low Temperature*, 3rd Edition, Springer (2007)

Course Number	**PH3203**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Advanced Quantum Mechanics
Learning Mode	Lectures & Tutorials
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	In this course students will learn time dependent perturbation theory, scattering theory and relativistic quantum mechanics.
Course Content	Time dependent perturbation theory, interaction picture; Einstein's coefficients, spontaneous and stimulated emission and absorption, application to lasers; Semi-classical and quantum theories of light-matter interactions; Scattering theory: Laboratory and centre of mass frames, differential and total scattering cross-sections, scattering amplitude; Born approximation, Partial wave analysis; Theory of open quantum system, density matrix, Markovian master equation; Quantum wave packet dynamics; Quantum Information; Symmetries in quantum mechanics: Conservation laws, and degeneracy associated with symmetries; Continuous symmetries, space and time translations, rotations; Rotation group; Discrete symmetries; parity, charge and time reversal; Relativistic quantum mechanics, Concept of antiparticles; Dirac equation, covariant form, Plane wave solution and momentum space, spinors; Spin and magnetic moment of the electron.
Learning Outcome	Complies with PLO 1, 2(a) and 3
Assessment Method	Assignments, Quizzes, Seminar, Mid-semester examination, End-semester examination
Suggested Readings:	**Textbooks:** 1. C. Cohen-Tannoudji, Quantum Mechanics (Vol-I and II), John Wiley & Sons (Asia), 2005. 2. L. I. Schiff, Quantum Mechanics, McGraw-Hill, 1968. 3. J. J. Sakurai, Advanced Quantum Mechanics, Pearson Education, 2007. 4. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education, 2002. 5. R. Shankar, Principles of Quantum Mechanics, Springer (India), 2008. 6. Heinz-Peter Breuer, Francesco Petruccione, Theory of Open Quantum Systems, Oxford University Press, 2003. **Reference Books:** 7. B. H. Bransden and C. J. Joachain, Quantum Mechanics, Parson Education 2nd Ed, 2004. 8. E. Merzbacher, Quantum Mechanics, John Wiley (Asia), 1999. 9. V.K. Thankappan, Quantum Mechanics, Wiley Eastern, 1985. 10. R.P. Feynman, R.B. Leighton and M.Sands, The Feynman Lectures on Physics, Vol.3, Narosa Publication House, 1992. 11. P.A.M. Dirac, The Principles of Quantum Mechanics, Oxford University Press, 1991.

	12. L.D.Landau and E.M. Lifshitz, Quantum Mechanics - Nonrelativistic Theory, 3rd Ed, Pergamon, 1981.

Course Number	**PH3204**
Course Credit	L – T – P : 3 – 1-0-4
Course Title	Power Sources for Electric Vehicles
Learning Mode	Physical Presence in Class Room
Learning Objectives	This course is highly relevant and industry demand driven contents in the emerging are of clean and green technology to reduce carbon foot print and bring transformation with "zero emission" transport system. It aims to impart a comprehensive training and skill pertaining to; 1. energy storage technologies from ab initio storage cells to current state of developments. 2. concept, design, fabrication and testing protocol of energy and power cells for EV applications. 3. bridge the technological gap with adequate skill focused content to fulfil the emerging need of competent workforce for EV industry.
Course Outline	**Module-1:** Power generation for transport with focus on zero emissions, an overview of electric vehicles and their power requirements, battery powered electric vehicles (EVs), performance criteria for EV batteries, laboratory testing protocols for EV batteries **Module-2:** Vehicle mechanics and power requirements, energy storage cell fundamentals, batteries, fly wheels and super capacitors, cell design and customization approach for cell voltage and current modification, cell and battery modelling for rated power requirement and design. **Module-3:** Concepts of super capacitors as a storage cell with large power delivery, supercapacitor classification, design, fabrication, testing and applications, advantage and challenges in integration of a super capacitor with battery and possible alternatives. **Module-4:** Design of a battery pack for EV application, operational safety challenges and need for thermal management and battery management systems (BMS), Safety considerations and protocols for battery pack development in EVs with case study for e-cycle, e-bike, 3-wheelers.
Learning Outcome	Learners of the course will be able upskill their knowledge and skill to fulfil emergent need of rapidly expanding electric vehicle (EV) industry.
Assessment Method	Class test and Quiz/Assignment (**20%**), MSE: (**30%**), ESE: (**50%**)
Suggested Readings:	1. Batteries for Electric Vehicles, D.A.J. Rand, R. Woods, R.M. Dell., John Wiley & Sons Inc. 2. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Husain, CRC Press 3. Electric Vehicle Technology Explained, James Larmenier, John Lowry, John Wiley & Sons

Course Number	**PH3205**
Course Credit	3–0–0–3
Course Title	Engineering Electromagnetics
Learning Mode	Class lectures, tutorials, assignments, discussions.
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	This course builds upon advanced engineering topics in electromagnetics, with focus on cutting edge engineering applications.
Course Outline	Review of Electromagnetic theory, wave guides and resonant cavities, rectangular and cylindrical waveguides. dielectric and surface waveguides, Multimode propagation in optical fibers, Introduction to radiating systems, localized oscillating source, dipole fields and radiation, Monopole and dipole antennas, Antenna arrays. Yagi, Horn, Parabola, micro strip and patch antennas, Microwave cavities. Scattering matrix, S parameters, reciprocity, coupling energy to a waveguide, Microwave components: Gunn, impatt and varacter diodes, etc and their use in designing RF circuits, Practical RF circuit design, Frequency-independent antennas, log-periodic antennas, spiral antennas. RF-Id systems, Studies of RF circuits in mobile phones and satellite communications.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination.
Suggested Readings:	**<u>Text books:</u>** 1. J. D. Jackson, Classical Electrodynamics, 3rd ed., Wiley, 1999. 2. Antennas and Wave propagation 5ED by John D. Kraus, Ronald J. Marhefka, et al (SIE) (PB 2018). 3. D. M. Pozar, Microwave Engineering; 4/e, John Wiley & Sons Inc, 2012. 4. R. E. Collin, Foundations for Microwave Engineering; 2/e, Wiley-IEEE Press, 2000. **<u>References:</u>** 5. D. J. Griffiths, Introduction to Electrodynamics, Third Edition, Pearson Education Inc., 2006. 6. J. D. Ryder, Networks, Lines and Fields, Second Edition, Prentice Hall of India, 2002. 7. Feynman Lectures on Physics Vol-II, Pearson, 2012. 8. *Antenna theory*: analysis and design. *CA Balanis*. John Wiley & Sons, Inc, 2016 9. M. Liao, Microwave devices and Circuits; 3/e, Prentice Hall of India, 2004.

Sl. No.	Course Code	Departmental Elective – II	L	T	P	C
1.	PH3206	Laser Physics	3	0	0	3
2.	PH3207	Advanced Mathematical Methods	2	1	0	3
3.	PH3208	Electron Microscopy	3	0	0	3
4.	PH3209	Quantum Computation	2	1	0	3
5.	PH3210	Device Modeling and Design	2	1	0	3

Course Number	**PH3206**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Laser Physics
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 1, 2a and 3
Course Description	Create understanding of basic light-matter interactions, design, and construction of laser. Learn expertise in usage and safety of laser. Acquire understanding of component of lasers and pulsing menthodology.
Course Content	*Introduction to laser physics;* Light-matter Interaction; Semiclassical theory, Wave and quantum properties of light, Spontaneous and stimulated emissions, Einstein's coefficients. Line shape function, Line broadening: Homogeneous and inhomogeneous broadening, natural, Doppler and collisional broadening. *Light amplification;* Optical saturation, Population inversion, Optical pumping, Rate Equations; 2-level, 3-level and 4-levl lasers, Laser action (gain, threshold, power, frequency), Gain saturation, Optimal conditions for laser operation; Laser saturation, *Optical Resonator:* Longitudinal and transverse laser cavity modes, cavity loss, Q-factor, ABCD matrix, Stable and unstable resonator, Properties of Gaussian Beam and propagation. *Laser Pulsing:* Hole Burning; Q-Switching; Mode Locking; Single Mode Lasers; Ultrafast laser systems, linear and nonlinear pulse propagation *Types of Lasers:* He-Ne Laser; Nd-YAG Laser; Solid-state laser, Gas Laser Dye Laser, Excimer Laser; Semiconductor Laser; Tuneable Lasers, Supercontinuum Laser, Fiber Lasers *Laser Safety and applications:*
Learning Outcome	Complies with PLO 1, 2a and 3
Assessment Method	Assignments, Quizzes, Presentation, Mid-semester examination and End-semester examination
Suggested Readings:	1. Optical Electronics, Ajoy Ghatak and K.Thyagarajan, CUP, 2003. 2. Photonics, Amnon Yariv and Pochi Yeh, 6 th ed., OUP, 2009. 3. Fundamentals of Photonics, B.E.A.Saleh and M.C.Teich, 2 nd ed., Wiley Interscience, 2007. 4. W. T. Silfvast, Laser Fundamentals, Cambridge University Press

Course Number	**PH3207**
Course Credit (L-T-P-C)	2-1-0-3
Course Title	Advanced Mathematical Methods
Learning Mode	Lectures & Tutorials
Learning Objectives	The purpose of the course is to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other advanced courses in physics.
Course Description	The course offers detailed study on group theory and advanced numerical techniques. Group theory plays an important role in particle physics. Numerical techniques are handy in solving several advanced physics and engineering problems.
Course Outline	Module A: Group Theory: Definition, Subgroups, Classes and Examples, Group representations (regular and product; reducible and irreducible), Characters, Physical applications, Infinite groups; Lie groups and Lie algebra, Generators: Representations of Z2, SU(1,1), SU(2), SU(3) and SO(3). Integral Equations: Generating functions, Newmann series. Module B: Numerical Optimisation:- Newton's method, Golden section search, Conjugate gradient method. Linear Programming, Simplex Method; Numerical Solution of Partial Differential Equations:- Difference Equation, Crank-Nicolson method, Split operator technique; Eigen value problems:- Jacobi transformation Fourier Transform:- Discrete Fourier Transform and Fast Fourier Transform in two or more dimensions; Engineering applications.
Learning Outcome	PLO 1b, 3
Assessment Method	Mid-semetser examination, End-semester examination, Quiz & Assignments
Suggested Readings:	**Textbooks:** • George B. Arfken and Hans J. Weber, Mathematical Methods for Physicists, Academic Press Inc., 4th Edition, 1995. • E. Kreyszig, Advanced Engineering Mathematics, Wiley India, 8th Edition, 2008. • M. Abramowitz and I. A. Stegan, Mandbook of Mathematical Functions, Dover Publs., INC., New York, 1965. **References:** • R.V. Churchill and J.W. Brown: Complex Variables and Applications. A. Zee: Group Theory in a Nutshell for Physicists, Princeton University Press, 2016.

Course Number	**PH3208**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Electron Microscopy
Learning Mode	Lectures
Learning Objectives	The objective of the course is to introduce the student to the electron microscopy and its utilization in modern technology. The students will learn about the electron-matter interaction, working principle of electron microscopes. The principle of electron optics and its use will be learned by the students. The opportunity in electron microscopy area will be known to the student.
Course Description	The course discusses different kinds of electron microscopy and electron spectroscopy. Analysis of TEM and SEM image, electron diffraction pattern, X-ray spectra analysis and, their applications in industry will be covered in this course.
Course Content	**Module 1:** Introduction to Microscopy, Limitations of the Human Eye, Optic, The X-ray Microscope, Electron Microscope, Low-Energy and Photoelectron Microscopes, Atom-Probe Microscopy. **Module 2:** Electron Sources, safety and precautions, Electron optics, electromagnetic lenses, Comparison of Magnetic and Electrostatic Lenses, Aberration Correctors and Monochromators, Electron and matter interaction, Scattering and diffraction, reciprocal space, Bloch waves, Diffraction from crystal, diffraction from small volume, elastic and inelastic scattering, absorption, dispersion, polarization, reflection, Imaging with Electrons, radiation damage, electron tomography, electron holography. **Module 3:** Transmission Electron Microscopy: Instrument, holders, lenses, cameras, apertures and resolution, imaging, amplitude contrast, phase contrast, bending effect, planer defects, bright field imaging, dark field imaging, high resolution imaging, Scanning transmission electron microscopy, image simulation and image analysis, Spectroscopy, X-ray spectroscopy, qualitative and quantitative X-ray analysis, electron energy loss spectroscopy and images, fine structure, diffraction pattern, indexing diffraction pattern, specimen (hard, soft, powder, ad biological) preparation, Industrial applications. **Module 4:** Scanning Electron Microscopy: Instrument, holders, lenses, apertures, resolution, Electron detectors, Back scattered electron, Secondary electron, Auger electron, imaging, Auger electron spectroscopy. Augur electron microscopy, image simulation and image analysis, Spectroscopy, X-ray spectroscopy, qualitative and quantitative X-ray analysis, EBSD, diffraction pattern and analysis, specimen preparation, Industrial applications.
Learning Outcome	The student will introduce himself/herself to the electron microscopy. The industrial applications of electron microscopy will be known. There are lots of opportunity in electron microscopy as it is a modern technique and it has lots of industrial applications. Hence, the students can take the job in the electron microscopy industries or they can make entrepreneur for supporting to the electron microscopy industries.
Assessment Method	Assignments, mini projects, Quizzes, Mid-semester examination, and End-semester examination.

Suggested Readings:	**Textbooks:** 1. Physical Principles of Electron Microscopy, Ray F. Egerton, springer, 2005, New York 2. Scanning Electron Microscopy, Ludwig Reimer, springer, 1998, New York, 3. Transmission Electron Microscopy, David B. Williams, C. Barry Carter, springer, 2009 **References:** 1. Electron Microscopy: Principles and Fundamentals, S. Amelinckx (Editor), Dirk van Dyck (Editor), J. van Landuyt (Editor), Gustaaf van Tendeloo (Editor), Wiley, 2007. 2. Electron microscopy Methods and Protocols, John Kuo, Springer, 2014. 3. The principles and Practice of Electron Microscopy, Ian M. Watt, Cambridge University Press, 1997.

Course Number	**PH3209**
Course Title	Quantum Computation
Course Credit (L-T-P-C)	2-1-0-3
Learning Mode	Lectures & Tutorials
Learning Objectives	Quantum Computing is one of the fastest growing topics for research, development and industry. A number of insightful questions arise in the mind of students, such as - what is quantum computer? Why is it required? How does it look like? How can these be implemented? When will we get quantum computer for personal use? – etc. This course is intended to provide answers to all these questions in the level of undergraduate students.
Course Contents	Fundamental idea of quantum computing: Moore's Law; Operators and matrices: Pauli matrices, inner, outer and tensor products, Unitarity; *(2 lectures+1 tutorial)* Quantum nonlocal superposition; Quantum entanglement; Basics of quantum measurements (General, Projective, POVM); From Bits to Qubits with examples, Bloch sphere, Single and multiple qubit logic gates, Universal quantum gates; Basic quantum circuits, Quantum Teleportation protocol; Quantum Fourier Transform, Quantum phase estimation, Factorization algorithm; *(8 lectures+4 tutorials)* Relevant knowledge of Quantum Optics & Quantum information; Physical realizations of Quantum computers: quantized harmonic oscillator; Density operator, ensemble of quantum states; *(5 lectures+2 tutorials)* Fundamentals of various quantum computers: semiconductor based quantum computer, photonic based quantum computer, cold- and ultracold-atom based quantum computers, use of cavity-QED; *(7 lectures+3 tutorials)* Applications of quantum computing in other fields: ideas of quantum communication & quantum security etc; Practical examples with Quantum Simulators; AI and Quantum computing; State-of-the-art quantum computation and Future outlook. *(8 lectures+4 tutorials)*
Learning Outcome	The course will build up the basic foundation required for knowing the working of a quantum computer, quantum information processing through quantum circuits, examples with well-known quantum algorithms, various quantum computers, important applications and future outlook. The students will also be given overview of the Indian and global companies and their contributions in quantum computing. It will impart the motivation to students for further applying their knowledge to the progress of the field in both R&D and industry.
Assessment Method	Assignments, Quizzes, MSE and ESE
Suggested readings	**Textbooks:** 1. Quantum Computation and Quantum Information, M. A. Nielsen and I. L. Chuang, Cambridge University Press, South Asian Edition, 10th Edition.

	2. An Introduction to Quantum Computing, Phillip Kaye, R. Laflamme, M. Mosca, Oxford University Press, 2007. 3. Preskill, John. Lecture notes for physics 229: Quantum information and computation. California Institute of Technology 16.1 (1998): 1-8. 4. Nakahara, Mikio, and Tetsuo Ohmi. Quantum computing: from linear algebra to physical realizations. CRC press, 2008. 5. Mermin, N. David. Quantum computer science: an introduction. Cambridge University Press, 2007. **References:** 1. Quantum Supremacy, Michio Kaku, Allen Lane-Penguin publisher, 2023. 2. McMahon, David. Quantum computing explained. John Wiley & Sons, 2007. 3. Riley Tipton Perry, Quantum Computing from the Ground Up, World Scientific Publishing Ltd (2012). 4. Scott Aaronson, Quantum Computing since Democritus, Cambridge, 2013. 5. Bouwmeester, D., Ekert, A. and Zeilinger, A., (2000), The Physics of Quantum Information, Reprint edition, Springer Berlin Heidelberg. 6. Barenco, Adriano, et al. Elementary gates for quantum computation. Physical review A 52.5 (1995): 3457. 7. Quantum Computing: Lecture Notes, Ronald de Wolf, QuSoft, CWI and University of Amsterdam, arXiv:1907.09415v3, 2022.

Course Number	**PH3210**
Course Credit	2-1-0-3
Course Title	Device Modeling and Design
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with Program goals 1, 2 and 3
Course Description	This course provides detailed theoretical overview of Device Modeling and Design
Course Outline	Crystal structure-Unit cell and Miller Indices Reciprocal Space, Doping, Band Structure, Effective Mass, Density of states, Distribution Function, and carrier concentration calculation, Carrier transport, Mobility and diffusivity, continuity equation, Poisson's equation, Semiclassical transport, carrier density equation, current density equation p-n junction, Metal-semiconductor junction, BJT, Heterojunction, Schottky junctions, MOS capacitor, MOSFET, JFET, Capacitor-Voltage Characteristics, Boltzmann Transport Equation (BTE), Relaxation-Time Approximation (RTA), Scattering and Mobility. Drift-Diffusion Model Derivation and dielectric relaxation time Generation and Recombination models, Derivation of SRH model, Boundary conditions, Gummel's Iteration Method and Newton's Method, As extension of DD model, Carrier Balance, Energy balance and momentum balance Equations, Direct solution scheme through Monte Carlo simulations, Models for DD, Hydrodynamic simulations, Mobility and G-R models, Introduction to Silvaco ATLAS (device) and ATHENA (process) simulation framework. Simulator syntax, Numerical method choice, TCAD tools, MixedMode simulation, Basics of semiconductor processing, Si-Based Nanoelectronics and Device Scaling, scaling implications, short channel effects, effective channel length, effects of channel length and width on threshold voltage, Compact models for MOSFET and their implementation in SPICE. MOS model parameters in SPICE.
Learning Outcome	Complies with PLO 1a. 1b. 2a and 3a
Assessment Method	Quiz, Assignments and Exams
Suggested Readings:	**Textbooks:** **1.** Umesh K. Mishra and Jasprit Singh, Semiconductor Device Physics and Design, Springer, 2008. **2.** G. Streetman, and S. K. Banerjee, "Solid State Electronic Devices," 7th edition, Pearson,2014. **3.** S. M. Sze and K. N. Kwok, "Physics of Semiconductor Devices," 3rd edition, John Wiley&Sons, 2006. **4.** D Vasileska, SM. Goodnick, G Klimeck, "Computational Electronics: Semiclassical and Quantum Device Modeling and Simulation," CRC Press 2010. **5.** Selberherr Siegfried, "Analysis and Simulation of Semiconductor Devices", 1984

Sl. No.	Subject Code	SEMESTER VII	L	T	P	C
1.	EP4105	Quantum Technology Laboratory	1	0	3	2.5
2.	PH41XX	DE-III	3	0	0	3
3.	HS41XX	HSS Elective – II	3	0	0	3
4.	XX41PQ	IDE – III	3	0	0	3
5.	PH4198	Summer Internship*	0	0	12	3
6.	PH4199	Project – I	0	0	12	6
Total Credit			**10**	**0**	**27**	**20.5**

Course Number	**EP4105**
Course Credit	1-0-3-2.5
Course Title	Quantum Technology Laboratory
Learning Mode	Laboratory course
Learning Objectives	Aligns with PLO 1, 2 and 3
Course Description	It provides hands-on experience and skills for experiments in quantum techniques that are challenging at varying levels of expertise.
Course Content	**(Around 10 experiments out of the following will run at a time)** **Theme: Quantum Simulators for Quantum Computing, Quantum Communication etc** **Designing of quantum circuits**: complex quantum circuits using universal quantum gates, and quantum state preparation. **Exp 1**: Logic operations in discrete-variable and continuous-variable quantum computations including quantum measurements. **Exp 2**: Decomposition of single qubit parameterized quantum gates, Controlled-parameterized quantum gates and multi-controlled quantum gates. **Exp 3**: Designing quantum states like superposition, GHZ etc. **Design prototype quantum circuits for quantum algorithms.** **Exp 4**: Implementing quantum Fourier transformation. **Exp 5**: Implementing quantum phase estimation. **Exp 6**: Implementing Grover's search algorithm. **Exp 7**: Implementing different quantum algorithms for fidelity estimation between pure quantum states. **Quantum communication.** **Exp 8**: Implementing quantum teleportation protocol. **Quantum computation for AI.** **Exp 9**: Designing quantum fidelity classifier using quantum Hadamard test. **Exp 10**: Designing quantum kernels using Gaussian states. **Theme: Quantum Interference:** This experimental setup investigate various aspects of quantum interference. **Exp 11: Two Photon Interferometer** **Exp 12: Single Photon Michelson Interferometer** **Theme: Quantum Entanglement:** Quantum entanglement is an important integral part of quantum technology. These experiments focus towards demonstration of quantum entanglement using photonic qubits and verify nonlocality through Bell inequality violation. **Exp 13: Quantum Entanglement Demonstrator** **Exp 14: Test of Bell's inequality** **Theme : Quantum Cryptography (BB84)** Quantum cryptography is a paradigm shift in secure quantum communication. These experiments provide hands-on exploration of cryptographic principles and its applications. **Exp 15:** Quantum Cryptography Demonstration, Quantum key distribution, **Exp 16:** Quantum Random Number Generator **Theme: Single Photon and SPDC sources:** Single photon counting detectors, photon statistics, the statistical properties of photon pairs are analyzed using the second-order correlation function ($g(2)$), measured through coincidence counting **Exp 17: Absolute Efficiency Measurement System for Single Photon Counting Detectors** **Exp 18: Demonstration of photon-statistics of different light sources** **Exp 19: Shot noise measurement of photon** **Exp 20: Statistical properties of photon pairs analysis using the second-order correlation function**

Learning Outcome	The learning outcomes align with 1a, 1b,2a and 3a
Suggested Reading:	1. M. Tinkham, Introduction to Superconductivity, 2/e (2004). 2. Barton Zweibach, Mastering Quantum Techniques-Essentials, Theory and Applications (2022).

Sl. No.	Course Code	Departmental Elective – III	L	T	P	C
1.	PH4106	Science and Technology of Nanomaterials	3	0	0	3
2.	PH4107	Optical Quantum Communication	3	0	0	3
3.	PH4108	Photovoltaics: Concepts and Applications	3	0	0	3
4.	PH4109	Electronic Devices and Circuits	3	0	0	3

Syllabus not available for PH4106

Course Number	**PH4107**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Optical Quantum Communication
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	This course provides engineering students to learn modern cutting edge optical quantum communication techniques which are very essential to pursue for advanced research and scientific jobs in the area of quantum communication and engineering applications. The course will also examine current research trends and potential future developments in the field of optical quantum communication.
Course Outline	classical v/s quantum information, quantum bits (qubits) and quantum gates, quantum entanglement and its properties, single-photon sources, entangled photon sources, photons as information carriers, polarization qubits, qubit generation and propagation, Bell state measurements, quantum repeaters, various protocols for quantum memory and its efficiency, implementation of quantum memory nodes, long distance quantum communication using quantum repeaters, quantum networks, multi-node quantum communication, ground-based and space-based quantum networks, entanglement distribution and quantum internet, Recent progress in quantum photonic chips for quantum communication and internet.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(b) and 3
Assessment Method	Exams, Quiz and Assignment
Suggested Readings:	**Textbooks:** 1. Gianfranco Cariolaro,Quantum Communications, Springer (2015). 2. P. Kok and B. W. Lovett, Introduction to Optical Quantum Information Processing, Cambridge university press. 3. Peter Lambropoulos, David Petrosyan, Fundamentals of Quantum Optics and Quantum Information, Springer (2007) 4. Ivan B. Djordjevic, Quantum Communication, Quantum Networks, and Quantum Sensing, Elsevier (2022) **References:** 1. L. Mandel, and E. Wolf. Optical Coherence and Quantum Optics, Cambridge University Press. 2. W. H. Louisell, Quantum Statistical Properties of Radiation, McGraw-Hill. 3. D. Bouwmeester, A. K. Ekert, and A. Zeilinger, eds. The Physics of Quantum Information, Springer 4. Serge Haroche, Jean-Michel Raimond, Exploring the Quantum: Atoms, Cavities, and Photons, Oxford Academic (2006)

Course Number	PH4108
Course Credit (L-T- P-C)	3-0-0-3
Course Title	Photovoltaics: Concepts and Applications
Learning Mode	Physical Presence in Class Room
Learning Objectives	Alternative energy sources have always been a core area of significant importance since long. Recent focus on harnessing natural energy from the Sun, has necessitated teaching of relevant course at undergraduate level to create talent pool to meet industry demand. It aims to impart; 1. Knowledge pertaining to solar energy harnessing conditions 2. Learning relevant to physics of photovoltaic cells. 3. Training and skill relevant for design, processing, fabrication, testing and installation of photovoltaic cells, i.e.; end to end industry skill.
Course Outline	**Module-1:** An introduction to different sources of energy with its implications and alternative solutions, energy balance of the Sun and optimal conditions for harnessing solar energy, efficient design to entrap solar energy, a state of-the-art review of solar photovoltaic cells. **Module-2:** Semiconductor fundamentals, drift, diffusion and charge transport, photon emission and absorption, PN junction design and control parameters, Junction solar cell configuration – design, fabrication, analysis and efficiency improvement considerations for efficient solar cells. **Module-3:** Silicon based solar cell technology - monocrystalline, polycrystalline, amorphous and thin film Si solar cells, Process form sand to Silicon and Silicon to Wafer, Cell design and fabrication process, Multi-junction Si solar cells. **Module-4:** Non-Si solar cell technology, its challenges and advancements, an introduction to protocols for solar cell installation.
Learning Outcome	The learners of the course would be ready with knowledge to; (a) harness solar energy and technologically competent to implement the technology and (b) fulfil emerging industry and R & D institution demand for technologically skilled workforce.
Assessment Method	Class test and Quiz/Assignment (**20%**), MSE: (**30%**), ESE: (**50%**)
Suggested Readings:	1. Solar Photovoltaics: Fundamentals, Technologies and Applications (2^{nd} ed.), C. S. Solanki, Prentice Hall of India 2. Solar Cell Device Physics, Stephen Fonash (2^{nd} ed.), Academic Press 3. Principles of Solar Cells, LEDs and Diodes, Adrian Kitai, Wiley

Course Number	**PH4109**
Course Credit	3-0-0-3
Course Title	Electronic Devices and Circuits
Learning Mode	Lectures
Learning Objectives	To pick-up skills for circuit analysis that uses Bipolar Junction Transistor (BJT), Operational Amplifiers (OPAMP) and Metal Oxide Semiconductor Field Effect Transistor (MOSFET).
Course Description	The course is focused on techniques used for analysis of various circuits that use electronic devices. The course is composed of three modules, namely, BJT, OPAMP and MOSFETs. The first module revolves around circuits that use discrete BJT as an amplifier. The second module introduces OPAMPs which are based on BJT. A wide variety of linear and non-linear applications of OPAMPs are discussed. The last module discusses various circuits of MOSFETs.
Course Outline	**Module 1:** Introduction to r_e-model of BJT, Analysis of CE, CB and CC configuration using r_e model; Introduction to *h*-parameter model of BJT, Analysis of CE, CB and CC configuration using *h*-parameter model; **Module 2:** Introduction to Differential Amplifier using BJT; Introduction to OPAMP, AC equivalent circuit of OPAMP (real and ideal); Various linear applications of OPAMP $\rightarrow$ Inverting amplifier (AMP), Non-inverting AMP, Summing AMP, Difference AMP, Unity follower, Positive and Negative voltage references, Voltage regulator, Howland Current source, etc.; Active filters $\rightarrow$ First-order & Second-order low-pass and high-pass Butterworth filter, All-pass filter, Band-pass and Band-reject filter, Notch filter; Basics of Oscillator, Wien-Bridge Oscillator, Phase-Shift Oscillator, Quadrature Oscillator, Square-wave, Triangular-wave and Sawtooth-wave generator, VCO. Various non-linear applications of OPAMP $\rightarrow$ Basics of Comparator, Zero crossing detector, Schmitt Trigger; Log AMP & Anti-log AMP. **Module 3:** MOSFET circuit at DC, MOSFET as an amplifier, Biasing in MOS AMP circuits: Biasing by fixing V_{GS} with and without resistance in the Source, Biasing using drain-to-gate feedback resistor, Biasing using constant current source, DC bias point in small signal operation; Introduction to small signal AC equivalent circuit with and without channel length modulation effect, *T*-equivalent circuit model, Characteristics parameter of single stage MOS AMP, CS amplifier with and without source resistance, CG amplifier and CD amplifier.
Learning Outcome	Students get to know the following: (a) Basics of circuit analysis (b) Circuit analysis skill for single stage low frequency BJT amplifier in various configurations (c) Circuit analysis skill for a wide variety of OP-AMP circuits that encompasses both linear and non-linear applications (d) Circuit analysis skill for single stage low frequency MOS amplifier in various configurations
Assessment Method	Quiz, Assignments and Exams
Suggested Readings:	**Textbooks:** **1.** Jacob Millman and Christos C. Halkias, *Integrated Circuits: Analog and Digital Circuits and Systems*, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1995 **2.** Ramakant A. Gayakwad, *Op-Amps and Linear Integrated Circuits, PHI Learning Private Ltd*., New Delhi, 2010 **3.** Adel S. Sedra and Kenneth C. Smith, Microelectronic Circuits, Oxford University Press, New York, 2006 **4.** Behzad Razavi, *Fundamentals of Microelectronics*, Wiley India Private Ltd., New Delhi, 2015

Sl. No.	Subject Code	SEMESTER VIII	L	T	P	C
1.	PH42XX*	DE-IV	3	0	0	3
2.	PH42XX	DE-V	3	0	0	3
3.	PH42XX	DE-VI	3	0	0	3
4.	PH42XX	DE-VII	3	0	0	3
5.	PH4299	Project – II	0	0	16	8
Total Credit			**9**	**0**	**16**	**20**
Grand Total Credit (Semester I to VIII)			**168**			

Sl. No.	Course Code	Departmental Elective – IV	L	T	P	C
1.	PH4205	Quantum Mechanics - II	2	1	0	3
2.	PH4206	Thin Film Technology	3	0	0	3
3.	PH4209	Solar Energy and Photovoltaics	3	0	0	3
4.	PH4210	Modeling Complex Systems	3	0	0	3
5.	PH4211	AC Network Analysis	3	0	0	3

Course Number	**PH4205**
Course Credit (L-T-P-C)	2-1-0-3
Course Title	Quantum Mechanics-II
Learning Mode	Lectures & Tutorials
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	In this course students will learn time dependent perturbation theory, scattering theory and relativistic quantum mechanics.
Course Content	Time dependent perturbation theory, Schrödinger, Heisenberg and interaction pictures.; Constant and harmonic perturbations Fermi's Golden rule; Scattering theory: Laboratory and centre of mass frames, differential and total scattering cross-sections, scattering amplitude; Born approximation, Greens functions, scattering for different kinds of potentials; Partial wave analysis; Special topics in radiation theory: semi-classical treatment of interaction of radiation with matter Symmetries in quantum mechanics: Conservation laws and degeneracy associated with symmetries; Continuous symmetries, space and time translations, rotations; Rotation group, Wigner-Eckart theorem; Discrete symmetries; parity and time reversal. Relativistic quantum mechanics, Klein-Gordon equation, Interpretation of negative energy states and concept of antiparticles; Dirac equation, covariant form, adjoint equation; Plane wave solution and momentum space, spinors; Spin and magnetic moment of the electron.
Learning Outcome	Complies with PLO 1, 2(a) and 3
Assessment Method	Assignments, Quizzes, Seminar, Mid-semester examination, End-semester examination
Suggested Readings:	
Textbooks:	• Quantum Mechanics (Vol-II), C. Cohen-Tannoudji, John Wiley & Sons, Asia, 2005. • Advanced Quantum Mechanics, J. J. Sakurai, Pearson Education, 2007. • Principles of Quantum Mechanics, R. Shankar, Springer, India, 2008.
References:	• Quantum Mechanics, L. I. Schiff, McGraw-Hill, 1968. • Quantum Mechanics, E. Merzbacher, John Wiley, Asia, 1999. • Quantum Mechanics, V.K. Thankappan, Wiley Eastern, 1985. • The Feynman Lectures on Physics, Vol.3, R.P. Feynman, R.B. Leighton and M.Sands, Narosa Pub. House, 1992. • The Principles of Quantum Mechanics, P.A.M. Dirac, Oxford Univ. Press, 1991. • Quantum Mechanics-Nonrelativistic Theory, L.D.Landau and E.M. Lifshitz, 3rd Edition, Pergamon, 1981. • Quantum Mechanics, B. H. Bransden and C. J. Joachain, Pearson Education 2nd Ed., 2004.

Course Number	**PH4206**
Course Credit L-T-P-C	3-0-0-3
Course Title	Thin Film Technology
Learning Mode	Classroom Lectures
Learning Objectives	The science of technology involved behind growth, characterization and uses of Thin Film of various materials.
Course Description	Module-1 deals introduces to thin film and its importance. The physical processes behind growth of thin film is also discusses. Module-2 deals with the knowledge of vacuum technology which is relevant for growth of thin film. Module-3 discusses about various techniques for growth of thin film which makes use of vacuum technology also. Module-4 deals with various characterization methods of thin films, and lastly discusses about applications.
Course Outline	**Module-1:** Motivation; Structure, defects, thermodynamics of materials, mechanical kinetics and nucleation; grain growth and thin film morphology; **Module-2:** Basics of Vacuum Science and Technology, Kinetic theory of gases; gas transport and pumping; vacuum pumps and systems; vacuum gauges; oil free pumping; aspects of chamber design from thin film growth perspectives; **Module-3:** Various Thin film growth techniques with examples and limitations; Spin and dip coating; Langmuir Blodgett technique; Metal organic chemical vapor deposition; Electron Beam Deposition; Pulsed Laser deposition; DC, RF and Reactive Sputtering; Molecular beam epitaxy; **Module-4:** Characterization of Thin films and surfaces; Thin Film processing from Devices and other applications perspective.
Learning Outcome	Complies with PLO 1a
Assessment Method	Quiz, Seminar, Mid-semsester examination, End-semester examination
Suggested Readings:	• Materials Science of Thin Films Deposition and Structure, Milton Ohring. • Thin Film Solar Cells, Chopra and Das. • Thin Film Deposition: Principles and Practice, Donald Smith. • Handbook of Thin Film Deposition (Materials and Processing Technology), Krishna Seshan • Handbook of Physical Vapor Deposition, D. M. Mattox

Course Number	**PH4209**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Solar Energy and Photovoltaics
Learning Mode	Lectures
Learning Objectives	Complies with program goal 1,2 and 3
Course Description	In this course, student will learn about solar spectrum, solar energy conversion, storage of energy for future use including how solar cell working principle.
Course Outline	Solar radiations as a source of energy and mechanism for its entrapment; Measurements and limits of solar energy entrapment; Flat plate collectors and solar concentrators; Solar energy for industrial process heat and design of solar green house; Solar refrigeration and conditioning; Solar thermo-mechanical power. Introduction of energy storage/conversion devices, State-of-the art status of portable power sources, Solar/photovoltaic (PV) cells as a source of green energy; Fundamentals, Materials, Design and Implementation aspects of PV energy generation and consumption; Solar cell technologies (Si-wafer based, Thin film, GaAs based, dye-sensitized, PESC and organic solar cells), Efficiency of solar cells and PV array analysis, Photovoltaic system design (stand alone and grid connected) and applications; Balance of system (BOS) with emphasis on role of storage batteries; Cost analysis, Case study for performance evaluation and problem identification in wide-spread commercialization of the technology.
Learning Outcome	Complies with PLO 1, 2(a) and 3
Assessment Method	Assignments, Quizzes, Seminar, Mid-semester examination, End-semester examination
Suggested Readings	
Textbooks	• Solar Energy: Fundamentals & Applications; H. P. Garg and J. Prakash; Tata McGraw Hill, 1997. • Fundamentals of Photovoltaic Modules and their Applications, G. N. Tiwari, S. Dubey & Julian C. R. Hunt, RSC Energy Series, 2009. • Solar Photovoltaics: Fundamentals, Technologies and Applications, 2nd Ed., C. S. Solanki, Prentice Hall of India, 2011 (ISBN: 978-81-203-4386-6) • Solar Cell Device Physics, Stephen Fonash, 2nd Ed., Academic Press, 2010 (ISBN: 978-0-12-374774-7).
References	• Energy Storage, R. A. Huggins, Springer, 2010. • Handbook of Advanced Electronic and Photonic Materials and Devices: Ferroelectrics & Dielectrics, Vol. 10, H. S. Nalwa (Ed.), Academic Press, 2001. • Electrochemical Nanotechnology, T. Osaka, M. Dutta, Y. S. Diamand (Eds.), Springer, 2010, (ISBN: 978-1-4419-1423-1). • Encyclopedia of Nanoscience & Nanotechnology, Vol. 10, H. S. Nalwa (Ed.), American Scientific Publishers, 2004.

Course Number	**PH4210**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Modeling Complex Systems
Learning Mode	Lectures and Computational exercises
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	This interdisciplinary course explores the practical application of modeling and simulation principles to complex systems. A complex system, characterized by interconnected or interwoven parts, can include biological organisms, ecological systems, economies, fluids, or strongly-correlated solids. The course draws from mathematics, nonlinear science, numerical simulations, and statistical physics. It begins with an overview of complex systems and then delves into modeling techniques using nonlinear differential equations, networks, and stochastic models. Throughout the course, students will model, program, and analyze a diverse range of complex systems, including dynamical and chaotic systems, cellular automata, and iterated functions. Through these, there will be ample scope for hands-on experience and a deeper understanding of complex systems emerging from elementary rules.
Course Content	Fundamentals of Modeling, A brief recap of Dynamical Systems; Discrete-Time Models: Modeling and Analysis; Continuous-Time Models: Modeling and Analysis; implications of bifurcation, chaos and catastrophe; interactive simulations of complex systems, cellular automata, continuous field models; basics of networks, small world network; dynamical networks: Modeling, Network topologiesand dynamics; Agent-based models; Examples including epidemiology, forest-fire, bioinformatics, message-passing, predator-prey, belief propagation, Hutchinson’s time-delay model, internet.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination
Suggested Readings:	**Textbooks:** 1. Hiroki Sayama, Introduction to the Modeling and Analysis of Complex Systems, Open SUNY (2015). 2. Nino Boccara, Modeling Complex Systems, Springer-Verlag Reprint (2024). **References:** 1. W. Krauth, Statistical Mechanics: Algorithms and Computations (Oxford Masters Series in Physics, 2006).

Course Number	**PH4211**
Course Credit	3-0-0-3
Course Title	AC Network Analysis
Learning Mode	Lectures and Tutorials
Learning Objectives	The course is focused on the application oriented knowledge that is required to analyze alternating current circuits whose frequency of operation is not as high as radio frequencies. The knowledge would be used to test and analyze various AC circuits.
Course Description	This course deals with development of skills that is required to analyze various AC circuits. The skills are not introduced abruptly but in a systematic manner. First, the course starts with fundamental knowledge on Network Transformations. Post that a section on Resonance in AC circuits is discussed. Lastly, the course ends with Impedance transformations in AC networks and methods to deal with coupled circuits, especially Transformer.
Course Outline	**Module 1:** Principle of duality, Reduction of complicated two port network to T and π equivalent circuits, Conversion between T and π sections, Bridged and Parallel T network, Reciprocity theorem, Compensation theorem, Maximum power transfer theorem, Transfer impedance, Matrix method for network calculations **Module 2:** Definition of Q-factor, Series resonance and its bandwidth, Parallel resonance, Conditions for maximum impedance, Currents in anti-resonant circuit, Universal resonance curves, Bandwidth of anti-resonance circuit, Anti-resonance at all frequencies, Reactance curves **Module 3:** Transformation of impedances, Reactance L section for impedance transformation, Image impedance and Everitt's theorem, Reactance T network for impedance transformation, Coupled circuits, Equivalent T network for magnetically coupled circuit, Iron core transformer
Learning Outcome	AC circuit analysis is primarily composed of three modules, namely, Network Transformation which is covered in Module 1, Resonance which is covered in Module 2 and Impedance Transformation which is covered in Module 3. In Module 1, the student gets trained in the fundamentals. It is important that the student should pick-up well in the fundamentals. Therefore, special emphasis would be given in solving numerical problems. Module 2 and 3 widen the scope of AC circuit analysis technique. Application of the techniques learnt in these modules is of prime importance. Therefore, solving problems, based on the concept taught in the lecture, forms and essential part.
Assessment Method	Quiz, Assignments and Exams
Suggested Readings:	**Textbooks:** 1. John D. Ryder, Network Lines and Fields, Prentice Hall of India, New Delhi, 2002. **References:** 1. M. B. Reed, Alternating-Current Circuits, Harper & Brothers, New York 1948. 2. W. R. LePage and S. Seelay, General Network Analysis, McGraw-Hill Book Company, Inc., New York, 1952. 3. W. L. Everitt, Communication Engineering, 2^{nd} Edition, McGraw-Hill Book Company, Inc., New York, 1937.

Sl. No.	Course Code	Departmental Elective – V	L	T	P	C
1.	PH4212	X-ray and Applications	3	0	0	3
2.	PH4213	Materials Engineering	3	0	0	3
3.	PH4214	Superconducting Qubits: Fundamentals and Operation	3	0	0	3
4.	PH4215	Analytical Techniques	3	0	0	3

Course Number	**PH4212**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	X-ray and Applications
Learning Mode	Lectures
Learning Objectives	The objectives of the course are to learn the X-ray mechanism, functions and applications of X-rays. The physics formulation and technological applications will be learned by the student. This will create opportunity to have a carrier in X-ray technology in both imaging and diffraction. More over the student will learn X-ray diffraction, X-ray absorption and photoemission with their current applications.
Course Description	The course discusses the physical mechanism of X-ray and Matter interaction, production of X-ray techniques, etc. The use of X-ray in biophysics, condensed matter physics, medical physics, cultural heritage and environmental science.
Course Content	**Module 1:** Introduction to X-ray physics, physical properties of x-rays, Macroscopic description of X-ray and material interaction, Microscopic description of interaction, Semi-classical theory of the interaction between radiation and hydrogen – like atoms, Fermi's golden rule for transitions to discrete and continuum states, Selection rules, Production of X-rays. **Module 2:** X-ray applications: X-ray optics, X-ray microscopy, X-ray diffraction, X-ray interference, X-ray Scattering, medical imaging, X-ray fluorescence and absorption spectroscopy, coherent diffraction imaging, industrial applications. **Module 3:** Synchrotron radiation: Sources of Synchrotron radiation, RF cavity, Beamlines and basics of x-ray optics, General characteristics of Synchrotron Radiation, Diffraction limit and Coherence lengths, industrial applications. **Module 4:** Photoemission spectroscopy: The Photoelectric effect, Experimental Setup, Theoretical Description, Primary and secondary structures occurring in the photoemission spectra, Photoelectron Spectroscopy of solids, Quantitative Analysis, Hard x-ray Photoelectron Spectroscopy, Industrial applications **Module 5:** X-ray absorption fine structure, Phenomenology of X-ray absorption spectroscopy, experimental layouts, Physical origin of the fine structure (self-interference phenomenon), Golden rule and further approximations, Approximate derivation of EXAFS (Muffin-tin approximation for two atomic system), Correction terms for the EXAFS function and final relation, EXAFS data analysis and resulting structural parameters, XANES phenomenological description, Chemical shift of the absorption edge, Linear dichroism in XANES and EXAFS, Industrial applications. Text Books: 1- J. Als – Nielsen and D. McMorrow, *Introduction to Modern X-ray Physics*, Wiley, New York, 2001.

	2- A. Balerna and S. Mobilio, *Introduction to Synchrotron Radiation*, in "Synchrotron Radiation: Basics, Methods and Applications", a cura di S. Mobilio, F. Boscherini e C. Meneghini, Springer (2015). 3- S. Hüfner, Photoelectron Spectroscopy – Principles and Applications, 3rd ed. (Berlin, Springer, 2003) Reference Books: 4- P. Fornasini, *Introduction to X-ray absorption spectroscopy*, in "Synchrotron Radiation: Basics, Methods and Applications", a cura di S. Mobilio, F. Boscherini e C. Meneghini, Springer (2015). 5- B. Bunker, *Introduction to XAFS: a practical guide to X-ray absorption spectroscopy*, Cambridge University Press (2010). 6- B.E. Warren, *X-ray diffraction*, Dover, New York, 1990. 7- S.J.L. Billinge e E.S. Bozin, *Pair distribution function technique: principles and methods*, in *Diffraction at the nanoscale*, a cura di A. Guagliardi & N. Masciocchi, Insubria University Press. 8- A. Guinier, *X-ray diffraction in crystals, imperfect crystals, and amorphous bodies*, Dover, New York, 1994. 9- C. Mariani e G. Stefani, *Photoemission Spectroscopy: fundamental aspects*in "Synchrotron Radiation: Basics, Methods and Applications", a cura di S. Mobilio, F. Boscherini e C. Meneghini, Springer (2015) 10- D. Attwood, *Soft X-rays and extreme ultraviolet radiation*, Cambridge University Press (1999).

Course Number	**PH4213**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Materials Engineering
Learning Mode	Lectures
Learning Objectives	The objective of the course is to develop basic knowledge about how Materials engineering lies at the core of technological advancement. Materials Engineering is an interdisciplinary field focused on understanding, designing, and improving materials to meet engineering challenges. This course provides a comprehensive foundation in the structure, properties, processing, and performance of materials, bridging scientific principles with practical applications. Students will explore a variety of materials, including metals, ceramics, polymers, composites, and advanced materials like nanomaterials and biomaterials, with an emphasis on their role in modern technology and industry.
Course Description	In beginning, overview of different material types will be discussed, followed by detailed insight how these materials are being used at present. The advancement in terms of their processing for modern technology and applications will be discussed.
Course Outline	Overview of material types: metals, ceramics & glasses, polymers, composites, Electronic Materials (Semiconductors, conductors, and insulators), Biomaterials (Materials used in medical implants and devices, Biocompatibility and degradation), Historical and modern advancements in materials engineering, Advanced materials (Nanomaterials, Materials for Energy Applications, Shape memory alloys). Atomic structure and bonding, Crystallography and crystal structures, Defects in materials (vacancies, dislocations), Microstructure and its influence on properties, Phase diagrams and phase transformations. Mechanical properties (strength, toughness, hardness, ductility, etc.). Thermal and electrical (conductivity, expansion)., magnetic, and optical properties, Corrosion and environmental degradation Techniques for shaping and forming materials (casting, forging, 3D printing), Heat treatment and phase transformations. Coating and surface modification, Powder metallurgy and ceramics processing. Criteria for selecting materials in engineering applications. Case studies in aerospace, automotive, electronics, and construction. Nanomaterials and their applications. Biomaterials for medical devices and implants. Smart materials and responsive systems.
Learning Outcome	Complies with PLO 2b, 3
Assessment Method	Quizzes, Mid-semester and End-semester examination
Suggested Readings:	• Materials Science and Engineering: An Introduction by William D. Callister Jr. and David G. Rethwisch, 10th Ed., Wiley, 2020. • Fundamentals of Materials Science and Engineering: An Integrated Approach by William D. Callister Jr. and David G. Rethwisch, 5th Ed., Wiley, 2007. • Engineering Materials 1 & 2 by Michael F. Ashby and David R. H. Jones, 4th Ed., Butterworth-Heinemann Ltd., 2012 • The Science and Engineering of Materials" by Donald R. Askeland and Wendelin J. Wright, 6th Ed., Cl-Engineering, 2010

Course Number	**PH4214**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Superconducting Qubits: Fundamentals and Operation
Learning Mode	Lectures and Tutorials
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	Equips the students with the fabrication techniques and operation intricacies of Superconducting Qubits with an eye on prospective applications
Course Content	**Introduction to Superconducting Qubits:** Overview of quantum computing, various physical qubits and the need for reliable qubits; Types of superconducting qubits (flux qubits, charge qubits, phase qubits, transmon qubits); Circuit quantum electrodynamics (cQED) and its relevance. **Quantum LC Circuits and Correspondence Principle**: Classical LC circuits and their resonance behavior; Superconducting qubits as classical circuit elements in a quantum regime; Circuit QED approach for quantizing classical Hamiltonians. **Josephson Junctions and Charge Qubits**: Cooper pairs and Josephson Junctions; Cooper pair box: Building blocks for charge qubits; Hamiltonian description of charge qubits based on tunneling and capacitance **Transmon Qubits**: Introduction to transmon qubits; Nonlinear inductance and capacitor design; Energy-level spectra and tunability **Operation and Control of Superconducting Qubits**: Initialization, manipulation, and readout of qubit states; Quantum gates (single-qubit and two-qubit gates); Decoherence and error correction **Applications and Challenges**: Quantum algorithms and applications using superconducting qubits; Challenges in scaling up qubit numbers; Recent advancements and future prospects
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination
Suggested Readings:	**Textbooks:** 4. Daniel D. Stancil and Gregory T. Byrd, Principles of Superconducting Quantum Computers, Wiley (2022). 5. Alan Salari, Microwave Techniques in Superconducting Quantum Computers, Artech Books, UK (2024). **References:** 7. Morten Kjaergaard *et al.* "Superconducting Qubits: Current State of Play". In: Annual Review of Condensed Matter Physics 11.1 (Mar. 2020), pp. 369– 395. DOI: 10.1146/annurev-conmatphys-031119-050605; URL: http://dx .doi.org/10.1146/ annurev-conmatphys-031119-050605. 8. Steven M. Girvin. Circuit QED: Superconducting Qubits Coupled to Microwave Photons, Les Houches Summer School on Quantum Machines, Oxford University Press (2014).

Syllabus not found for PH4215

Sl. No.	Course Code	Departmental Elective – VI	L	T	P	C
1.	PH4216	Computational Methods for Classical and Quantum Physics	3	0	0	3
2.	PH4217	LASER Technology	3	0	0	3
3.	PH4218	Atomtronics & Quantum Technology	3	0	0	3
4.	PH4219	Nanoscale Devices	3	0	0	3

Course Number	**PH4216**
Course Credit	3-0-0-3
Course Title	Computational methods for classical and quantum physics
Learning Objectives	To make students capable of solving specific advanced physics problems using the techniques developed in EP3101 (Computational Techniques).
Course Description	The student will learn computationally solving problems related to Quantum and Classical physics. The course has class room discussion which will be completed in computational lab by developing a code based on it.
Course Outline	Solving partial differential equations, Finite difference methods, Successive over-relaxation (SOR) method, Time dependent problems; The wave equation, Laplace equation, Traffic flow, Shock solution, Fluids, Solving the Schrodinger equation; One-Dimension, Higher dimensional Basic techniques, Quantum scattering, The variational principle, Time propagation, Central potentials, Multi-electron systems, The Hartree and Hartree-Fock approximations, Modelling Lithium atoms, Quantum dots.
Learning Outcome	Complies with PLO 1b, 3
Assessment Method	Mid-term written examination, Mid-term lab examination, End-term written examination, End-term lab examination, Assignment & Quiz
Suggested Readings:	
Textbooks:	• J. Izaac and J. Wang, Computational Quantum Mechanics, Springer , 2022. • J. Franklin, Computational Methods for Physics, Cambridge publications, 2013. • J. M. Thijssen, Computational Physics, Cambridge Univ. Press, 2nd Edition, 2007. • Tao Pang, An Introduction to Computational Physics, Cambridge Univ. Press, 2ndEdition, 2006. • Steven E. Kooning and Dawn C. Meredith, Computational Physics, Westview Press, 1990. • An Introduction to Computer Simulation Methods: Applications to Physical Systems, 3rdEdition, Harvey Gould, Jan Tobochnik, Wolfgang Christian, Addison-Wesley, 2006.
References:	• Rubin H. Landau, Manuel José Páez Mejía, Cristian C. Bordeianu, A Survey of Computational Physics: Introductory Computational Science, Volume 1, Princeton Univ. Press, 2008. • Werner Krauth, Statistical Mechanics: Algorithms and Computations, Oxford Masters Series in Physics, 2006.

Course Number	**PH4217**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	LASER Technology
Learning Mode	Lectures
Learning Objectives	The main objective is to learn various techniques used in building CW and pulsed lasers, different techniques developed based on lasers, and applications of lasers in various disciplines.
Course Description	This course allows engineering students to learn various techniques used in building CW and pulsed lasers, different techniques developed based on lasers, and applications of lasers in various disciplines, which are essential to pursuing research and scientific jobs in laser and relevant industries.
Course Outline	Principles of CW and Pulsed lasers, Laser modulation techniques, Different Q-switching and Mode-locking techniques, Laser amplifiers, Laser frequency stabilization techniques, Laser tuning techniques, Mode-selection methods, Harmonic generations, Non-linear optical methods, Raman lasers, Micro and Nanolasers. Laser remote sensing of the atmosphere, Photosensitization, Photodynamic therapy, Optical tweezers, Laser cleaning, Laser satellite communications, Laser cooling, Optical atomic clock, Laser pyrolysis, Laser micromachining, Laser 3D printing, High precision laser wavelength meters, Laser ablation techniques, Dynamic light scattering, Data storage, Fabrication of photonic crystals, Single molecule laser fluorescence and Raman microscopy, Photoacoustic imaging, Coherent anti-Stokes Raman scattering (CARS) imaging, Ultrasensitive Optical biosensors.
Learning Outcome	The students will be fully aware of various techniques used in building CW and pulsed lasers, different techniques developed based on lasers, and applications of lasers in various disciplines
Assessment Method	Designing of optical setups/theoretical simulations, Quizzes, Mid-semester and End-semester examination
Suggested Readings:	
Textbooks:	[1]. C. B. Hitz, J. J. Ewing, and J. Hecht, Introduction to Laser Technology, Wiley, 2012. [2]. C. Guo and S. C. Singh, Handbook of Laser Technology and Applications, CRC Press, 2021. [3]. Lan Xinju, Laser Technology, CRC Press, 2010 [4]. A. Donges and R. Noll, Laser Measurement Technology, Springer, 2015. [5]. W. T. Silfvast, Laser Fundamentals, Cambridge University Press, 1996. [6]. J-X Cheng, X. S. Xie, Coherent Raman Scattering Microscopy, CRC Press, 2013.

Course Number	**PH4218**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Atomtronics & Quantum Technology
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 1, 2 and 3
Course Description	Atomtronics is an emerging interdisciplinary topic for Quantum Technology. This course will provide students with a comprehensive introduction to the principles, techniques, and applications of atomtronics. Topics covered will include Bose-Einstein condensates, atom optics, atom interferometry, atom-based circuits, and potential applications in quantum computing and precision measurements.
Course Content	Introduction to Atomtronics, Techniques for preparing the system: cooling and trapping; Dynamics of Bose-Einstein condensates, Nonlinear excitations in ultra-cold atoms: Solitons and Quantum Droplets; Basics of Atom Optics, Manipulation of atomic beams: waveguide of various curvatures, Phase Imprinting, and persistent currents: AQUIDS, Atom lenses, mirrors and beam-splitters, Atomtronics Matter wave lensing, Ring trap and ring lattice atomtronics; Atom Interferometry: basic ideas, Mach-Zehnder interferometer, Aharonov-Bohm interferometer, Atomic soliton-barrier interferometer, Sagnac Interferometer; Quantum Computing with Atomtronics, use of quantum information processing with ultra-cold atoms, quantum logic gates, design, and implementation of atomtronic components (atomtronics diodes, transistors, etc.); Precision Measurements and other applications, Gravimeter, Accelerometer, Navigation; Current applications of atomtronics in research, industry, and future directions.
Learning Outcome	Complies with PLO 1(a), 1(b), 2(a) and 3 The course aims to establish a foundational understanding on atomtronics and its importance in Quantum Technology. Through comprehensive study, students will acquire proficiency in methods for controlling and guiding ultra-cold atomic gases as atom-lasers. Additionally, we will explore atom interferometry, exploiting its utility in quantum precision measurement, and quantum computing. Furthermore, the course will provide current status of the relevant quantum technologies, the approaches by leading industries and research outlook.
Assessment Method	Assignments, Quizzes, Mid-semester examination and End-semester examination
Suggested Readings:	**Textbooks:** 1) Quantum Atom Optics: Theory and Applications, E. O. Ilo-Okeke and Tim Byrnes, Cambridge University Press (2021). 2) Roadmap on Atomtronics: State of the art and perspective, Amico, L., et al., AVS Quantum Science 3, no. 3 (2021). 3) Colloquium: Atomtronic circuits: From many-body physics to quantum technologies, Amico, L., et al., Reviews of Modern Physics, 94(4), 041001 (2022). **References**: 1) Atom Interferometry: Paul R. Berman, Academic Press, 1997.

	2) Focus on atomtronics-enabled quantum technologies. New Journal of Physics, Amico, L et al., 19(2), 020201 (2017). 3) Advances in atomtronics, Pepino, R. A., Entropy, 23(5), 534 (2021).

Syllabus not found for PH4219

Sl. No.	Course Code	Departmental Elective – VII	L	T	P	C
1.	PH4220	Medical Physics and Applications	3	0	0	3
2.	PH4221	Emerging Technologies in Photonics	3	0	0	3
3.	PH4222	Micro Nano Fabrication	3	0	0	3
4.	PH4223	Nanogenerators and Application in Self-powered System	3	0	0	3

Course Number	**PH4220**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Medical Physics and Applications
Learning Mode	Lectures
Learning Objectives	The objectives of the course are to learn the mechanism and functions of different senses of the human body and, to understand the physics formulation of the human body. Also to understand the different equipment used for imaging the human body and, how it helps the medical practitioner.
Course Description	The course discusses breathing and the metabolism of the human body. Biomechanics and fluid dynamics of the circulatory system are discussed elaborately. The functions of ultrasound, X-ray, MRI, etc. is elaborately taught. Radiation physics and its use in medical science for cancer treatment is discussed.
Course Content	Module 1: Breathing, fluid dynamics of the circulatory system, Biomechanics, senses, Electric currents, Fields and Potential, Applications: Foot ware design, Cloth design, Optical glasses for eye, Hearing kits, Retina implantation, threshold of vision of the human eye, Electrical model of a cell membrane, Measurement of cell membrane potentials. Module 2: Diagnostics and Therapy: EKG, X-ray and Computed tomography digonistic, Ultrasound, Magnetic Resonance Imaging, Nuclear diagnostics and positron emission tomography, Temperature measurement system, Blood Pressure measurement, ECHO; and PCR, Applications of techniques in medical diagnosis. Module 3: Radiation medicine and protection, radiation therapy, Compton scattering, Lethal energy dose, Fatal does equivalents, Laser therapy.
Learning Outcome	Complies with PLO 2b
Assessment Method	Assignments, Mini projects, Quizzes, Mid-semester examination, End-semester examination.
Suggested Readings:	Textbooks: 1. Medical Physics, W. A. Worthoff, H. G. Krojanski, D. Suter, De Druyter, 2014. 2. Medical Physics and Biomedical Engineering, B. H. Brown, R. H. Smallwood, D. C. Barber, P. V. Lawford and D. R. house, Taylor & Francis, New York, 1999. References: 3. The Essential Physics of Medical Imaging, Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt, Jr., and John M. Boone, Wolters Kluwer | Lippincott, Williams & Wilkins, 2011. 3rd Edition, Philadelphia. 4. Medical Physics, Martin Hollins, Nelson Thornes Ltd. 2001. 5. The Physics of Radiology, H. E. Jones, J. R. Cunningham, Charles C. Thomas, New York, 2002. 6. Radiation Oncology Physics: A Handbook for Teachers and Students, E.B. Podgorsak, IAEA Publ., 2005.

	7. Handbook of Bio-Medical Engineering, Jacob Kline, Academic Press Inc., Sandiego, Oxford University Press, 2004. 8. Smart Biosensor Technology, G. K. Knoff, A. S. Bassi, CRC Press, 2006. 9. Physics of Diagnostic Radiology, Thomas S Curry, IV Edition, Lippincott Williams & Wilkins, 1990. 10. The Essential Physics for Medical Imaging, Jerrold T Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., John M. Boome, Lippincott Williams & Wilkins, 2nd Edition, 2012. 11. Medical Physics: Imaging, Jean A. Pope, Heinemann Publishers, 2012. 12. Nanobiotechnology: Concepts, Applications and Perspectives, Niemeyor, Christober M. Mirkin, Kluwer publications, USA, 2004. 13. Physical Principles of Medical Ultrasonics, C. R. Hill, J. C. Bamber, G. R. ter Haar, John Wiley & Sons, 2005. 14. Diagnostic Ultrasonic Principles and Use of Instrument, W. M. McDicken, 2nd Edition, John Wiley & Sons, New York, 1992.

Course Number	**PH4221**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Emerging Technologies in Photonics
Learning Mode	Lectures & Demonstrations
Learning Objectives	The main objective is to learn (i) the emerging photonics technologies, (ii) the theory behind these technologies, and (iii) the various techniques to fabricate advanced optical and photonic devices.
Course Description	This course allows engineering students to learn modern cutting-edge photonics-based technologies, essential to pursue research and scientific jobs in advanced photonics-based engineering applications.
Course Outline	Photonic integrated circuits for optical communications. Classical light pulse storage and retrieval using Electromagnetically Induced Transparency, Quantum Memory and Quantum Repeaters, and Quantum Entanglement. Scalar and vector beams; Orbital angular momentum (OAM) states of light; Phase and Polarization singularities, OAM-based optical communication, structured light Optical cryptography; Symmetric and asymmetric optical encryption techniques, Various optical transforms and its application in image/data encryption Portable nanophotonic sensors, Microlasers, Nanolasers, Plasmonic photothermal therapy, Photonic nanojet lithography, Plasmonic tweezers for nanoscale trapping, Super-resolution imaging, Quantum imaging, and Nanophotonics for solar cells
Learning Outcome	The students will be fully aware of (i) various emerging photonics technologies, (ii) the theory behind these technologies, and (iii) various techniques to fabricate advanced optical and photonic devices.
Assessment Method	Assignment; Seminar; Mid-sem and End-sem examinations
Suggested Readings:	**Textbooks:** ▪ Communication System, B.P Lathi ▪ Optical Fiber Communications: Principles and Practice, John M. Senior, Prentice Hall of India ▪ Optical Communication Systems, John Grower, Prentice Hall of India ▪ Optical Fiber Communications- Gerd Keiser, McGraw Hill, 3rd ed. ▪ Orbital Angular Momentum States of Light: Propagation Through Atmospheric Turbulence, Kedar Khare, P. Lochab, and P. Senthilkumaran, IOP Publs., UK, 2020. ▪ Structured Light and its Applications, David L. Andrews, Science Direct, 2008. ▪ Applied Nanophotonics, Sergey V. Gaponenko, Hilmi Volkan Demir, Cambridge Univ. Press, 2019. ▪ Quantum Nano-plasmonics, Witold A Jack, Cambridge Univ. Press, 2020. ▪ Introduction to Nanophotonics, Henri Benisty, Jean Jacques Greffet, Philippe Lalanne, Oxford Univ. Press, 2022. ▪ Fundamentals of Quantum Optics and Quantum Information, Peter Lambropoulos and David Petrosyan, Springer, 2007. ▪ Introduction to Optical Quantum Information Processing, P. Kok and B. W. Lovett, Cambridge Univ. Press, 2014.

	References: ▪ An Introduction to Metamaterials and Nanophotonics, Constantin Simovski and Sergei Tretyakov, Cambridge Univ. Press, 2020. ▪ Nanophotonics, Arthur McGurn, Springer, 2019. ▪ The Physics of Quantum Information, D. Bouwmeester, A. K. Ekert and A. Zeilinger, Editors, Springer, 2000. ▪ Optical Cryptosystems, N. K. Nishchal, IOP Publs., UK, 2019.

Course Number	**PH4222**
Course Credit (L-T-P-W-C)	3-0-0-3
Course Title	Micro Nano Fabrication
Learning Mode	Lectures
Learning Objectives	The objective of the course is to develop basic knowledge about how semiconductor devices are fabricated in clean room environment. Also, introduces various characterization methods adopted till now to realize performance of semiconductor devices at different operating conditions.
Course Description	In beginning, course introduces about clean room and related functionalities with a fundamental question such as Why do we need clean room? Later, course provides the basic background of semiconductor available and used till now in semiconductor industries by answering questions like why do we need semiconductor and semiconductor-based devices? What kind of semiconductor materials are really useful for semiconductor technology? Then, course introduces importance of semiconductor surfaces and how these surfaces are prepared. Impurities, Importance of doping, dopants and doping densities. By taking an example of solid-state device, Design and layout methods are introduced. To realize these patterns/design, various lithography techniques are introduced. Later, deposition of various materials using various deposition techniques are introduced by highlighting the importance of parameters chosen for deposition. Wet and dry etching methods are introduced as successive process thereafter. Device fabrication steps and device characterization tools are introduced to know the device performance. Various related tools will be introduced to students wherever the fabrication process's details are explained.
Course Outline	Introduction to clean rooms and safety measures, process overview, Contamination Background to semiconductor materials, Silicon wafers, Wafer cleaning steps, safety and emergency acts Fundamentals of MOSFET Devices, Scaling Rules, Silicon-Dioxide Based Gate Dielectrics, Metal Gates, Junctions and Contacts, Advanced MOSFETs Concepts Device layout and design, Mask design, Lithography (Optical Lithography, Extreme Ultraviolet Lithography, Electron Beam Lithography, Shadow lithography, Alignment of Several Mask Layers) Fundamentals of Film Deposition, Top-down and bottom-up approaches Etching processes (surface and bulk micromachining), Sputtering techniques for deposition of oxides and metals, Chemical vapour deposition (CVD), Plasma enhanced chemical vapour deposition (PECVD), Atomic layer deposition (ALD), Focussed Ion Beam milling and deposition Characterization techniques: Optical inspection, Optical profilometer, SEM, SPM
Learning Outcome	Complies with PLO 2b, 3
Assessment Method	Quizzes, Mid-semester and End-semester examination
Suggested Readings:	• Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Rainer Waser, 3rd Ed., Wiley-VCH, 2012. • Fundamental of semiconductor Manufacturing and process control, Gray S. May, Costas J. Spanos, John Wiley and Sons, 2006.

	• Fundamental of Semiconductor Fabrication, Gray S. May, Simon M. Sze, Wiley India Pvt. Ltd., 2011. • Introduction to semiconductor materials and Devices, M. S. Tyagi, Wiley, 2009. • Semiconductor manufacturing technology, Michael Quirk, Julian Serda, 1st ed., Pearson, 2000. • Semiconductor Material and device characterization, Dieter K. Schroder, 3rd ed., Wiley, 2006.

Course Number	**PH4223**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Nanogenerators and Application in self-powered system
Learning Mode	Lectures
Learning Objectives	The learning objectives of nanogenerators revolve around comprehending the fundamental principles governing energy harvesting at the nanoscale. Students aim to grasp the operational mechanisms of nanogenerators, enabling them to harness ambient energy for diverse applications. Understanding nanomaterial applications for energy conversion efficiency is pivotal. Moreover, students strive to master the design and optimization of nanogenerator architectures to enhance performance and drive progress toward a more efficient and sustainable future.
Course Description	The nanogenerator course delves into the principles of energy harvesting and exploring nanomaterial application. Students will learn to design and optimize nanogenerator architectures for diverse applications, fostering innovation in sustainable energy solutions and nanotechnology advancements.
Course Content	**Module 1:** **Nanogenerators:** Introduction, Overview of nanotechnology in energy conversion, Historical development and current research trends, Materials for Nanogenerators (2D materials, Carbon based materials, Ceramics, Polymers, etc.), Basic principles of energy harvesting at the nanoscale, Types of Nanogenerators: Piezoelectric, Thermoelectric, Pyro-electric, Electromagnetic, and Triboelectric, Hybrid nanogenerators. **Module 2:** Mechanism, principles, and applications of different types of nanogenerators. Self-powered sensors and wearable electronics, nanogenerator devices (pressure sensor, voltage source, gas sensors, self-charging supercapacitor, wireless charger). **Module 3:** Key challenges for choosing nanomaterials for nanogenerators, Different types of synthesis techniques, Influence of material properties on energy conversion efficiency, Designing of the device for practical, real-life application, and Other conventional energy generation techniques: Wind energy, Tidal, Thermal, hydropower generation, Nuclear, and geothermal energy production.
Learning Outcome	Complies with PLO 1, 2a and 3
Assessment Method	Assignments, Mini projects, Quizzes, Mid-semester examination, End-semester examination.
Suggested Readings:	**Textbook:** **1.** Nanogenerators: Basic Concepts, Design Strategies, and Applications: Inamuddin, Mohd Imran Ahamed, Rajender Boddula, Tariq Altalhi, CRC Press, Year: 2022. **References:** 1. Triboelectric Nanogenerators, Zhong Lin Wang, Long Lin, Jun Chen, Simiao Niu, Yunlong Zi Springer International Publishing (ISBN-978-3-319-40038-9, 978-3-319-40039-6)

	2. Handbook on Triboelectric Nanogenerator, Zhong Lin Wang, Ya Yang, Junyi Zhai, Jie Wang. Springer (ISBN-9783031281105, 9783031281112) **3.** 3. Nanogenerators, Sang-Jae Kim, Arunkumar Chandrasekhar, Nagamalleswara Rao Alluri, IntechOpen, 2020.

Interdisciplinary Electives (Available to students of B. Tech. other than Dept. of Physics)

Sl. No.	Subject Code	Subject	L	T	P	C
IDE-I						
1.	PH2201	Fundamentals of Electromagnetism	3	0	0	3
2.	PH2202	Waves and Particles	3	0	0	3
3.	PH2203	Fuel Cell Fundamentals	3	0	0	3
IDE-II						
1.	PH3101	Energy Materials Processing	3	0	0	3
2.	PH3102	Mechanics in Physics	3	0	0	3
IDE-III						
1.	PH4110	Photovoltaics and Fuel Cell Technology	3	0	0	3

Course Number	**PH2201**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Fundamentals of Electromagnetism
Learning Mode	Lectures
Learning Objectives	The students without a physics background are exposed to fundamental ideas in electromagnetism. Starting with elements of vector analysis, this course illustrates ideas in electrostatics, magnetostatics and electromagnetic waves Complies with Program Goals 1 and 3
Course Description	This course deals with fundamentals in electromagnetism. Also the practical examples will be explained along with its uses in various engineering domains.
Course Outline	Vector Calculus: Gradient, Divergence and Curl. Line, Surface and Volume integrals. Gauss's divergence theorem and Stokes' theorem in Cartesian, Spherical polar and cylindrical polar coordinates. Dirac Delta function. Electrodynamics: Coulomb's law and Electrostatic field, Fields of continuous charge distributions. Gauss's law and its applications. Electrostatic Potential. Work and Energy. Conductors, capacitors. Laplace's equation. Method of images. Dielectrics. Polarization. Bound charges. Energy in dielectrics. Boundary conditions. Lorentz force. Biot-Savart and Ampere's laws and their applications. Vector Potential. Force and torque on a magnetic dipole. Magnetic materials. Magnetization, Bound currents. Boundary conditions. Motional EMF, Ohm's law. Faraday's law. Lenz's law. Self and Mutual inductance. Energy stored in magnetic field. Maxwell's equations. Optics: huygens' principle. Young's experiment. Superposition of waves. Concepts of coherence sources. Interference by division of wavefront. Fresnel's biprism, Phase change on reflection. Lioyd's mirror. Interference by division of amplitude. Parallel film. Film of varying thickness. Colours of thin films. Newton's rings. The Michelson interferometer. Fraunhofer diffraction. Single slit, double slit and N-slit patterns. The diffraction grating.
Learning Outcome	Complies with 1a. 3
Assessment Method	Quiz and/or Assignments and Examinations
Suggested Readings:	**Texts:** D. J. Griffiths, Introduction to Electrodynamics, Prentice Hall, New Delhi, 1995. F. A. Jenkins and H. E. White, Fundamentals of Optics, McGraw-Hill, 1981. **References:** R. P. Feynman, R. B. Leighton and M. Sands, The Feynman Lecture in Physics, Vol I, Narosa Publishing House, New Delhi, 1998 I. S. Grant and W. R. Philips, Electromagnetism, John Wiley, 1990. E. Hecht, Optics, Addison-Wesley, 1987.

Course Number	**PH2202**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Waves and Particles
Learning Mode	Lectures
Learning Objectives	The objective of the course is to develop a basic understanding of wave and particle concept of physics formulation. The student will understand the observation by considering particles as well as waves. Complies with Program Goals 1 and 3
Course Description	The course provides fundamental physics knowledge on the concept of particles and waves. Different experimental evidence and theoretical models will be built upon a realization of science formulation and its utility. The student will learn the application of physics in another science subject.
Course Outline	Introduction to waves, Particles, Wave-particle duality, Newton's corpuscular theory to understand the properties of light, Blackbody radiation, photoelectric effect, Crompton effect, Davison-Germer experiment, Pair production, Refraction, reflection and transmission, Superposition of waves and interference, Diffraction, Polarisation, Scattering, Schrodinger equation, Atomic structure, Particles, Spectra and radiation.
Learning Outcome	Complies with 1a. 3
Assessment Method	Quiz and/or Assignments and Examinations
Suggested Readings:	**Test Books:** 1- Concepts of Modern Physics, Arthur Beiser, Tata McGraw Hill, 2009. 2- Optics, E. Hect, A. R. Ganesan, Pearson, 2019. **Reference Books:** 3- Fundamentals of Optics, Jenkins F, Tata McGraw Hill, 2017. 4- Waves - Berkeley Series - Sie by Franks Crawford, 2017 5- Modern Physics, G. M. Felder and K. N. Felder, Cambridge University Press, ISBN: 9781108842891,

Course Number	**PH2203**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Fuel Cell Fundamentals
Learning Mode	Physical Presence in Classroom
Learning Objectives	The emergent need of clean and green energy to meet “zero emission” target worldwide has put pressing demand for teaching courses relevant to meet this target. It aims to impart skill focused training to understand; 1. The impact of carbon foot print on environment and climate 2. Hydrogen energy technologies with zero emission potential 3. Clean and green energy conversion system design and implementation
Course Outline	**Module-1:** Carbon footprint and its impact on environment, need for zero emission energy system, origin of fuel cell concept and historical perspective in brief, energy and power in fuel cells, fuel cell operation and performance, thermodynamics of fuel cells, transport in fuel cells. **Module-2:** Fuel cell classification, characteristics features and operation, comparative analysis of different fuel cell systems (AFC, PAFC, MCFC, PEMFC and SOFC), Fuel cell characterization and evaluation approach. **Module-3:** Modelling, design and fabrication of fuel cells with case study of PEMC and SOFC, Experimental diagnostics and diagnosis **Module-4:** Hydrogen generation, storage and delivery, Environmental impact of fuel cells, Fuel Cell application in EVs
Learning Outcome	Learners of the course will be able upskill their knowledge creating; (a) awareness and implementation need for clean and green energy technology and (b) readiness with skill to fulfil emerging industry and R & D institution demand of workforce with core competency.
Assessment Method	Class test and Quiz/Assignment (**20%**), MSE: (**30%**), ESE: (**50%**)
Suggested Readings:	1. Principles of Fuel Cells, Xianguo Li, Taylor & Francis 2. Fuel Cell Fundamentals, Ryan O'Hare, Suk-Won Cha, Whitney Colella, Fritz B. Prinz, John Wiley & Sons 3. Fuel Cell Engines, Matthew M. Mench, John Wiley & Sons, Inc.

Course Number	**PH3102**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Mechanics in Physics
Learning Mode	Lectures
Learning Objectives	This course is an interdisciplinary course. The students without a physics background in Undergraduate will understand the different mechanics and their utility in explaining physical phenomena and their importance in modern technology. Complies with Program Goals 1 and 3
Course Description	This course deals with fundamentals in Classical mechanics, Quantum Mechanics, Relativistic Mechanics, and Statistical Mechanics. Also the practical examples will be explained along with its uses in industry and computation.
Course Outline	Newtonian formulation, D'Alembert's principle, Variational Principle, Lagrangian and Hamiltonian dynamics, Poisson's Bracket, Maxwell Electromagnetic equation, Postulates of relastivistic mechanics, Lorentz transformation, Covariant and Contravariant formulation, light Cone, Need of Quantum mechanics, Wave-particle duality, postulates of Quantum Mechanics, Schrodinger's equation, Operator algebra, Commutation relation, Particle in a box, Harmonic Oscillator, Elementary Statistical Mechanics, Ensembles, Maxwell-Boltzmann distribution, Bose-Einstein and Fermi-Dirac distribution. Phase transition.
Learning Outcome	Complies with 1a. 3
Assessment Method	Quiz and/or Assignments and Examinations

Course Number	**PH4110**
Course Credit (L-T-P-C)	3-0-0-3
Course Title	Photovoltaics and Fuel Cell Technology
Learning Mode	Physical Presence in Classroom
Learning Objectives	Alternative energy sources have always been a core area of significant importance since long. Recent focus on harnessing natural energy from the Sun, has necessitated teaching of relevant course at undergraduate level to create talent pool to meet industry demand. It aims to impart; 4. Knowledge pertaining to solar energy harnessing conditions 5. Learning relevant to physics of photovoltaic cells. 6. Training and skill relevant for design, processing, fabrication, testing and installation of photovoltaic cells, i.e.; end to end industry skill.
Course Outline	**Module-1:** Global energy scenario and impending energy crisis, Basic introduction of energy storage/conversion devices, State-of-the art status of portable power sources, Solar photovoltaic (PV) cells, PV energy generation and consumption, fundamentals of solar cell materials, **Module-2:** Elementary concept of solar cell and its design, solar cell technologies (Si-wafer based, Thin film and concentrator solar cells), Emerging solar cell technologies (GaAs solar cell, dye-sensitized solar cell, organic solar cell, Thermo-photovoltaics), Photovoltaic system design and applications, Analysis of the cost performance ratio for the photovoltaic energy and problems in wide-spread commercialization of the technology. **Module-3:** Fuel cells and its classification; Transport mechanism in fuel cells and concept of energy conversion; Fuels and fuel processing, Fuel cell design and its characterization **Module-4:** Technological issues in Solid oxide fuel cells (SOFC); PEM fuel cells; Direct methanol fuel cells (DMFC), Molten carbonate fuel cell (MCFC), Power conditioning and control of fuel cell systems.
Learning Outcome	Learners of the course will diversify their interdisciplinary knowledge creating; (a) awareness and need for clean and green energy technology in a very simpler form even if original background is different.
Assessment Method	Class test and Quiz/Assignment (**20%**), MSE: (**30%**), ESE: (**50%**)
Suggested Readings:	1. Fundamentals of Photovoltaic Modules and their Applications, G. N. Tiwari, S. Dubey & Julian C. R. Hunt, RSC Energy Series. 2. Solar Photovoltaics: Fundamentals, Technologies and Applications (2nd ed.), C. S. Solanki, Prentice Hall of India. 3. Principles of Fuel Cells, Xianguo Li, Taylor & Francis.