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Department of Physics and Photonics Science

National Institute of Technology Hamirpur,
Hamirpur – 177 005 (India)

Second Year																
3rd Semester								4th Semester								
SN	**Code**	**Subject**	**L**	**T**	**P**	**Credits**		**SN**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**		
1	PH-211	Mathematical Physics (DC)	3	0	0	3		1	PH-221	Numerical Analysis and Computational Physics (DC)	3	0	0	3		
2	PH-212	Quantum Physics (DC)	3	1	0	4		2	PH-222	Atomic and Molecular Spectroscopy (DC)	3	1	0	4		
3	PH-213	Solid State Physics (DC)	3	0	0	3		3	PH-223	Classical Mechanics (DC)	3	0	0	3		
4	PH-214	Electromagnetic Theory (DC)	3	1	0	4		4	PH-224	Heat and Thermodynamics (DC)	3	0	0	3		
5	PH-215	Data Structure (DC)	3	0	0	3		5	**PH-241-245**	**Discipline Elective-I (DE)**	3	0	0	3		
6	PH-216	Solid State Physics Lab (DC)	0	0	2	1		6	PH-226	Spectroscopy Lab (DC)	0	0	2	1		
7	PH-217	Electricity & Magnetism Lab (DC)	0	0	2	1		7	PH-227	Thermal Physics Lab (DC)	0	0	2	1		
8	PH-218	Data Structure Lab (Basic Engg Skills) (DC)	0	0	2	1		8	PH-228	Computational Lab-I (DC)	0	0	2	1		
								9	**SA-201-SA-209**	LA/CA (IE)	0	0	1	1		
		Total	**Hours = 23**			**20**				**Total**	**Hours = 23**			**20**		

Third Year

5th Semester							6th Semester						
SN	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	**SN**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**
1	**PH-301-305**	**Institute Elective-I (IE)**	**3**	**0**	**0**	**3**	1	PH-321	Measurements & Instrumentation (DC)	2	0	0	2
2	PH-311	Nuclear & Particle Physics (DC)	3	1	0	4	2	PH-322	Analog & Digital Electronics (DC)	3	0	0	3
3	PH-312	Signals & Systems (DC)	3	1	0	4	3	PH-323	Lasers and Photonics (DC)	3	0	0	3
4	PH-313	Statistical Mechanics (DC)	**3**	**1**	**0**	**4**	4	**PH-341-343**	**Discipline Elective-III (DE)**	**3**	**0**	**0**	**3**
5	**PH-351-353**	**Discipline Elective-II (DE)**	3	0	0	3	5	**PH-361-364**	**Discipline Elective-IV (DE)**	**3**	**0**	**0**	**3**
6	PH-314	Modern Physics Lab-I (DC)	0	0	2	1	6	**PH-381 - PH-385**	Stream Core-I (SC-I)	2	0	0	2
7	PH-315	Computational Lab-II (DC)	0	0	2	1	7	PH-325	Digital Electronics Lab (DC)	0	0	2	1
							8	PH-326	Lasers and Photonics Lab (DC)	0	0	2	1
								HSS-311	Institute Core (IC)	2	0	0	2
		Total	**Hours = 22**			**20**			**Total**	**Hours = 22**			**20**

Fourth Year															
7th Semester								**8th Semester**							
SN	**Code**	**Subject**	**L**	**T**	**P**	**Credits**		**SN**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	
1	PH-411	Materials Synthesis and Characterization (DC)	3	0	0	3		1	PH-499	UG Project (DE)	0	0	12	12	
2	PH-412	Physics of Nano systems (DC)	3	0	0	3		2	**PH-461-462**	Free Elective/Engineering Course/**Open Elective Course(SE)**	3	0	0	3	
3	PH-413	Semiconductor Optoelectronic Devices (DC)	3	0	0	3		3	**PH-481-482**	Free Elective/Engineering Course/**Open Elective Course(SE)**	3	0	0	3	
4	**PH-431-433**	**Discipline Elective-V (DE)**	3	0	0	3		4	PH-498	General Proficiency	0	0	2	2	
5	**PH-451 – PH-455**	**Stream Core (SC-II)**	2	0	0	2									
6	**PH-471 – PH-475**	**Stream Core (SC-III)**	2	0	0	2									
7	PH-415	Measurements and Instrumentation Lab (DC)	0	0	2	1									
8	PH-416	Materials Characterization Lab (DC)	0	0	2	1									
9	PH-417	Summer Training (DC)	0	0	2	2									
		Total	**Hours = 22**			**20**				**Total**	**Hours = 20**			**20**	

Semester Wise Credits									
Semester	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Total**
Credits	20	20	20	20	20	20	20	20	**160**
Hours/week	22	22	23	23	22	22	22	20	**176**

Discipline Elective Courses

Discipline Elective-I
PH-241: Machine Learning
PH-242: High Energy Physics
PH-243: Astrophysics
PH-244: Cosmology
PH-245: Integrated Circuit (IC) Technology

Discipline Elective-II
PH-351: Meta Materials
PH-352: Photovoltaic Solar Cells
PH-353: Advanced Condensed Matter Physics

Discipline Elective-III
PH-341: Artificial Intelligence
PH-342: Quantum Electronics
PH-343: Microcontroller & Embedded Systems

Discipline Elective-IV
PH-361: Microprocessor Architecture and Applications
PH-362: Functional Nano-materials
PH-363: Low Dimensional Physics
PH-364: Introduction to Quantum Computing

Discipline Elective-V
PH-431: Laser Measurement Technology
PH-432: Optical Fiber Communication
PH-433: Thin Film Technology

Stream Core-I
PH-381: Fundamentals of Semiconductor Devices
PH-382: Basics of Rocket Propulsion
PH-383: Machine Learning in Physics
PH-384: Electromagnetic Wave Propagation
PH-385: Fundamentals of Energy Engineering

Stream Core-II
PH-451: Semiconductor Fabrication Techniques
PH-452: Space Dynamics
PH-453: Elements of Artificial Intelligence
PH-454: Photonic Crystals
PH-455: Energy Storage Systems

Stream Core-III
PH-471: Semiconductor Heterostructure Devices
PH-472: Astronomical Observation Technique
PH-473: Quantum Computation and Information
PH-474: Nanophotonics
PH-475: Hydrogen Economy

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Institute Elective Courses

Institute Elective-I
PH-301: Physics of Semiconductor Devices
PH-302: Nuclear Science and Engineering
PH-303: Elements of Solid State Physics
PH-304: Optoelectronics
PH-305: Semiconductors Processing Technology

Free Elective/Engineering Course/Open Elective Course (SE)
PH-461: Introduction to Astronomy
PH-462: Experimental Techniques for Material Characterization

Free Elective/Engineering Course/Open Elective Course (SE)
PH-481: Introduction to Relativistic Mechanics
PH-482: Renewable Energy and Storage Devices

Minor Degree Programme (Courses):

PH-310: Quantum Mechanics
PH-320: Mechanics
PH-410: Thermodynamics and Statistical Physics
PH-420: Modern Physic

SN	Semester	Subject Code	Subject	L	T	P	Credits
1.	5	PH-310	Quantum Mechanics	3	0	0	3
2.	6	PH-320	Mechanics	3	0	0	3
3.	7	PH-410	Thermodynamics and Statistical Physics	3	0	0	3
4.	8	PH-420	Modern Physics	3	0	0	3

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Course Name: **Mathematical Physics**
Course Code: **PH-211**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand mathematical concepts from the perspective of Physics.
- An understanding of concepts of complex variables, special functions and group theory.
- The broad education necessary to understand the different applications of mathematics to understand physics.

Unit Number	Course Content	Lectures
UNIT-1	**Special Functions-I:** Special equations of Mathematical Physics; Legendre and associated Legendre equations.	**6L**
UNIT-2	**Special Functions-II:** Hermite equation; Laguerre and associated Laguerre equations; Bessel's equation; Hypergeometric equation; Beta and gamma functions, Dirac-delta function.	**6L**
UNIT-3	**Complex variables:** Analytic functions, contour integration, residue calculus, conformal mapping and its applications. Fourier and Laplace transforms, evaluation of integral transforms and their inverses using contour integrals.	**6L**
UNIT-4	**Green's functions:** Green's functions and solutions to inhomogeneous differential equations and applications.	**6L**
UNIT-5	**Group Theory:** Classification and examples of (finite) groups, homomorphisms, isomorphisms, representation theory for finite groups, reducible and irreducible representations, Schur's Lemma and orthogonality theorem.	**6L**
UNIT-6	**Tensors:** Covariant and Contravariant tensors, covariant derivatives, affine connections Christoffel symbols, Curvature tensor.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO 1: Describe the mathematics concepts and their applications to problems of physics.

CO 2: Identify the applications of complex variables, tensors and group theory.

CO 3: Learn and to apply concepts learnt in Mathematical Physics in Industry and in real life.

CO 4: Learn the idea of Green Functions and its uses in different problems in physics.

Books and References

1. Mathematical Methods for Physicists by G.B. Arfken and H. J. Weber, Academic Press.
2. A Course of Modern Analysis by E.T. Whittaker and E.W. Watson, Cambridge University Press.
3. Group Theory and Applications to Physical Problems by M. Hammermesh, Dover publications, NY.
4. Theory of Linear Operator in Hilbert Space by N. I. Akhiezer and I. M. Glazman, Dover Publications.

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Course Name: **Quantum Physics**
Course Code: **PH-212**
Course Type: **Discipline Core**

Contact Hours/Week: **3L+1T** Course Credits: **04**

Course Objectives

- An ability to understand the framework of quantum mechanics.
- An understanding of the methods used to solve physics problems using quantum mechanics.
- The broad education necessary to understand microscopic systems.
- A knowledge of concepts like wave packet, operators, commutators etc.

Unit Number	Course Content	Lectures
UNIT-1	**Wave Packets and Uncertainty Principle:** Plane waves; Superposition of plane waves; Wave packets; Fourier analysis; Group velocity; Propagation of wave packets; Wave packet broadening; Gaussian wave packet.	**7L**
UNIT-2	**Schrödinger Equation**: The wave equation and the interpretation of ψ; Operators and expectation values of dynamical variables; Commutators and operator algebra; Stationery states; Dirac notations.	**7L**
UNIT-3	**Postulates of Quantum Mechanics:** The Basic Postulates of Quantum Mechanics, The State of a System, Observables and Operators, Measurement in Quantum, Time Evolution of the System's State.	**7L**
UNIT-4	**Problems in one and three dimensions:** Potential step, rectangular potential barrier, symmetries and invariance properties, reflection and transmission coefficients, potential well, Hydrogen atom, Rigid rotor & Harmonic Oscillator,	**7L**
UNIT-5	**Angular Momentum:** Orbital angular momentum, General Formalism of angular momentum, Spin angular momentum, Eigenfunctions of Orbital angular momentum, Clebsch-Gordon coefficients.	**7L**
UNIT-6	**Approximation method:** Time independent perturbation theory, Variational Principle, WKB method, and Time dependent perturbation theory.	**7L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO 1: Describe the quantum mechanical systems.
CO 2: Identify the applications of quantum mechanics.
CO 3: Write down the concepts related to the framework of quantum mechanics.
CO 4: Learn and to apply concepts learnt in Quantum mechanics to one & three dimensional problems.

Books and References

1. Quantum Physics by S. Gariorowicz, John Wiley & Sons.
2. Concepts of Modern Physics by A. Beiser, McGraw Hill International.
3. Quantum Mechanics by A. Ghatak and S. Lokanathan, McMillan India Ltd.
4. Introduction to Quantum Mechanics, D. J. Griffiths, Pearson Prentice Hall.
5. A Text Book of Quantum Mechanics by P.M. Mathews and K. Venkatesan, Tata Mc Graw Hill.

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Course Name: **Solid State Physics** Course Code: **PH-213** Course Type: **Discipline Core**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives ● An ability to understand the basic framework of solid state physics ● An understanding of concepts bonding, crystal structure, crystal lattice. ● The broad education necessary to understand material science. ● A knowledge of concepts like lattice vibrations, defects in solids and magnetism.		
Unit Number	**Course Content**	**Lectures**
UNIT-1	**Bonding and Mechanical Properties:** Covalent bonding, ionic bonding, metallic bonding, hydrogen bonding and Van der Waals bonding. Elastic constants and elastic waves.	**6L**
UNIT-2	**Crystal Structure:** Point symmetry, translational symmetry, two and three-dimensional lattices, simple crystal structures, Miller indices, diffraction from periodic structures, reciprocal lattice, Brillouin zones.	**6L**
UNIT-3	**Lattice Vibrations:** One dimensional lattices (monoatomic and diatomic), quantization of elastic waves, phonon momentum, density of modes.	**6L**
UNIT-4	**Electrons in Solids:** Free electron gas in metals, periodic potential and Bloch's theorem and Kronig-Penney model	**6L**
UNIT-5	Magnetism: Langevin theory of dia- and para- magnetism, quantum theory of dia- and para- magnetism, magnetic ordering, Weiss molecular field theory of ferromagnetism and Neel theory of anti-ferromagnetism.	**6L**
UNIT-6	**Defects in Solids**: 0-D, 1D, 2D and 3D defects, color centers.	**6L**
Course Outcomes Upon successful completion of the course, the students will be able to CO 1: Describe the concepts of solid state physics and their applications. CO 2: Identify the applications of symmetries. CO 3: Write down the concepts related to solid state physics and material science. CO 4: Learn and to apply concepts learnt in solid state Physics to problems like electrical conductivity.		
Books and References 1. Introduction to Solid State Physics by C. Kittel, Wiley Eastern Ltd.. 2. Solid State Physics by N.W. Ashcroft and N.D. Mermin, Holt-Saunders. 3. Solid State Physics by J.R. Hook and H.E. Hall, John Wiley. 4. Solid-State Physics: An Introduction to Principles of Materials Science, by H. Ibach and H. Lüth, Springer. 5. Magnetism in Condensed Matter by S. Blundell, Oxford University Press.		

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Course Name: **Electromagnetic Theory** Course Code: **PH-214** Course Type: **Discipline Core**		
Contact Hours/Week: **3L+1T**		Course Credits: **04**
Course Objectives ● An ability to understand electricity and magnetism ● An understanding of concepts of vector calculus. ● The broad education necessary to understand electrostatic and magnetostatic environments. ● A knowledge of concepts like polarization, magnetization and electromagnetic induction.		
Unit Number	**Course Content**	**Lectures**
UNIT-1	**Vector calculus:** Vectors in Cartesian, Cylindrical, and Spherical Polar coordinate system and transformation among these systems. Vector calculus: differential length, area, volume, Del operator, Gradient, divergence and curl, in three coordinate systems. Gauss's divergence theorem and Stoke's theorem, Dirac-delta function and its applications.	**7L**
UNIT-2	**Electrostatics:** Electric field, Gauss's law and its applications. Electric potential, Work and Energy in electrostatics, Poisson and Laplace equations, Earnshaw's theorem, Boundary conditions and Uniqueness theorem, Multipole expansion, Method of electrostatic images.	**7L**
UNIT-3	**Magnetostatics:** Biot-Savart law, Magnetic scalar and vector potentials, magnetic field vector and Boundary conditions, Continuity equation, Maxwell's modification of Ampere's law.	**7L**
UNIT-4	**Maxwell's equations:** Derivation and interpretation of Maxwell's equations, Solution of Maxwells equation in free space and in a dielectric medium, refractive index and impedance of a medium, Poynting theorem, Poynting vector.	**7L**
UNIT-5	**Applications of Maxwell's equations:** Electromagnetic waves in conducting media, skin depth, polarization of electromagnetic waves, Reflection and refraction of electromagnetic waves at a dielectric interface, total internal reflection, polarization by reflection, reflection from the surface of a metal.	**7L**
UNIT-6	**Electrodynamics:** Electromagnetic scalar and vector potential, Gauge transformations, Lorentz gauge, gauge invariance of electromagnetic potentials. Radiation from moving charges, Retarded Potentials, Lienard-Wiechert Potentials, Transmission lines and waveguides.	**7L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Describe the vector calculus and its applications. CO2: Identify the applications of laws of electrostatics and magnetostatics in everyday life. CO3: Learn and to apply concepts learnt in electromagnetic induction.		
Books and References 1. Engineering Electromagnetics by Jr. W.H. Hayt and J. A. Buck, Tata McGraw Hill Publishing Company Ltd, New Delhi. 2. Elements of Engineering Electromagnetics by N. O. Sadiku, Oxford University Press. 3. Elements of Engineering Electromagnetics by N. N. Rao, Prentice Hall of India, New Delhi. 4. Introduction to Electrodynamics by D. J. Griffiths, Prentice Hall.		

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Course Name: **Data Structures**
Course Code: **PH-215**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about linear and non-linear data structures as the foundational base for computer solutions to problems.
- To introduce the fundamental concepts relevant to binary trees, binary tree traversals, binary search trees and perform related analysis to solve problems.
- To enable the students to understand various types of sorting algorithms.

Unit Number	Course Content	Lectures
UNIT-1	**Introduction:** Data types, data structures, abstract data types, the running time of a program, the running time and storage cost of algorithms, complexity, asymptotic complexity, big O notation, obtaining the complexity of an algorithm.	**6L**
UNIT-2	**Development of Algorithms:** Notations and Analysis, Storage structures for arrays - sparse matrices - structures and arrays of structures, Stacks and Queues: Representations, implementations and applications. Linked Lists: Singly linked lists,	**6L**
UNIT-3	Stacks: Linked stacks and queues, operations on Polynomials, Doubly Linked Lists, Circularly Linked Lists, Operations on linked lists- Insertion, deletion and traversal, dynamic storage management – Garbage collection and compaction.	**6L**
UNIT-4	**Trees:** Basic terminology, General Trees, Binary Trees, Tree Traversing: in-order, pre-order and post-order traversal, building a binary search tree, Operations on Binary Trees - Expression Manipulations - Symbol Table construction, Height Balanced Trees(AVL), B-trees, B+-trees.	**6L**
UNIT-5	**Graphs:** Basic definitions, representations of directed and undirected graphs, the single-source shortest path problem, the all-pair shortest path problem, traversals of directed and undirected graphs, directed acyclic graphs, strong components, minimum cost spanning tress, articulation points and biconnected components, graph matching.	**6L**
UNIT-6	**Sorting and Searching Techniques:** Bubble sorting, Insertion sort, Selection sort, Shell sort, Merge sort, Heap and Heap sort, Quick sort, Radix sort and Bucket sort, Address calculation, Sequential searching, Binary Searching, Index searching, Hash table methods.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO 1: Interpret and compute asymptotic notations of an algorithm to analyze the time complexity; CO 2: Use of linear and non-linear data structures as the foundational base for computer solutions to problems; CO 3: Demonstrate the ability to implement various types of static and dynamic lists; CO 4: Implement binary trees, binary tree traversals, binary search trees and perform related analysis to solve problems; CO 5: Implement various types of sorting algorithms.

Books and References

1. An Introduction to Data Structures with applications by J.P. Tremblay and P.G. Sorenson, Tata McGraw Hill.
2. Data structures, Algorithms and Applications in C++ by Sartaj Sahni, WCB/McGraw Hill.
3. Data Structures and Algorithms by Alfred V. Aho, Jeffrey D. Ullman, John E. Hopcroft, Addison Wesley.
4. Data Structures using C by Y. Langsam, M. J. Augenstein and A. M. Tenenbaum, Pearson Education.
5. Data Structures – A Pseudocode Approach with C by Richard F. Gilberg and Behrouz A. Forouzan, Thomson Brooks /Cole.

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Course Name: **Solid State Physics Lab**
Course Code: **PH-216**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge by applying the experimental methods to correlate with the theory of Solid state.
- To learn the use of electromagnetic systems for various measurements.
- Apply the analytical techniques and graphical analysis of the experimental data.
- To develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.

List of Experiments

1. To identify the crystal structure and to determine the lattice constant using X-ray diffraction.
2. To study the Hall effect in semiconductors and to determine the carrier concentration.
3. To measure the magnetic susceptibility of different materials.
4. To measure the resistivity of semiconductor crystals (Ge & Si) with temperature by Four probe method.
5. To demonstrate dia-para-ferro magnetism in a homogenous magnetic field.
6. To study hysteresis of an iron core.
7. To investigate the elastic and plastic extension of metal wires.
8. To determine unit cells of various crystal classes.
9. To determine value of e/m by bar magnet
10. To perform Frank-Hertz experiment
11. Study of thermoluminescence of F centers in alkali halides
12. To measure the resistivity of the insulator with temperature by Two probe method.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the various procedures and techniques for the experiments.

CO2: Use the different measuring devices and meters to record the data with precision.

CO3: Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.

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Course Name: **Electricity and Magnetism Lab**
Course Code: **PH-217**
Course Type: Discipline core

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge by applying the experimental methods to correlate with the Physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- Apply the analytical techniques and graphical analysis of the experimental data.
- To develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.

List of Experiments

1. To demonstrate Lenz's law and effects of electromagnetically induced currents.
2. To investigate the equipotential lines of the electric field for different shape electrodes.
3. To measure the force between current carrying conductors and to determine the permeability of air.
4. To measure the force of attraction between charged capacitor plates and to determine the permittivity of air.
5. To determine the dielectric constant of different dielectric materials.
6. To measure the spatial distribution of the magnetic field between a pair of identical coils in Helmholtz arrangement.
7. To investigate the spacing between the coils at which magnetic field is uniform and to measure its spatial distribution.
8. To study the magnetic field along the axis of a current carrying multi turn coil.
9. To study the dependency of a magnetic field on coil diameter and number of turns.
10. To study the Biot-Savart's law.
11. To study the magnetic behavior of a circular conductor as a function of the current.
12. To study optical phenomena in microwave optics systems.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the various procedures and techniques for the experiments.

CO2: Use the different measuring devices and meters to record the data with precision.

CO3: Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.

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Course Name: **Data Structures Lab**
Course Code: **PH-218**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To provide skills for designing & writing algorithms.
- To provide skills for writing C/C++ programs.
- To enable the students to debug programs.

List of Experiments

1. Write a program to sort an array (make a dynamic array) using Bubble sort. Use 1-bit variable FLAG to signal when no interchange takes place during pass. If FLAG is 0 after any pass, then the list is already sorted and there is no need to continue.
2. WAP to search an ITEM (integer) in an array using binary search, if FOUND then delete that item from array and if NOT FOUND then insert that item in kth position (Input “k” from user).
3. WAP to enter records of Five students, which should contain fields like roll No., name, CGPI, semester.
   a. List all records of all students having CGPI greater than k.
   b. Insert a new record of students at kth position and print the final record.
4. Implement linked lists and insert and delete an element into the list.
5. Evaluate a postfix algebraic expression with the help of stack.
6. Implement a circular queue by adding or deleting a few elements. Make sure to incorporate “Queue Empty”, “Queue Full” constraints in your program.
7. WAP to implement Binary Search Tree with insertion and deletion operations.
8. Implement any one of the tree traversing techniques.
9. Implement various sorting algorithms like Quick sort, Merge Sort, Insertion Sort, Selection Sort etc.
10. Implement hashing.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on the above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To gain knowledge of popular available data structures.
CO2: To develop programming skills in students.
CO3: To impart knowledge of syntax and semantics of basic languages.

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Course Name: **Numerical Analysis and Computational Physics** Course Code: **PH-221** Course Type: **Discipline Core**		
Contact Hours/Week: **3L** Course Credits: **03**		
Course Objectives • To introduce the fundamental concepts relevant to numerical differentiation and integration and numerical solution of linear, non-linear and system of equations. • To understand the concept of approximating & interpolating polynomials and finding values of function at arbitrary points. • To impart knowledge of various numerical techniques to solve ODE.		
Unit Number	**Course Content**	**Lectures**
UNIT-1	**Numerical Solution of Linear and Non Linear Equations** Nonlinear Equations: Bisection Method, Regula Falsi Method, Newton-Raphson Method, Iteration method.	**6L**
UNIT-2	**Linear Equations:** Jacobi and Gauss Seidel Iteration methods, Relaxation method.	**6L**
UNIT-3	**Interpolation:** Least square curve fit and trigonometric approximations, Finite differences and difference operators, Newton's interpolation formulae, Gauss forward and backward formulae, Stirling and Bessel's formulae, Lagrange's interpolation.	**6L**
UNIT-4	**Numerical Integration:** Integration by trapezoidal and Simpson's rules 1/3 and 3/8 rule, Romberg integration, and Gaussian quadrature rule, Numerical integration of function of two variables.	**6L**
UNIT-5	**Numerical Solution of Ordinary Differential Equations-I:** Taylor series method, Picard's method, Euler's method, Modified Euler's method.	**6L**
UNIT-6	**Numerical Solution of Ordinary Differential Equations-II:** Runge- Kutta method. Predictor corrector methods, Adam Bashforth and Milnes method, convergence criteria, Finite difference method.	**6L**
Course Outcomes Upon successful completion of the course, the student will be able to: CO1: Understand and analyze the concept of Numerical Solution of Linear and Non-Linear Equations, Ordinary Differential Equations. CO2: Identify an appropriate technique to solve the linear, non-linear equations, ordinary differential equations. CO3: Formulate the problems on related topics and solve them analytically. CO4: Apply the concepts of linear, non-linear equations, differential equations and complex analysis in various engineering problems. CO5: Demonstrate the concepts through examples and applications.		
Books and References 1. Numerical Methods for Scientific and Engineering Computation by M. K. Jain, S. R. K. Iyenger and R. K. Jain, New Age International Publishers, New Delhi 2. Numerical Methods for Engineers and Scientists (2nd Ed.) by J D Hoffman, CRC Press. 3. Numerical Analysis Mathematics and Scientific computing (3rd ed.) by D. Kincaid and W. Cheney, American Mathematical Society.		

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Course Name: **Atomic and Molecular Spectroscopy**
Course Code: **PH-222**
Course Type: **Discipline Core**

Contact Hours/Week: **3L+1T** Course Credits: **04**

Course Objectives

- An ability to understand atomic and molecular systems and basics of spectroscopy.
- An understanding of concepts of electronic and molecular energy levels.
- The broad education necessary to understand the importance of spectroscopy.
- A knowledge of concepts like coupling of angular momentum, electronic and molecular spectroscopy.

Unit Number	Course Content	Lectures
UNIT-1	**Review of single electron systems:** Quantum States of One Electron Atom: Atomic orbitals –Hydrogen spectrum – The Pauli Exclusion Principle – Ritz combination principle, Spectra of alkali elements, Spin – orbit interaction; Larmor's theorem and the fine structure in alkali spectra.	**7L**
UNIT-2	**Two Electron Systems:** General characteristics of the energy levels of alkaline earth elements; selection rules and intensity rules, Interaction energy in LS or Russell-Saunders coupling and JJ- coupling, LS-coupling.	**7L**
UNIT-3	Hyperfine structure (qualitative) Normal and Anomalous Zeeman effect, Paschen Back effect, Stark effect, Lande's g-factor in LS coupling. MolecularStructure.	**7L**
UNIT-4	**Molecular systems**: Diatomic linear symmetric top, asymmetric top and spherical top molecules, Types of molecular energy states and molecular spectra, Born Oppenheimer approximation-Rotational Spectra, Spectra of diatomic molecules as a rigid rotor-Energy levels and spectra, diatomic molecules as non rigid rotor.	**7L**
UNIT-5	**Vibrational Spectra:** Vibrational energy of a diatomic molecule as a simple harmonic oscillator – Energy Levels and spectrum, Vibrating molecule as an-harmonic oscillator– Morse potential energy curve - Molecules as vibrating rotator.	**7L**
UNIT-6	**Spectroscopy:** Raman effect - Quantum theory, Pure rotational spectra of diatomic molecules, Vibration rotation Raman spectrum of diatomic molecules, Franck Condon principle.	**7L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the electronic and molecular systems and their applications.

CO2: Write down the concepts related to, electronic, rotational and vibrational spectra.

CO3: Learn and to apply concepts of spectroscopy in the determination of atomic and molecular parameters.

Books and References

1. Physics of atoms and molecules by B.H. Bransden and C.J. Joachain, Pearson Education.
2. Fundamentals of molecular spectroscopy by A.N. Banwell and E.M. McCash, Tata McGraw Hill.
3. Introduction to atomic spectra by L.E. White, McGraw Hill.

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Course Name: **Classical Mechanics**
Course Code: **PH-223**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand classical mechanics and the need for non Newtonian formalisms.
- An understanding of concepts of Lagrangian and Hamilton's principles.
- The broad education necessary to understand different classical systems.
- A knowledge of concepts like small oscillations, central force, rigid body and canonical transformations.

Unit Number	Course Content	Lectures
UNIT-1	**Introduction to Constrained Motions:** Principle of virtual work, generalized coordinates, Configuration space, Lagrange's equation of motion, generalized momenta,, properties of kinetic energy function, Gauge function for Lagrangian, Invariance of Euler-Lagrange equation of motion under generalized coordinate transformation, cyclic coordinates	**6L**
UNIT-2	**Central Force:** Equations of motion, equivalent one body problem, orbits, Virial theorem, Kepler's problem, scattering theory, centre of mass and laboratory frames of reference.	**6L**
UNIT-3	**Small Oscillations:** Types of equilibrium, Study of oscillations using generalized coordinates, Eigenvalue problem, Normal coordinates, Frequencies of vibrations, Forced vibrations and resonances.	**6L**
UNIT-4	**Rigid Body Motion:** Orthogonal transformation, transformation matrix, Euler angles, Cayley-Klein parameters, Euler's theorem, Finite & infinitesimal rotations; Rotating frames of reference, Coriolis' force; Angular momentum and kinetic energy, dyadic & tensors	**6L**
UNIT-5	**Hamilton's equations of motion:** Phase space, Legendre transformation, Hamilton's function, Hamilton's equations of motion, cyclic coordinates and conservation theorems, derivation of Hamilton's equations from a variational principle	**6L**
UNIT-6	**Canonical Transformations:** Generating functions, properties of canonical transformations, the equation of canonical transformations, examples of canonical transformations, Poisson brackets, Invariance of Poisson bracket under canonical transformations, Poisson brackets involving angular momentum.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the classical systems and analyze them.
CO2: Identify the applications of Lagrangian and Hamiltonian mechanics.
CO3: Learn and to apply the concepts learnt in classical mechanics in different situations.

Books and References

1. Classical Mechanics by N.C. Rana and P.S. Joag, Tata McGraw-Hill, New Delhi.
2. Classical Mechanics by H. Goldstein, Narosa New Delhi.
3. Classical Mechanics by J. R.Taylor, University Science Books.
4. The Classical Theory of Fields by L.D. Landau and E.M. Lifshitz, Elsevier.
5. Classical Mechanics of Particles and Rigid Bodies by K.C. Gupta, Wiley Eastern.
6. Classical Mechanics by J.C. Upadhyaya, Himalaya Publishing House.

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Course Name: **Heat and Thermodynamics**
Course Code: **PH-224**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand the principles of thermodynamics and its various aspects.
- An understanding of concepts of thermodynamics and its laws.
- The broad education necessary to understand thermodynamics and its applications.
- A knowledge of concepts thermodynamic cycles.

Unit Number	Course Content	Lectures
UNIT-1	**Kinetic theory and Transport phenomena:** Equation of state of a perfect gas, Maxwell velocity distribution (3D, 2D, 1D cases), effusion, real gas and Van der Waals equation, Brownian motion, mean free path, viscosity and thermal conductivity.	**6L**
UNIT-2	**Laws of thermodynamics and applications:** Review of thermodynamic systems, state variables, intensive and extensive parameters, compressibility and expansion coefficients, thermodynamic processes, Zeroth and first law of thermodynamics; sign conventions and work done in various processes, State functions, internal energy and enthalpy, Joule Thomson effect.	**6L**
UNIT-3	**Second law of thermodynamics:** Kelvin-Planck and Clausius statements and their equivalence, Carnot heat engine, Refrigerator and pump, Thermodynamic temperature scale, equivalence between thermodynamic and the ideal gas scales.	**6L**
UNIT-4	**Entropy and Third Law of Thermodynamics:** Clausius theorem (reversible and irreversible case), examples of entropy change in various systems (including free expansion, expanding a spring, charging a capacitor), T-S diagrams, Nernst theorem (third law of thermodynamics), heat death of universe.	**6L**
UNIT-5	**Thermodynamic Potentials, Maxwell's relations & their applications**: The internal energy U, enthalpy H, Helmholtz free energy F, Gibbs free energy G, Physical meaning of free energy, Maxwell's relations and mnemonic diagram, Isothermal stretching of an elastic rod, Adiabatic stretching of a wire, Clausius-Clapeyron equation, Phase transformation in pure substances, first & Second order phase transitions with examples (qualitative discussion) TdS equations.	**6L**
UNIT-6	**Magneto-caloric effect and applications to some irreversible changes, cooling of real gases:** Magneto-caloric effect, Adiabatic demagnetization, Joule expansion (ideal and real gases), Joule-Kelvin expansion, Distinction between adiabatic expansion, Joule expansion and Joule-Kelvin expansion, magnetic cooling.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Describe the thermodynamic systems and their applications.
CO2: Identify the applications of thermodynamics.
CO3: Learn and to apply concepts learnt in thermodynamics in different applications based on thermodynamic principles.

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Books and References

1. Thermodynamics and kinetic theory of gases by W. Pauli, Dover Publications.
2. Heat and thermodynamics by M. W. Zeemansky and R. H. Dittman, McGraw Hill.
3. Thermodynamics, Kinetic Theory and Statistical Thermodynamics by F. W. Sears and G. L. Salinger, Narosa, New Delhi.
4. Thermal Physics by C. Kittel and H. W. Kroemer, Freeman & Co.
5. Thermodynamics and Statistical Mechanics by W. Greiner, L. Neise, and H. Stocker, Springer.
6. Thermal and Statistical Physics, Concepts and Applications by Sandeep Sharma, Springer Nature 2022.

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Course Name: **Machine Learning** Course Code: **PH-241** Course Type: **Discipline Elective-I**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives ● Able to understand the basics of Machine Learning. ● Apply different machine learning models using various datasets. They should be able to develop. ● Understand the role of machine learning in massive scale automation.		
Unit Number	**Course Content**	**Lectures**
UNIT-1	**Introduction:** Machine Learning, Feature sets, Dataset division: test, train and validation sets, cross validation, Data handling- missing data, feature scaling, Dimensionality reduction- principal component analysis.	**6L**
UNIT-2	**Basics of machine learning:** Applications of Machine Learning, processes involved in Machine Learning, Introduction to Machine Learning Techniques: Supervised Learning, Unsupervised Learning and Reinforcement Learning, bias-variance trade- off, overfitting-underfitting	**6L**
UNIT-3	**Supervised learning:** Classification and Regression: K-Nearest Neighbor, Linear Regression, Logistic Regression, gradient descent algorithm, Support Vector Machine (SVM), Evaluation Measures: SSE, MME, R2, confusion matrix, precision, recall, F-Score, ROC-Curve.	**6L**
UNIT-4	**Unsupervised and bayesian learning:** Introduction to clustering, Hierarchical clustering, K-means clustering, Density based clustering, Probability theory and Bayes rule, Naive Bayes learning algorithm, Bayes nets.	**6L**
UNIT-5	**Decision trees:** Representing concepts as decision trees, Recursive induction of decision trees, best splitting attribute: entropy and information gain, Overfitting, noisy data, and pruning.	**6L**
UNIT-6	**Reinforcement learning and ensemble methods:** Reinforcement learning through feedback network, function approximation, Bagging, boosting, stacking and learning with ensembles, Random Forest.	**6L**
Course Outcomes Upon successful completion of the course, the students will be able to CO 1: Understand basic concepts and applications of Machine Learning CO 2: Compare and Analyze various learning algorithms CO 3: Apply various machine learning algorithms in a range of real-world applications.		
Books and References 1. Machine Learning: The New AI, By Ethem Alpaydin, The MIT Press, 2016. 2. Machine Learning, Tom M. Mitchell, McGraw Hill Education, 2017. 3. Ethem Apaydin, Introduction to Machine Learning, 2e. The MIT Press, 2010. 4. Kevin P. Murphy, Machine Learning: a Probabilistic Perspective, The MIT Press, 2012. 5. Machine Learning for Dummies, By John Paul Mueller and Luca Massaron, For Dummies, 2016.		

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Course Name: **High Energy Physics** Course Code: **PH-242** Course Type: **Discipline Elective-I**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives ● To impart knowledge about the developments in the area of high energy Physics. ● To introduce the fundamental concepts relevant to interactions and fields in particle Physics, invariance principles and conservation laws ● To enable the students to understand concepts of QCD and quark model, flavor symmetry, weak decay processes.		
Unit Number	**Course Content**	**Lectures**
UNIT-1	**Introduction and Overview**: Historical development, Particle classification: Bosons, Fermions, Particles and Antiparticles, Quarks and Leptons; Basic ideas about the interactions and fields in Particle Physics, Types of interactions: Electromagnetic, Weak, Strong and Gravitational, Natural System of Units in High Energy Physics.	**6L**
UNIT-2	**Kinematics of decay and scattering reactions:** Four-vector (Position, Time, energy momentum), Fixed target and colliding beam accelerators (brief idea), Differential decay rates and differential reaction rates. Two Nucleon System, Pion-Nucleon System, Pion and muon decay and basic nature of weak interactions.	**6L**
UNIT-3	**Weak interactions:** Classification of weak processes, Fermi theory of β-decay, Parity non conservation in β-decay, two component theory of neutrino and determination of helicity, V-A interaction, Strangeness changing and non-changing decays, Cabibbo's theory.	**6L**
UNIT-4	**Invariance and Conservation Laws:** G-parity, Time reversal invariance, Associated production of particles and Gell-Mann Nishijima scheme, $K0-K0$ doublet, CP violation in K- decay, CPT theorem. Electromagnetic Interactions: Form factors of nucleons.	**6L**
UNIT-5	**QCD and Quark model:** Asymptotic freedom, confinement hypothesis. Classification of hadrons by flavor symmetry: SU(2) and SU(3) multiplets of Mesons and Baryons. The Baryon Octet and Decuplet, Pseudoscalar mesons and Vector mesons.	**6L**
UNIT-6	**Gauge Theory and Standard Model** : Gauge Principle, Local and Global gauge transformations, Abelian and non-Abelian gauge fields, standard model and symmetry.	**6L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Identify different mechanisms in the field of high energy Physics. CO2: Describe problems with different types of particle interactions and fields involved. CO3: Apply the concepts and principles/laws to describe the particle decay mechanism.		
Books and References 1. Introduction to High Energy Physics by D.H. Perkins, Cambridge University Press. 2. Introduction to Particle Physics by M.P. Khanna, PHI Learning. 3. Introduction to Elementary Particles by D. Griffiths, Wiley-VCH Verlag, GmbH & Co KGaA, Weinheim. 4. Particle Physics by Martin and Shaw, Wiley 5. A Modern Introduction to Particle Physics by Fayyazuddin and Riazuddin, World Scientific Publishing Co Pte Ltd.		

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Course Name: **Astrophysics**
Course Code: **PH-243**
Course Type: **Discipline Elective- I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To provide a basic knowledge of the Universe outside the Solar System.
- To prepare students for more advanced astronomy courses.
- To help students gain skills in solving scientific problems based on Astrophysics.

Unit Number	Course Content	Lectures
UNIT-1	**Sky coordinates and motions**: Earth Rotation, Sky coordinates, Seasons, Phases of the Moon, Moon's orbit and eclipses, timekeeping (sidereal vs synodic period).	**6L**
UNIT-2	**Planetary motions - Kepler's Laws** - Gravity, Light & Energy, Telescopes. Optics - Detectors, Planets: Formation of Solar System. Planet types, Planet atmospheres, Extrasolar planets.	**6L**
UNIT-3	**Stars and Stellar characteristics:** Measuring stellar characteristics (temperature, distance, luminosity, mass, size), HR diagram, Stellar structure, equilibrium, nuclear reactions, Energy transport, Stellar evolution, HR diagram - stellar structure (equilibrium, nuclear reactions, energy transport) - stellar evolution.	**6L**
UNIT-4	**Galaxies:** Our Milky Way - Galactic structure - Galactic rotation - Galaxy types - Galaxy formation.	**6L**
UNIT-5	**Cosmology I:** Expansion of the Universe, Redshifts, Supernovae, the Big Bang, history of the Universe and fate of the Universe.	**6L**
UNIT-6	**Cosmology II:** The cosmic microwave background. Early nucleosynthesis and cosmo-chronology. The matter content of the universe. Dark matter. Dark energy. The determination of the cosmological parameters.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Identify the fundamental concepts of Astrophysics.
CO2: Measure the properties of distant stars and galaxies using observations from the Earth and space.
CO3: Understand the most chemical elements are synthesized in stellar cores through nuclear fusion. How the Sun and other stars form and die.
CO4: Determine the main constituents of the Universe, how it began, and what its ultimate fate will be.

Books and References

1. BW Carroll & DA Ostlie, An Introduction to Modern Astrophysics, Latest Edition, Addison-Wesley.
2. Frank Shu, The Physical Universe, Latest Edition, University Science Books.
3. Martin Harwit, Astrophysical Concepts, Latest Edition, Springer.
4. T. Padmanabhan, Invitation to Astrophysics, Latest Edition, World Scientific Publishing Co.
5. T. Padmanabhan, Theoretical Astrophysics vols 1-3, Latest Edition, Cambridge University Press.
6. Malcolm Longair, High Energy Astrophysics, vols 1-2, Latest Edition, Cambridge University Press.
7. Sparke and Gallaghar, Galaxies in the Universe: An Introduction, Latest Edition, Cambridge University Press.
8. Dina Prialnik: An Introduction to the Theory of Stellar Structure and Evolution, Latest Edition, Cambridge University Press.

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Course Name: **Cosmology**
Course Code: **PH-244**
Course Type: **Discipline Elective- I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about Cosmology.
- To understand the fundamental concepts of Special Relativity.
- To enable the students to understand the various problems of Physical Cosmology and the early Universe.

Unit Number	Course Content	Lectures
UNIT-1	**Principles of Relativity:** Overview of Special Relativity, Spacetime interval and Lorentz metric four vectors - Introduction to General Relativity (GR), equivalence principle, notions of curvature.	**6L**
UNIT-2	**Gravitation:** Gravitation as a manifestation of the curvature of spacetime, Gravitational redshift and clock corrections, Orbits in strong gravity, light bending and Gravitational lensing - concept of horizon and ergo-sphere, hydrostatic equilibrium in GR, gravitational radiation.	**6L**
UNIT-3	**Cosmological Models:** Universe at large scales – Homogeneity and isotropy, distance ladder, Newtonian cosmology, expansion and redshift , Cosmological Principle, Hubble's law, Robertson-Walker metric, Observable quantities, luminosity and angular diameter distances, Horizon distance.	**6L**
UNIT-4	**Dynamics of Friedman- Robertson-Walker models:** Friedmann equations for sources with p=wu and w =−1, 0, 1/3, discussion of closed, open and flat Universes, Physical Cosmology and Early Universe: Thermal History of the Universe – distribution functions in the early universe.	**6L**
UNIT-5	**Relativistic and Nonrelativistic limits:** Decoupling of neutrinos and the relic neutrino background, Nucleosynthesis, Decoupling of matter and radiation - Cosmic microwave background radiation (CMB), Anisotropies in CMB, Inflation, Origin and growth of Density Perturbations.	**6L**
UNIT-6	**Formation of galaxies and large scale structures:** Accelerating universe and type-Ia supernovae - The Intergalactic medium and re-ionization.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Describe observational methods that are used to determine the fundamental properties of the universe.
CO2: Apply the theoretical background to physical cosmology and the early universe.
CO3: Perform the calculations concerning cosmological distances, cosmic dynamics.
CO4: Understand the concept of cosmic background radiation.

Books and References

1. Cosmological Physics, Cambridge University Press, J . A. Peacock.
2. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan, Cambridge University Press, 2002.
3. Classical Theory of Fields, Vol. 2, L. D. Landau and E. M. Lifshitz, Oxford : Pergamon Press, 1994.
4. Introduction to Cosmology, J. V. Narlikar, Cambridge University Press, 1993 (For the lectures on Cosmology).
5. First course in general relativity, B. F. Schutz, Cambridge university press, 1985 (For material on General Relativity).
6. Structure Formation in the Universe. T. Padmanabhan, Cambridge University Press, 1995.

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Course Name: **Integrated Circuit (IC) Technology**
Course Code:**PH-245**
Course Type: **Discipline Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to learn Integrated Circuit Technology
- An understanding of semiconductor processing technology.
- To impart education necessary to understand semiconductor device fabrication
- To make students understand IC technology.

Unit Number	Course Content	Lectures
UNIT-1	Modern CMOS technology, planar MOSFET technology, CMOS Process flow, substrate choice, crystal growth (Czochralski and float zone methods), wafer fabrication and basic properties of silicon wafers	**7L**
UNIT-2	Semiconductor manufacturing, clean rooms, wafer cleaning and gettering, limits and future trends in technologies, e-beam lithography, X-ray lithography, limitations and future trends in silicon industry	**3L**
UNIT-3	Thermal oxidation and Si/SiO_2 interface, MOS capacitor, first order planar growth kinetics, thin oxide (SiO_2) kinetics, growth kinetics dependence on pressure, crystal orientation,2D SiO_2 growth, substrate doping effect, polysilicon oxidation, silicide oxidation, use of high k dielectrics (HfO_2) as gate oxide	**8L**
UNIT-4	Dopant diffusion, dopant solid solubility, macroscopic viewpoint of diffusion, Fick's laws of diffusion, high energy implantation, thermal annealing, dopant activation, transient enhanced diffusion,	**6L**
UNIT-5	Thin film deposition techniques, historical developments and basic concepts, physical vapor deposition (PVD), evaporation techniques, sputter deposition, chemical vapor deposition (CVD), atmospheric pressure chemical vapor deposition (APCVD), plasma enhanced chemical vapor deposition (PECVD)	**8L**
UNIT-6	Epitaxy, epitaxial/ polycrystalline silicon deposition, silicon nitride and Al deposition, tungsten, $TiSi_2$, WSi_2 deposition, silicided GATES, via formation.	**4L**

Course Outcomes

Upon successful completion of the course, the students will be able to:
CO1: Understand semiconductor processing technology.
CO2: Identify the applications of thin film processing in IC technology.
CO3: Understand Integrated Circuit technologies in manufacturing ICs.
CO4: Understand the limitations of silicon based technology

Books and References

1. Silicon VLSI technology, Fundamentals Practice and Modeling, James D Plummer, Michael D. Deal, Peter B. Griffin, Prentice Hall Electronics and VLSi Series.
2. Analysis and Simulation of Semiconductor Devices, Siegfried Selberherr, Springer.
3. Silicon Processing for the VLSI era, Process technology, Stanley Wolf, N Richard Tauber.

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Course Name: **Spectroscopy Lab**
Course Code: **PH-226**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge by applying the experimental methods to correlate with the Physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- Apply the analytical techniques and graphical analysis of the experimental data.
- To develop communication skills and discuss the basic principles of scientific concepts in a group.

List of Experiments

1. To study the Zeeman effect.
2. Measurement of the wavelength separation of sodium D-lines using a diffraction grating and to calculate the angular dispersive power of the grating.
3. To determine the wavelength of the Balmer series in the visible region of the hydrogen emission spectrum.
4. To study Raman spectra of a given sample.
5. To observe the Balmer series of Hydrogen using Bunsen-Kirchhoff spectroscopy.
6. To study the spectrum of any source (glowing lamp, candle etc.).
7. To observe the neon spectral band's formation in a Frank Hertz tube.
8. To study transmission spectra of a given sample using UV-visible spectroscopy.
9. To measure the value of the Rydberg constant.
10. To study the absorbance and transmittance of different samples in different wavelengths.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Apply the various procedures and techniques for the experiments.
CO2: Use the different measuring devices and meters to record the data with precision.
CO3: Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.

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Course Name: **Thermal Physics Lab**
Course Code: **PH-227**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge by applying experimental methods to correlate with Physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- Apply the analytical techniques and graphical analysis of the experimental data.
- To develop communication skills and discuss the basic principles of scientific concepts in a group.

List of Experiments

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To study linear expansion for different kinds of solids.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of copper by Searle's Apparatus.
5. To study various thermal properties of materials using a Differential Scanning Calorimeter.
6. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
7. To determine experimentally the relationship between gas volume and pressure at constant temperature.
8. To determine the temperature coefficient of resistance by Platinum resistance thermometer.
9. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
10. To determine the heat capacity of solids.
11. To calibrate a thermocouple to measure temperature in specified range using the Null method.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the various procedures and techniques for the experiments.

CO2: Use the different measuring devices and meters to record the data with precision.

CO3: Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.

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Course Name: **Computational Lab-I**
Course Code: **PH-228**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge by applying experimental methods to correlate with Physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- Apply the analytical techniques and graphical analysis of the experimental data.
- To develop communication skills and discuss the basic principles of scientific concepts in a group.

List of Experiments

1. To realize motion of a projectile for different projection angles and velocities.
2. To find roots of transcendental equations using Newton's Raphson formula.
3. To write a program for least square fitting of data and find TCR from resistivity vs temperature data.
4. To study current voltage characteristics of a p-n junction diode with finite series resistance.
5. To fit p-n diode current-voltage data in diode equation and to find diode parameters.
6. To study the polarization behavior of electromagnetic waves.
7. To draw two-dimensional plots and realize variation of temperature over a surface of finite shape.
8. To solve the Schrodinger equation to find energy states of a particle confined in a box.
9. To study Motion of particles in a central force field and plot the output for visualization.
10. To write a program to find energies of a harmonic oscillator.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the various procedures and techniques for the experiments.

CO 2: Use the different measuring devices and meters to record the data with precision.

CO 3: Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.

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Course Name: **Physics of Semiconductor Devices**
Course Code: **PH-301**
Course Type: **Institute Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand the principles of semiconductors.
- An understanding of concepts of semiconductor devices.
- The broad education necessary to understand semiconductor devices.
- A knowledge of concepts / technologies based on semiconductor devices.

Unit Number	**Course Content**	**Lectures**
UNIT-1	Elemental and compound semiconductors, intrinsic and extrinsic materials, density of states and Fermi function, carrier concentration in conduction and valence bands, temperature dependence of carrier concentration and resistivity.	**6L**
UNIT-2	Mobility, diffusion, effective mass concept, drift and diffusion currents in semiconductors, Einstein relation, Direct and indirect band-gap semiconductors.	**6L**
UNIT-3	P-n junction formation, constancy of Fermi level across junction, built-in potential, depletion layer, diode capacitance, current conduction across p-n junction, temperature dependence of I-V characteristic of junction, breakdown in p-n junctions.	**6L**
UNIT-4	tunnel diode, photodiodes, light emitting and laser diodes, p-n-p-n thyristor.	**6L**
UNIT-5	Bipolar junctions transistors, field effect transistors, metal oxide semiconductor structure, MOSFET (n and p channel), threshold voltage, short channel effect, Drain Induced Barrier Lowering (DIBL), channel length modulation, velocity saturation.	**6L**
UNIT 6	Crystal growth techniques, epitaxial growth, doping mechanisms. Metal-Semiconductor contacts, formation of barrier, current transport processes, measurement of barrier height, Ohmic contacts.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the concepts of semiconductor devices.
CO2: Identify the applications of semiconductor devices.
CO3: Write down the concepts related to semiconductor devices.
CO4: Learn and to apply concepts learnt in semiconductor devices in Industry and in real life.

Books and References

1. Introduction to Semiconductor Materials and Devices by M.S.Tyagi, John Wiley & Sons.
2. Physics of Semiconductor Devices by S. M. Sze, Wiley Eastern Limited.
3. The Science and Engineering or Microelectronics fabrication by Stephen A.Campbell, Oxford University Press.
3. Electronic Materials Science by W. Mayer James and S. S. Lau, Macmillan publishing Co..
4. Semiconductor Devices An Introduction by Jasprit Singh, McGraw Hill.
5. Semiconductor Physics and Devices, Donald A Neamen, Tata McGraw Hill.

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Course Name: **Nuclear Science and Engineering**
Course Code: **PH-302**
Course Type: **Institute Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to learn nuclear technology
- An understanding of concepts of Nuclear Science and Engineering.
- To impart education necessary to understand nuclear science and engineering
- To make students understand the use of nuclear technologies.

Unit Number	Course Content	Lectures
UNIT-1	**Review of nuclear physics:** general nuclear properties, models of nuclear structure, nuclear reactions,nuclear decays and fundamental interactions; Nuclear radiation: radioactivity, radiation dosimetry, dosimetry units and measurement; radiation protection and control; applications of radiation: medical applications, industrial radiography, neutron activation analysis, instrument sterilization, nuclear dating.	7L
UNIT-2	**Nuclear fission:** nuclear energy, fission products, fissile materials, chain reactions, moderators neutron thermalization, reactor physics, criticality & design; nuclear power engineering; energy transport and conversion in reactor systems, nuclear reactor safety.	7L
UNIT-3	**Nuclear fusion:** controlled fusion, nuclear fusion reactions, fusion reactor concepts, magnetic confinement, tokamak, inertial confinement by lasers.	6L
UNIT-4	**Nuclear waste management:** components and material flow sheets for nuclear fuel cycle, waste characteristics, sources of radioactive wastes, compositions, radioactivity and heat generation waste treatment and disposal technologies; safety assessment of waste disposal.	6L
UNIT-5	**Particle accelerators:** interactions of charged particles, gamma rays and neutrons with matter, electrostatic accelerators, cyclotron, synchrotron, linear accelerators, colliding beam accelerators.	6L
UNIT-6	**Particle detectors:** gas-filler counters, scintillation detectors, and semiconductor based particle detectors.	4L

Course Outcomes

Upon successful completion of the course, the students will be able to:
CO1: Understand nuclear technologies.
CO2: Identify the applications of nuclear techniques.
CO3: Use the concepts of nuclear technologies in useful applications.

Books and References

1. Introductory Nuclear Physics by K. S. Krane, John Wiley.
2. Nuclear and Particle Physics by R. J. Blin-Stoyle, Springer.
3. Nuclear Energy by R. L. Murray, Butterworth-Heinemann.
4. Nuclear Reactor Analysis by J. J. Duderstadt and L. J. Hamilton, Wiley.
5. Introduction to Nuclear Engineering by J. R. Lamarsh and A. J. Baratta, Prentice Hall.

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Course Name: **Elements of Solid State Physics** Course Code: **PH-303** Course Type: **Institute Elective-I**
Contact Hours/Week: **3L** Course Credits: **03**
Course Objectives • An ability to learn solid state physics. • An understanding of the origin of properties in the solids. • To make students understand the use of different interesting properties i.e. specific heat, magnetism, crystal structure etc..

Unit Number	Course Content	Lectures
UNIT-1	Introduction to solid, Periodic array of atoms, Lattice translational Vectors, Basis and crystal structure, Primitive lattice cell, Elements of symmetry, Fundamental type of Lattices in 2D and 3D, Miller indices, BCC, FCC and HCP crystal structure.	**6L**
UNIT-2	Introduction to X-ray, Generation and absorption of X-ray, Bragg's law, Scattering from an atom and crystals, Brillouin zone, Reciprocal Lattices to SC, BCC and FCC lattices, Atomic form factor, Experimental XRD Techniques, Different types of bonding. e. ionic, covalent and hydrogen bonding.	**6L**
UNIT-3	Failure of classical mechanics, black body radiation, Davisson Germer Effect, Stern Gerlach experiment, Heisenberg uncertainty principle, wave function and probability, Wave packet, Phase velocity and group velocity, Schrodinger wave equation, Average value, Infinite potential box.	**8L**
UNIT-4	Conduction electrons, Concept of electrical and thermal conductivity, Drude model, Electrical conductivity vs Temperature, Heat capacity, Fermi energy and Fermi surface, Effect of Fermi surface on electrical conductivity, Motion in magnetic field, Hall Effect, Quantum Hall effect. Edge conduction, Topological insulator, DOS in 1D, 2D and 3D, Periodicity in the crystal and the concept of the band gap, Positive and negative effective mass, Mobility.	**8L**
UNIT-5	Introduction of magnetism, Magnetic susceptibilty, Classification of Materials on the basis of magnetism, Dia, Para, Ferro, Ferri and antiferromagnetism, Ferromagnetic domains.	**4L**
UNIT-6	Introduction to superconductivity, Zero resistance, Perfect diamagnetism, Different types of superconductors, BCS theory, Josephson effect and it's practical and industrial applications.	**4L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Understand Different interesting properties of solids.

CO2: Identify the applications of characterization techniques.

CO3: Use the concepts of different properties in useful applications.

Books and References

1. Introductory to Solid state Physics- Charles Kittel, Wiley production.
2. Solid State Physics by N.W. Ashcroft and N.D. Mermin, Holt-Saunders.
3. Elementary Solid state Physics-M. Ali Omar, Pearson publication.
4. Solid State Physics- A.J. Dekkar, Macmillan student edition.
5. Solid State Physics-S.O. Pillai, New age international publishers.

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Course Name: **Optoelectronics**
Course Code: **PH-304**
Course Type: **Institute Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand the basic optoelectronic devices including LEDs, lasers, photodetectors, solar cells and optical fibers.
- Impart knowledge about applications of optoelectronic devices.
- Be familiar with recent advancement in optoelectronics.

Unit Number	Course Content	Lectures
UNIT-01	**Semiconductors:** Introduction to semiconductors, compound semiconductors, bandgap engineering, luminescence, absorption of photons in semiconductors, electron-hole pair formation and recombination.	**6L**
UNIT-02	**Light emitting diode (LED):** Electroluminescent process, choice of LED materials, device configuration and efficiency, light output from LED, LED structure, device performance characteristics, frequency response and modulation bandwidth.	**6L**
UNIT-03	**Laser:** Basic semiconductor laser, population inversion at a junction, device Structure, materials for semiconductor lasers, effect of temperature, emission spectrum of a semiconductor laser, quantum-well laser, applications.	**6L**
UNIT-04	**Semiconductor photodetectors:** Classification of photodetectors, I-V characteristics under illumination and dark, photodiode's characteristic parameters, photodiode materials, electric circuits with photodiodes, applications.	**6L**
UNIT-05	**Solar Cells:** Light absorption, **s**olar energy spectrum, device principles, I-V characteristics, equivalent circuit, temperature effects, materials, devices and efficiencies, antireflection coatings, recent progress in solar cells.	**6L**
UNIT-06	**Optical fiber:** Numerical aperture, modes of a fiber, single and multimode fibers, step-index and graded-index fibers, attenuation and losses in optical fibers, optical fiber materials, fiber fabrication techniques, fiber optic cables and connection techniques, fiber alignment and joint loss.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Describe the optoelectronic devices like LEDs, lasers, photodetectors, solar cells and optical fibers.

CO2: Know the applications of these optoelectronic devices.

CO3: Understand the concept of these optoelectronic device febrications.

Books and References

1. Solar Photovoltaics: Fundamental, Technologies and Applications by Chetan Singh Solanki, PHI.
2. Semiconductor Devices - Physics and Technology by S.M. Sze, 2nd ed., Wiley.
3. Optical Electronics by A. K. Ghatak and K. Thyagarajan, Cambridge University Press
4. Principles of Solar Cells, LEDs and Diodes by Adrian Kitai, Wiley.
5. Optoelectronics and Photonics: Principles and Practices by S. O. Kasap, Pearson Education

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Course Name: **Semiconductors Processing Technology**
Course Code: **PH-305**
Course Type: **Institute Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to learn Integrated Circuit Technology.
- An understanding of semiconductor processing technology.
- To impart education necessary to understand semiconductor device fabrication
- To make students understand IC technology.

Unit Number	Course Content	Lectures
UNIT-01	Modern CMOS technology, CMOS Process flow, choice of substrate, crystal growth (Czochralski and float zone methods), wafer fabrication and basic properties of silicon wafers	**7L**
UNIT-02	Semiconductor manufacturing, clean rooms, wafer cleaning and gettering, limits and future trends in technologies, e-beam lithography, X-ray lithography	**4L**
UNIT-03	Thermal oxidation and Si/SiO2 interface, MOS capacitor, first order planar growth kinetics, thin oxide (SiO2) kinetics, growth kinetics dependence on pressure, crystal orientation, 2D SiO2 growth, substrate doping effect, polysilicon oxidation, silicide oxidation	**7L**
UNIT-04	Dopant diffusion, dopant solid solubility, macroscopic viewpoint of diffusion, Fick's laws of diffusion, high energy implantation, thermal annealing, dopant activation, transient enhanced diffusion,	**6L**
UNIT-05	Thin film deposition techniques, physical vapor deposition (PVD), evaporation, sputter deposition, chemical vapor deposition (CVD), atmospheric pressure chemical vapor deposition (APCVD), plasma enhanced chemical vapor deposition (PECVD)	**8L**
UNIT-06	Epitaxy, epitaxial/polycrystalline silicon deposition, silicon nitride and Al deposition, tungsten, TiSi2, WSi2 deposition, silicided GATES, via formation	**4L**

Course Outcomes

Upon successful completion of the course, the students will be able to:
CO1: Understand semiconductor processing technology.
CO2: Identify the applications of thin film processing in IC technology.
CO3: Understand Integrated Circuit technologies in manufacturing ICs.

Books and References

1. Silicon VLSI technology, Fundamentals Practice and Modeling, James D Plummer, Michael D. Deal, Peter B. Griffin, Prentice Hall Electronics and VLSi Series.
2. Analysis and Simulation of Semiconductor Devices, Siegfried Selberherr, Springer.
3. Silicon Processing for the VLSI era, Process technology, Stanley Wolf, N Richard Tauber.

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Course Name: **Quantum Mechanics**
Course Code: **PH-310**
Course Type: **Minor Degree Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand the framework of quantum mechanics.
- An understanding of the methods used to solve physics problems using quantum mechanics.
- The broad education necessary to understand microscopic systems.
- A knowledge of concepts like wave packet, operators, commutators etc.

Unit Number	Course Content	Lectures
UNIT-1	**Wave Packets and Uncertainty Principle:** Plane waves; Superposition of plane waves; Wave packets; Fourier analysis; Group velocity; Propagation of wave packets; Wave packet broadening; Gaussian wave packet.	**6L**
UNIT-2	**Schrödinger Equation**: The wave equation and the interpretation of ψ; Operators and expectation values of dynamical variables; Commutators and operator algebra; Stationery states; Dirac notations.	**6L**
UNIT-3	**Postulates of Quantum Mechanics:** The Basic Postulates of Quantum Mechanics, The State of a System, Observables and Operators, Measurement in Quantum, Time Evolution of the System's State.	**6L**
UNIT-4	**Problems in one and three dimensions:** Potential step, rectangular potential barrier, symmetries and invariance properties, reflection and transmission coefficients, potential well, Hydrogen atom, Rigid rotor & Harmonic Oscillator,	**6L**
UNIT-5	**Angular Momentum:** Orbital angular momentum, General Formalism of angular momentum, Spin angular momentum,	**6L**
UNIT-6	**Approximation method:** Time-independent perturbation theory, Variational Principle, WKB method, and Time-dependent perturbation theory.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO 1: Describe the quantum mechanical systems.
CO 2: Identify the applications of quantum mechanics.
CO 3: Write down the concepts related to the framework of quantum mechanics.
CO 4: Learn and to apply concepts learnt in Quantum mechanics to one & three dimensional problems.

Books and References

1. Quantum Physics by S. Gariorowicz, John Wiley & Sons.
2. Concepts of Modern Physics by A. Beiser, McGraw Hill International.
3. Quantum Mechanics by A. Ghatak and S. Lokanathan, McMillan India Ltd.
4. Introduction to Quantum Mechanics, D. J. Griffiths, Pearson Prentice Hall.
5. A Text Book of Quantum Mechanics by P.M. Mathews and K. Venkatesan, Tata Mc Graw Hill.

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Course Name: **Nuclear & Particle Physics**
Course Code: **PH-311**
Course Type: **Discipline Core**

Contact Hours/Week: **3L+1T** Course Credits: **04**

Course Objectives

- An ability to understand the properties of an atomic nucleus and its stability.
- An understanding of concepts of nuclear physics and engineering.
- The broad education necessary to understand radioactivity and nuclear reactions.
- A knowledge of concepts like semi empirical mass formula, shell model and nuclear radioactivity.

Unit Number	Course Content	Lectures
UNIT-1	**Nuclear Properties:** Nuclear shape, size, radii, matter/charge distributions; Nuclear force; Conc of isospin; Charge Z independence of nuclear forces in the light of isospin. Mass defect and binding energy	**6L**
UNIT-2	**Nuclear Models:** Liquid drop model; Semi empirical mass formula; Evidence of shell structure; S model with harmonic oscillator and spin-orbit potential and its predictions.	**6L**
UNIT-3	**Radioactivity:** α-decay, its properties, range, range-energy relationship, Geiger-Nuttal law, theory of α-decay, β-Decay and its classifications (only the basics), γ-decay: range, properties, pair production, energy spectra and nuclear energy levels.	**6L**
UNIT-4	**Nuclear Reaction:** Kinematics, Direct nuclear reaction, Compound nuclear reaction, Nuclear reactors; Nuclear fission, various types of fission reactors, Source of stellar energy, Nuclear fusion, Power from fusion	**7L**
UNIT-5	**Nuclear Detectors and Accelerators:** Gas, Scintillation and Semiconductor detectors. Neutron detectors, Accelerators: Cyclotron and Linac. Industrial, analytical and medical applications	**7L**
UNIT-6	**Particle Phenomenology:** Fundamental interactions; Elementary particles and their quantum numbers (charge, lepton number, baryon number, spin, parity, isospin, strangeness, etc.); Gellmann-Nishijima formula, Quark model, baryons and mesons; C, P, and T invariance, Symmetries and conservation laws - application of symmetry arguments to particle reactions; Parity non-conservation in weak interaction; Elementary idea about electroweak unification, Higgs boson and origin of mass; Relativistic kinematics.	**10L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the atomic nucleus and its properties; CO2: Identify the applications of nuclear models.
CO3: Write down the concepts related to nuclear structure and nuclear reactions; CO4: Learn the idea of nuclear detectors and accelerators and their use in nuclear technologies.

Books and References

1. Nuclear Physics by J. S. Lilley, John Wiley & Sons.
2. Nuclear Physics by S.N. Ghoshal, S. Chand & Comp. Ltd.
3. Particles and Nuclei by B. Povh, K. Rith, C. Scholz and F. Zetsch, Springer.
4. From Nucleons to the Atomic Nucleus by K. Heyde, Springer.

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Course Name: **Signals & Systems**
Course Code: **PH-312**
Course Type: **Discipline Core**

Contact Hours/Week: **3L+1T** Course Credits: **04**

Course Objectives

- An ability to understand signals for application in communication systems.
- An understanding of concepts of remote sensing systems.
- Understanding transforms representation of signals.
- Knowledge of transforms for application in signal communication.

Unit Number	Course Content	Lectures
UNIT 1	Overview of communication, control and remote sensing systems, properties of systems, classifications of signals, basic operations on signals, elementary signals, exponential and sinusoidal, damped signals, step, impulse and ramp functions, systems as interconnections of operations, properties of systems.	**7L**
UNIT 2	Convolution, impulse response representation of linear time invariant (LTI) systems, convolution integral, step response.	**7L**
UNIT 3	Fourier representation of signals, periodic and non-periodic signals, Fourier series and Fourier transform, properties of Fourier representation, relationship between Fourier transform and Fourier series; Generalized Fourier transform; Amplitude and phase spectra, energy and power spectral density, signal bandwidth.	**7L**
UNIT 4	Laplace Transform, relationship of Laplace and Fourier transforms, transfer function and its block diagram representation, convolution integral and the Fourier transfer function.	**7L**
UNIT 5	Review of z-transform and its properties, Discrete time Fourier transform and its properties; Discrete convolution and duality; Discrete Fourier transform and its properties; Computation of discrete time Fourier transform and discrete Fourier transform, approximation of Fourier transform and discrete convolution using discrete Fourier transform.	**7L**
UNIT 6	Applications to communication systems, sampling, modulation, multiplexing, phase and group delays.	**7L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Describe signals is their importance in communication systems; CO2: Identify the role of remote sensing systems in technology advancement; CO3: Write down the concepts related to transforming representation of signals; CO4: Apply the knowledge of transforms for application in signal communication.

Books and References

1. Svelto O, “Principles of Lasers”, Springer
2. Ghatak A K and Thyagarajan K, “Optical Electronics”, Cambridge University Press.
3. Yariv A, “Quantum Electronics”, John Wiley & Sons.
4. Thyagarajan K and Ghatak A, “Lasers:Theory and Applications”, Macmillan
5. Yariv A, “Optical Electronics”, Oxford University Press.
6. Laud B B, “Lasers and Nonlinear Optics”, Wiley Eastern Ltd.

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Course Name: **Statistical Mechanics** Course Code: **PH-313** Course Type: **Discipline Core**		
Contact Hours/Week: **3L+1T**		Course Credits: **04**
Course Objectives ● An ability to understand statistics and its applications to physics problems. ● An understanding of concepts of statistical mechanics. ● The broad education necessary to understand ensemble theory, quantum statistics and phase transition. ● A knowledge of concepts like Ideal Fermi and Bose gas and ensemble theory.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	**Classical Statistical Mechanics**: Macro and microstates, connection between statistics and thermodynamics, phase space; Liouville's Theorem.	**7L**
UNIT-02	**Ensemble Theory:** Microcanonical, canonical and grand canonical ensembles; Energy and Density fluctuations; equivalence of various ensembles. Equipartition and virial theorem, partition function; Derivation of thermodynamic properties; some examples, including (i) classical ideal gas (ii) system of classical harmonic oscillators, (iii) system of magnetic dipoles in magnetic field.	**7L**
UNIT-03	**Quantum Statistics I:** Quantum mechanical ensembles theory, the density matrix and partition function with examples, including (i) an electron in a magnetic field (ii) a free particle in a box (iii) a linear harmonic oscillator. Symmetric and Antisymmetric Wavefunctions.	**7L**
UNIT-04	**Quantum Statistics II:** Microcanonical ensemble of ideal Bose, Fermi and Boltzmann gases, derivation of Bose, Fermi and Boltzmann statistics; Grand Partition function of ideal Bose and Fermi gases; Statistics of the occupation.	**7L**
UNIT-05	**Ideal Bose and Fermi Systems:** Thermodynamic behaviour of an ideal Bose gas; Bose condensation; Liquid Helium; Blackbody radiation and Planck's law of radiation; Thermodynamic behaviour of an ideal Fermi gas; Electrons in metals, specific heat and Pauli susceptibility of electron gas.	**7L**
UNIT-06	**Phase Transitions and Critical Phenomenon:** Order parameter, Ist and IInd order phase transitions. Ising model in zeroth and first approximation. Critical exponents, thermodynamic inequalities, Landau theory of phase transitions.	**7L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Describe statistical systems and the underlying principles. CO2: Identify the applications of ensemble theory and different types of statistics. CO3: Write down the concepts related to classical and quantum statistics. CO4: Learn to apply the concepts of statistical mechanics in understanding the collective behaviour of physical systems.		
Books and References 1. Statistical Mechanics by R.K.Patharia, Pergaman press. 2. Statistical Mechanics by K. Huang, John Wiley & Sons. 3. Statistical Mechanics by Butteworth-Heinemaun, D.A. McQuarrie, Harper & Row.		

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Course Name: **Meta Materials**
Course Code: **PH-351**
Course Type: **Discipline Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand meta materials.
- An understanding of concepts of electrodynamics used in science of metamaterials.
- The broad education necessary to understand potential uses of metamaterials.

Unit Number	Course Content	Lectures
UNIT-1	**Wave propagation:** Light interaction with matter. Review of Maxwell's equations, Wave propagation in isotropic and anisotropic media, Basics of photonic Band gap materials, Types of Photonic Band Gap Materials.	**6L**
UNIT-2	**Photonic band materials:** Introduction to Photonic Crystals**,** Plasmonics**,** Optical properties and Band structure of 1D, 2D & 3D Photonic Band Gap Materials. Optical properties and Band structure of PBG materials with Defects.	**6L**
UNIT-3	**Metamaterials:** Introduction of Metamaterials, Electric and magnetic metamaterials, Negative refractive index, left handed materials and Two-Dimensional Optical Metamaterials, Super-lens and hyper-lens, Transformation optics and invisibility cloak, Metasurfaces and phase engineering	**6L**
UNIT-4	**Fabrication:** Fabrication of optical meta-devices,Lithography, lift-off, wet and dry etching, Colloidal synthesis and self-assembly, Nano-imprinting, Direct laser writing, Fabrication techniques of PBG materials, Analysis of Photonic band gap materials transfer matrix, plane wave expansion method.	**6L**
UNIT-5	**Applications**: Fundamentals of Metamaterials, Optical Properties of Metal-Dielectric Composites. Applications of meta-devices in imaging, communication, information processing, sensing.	**6L**
UNIT-6	**Nonlinear optics:** Nonlinear Optics in Metamaterials, Super Resolution with Meta-Lenses. Other applications of metamaterials.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Describe the metamaterials.
CO2: Identify the applications of metamaterials.
CO3: Write down the concepts of metamaterials.
CO4: Learn the uses of metamaterials.

Books and References

1. Photonics by Yariv Amnon and Yeh Pochi, Oxford University Press.
2. Wave propagation from electron to photonic crystals and metamaterials by P. Markos and C.M. Soukoulis, Princeton University Press.
3. Photonic crystal: Modeling the flow of light by J.D. Jonapolous, Princeton University Press.
4. Plasmonics: Fundamentals and Applications, S. Maier, Springer
5. Classical Electrodynamics, J. D. Jackson, John Willey & Sons

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Course Name: **Photovoltaic Solar Cells**
Course Code: **PH-352**
Course Type: **Discipline Elective-II**

Contact Hours/Week: 3L   Course Credits: **03**

Course Objectives

- An ability to understand energy requirements and photovoltaics.
- An understanding of concepts of solar photovoltaics.
- The broad education to understand solar harvesting of energy through photovoltaics.

Unit Number	Course Content	Lectures
UNIT -1	**Energy and Role of Photovoltaic**: World Energy Requirement, renewable Energy Sources, Photovoltaic in Energy Supply, Solar PV production, Fundamentals of solar cell: Semiconductors as basic solar cell material, materials and properties, P – N junction and solar cell, Sources of losses and prevention.	**6L**
UNIT -2	**Solar Cell technologies Crystalline Cells**: Mono- crystalline and poly – crystalline cells, Metallurgical Grade Si, Electronic Grade Si, wafer production, Mono – crystalline Si Ingots, Poly – crystalline Si Ingots, Si – wafers, Si – sheets, Solar grade Silicon, Si usage in solar PV, Commercial Si solar cells, process flow of commercial Si cell technology, process in solar cell technologies, Sawing and surface texturing, diffusion process.	**6L**
UNIT -3	**Metal Contact Solar Cells**: Metal contact Thin Film Cells: Advantage of thin film, thin film deposition techniques, Evaporation, Sputtering, LPCVD and APCVD, PECVD, Hot Wire CVD, closed space sublimation, Ion Assisted Deposition. Amorphous Si Solar cell technology, CdTe and CIGS solar Cell.	**6L**
UNIT -4	**Concentrators & PV Modules:** Concentration: Advantages & disadvantages, Series Resistance optimization, Concentrating techniques; tracking/ non-tracking systems, Cooling requirements, High concentration solar cells.	**6L**
UNIT -5	**Solar PV modules:** Series and Parallel connections, Mismatch between cell and module, Design and structure, PV module power output. Electrical Storage: Battery technology, Batteries for PV systems.	**6L**
UNIT -6	DC – DC converters, Charge Controllers, DC – AC inverters; single phase, three phase. Photovoltaic System configuration, standalone system with DC / AC load with and without battery.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand the working of solar cells.
CO2: Identify the applications of solar cells
CO3: Learn and to use solar cells for innovative applications.

Books and References

1. Handbook of Photovoltaic Science and Engineering by Eds. A. Luque and D.S. Hegedus, Wiley.
2. The Physics of Solar Cells by Jenny Nelson, Imperial College Press.
3. Thin Films Solar Cells by K.L. Chopra, McGraw Hill.
4. Solar Energy by Sukhatme, McGraw Hill Education.
5. Solar photovoltaics -Fundamental, Technologies and Applications, By chetan Singh Solanki, PHI.

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Course Name: **Advanced Condensed Matter Physics**

Course Code: **PH-353**

Course Type: **Discipline Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand matter.
- An understanding of concepts of condensed matter physics.
- The broad education necessary to understand condensed matter physics. .

Unit Number	Course Content	Lectures
UNIT-1	Lattice Vibrations: Born-Oppenheimer Approximation, Hamiltonian for Lattice Vibrations in the Harmonic Approximation, Normal Modes of the System and Quantization of Lattice Vibrations - Phonons.	**6L**
UNIT-2	Topology of Fermi-surface; Quantization of orbits in a magnetic field, de Haas-van Alphen effect; Boltzmann transport equation -relaxation time approximation.	**6L**
UNIT-3	Electron Interaction: Perturbation Formulation, Dielectric Function of an Interacting Electron Gas (Lindhard's Expression), Static Screening, Screened Impurity, Kohn Effect, Friedel Oscillations and Sum Rule, Dielectric Constant of Semiconductor, Plasma Oscillations.	**6L**
UNIT-4	Magnetic properties of solids: Absence of magnetism in classical statistics; Origin of the exchange interaction; Direct exchange, superexchange, and double exchange; DM interactions, RKKY interactions.	**6L**
UNIT-5	Heisenberg and Ising models; Spin-waves in ferromagnets and antiferromagnets (semi classical and quantum treatment using Holstein Primakoff transformation), spontaneous symmetry breaking in magnetic systems with continuous symmetry, thermodynamics of magnons, mean field theory and critical behaviour for large S models.	**6L**
UNIT-6	Disordered systems: Disorder in condensed matter — substitutional, positional and topographical disorder; Short- and long-range order; Atomic correlation function and structural descriptions of glasses and liquids; Anderson model; mobility edge; Minimum Metallic Conductivity. Important topics: Mott transition, Stoners criterion for metallic ferromagnet.	**6L**

Course Outcomes: Upon successful completion of the course, the students will be able to

CO1: Describe the matter for different properties.

CO2: Identify the applications of different materials.

CO3: Write down the concepts related to different properties of the materials.

CO4: Learn the idea of superconductivity and importance in advancement of technologies.

Books and References

1. Solid State Physics by N.W. Ashcroft and N.D. Mermin, Harcourt College Publishers.
2. Fundamentals of Solid State Physics by J.R. Christman, Wiley Edition.
3. Solid State Physics by A.J. Dekker, Macmillan & Co. Ltd.
4. Introduction to Solid State Physics by C. Kittel, Wiley Edition.
5. Elements of Solid State Physics by J.P. Srivastava, Prentice Hall of India.
6. Solid State and Semiconductor Physics by J.P. McKelvey, Krieger Publishing Campus.
7. Principles of the Theory of Solids by J.M. Ziman, Cambridge University Press.
8. Advanced Solid State Physics by Philip Phillips, Cambridge University Press.

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Course Name: **Modern Physics Lab-I** Course Code: **PH-314** Course Type: **Discipline Core**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To gain practical knowledge by applying experimental methods to correlate with Physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- Apply the analytical techniques and graphical analysis of the experimental data.
- To develop communication skills and discuss the basic principles of scientific concepts in a group.

List of Experiments

1. To determine the value of Boltzmann constant using the V-I characteristic of the PN diode.
2. To determine the work function of the material of a filament of directly heated vacuum diode.
3. To determine the value of Planck's constant using LEDs of at least 4 different colours.
4. To determine the ionization potential of mercury.
5. To determine the wavelength of the H-alpha emission line of the Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study IV characteristics and demonstrate the tunnelling effect in tunnel diodes.
8. To determine the absorption coefficient of Al using G.M. Counter.
9. To determine the value of e/m by magnetic focusing.
10. To set up the Millikan oil drop apparatus and determine the charge of an electron.
11. To determine the spectroscopic splitting of DPPH using ESR technique.
12. Study of nuclear magnetic resonance.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the various procedures and techniques for the experiments.
CO2: Use the different measuring devices and meters to record the data with precision.
CO3: Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.

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Course Name: **Computational Lab-II**
Course Code: **PH-315**
Course Type: **Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge by applying experimental methods to correlate with Physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- Apply the analytical techniques and graphical analysis of the experimental data.
- To develop communication skills and discuss the basic principles of scientific concepts in a group.

List of Experiments

11. To solve the equation of motion of a projectile fired horizontally and plot the trajectory.
12. To find the solution of Laplace Equation.
13. To solve the diffusion equation.
14. Motion of particle in a central force field and plot the output for visualization.
15. Motion of a projectile using simulation and plot the output for visualization.
16. Numerical solution of equation of motion of simple harmonic oscillator and plotting of output..
17. Plotting trajectory of a projectile projected making an angle with horizontal.
18. To solve the Schrodinger equation to fins energy states of particle confined in a box.
19. To solve Laplace's equations in the depletion layer of p-n junction.
20. To find energies of a harmonic oscillator.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the various procedures and techniques for the experiments.
CO 2: Use the different measuring devices and meters to record the data with precision.
CO 3: Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.

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Course Name: **Mechanics**
Course Code: **PH-320**
Course Type: **Minor Degree Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand the framework of classical mechanics.
- Understand the concept of motion of particles and rigid bodies.
- An understanding of the methods used to solve physics problems.

Unit Number	Course Content	Lectures
UNIT-1	**Fundamentals of Dynamics**: Frames of reference, Inertial and accelerated frames, Galilean transformations, fictitious forces, uniformly rotating frame, Laws of Physics in rotating coordinate systems, Centrifugal force, Coriolis force and its applications.	**6L**
UNIT-2	**Conservation laws**: Conservation of energy, momentum and angular momentum, Their connection with symmetry principles, Collisions: Elastic and inelastic collisions between particles, Centre of Mass and Laboratory frame of references	**6L**
UNIT-3	**Rotational Dynamics**: Angular momentum of a system of particles, Torque, Rotation about a fixed axis, Moment of Inertia, Calculation of moment of inertia for rectangular, cylindrical, spherical bodies, etc, Kinetic energy of rotation, Motion involving both translation and rotation.	**6L**
UNIT-4	**Central Force Motion:** Motion of a particle under a central force field, Two-body problem and its reduction to one-body problem, energy diagram, Kepler's Laws, Satellite in circular orbit and applications, Geosynchronous orbits, Basic idea of global positioning system (GPS)	**6L**
UNIT-5	**Special Theory of Relativity**: Michelson-Morley Experiment and its outcomes, Lorentz Transformations, Lorentz contraction, Time dilation, velocities addition, Mass-energy Equivalence, Relativistic Doppler effect, Relativistic Kinematics	**6L**
UNIT-6	**Lagrangian and Hamiltonian mechanics**: Degrees of freedom, Constraints, Generalized coordinates, Lagrange's equations of motion, Ignorable coordinates, Variational principle, Hamilton's principle, Hamilton's equations of motion and applications.	**6L**

Course Outcomes: Upon successful completion of the course, the students will be able to
Upon successful completion of the course, the students will be able to:
CO 1: Students will understand the concepts of engineering mechanics
CO 2: To realize the reduction of a two-body problem to a one-body problem in a central force system.
CO 3: To appreciate the theory of relativity for particles moving with relativistic speeds
CO 4: Estimate the moment of inertia of composite area or any arbitrary axis
CO 5: Apply Lagrangian and Hamiltonian mechanics equations to solving practical problems.

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Course Name: **Measurements & Instrumentation**
Course Code: **PH-321**
Course Type: **Discipline Core**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- An ability to understand measurement and instrumentation.
- An understanding of concepts of sensors and transducers.
- The broad education necessary to understand instrumentation and measurement.
- A knowledge of concepts / technologies like sensors, spectrophotometers and interferometers .

Unit Number	Course Content	Lectures
UNIT-01	**Sensors:** Basics of transducers, sensors and actuators; Active and passive transducers, Static and dynamic characteristics of transducer and transducer system, Resistive, capacitive, inductive, electromagnetic, thermoelectric, elastic, piezoelectric, piezoresistive, photosensitive and electrochemical sensors, Interfacing sensors and data acquisition using serial and parallel ports.	**7L**
UNIT-02	**Low pressure pumps:** Rotary, Positive displacement, momentum transfer, oil diffusion, turbo molecular, getter and cryo pumps; entrapment, sorption pumps.	**5L**
UNIT-03	**Low temperature:** Gas liquifiers; Cryo-fluid baths; liquid He cryostat design; closed cycle He refrigerator; low temperature measurement: Resistance temperature detector, NTC and PTC thermistors, Seebeck effect, thermocouple and thermopile.	**6L**
UNIT-04	Laboratory component: Physical parameter measurement using different sensors; low pressure generation and measurement; calibration of secondary gauges; cryostat design; CCR operation; data collection from analytical instruments in the department.	6L

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the measurement and instrumentation and its applications.

CO2: Identify the applications of measurement and instrumentation.

CO3: Learn and to apply concepts of measurement and instrumentation to Industry and real life.

Books and References

1. Modern Electronic Instrumentation and Measurement Techniques by A.D. Helfrick and W.D. Cooper, Prentice-Hall of India.
2. Principles of Measurement Systems by J.P. Bentley, Longman.
3. Instrumentation Measurements & Analysis by B. C. Nakra and K. K. Chaudhry, McGraw Hill.
4. Instrumentation Devices and Systems by C. S. Rangan, G. R. Sharma and V. S. V. Mani, Tata McGraw-Hill.

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Course Name: **Analog & Digital Electronics** Course Code: **PH-322** Course Type: **Discipline Core**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • An ability to understand analog and digital electronics. • An understanding of concepts of Junctions devices, amplifiers and logic families. • The broad education necessary to understand analog and digital electronics.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	**Amplifiers:** Classification of amplifiers: Class A, Class B, Class C amplifiers, Two stage R-C coupled and Transformer coupled amplifier along their frequency response curves.	**6L**
UNIT-02	**Oscillators:** Feedback in amplifiers, Barkhausen Criterion for Oscillations, Sinusoidal oscillator and Non-Sinusoidal oscillator, Tuned collector and Hartley Oscillators.	**6L**
UNIT-03	**Operational Amplifiers**: Inverting and Non-Inverting amplifier, arithmetic circuits: Summing, Subtractor, differentiator and integrator circuits, gain vs frequency plot for Op-Amp, Slew rate.	**6L**
UNIT-04	**Digital Electronics:** Review of number systems and their inter conversion, Logic Gates, A/D and D/A converters.	**6L**
UNIT-05	**Sequential Circuits & Memories:** Flip-flop, RS flip-flop, Edge-triggered flip flops, JK Flip flop, 555 timer-Astable, 555 timer-Monostable, registers, counters. Read only memory (ROM), EPROM, Flash, static and dynamic random access memories	**6L**
UNIT-06	**Communication:** Concepts of Modulation, Amplitude modulation, frequency modulation and Pulse modulation, De-modulation, Antenna and wave propagation.	**6L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Describe the electronic devices and their applications. CO2: Identify the applications of junction devices, amplifiers and logic circuits. CO3: Learn and to apply concepts learnt in analog and digital electronics in real life. CO4: Learn the idea of logic families and their importance in advancement of technologies.		
Books and References 1. Microelectronic Circuits by S. Sedra and K. C. Smith, Oxford University Press. 2. Op-Amps and Linear Integrated Circuits by R. A. Gaykwad, Prentice- Hall of India. 3. Digital Principles and Applications by D. P. Leach, A. P. Malvino and G. Saha, Tata McGraw Hill. 4. Digital Design - Principles and Practices by J. F. Wakerly, Prentice Hall of India. 5. Antenna and Wave Propagation by K D Prasad, Satya Prakshan New Delhi 6. Electronic Communication Systems by G. Kennedy, Mc Graw Hill Education Publisher.		

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Course Name: **Lasers and Photonics**
Course Code: **PH-323**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand a Laser system and photonics.
- An understanding of concepts of Lasers and photonics.
- The broad education necessary to understand the working of laser and photonics.
- A knowledge of concepts like nonlinear optics and acousto-optics.

Unit Number	Course Content	Lectures
UNIT-1	Light Matter Interaction: Quantum theory for the evaluation of the transition rates and Einstein's coefficients, interaction of matter with radiation having broad spectrum, interaction of near monochromatic radiation with an atom having broad frequency response.	**6L**
UNIT-2	Line Broadening: Line broadening mechanisms, homogeneous and inhomogeneous broadening, natural collision and Doppler broadening mechanisms and line shape functions.	**6L**
UNIT-3	Rate Equations: Laser rate equations, two levels, three levels and four levels system, variation of power around threshold, optimum output coupling, quality factor, the ultimate line width of the laser.	**6L**
UNIT-4	Laser Resonators: Optical resonators, modes of a rectangular cavity , modes of a open planar resonators, The quality Factor, The Ultimate linewidth of a laser	**6L**
UNIT-5	Transverse Mode Selection, Longitudinal Mode Selection, Q-switching techniques for Q-switching, mode-locking, various techniques for mode-locking of a laser.	**6L**
UNIT-6	Photonic crystals, Classification of Photonic crystals, applications of Photonic crystals, Liquid crystals, classification of Liquid crystals, applications of Liquid crystals.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the laser systems and their applications.

CO2: Identify the applications of lasers and photonics.

CO3: Learn and to apply concepts learnt in laser and photonics in Industry.

CO4: Learn the idea of optical fiber communications and importance in the advancement of technologies.

Books and Reference

1. Lasers Theory and applications, K. Thyagarajan and A.K. Ghatak, Plenum Publishing Corporation, New York, 1991.
2. Lasers and Non-linear Optics, B.B. Laud, New Age International Publishers.
3. Principles of Lasers, Orzaio Svelto, fifth edition, Springer.

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Course Name: **Artificial Intelligence** Course Code: **PH-341** Course Type: **Discipline Elective-III**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To present an overview of artificial intelligence (AI) principles and approaches. • To develop a basic understanding of the building blocks of AI as presented in terms of intelligent agents: Search, knowledge representation, Knowledge acquisition. • To implement knowledge of AI in some applications.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	**Introduction:** Introduction to AI, AI techniques, level of model, criteria for success, Turing test, Reactive, deliberative, goal-driven, utility-driven, and learning agents Artificial Intelligence programming techniques	**6L**
UNIT-02	**Problem Solving:** Problem as a space, search, production system, problem characteristics, production system characteristics, issues in the design of search programs, Solving problems by searching, Heuristic search techniques, constraint satisfaction problems, stochastic search methods.	**6L**
UNIT-03	**Knowledge Representation and Reasoning-I:** Ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; frame representation.	**6L**
UNIT-04	**Knowledge Representation and Reasoning-II**: Semantic network, predicate logic, resolution, natural deduction, situation calculus, description logics, reasoning with defaults, reasoning about knowledge.	**6L**
UNIT-05	**Representing and Reasoning with Uncertain Knowledge:** Probability, connection to logic, independence, Bayes rule, Bayesian networks, probabilistic inference	**6L**
UNIT-06	**Machine Learning and Knowledge Acquisition:** Overview of different forms of learning, learning decision tress, Learning from memorization, Learning nearest neighbor, naive Bayes, Introduction to Natural language Processing.	**6L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Design a knowledge based system. CO2: Analyze and formalize the problem as a state space, graph, design heuristics and select amongst different search or game based techniques to solve them. CO3: Formulate and solve problems with uncertain information using Bayesian approaches. CO4: Apply knowledge representation, reasoning, and machine learning techniques to real-world problems.		
Books and References 1. Artificial Intelligence: A Modern approach by S. Russell, P. Norvig, Prentice Hall of India. 2. Artificial Intelligence by S. Kaushik, Cengage Learning India Pvt Ltd. 3. Principles of Artificial Intelligence by N.J. Nilsson, Narosa Publishing House. 4. Artificial Intelligence by E. Rich, K. Knight and S.B. Nair, Tata McGraw Hill International. 5. Logic and Prolog Programming by S. Kaushik, New Age International Pvt. Ltd, 2012.		

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Course Name: **Quantum Electronics** Course Code: **PH-342** Course Type: **Discipline Elective-III**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • The goal of this course is to introduce the quantum mechanical concept. • To understand the operation of current nanoelectronics and nanophotonics as well as next generation quantum information processing technologies. • To learn the fundamentals of quantum cryptography.		
Unit Number	**Course Content**	**Lectures**
UNIT-1	**Matrix Formulation in Quantum Mechanics:** Introduction, some basics matrix properties, Transformation of matrix, Matrix diagonalization, Representation of operator as matrices, Eigenvalues and Eigenfunction of operator by matrix method, Matrix element of angular momentum operator, spin angular momenta, addition of angular momentum.	**6L**
UNIT-2	**Electromagnetic field and their quantization:** Maxwell's equations in isotropic medium, Power transport, Storage and dissipation in Harmonic field, Dipolar dissipation in harmonic field, Propagation of EM waves in anisotropic crystal, propagation of EM waves in uniaxial crystals, Quantization of radiation field, Mode density and Blackbody radiations, The coherent state.	**6L**
UNIT-3	**Optical beams and Optical resonators:** Lens waveguides, Propagation of rays by mirror, Rays in lens like medium, Wave equation in quadratic media, The ABCD law, Gain profile, elliptical Gaussian Beam, Spherical mirror resonator, Mode stability criteria, Losses in optical resonator, unstable optical resonator.	**6L**
UNIT-4	**Interaction of radiations and atomic systems:** Density matrix derivation of atomic susceptibility and its significance, Spontaneous and induced transitions, The gain coefficient, The laser oscillation condition, Power output from lasers, Quantum well lasers.	**6L**
UNIT-5	**Introduction to Nonlinear optics:** Nonlinear optical tensor, Non linear field Hamiltonian, electromagnetic formulation of nonlinear interactions, optical second harmonic generation, Second harmonic generation with depleted input, Second harmonic generation with Gaussian input, internal second harmonic generation, Third harmonic generation, stimulated Raman and Brillouin scattering.	**6L**
UNIT-6	**Modulation and Amplification:** Electroopic effect, electro optic retardation, amplitude modulation, phase modulation of light, Bragg's diffraction of light by Acoustic waves, Parametric oscillations and Amplifications, Q-switching and mode locking in laser.	**6L**
Course Outcomes Upon successful completion of the course, the students will be able to CO 1: Students will understand new physical effects. CO 2: Understand the operation of current nanoelectronics and nanophotonics. CO 3: Learn quantum teleportation for processing quantum information. CO 4: Understand basic principles of quantum cryptography.		
Books and References 1. Quantum Electronics by A. Yariv, John-Willey. 2. Optical Electronics by A. K. Ghatak, Cambridge University Press. 3. Laser Fundamentals by T. Silfvast William, Cambridge University Press.		

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Course Name: **Microcontroller & Embedded Systems**
Course Code: **PH-343**
Course Type: **Discipline Elective-III**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To present an overview of Microcontrollers and embedded systems.
- To develop a basic understanding of the related programmings.
- To implement knowledge in embedded software development.

Unit Number	Course Content	Lectures
UNIT-01	**Microcontroller:** Introduction to Microcontrollers, Evolution, Microprocessors vs. Microcontrollers, MCS-51 Family Overview, Important Features, Architecture. 8051 Pin Functions, Architecture, Addressing Modes, Instruction Set, Instruction Types.	**6L**
UNIT-02	**Programming:** Assembly Programming, Timer Registers, Timer Modes, Overflow Flags, Clocking Sources, Timer Counter Interrupts, Baud Rate Generation. Serial Port Register, Modes of Operation, Initialization, Accessing, Multiprocessor Communications, Serial Port Baud Rate.	**6L**
UNIT-03	**Interrupts:** Interrupt Organization, Processing Interrupts, Serial Port Interrupts, External Interrupts, and Interrupt Service Routines. Microcontroller Specification, Microcontroller Design, Testing, Timing Subroutines, Look-up Tables, Serial Data Transmission.	**6L**
UNIT-04	**Introduction to Embedded Systems:** Background and History of Embedded Systems, Definition and Classification, Programming languages for embedded systems: desirable characteristics of programming languages for embedded systems, Low-level versus high-level languages, Main language implementation issues: control typing. Major programming languages for embedded systems. Embedded Systems on a Chip (SoC), IP Cores and the use of VLSI designed circuits.	**6L**
UNIT-05	**Embedded software development:** Software development flow, polling, interrupt driven, multi-tasking systems, data types in C programming, Inputs, outputs and peripheral accesses, microcontroller interfaces. Architecture of an RTOS, Important features of RTOS, Embedded Systems Programming, Locks and Semaphores, Operating System Timers and Interrupts, Exceptions, Tasks. Task states and scheduling, Task structures, Synchronization, Communication and concurrency, Semaphores, Real-time clock and system clock.	**6L**
UNIT-06	**32-Bit Cortex-M Architecture:** Technical overview, Important features, Instruction set, Memory system, exceptions and interrupts, exception handling, low power and system control features. Development with Keil and mbed.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Able to understand microcontrollers and embedded systems.
CO2: Acquire a basic knowledge about programming and system control to perform a specific task.
CO3: Develop programming skills in embedded systems for various applications.

Books and References

1. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 processors, third edition, Newnes publication.
2. Mazidi Muhammad Ali, The 8051 Microcontroller and Embedded Systems, second edition, Pearson publications.
3. Jonathan W. Valvano, Volume 1, Introduction to ARM Cortex-M Microcontrollers (fifth edition, CreateSpace).
4. Jonathan W. Valvano, Volume 2, Real-Time Interfacing to ARM Cortex-M Microcontrollers (fourth edition, CreateSpace).
5. Jonathan W. Valvano, Volume 3, Real-Time Operating Systems for ARM Cortex-M Microcontrollers (second edition, CreateSpace).

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Course Name: **Microprocessor Architecture and Applications** Course Code: **PH-361** Course Type: **Discipline Elective-IV**	
Contact Hours/Week: **3L**	Course Credits: **03**

Course Objectives:

- To impart knowledge about the architecture and instruction set of a typical 8-bit microprocessor.
- To introduce the fundamental concepts relevant to understanding of Assembly Language, Timers, Interrupts.
- To enable the students to understand Input-output techniques and important programmable support chips used in microprocessor-based systems are discussed in detail.

Unit Number	Course Content	Lectures
UNIT-01	Introduction to Microprocessors: History and Evolution, types of microprocessors, Microcomputer Programming Languages, Microcomputer Architecture, Pipelining, Clocking.	**6L**
UNIT 02	Microprocessor Architecture: Intel 8085 Microprocessor, Register Architecture, Bus Organization, ALU, Control section, ISA of 8085, Instruction format, Addressing modes, Types of Instructions	**6L**
UNIT-03	Assembly Language Programming and Timing Diagram: Assembly language programming in 8085, Macros, Labels and Directives, Microprocessor timings, Micro instructions, Instruction cycle, Machine cycles, T-states, State transition diagrams, Timing diagram for different machine cycles, Memory and I/O interface.	**6L**
UNIT-04	Serial I/O, Interrupts: Serial I/O using SID, SOD, Interrupts in 8085, RST instructions, Issues in implementing interrupts, Multiple interrupts and priorities, Daisy chaining, Interrupt handling in 8085, Enabling, Disabling & masking of interrupts.	**6L**
UNIT-05	Data Transfer techniques: Data transfer techniques, Parallel & Programmed data transfer using 8155, Programmable parallel ports & handshake input/output, Asynchronous and Synchronous data transfer using 8251, PIC (8259), PPI (8255), DMA controller (8257). Interfacing Traffic Light Interface, Stepper Motor, 4 Digit 7 Segment LED, stepper motor and LCD.	**6L**
UNIT-06	16-Bit Microprocessors (Intel 8086): Introduction to a 16 bit microprocessor, Memory address space and data organization, Segment registers and Memory segmentation, Generating a memory address, I/O address space, Addressing modes, Comparison of 8086 & 8088, Basic configurations of 8086/8088, Min. Mode, Max. Mode & System timing, Introduction to Instruction Set of 8086.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the architecture of 8085 and 8086.
CO2: Impart the knowledge about the instruction set.
CO3: Understand the basic idea about the data transfer schemes and its applications.

Books and References

1. Microprocessor Arch., Prog. & Applications with 8085/8080A by R.S. Gaonkar, Wiley Eastern Ltd.
2. Microprocessors & Interfacing by D.V. Hall, McGraw Hill.
3. Microprocessors: Theory & Applications (Intel & Motorola) by M. Rafiquzzman, PHI.
4. INTEL 8086/88, 80186, 286, 386, 486, Pentium Pro & Pentium IV by Berry B. Bray.

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Course Name: **Functional Nanomaterials**
Course Code: **PH-362**
Course Type: **Discipline elective-IV**

Contact Hours/Week: 3L Course Credits: **03**

Course Objectives

- An ability to understand nanomaterials.
- An understanding of concepts of functional materials.
- The broad education necessary to understand properties of materials.
- A knowledge of concepts / technologies based on material use.

Unit Number	Course Content	Lectures
UNIT-1	Synthesis, properties and applications of organic, inorganic, hybrid nanomaterials.	**6L**
UNIT-2	core-shells, nanoshells, self-assembled nanostructures, superlattices, nanoceramics metallic, polymeric and ceramic nanocomposites, nanoporous materials, nanofluids, nanolayers and carbon based nano materials.	**6L**
UNIT-3	Occurrence, production, purification, properties and applications of fullerene, carbon nanotube, graphene, carbon onion, nanodiamond and films, transition metal dichalcogenides (TMDCs) & oxides, MXenes.	**8L**
UNIT-4	Introduction to biomimetics, mimicking mechanisms found in nature, synthesis and applications of bioinspired nanomaterials and self-assemblies Applications of nanomaterials.	**6L**
UNIT-5	Application of nanomaterials in healthcare, biosensors, coatings environment, catalysis, agriculture, automotives, sensors, electronics, photonics, information technology, quantum computing, energy and aerospace sectors.	**6L**
UNIT-6	Application of nanomaterials in Optoelectronics.	**4L**

Course Outcomes: Upon successful completion of the course, the students will be able to
CO1: learn the application of functional materials.
CO2: identify the properties of functional materials.
CO3: understand to apply the use of materials in the Industry.

Books and References

1. Nanoscale Materials in Chemistry by K. J. Klabunde, and R.M. Richards, John Wiley & Sons.
2. Nano: The Essentials by T. Pradeep, McGraw-Hill.
3. Handbook of Nanotechnology by Bharat Bhushan, Springer.
4. Nanostructured Materials: Processing Properties and Applications by C. Koch Carl, William Andrew Inc.
5. Carbon Materials and Nanotechnology by Anke, Krueger, Wiley-VCH Verlag GmbH & Co. KGaA.

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Course Name: **Low Dimensional Physics**
Course Code: **PH-363**
Course Type: **Discipline Elective-IV**

Contact Hours/Week: 3L — Course Credits: **03**

Course Objectives

- An ability to understand low dimension system.
- An understanding of concepts of low dimension system.
- The broad education necessary to understand the physics of low dimensional system.
- A knowledge of complex systems.

Unit Number	Course Content	Lectures
UNIT-1	**Introduction:** Summary of key properties of semiconductors and motivation for low dimensional structures, Potential wells in semiconductor heterostructures; transport, Concepts of 2D nanostructures (quantum wells),1D nanostructures (quantum wires) 0D nanostructures (quantum dots), Quantum mechanical treatment of quantum wells, wires and dots.	**6L**
UNIT-2	**Nanoclusters and Nanoparticles:** Introduction, bulk to nano transition, metal nanoclusters, magnetic clusters, semiconducting nanoparticles, magic numbers, geometric structures, electronic structure, molecular clusters, fullerenes, carbon nanotubes, graphene.	**6L**
UNIT-3	**Band structure and density of states at nanoscale:** Energy bands, density of states at low-dimensional structures, quantum confinement – semiconductors, quantum wells, quantum wires, quantum dots, density of states for low dimensional systems, quantized conductance, conductance behavior of quantum point contact; quantum Hall effect, screening and collective excitations in low dimensional systems, Coulomb blockade, Kondo effect, superconducting dots, single electron transistor (SET).	**6L**
UNIT-4	**Basics of electron transport**: Two dimensional electron gas, characteristic length scales, ballistic and diffusive transport, confinement and quantization of electronic states in quantum wires and quantum dots, quantum point contact, Landauer-formalism, ballistic FET.	**6L**
UNIT-5	**Magnetic field effect:** Magnetic field effect on low dimensional materials, Magnetic nanostructures-magnetism in small and nanoparticles, superparamagnetism, introduction to spintronics, spin valve, magnetic tunnel junction, memory elements.	**6L**
UNIT 6	**Applications of nanotechnology:** LEDs, CNT and Graphene based Electronic devices - transistor based sensors, Optoelectronics: Semiconductor Quantum dots (QDs) – QD LASER- Quantum cascade LASER-QD, Storing and reading device, current trends of spin based electronic devices, Nanosensors.	**6L**

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Describe the low dimension system.
CO2: Identify the applications of low dimension system.
CO3: Write down the concepts related to low dimension system.

Books and References

1. The Physics of Low-dimensional Semiconductors: An Introduction by J. H. Davies, Cambridge Uni Press.
2. The textbook of Nanoscience and Nanotechnology by T. Pradeep, Tata McGraw Hill.
3. Materials Characterization by Leng Yang, Wiley-VCH.
4. Nanoscience and Nanoengineering: Advances and Applications, Ajit D. Kelkar, Daniel J.C. Herr, James G. Ryan, CRC Press.
5. Nanostructures & Nanomaterials: Synthesis, Properties & Applications, G. Cao, Imperial College Press.

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Course Name: **Introduction to Quantum Computing**
Course Code: **PH-364**
Course Type: **Discipline Elective-IV**

Contact Hours/Week: 3L | Course Credits: **03**

Course Objectives

- An ability to understand a quantum system.
- An understanding of concepts of quantum computing.
- The broad education necessary to understand quantum computing.
- A knowledge of concepts / technologies like quantum computing.

Unit Number	Course Content	Lectures
UNIT -1	**Introduction to Quantum Computation:** Quantum bits, Bloch sphere representation of a qubit, multiple qubits.	**6L**
UNIT -2	**Background Mathematics and Physics:** Hilber space, Probabilities and measurements, entanglement, density operators and correlation, basics of quantum mechanics, Measurements in bases other than computational basis.	**6L**
UNIT -3	**Quantum Circuits:** single qubit gates, multiple qubit gates, design of quantum circuits.	**6L**
UNIT -4	**Quantum Information:** Comparison between classical and quantum information theory. Bell states, Quantum teleportation.	**6L**
UNIT -5	**Cryptography:** Introduction to cryptography. Quantum Cryptography, no cloning theorem.	**6L**
UNIT -6	**Quantum Algorithms:** Classical computation on quantum computers. Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search.	**6L**

Course Outcomes:
Upon successful completion of the course, the students will be able to
CO1: Describe the Optical devices and their applications.
CO2: Identify the applications of quantum computing.
CO3: Understand the concepts related to quantum computing.
CO4: Learn and to understand the use of quantum computing.

Books and References

1. Quantum Computation and Quantum Information by M. A. Nielsen, Cambridge University Press.
2. Principles of Quantum Computation and Information by G. Benenti, G. Casati and G. Strini, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific.
3. An Introduction to Quantum Computing Algorithms by A. O. Pittenger, Springer.

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Course Name: **Fundamentals of Semiconductor Devices**

Course Code: **PH-381**

Course Type: **Stream Core (SC)-I**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To understand the fundamental concepts of semiconductor physics.
- To understand conduction mechanisms in semiconductors.
- To enable the students to understand the various problems of semiconductors.

Unit Number	Course Content	Lectures
UNIT-01	**Basic of semiconductors:** Density of states, energy bands, intrinsic and extrinsic semiconductors, Fermi level, carrier concentration in conduction and valence bands, temperature dependence of carrier concentration, effective mass, mobility, diffusion constant, drift and diffusion currents, conduction mechanisms, metal-semiconductor contacts.	**8L**
UNIT-02	**Junction Devices:** PN Junction, built-in potential, depletion region, forward and reverse biasing, current-voltage characteristic, p-n junction capacitance, metal-semiconductor ohmic and Schottky contact, tunnel diode, LED and Laser diode, photodiode.	**8L**
UNIT-03	**Multijunction devices:** BJT, CE, CB, CC configurations (Input-output characteristics) and FET, JFET, MESFET (Enhancement and Depletion type), MOS structure (accumulation, depletion, and inversion cases), MOSFET, p-n-p-n thyristor and SCR.	**8L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Know about semiconductor materials, important discoveries, and their impact on our society.

CO2: Understand concepts of junction devices.

CO3: Apply the knowledge for device applications.

CO4: Apply knowledge of semiconductor manufacturing to real-world applications.

Books and References

6. Semiconductor Physics and Devices by D.A. Neamen and D. Biswas, McGraw Hill Education (India).
7. Semiconductor Materials and Devices by M. S. Tyagi Wiley.
8. Solid State Electronics by B. G. Streetman.
9. Semiconductor Devices by S. M. Sze.
10. Semiconductor Devices: An Introduction by Jasprit Singh, McGraw-Hill International Edition.

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Course Name: **Basics of Rocket Propulsion** Course Code: **PH-382** Course Type: **Stream Core (SC)-I**		
Contact Hours/Week: **2L**		Course Credits: **02**
Course Objectives • Describe various types of propulsion system with their merits of challenges. • Identify the working concept of a nozzle with their applications in a propulsion system. • Generate sufficient information about the thrust chamber and their associated parameters along with their significance in practical applications.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	Jet Propulsion and Rocket Propulsion – Definition, Principle, Classification, Description and Application; Electrical, Nuclear and other Advanced Propulsion Systems, Application and Classification of various Propellant Rocket Motors and Characteristics.	**8L**
UNIT-02	Nozzle Theory: Ideal Rocket; Isentropic Flow through Nozzles; Exhaust Velocity; Choking; Nozzle Types; Nozzle Shape; Nozzle Area Expansion Ratio; Under-expansion and Overexpansion; Nozzle Configurations; Real Nozzles; Multiphase Flow.	**8L**
UNIT-03	Thrust and Thrust Chambers: Thrust Equation; Specific Impulse, Thrust Coefficient, Characteristic Velocity and other Performance Parameters; Thrust Chambers; Methods of Cooling of Thrust Chambers; Steady State and Transient Heat Transfer; Heat Transfer Distribution; Steady State Heat Transfer to Liquids in Cooling Jackets; Uncooled Thrust Chambers.	**8L**
Course Outcomes Upon successful completion of the course, the students will be able to: CO1: Analyse the propulsion system along with the advanced propulsion system. CO2: Explain the fundamental concept of a nozzle along with their designing challenges. CO3: Comprehend and illustrate the basics of thrust chamber in terms of their designing approach.		
Books and References 1. Rocket Propulsion Elements, Sutton, G.P., Biblarz, O., 7thEd. John Wiley & Sons, Inc., New York, 2001. 2. Rocket Propulsion, Barrere, M., Jaumotte, A., Fraeijs de Veubeke, B.,Vandenkerckhove J., Elsevier Publishing Company, 1960. 3. Rocket and Spacecraft Propulsion: Principle, Practice and New Developments, Turner, M. J. L., Springer Verlag. 2000. 4. Understanding Chemical Rocket Propulsion, Mukunda, H.S., Interline Publishing, 2017. 5. Rocket Propulsion, Ramamurthi, K., 2nd Edition, Trinity Press of Laxmi Publications Private Limited, India, 2016.		

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Course Name: Machine Learning in Physics
Course Code: PH-383
Course Type: Stream Core -I

Contact Hours/Week: 2L **Course Credits:** 02

Course Objectives

- To introduce the basics of Machine Learning to the students.
- To make students familiar with different machine learning techniquess using datasets.
- To make students realise the role of machine learning in massive scale automation.

Unit Number	Course Content	Lectures
Unit-1	Introduction: Machine Learning, Feature sets, Dataset division: test, train and validation sets, cross validation, Data handling-missing data, feature scaling, Dimensionality reduction-principal component analysis.	8L
Unit-2	Basics of machine learning: Applications of Machine Learning, processes involved in Machine Learning, Introduction to Machine Learning Techniques: Supervised Learning, Unsupervised Learning and Reinforcement Learning, bias-variance trade- off, overfitting-underfitting	8L
Unit-3	Decision trees: Representing concepts as decision trees, Recursive induction of decision trees, best splitting attribute: entropy and information gain, Overfitting, noisy data, and pruning.	8L

Course Outcomes

Upon successful completion of the course, the students will be able to:
CO 1: Understand basic concepts and applications of machine learning.
CO 2: Compare and Analyze various machine learning algorithms.
CO 3: Apply various machine learning algorithms to a variety of physics problems.

Books and References

1. Machine Learning: The New AI, By Ethem Alpaydin, The MIT Press, 2016.
2. Machine Learning, Tom M. Mitchell, McGraw Hill Education, 2017.
3. Ethem Apaydin, Introduction to Machine Learning, 2e. The MIT Press, 2010.
4. Kevin P. Murphy, Machine Learning: a Probabilistic Perspective, The MIT Press, 2012.
5. Machine Learning for Dummies, By John Paul Mueller and Luca Massaron, For Dummies, 2016.

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Course Name: **Electromagnetic Wave Propagation**
Course Code: **PH-384**
Course Type: **Stream Core -I**

Contact Hours/Week: 2L **Course Credits: 02**

Course Objectives
• To introduce the basic formulation of propagation of electromagnetic waves to the students.
• To make students familiar with basic principles involved in reflection and propagation of electromagnetic waves.
• To make students understand the role of optics in optical Engineering.

Unit Number	Course Content	Lectures
Unit-1	Reflection of Electromagnetic waves: Introduction, reflection at the interface of two homogeneously nonabsorbing dielectrics, Total internal reflection and evanescent waves, reflection and transmission by a film, extension to two films, interference filters, periodic media.	8L
Unit-2	Introduction: Controlling the properties of the materials, Photonic Crystals, Macroscopic Maxwell's equations, Electromagnetism as an eigenvalue problem, General properties of the Harmonic modes, electromagnetic energy and the Variational Principle, effects of small perturbations, scaling properties of Maxwell's equations.	8L
Unit-3	Symmetries and Solid State Electromagnetism: Using symmetries to classify the electromagnetic modes, Continuous translational symmetry, Index guiding, discrete translational symmetry, Photonic band structures, symmetry, and the irreducible Brillouin Zone, Mirror symmetry, and separation of modes.	8L

Course Outcomes
Upon successful completion of the course, the students will be able to:
CO 1: Understand basic concepts and applications of electromagnetic waves.
CO 2: To understand Maxwell's equation in different forms and different media.
CO 3: To understand electromagnetic wave propagation in different environment.

Books and References
1. Photonic Crystals: Molding the Flow Light by John D. Joannopoulos, Stevon G.Johnson, Joshua N. Winn, Robert D. Meade, Princeton University Press, 2008.
2. Photonic Crystals, Theory, Applications and Fabrication by Dennis W Prather, Ahmed Sharkawy, Shouyuan Shi, Janusz Murakowski, Garrett Schneider, Wiley Publisher Pvt. Ltd.
3.Optical Electronics by Ajoy Ghatak and K. Thyagarajan, Cambridge University Press, 1991.

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Course Name: **Fundamentals of Energy Engineering**
Course Code: **PH-385**
Course Type: **Stream Core (SC)-I**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To introduce various energy sources and its challenges.
- To provide a broad overview of the technological developments in the field of energy.
- To envisage future pathways for energy sector development and management.

Unit Number	Course Content	Lectures
UNIT-01	Introduction to various energy resources, energy consumption pattern in different sectors, power generation using steam turbine power plant, gas turbine power plant, internal combustion engines and fuel cell, associated limitations, challenges and environmental effects.	**8L**
UNIT-02	Unconventional and renewable energy sources and technologies such as nuclear power plants, solar power plants (Photovoltaic and Thermal), wave and tidal power, hydrogen energy, hydro-power plant, wind power plant, bioenergy and power generation etc.	**8L**
UNIT-03	Fundamental and applied concepts of energy for strengthening of sustainable energy and environment, thermal and electrical utilities, energy flow and Sankey diagram, measures of energy efficiency improvements, demand and supply analysis, life cycle assessment, and emerging issues in the built environment.	**8L**

Course Outcomes

Upon successful completion of the course, the students will be able to:
CO1: Explain various energy related systems, resources and their associated challenges.
: Explain the fundamentals of different energy conversion systems.
CO3: Understand the recent technological development in the field of energy and future direction.

Books and References

1. Twidell J. and Weir T., Renewable Energy Resources, 3rd Edition, Routledge, 2015.
2. Fowler J. M., Energy and the Environment, McGraw Hill, 2nd edition, New York, 1984.
3. Cheng J., Biomass to Renewable Energy Processes, CRC Press; 1st Edition, 2019.
4. Nag, P. K., Power Plant Engineering, McGraw Hill Education, 4th Edition, 2017.
5. Culp A. W. Jr., Principles of Energy conversion, McGraw Hill. 1996.
6. Johannson T. B., Kelly H., Reddy A. K. N. and Williams R. H. (Ed), Renewable Energy: sources for fuel and electricity, Island Press, Washington DC, 1993.
7. Kothari D. P., Sharma D. K., Energy Engineering: Theory and Practice, S. Chand Publisher, 2000.

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Course Name: **Digital Electronics Lab**
Course Code: **PH-325**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

1. To gain practical knowledge by applying the experimental methods to correlate with the Physics theory.
2. To learn the usage of electrical and optical systems for various measurements.
3. Apply the analytical techniques and graphical analysis of the experimental data.
4. To develop communication skills and discuss the basic principles of scientific concepts in a group.

List of Experiments

1. To understand AND, OR, NOT and XOR gates operations.
2. To study the MOSFET characteristics.
3. To minimize a given logic circuit.
4. To design an astable multivibrator of given specifications using 555 Timer.
5. To design a monostable multivibrator of given specifications using 555 Timer.
6. To study IV characteristics of PN diode, Zener and Light emitting diode.
7. To study the characteristics of a Transistor Junctions.
8. To design a CE amplifier of a given gain (mid-gain) using voltage divider bias.
9. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.
10. To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.
11. To study a precision Differential Amplifier of given I/O specification using Opamp.
12. To investigate the use of an op-amp as a Differentiator.
13. To design a Wien Bridge Oscillator using an op-amp.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Apply the various procedures and techniques for the experiments.
CO2: Use the different measuring devices and meters to record the data with precision.
CO3: Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.

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Course Name: **Lasers and Photonics Lab** Course Code: **PH-326** Course Type: **Discipline Core**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To gain practical knowledge by applying the experimental methods to correlate with the Physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- Apply the analytical techniques and graphical analysis of the experimental data.
- To develop communication skills and discuss the basic principles of scientific concepts in a group.

List of Experiments

5. Examine the spatial and optical filtering of Laser
6. Characteristics study of Diode Laser.
7. Characteristics study LED and Laser.
8. Measurement of light using Precision interferometer (Michelson interferometer)
9. Study of Fabry Perot interferometer
10. Study of Mach-Zender interferometer
11. Study of low coherence interferometry for biological and material structure.
12. Measurement of optical parameters of single/ multimode optical fiber using Optical fiber kit.
13. Recording / reconstruction of Hologram using holographic interferometry.
14. Optical microscope for study of various kinds of samples.
15. To develop the different crystal structures using a laser beam.
16. To study the emission spectra of optical materials.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the various procedures and techniques for the experiments.
CO2: Use the different measuring devices and meters to record the data with precision.
CO3: Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results.

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Course Name: **Thermodynamics and Statistical Physics** Course Code: **PH- 410** Course Type: **Minor Degree Core**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • An ability to understand the fundamentals of thermodynamics and statistical mechanics. • Understand the concept of thermodynamics and its applications to magnetism, black body radiation and phase transition. • To introduce the fundamental concepts relevant to thermodynamic potentials, probability, classical and quantum statistics.		
Unit Number	**Course Content**	**Lectures**
UNIT-1	**Thermodynamics:** Macroscopic and microscopic coordinates, Extensive and intensive variables, Thermal equilibrium, The laws of thermodynamics and their consequences, Thermodynamic potentials and Maxwell's relations, Chemical Potential, TdS and energy equations	**6L**
UNIT-2	**Probability and Kinetic theory:** The macroscopic and microscopic states, Postulate of equal a priori probability, Probability densities, connection between statistics and thermodynamics, classical ideal gas, Gibbs' paradox, Phase space, Liouville's theorem and its consequences.	**6L**
UNIT-3	**The Classical Ensemble Theory:** Boltzmann equation transport phenomena. Classical Statistical Mechanics: Postulates; Microcanonical, canonical, and grand canonical ensembles, partition functions, fluctuation of energy and density, Equipartition and virial theorems	**6L**
UNIT-4	**Applications of ensemble theory**: Ideal gas and one dimensional simple harmonic oscillator in microcanonical ensemble, Ideal gas, system of harmonic oscillators and statistics of paramagnetism in canonical ensemble.	**7L**
UNIT-5	**Quantum Statistics**: Statistical mechanics of Bosons, Fermions, Bose-Einstein condensation, Blackbody radiation and Planck's law of radiation, low-temperature behavior of Bose gas	**6L**
UNIT-6	**Phase Transition and Critical Phenomenon**: First and second order phase transitions, Ising model, Critical phenomena, Introduction to Landau theory of phase transitions.	**5L**
Course Outcomes Upon successful completion of the course, the students will be able to: CO1: Identify the link between statistics and thermodynamics, classical and quantum statistics and its applications. CO2: Describe problems like an ideal gas, transport phenomenon, critical phenomenon and blackbody radiation. CO3: Apply principles to explain Gibbs' paradox, magnetism, and phase transitions. CO4: Assess the results obtained by solving the above problems		
Books and References Heat and Thermodynamics by M. W. Zemansky and R. Dittman McGraw Hill Co., NewYork. Statistical Mechanics by R. K. Pathria, Pergamon, Oxford. Statistical Mechanics by K. Huang, Wiley Eastern, New Delhi. Elementary Statistical Physics by C. Kittel, Wiley Eastern, New Delhi. Statistical Mechanics by B.K. Agarwal and M. Eisner, Wiley Eastern, New Delhi. Introduction to Modern Statistical Mechanics by D. Chandler, Oxford University Press, New Delhi.		

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Course Name: **Materials Synthesis and Characterization**
Course Code: **PH-411**
Course Type: **Discipline Core**

Contact Hours/Week : **3L** Course Credits: **03**

Course Objectives

- An ability to understand a material synthesis.
- An understanding of concepts of material characterization.
- The broad education to understand the different concepts of material synthesis.

Unit Number	Course Content	Lectures
UNIT-1	**Synthesis techniques (Physical methods):** Top down and bottom up approaches to produce nanomaterials. mechanical methods, evaporation methods, sputter deposition, electric arc deposition, laser ablation, laser pyrolysis and ion beam techniques, molecular beam epitaxy.	**6L**
UNIT-2	**Synthesis techniques (Chemical methods):** chemical vapour deposition method, Growth of nanoparticles, colloids and Colloidal techniques, Sol-gel method, Langmuir-Blodgett method.	**6L**
UNIT-3	**Structural analysis:** UV-Vis, IR and Raman spectroscopy, Photoluminescence (PL) spectroscopy.	**6L**
UNIT-4	**Microscopy techniques**: scanning electron microscopy (SEM) , electron microscopy, EDAX analysis, scanning probe microanalysis, atomic force microscopy (AFM) and scanning tunneling microscopy (STM).	**6L**
UNIT-5	**Surface analysis techniques**: X-ray photoelectron spectroscopy (XPS), Ultraviolet photoelectron spectroscopy (UPS), Auger electron spectroscopy (AES) & Scanning auger microprobe (SAM), Secondary ion mass spectroscopy (SIMS), Electron spectroscopy for chemical analysis (ESCA), Scanning probe microscopy (SPM), Atomic force microscopy (AFM)	**6L**
UNIT-6	**Thermal analysis:** Principle of thermal analysis, differential thermal analysis, differential scanning calorimetry DSC/DTA/TGA), Dilatometer, thermogravimetric analysis, differential thermogravimetric analysis.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand methods for synthesis of different materials.

CO2: Identify the structure of materials by different techniques.

CO3: to apply concepts learnt in material synthesis to industrial applications.

Books and References

1. Materials Science of thin films: Deposition and structures by O. Milton, Academic press.
2. Nano Materials by A.K. Bandyopadhyay, New Age International Publishers, New Delhi.
3. Nanomaterials- Synthesis, Properties and Applications by A. A. Edelstein and R. C. Cammarata, Institute of Physics Publishing, London.
4. Nanotechnology: Principles and Practices by Sulabha K. Kulkarni, Capital Publishing Company.

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Course Name: **Physics of Nanosystems** Course Code: **PH-412** Course Type: **Discipline Core**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • An ability to understand nanosystems. • An understanding of concepts of nanosystem. • The broad education necessary to understand nanosystem. • A knowledge of the concepts of nanoscale phenomenon.		
Unit Number	**Course Content**	**Lectures**
UNIT-1	**Introduction:** An overview of quantum mechanical concepts related to low dimensional systems, Bulk to nano transition, Characteristic scales in mesoscopic systems, nanoparticles, surface to volume ratio, grain boundary volume, surface energy, lattice contraction in nanostructured materials, semiconductor nanoparticles, Low-dimensional systems, density of states in semiconductor materials, Magic numbers, geometric structure.	**6L**
UNIT-2	**Quantum Size Effect:** Overview of nanostructures, quantum dots, artificial atoms, quantum confinement, weak confinement regime, strong confinement limit, blue shift of band gap, semiconductor quantum dots as zero dimensional electron systems (0 DES).	**6L**
UNIT-3	**Carbon Nanostructures:** Introduction, carbon molecules, carbon clusters, structure of C_{60} and its crystal, small and large fullerenes and other buckyballs, carbon nanotubes and their electronic structure.	**6L**
UNIT-4	**Properties of Nanostructures:** Size dependence of properties, Phenomena and Properties at nanoscale, Mechanical/Frictional, Optical, Electrical Transport, Magnetic properties.	**6L**
UNIT-5	**Synthesis of nanostructures:** Fabrication techniques: Self- Replication, Sol-Gels. Langmuir-Blodgett thin films, Nanolithography, Chemical Vapor Deposition, Chemical methods, Pulse laser deposition, mechanical milling, and self-assembly.	**6L**
UNIT-6	**Applications of Nanotechnology:** Nanoelectronics, Nanosensors, Environmental, Biological, Energy Storage and fuel cells.	**6L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Describe the nanosystem. CO2: Understand the principles of nanosystems. CO3: Learn and apply concepts of nanosystems.		
Books and References 1. Nanomaterials-Synthesis, Properties & Applications by A.A. Edelstein, and R.C. Cammarata, Institute of Physics Publishing, London. 2. Quantum Wells:Physics and Electronics of 2-dimensional systems by Ashik, World Sci.. 3. Nanostructured Carbon for advanced Apps by G. Benedek, Kluwer Acad. Publishers. 4. Quantum Wells,Wires, and Dots; Theoretical and Computational Physics by P. Harrison, John Wiley. 5. Introduction to Nanotechnology by C.P. Poole, and F. J. Owens, Wiley India.		

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Course Name: **Semiconductor Optoelectronic Devices** Course Code: **PH-413** Course Type: **Discipline Core**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • An ability to understand the basic semiconductor optoelectronic devices including LED, laser, photodetector and solar cell. • Impart knowledge about applications of semiconductor optoelectronic devices. • Be familiar with recent trends in optoelectronics.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	Compound semiconductors, bandgap engineering, physics of light emission, optical process in semiconductors, luminescence and absorption of photons.	**6L**
UNIT-02	**Semiconductor Light Sources: Part-I** Semiconductor light sources, Light Emitting Diode (LED), device structure and parameters, device characteristics, LED materials, non-radiative recombination, optical outcoupling, modulation bandwidth, applications of LEDs.	**6L**
UNIT-03	**Semiconductor Light Sources: Part-II** Basic semiconductor laser, population inversion at a junction, heterojunction laser, device Structure, emission spectra, materials for semiconductor lasers, quantum-well laser.	**6L**
UNIT-04	**Semiconductor photodetectors:** General characteristics of photodetectors, characteristic parameters, photoconductors, photodiodes, self-biased photodetectors, electric circuits with photodiodes, applications.	**6L**
UNIT-05	**Solar cells: S**olar radiation, light absorption in semiconductor, antireflection coatings, solar cell design & analysis, I-V characteristics, thin film solar cells, tandem solar cells, related materials.	**6L**
UNIT-06	Organic semiconductors, Organic Light Emitting Diode (OLED), hole injection layer, electron injection layer, hole transport layer, electron transport layer, organic solar cells, advantages and disadvantages of organic devices.	**6L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Describe the semiconductor optoelectronic devices like LEDs, lasers, photodetectors, and solar cells. CO2: Know the applications of these semiconductor optoelectronic devices. CO3: Understand the concept of semiconductor optoelectronic device fabrications.		
Books and References 1. Semiconductor Devices: Physics and Technology by S.M. Sze, 2nd ed., Wiley. 2. Principles of Solar Cells, LEDs and Diodes by Adrian Kitai, Wiley 3. Solar Photovoltaics: Fundamental, Technologies and Applications by Chetan Singh Solanki, PHI. 4. Optical Electronics by A. K. Ghatak and K. Thyagarajan, Cambridge University Press 5. Semiconductor Optoelectronic Devices by Pallab Bhattacharya, 2nd ed., Pearson Education		

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Course Name: **Modern Physics**
Course Code: **PH- 420**
Course Type: **Minor Degree Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand atomic and molecular systems and basics of spectroscopy.
- The broad education necessary to understand the importance of spectroscopy.
- An ability to understand the properties of an atomic nucleus and its stability.
- An understanding of concepts of nuclear physics and engineering.

Unit Number	Course Content	Lectures
UNIT-1	**Review of Single Electron Systems:** Quantum States of One Electron Atom: Atomic orbitals, Hydrogen spectrum, The Pauli Exclusion Principle, Ritz combination principle, Spectra of alkali elements, Spin-Orbit interaction.	**6L**
UNIT-2	**Two Electron Systems:** General characteristics of the energy levels of alkaline earth elements, selection rules, Interaction energy in LS and JJ coupling, Normal and Anomalous Zeeman effect, Paschen Back effect, Stark effect.	**6L**
UNIT-3	**Molecular Systems & Spectroscopy:** Molecular energy states and molecular spectra, Raman effect - Quantum theory, Spectra of diatomic molecules.	**6L**
UNIT-4	**Introduction to Nuclear Physics:** Nuclear shape, size, radii, matter/charge distributions, Nuclear force, Mass defect and binding energy, Nuclear Models, Radioactivity, α-decay, β-decay and γ-decay.	**6L**
UNIT-5	**Nuclear Reaction:** Kinematics, Direct nuclear reaction, Compound nuclear reaction, Nuclear reactors, Nuclear fission and Nuclear fusion; **Nuclear Detectors and Accelerators:** Gas and Semiconductor detectors, Neutron detectors, Particle accelerators and its industrial applications.	**6L**
UNIT-6	**Particle Phenomenology:** Fundamental interactions, Elementary particles and their quantum numbers (charge, lepton number, baryon number, spin, parity, isospin, strangeness, etc.), Gellmann-Nishijima formula, Quark model.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to:
CO1: Describe the electronic and molecular systems and their applications.
CO2: Learn and to apply concepts of spectroscopy in the determination of atomic and molecular parameters.
CO3: Describe the atomic nucleus and its properties.
CO4: Understand the concepts related to nuclear reactions, nuclear detectors and accelerators, and their use in nuclear technologies.

Books and References

1. Physics of atoms and molecules by B.H. Bransden and C.J. Joachain, Pearson Education.
2. Fundamentals of molecular spectroscopy by A.N. Banwell and E.M. McCash, Tata McGraw Hill.
3. Introduction to atomic spectra by L.E. White, McGraw Hill.
4. Nuclear Physics by J. S. Lilley, John Wiley & Sons.
5. Nuclear Physics by S.N. Ghoshal, S. Chand & Comp. Ltd.
6. Particles and Nuclei by B. Povh, K. Rith, C. Scholz and F. Zetsch, Springer.
7. From Nucleons to the Atomic Nucleus by K. Heyde, Springer.

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Course Name: **Laser Measurement Technology**
Course Code: **PH-431**
Course Type: **Discipline Elective-V**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand the importance of lasers in measurement Technology.
- An understanding of the different kinds of interactions.
- A knowledge of concepts / laser technologies used in metrology.

Unit Number	Course Content	Lectures
UNIT-1	**Properties of Laser Radiation:** Optical Metrology and Laser Measurement Technology, Schematic Set-up, Beam Parameters, Diffraction, Measurement of Temporal Coherence, Measurement of Spatial Coherence, Comparison of Laser Radiation and Thermal Light, Description of the Gaussian Beam, Higher Transverse Modes, Beam Parameters of Specific Laser Systems, Dangers of Laser Radiation.	8L
UNIT-2	**Interaction of Laser Radiation and Matter**: Reflection and Refraction at a Plane Interface, Reflection at Rough Surfaces, Classical Absorption, Non-linear Absorption, Two-Photon Absorption, Frequency Doubling, Optical Doppler Effect.	7L
UNIT-3	**Beam Shaping and Guiding:** Optical Elements for Beam Modulation**,** Propagation of Gaussian Beams.	5L
UNIT-4	**Laser Interferometry**: Fundamentals of Interferometry, Distance Measurement Using Laser Interferometers.	5L
UNIT-5	**Light Detection and Ranging**: Differential Absorption LIDAR, Signal Processing, Measuring Range, Examples of Applications.	5L
UNIT-6	**Laser-Induced Fluorescence:** Fluorescence Spectroscopy, Fluorescence Markers, Fluorescence Correlation Spectroscopy, Fluorescence Polarization Spectroscopy., Time-Resolved Fluorescence Analytics, Examples of Applications.	6L

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the laser systems and their applications.

CO2: Identify the applications of lasers in the advanced measurement systems.

CO3: Learn the concepts of laser and its industrial need.

CO4: Learn the interaction of laser with matter and laser-induced fluorescent systems.

Books and References

1. Laser Measurement Technology: Fundamentals and Applications, Axel Donges, Reinhard Noll, Springer-Verlag Berlin Heidelberg (2015)..
2. M. Born, E. Wolf, A.B. Bhatia, P.C. Clemmow, D. Gabor, A.R. Stokes, A.M. Taylor, P.A. Wayman, W.L. Wilcock, Principles of Optics (Cambridge University Press, Cambridge,(2003).
3. C. Janzen, R. Noll, Laser-induced fluorescence, in Tailored Light ,Springer, Berlin, (2011)..

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Course Name: **Optical Fiber Communication**
Course Code: **PH-432**
Course Type: **Discipline Elective-V**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand an optical communication system.
- An understanding of concepts of optical communication.
- The broad education necessary to provide knowledge about optical communication.
- A knowledge of concepts / technologies of optics.

Unit Number	Course Content	Lectures
UNIT-1	**Optical Fibers- Basics:** Light propagation through fiber, Types of optical fibers, Basic concept of modes, Intermodal dispersion, Bitrate and bandwidth, Attenuation and losses in optical fibers.	**6L**
UNIT-2	Propagation of EM waves in optical waveguides, concept of TEM, TE, and TM waves hybrid and linearly polarized modes, material dispersion, dispersion and bandwidth.	**6L**
UNIT-3	**Optical sources and transmitters**: Basic principles of LEDs and LDs, modulation characteristics and drive, circuits block diagram and circuit of a transmitter.	**6L**
UNIT-4	**Optical detectors and receivers:** Concept of light detection, photo-diodes, power relationship and bandwidth, responsivity and quantum efficiency of a photodetector, p-i-n photodiode, metal-semiconductor-metal photodetectors, performance characteristics, receiver performance , circuits block diagram and circuit of a receiver.	**6L**
UNIT-5	**Fiber materials, fabrication:** Fiber materials, fabrication techniques, fiber optic cables and connection techniques, Fiber alignment and joint loss.	**6L**
UNIT-6	**Components of optical fiber networks**: Transceivers, semiconductor optical amplifiers, erbium doped fiber amplifiers, multiplexures and de-multiplexures, filters, isolators, circulators, attenuators, repeaters, wavelength converters.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand principles and working of optical communication and devices.
CO2: Identify the applications of optical fiber communication.
CO3: Identify applications related to optical communication.
CO4: Learn to use optical communication techniques and idea of optical fiber communication.

Books and References

1. Fiber-Optic Communication Technology by Djafer K. Mynbaev and Lowell L. Scheiner, Pearson Education
2. Optical Fiber Communications: Principles and Systems by A Selvarajan, S. Kar and T. Srinivas.
3. Optical Fiber Communication by Gerd Keiser, Mc Graw Hill Publication.
4. Optical Fiber Communications Principles and Practiceby John M. Senior Pearson, Prentice Hall.
5. Optical Fiber Communications: Principles and Practice by Edition by S. John, Pearson Education.

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Course Name: **Thin Film Technology**
Course Code: **PH-433**
Course Type: **Discipline Elective-V**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand the physics of thin films.
- Understanding concepts of thin film formation.
- The broad education necessary to understand the use of thin film devices.
- A knowledge of concepts/technologies based on thin film techniques.

Unit Number	Course Content	Lectures
UNIT-01	**Vacuum generation:** Basic terms and concepts; Continuum and Kinetic gas theory, Pressure ranges, Types of flow; Conductance. Vacuum pumps – a survey, Principle of operation, Diaphragm pump, Rotary pump, Diffusion Pump, Turbomolecular Pump (TMP), Sputter-ion pumps, Cryogenic Pump.	**7L**
UNIT-02	**Vacuum gauges:** Thermal conductivity vacuum gauges, Ionization vacuum gauges. Analysis of gas at low pressures: Residual gas analyzers, Quadrupole mass spectrometer. Leaks and their detection.	**7L**
UNIT-03	**Thin Film Fabrication:** Nucleation and Growth: Film formation and structure; Thermodynamics of nucleation, Nucleation theories, Capillarity model – homogeneous and heterogeneous nucleations, Atomistic model – Walton-Rhodin theory; Post-nucleation growth; Deposition parameters; Epitaxy; Thin film structure, Structural defects and their incorporation.	**7L**
UNIT-04	**Thin Film Fabrication methods-I:** Physical Vapor Deposition (PVD)- thermal evaporation, electron beam evaporation, rf-sputtering, Pulsed Laser deposition (PLD).	**4L**
UNIT-05	**Thin Film Fabrication methods-II:** Electrochemical Deposition (ECD), Spin coating, Chemical Vapor Deposition (CVD), Plasma-Enhanced CVD, Atomic Layer Deposition (ALD), Molecular Beam Epitaxy (MBE).	**5L**
UNIT-06	**Thickness measurement and monitoring:** Electrical, mechanical, optical interference, microbalance, quartz crystal methods	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Learn the formation and growth of thin films.
CO2: Identify the applications of thin films.
CO3: Understand the concepts related to thin film properties.
CO4: Describe the devices based on thin films.

Books and References

1. Fundamentals of Vacuum Technology by Walter Umrath, Leybold Vacuum.
2. Handbook of Vacuum Science and Technology by Dorothy M. Hoffman, 1st ed., Elsevier.
3. Vacuum Science, Technology & Applications by Pramod K. Naik, 1st ed., CRC Press.
4. Material Science of Thin Films by Milton Ohring, 2nd ed., Elsevier.
5. Handbook of Thin Film Technology, Hartmut Frey, Hamid R. Khan, Springer.
6. Thin Film Processes, John L. Vossen & Verner Kern, 1st ed., Elsevier.

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Course Name: **Semiconductor Fabrication Techniques**
Course Code: **PH-451**
Course Type: **Stream Core-II**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives:

- To make students aware of the processes used to make semiconductors.
- To enable students to understand techniques of semiconductor device fabrication.
- To enable students to understand the concept of semiconductor manufacturing processes.

Unit Number	Course Content	Lectures
UNIT-01	**Crystal growth and wafer preparation:** Czochralski, Bridgman and Float zone techniques of materials purification and crystal growth, epitaxial growth, Chemical Vapor Deposition (CVD), Molecular Beam Epitaxy (MBE)	**8L**
UNIT-02	**Doping mechanisms:** Diffusion mechanism, Fick's laws of diffusion, diffusion profiles, ion implantation concepts and mechanism of doping semiconductors,.	**8L**
UNIT-03	**Photolithography:** Oxidation, lithography techniques, photoresist materials and processes, masks and patterning processes, etching, thin film deposition and metallization.	**8L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Identify the challenges of device fabrication.

CO2: Understand the flow process of semiconductor manufacturing from growth to packaging.

CO3: Understand the importance of semiconductor fabrication.

CO4: Explore Integrated Circuit technologies in manufacturing IC.

Books and References:

1. Semiconductor Physics and Devices by D. A. Neamen, Tata McGraw Hill Press.
2. Electronic Materials Science for Integrated Circuits in Si and GaAs by J. W. Mayer and S. S. Lau. MacMillan Publishing Company, New York.
3. VLSI Technology by S.M.Sze Tata McGraw Hill education Pvt.Ltd. New delhi.
4. Semiconductor Device Physics and Technology by S. M. Sze, Wiley Student Edition, India.

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Course Name: **Space Dynamics** Course Code: **PH-452** Course Type: **Stream Core-II**		
Contact Hours/Week: **2L**		Course Credits: **02**
Course Objectives: ● To introduce the fundamentals of orbital mechanics. ● To introduce rocket motion. ● Understanding of basic ideas of rocket dynamics of atmospheric entry.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	Astrodynamics: Orbits and trajectories, Kepler's laws, orbital velocity and periods, eccentric elliptical orbits; effect of injection conditions, effect of earth's rotation, perturbation analysis; parking orbit, transfer trajectory, impulsive shot; recent interplanetary missions.	**8L**
UNIT-02	Trajectory of a Rocket: mass ratio and propellant mass fraction; equation of motion of an ideal rocket; motion of a rocket in a gravitational field; simplified vertical trajectory; burn-out velocity and burn-out height; step-rockets; ideal mission velocity and losses; effect of launch angle; factors causing dispersion of rockets in flight; dispersion of finned rockets; stability of flight.	**8L**
UNIT-03	Atmospheric Entry, Attitude Determination and Control: Entry flight mechanics, entry heating, entry vehicle design, aero-assisted orbit transfer; concepts and terminology of attitude determination, rotational dynamics, rigid body dynamics, disturbance torques, passive attitude control, active control, attitude determination, system design considerations.	**8L**
Course Outcomes Upon successful completion of the course, the students will be able to: CO1: Analyze the orbits of space vehicles using classical methods. CO2: Analyze dynamics of space vehicles. CO3: Identify design requirements for different phases of a space exploration program.		
Books and References: 1. M.D. Griffin and J.R. French, Space Vehicle Design. 2nd Edition, AIAA Education Series (2004). 2. J.W. Cornelisse, H.F.R. Schöyer, and K.F. Wakkar. Rocket Propulsion and Spacecraft Dynamics. 1st Edition, Pitman (1979). 3. W.N. Hess. Introduction to Space Science. 1st Edition, Blackie and Son (1965). 4. E. Stuhlinger and G. Mesmer. Space Science and Engineering. 1st Edition, McGraw-Hill, New York (1965).		

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Course Name**: Elements of Artificial Intelligence**
Course Code**: PH-453**
Course Type**: Stream Core -II**

Contact Hours/Week: 2L **Course Credits: 02**

Course Objectives
• To present an overview of artificial intelligence (AI) principles and approaches.
• To develop a basic understanding of the building blocks of AI as presented in terms of intelligent agents: Search, knowledge representation, Knowledge acquisition.
• To implement knowledge of AI in some applications.

Unit Number	Course Content	Lectures
Unit-1	**Introduction:** Introduction to AI, AI techniques, level of model, criteria for success, Turing test, Reactive, deliberative, goal-driven, utility-driven, and learning agents Artificial Intelligence programming techniques.	8L
Unit-2	**Problem Solving:** Problem as a space, search, production system, problem characteristics, production system characteristics, issues in the design of search programs, Solving problems by searching, Heuristic search techniques, constraint satisfaction problems, stochastic search methods.	8L
Unit-3	**Knowledge Representation and Reasoning:** Ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; frame representation.	8L

Course Outcomes
Upon successful completion of the course, the students will be able to
CO1: Design a knowledge based system.
CO2: Analyze and formalize the problem as a state space, graph, design heuristics and select amongst different search or game based techniques to solve them.
CO3: Formulate and solve problems with uncertain information using Bayesian approaches.
CO4: Apply knowledge representation, reasoning, and machine learning techniques to real world problems.

Books and References
1. Artificial Intelligence: A Modern approach by S. Russell, P. Norvig, Prentice Hall of India.
2. Artificial Intelligence by S. Kaushik, Cengage Learning India Pvt Ltd.
3. Principles of Artificial Intelligence by N.J. Nilsson, Narosa Publishing House.
4. Artificial Intelligence by E. Rich, K. Knight and S.B. Nair, Tata McGraw Hill International.
5. Logic and Prolog Programming by S. Kaushik, New Age International Pvt. Ltd, 2012.

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Course Name: **Photonic Crystals**
Course Code: **PH-454**
Course Type: **Stream Core -II**

Contact Hours/Week: 2L **Course Credits: 02**

Course Objectives
- To present an overview of different types of photonic crystals.
- To develop a basic understanding of the light propagation in different dimensional photonic crystals.
- To implement knowledge of photonic crystals in some applications.

Unit Number	Course Content	Lectures
Unit-1	**Multilayer Film:** Multilayer Film, The Physical origin of Photonic band gaps, The size of band gap, Evanescent modes in photonic band gaps, off axix propagation, Localized modes of defects, surface states, omnidirectional multilayer mirrors.	8L
Unit-2	**Two Dimensional Photonic Crystals:** Two dimensional Bloch states, a square lattice of dielctric columns, a square lattice of dielctric veins, a complete band gap of all polarizations, out of plane progagation, localization of light by point defects, points defects in a larger gap, linear defects and waveguide	8L
Unit-3	**Three Dimensional Photonic Crystals:** Three dimensional lattices, crystals with complete band gap, localization at point defect, localization at linear defect. Designing photonic crystal for applications.	8L

Course Outcomes
Upon successful completion of the course, the students will be able to

CO1: Understand the preliminary concepts of electromagnetic waves and periodic media.

CO2: Fabricate the different Photonic crystals.

CO3: Apply knowledge to real world problems.

Books and References
1. Photonic Crystals: Molding the Flow Light by John D. Joannopoulos, Stevon G.Johnson, Joshua N. Winn, Robert D. Meade, Princeton University Press, 2008.
2. Photonic Crystals, Theory, Applications and Fabrication by Dennis W Prather, Ahmed Sharkawy, Shouyuan Shi, Janusz Murakowski, Garrett Schneider, Wiley Publisher Pvt. Ltd.
3.Optical Electronics by Ajoy Ghatak and K. Thyagarajan, Cambridge University Press, 1991.

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Course Name: **Energy Storage Systems**
Course Code: **PH-455**
Course Type: **Stream Core-II**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives:

- To present an overview of various thermal and electrical energy storage devices.
- To introduce Optimization of energy storage for optimal use.
- To understand the recent deadvancedment in the energy storage systems.

Unit Number	Course Content	Lectures
UNIT-01	Introduction to energy storage devices, Sensible thermal energy storage, Latent energy storage, Thermal management system design using Latent thermal energy storage, Thermochemical heat storage system.	**8L**
UNIT-02	Hydrogen energy and chemical energy storage and production, Battery electrical energy storage systems, Pumped storage systems.	**8L**
UNIT-03	Other electrical energy storage systems, Compressed air storage, Flywheels, Superconducting Magnetic energy storage, Integration of energy storage systems, energy storage system optimization.	**8L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Understand the working of energy storage devices.

CO2: Identify the applications energy storage devices.

CO3: Visualize the recent developments in energy storage devices.

Books and References:

1. Lehmann C., Kolditz O., Nagel T., Models of Thermochemical Heat Storage, Springer, 2018.
2. Zini G., Green Electrical Energy Storage: Science and Finance for Total Fossil Fuel Substitution, Mc Graw Hill Education, 2016.
3. Khalilpour R. K., Vassallo, A., Community Energy Networks with Storage, Community Energy Networks with Storage, Springer, 2016.
4. Kalaiselvam S., Parameshwaram R., Thermal Energy Storage for Sustainability- Academic Press, 2014.
5. Cabeza L., Advances in Thermal Energy Storage Systems Methods and Applications - Woodhead Publishing, 1st Edition, 2014.

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Course Name: **Semiconductor Heterostructure Devices**
Course Code: **PH-471**
Course Type: **Stream Core-III**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives:

- To make students aware of the heterostructures used to make various semiconductor devices.
- To enable students to understand different concepts in quantum heterostructures.
- To enable students to understand the applications of semiconductor heterostructures in nanotechnology.

Unit Number	Course Content	Lectures
UNIT-01	**Semiconductor Heterostructure:** Heterostructure physics (N-N and P-N Heterojunctions), types of heterostructures, band-diagrams under equilibrium, quantum heterostructures: 0D (Quantum dots), 1D (Quantum wire/rod), 2D (Quantum sheet) and 3D (bulk) heterostructures, quantum confinement, 2D gas.	**9L**
UNIT-02	**Heterojunction FET (Modulation doped FET) & HEMT:** principle, band diagram, estimation of threshold, 2DEG, Photodetectors: operation, responsivity, QE, bandwidth, noise, detectivity.	**8L**
UNIT-03	**Role of heterojunctions in nanotechnology:** Heterojunction lasers, energy harvesting applications: photovoltaic and solar hydrogen production.	**7L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Identify the challenges of heterojunction device fabrication.

CO2: Understand and interpret band diagrams of semiconductor heterostructures used in different devices.

CO3: Understand the principles of quantum mechanical effects in semiconductor nanostructures.

CO4: Apply the heterojunction knowledge in practical applications

Books and References:

1. Semiconductor Physics and Devices by D. A. Neamen, Tata McGraw Hill Press.
2. Electronic Materials Science for Integrated Circuits in Si and GaAs by J. W. Mayer and S. S. Lau. MacMillan Publishing Company, New York.
3. VLSI Technology by S.M.Sze Tata McGraw Hill education Pvt.Ltd. New delhi.
4. Semiconductor Device Physics and Technology by S. M. Sze, Wiley Student Edition, India.

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Course Name: **Astronomical Observation Technique**
Course Code: **PH-472**
Course Type: **Stream Core-III**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives:

- To introduce the various observation techniques related to astronomy.
- To understand the fundamental concepts and applications of the various Astronomical techniques.
- To interpret the various signal mechanisms.

Unit Number	Course Content	Lectures
UNIT-01	Astronomical observatories, telescopes, working principle, adaptive/active optics and interferometry, optical detectors.	**8L**
UNIT-02	Photometry, spectroscopy and polarimetry, interstellar absorption law, photometric measurements, astronomical spectrograph, wavelength resolution, prism, gratings and slit spectrograph.	**8L**
UNIT-03	Radio signals & emission mechanisms, astronomical radio telescopes, polarization measurement, radio observations-continuum, HI 21 cm-line, molecular lines, X-ray & Gamma-ray observational techniques.	**8L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Learn about the different observation technique used in astronomy.

CO2: Explain the working principle and methodology of the observational systems.

CO3: Realize the application and importance of those observation technique used in astronomy.

Books and References:

1. Telescopes and Techniques by C. R. Kitchin.
2. Handbook of CCD Astronomy by S. B. Howell.
3. Astronomy Method by Hale Bradt.
4. Astronomical Polarimetry by Jaap Tinbergen.
5. Observational Astrophysics by Pierre Lena.
6. X-ray Astronomy by R. Giacconi.

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Course Name**: Quantum Computation and Information**
Course Code**: PH-473**
Course Type**: Stream Core-III**

Contact Hours/Week: 2L **Course Credits: 02**

Course Objectives
• To understand the potential of quantum computing system.
• To understand the mechanism of quantum algorithms and quantum gates.
• To investigate the feasibility of physical quantum computer.

Unit Number	**Course Content**	**Lectures**
Unit-1	Introduction to Quantum Computation: Quantum bits, Bloch sphere representation of a qubit. Quantum Circuits: single qubit gates, multiple qubit gates, design of quantum circuits. Quantum Algorithms: Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search.	8L
Unit-2	Background Mathematics and Physics: Hilber space, Probabilities and measurements, entanglement, density operators and correlation, basics of quantum mechanics, Measurements in bases other than computational basis.	8L
Unit-3	Quantum Information Theory: Comparison between classical and quantum information theory. Bell states, Quantum teleportation.	8L

Course Outcomes
Upon successful completion of the course, the students will be able to:
CO1: Describe the Optical devices and their applications.
CO2: Identify the applications of quantum computing.
CO3: Understand the concepts related to quantum computing.
CO4: Learn and understand the use of quantum computing.

Books and References
1. Quantum Computation and Quantum Information by M. A. Nielsen, Cambridge University Press.
2. Principles of Quantum Computation and Information by G. Benenti, G. Casati and G. Strini, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific.
3. An Introduction to Quantum Computing Algorithms by A. O. Pittenger, Springer.

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Course Name: **Nano Photonics**
Course Code: **PH-474**
Course Type: **Stream Core-III**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives:

- To familiarize students to the research frontiers in Nano Optics.
- To understand the fundamental principles with emphasis on developing intuitive understanding and developing analytical techniques.
- To learn the fabrication of photonic devices.

Unit Number	Course Content	Lectures
UNIT-01	Introduction to nanophotonics – Why nanophotonics? Review of electromagnetics, Maxwell equations and Wave Optics, Electromagnetic radiation and evanescent waves, the Diffraction limit of light.	**6L**
UNIT-02	Light-matter interaction - Dielectric function, Kramers-Kronig relationship, Drude-Lorentz and Drude models, Interband and Intraband transitions	**8L**
UNIT-03	Plasmonics - Quasi-static limit, nanoparticle as a plasmonic atom, size-dependent absorption and scattering, coupled nanoparticles, plasmon hybridization	**7L**
UNIT-04	Nanofabrication of photonic devices – examples from recent literature on nanophotonic devices, Classical to quantum nanophotonics (small dimensions + low intensity/few photons)	**3L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Describe the potential and challenges associated with Nano Photonics.

CO2: Understand the concepts related to light-matter interaction.

CO3: Understand the understand plasmonics and its significance.

Books and References:

1. S. V. Gaponenko., Introduction to Nanophotonics. Cambridge University Press, 2010.
2. Henri Benisty. Jean-Jacques Greffet, Philippe Lalanne, Introduction to Nanophotonics. Oxford Academic Press, 2022.
3. Stefan Alexander Maier, Plasmonics: Fundamentals and Applications, Springer Science & Business Media, 2007.

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Course Name: **Hydrogen Economy**
Course Code: **PH-475**
Course Type: **Stream Core-III**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives:

- To present the potential of hydrogen in the energy sector.
- To understand the importance of hydrogen economy on the achievement of sustainable energy and the environment.
- To understand the different pathways of hydrogen economy implementation.

Unit Number	Course Content	Lectures
UNIT-01	Hydrogen potential and role in decarbonizing the global Energy System; Hydrogen Characteristics, Forecast / Resource Assessment of Hydrogen demand and supply; Impact of Hydrogen on economy and environment, Different Pathways for Implementation of Hydrogen economy; Grey, blue and green hydrogen; Aggregated and Disaggregated models for GDP with Hydrogen and GHG Emissions.	**8L**
UNIT-02	Technology for Hydrogen production from Conventional and Renewable Energy Resources (Coal, Natural Gas, Biomass, Solar energy, Wind Energy, Nuclear energy); Hydrogen Storage (Gaseous, Cryogenic, Slush, Metal hydrides); Hydrogen Transportation (Gas grid (Pipeline network), gas tubular, liquid containers and hydrides); Application of Hydrogen in Fuel Cells and IC Engines for Transportation sectors (Automotive vehicles, Passenger Trains, Locomotives, Flights, Ships) and Industrial sectors (Ammonia industry, Fertilizer industry, Oil Refineries etc.)	**8L**
UNIT-03	Role of Carbon Capture Storage/Sequestration in Hydrogen production from fossil fuels Life Cycle Assessment of Hydrogen energy (Production to Utilization and Disposal); Analysis of Specific Energy Input to Hydrogen production from different feedstock/resources, Well to wheel efficiency; Techno-Economic Analysis, Levelized Cost of Energy (LCOE), Average Transportation Cost Hydrogen safety- Codes and Standards, Hydrogen fuel quality norms, Emission Norms; Infrastructure development for supply-chain Hydrogen systems; Hydrogen Energy Policy and Programs.	**8L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Describe the potential and challenges associated with hydrogen in the energy sector.

CO2: Understand the concepts related to production of hydrogen and storage.

CO3: Understand the impact of hydrogen on the mitigation of greenhouse gas emissions and environment.

Books and References:

4. Ball M. and Wietschel M., The Hydrogen Economy: Opportunities and Challenges. Cambridge University Press, 2009.
5. Jones R. H. and Thomas G. J., Materials for the Hydrogen Economy. CRC Press, 2007.
6. Winter C. J. and Nitsch J., Hydrogen as an Energy Carrier: Technologies, Systems, Economy, Springer Science & Business Media, 2012.

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Course Name: **Measurements and Instrumentation Lab**
Course Code: **PH-415**
Course Type: **Discipline core**

Contact Hours/Week: **2** Course Credits: **01**

Course Objectives

- An ability to understand measurement and instrumentation.
- An understanding of the concepts of instrumentation and measurement.
- Introduce the working principles and characteristics of transducers and analytical instruments commonly used for industrial applications.

List of Experiments

1. Measurement of pressure, strain and torque using strain gauge.
2. Measurement of speed using photoelectric transducers and compass
3. Measurement of angular displacement using Potentiometer.
4. Experiment of Opto coupler using photoelectric transducers.
5. Measurement of displacement using LVDT.
6. Measurement using load cells.
7. Measurement using capacitive transducer.
8. Measurement using inductive transducer.
9. Measurement of Temperature using Temperature Sensors/RTD.
10. Measuring change in resistance using LDR.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO 1: Describe the measurement and instrumentation and its applications.
CO 2: Write down the concepts related to measurement.
CO 3: Identify the applications of measurement and instrumentation.
CO 4: Learn and to apply concepts of measurement and instrumentation to Industry and real life.

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Course Name: **Materials Characterization Lab** Course Code: **PH-416** Course Type: **Discipline Core**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To provide an insight into latest developments in materials characterization.
- To provide an insight into selection of specific characterization for materialsTo gain practical.

List of Experiments

1. To study the microstructure analysis using Optical microscopy (Different modes)
2. To analyze the lattice parameters and crystallite size of powder sample using X-Ray Diffraction.
3. To study the various functional groups using FTIR Spectroscopy analysis
4. To study the chemical structure, phase and crystallinity using Raman Spectroscopy analysis
5. To measure the absorption and band gap using UV- Spectroscopy analysis
6. To study the purity and crystalline quality of semiconductor material using Photo luminance Analysis.
7. To study the microstructure and morphology of different samples using SEM analysis.
8. Demonstration of EDX spectroscopy
9. To study the glass transition temperature/melting point of given sample usingDSC/TGA/DTA analysis
10. To study the surface topography using Atomic force microscopy
11. To measure the mechanical properties using scratch and nanoindentation tests.
12. To measure the surface observations using Scanning probe microscopy (SPM).
13. To determine the thermal expansion coefficient of materials using a dilatometer.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand various materials characterization techniques
CO2: Competent to know principles in different analysis of materials structure
CO3: Competent to comment on selection of specific characterization for materials to be used for particular application

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Course Name: **Introduction to Astronomy**
Course Code: **PH-461**
Course Type: **Free Elective/Engineering Course/Open Elective Course (SE)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

1. To understand the fundamental concepts of Solar Physics.
2. To promulgate the interesting astronomical facts and the related scientific theories associated with our universe.
3. To enable the students to understand the various problems of Solar and Astrophysics.

Unit Number	Course Content	Lectures
UNIT-01	The Sun: Structure of the sun, solar interior, solar atmosphere, sun spots and their properties.	**6L**
UNIT-02	Solar Physics: Solar flare, small & large scale solar structures and their classifications, phases and flare theory, solar cycle, solar magnetic field, solar wind.	**6L**
UNIT-03	Qualitative description of astro-objects: From planets to large scale structures, length, mass and time scales.	**6L**
UNIT-04	Radiative Processes: Radiation theory and Larmor formula, different radiative processes.	**6L**
UNIT-05	Introduction to cosmology: Red shift and the expansion of our universe, role of gravity in different astrophysical systems, star formation, stellar evolution, supernovae, H-T diagram, compact stars, milky way galaxy, black holes.	**6L**
UNIT-06	Dark Matter and Cosmological models: Flat rotation curve of galaxies and introduction to dark matter, Big Bang and steady state models.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Learn about the birth, evolution and the probable fate of our universe.

CO2: Enhance the learning appetite for planets and their moons, stars, constellations, and other celestial formations.

CO3: Realize and appreciate the vastness of the universe which in turn help to set them up the much-needed thoroughfare of scientific philosophy.

Books and References

1. Solar System Astrophysics by Brandt J. C. & Hadge P.W.
2. Astrophysical Concepts by Harwitt M., Springer-Verlag, New York.
3. An Introduction to Modern Astrophysics by Carroll W. & Ostlie D. A., Pearson.

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Course Name: **Experimental Techniques for Material Characterization**

Course Code: **PH-462**

Course Type: **Free Elective/Engineering Course/Open Elective Course (SE)**

Contact Hours/Week : **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the experimental techniques used in Physics
- To introduce the fundamental concepts of X-ray diffraction and spectroscopy.
- To enable the students to understand the theory of X-ray diffraction and different spectroscopic techniques.

Unit Number	Course Content	Lectures
UNIT-1	Crystal structure identification and lattice parameter determination, Particle size determination using Bragg's law of X-ray diffraction.	**6L**
UNIT-2	Ultraviolet photoelectron spectroscopy (UPS), Auger electron spectroscopy (AES) & Scanning auger microprobe (SAM), Secondary ion mass spectroscopy (SIMS), Electron spectroscopy for chemical analysis (ESCA), Scanning probe microscopy (SPM), Atomic force microscopy (AFM).	**6L**
UNIT-3	Scanning electron microscopy (SEM) , electron microscopy, EDAX analysis, scanning probe microanalysis, atomic force microscopy (AFM) and scanning tunneling microscopy (STM).	**6L**
UNIT-4	Transmission Electron Microscopy, Low Energy Electron Diffraction, High Energy Electron Diffraction, X-ray Photoelectron Spectroscopy (XPS).	**6L**
UNIT-5	Raman spectroscopy, Photoluminescence (PL) spectroscopy, FTIR, UV-VIS-NIR spectrophotometry , Spectroscopic Ellipsometer.	**6L**
UNIT-6	**Thermal analysis:** Principle of thermal analysis, differential thermal analysis, differential scanning calorimetry DSC/DTA/TGA), Dilatometer, thermogravimetric analysis, differential thermogravimetric analysis.	**6L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of X-ray diffraction and spectroscopy.

CO2: Identify the structure of materials by different techniques.

CO3: Apply principles to determine crystal structures, microstructure, band gap and specific heat.

CO4: Assess the results obtained by solving problem related crystal structure and energy band determination

Books and References

5. Instrumentation and Experiment Design in Physics and Engineering by Sayer, M., Mansingh, A., Measurement.
6. Nanoparticles and Nanostructured Films–Preparation, Characterization and Application by J.H. Fendler (Wiley).
7. Elements of X-Ray Diffraction, by B.D. Cullity and S.R. Stock Pearson New International Edition.
8. X-Ray Diffraction: A Practical Approach by C. Suryanarayana and M. Grant Norton, Springer-Verlag New York Inc.
9. Semiconductor Material and Device Characterization By Dieter K. Schroder, Wiley Publication.

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<table>
<tr><td colspan="3">Course Name: Introduction to Relativistic Mechanics
Course Code: PH-481
Course Type: Free Elective/Engineering Course/Open Elective Course (SE)</td></tr>
<tr><td colspan="3">Contact Hours/Week: 3L Course Credits: 03</td></tr>
<tr><td colspan="3">Course Objectives
To demonstrate the students how physical properties of matter get affected by its ultra-high velocity.
To show the obvious compatibility of Maxwell's electrodynamics with Einstein's special theory of relativity.
Eventually which brought the end to the concept of ether.</td></tr>
<tr><td>Unit Number</td><td>Course Content</td><td>Lectures</td></tr>
<tr><td>UNIT -1</td><td>Lagrangian Mechanics: Constraints, Principle of virtual work, Generalized coordinates, Lagrange's equations, applications of Lagrange's equations of motion.</td><td>3L</td></tr>
<tr><td>UNIT -2</td><td>Hamiltonian Mechanics: Cyclic coordinates, Hamilton's principle, Hamilton's equations of motion, applications of Hamilton's equations of motion..</td><td>6L</td></tr>
<tr><td>UNIT -3</td><td>CENTRAL FORCES: Gravitation, Kepler's law, hyperbolic, elliptic and parabolic orbits, Scattering theory, Center of mass and laboratory frames of reference.</td><td>7L</td></tr>
<tr><td>UNIT -4</td><td>The Special Theory of Relativity: Einstein's postulates, the geometry associated with the relativity theory, the Lorentz transformations, the structure of spacetime.</td><td>6L</td></tr>
<tr><td>UNIT -5</td><td>Consequences of the Special Theory of Relativity: Length contraction, simultaneity, time dilation, and addition of velocities.</td><td>7L</td></tr>
<tr><td>UNIT -6</td><td>Relativistic Mechanics: Proper time and proper velocity, relativistic energy and momentum, relativistic kinematics, relativistic dynamics, introduction to four vectors.</td><td>7L</td></tr>
<tr><td colspan="3">Course Outcomes
Upon successful completion of the course, the students will be able to
CO1: Explain the meaning and significance of the postulates of Special Relativity.
CO2: Have a broader understanding of Special Relativity.
CO3: Explain the four-vector formulation and its importance.</td></tr>
<tr><td colspan="3">Books and References
Resnick R, "Introduction to Special Relativity", Wiley Publications
1. Classical Mechanics by Goldstein H., Narosa Publishing House, New Delhi.
Mechanics by Landau L D and Lifshitz E. M., Pergamon Press, Oxford.
The Feynman Lectures on Physics by Feynman, Leighton, and Sands, Pearson.
Classical Mechanics by Upadhyaya J. C., Himalaya Publishing House.</td></tr>
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Course Name: **Renewable Energy and Storage Devices**
Course Code: **PH-482**
Course Type: **Free Elective/Engineering Course/Open Elective Course (SE)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand renewable energy and energy storage.
- An understanding of concepts of energy storage devices.
- The broad education necessary to understand energy demands and energy storage.

Unit Number	Course Content	Lectures
UNIT -1	**Introduction to world energy scenario:** Environmental impacts of energy extraction and conversion technologies. Energy consumption pattern in different sectors (Industries, commercial and residential buildings, agriculture, service industries, etc.).	**3L**
UNIT -2	**Different Renewable Energy resources:** various renewable Energy resources (Solar, wind, biomass, hydro, geothermal, OTEC, tidal, etc.): resource assessment and utilization for heat and power generation.	**6L**
UNIT -3	**Photovoltaics and its applications-I:** Solar PV production, Fundamentals of solar cell: crystalline solar cell: Mono-crystalline and poly– crystalline cells, Metallurgical Grade Si, Electronic Grade Si, wafer production, Mono–crystalline Si Ingots, Poly– crystalline Si Ingots, Si–wafers, Si–sheets. Amorphous Si solar cell.	**7L**
UNIT -4	**Photovoltaics and its applications-II:** thin film solar cells, different techniques and challenges. Module, panel (Series and Parallel connections) and Array constructions. Design and structure.	**6L**
UNIT -5	**Energy storage-I:** Significance and types of energy storage. Sensible thermal energy storage and its classifications. Hydrogen energy storage, Chemical energy storage and production. Battery electrical energy storage systems: Types of batteries, electrical behavior, influence in interconnected systems.	**7L**
UNIT -6	**Energy Storage-II:** Other electrical energy storage systems e.g. Flywheel, super-capacitors etc.Superconducting magnetic energy storage and its classification. Various thermal and electrical energy storage devices. Optimization of energy storage for optimal use	**7L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand the working of energy storage devices.
CO2: Identify the applications energy storage devices.
CO3: Know the concepts of energy storage devices.

Books and References

1. Non-Conventional Energy Resources by B.H Khan, McGraw Hill Education.
2. Energy for a sustainable world by Jose Goldenberg, Johansson Thomas, A.K.N. Reddy and Robert Williams, Wiley Eastern.
3. Solar Energy by Sukhatme, McGraw Hill Education.
4. Solar Hydrogen Energy Systems by T. Ohta, Pergamon Press.
5. Lehmann C., Kolditz O., Nagel T., Models of Thermochemical Heat Storage, Springer, 2018.
6. Zini G., Green Electrical Energy Storage: Science and Finance for Total Fossil Fuel Substitution, McGraw Hill Education, 2016.
7. Twidell, J. and Weir, T., Renewable Energy Resources, Taylor & Francis, 3rd Edition, 2015.

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