Syllabus for M.Sc. Physics

DEPARTMENT OF PHYSICS

National Institute of Technology, Raipur

G. E. Road Raipur-492010

Chhattisgarh, India

(Website: www.nitrr.ac.in)

PH91101PH: Mathematical Methods in Physics [Core Theory 3 1 0 4]

Course Objective: To provide mathematical concepts, techniques and essential tools for the studies of advance Physics.

Module-1: Vector, Tensor and Matrix algebra

Review of vector integrals and theorems, Linear vector space, Subspaces, Linear independence, Basis and dimension, Tensors and its type, , Einstein's summation convention,Invariant tensors, Kronekar delta symbol and Levi-Civita tensors, Matrix representation, The algebra of matrices, special matrices, Rank of matrix, equivalent matrices, Eigen values and Eigen vectors of matrices, Cayley-Hamilton theorem, Function of matrices, Diagonalization of matrices, Quadratic form, Principal axis transformation, Jacobian.

Module-2: Complex analysis

Analytic functions, Cauchy-Riemann differential equations, Line integral of a complex function, Cauchy's Integral theorem, Cauchy's integral formula, Derivatives of an Analytic function, Taylor and Laurent expansion, singular points and their classifications, Branch point and branch cut, Riemann's sheets, Application of residue theorem to the evaluation of definite integrals and the summation of infinite series.

Module-3: Differential Equations

Partial differential equations, Singular points, Linear independence of solution and Wornskian Series solutions (Frobenius method) of Legendre, Bessel, Hermite and Laguerre differential equations, Legendre, Bessel and Hermite, Laguerre functions, Generating functions and their recurrence relations, Rodrigues formula, Integral representation, and orthogonality.

Module-4: Special Functions

Beta, Gamma and Error Function, Dirac-Delta function, Heaviside function, Green's function, Eigen function, expansion of Green's function, application of Green's function in quantum mechanics and electrodynamics. Fourier series, Fourier and Laplace transforms, inverse transformation and its properties, convolution theorem, elementary probability theory, random variables, binomial, Poisson and normal distributions.

Text Books

1. Mathematical Methods for Physicists: G. Arfken, Academic Press
2. Mathematics for Physicists: P. Dennery and A. Krzywicki, Harper and Row Publication

Reference Books

1. Mathematical Methods of Physics: J. Mathews and R. I. Walker (Benjamin),
2. Mathematical Methods of Physics: Charle Harper, PHI India

Course Outcomes: On completion of the course the learner shall be able to:

- Identify basic mathematical tools to solve physics problems.
- Apply the mathematical tools, such as integral transforms and Matrix diagonalization for solving fundamental and applied physics problems.
- Formulatenewmathematicalapproachestoanalyticallysolvenewandexistingphysicsproblems.

PH91102PH: Classical Mechanics [Core Theory 3 1 0 4]

Course Objective: To provide the idea of fundamentals of all physical sciences and subsequently relatively modern and challenging topic like mechanics of a system of particles at advanced level.

Module-1: Lagrangian Formulation

Constraints, generalized coordinates, degrees of freedom, D' Alembert's principle and Lagrange's equation, velocity dependent potentials and dissipation function, simple applications of Lagrangian equations. Hamilton's principle, derivation of Lagrange's equation from Hamilton's principle, conservation theorems and symmetry properties, energy function and conservation of energy.

Module-2: Hamiltonian Formulation

Phase space, Hamilton's equation of motion, cyclic coordinates and conservation theorems, Routh's procedure, Derivation of Hamilton's equation from variational principle, principle of least action and its Jacobi's form.

Module-3: Canonical Transformations

Equations and examples of canonical transformations, generating functions, Poisson and Lagrange brackets as canonical invariants, equations of motion in the Poisson bracket formulation, Liouville's theorem, Hamilton-Jacobi equation.

Module-4: Central force problem

Equivalent one body problem, equation of motion and first integrals, equivalent one-dimensional problem and classification of orbits, differential equation for the orbit and integrable power-law potentials, Kepler's problem: Inverse square law of force, motion in time in the Kepler problem, scattering in a central force field.

Text Books

1. Classical Mechanics: G. Aruldas, Eastern Economic Edition.
2. Classical Mechanics: H. Goldstein, Narosa.
3. Mechanics: L.D Landau and E. M. Lifshitz, Pergamon press.

Reference Books

1. Classical mechanics: J. W. Muller-Kirsten World Scientific.
2. Classical Mechanics: TBW Kibble and Frank Berkshire Imperial College Press..

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of Lagrangian and Hamiltonian formalisms to solve the classical mechanical problems.
- Analyze classical problems, such as the harmonic oscillator problem, using advanced mathematical approaches.
- Formulate new problems in terms of Hamiltonian and Lagrangian formalisms.

PH911103PH: Quantum Mechanics-I [Core Theory 3 1 0 4]

Course Objective: To provide ideas which are beyond the scope of classical mechanics, origin of QM, mathematical tools, angular momentum and variational principles of quantum mechanics.

Module-1: Development of quantum mechanics

Wave packets and uncertainty relation; Schrödinger equation: eigen function and eigen values, momentum eigen function; application to 1-D potentials: free states, potential step, potential barriers and tunneling; bound states- infinite, finite square potential well and linear harmonic oscillator.

Module-2: Operator formalism of quantum mechanics

Vectors and Hilbert space, algebra of ket and bra vectors; operators: linear, adjoint, unitary, hermitian and commutation relations; expansion theorem of eigen function: orthogonality, parity, completeness and closure property; matrix representation: ket and bra vectors and operators, unitary transformations of basis vectors and operators, harmonic oscillator creation and annihilation operators.

Module-3: 3D Schrödinger equation and quantum dynamics

Schrödinger equation in 3D, degeneracy in particle in a box and harmonic oscillator, spherical coordinates separation of variables, hydrogen atom, radial equation, eigen values and eigen functions, ground state and degeneracy of H-atom, quantum dynamics: time evolution of quantum states, operator and expectation values, quantum equation of motion, Schrödinger picture, Heisenberg picture, Dirac (interaction) picture.

Module-4: Angular momentum in quantum mechanics

Operators, rotation matrix, L_x, L_y, L_z, and L^2, commutation relations, raising and lowering operators. spin angular momentum: spin-½ particles, Pauli spin matrices and their properties, spinor transformation under rotation. addition of angular momentum and Clebsch-Gordan (CG) coefficients, angular momentum states for composite systems.

Text Books

1. Modern Physics:A. Beiser, McGrawHill Publication.
2. Quantum Mechanics: David. J. Griffith, PHI Publication.
3. Quantum Mechanics: Eisberg and Resnik, John-Wiley and Sons.
4. Quantum Mechanics: Ghatak, MaMillan Press.

Reference Books

1. Quantum Mechanics: LI Schiff, John- Wiley and Sons.
2. Quantum Mechanics: Gasiorowick, John-Wiley and Sons.
3. Quantum Mechanics: Merzbacher, John-Wiley and Sons.
4. Quantum Mechanics: N. Zettilli, Wiley Publication.

Course Outcomes: On completion of the course the learner shall be able to:

- Identify the fundamental concepts and realm of quantum mechanics.
- Solve different problems related to the dynamics of subatomic particles.
- Formulate new approximation methods for solving quantum mechanical problems.

PH91104PH: Condensed Matter Physics-I [Core Theory 3 1 0 4]

Course Objective: To provide understanding of the entity of the materials with their properties and behaviour. This gives idea about tailoring the properties of the materials for diverse applications.

Module-1: Structure and Bonding in Crystals

Review of crystal structure, symmetry operations, reciprocal lattice; structure determination: Bragg's law, X-ray diffraction; scattered wave amplitude and atomic form factor, point and line defects and dislocations in crystals. Bonding in solids: Van der Waals bond, cohesive energy and bulk modulus, ionic bond, Medelung constant, covalent bond, metallic bond.

Module-2: Phonon Dynamics and Thermal Properties

Vibrations of one-dimensional mono and diatomic lattice, localized vibrations, quantization of lattice vibration, specific heat, Lattice heat capacity: classical theory, Einstein theory, Debye theory, lattice thermal conductivity, phonon mean free path, phonon- phonon scattering: the umklapp process.

Module-3: Free Electron Theory of Metals

Free electron Fermi gas in three dimension, energy levels and density of states, Fermi energy, effect of temperature on Fermi-Dirac distribution, heat capacity of electron gas, electrical conductivity and Ohm's law, Hall effect, thermal conductivity of metals, Wiedemann-Franz law, Lorentz number, Boltzmann transport equation.

Module-4: Band Theory of Solids

Bloch theorem, The Kronig-Penny model, construction of brillouin zones, reduced zone schemes, effective mass of an electron. Semiconductor crystal: effective mass, physical interpretation of effective mass, Fermi level, intrinsic carrier concentration, mobility.

Text Books

1. Introduction to Solid State Physics: C. Kittel, John Wiley.
2. Solid State Physics: A. J. Dekker, Macmillan.

Reference Books

1. Elementary Solid State Physics: M. A. Omar, Addison-Wesley.
2. Solid State Physics: N. W. Ashcroft and N. D. Mermin, HBC Publication.

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of structure and binding in a crystal, phonon and electron theory to understand properties of condensed matter systems.
- Analyze and solve simple problems related to fundamental ideas of condensed matter systems.
- Formulate new models to study various properties of advanced condensed matter systems.

PH911401PH: Modern Physics Lab [Core Practical 0 0 6 3]

Course Objective: The objective of the course is to offer experimental hands in experience in various Modern Physics experiments and equipment.

Course Outcomes: On completion of the course the learner shall be able to:

- Identify basic experiments of Modern Physics
- Apply the gained experimental knowledge to validate Phenomena of Modern Physics and applied physics problems.
- Formulate new Technology using experiments of Modern Physics

PH911402PH: Computational Physics Lab [Core Practical 0 0 4 2]

Course Objective: The objective of the course is to offer computational hands in experience to program and solve physics problem using computer.

Course Outcomes: On completion of the course the learner shall be able to:

- Identify basic computational programming to solve physics problem in numerical way.
- Apply the knowledge of computer to validate the physical phenomena numerically.
- Formulate programming skills and applications.

PH912101PH: Quantum Mechanics-II [Core Theory 3 1 0 4]

Course Objective: To offer ideas related to variational principles, Quantum scattering and relativistic Quantum Mechanics of sub-atomic particles.

Module-1: Perturbation Theory-I

Time-independent perturbation theory (non-degenerate and degenerate states), second order perturbations. Applications: anharmonic oscillator, He-atom, Linear and quadratic Stark effect, Normal and anomalous Zeeman Effect.

Module-2: Perturbation Theory-II

Time-dependent perturbation theory: transition probability, constant and harmonic perturbation, Fermi golden rule, Electric dipole radiation and selection rules. The fine structure of hydrogen: Lamb shift, the relativistic correction.

Module-3:Variational Principle

Theory of variational principle: the ground state of helium, WKB approximation: the classical region and tunneling, the connection formulas, Adiabatic theorem: only introduction.

Module-4: Quantum Scattering

Scattering amplitude and cross section, Born approximation, Application to Coulomb and Screened Coulomb potentials, Partial wave analysis for elastic and inelastic scattering, optical theorem.

Text Books

1. Quantum Mechanics: D. J. Griffith, PHI Publishing
2. Quantum Mechanics: L. I. Shiff, McGraw-Hill Book Company
3. Quantum Mechanics: E. Merzbacher, John Wiley Sons Publishing

Reference Books

1. Quantum Mechanics: R. Shankar, Plenum Press, NewYork
2. Quantum Mechanics: F. Schwabl, Springer
3. Quantum Mechanics: P.A.M. Dirac, Oxford Univ Press.

Course Outcomes: On completion of the course the learner shall be able to:

- Identify the fundamental concepts of approximations in quantum mechanics.
- Solve and explain different problems related to the dynamics of subatomic particles.
- Formulate new methods to solve relativistic quantum mechanical problems.

PH912103PH: Condensed Matter Physics-II [Core Theory 3 1 0 4]

Course objective: To provide understanding of various properties and behaviour of materials. This also gives idea about tailoring the properties of the material for different device applications.

Module-1: Magnetic Properties

Langevin classical theory of diamagnetism and paramagnetism, quantum theory of paramagnetism, Curie law, ferromagnetism, Curie-Weiss law, saturation magnetization and temperature, ferromagnetic domains and their origin, ferrimagnetic order, susceptibility, antiferromagnetic order, Neel Temperature and susceptibility.

Module-2: Superconducting Properties

Occurrence of superconductivity, Meissner effect, heat capacity, energy gap, isotope effect, thermodynamics of superconductors, London's equations and coherence length, BCS theory and ground state, flux quantization, type-I and type-II superconductors, vertex state, particle tunneling, dc and ac Josephson effect.

Module-3: Dielectric Properties

Local electric field of an atom, Clausius-Mossotti relation, polarization and its types, frequency dependence of polarizability, ferroelectricity, ferroelectric domain, properties of piezoelectric, pyroelectric and ferroelectric materials.

Module-4: Optical Properties

Excitons, weakly and tightly bound excitons, photoconductivity, influence of traps and space charge effect, luminescence and its types, color centers, types of color centers generation.

Text Books

1. Introduction to Solid State Physics: C. Kittel, John Wiley.
2. Solid State Physics: A. J. Dekker, Macmillan.

Reference Books

1. Solid State Physics: N. W. Ashcroft and N. D. Mermin, HBC Publication.
2. Elementary Solid State Physics: M.A. Omar, Addison-Wesley.

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of various properties of condensed matter systems.
- Analyze and solve simple problems related to fundamental ideas of solid state physics.
- Formulatenewmethodstostudycorrelatedelectronsystemsexhibitingmagnetismandsupercondu ctivity.

PH912102PH: Electrodynamics-I [Core Theory 3 1 0 4]

Course Objective: To provide understanding and knowledge of special techniques in solving boundary value problems of electro-magneto-statics and theory of generation and its propagation of electromagnetic waves in vacuum and different media.

Module-1: Electrostatics and Boundary value problems

Poisson's and Laplace's equation in cartesian, spherical coordinate system and its solution, uniqueness theorem, method of images, separation of variables, multipole expansion, polarization, field of a polarized object, electric displacement, boundary conditions for D and E, dielectric constant, boundary value problems, energy, forces on dielectrics

Module-2: Magnetostatics

Vector potential, magnetostatic boundary conditions, multipole expansion of the vector potential, torque and forces on magnetic dipoles and atomic orbits, magnetization, field of a magnetized materials, Ampere's law in magnetized materials, boundary conditions, susceptibility and permeability of linear and nonlinear magnetic media, energy in magnetic fields,

Module-3: Electrodynamics

Electromotive force, electromagnetic induction, displacement current, Maxwell equations in free space and in matter, magnetic charge, boundary conditions, continuity equation, Poynting theorem, Newton's third law in electrodynamics, Maxwell stress tensor.

Module-4: Electromagnetic Waves

Waves in one dimension, electromagnetic waves in vacuum: wave equation, energy and momentum and in non -conducting medium, energy and momentum in electromagnetic waves, linear and circular polarization; Stokes parameters, propagation in linear media, reflection and transmission at normal and oblique incidence, polarization by reflection, total internal reflection, Brewster's angle.

Text Books

1. J.Griffit, Electrodynamics, Cambridge Univ. Press
2. S. P. Puri, Electrodynamics, New Age publications.

Reference Books

1. Tai L.Chow, Introduction to Electromagnetic theory, Jones& Bartlett student edition.
2. J. D. Jackson, Classical Electrodynamics, John Wiley.

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of electricity, magnetism and electromagnetic waves in various media.
- Analyze and solve simple problems related to fundamental ideas of electricity, magnetism and electromagnetic waves in various media.
- Formulate new methods to study electricity, magnetism and electromagnetic waves in various media for device application and in technology.

PH912104PH: Electronic Devices [Core Theory 3 1 0 4]

Course Objective: To provide an idea about basics of operating principles and applications of bi-junction transistor, field effect transistors, oscillators and operational amplifiers.

Module-1: Transistor Fundamentals

Transistor and its current components, construction and CE configuration and their comparisons, transistor characteristics and Ebers-Moll model, graphical analysis of CE configuration, two port devices and hybrid model, transistor *h* parameters, analysis of transistor amplifier using *h* parameters, Cascading transistor amplifier, operating point, load lines, bias and thermal stability.

Module-2: Oscillators

Class A, B, AB, C amplifiers, distortion, frequency response, RC coupled amplifier and noise, feedback concept, transfer gain of a feedback amplifier, characteristics of negative and positive feedback, output resistance, principle of oscillators and Barkhausen criterion, Hartley, Colpitts, phase-shift and Wein-Bridge oscillators, astable, bistable and mono-stable multivibrators.

Module-3: Field Effect Transistors

Junction field effect transistor (JFETs) and Metal-oxide- semiconductor FETs (MOSFETs), biasing of FETs and MOSFETs, enhancement and depletion type MOSFETs and their operations, MOSFET equations, small-signal MOSFET model, digital MOSFET, operating points and FET parameters, FET as a voltage-variable resistor, comparison of bipolar and FET/MOSFET.

Module-4: Operational Amplifiers

Characteristics of an ideal operational amplifier, differential amplifier, operational amplifier and its frequency response, slew rate, emitter coupled differential amplifier and its transfer characteristics, applications (linear and non-linear). Analysis of inverting amplifier, non-inverting amplifier, summing amplifier, integrator, differentiator, voltage to current and vice-versa converter, comparator, logarithmic amplifier and exponential amplifier, square wave, rectangular and triangular wave generators, voltage comparator.

Text Books

1. Foundation of Electronics: D Chattopadhaya, New-Age Publication.
2. Integrated Electronics: J Millman, C Halkias, CD Parikh, Tata McGraw Hill.
3. Semiconductor Devices: Physics and Technology: S. M. Sze, John Wiley.

Reference Books

1. Physics of Semiconductor Devices: Shur, Prentice Hall India, New Delhi
2. Electronic Device and Circuit Theory, R.L. Boylestad and, L. Nashelsky, Pearson.

Course Outcomes: On completion of the course the learner shall be able to:

- Identify bi junction transistor, field effect transistors, oscillators and operational amplifiers and their basic operational principles.
- Apply the transistor, field effect transistors, oscillators and operational amplifiers in basic circuits for solving electronic problems.

PH912401PH: Condensed Matter Physics Lab [Core Practical 0 0 6 3]

Course Objective: The objective of the course is to offer experimental hands in experience in various Condensed Matter Physics experiments and equipment.

Course Outcomes: On completion of the course the learner shall be able to:

- Identify basic experiments of Condensed Matter Physics
- Apply the gained experimental knowledge to validate Phenomena of Condensed Matter Physics and applied physics problems.
- Formulate new Technology using experiments of Condensed Matter Physics

PH912402PH: Electronics Devices Lab [Core Practical 0 0 4 2]

Course Objective: The objective of the course is to offer experimental hands in experience in various electronic devices, its operation and working.

Course Outcomes: On completion of the course the learner shall be able to:

- Identify basic operation and working of electronic devices
- Apply the gained experimental knowledge to validate phenomena used in electronic devices.
- Formulate new technology using experiments of electronic devices.

PH913101PH: Statistical Physics [Core Theory 3 1 0 4]

Course Objective: To provide understanding and knowledge a bridge between macroscopic thermodynamics and microscopic statistical mechanics by using mathematical methods and fundamental physics for individual particles.

Module-1: Review of Thermodynamics

Laws of thermodynamics, entropy, thermodynamic potentials, Maxwell relations, chemical potential, connection between statistics and Thermodynamic, classical ideal gas, Gibb's paradox.

Module-2: Ensemble Theory

Phase space, relation between eigen states and phase space volume, Liouville's theorem, ensembles, micro-canonical, canonical and grand canonical ensembles and partition functions. Maxwell's Boltzmann's distribution, Gibb's formulation for canonical and grand canonical ensembles, partition function, their thermodynamic properties

Module-3: Quantum Statistics

Drawbacks of M B distribution, Bose-Einstein's and Fermi-Dirac distribution, symmetric and antisymmetric particles, non-degenerate, weakly degenerate and strongly degenerate, Quantum mechanical ensemble theory, Density Matrix, Statistics of various ensembles, examples: Free particle in a box, harmonic Oscillator, Theory of Simple Gases: Ideal gas in different quantum mechanical ensembles.

Module-4: Application of Quantum Statistics

Ideal Bose Gas: Thermodynamics, Bose-Einstein Condensation, Blackbody Radiation, Phonons, Ideal Fermi Gas: Thermodynamics, Pauli paramagnetism, Landau diamagnetism, Electron gas in metals.

Text Books

1. Statistical Mechanics: R. K. Pathria, Butterworth-Heinemann.
2. Statistical and Thermal Physics: F. Reif, McGraw Hill.
3. Thermodynamics and Statistical Mechanics: Greiner, Neise and Stocker,Springer.

Reference Books

1. Statistical Mechanics: K. Huang, John Wiley.
2. Statistical Physics: L.D. Landau and E.M. Lifshitz, Pergamon.

Course Outcomes: On completion of the course the learner shall be able to:

- DemonstrateknowledgeofthermodynamicsandstatisticalPhysicsatindividualparticlelevel.
- Analyze and solve simple problems related to fundamental ideas of thermodynamics and statistical Physics at micro level in various media.
- Formulate new methods to study fundamental ideas of thermodynamics and statistical Physics at micro level in various media.

PH913102PH: Electrodynamics-II [Core Theory 3 1 0 4]

Course objective: To provide understanding and knowledge of interaction of different frequency electromagnetic wave with various media and radiation emitted by accelerated charges with relativistic electrodynamics.

Module-1: Absorption and dispersion of EM waves

Electromagnetic waves in conductors, reflection at a conducting surface, frequency dispersion characteristics of dielectrics, conductors and plasmas: normal and anomalous dispersion, low and high frequency behavior, refractive index and absorption coefficient Cauchy's formula, Causality in the connection between D and E; Kramers- Kronig relations.

Module-2: Wave guides and resonant cavities

Fields at the surface and within a conductor, cylindrical cavities and wave guides, modes in rectangular wave guide, co-axial transmission line, energy flow, attenuation and power loss in waveguides, resonant cavities, dielectric wave guides, scattering of radiation: Thomson and Rayleigh scattering.

Module-3: Radiation from moving charges

Vector and scalar potentials, gauge transformations, Lorentz and Coulomb gauge, retarded potentials, Lienard - Wiechert potentials, Radiation from an oscillating source, Electric dipole radiation, Magnetic dipole and quadrupole radiation, power radiated by an accelerated charge, Larmour formula and its generalization, Radiation reaction.

Module-4: Relativistic electrodynamics

Lorentz transformation, structure of four vectors and space-time diagrams, proper time, relativistic energy and momentum, relativistic kinematics, relativistic dynamics, magnetism as a relativistic phenomenon, transformation of fields, electromagnetic field tensor, four current densities, covariant four-vector, covariant form of Maxwell's equations and relativistic potentials.

Text Books

1. S. P. Puri, Electrodynamics, New Age publications
2. J. Griffith, Electrodynamics, Cambridge Univ. Press
3. B. Laud, Electrodynamics, New Age international publications

Reference Books

1. Tai L. Chow, Introduction to Electromagnetic theory, Jones and Bartlett student edition
2. J. D. Jackson, Classical Electrodynamics, John Wiley (Asia).

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of electromagnetic waves in various media.
- Analyze and solve simple problems related to fundamental ideas of electromagnetic waves in various media.
- Formulate new methods to study electromagnetic waves in various media for device application and in technology.

PH913103PH: Laser and Fiber Optics [Core Theory 3 1 0 4]

Course Objective: To provide understanding and basic properties of laser and fiber optics. It offers the capability of elementary problem solving in laser and fiber optics, and relating theoretical predictions and measurement of results.

Module-1: Laser Fundamentals

Principle and properties of laser, coherence, spontaneous and stimulated emission, Einstein's coefficients, population inversion, laser rate equations: three level system and four level system, saturation intensity, development, growth and threshold condition of a laser beam.

Module-2: Components and Laser Sources

Basic components of laser, pumping schemes, optical resonators, line broadening mechanisms: spontaneous and stimulated transition, collision broadening and doppler broadening,

Laser sources: Gas laser: He-Ne laser, CO_2 laser, Solid state laser: Ruby Laser, Nd-YAG Laser, semiconductor diode laser and dye laser

Module-3: Fundamentals of Fiber Optics

Principle of optical fiber, propagation of light through a fiber, acceptance angle, numerical aperture, step index and graded index fiber, modes in fiber, attenuation in optical fibers, loss mechanisms, dispersion in step index fiber, planar optical waveguide and graded index optical fibers, signal distortion

Module-4: Light Propagation in Fiber Cable

Propagation of radiation in dielectric waveguides, rectangular and cylindrical waveguides, TE and TM modes in planar waveguides power launching and coupling, fiber parameter specifications, modal analysis for step index and graded index fiber, mode coupling, optical couplers, splicing, fiber sensors.

Text books

1. Laser: A. Ghatak, K. Thyagarajan, Cambridge Univ. Press.
2. Int to FiberOptics: A. Ghatak, K.Thyagarajan,Cambridge Univ. Press
3. Optical Electronics:A.Ghatak, K.Thyagarajan, Cambridge Univ. Press.

Reference books

1. Laser Fundamentals:W. Silfvast Cambridge Univ. Press
2. Optoelectronics J. WilsonandJ. Hawkes, , Prentice Hall of India Pvt. Ltd.,2nd ed.
3. Femtosecond Laser Pulse: Principles and Experiments, C.Rulliere, Springer

Course outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of laser and its applications
- Analyze and solve simple problems related to lasers and fibers

Formulate new methods to study laser, fiber and its classification

PH913104PH: Advanced Electronics [Core Theory 3 1 0 4]

Course objective: To provide an idea about fundamentals of digital electronics and systems with applications. and basics of modulation and demodulation in communication systems.

Module-1: Digital Fundamentals

Logic circuits, Boolean law and theorems, Exclusive-OR and-NOR gates, sum of product, Karnaugh Maps, Karnaugh simplifications, don't care condition, product of sums simplification, multiplexer, demultiplexer, BCD to decimal decoder, seven segment decoder, encoder, digital comparator, parity generator, 2's complement and half adder, full adder, adder-subtracter.

Module-2: Digital Systems

RS Flip-Flop, clocked RS flip-flop, D flip-flop and Trigger, switching time, JK flip-flop, Race-around condition, master-slave JK flip-flop, clock waveforms, 555 timer, Serial in serial out, serial in parallel out shift registers, ring counters, synchronous and asynchronous counters, ROMS, PROMS, EPROMS, random access memory (RAM), magnetic memories. D/A converters and A/D converters.

Module-3: Communication Basics

Modulation: need of modulation, basic principles of amplitude, frequency and phase modulation. FM transmitter and receiver. basic concepts of information theory, digital modulation and demodulation, PM, PCM, ASK, FSK, PSK, Time-division multiplexing, frequency-division multiplexing, intermediate frequency and principle of super-heterodyne receiver

Module-4: Communication systems

Radio communication, radio transmitter, antenna, propagation of radio waves, ionosphere influence on wave propagation, satellite communication, radio receiver, digital communication, cellular telephone networks.

Principle of radar, basic arrangement of radar system, azimuth and range measurement, operating characteristics of systems, radar transmitters and receivers, duplexers, indicator unit, maximum range of a radar set.

Text books

1. Hand Book of Electronics: Gupta and Kumar; Pragati Prakashan.
2. Integrated Electronics: Millman and Halkias, New Age Publications.
3. Digital Principles: Malvino and Leach, sMcGraw-Hill
4. Digital Computer: Malvino and Brown, Tata-McGrawHill

Reference books

1. Electronic Communication Systems: G. Kennedy & B. Davis, Tata McGraw-Hill
2. Digital Fundamentals: F. Loyed
3. Modern Digital Electronics: R.P. Jain.

Course outcomes: On completion of the course the learner shall be able to:

- Apply the knowledge and skill in the research and design/development of digital circuits to fulfill the needs of technology.
- Work in the multicultural and multidisciplinary groups for the sustainable development and growth of electronics and communication projects and profession.

PH913501PH: Minor Project [Core Practical 0 0 6 3]

Course Objective: The objective of the course is to inculcate research motivation in students.

Course Outcomes: On completion of the course the learner shall be able to:

- Identify an area of interest to pursue their further studies.
- Develop enthusiasm toward innovative research.

PH913401PH: Laser and Fiber Optics Lab [Core Practical 0 0 4 2]

Course Objective: The objective of the course is to offer hands in experience in the field of Optics and Photonics

Course Outcomes: On completion of the course the learner shall be able to:

- Identify basic photonic components and their uses.
- Apply the knowledge of photonics in various application areas such as sensing, optical communication, applied optics, etc.

PH914101PH: Atomic and Molecular Physics [Core Theory 3 1 0 4]

Course objective: To provide understanding and knowledge of atomic structure and the interaction between atoms and fields. Further, it deals with the binding of atoms into molecules, and theory of electronic, vibrational, rotational and molecular spectroscopy.

Module-1: Spectra of one electron atoms

Vector atom model, Sterrn-Gerlach Experiment, hydrogen spectrum, spin-orbit interaction and fine structure in alkali spectra, intensity rules - equivalent and non-equivalent electrons, l-s and j-j coupling-hyperfine structure and isotopic shift.

Module-2: Spectra of many electron atoms

Zeeman effect-normal and anomalous, Paschen-Back effect, Stark effect, two electron systems, broadening of spectral lines– line broadening, Doppler and Lorentz broadening mechanisms, lamb shift, X- ray spectra-Moseley's Law.

Module-3: Theory of molecular spectra

Born-Openheimer approximation, rotational spectra of diatomic molecules-rigid rotator and non-rigid rotator, vibrational-rotational spectra of diatomic molecule- harmonic oscillator, effect of an-harmonicity, electronic spectra of diatomic molecules, Frank-Condon principle.

Module-4: Raman spectroscopy

Raman spectroscopy, Rotational and vibrational Raman spectra of diatomic molecules, Electron spin resonance (ESR), Nuclear magnetic resonance (NMR), Effect of Nuclear spin on intensities of rotational Raman spectra.

Text Books

1. Introduction to Atomic Spectra; White; Mcgraw-Hill Education.
2. Atomic Spectra and AtomicStructure; Herzberg; Dover
3. Physics of Atoms and Molecules: Bransden and Joachain; Pearson.
4. Atomic & Molecular Spectra; Raj Kumar, Kedar Nath Ram Nath, New Delhi.

Reference Books

1. Fundamentals of Molecular Spectroscopy; Banwell; Mcgraw-Hill (India) Ltd.
2. Introduction to Molecular Spectroscopy; Barrow; Mcgraw-Hill Education.
3. Modern Spectroscopy; Hollas; Wiley India Pvt Ltd.
4. Principle of Atomic Spectra-Shoreand Menzel
5. Spectra of Diatomic molecules-G. Herzberg).

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of atomic and molecular physics
- Analyze and solve simple problems related to atomic and molecular physics
- Formulate new methods to study atomic and molecular physics

PH914102PH: Nuclear and Particle Physics

[Core Theory 3 1 0 4]

Course objective: To provide understanding of the basic properties of nuclei and nuclear structure. It offers the capability of elementary problem solving in nuclear and particle physics, and related theoretical predictions and measurement of results.

Module-1: Properties of nucleus and nuclear decay

Static properties of nuclei: nuclear size, nuclear charge distribution. angular momentum, spin and moments of nuclei, binding energy and stability, semi-empirical mass formula, mass parabola, electric quadrupole moments. nuclear forces and its properties, two-body problem: ground state of deuteron, isospin formalism.

Alpha decay: Geiger-Nuttall law, electromagnetic decay: selection rules, Fermi theory of beta decay, Fermi and Gamow-Teller transitions. parity violation in beta-decay, radioactive series.

Module-2: Nuclear models and nuclear reactions

Liquid drop model, experimental evidence for shell effects, shell model, spin orbit coupling, magic numbers, angular momenta and parities of nuclear ground states, magnetic moments and Schmidt lines, validity and limitations of shell model, collective model: rotational and vibrational spectra, nuclear shapes.

Nuclear fission and fusion, nuclear kinematics, classification of nuclear reactions, compound nucleus hypothesis.

Module-3: Detectors and instrumentation

Energy loss by charged particles in matter, interaction of electromagnetic radiation with matter: photoelectric effect, Compton scattering and pair production, elementary idea about gas detector, Geiger-Muller counter, scintillation counter, solid-state detectors, modern accelerators.

Module-4: Elementary particles physics and quark model

Classifications of forces of nature, parity in weak interactions, baryons, mesons: meson and baryon octet and decuplet, leptons, classification: spin and parity assignments; conservation laws with respect to spin and parity, baryon number, lepton number, isospin, strangeness, hypercharge. Gell-Mann-Nishijima scheme. C, P and T invariance and application of symmetry arguments to particle reaction, quark model, introduction to the standard model.

Text books

1. Nuclear Physics by S.N. Ghoshal, S. Chand & Company Ltd.
2. Introducing Nuclear Physics by K. S. Krane Wiley India.
3. Nuclear Physics - R.R. Roy & B. P. Nigarn New Age lnternational.

Reference books

1. Nuclear & Particle Physics: An Introduction by B. Martin Willey
2. Introduction to Elementary Particles by D. J. Griffiths Academic Press 2nd Ed.
3. Concept of Nuclear Physics by B. L. Cohen, McGraw-Hill.

Course outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of nuclear physics
- Analyze and solve problems related to nuclear physics
- Formulate new methods to study nuclear physics.

[Elective Theory 0 0 5 5]

PH914501PH: Major Project with seminar

Course Objective: To provide initial research orientation to students in theoretical and/or experimental physics.

Course Outcomes: On completion of the course the learner shall be able to:

- Identify an area of interest to pursue their further research work.
- Develop enthusiasm toward innovative research carrier.

PH914201PH: Characterization Techniques [Elective Theory 3 1 0 4]

Course Objective: To provide understanding and basic idea of various characterization methods and techniques.

Module-1: Optical Microscopy

Optical microscope - Basic principles and components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarized light, Hot stage, Interference techniques), Stereomicroscopy, Photo-microscopy, Colour metallography, Specimen preparation, Applications.

Module-2: Electron Microscopy:

Interaction of electrons with solids, Scanning electron microscopy Transmission electron microscopy and specimen preparation techniques, Scanning transmission electron microscopy, Energy dispersive spectroscopy, Wavelength dispersive spectroscopy.

Module-3: Diffraction Methods:

Fundamental crystallography, Generation and detection of X-rays, Diffraction of X-rays, X-ray diffraction techniques, Electron diffraction. Surface Analysis: Atomic force microscopy, scanning tunneling microscopy, X-ray photoelectron spectroscopy.

Module-4: Spectroscopy:

Atomic absorption spectroscopy, UV/Visible spectroscopy, Fourier transform infrared (FTIR) spectroscopy, Raman spectroscopy. Thermal Analysis: Thermo gravimetric analysis, Differential thermal analysis, Differential Scanning calorimetry (DSC), Thermo mechanical analysis and dilatometry.

Text Books

1. Li Lin, Ashok Kumar, Materials Characterization Techniques Sam Zhang; CRC Press.

Reference Books

1. B.D. Cullity, and Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall.

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of various experimental and characterization techniques used in preparation and material synthesis process.
- Analyze and solve simple problems related to preparation and material synthesis process.
- Formulate new methods to study preparation and material synthesis process.

PH914202PH: Optoelectronics [Elective Theory 3 1 0 4]

Course Objective: To provide the understanding and basic properties of semiconductor and its application in optoelectronics devices.

Module-1: Semiconductor Physics for Optoelectronics

Density of states in a quantum well structure, occupation probability, carrier concentration and Fermi level, quasi Fermi levels, semiconductor hetero-structures lattice matched layers, strained - layer epitaxy and quantum well structures, bandgap engineering, hetero-structure p-n junctions, Schottky junction and Ohmic contacts, fabrication of heterostructure devices

Module-2: Light Emission & Modulation

Interaction of photons with electrons and holes in a semiconductor, optical joint density of states, rates of emission and absorption, amplification by stimulated emission, semiconductor (Laser) amplifier, absorption spectrum of semiconductor, gain and absorption spectrum of quantum well structures, electro-absorption modulator, and device configuration.

Module-3: Semiconductor LED & LD

Light Emitting Diode: device structure and parameters, device characteristics, modulation bandwidth, LED- materials and applications, Laser diode basics: semiconductor Laser device structure, output characteristics, single frequency Lasers, vertical cavity surface emitting laser (VCSEL), quantum well laser, practical laser diodes and handling

Module-4: Photo detectors and Solar cells

Photo diode, quantum efficiencies (internal and external), responsivities, Characteristics and applications of various photodetectors: p-i-n, Avalanche, Metal–Semiconductor-Metal (M-S-M), quantum well, multi-quantum well, infrared photodetector; Charge coupled devices (CCD), Photovoltaic effect, principle and quantum efficiency, V-I characteristics and parameters of solar cell circuits, types of solar cells: solar cell generation, materials: II-VI chalcoprite solar cells, etc

TextBooks

1. P. Bhattacharya, Semiconductor opto-electronic devices
2. Ghatak and Thyagarajan, Optical Electronics, Cambridge Univ. Press
3. J. Singh: Electronic, Optoelectronic properties of semiconductors, Cambridge Univ. Press

Reference Books

1. S. M. Sze Physics of semiconductor devices.
2. S. O. Kasap, Optoelectronics and Photonics principles and practices
3. M A Green, Solar Cells: Operating Principles, and Technology,

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of operating principles of LED and LD and its applications
- Analyze and solve simple problems related to operating principles of LED and LD
- Formulate new methods to explore applications of LED and LD.

PH914203PH: Nanoscience [Elective Theory 3 1 0 4]

Course Objective: To provide a comprehensive description of the phenomena and changes that can be expected due to size quantization along with their synthetic route.

Module-1: Background to nanoscience

Definition of Nano, Scientific revolution-Atomic Structure and atomic size, emergence and challenges of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, role of surface to volume ratio, surface effects on the properties.

Module-2: Classification, synthesis and properties of nanomaterials

One dimensional, Two dimensional and Three-dimensional nanostructured materials, Quantum dots shell structures. Synthesis of nanostructured materials: Top-down method (mechanical methods and lithographic techniques), Bottom-up methods: Physical Vapor deposition (PVD), Sputtering, Chemical Vapor Deposition (CVD), Spin coating, chemical bath deposition (CBD), sol-gel, Shape and size dependent properties.

Module-3: Surface and colloidal nanoscience

Introduction to surface active agents, Theory and applications, Types of surfactants. Colloidal nanoscience: Introduction to colloidal material, surface properties, origin of colloidal particles, preparation & characterization of colloidal particles, Applications of super hydrophilic, hydrophobic surfaces, self-cleaning surfaces, Surface viscosity.

Module-4: Renewable energy

Energy conversion process, Introduction to semiconductor physics, conducting and semiconducting materials, Semiconductor nanostructures, Electronic structure and physical process, material aspect of solar cells, Thin film solar cells, Solar cell characteristics and characterization techniques. Nano-, micro-, and poly crystalline and amorphous Si for solar cells, Energy storage (Supercapacitor): Principle, working, materials.

Text Books

1. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
2. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim.
3. Takaaki Tsurumi, Hiroyuki Hirayama, Martin Vacha, Tomoyasu Taniyama,Nanoscale
4. Physics for Materials Science, CRC Press.

Reference Books

1. A.W. Adamson and A.P.Gast, Physical Chemistry of Surfaces, Wiley Interscience, NY.
2. P.C Hiemenand R.Rajgopalam, Principle of colloid and surface Chemistry, NY Marcel Dekker.
3. Solar cells: Operating principles, technology and system applications by Martin A Green,Prentice, Hall Inc, Englewood Cliffs, NJ, USA.
4. Semiconductor for solar cells, H J Moller, Artech House Inc, MA, USA.

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrate the knowledge of dimensional dependence of various properties of materials.
- Analyze and solve simple problems related to electrical, optical and magnetic properties of nano materials
- Formulate new methods to study size quantization on various properties.

PH914204PH: Nonlinear Optics [Elective Theory 3 1 0 4]

Course Objective: To provide advanced knowledge in nonlinear optics.

Module-1: Laser oscillation

Laser gain saturation, steady state laser intensity, decay time and basic laser cavity rate equation and solution, laser spiking, Fabry-Perot and longitudinal laser cavity modes, properties of laser modes, unstable resonators.

Module-2: Laser Q-switching and mode locking

Theory and production of Q-Switching: Electro-optic Shutter (Pockels cell and Kerr cell), acoustic-optic shutters and saturable absorber. gain switching, mode locking theory and production: general cavity consideration, active shutter, passive shutters. pulse shortening techniques, giant pulse dynamics, ultra-fast light pulses, distributed feedback, Nd: YAG, edge emitting, surface emitting and quantum cascading laser

Module-3: Basics of nonlinear optics

Wave propagation in an anisotropic crystal, polarization response of materials to light, harmonic generation: second harmonic generation, sum and difference frequency generation, optical parametric oscillation, third harmonic generation, intensity-dependent refractive index, nonlinear optical materials, phase matching.

Module-4: Nonlinear Absorption and Refraction

Saturable absorption, optical bi-stability, two photon absorption, stimulated Raman scattering, multi-quantum photoelectric effect – theory of two photon process – experiment evidences, multi and three photon process –self-focusing of light – phase conjugated optics–photo refractive effect.

Text Books

1. Lasers: Principles and Applications- K. R. Nambiar, (NewAge International Publishers Ltd, NewDelhi).
2. Lasers and Nonlinear Optics: B. B. Laud, 3rdEdn. (New Age International Pvt. Ltd., NewDelhi).

Reference Books

1. Laser Fundamentals: W. T. Silfvast, (Cambridge University Press, Cambridge).
2. The Principles of Nonlinear Optics: Y. R. Shen, (Wiley & Sons, New Jersey)
3. Hand book of Nonlinear Optics: R. L. Sutherland, (Marcel Decker Inc, New York).

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrate knowledge of advanced laser process of Q-switching and mode locking and basics of harmonic generations.
- Analyze and solve simple problems related to Q-switching and mode locking and harmonic generations
- Formulate new methods to study Q-switching and mode locking and harmonic generation

PH914105E: Advanced Spectroscopy [Elective Theory 3 1 0 4]

Course Objective: The objective of the course is to provide understanding and knowledge ofadvancedspectroscopic techniques and its applications in various fields.

Module-1: NMR Spectroscopy

Basic principle of interaction of spin and applied magnetic field, Larmour precession, Concept of NMR spectroscopy, Concept of spin-spin and spin-lattice relaxation, Chemical shift, Experimental set up of continuous wave NMRspectroscopy.

Module-2: ESR Spectroscopy

Principle of electron-spin resonance, Effects of L-S coupling – fine and hyperfine structure, Hyper fine structure from reaction with two or more nuclei, g-value, Unpaired electron spin density of hydrogen-Mc Connel relation, Simple experimental set-up for ESR.

Module-3: Laser Spectroscopy

Molecular Laser-Induced Fluorescence Spectroscopy and their experimental aspects, Laser- Induced Breakdown Spectroscopy LIBS, Laser Raman Spectroscopy: Basic Considerations, Experimental Techniques of Linear Laser Raman Spectroscopy, Resonance Raman Effect, Coherent Anti-Stokes Raman Scattering, Surface-Enhanced Raman Scattering, Applications of Laser Raman Spectroscopy.

Module-4: Modern Spectroscopic Techniques and detectors

Energy dispersive X-ray spectroscopy (EDX or EDS), X-ray fluorescence spectroscopy (XRF), X-ray photoelectron spectroscopy (XPX), Photodiodes, Photodiode Arrays, Charge- Coupled Devices (CCDs) and Detection Techniques.

Text Books

1. Molecular Spectroscopy by Jean Le.McHale
2. Introduction to Molecular Spectroscopy by G. M.Barrow
3. Fundamental of Molecular Spectroscopy by C. B.Bnwell

Reference Books

1. Spectra of Diatomic Molecules byHerzberg
2. Molecular Quantum Mechanics by P. W. Alkins and R. S.Friedmain
3. Laser Spectroscopy Vol. 1 & 2 by W.Demtroder.

Course Outcomes: On completion of the course the learner shall be able to:

- Demonstrateknowledgeofadvancedtechniquesofspectroscopyanditsapplications
- Analyze and solve simple problems related to spectroscopicanalysis
- Formulate new methods to study material characterization usingspectroscopy.