M.Sc. CURRICULUM

DEPARTMENT OF **PHYSICS**

NATIONAL INSTITUTE OF TECHNOLOGY, AGARTALA

Semester-I

Sl No.	Subject code	Name of the Subject	L	T	P	CP
1	PPH01Bxx	Classical Mechanics	3	1	0	4
2	PPH01Bxx	Mathematical Physics	3	1	0	4
3	PPH01Bxx	Quantum Mechanics - I	3	1	0	4
4	PPH01Bxx	Numerical Analysis	3	1	0	4
5	PPH01Pxx	Physics Lab-I	0	0	4	2
			TOTAL CREDIT			**18**

Semester-II

Sl No.	Subject code	Name of the Subject	L	T	P	CP
1	PPH02Bxx	Quantum Mechanics – II	3	1	0	4
2	PPH02Bxx	Analog Electronics	3	1	0	4
3	PPH02Bxx	Statistical Mechanics	3	1	0	4
4	PPH02Exx	Elective - I	3	1	0	4
5	PPH02Bxx	Electrodynamics	3	1	0	4
6	PPH02Pxx	Physics Lab – II	0	0	4	2
7	PPH02Pxx	Electronics Lab-I	0	0	4	2
			TOTAL CREDIT			**24**

Semester-III

Sl No.	Subject code	Name of the Subject	L	T	P	CP
1	PPH03Bxx	Atomic Physics	3	1	0	4
2	PPH03Bxx	Condensed Matter Physics – I	3	1	0	4
3	PPH03Bxx	Digital Electronics	3	1	0	4
4	PPH03Exx	Elective-II	3	1	0	4
5	PPH03Exx	Elective-III	3	1	0	4
6	PPH03Pxx	Physics Lab-III	0	0	6	3
7	PPH02Pxx	Electronics Lab-II	0	0	4	2
			TOTAL CREDIT			**25**

Semester-IV

Sl No.	Subject code	Name of the Subject	L	T	P	CP
1	PPH04Bxx	Molecular Spectroscopy	3	1	0	4
2	PPH04Bxx	Nuclear and Particle Physics	3	1	0	4
3	PPH04Bxx	Condensed Matter Physics –II	3	1	0	4
4	PPH04Pxx	Project + Grand Viva + Dissertation + Seminar Presentation	0	0	16	10
			TOTAL CREDIT			**22**

Total Course Credit: 89

Electives for M.Sc

Sub. Code	Name of the Subject	L	T	P	CP
E01	Physics of Plasmas	3	0	0	3
E02	Plasma Production & Diagnostics	3	0	0	3
E03	Thin film Science & Nanotechnology	3	0	0	3
E04	Antennas & Microwave Devices	3	0	0	3
E05	Liquid Crystal & Applications	3	0	0	3
E06	Physics of Semiconductor Devices	3	0	0	3
E07	Quantum Field Theory	3	0	0	3
E08	General Theory of Relativity	3	0	0	3
E09	Spintronics				

N.B: Course Codes will be assigned as per MIS rules,
Electives are to be taken only after consultation and approval from concerned department,
Electives will be offered as per availability of the faculty concerned.

Course: Classical Mechanics **Code: PPH01Bxx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of Classical Physics, Concept of Lagrangian and Hamiltonian, Differential and Integral Calculus, Ordinary Differential Equations.

Course Objective

1. To impart knowledge of canonical transformation, express equation of motion in terms of Poisson Bracket.

2. To develop the problem honing capability of students in classical physics.

Course content:

Principle of Least Action, Lagrange multipliers and applications; Canonical invariants; infinitesimal canonical transformations and conservation laws, Hamilton-Jacobi theory, characteristic function, action-angle variables; Hamilton's canonical equations of motion, Rouths procedure, Lagrangian and Hamiltonian for field and Relativistic field theory.

Gauge function for Lagrangian, Canonical Transformations, Generating functions, Poisson Bracket and other canonical invariants, Poisson brackets and equations of motion, angular momentum PB relations, Liouville's theorem.

Rigid body dynamics: Independent coordinates of rigid body, infinitesimal rotations as vectors (angular velocity), and finite rotations, angular momentum, Euler's angles, Euler's equations of motion.

Symmetric bodies, Euler's equations of motion for a rigid body, Torque-free motion of a rigid body, heavy symmetrical top, Gyroscope, The Coriolis Effect.

Small oscillations: solutions, normal coordinates and normal modes, kinetic and potential energies in normal coordinates. General theory of small oscillation, normal coordinates and normal modes, free vibration of a linear triatomic molecule.

Course outcome

At the end of the course, students will be able to

1. Apply the Variational principles to real physical problems,

2. Formulate mathematical methods of classical mechanics both in inertial and rotating frames, using Lagrange and Hamilton equations

Recommended Books:

1. H. Goldstein, Classical Mechanics, 2nd edition, Narosa Publishing House (1994).
2. W. Greiner, Classical Mechanics, Springer-Verlag.
3. J.C. Upadhyaya, Classical Mechanics,Himalaya Publication
4. G.Aruldhas, Classical Mechanics,PHI Learning
5. N.C Rana and P.S.Joag, ClassicalMechanics, TataMcGRAW Hill

Course: Mathematical Physics **Code: PPH01Bxx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of Complex Numbers, Differential and Integral calculus and ordinary differential equations.

Course Objective:

1. To impart knowledge and develop the aptitude of students with certain mathematical techniques.
2. To develop required mathematical skills and highlight applications of mathematical methods to physical systems.

Course content:

Complex Analysis: Functions of complex variable, derivative and Cauchy-Riemann differential equations, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, Cauchy's residue theorem, singular points of an analytic function, evaluation of residues, evaluation of definite integrals;

Integral Transforms Fourier series, Fourier integral theorem, Fourier transform, Parseval's identity, related problems:

Laplace transform, convolution theorem, transform of derivates, application to ordinary differential equation;

Linear Differential Equations: Introduction, reduced equation, method of partial fraction, linear dependence and Wronskian, Second order equations, Frobenius method, Applications of differential equations. Special functions: (Hermite, Bessel, Laguerre and Legendre) and associated polynomials.

Tensors: Cartesian tensors, Symmetric and antisymmetric tensors, Pseudo tensors, Dual tensors, Direct product and contraction, Dyads and dyadic, Covariant, Contravariant and mixed tensors, metric tensor. Christoffel symbols and differentiation of tensors.

Group theory: Introduction, Discrete groups, Continuous groups, Generators, SU(2), SU(3) and homogeneous Lorentz groups.

Course Outcome:

At the end of the course, students will be able to

1. Understand the basic elements of complex analysis, including the important integral theorems,
2. Solve ordinary second order differential equations important in the physical sciences; series expansion (Fourier-type series) and integral transforms,
3. Learn how to expand a function in a Fourier series, and under what conditions such an expansion is valid. Students will be aware of the connection between this and integral transforms (Fourier and Laplace) and be able to use the latter to solve mathematical problems relevant to the physical sciences,
4. Understand Tensor and its basic operations,
5. Explain the basics of Group Theory.

Books Recommended:

1. G. Arfken: Mathematical methods for physicists. Academic Press Int. Ed. 1970.
2. J. Mathews and R.L. Walker: Mathematical methods of physics. India Book House Pvt. Ltd.
3. M. R. Spiegel (Schaum's Outline Series): Complex Variables
4. A. W. Joshi: Matrices and Tensors for Physicists.
5. H.O. Jeffreys and Lady Jefferys : Methods of mathematical physics. Cambridge Univ. Press. 1978.
6. R.V. Churchill : Complex variables and applications.
7. D.R. Halmos : Finite dimensional vector spaces.
8. C. Harper : Introduction to mathematical physics.
9. P.M. Morse and H. Feshbach : Methods of theoretical physics. Vol 1 & 2. McGraw Hil.
10. D.T. Finkbeiner : Introduction to matrices and linear trans- formations.
11. P.K. Chattopadhyay : Mathematical methods of physics. Wiley Eastern

Course: Numerical Analysis I **Code: PPH01Bxx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Concepts of differential and integral calculus, knowledege of computer Programming, algorithm and flowcharts.

Objective: To familiarize the students with the numerical techniques to solve the problem related to science and engineering. To impart basic algorithmic approach so that the students can tackle a real life problem involving ideas from science and engineering.

Course contents:

Errors: its sources, propagation and analysis. Representation of integers and real numbers. Numerical instability. **Root finding methods :** Fixed-point iteration, Bisection, Newton-Raphson, Secant method, Chebyshev method, Graffe's root squaring method, Bairstow's method- Theory, Flowchart, Algorithm , C-Programming, condition for convergence. **Linear equations** - Gauss and Gauss-Jordan elimination, Gauss-Jacobi method, method of triangular decomposition, iterative methods-Gauss Seidel iteration, Relaxation method, power method . **Finite Differences: F**orward, backward and centered difference formulae, relation between finite difference operators, difference of a polynomial. **Interpolation:** Newton's and Chebyshev polynomials, forward and backward interpolation formulas, Stirling's formula, Bessel's formula, Laplace formula. Divided differences, Lagrange interpolation formula with unequal intervals, Hermite's interpolation formula, Piecewise interpolation, Cubic spline interpolation**. Differentiation**: Newton's (forward and backward) , Stirling's method, Method of undetermined multipliers - Theory, Flowchart, Algorithm , C-Programming. **Integration**: Newton-Cote's quadrature formula, Roomberg's method, Trapezoidal and Simpson's rule(s), Gauss-Legendre integration, Gauss quadrature formula, Double integrals-Theory, Flowchart, Algorithm , C-Programming.

Course outcome:

At the end of the course, students will be able to

1. Solve numerically equations which were not solvable earlier analytically.
2. Apply the methods of various numerical techniques to the problems appearing in science and engineering
3. Develop computer based programmes of very complicated and tiresome problems.

References:

1. K. E. Atkinson, Numerical Analysis- John Wiley (Asia) (2004).

2. Sankara K. Rao , Numerical Methods for Scientists and Engineers, Prentice Hall of India.
3. S.S. sastry, Introductory methods of numerical analysis, Prentice Hall of India, 2006 .
4. M.K. Jain, S. R. K. Iyenger, R. K. Jain , Numerical Methods, New Age Techno Press .
5. S. S. M. Wong, Computational Methods in Physics and Engineering, World Scientific, 1997.
6. W. H. Press, S. A. Teukolsky, W. T. Verlling and B. P. Flannery,
   Numerical Recipes in C/Fortran.
7. W. F. Ames, Numerical Methods for Partial Differential Equations, Academic Press-1977.

Course: Quantum Mechanics - I **Code: PPH01Bxx**

L-T-P: 3-1-0 **Credits** – 4

Pre-requisite: Basic knowledge of Modern Physics, Differential & Integral Calculus and Ordinary Differential Equations, Polynomial, Primary concepts of Quantum and Wave mechanics.

Course Objective:

1. To explain the physical concepts of Quantum Mechanics,
2. To describe the mathematical formalism and to present illustrative examples of both the ideas and the methods.

Course Content:

Need of Quantum Mechanics; Inadequacy of classical mechanics; Schrodinger equation; continuity equation; Ehrenfest theorem; Admissible wave functions; Stationary states. Operators, expectation values, transition probabilities, harmonic oscillator, reflection at a step potential, transition across a potential barrier. Hydrogen atom; natural occurrence of n, l, and m quantum numbers, the related physical quantities, comparison with Bohr's theory; One-dimensional problems, well and barriers; Harmonic oscillator by Schrodinger equation and by operator method; Uncertainty relation of x and p, States with minimum uncertainty product; General formalism of wave mechanics, Commutation relations; Representation of states and dynamical variables; Completeness of eigen functions ; Dirac delta function, bra and ket notation; Matrix representation of an operator, unitary transformation; Angular momentum in QM, Commutation relations, spherical harmonics, spin - orbit coupling, total angular momentum; Central force problem; Solution of Schrodinger equation for spherically symmetric potentials; Hydrogen atom, energy levels, degeneracy.

Course Outcome:

At the end of the course, students will be able to

1. The physical concepts are discussed and the Schrodinger wave formalism is established.
2. Formulate problems to solve Schrodinger equation to obtain eigenvectors using matrix theory.

3. Explain fundamental concepts of quantum mechanics,

References Books:

1. L I Schiff, Quantum Mechanics (McGraw- Hill)
2. S Gasiorowicz, Quantum Physics (Wiley)
3. J D Powell and B Craseman, Quantum Mechanics (Addison wesley)
4. C.Cohen-Tannoudji, B.Diu and F.Laloe, Quantum Mechanics I
5. J J Sakurai, Modem Quantum Mechanics
6. Mathews and Venkatesan. Quantum mechanics
7. David J. Griffiths, Introduction to Quantum Mechanics (Pearson)

M.Sc 1st Semester

General Physics Lab. - I

List of Experiments:

1. Determination of ultrasonic velocity in a given liquid by ultrasonic interferometer
2. Study of characteristics of opto-coupler.
3. Determination of wavelength of monochromatic light source using Michelson Interferometer.
4. (a) Study and verify Malu's law using a plane glass plate and a Polaroid
   (b) Study and verify Malu's law using two Polaroid
5. Determination of the damping constants of the Pohl's pendulum for different eddy damping current and estimation of the natural frequency of the Pohl's pendulum.
6. a. Drawing of resonance curve for the Pohl's pendulum under eddy damping current.
   b. Estimation of the resonance amplitude and resonance frequency.
7. Determination of electrical resistivity of a semiconductor as a function of temperature by four probe method and determine the band gap of the semiconductor.

Course: Analog Electronics **Code: PPH02Bxx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of semiconductor, P-n junction diode and BJT

Course Objective: To develop fundamental knowledge related to FET, BJT, various devices that can be fabricated using semiconductors and familiarity with practical applications of semiconductor devices like transistors, operational amplifiers and power amplifiers.

Course content

Biasing of transistor: Operating point, DC biasing of different transistor bias configuration and bias stabilization, AC analysis of BJT- The r_e transistor modeling, AC analysis of different transistor biasing circuits, darlington connection, hybrid equivalent model, hybrid $-\pi$ model, variations of transistor parameters.

Field-effect transistor: Ideal voltage controlled current source, JFET, MESFET, MOSFET (both enhancement and depletion type), structure, volt-ampere characteristics, the DC analysis of FET, AC analysis of FET, the MOSFET as a resistance, the FET as a switch, the FET as an amplifier, small signal FET model.

Microwave device: Conception of negative resistance and its significance, the Tunnel diode, Gunn diode, p-i-n diode, Avalanche photo-diode, IMPATT, TRAPATT, BARITT diodes

Photonic device: Radiative and non-radiative transitions, Optical absorption, Principle photoconductive device, quantum efficiency and photoconductive gain, LED: Commercial LED material, LED construction, response time in LED, LED drive circuitry, photodiode, photovoltaic mode and photoconductive mode, photo-transistors, Optical feedback, optical gain threshold current for lasing.

Operational Amplifiers (OPAMP) applications: Butterworth active filters of first and second order, RC phase shift oscillator, multivibrators, logarithmic and antilogarithmic amplifiers, comparator, zero-crossing detector, Schmitt trigger, triangular and square wave generators, sawtooth wave generator, high input impedance voltmeter, clipper, clamper circuits.

Feedback amplifiers: Classification of amplifiers, the feedback concept, the transfer gain with feedback, input and output resistances in the case of voltage-series-, current-series-, voltage shunt-, and current shunt negative feedback, bandwidth expansion and reduction of noise by negative feedback.

Power circuits and system: Large signal amplifiers, harmonic distortion, Class A, -B and – AB operation, efficiency of class A amplifier, Class A and –B Push pull amplifiers.

Course Outcome:

At the end of this course students will be able to

1. Relate and analyze the transistor and FET parameters for optimized circuit applications and designing practical circuits
2. Understand the operations and applications of different photonic and microwave devices according to the need.
3. Analyze different electronic circuits related to OPAMPS, feedback amplifiers, power circuits and use them in practical applications according to the need.

Recommended Books:

1. Microelectronics : Millman and Grabel
2. Microwave Devices and circuits: S.Y. Liao]
3. Optoelectronics – An Introduction: J. Wilson and J.F.B. Hawkes
4. Operational amplifier: Robert F. Coughlin and Fredrick F. Driscoll
5. Integrated Electronics: J. Millman and C Halkias
6. Integrated Electronics: J. Millman and C Halkias

Course: Electrodynamics **Code: PPH02Bxx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Introduction to basic electricity and magnetism principles, ordinary differential equations and mathematical physics.

Course Objective:

1. To familiarize the students with the concept of propagation of electromagnetic wave in various media,
2. To familiarize the students with the design of transmission lines and working principles of antennas,
3. To introduce the students with radiation physics and realm of relativistic Electrodynamics.

Electrostatics: Poisson and Laplace equations, Dirichlet and Neumann boundary conditions; Boundary value problems: Method of images, Laplace equation in Cartesian, spherical and cylindrical coordinate systems, applications; Green function formalism: Green function for the sphere, expansion of Green function in spherical coordinates; Multipole expansion; Boundary value problems for dielectrics;

Magnetostatics: Biot-Savart law, Ampere's law, electromagnetic induction, Lenz's law, Magnetic Vector Potential;

Maxwell's equations in free space and linear isotropic media; boundary conditions on fields at interfaces; Scalar and vector potentials; Gauge Transformation; Maxwell's equations, Gauge transformations, Poynting's theorem, Energy and momentum conservation; Electromagnetic waves: wave equation, propagation of Electromagnetic waves in non-conducting medium, reflection and refraction at dielectric interface, total internal reflection, Brewster's angle, complex refractive index, waves in conducting media, Frequency dependence of permittivity, permeability and conductivity, electrons in conductors and plasma;

Electromagnetic waves in conducting medium: reflection and transmission, skin depth;

Wave Guides: waves between parallel conductors, TE and TM waves, rectangular and cylindrical wave guides, resonant cavities; Radiating Systems and Multipole fields: retarded potential, field and radiation of a localized oscillating source, electric dipole fields and radiation, quadrupole fields, multipole expansion, energy and angular momentum, multipole radiations; **Scattering**: Scattering at long wavelengths, perturbation theory, Rayleigh scattering;

Radiation by Moving Charges: Lienard - Wiechert potential, radiation by nonrelativistic and relativistic charges, angular distribution of radiations, distribution of frequency and energy, Thomson's scattering, bremsstrahlung in Coulomb collisions;

Relativistic Electrodynamics: Covariant formalism of Maxwell's equations, transformation laws and their physical significance, relativistic generalization of Larmor's formula, relativistic formulation of radiation by single moving charge.

Course Outcome:

At the end of this curse the students will be able to

1. Solve problems on propagation of electromagnetic waves through various media,
2. Design transmission lines and antenna apertures,
3. Understand the concepts of Radiation fields and calculate the related electric and magnetic potentials.

Books Recommended:

1. J.D. Jackson, Classical Electrodynamics, John Wiley & Sons, 2nd Edition (1990).
2. D. J. Griffiths, Introduction to Electrodynamics, Prentice Hall of India, (1989).
3. J.R. Reitz., F.J. Milford and R.W. Christy, Foundations of Electromagnetic Theory, 3rd edition, Narosa Publishing House (1979).
4. E.C. Jordon and K.G. Balmain, Electromagnetic Waves and Radiating Systems, 2nd edition, Prentice-Hall of India (1998).
5. W. Greiner, Classical Electrodynamics, Springer (2006).

Quantum Mechanics- II **Code: PPH02Bxx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of Quantum Mechanics, Schrodinger equation and Ordinary Differential Equations, Complex variable, Special functions

Objective:

1. To solve the advanced physical phenomena and applications of Quantum Mechanics.
2. The deeper quasi-philosophical questions are saved for the end.
3. Introduction of relativistic particle theory and to quantized fields.

Course Content:

Time- independent perturbation theory; Non-degenerate and degenerate cases; Applications such as stark effect, Zeeman effect. Variational method; WKB approximation, Time-dependent perturbation theory; Harmonic perturbation; Fermi's golden rule; Adiabatic and sudden approximations.

Collision in 3-D and scattering; Laboratory and CM reference frames; Scattering amplitude; differential scattering cross section and total scattering cross section, Born approximation; Scattering by spherically symmetric potentials; Partial waves and phase shifts, Scattering by perfectly rigid sphere and by square well potential and absorption; Complex potential and absorption.

Identical particles; symmetric and antisymmetric wave functions; Collision of identical particles; spin angular momentum;

Semiclassical theory of radiation; transition probability for absorption and induced emission; Electric dipole and forbidden transitions; Fermi's Golden rule; selection rules;

Relativistic quantum mechanics for free particle: Klein Gordon and Dirac equation.

Course Outcome:

At the end of the course, students will be able to

1. Explain fundamental concepts of quantum mechanics,
2. Formulate problems to solve Schrodinger equation to obtain eigenvectors of any particle.
3. Formulate problems to solve Schrodinger equation to describe the propagation of a particle in various potentials.
4. Learn how to do quantum mechanics.

References Books

1. L I Schiff, Quantum Mechanics (McGraw- Hill)

2. S Gasiorowicz, Quantum Physics (Wiley)
3. B Craseman and J D Powell, Quantum Mechanics (Addison wesley)
4. A P Messiah, Quantum Mechanics
5. J J Sakurai, Modem Quantum Mechanics
6. Mathews and Venkatesan. Quantum mechanics
7. David J. Griffiths, Introduction to Quantum Mechanics (Pearson)

Course: Statistical Mechanics **Code: PPH02Bxx**
L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of Probability and MB, BE and FD Statistics, Differential and Integral Calculus, Concept of Thermodynamics.

Course Objective

1. To develop an introduction to the probability and distribution function.
2. To develop the concept of ensembles.
3. To develop the concept of Phase Transitions.

Course Content:

Revision of Probability: Random walk problem, distribution function, Binomial distribution, Poission's distribution, Fluctuations, Brownian motion (Langevin's Theorem), Fluctuation-dissipation theorem.

Statistical description: macroscopic and microscopic states for classical and quantum systems, connection between statistics and thermodynamics, entropy, classical ideal gas, entropy of mixing and Gibb's paradox.

Microcanonical Ensemble: applications of ensemble theory to classical and quantum systems.

Canonical Ensemble: partition function, thermodynamics in canonical ensemble, classical systems, ideal gas, energy fluctuation, equipartition and Virial theorem, system of harmonic oscillators.

Grand Canonical Ensemble: equilibrium between a system and a particle-energy reservoir, partition function, density and energy fluctuation.

Formulation of Quantum Statistics: Inadequacy of classical theory, quantum mechanical ensemble theory, density matrix, statistics of various ensembles, examples; Theory of quantum ideal gases: Ideal gas in different quantum mechanical ensembles, identical particles and symmetry requirements, many particle wave function, occupation numbers, classical limit of quantum statistics, molecules with internal motion.

Ideal Bose Gas: Bose-Einstein condensation, blackbody radiation–– Stephan Boltzmann law, Rayleigh Jeans' formula, Wien's Displacement Law, Plank radiation law. Phonons-specific heat, Einstein formula.

Ideal Fermi Gas: Pauli's Paramagnetism, Landau diamagnetism, thermionic and photoelectric emissions, white dwarfs; Interacting Systems, Ising model, Transfer matrix.

Phase Transitions: First and Second order phase transitions, elementary idea of critical phenomena, Elementary ideas of Mean field theories.

Course outcome

At the end of the course, students will be able to

1. Solve statistical mechanics problems for simple non-interacting systems,

2. Formulate mathematical methods of different ensembles.

3. Deep understanding of universality in second order phase transitions.

Recommended Books:

1. R.K. Pathria, Statistical Mechanics, Butterworth Heinemann, 1996.
2. K. Huang, Statistical Mechanics, John Wiley, Asia, 2000.
3. L.D. Landau and E.M. Lifshitz, Statistical Physics-1, Pergamon, 1980.
4. B. B. Laud, Fundamentals Of Statistical Mechanics.
5. F. Reif, Fundamentals of Statistical And Thermal Physics.
6. P. B. Paul, An Introductory Course of Statistical Mechanics.

M.Sc 2nd Semester

General Physics Lab. - II

List of Experiments:

1. Determination of Wavelength of a Monochromatic Light by Fresnel's Biprism.
2. Determination of specific rotation of an optically active substance by Polarimeter.
3. Determination of the Hall voltage developed across the sample material and also the Hall Co- efficient of that material.
4. Determination of the numerical aperture (NA) of optical fiber at 660 nm.
5. Study of various types of losses that occurs in optical fibers and measures the loss in dB of two optical fiber patch cords.
6. Determination of the resistivity and energy band gap of a semiconducting material using 4-Probe Method.
7. Determination of the excitation potential of Argon using Franck-Hertz apparatus.

Electronics Lab. - I

List of Experiments:

1. Study of frequency response characteristics and voltage response characteristics of buffer.
2. Study of gain of Inverting amplifier and also study the frequency response characteristics.
3. Study of gain of Non-inverting amplifier and also frequency response characteristics and hence find out its band width.
4. Study of frequency response characteristics of integrator.
5. Study of frequency response characteristics of differentiator.
6. Study of frequency response characteristics of Clipper circuit.
7. Study of frequency response characteristics of Clamper circuit.

Course: Physics of Atoms **Code: PPH03Bxx**

L-T-P: 3-1-0 **Credits** – 4

Pre-requisite: Basic knowledge of Mathematical methods in Physics, Quantum Mechanics, atoms and molecules.

Objective: To impart the basic understanding of the

1. Structure of atoms, its electronic orbits and space quantization.
2. Angular momentum of atomic electrons and quantization of energy levels
3. Atomic interaction with external fields.

Quantization of atomic orbital angular momentum and energy, Bohr magnetron, effect of finite mass of nucleus on Rydberg constant, discovery of isotopes, Sommerfeld's Extension of Bohrs Model, Vector atom model, space quantization, Larmor precession.

Quantum states of electrons in an atom (Hydrogen atom), concept of spin, Stern and Gerlach experiment, Fine structure of energy in one-electron atom- relativistic corrections for energy levels of hydrogen atom, Spin orbit interaction and energy correction, Darwin correction.
Helium and alkali atoms, exchange degeneracy, Ortho and para states of Helium, Slater determinants, Ground state energy of Helium.

Hyperfine structure and isotopic shift, width of spectrum lines

L-S and j-j coupling, Spectroscopic terms of equivalent and nonequivalent electrons, Lande interval rule; Hund's rule.

Interaction with Electromagnetic fields: Zeeman Effect, Paschen Back effect and Stark effects; Hyperfine structure and isotope shift, selection rules; Lamb shift.

Course outcome

At the end of the course, students will be able to

1. Understand the concept of quantization, spin, and energy of electrons in atomic orbits.
2. Develop the spectroscopic term values of atomic electrons.
3. Analyse the atomic spectra in external fields.

Recommended Books:

1. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules, 2nd Ed. Pearson (2008).
2. H.E. White: Introduction to Atomic Spectra –
3. C.N. Banwell: Fundamentals of Molecular Spectroscopy. Tata – McGraw Hill.
4. G.M. Barrow Introduction to Molecular Spectroscopy, McGraw Hill.
5. G. K. Woodgate, Elementary Atomic Structure, Clarendon Press (1989).1950.
6. B.W. Shore and D.H. Menzel: Principles of Atomic Spectra. John Wiley.
7. G.M. Barrow: Introduction to Molecular Spectroscopy, McGraw Hill.

Course: Condensed Matter Physics-I **Code: PPH03Bxx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Preliminary knowledge in Quantum Physics and Statistical Physics

Course Objective:

1. To provide important principles and techniques to study the physics of crystalline solids.
2. To study some of the basic properties of the condensed phase of matter especially solids.

Course Content:

Basic Crystallography: Single crystalline, Polycrystalline, and Amorphous materials; Crystal Translational Vectors, Unit Cell, Lattice and Basis, Symmetry Operations for 2D and 3D crystals, Bravis lattice, Point group, Space group; Simple crystal structures: Hexagonal close packed, Simple cubic, Body Centered cubic, Face Centered cubic, Diamond structure, Zinc Blend Structure (ZnS) , Sodium Chloride Structure (NaCl), Cesium Chloride structure (CsCl); Crystal Planes, Miller indices, Interplanner spacing.

X-ray Diffraction and Introduction to Reciprocal Lattice: Scattering of x-ray by a crystal, Bragg Diffraction, Von Laue treatment, X-ray Scattering Intensity and diffraction spectrum, Reciprocal lattice vector, Brillouin zone, Atomic form factor, Structure factor, Temperature effect on x-ray diffraction in crystal, Debye Waller factor, Experimental Methods and determination of crystal structure, Laue Method, Rotating Crystal Method, Powder method.

Crystal Binding and Elastic Constant: Ionic crystals, Covalent crystal, Metals, Hydrogen Bonds, Crystals of inert Gases, Van der Waals Bonding, Lennard-Jones potential, Calculation of binding energy, Madelung constant, Analysis of stress & Strain, Elastic Compliance and Stiffness Constant, Elastic Energy, Elastic Waves in cubic crystals.

Lattice Dynamics: Vibrations of mono-atomic and diatomic linear lattice. Optical and Acoustical branches, Quantization of elastic waves, Equivalence of vibrational mode and simple harmonic oscillator, Phonons, Phonon momentum, Inelastic scattering by photons, Experimental determination of phonon dispersion curve, Triple axis neutron spectrometer.

Thermal Properties of Solids: Phonon density of states, Normal modes, Lattice heat capacity, classical theory, Einstein Theory, Debye Theory, Born's modification of Debye theory, Electronic Specific heat, Lattice thermal conductivity, Phonon mean free path, Phonon-phonon scattering, Umklapp process, Anharmonic crystal interactions, thermal expansion.

Concepts of Energy Band in Crystalline Solids: Nearly free electron Model, Origin of band gap, Bloch functions, Wave equation of electrons in a periodic potential, Empty lattice approximation, Tight binding approximation.

Imperfections in Crystalline Solid: Point Defects, Impurities, Vacancies, Schottky and Frenkel vacancies, Diffusion through Solids, Measurement of Diffusion and applications, Kirkendall effect, Ionic conductivity, Color centers, F-centers, V-centers, dislocations, plane defects.

Course outcome

At the end of the course, students will be able to learn about

1. The lattice, basis, crystal planes and arrangements, symmetry and related numerical problems
2. Importance of X-ray diffraction in crystal and its application, concepts of reciprocal lattice, various experimental techniques for x-ray diffraction in crystals
3. Crystal bonding, lattice dynamics and thermal properties of solids
4. Concepts about the formation of energy bands in solid
5. Various Imperfections in Crystalline Solid

Recommended Books:

1. Introduction to Solid State Physics, Charles Kittel, Wiley

2. Fundamentals of Solid State Physics, J. Richard Christman, *John Wiley & Sons*

3. Solid State Physics, J. R. Hook and H E Hall, Wiley

4. The Oxford Solid State Basics, Steven H. Simon, Oxford University Press

5. Solid State Physics A J Dekker, Macmillan.

6. Philip Hofmann, Solid State Physics, Wiley-VSH

Course: Digital Electronics **Code: PPH03Bxx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of Boolean Algebra

Objective:

1. To develop familiarity with practical applications of digital logic circuits so that students may design various logic based electronic circuits for simple operations.

2. To impart knowledge about the design of communication system and familiarizing them with the concept of Microprocessors, memory organization, addressing modes and programming

Methods of minimization: Product of Sum (Pos) and Sum of Products (Sop) expressions of 2, 3, 4, 5 and 6 variables Boolean expression, minimization of digital expression using Karnaugh mapping and Quine–McCluskey method.

Combinational logic circuits:, designing combinational logic from truth table. Half adder, full adder, Half Subtractor and full Subtractor, look-ahead-carry implementation, Magnitude comparator, decoder, encoder, multiplexer, de-multiplexer. D/A and A/D convertor

Flip Flop and its application: S-R flip-flop (clocked), D flip-flop, J-K flip-flop, J-K master slave flip-flop, operation and functions. T-flip flop.
Synchronous and Asynchronous counter, modulo-Counter, decade counter; Shift Register, Serial in Serial out, Parallel in Serial out, Parallel in parallel out registers, Johnson counter.

Memory device: Definitions and characteristics of ROM, EROM, EPROM, RAM, SRAM & DRAM; NMOS inverter, propagation delay in NOMOS inverter, the NMOS logic gates, the CMOS inverter, the CMOS logic gates, CCD, introduction to magnetic, optical and ferroelectric memories.

Communication Electronics: Basic architecture of electronic communication. Amplitude Modulation: Ordinary AM generation demodulation; Generation of DSB signal and demodulation of DSB signal; Generation of SSB signal and demodulation of SSB signal; Generation of VSB signal and demodulation of VSB signal; Frequency translation and mixing , Frequency division multiplexing (FDM)

8085 Microprocessor: Internal microprocessor architecture, Memory mapping, Data addressing modes, Program addressing modes, Stack memory addressing modes, Data movement instructions, Arithmetic and logic instructions, Program control instructions, Assembler details.

Course outcome: At the end of the course students will be able to

1. Develop a digital logic to apply for solving real life problems.
2. Analyze, design and implement combinational and sequential logic circuits.
3. Classify and design of different semiconductor memory devices.

4. Identify and solve basic communication problems.
5. Write assembly language program to design microcontroller based device for various applications

Books Recommended:

1. R P Jain, Modern digital electronics, Tata McGraw Hill.
2. Millman and Halkias, Microelectronics. Tata McGraw Hill.
3. Malvino and Leach, Digital Principleas and Applications, Tata McGraw Hill.
4. Taub and Schilling, Digital Integrated Electronics, Tata McGraw Hill.
5. R.S. Gaonkar, Microprocessor Architecture: Programming and Applications
6. Microelectronics : Millman abd Grabel)
7. Analog and digital communications: H. P. Hsu

M.Sc 3rd Semester

Advanced Physics Lab.

List of Experiments:

1. Determination of the Verdet constant using Faraday Effect apparatus.
2. Determination of the birefringence of a crystal using Pockel Effect apparatus.
3. Determination of the value of $\frac{\mu_0}{hc}$ using Zeeman Effect apparatus.
4. Determination of the thickness of a transparent material (glass) using Michelson Interferometer.
5. Determination of the refractive indices of different liquid using Refractometer.
6. To study the characteristic curve of an Infrared Pulsed Diode Laser.

Electronics Lab. - II

List of Experiments:

1. Design and study of 4:1 multiplexor
2. Design and study of 1:4 De multiplexor
3. Design of an encoder circuit and verification of truth table.
4. Design and study of BCD to decimal decoder.
5. Asynchronous up counter and MOD counter.
6. Filp flops
    a. SR flip-flop
    b. Clocked SR flip-flop
    c. JK flip-flop
    d. Master-slave flip-flop
    e. D- flip-flop
    f. T- flip-flop
7. Design of full adder.
8. Design of full subtractor.

Course: Condensed Matter Physics - II **Code: PPH04Bxx**
L-T-P: 3-1-0 **Credit: 4**

Pre-Requisite- Schrodinger equation and basic quantum mechanics

Course Objectives:
1. To introduce the students some of the basic properties of the condensed phase of matter, especially solids,
2. To familiarize the students with some interesting features of materials.

Band Theory of solids: Kronig-Penny Model, Brillouin Zones, Electronic distraction between conductors, semiconductor and insulator.

Dielectric properties of materials: Polarisation and dielectric constant, Frequency and temperature dependence of relative permittivity behaviour of dielectric under alternating fields, dielectric losses.

Conductors: Electrical conductivity of metals, Lorentz theory, free electron theory, electron scattering, Resistivities of conductors including alloys.

Semiconductor: Intrinsic and extrinsic semiconductor, Fermi-Dirac distribution, dependence of carrier concentration on temperature, Measurements of resistivity, Four probe method, Hall effect, Measurements of carrier concentration, Zener breakdown phenomena, Photo-electric effect in semiconductors.

Magnetic properties of materials: Diamagnetism, paramagnetism, ferromagnetism. Exchange interaction, antiferromagnetism, ferrimagnetism, and ferrites, Magnetic resonance, Magnetotriction, Curie-Weiss Law, Curie Law, Curie temperature of ferromagnetic material, Soft and hard magnetic materials, Ni-Fe alloy and application, Alnico, Alcomax and application.

Superconductivity: Superconductivity phenomena, Meissner effect, Type 1 and Type 11 superconductors, High TC superconductors, Josephson junction, SQUID.

Special Materials: Ceramics polymers, XLPE, nanostructures and nanomaterials, Biomaterials and bioceramics.

Course Outcome:

At the end of the course the students will be able to

1. Deduce Bloch's theorem from the Schrödinger equation for electrons in a periodic potential.

2. Explain the effective electron mass and apply it to describe electron dynamics in semiconductors.
3. Explain the concept of energy bands and effect of the same on electrical properties.
4. Describe the dielectric properties of insulators.
5. Explain the properties of semiconductor and its suitability of application
6. Explain various types of magnetic phenomenon, physics behind them, their properties and applications.
7. Explain superconductivity, its properties, important parameters related to possible applications.
8. Have the knowledge of applied materials

Books Recommended:

1. Charles Kittel, Introduction to Solid State Physics, Wiley Eastern, 5th edition, (1983).
2. A.J. Dekker, Solid State Physics, Prentice Hall of India (1971).
3. N.W. Ashcroft and N.D. Mermin, Solid State Physics, Saunders College Publishing (1976).
4. Ali Omar, Elementary Solid State Physics, Narosa Publishing House.
5. J.S. Blakemore, Solid State Physics, 2nd edition, Cambridge University Press (1974).

Course: Molecular Spectroscopy **Code: PPH04Bxx**
L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of modern physics, atoms and molecules.

Objective:

1. To impart the basic understanding of the nature,
2. To familiarize the students with essential principles of spectroscopy, fundamental techniques and their prospective applications.

Molecular Structure: Born Oppenheimer approximation for diatomic molecules. Heitler London theory, linear combination of atomic orbitals (LCAO) approach, states for hydrogen molecular ion; shapes and term symbols for simple molecules.

Rotational spectra: Diatomic, linear symmetric top, asymmetric top and spherical top molecules. Rotational spectra of diatomic molecules as a rigid rotor. Energy levels and spectra of non rigid rotor. Intensity of rotational lines. Isotopic effect, Vibrating rotator.

Vibrational energy of diatomic molecules. Diatomic molecule as a simple harmonic oscillator. Energy levels and spectrum. Morse potential energy curve. Molecules as vibrating rotator. Rotational - Vibrational spectrum of diatomic molecule – PQR branches. Isotopic effect.

Raman effect: Quantum theory. Molecular polarisability. Pure rotational Raman spectra of diatomic molecules. Vibration rotation Raman spectrum of diatomic molecules. Intensity alterations in Raman spectra of diatomic molecules.

Electronic spectra of diatomic molecules: Vibrational band structure, Progressions and sequences, Deslandres tables. Molecular constants in the ground and excited electronic states, Rotational structure of electronic spectra. P, Q and R branches. Band head formation and shading of bands, Intensity distribution in the vibrational structure of electronic spectra and Franck Condon principle, Fortrat diagram dissociation energy.

Mossbauer effect: Resonance fluorescence. Kramors Heisenberg formula. Mossbauer effect. Elementary theory of recoil less emission (absorption) of gamma rays. Shift and splitting of Mossbauer lines. Isomer shift. Quadrupole interactions. Magnetic hyper-fine interactions. Line broadening.

Course outcome

At the end of the course

1.The student should have had a knowledge on the techniques and instrumentation of microwave spectroscopy

2. The student should have understood the basics of spectroscopic techniques

3. The student should be able to interpret spectra of the samples

Recommended Books:

1. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules,2nd Ed. Pearson (2008).
2. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed.,Tata McGraw (2004).
3. H.E. White: Introduction to Atomic Spectra –
4. C.N. Banwell: Fundamentals of Molecular Spectroscopy. Tata – McGraw Hill.
5. G.M. Barrow Introduction to Molecular Spectroscopy, McGraw Hill.
6. G. Herzberg: Molecular Spectra and Molecular Structure. Vol. . Van Nostran 1950.
7. B.W. SHore and D.H. Menzel : Principles of Atomic Spectra. John Wiley.

Course: Nuclear and Particle Physics **Code: PPH04Bxx**
L-T-P: 3-1-0 **Credits** – 4

Pre-requisite: Basic knowledge of Mathematical methods in Physics, Quantum mechanics, Physics of atoms.

Course Objective: To impart the basic understanding of the
1. Structure of nucleus, nuclear force and energy of nucleons
2. Theory of nuclear decay processes.
3. Concept of elementary particles, classification and fundamental interactions.

Nature of the nuclear force, form of nucleon-nucleon interaction potential, charge-independence and charge-symmetry of nuclear forces, Concept of exchange of particles-Meson theory, Field theory of Nuclear forces, Yukawa potential.

Nuclear magnetic moment, Quadropole moment, Schmidt model, Deuteron problem-ground state wave function and energy.

Nuclear shell structure, single-particle shell model, shell model term values, angular momenta and parities of nuclear ground states, Collective model.

Elementary ideas of alpha, beta and gamma decays and their selection rules, Gamows theory, Neutrino hypothesis, Fermi's theory of beta decay, Gamma decay-angular momentum and parity selection rules.

Nuclear reactions, reaction mechanism, compound nuclei and direct reactions, cross-section in terms of partial wave amplitude, Resonance scattering with reactions, optical model of nuclear reactions.

Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.

Course Outcome:
At the end of the course, students will be able to
1. Understand the nucleon-nucleon interaction, their potentials, and nuclear moments.
2. Formulate and develop the theory of ground state energy and various decay processes.
3. Know the classes of elementary particles, their production and decay processes.
4. Understand the fundamental interactions.

Reference Books:

1. A. Das and T. Ferbel, Introduction to nuclear and particle physics, John Wiley (1994).
2. S. N. Ghoshal: Nuclear Physics
3. D. Griffith: Introduction to Elementary Particles
4. R. R. Roy and B. P.Nigam: Nuclear Physics:

Course: General Theory of Relativity **Code: PPH0xExx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of Tensor Calculus, Concept of Special theory of Relativity

Course Objective:

1. To impart knowledge of fundamental principles of the general theory of relativity.
2. To provide conceptual skills and analytical tools necessary for astrophysical and cosmological applications of the theory.

Course Content:

Tensors: metric tensor and its properties, Covariant and Contravariant derivatives and Christoffel symbols. Review of special theory of Relativity: four vectors.

General Theory of Relativity: Principle of Equivalence. Gravity and Geometry. Curvature tensors, parallel transport, Bianchi Identities, Ricci tensor. Motion of a particle in a gravitational field, geodesic equations. Invariance of equations of electrodynamics in the presence of a gravitational field.

Gravitational field equations: Action for gravitational field, Energy-momentum tensor. Lightcone. Field of gravitating bodies: Schwarzschild solution, Birkhoff's theorem. Motion in a centrally symmetric gravitational field, Precession of perihelion of Mercury. Deflection of light, Gravitational lensing. Black holes: Schwarzschild black holes. Gravitational waves: Plane waves, Weak field approximation. Cosmological constant, de Sitter space, Anti-de Sitter space. Cosmology: Thermal background, Hubble expansion, Big bang, Age and density of the universe, Friedmann-Robertson-Walker universe.

Course Outcome:

At the end of the course, students will be able to

1. Develop the detailed physical and mathematical understanding of a variety of systems in astrophysics and cosmology;
2. Explain the observational effects at the scale of the Solar System from a general relativistic point of view.

References:

1. L. D. Landau and E. M. Lifshitz, The Classical Theory of Fields, Butterworth Heinmann, 1996.
2. C. W. Misner, K. S. Thorne, and J. A. Wheeler, Gravitation, Freeman, NewYork, 2000.
3. S. Wienberg, Gravitation and Cosmology,John Wiley, 2004 (Indian Reprinting).
4. J. V. Narlikar, Introduction to Cosmology, Cambridge University Press, New Delhi, 1993.
5. Ray D'Inverno, Introducing Einstein's Relativity, Oxford University Press (1992).

6. T. Padmanabhan, Gravitation, Cambridge University Press-2010.

Course: Liquid crystals and its applications **Code: PPH0xExx**
L-T-P: 3-1-0 **Credit:** 4

Pre-requisite: Fundamental properties of basic states of matter, nature and behaviour of light through different mediums

Course Objective
1. To impart knowledge of basic physical and fundamental concepts of liquid crystals
2. To enhance the idea of LCDs

Introduction to liquid crystals, History, Symmetry, Structure and classification of liquid Crystals, Thermotropic and lyotropic liquid crystals; Calamitic and Discotic Liquid Crystals, Different molecular ordering in nematic, smectic and cholesteric phases; different modifications of smectic phases, ferro-electric, ferroelectric and antiferroelectric LCs, basic requirements for a material to exhibit liquid crystallinity, effects of various chemical compositions on the properties of liquid crystals, Polymorphism in thermotropics, Polymer liquid crystals, Reentrant phenomena in liquid crystals, induced smectics phases, defect phases-Blue phases and TGB phases.

Textures of different types of liquid crystals, light and nematic liquid crystals, Basic properties of liquid crystal, effect of electric field and magnetic field on liquid crystals, anisotropy in LCs, order parameters-microscopic and macroscopic, Transport phenomena, temperature dependence of optical and electrical parameters of liquid crystals, effects in thin samples of liquid crystals, defects and deformations of liquid crystals, Freedericksz transition, surface preparartions.

LC theroies, Nature of phase transitions and critical phenomena in liquid crystals, Nematic–isotropic (NI) phase transition — Maier-Saupe theory; Generalized mean field theory, Elastic Continuum theory, Mcmillan theory of smectics, Onsager Hard rod model of N-I phase transition, Maier and Meier equations of static dielectric permittivities of liquid crystals

Different techniques for the study of LCs, Raman spectroscopy, XRD, Imaging LC molecules,
Liquid crystal displays, basic principle and working, different types of LCDs, Twisted nematic crystal and cholesteric liquid crystal displays, advantages of LCDs, LCD technology and its applications, Recent interests in liquid crystals.

Course outcome
At the end of the course, students will be able to
1. Grab the knowledge of a completely different state of matter
2. Develop the physical and fundamental concepts of liquid crystals
3. Understand the mechanism and advantages of LCDs

Reference Books:
Chandrashekhar : Liquid Crystals
De Gennes & Prost : The Physics of Liquid Crystals
P. J. Collings: Liquid crystals
I. Dierkins: Textures of Liquid crystals
Shri Singh: Liquid crystals fundamentals

Course: Physics of Plasmas **Code:PPH0xExx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of classical physics, electromagnetic theory including Maxwell's equations.

Course Objective:

1. To impart the basic understanding of the plasma state of matter,
2. To understand the motion of charged particles in various electric and magnetic fields,
3. To understand the MHD models of wave propagation in plasma.

Course Content:

Concept of temperature, Debye shielding, criteria for plasmas, Single charged particle motion in – uniform/non-uniform electric & / or magnetic fields, Fluid equation for plasma, fluid drifts parallel and perpendicular to magnetic field, plasma approximation;

Diffusion and mobility in weakly ionized gases, diffusion in plasma, steady state solution, recombination, diffusion parallel and perpendicular to magnetic field, collisions in fully ionized plasmas, single fluid MHD equation, diffusion in fully ionized plasmas, solution of diffusion equation, Bohm diffusion and Neoclassical diffusion, experimental applications of waves in plasmas;

Plasma oscillations, electron plasma waves, ion acoustic waves, validity of plasma approximation, comparison of ion waves and electron waves, validity of plasma approximation, comparison of ion waves and electron waves, electrostatic electron oscillations perpendicular to magnetic field, electrostatic ion waves perpendicular to magnetic field, lower hybrid frequency of plasmas, electromagnetic waves perpendicular to magnetic field, cut-off and resonances, electromagnetic waves parallel to magnetic field, Hydromagnetic waves and Magnetosonic waves in plasma, CMA diagram.

Course outcome

At the end of the course, students will be able to

1. Develop the physical concept of dynamics of group of charged particles,
2. Formulate mathematical models for the classical behavior of charge particles in electric and

magnetic fields,

3. Analyze the distribution and balancing of forces acting on quasineutral system of charges.

Books Recommended:

1. F. F. Chen- Introduction to Plasma Physics
2. Nicholas A. Krall, Alvin W. Trivelpiece - Principles of Plasma Physics
3. P.M.Bellan- Introduction to Plasma Physics, Cambridge University Press.
4. Donald A. Gurnett, Amitava Bhattacharjee - Introduction to plasma physics: with space and laboratory applications, Press Syndicate of Univ. of Cambridge
5. C. Uberoi - Introduction to Unmagnetized Plasmas, PHI Pub.

Course: Plasma Production & Diagnostics **Code: PPH0xExx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of classical physics, electromagnetic theory including Maxwell's equations.

Course Objective:

1. To impart the basic understanding of the plasma parameters in technological devices, laboratory and nature;
2. To formulate classical models of simple equilibrium and diffusion of plasma using two fluid MHD models.
3. Basic understanding of various electric and magnetic plasma diagnostics.

Course Content:

Gas Discharge Physics: Kinetic Theory, Ionization & recombination, Breakdown, Townsend's coefficients; concept of temperature in plasma, Debye shielding, criteria for plasma state; Various methods of plasma production: Electrical, Radio Frequency, Microwave, Barrier Discharge, Beam generated plasma, related applications.

Methods of confinement of plasma: Magnetic confinement systems (Tokamak), Inertial confinement, MHD Generation; Diffusion parallel and perpendicular to magnetic field, collisions in fully ionized plasmas, diffusion in fully ionized plasmas, Bohm diffusion and Neoclassical diffusion, experimental applications of waves in plasmas;

Plasma diagnostic techniques: Single & double probe method, Radiofrequency probe method, Microware probe method, Spectroscopic method, Neutral beam;

Applications of Plasmas: Fusion, Industrial Applications, Plasma propulsion, Plasma devices.

Course Outcome:

At the end of the course, students will be able to

1. Design plasma diagnostics on the basis of the physical concept of dynamics of group of charged particles,
2. Formulate mathematical models for the classical diffusion of charge particles in electric and magnetic fields,
3. Analyze the distribution and balancing of forces acting on quasineutral system of charges.

Books Recommended:

1. Richard H. Huddlestone, Stanley L. Leonard - Plasma Diagnostic Techniques, Academic Press
2. J. Wesson, D. J. Campbell - Tokamaks, Clarendon Press
3. I. Hutchinson- Principles of Plasma Diagnostics, Press Syndicate of Univ. of Cambridge
4. Michael A. Lieberman, Alan J. Lichtenberg - Principles of Plasma Discharges and Materials Processing

Course: Antennas & Microwave Devices **Code: PPH0xExx**
L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of Electromagnetics.

Course Objective:

1. To familiarize the students with the concept of Radio wave propagation and antenna principles,
2. To impart knowledge of microwave tubes and uses in related devices.

Radio wave propagation: Ground wave, Ionospheric wave and space wave and their characteristics, reflection and refraction of radio waves in ionosphere.

Antenna: Dipole antenna, half wave antenna, antenna with two half elements, N elements array, induction field and retardation field.

Introduction to Microwaves, Microwave devices and systems, Electron motion in Electric, Magnetic and Electromagnetic fields, Boundary Conditions, Plane wave propagation in lossy media, Transmission line equations, Reflection & Transmission coefficients, Standing Wave Ratio, Line impedance and impedance matching, Smith Chart;

Microwave waveguides and components: Rectangular Waveguides, Circular Waveguides, Microwave Cavities, Microwave hybrid circuits, Directional Couplers, Transistors and diodes;

Microwave linear-beam Sources: Klystrons, Travelling-Wave Tubes, Magnetron Oscillators, Concept of Strip lines.

Course outcome

At the end of the course, students will be able to

1. Develop the physical concept and design transmission lines for microwave applications,
2. Formulate mathematical models for the electromagnetic wave propagation through microwave tubes,
3. Understand the working of microwave beam sources.

Books Recommended:

1. J.D.Ryder, Electronics fundamental and application(PHI).
2. Roddy and Coolen, Electronic Communication systems. (PHI)
3. Frazier- Telecommunications.
4. Electronic and Radio Engineering – F. E Terman.
5. S. K. Roy and M. Mitra – Microwave Semiconductor Devices, Prentice Hall of India Pubs.
6. M. L. Sisodia – Microwave Active Device: Vacuum and Solid State, New Age International Pubs.
7. S. L. Liao - Microwave Devices & Circuits, Prentice Hall of India Pubs.
8. Networks, Lines and Fields – J. D. Ryder, Prentice Hall of India Pubs.

Course: Quantum Field Theory **Code: PPH0xExx**
L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of Classical Physics, Quantum Mechanics, Differential and Integral Calculus, Ordinary Differential Equations.

Course Objective

1. To impart basic knowledge of fundamental properties of nature which can not be explained using ordinary quantum mechanics.
2. To show how various physical processes are intertwined by underllying symmetries and hence explain them from the ponit of view of a common structure.

Course content:

Symmetries and conservation laws: Rotation, Translation, Lorentz and Poincare symmetries. Green's functions. Klein Gordon equation: canonical quantisation, time ordered product, Wick's theorem , Fock space construction, complex scalar field. Dirac equation : plane wave solution, continuity equations, normalisation, gamma matrices, helicity, chirality. Free propogator calculations. Maxwell Field: its quantisation, Lorentz gauge, Coulomb Gauge, Gupta-Bleuler formalism, Massless and massive vector and spinor fields. Parity, charge conjugation, time reversal symmetries, CPT theorem. Spontaneous breakdown of symmetries and Goldstone theorem, Higgs phenomenon; S-matrix calculation Electron-electron, electron-positron scattering, Renormalisation.

Course outcome:

At the end of the course, students will be able to

i. Understand how various subatomic particles emerge out from common theories and show different properties.

ii. Construct by themselves a theoretical model of natural phenomenon and explore it using the concepts of symmetries and quantisation.

References:

1. C. Itzykson and J. B. Zuber, Quantum Field Theory, McGraw Hill (1985).
2. P. Ramond, Field Theory: A Modern Primer, Addison-Wesley (1990).
3. S. WeinBerg,The Quantum Theory of Fields: Volume 1, Foundations, Cambridge University Press.
4. M. E. Peskin, D. V. Schroeder, An Introduction to Quantum Field Theory, Westview Press.
5. A. Lahiri, P. B. Paul, A First Book of Quantum Field Theory, Narosa Publications.
6. L. H. Ryder, Quantum Field Theory, Cambridge University Press.
7. A. Das, Lectures on Quantum Field Theory, World Scientific.

Course: Physics of Semiconductor Devices **Code: PPH0xExx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Condensed Matter Physics

Course Objective:

1. To introduce the students to the physics of semiconductors and the inner working principle of semiconductor devices.
2. To provide students the insight useful for understanding new semiconductor devices and technologies.

Course Content:

Semiconductor physics:

Introduction to Semiconductor Materials, Direct and Indirect Semiconductors, Electrons and Holes, Intrinsic and Extrinsic Material, Carrier Concentration in Semiconductor, Electron and Hole Concentrations at Equilibrium, Temperature Dependence of Carrier Concentrations, Compensation and Space Charge Neutrality, Conductivity and Mobility, Drift and Resistance, Effects of Temperature and Doping on Mobility, Transport Phenomena.

p-n junctions: Fabrication of p-n Junctions, The Contact Potential, Equilibrium Fermi Levels, Space Charge at a Junction, Forward and Reverse-Biased Junctions; Steady State Conditions, Quantitative Description of Current Flow at a Junction, Diode equation, Carrier Injection, Reverse Bias, Zener Breakdown, Avalanche Breakdown, Rectifiers, The Breakdown Diode, Capacitance of p-n junctions, Application of junction capacitance, The Varactor Diode, Ohmic losses, Graded Junctions.

Metal-Semiconductor junction: Schottky Barriers, Rectifying Contacts, Ohmic Contacts, Typical Schottky Barriers, Schottky diode equation, Applications of metal-semiconductor junctions.

Field Effect Transistors: The Junction Field Effect Transistors (FET), Pinch-off and Saturation, Gate Control, Current-Voltage Characteristics, The Metal-Semiconductor FET, The Metal-Insulator-Semiconductor FET, Metal Oxide Semiconductor FET, MOS capacitor, Bipolar Junction Transistors (BJT).

Recombination in Semiconductor: Photon induced electron hole pair formation and recombination, band to band absorption and recombination in direct and indirect band gap semiconductor, recombination rate and time-relations. Process of thermalization and involvement of phonon in semiconductor.

Defect levels and Recombination process: Shockley-Read-Hall recombination process, concept of Shallow level, deep level and recombination, concept of exciton, types of excitons in semiconductor, exciton assisted carrier recombination, surface defect levels and recombination.

Light emitting diode: Design of double heterojunction device structure of LED, Properties of semiconductors for LED applications and examples. Internal and external quantum efficiency, Spontaneous emission rate for LED electroluminescent spectra,frequency response and modulation band width of LED.

Photovoltaic Devices: Photovoltaic affect, properties and design of solar energy materials, Solar cell characterizations: Short circuit current, open circuit voltage, fill factor, efficiency of solar cell.Solar cell I-V equation, effect of shunt resistance, solar radiation and temperature on cell efficiency,Different losses in solar cell.

Quantum effect devices: Tunnel diode, Impatt diode, Gun diode.

Course Outcome:

1. Understand the electron and hole statistics of intrinsic and doped semiconductors
2. Understand current in terms of drift and diffusion of electrons and holes and how these are related to mobility, concentration gradients, and electric field
3. Understand the fundamentals of the operation of the p-n junction in forward and reverse bias including knowledge of drift and diffusion currents, generation and recombination currents, contact potential, reverse bias capacitance and breakdown
4. Understand the fundamental physics of BJT, JFET, MOSFET operation
5. Understand the recombination mechanism in semiconductor under illumination
6. Understand the basic operation of optical p-n junction devices including photo-detectors, solar cells, LEDs and LASER diodes

References

1. S. M. Sze, K. K. Ng,*Physics of Semiconductor Devices*, John Wiley & Sons, 2006
2. B. G. Streetman, S. K. Banerjee,*Solid State Electronic Devices*, Prentice-Hall, 2006
3. S. M.Sze,*Semiconductor Devices*: *Physics and Technology*, John Wiley & Sons, 2008
4. Pierret,*Semiconductor Device Fundamentals*, Pearson Education India, 1996
5. Jasprit Singh , *Semiconductor devices: basic principles*, Wiley, 2001
6. Mauro Zambuto,*Semiconductor devices*, McGraw-Hill, 1989

Course: Simulation Techniques **Code: PPH0xExx**
L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Basic knowledge of Differential and Integral Calculus, Computer Programming.

Course Objective

1. To impart knowledge of numerical methods to solve various problems arising in science and engineering.
2. To motivate the students to take up problems and apply computer based algorithms and solve it.

Course content

Numerical considerations and numerical approach to solving differential equations for physical problems. Numerical solution of linear and nonlinear differential equation in one and higher dimensions. Its application to various physical systems. Shooting methods to solve time-independent Schrodinger wave equation for a particle in a box. Quantum mechanical scattering problems. Time dependent Schrodinger wave equations - direct solution. Solution of heat conduction equation using explicit, implicit and Crank Nicholson methods. Solution of wave equation- method of characteristics, CFL condition, explicit and implicit schemes. Solution of Laplace and Poisson equations, Relaxation methods. Stability of quasi linear system of equations- Fourier method of stability analysis. Spectral methods and finite element methods (elementary introduction). Random walks-Classical simulations (eg. Monte Carlo), Ising Model.

Course outcome:

At the end of this course students will be able to

1. Construct and solve differential equations which are very complex in nature.
2. Simulate the outcome of a problem from science and engineering by constructing its corresponding partial differential equation and predict the outcomes.

References:

1. K. E. Atkinson, Numerical Analysis- John Wiley (Asia) (2004).
2. C. Robert, G. Casella , Monte Carlo Statistical Methods, Springer .

3. S. S. M. Wong, Computational Methods in Physics and Engineering, World Scientific, 1997.
4. W. H. Press, S. A. Teukolsky, W. T. Verlling and B. P. Flannery, Numerical Recipes in C/Fortran.
5. W. F. Ames, Numerical Methods for Partial Differential Equations, Academic Press-1977.

Course: Spintronics and Devices **Code**: **PPH0xExx**

L-T-P:3-1-0 **Credit**: 4

Pre-Requisite:- Concept of spin and its properties. Basic phenomena of electronics and electronic devices.Nanotechnology

Course Objective:- To give ideas on the recent trends of research on spintronics and its devices with basic concepts and physical phenomena embaded with nanotechnology.

Course Content:

Module 1:

History and overview of Spin electronics; Class of magnetic materials; The early history of spin; Quantum mechanics of spin; The Bloch Sphere; Spin-orbit interaction; Exchange interaction; Spin relaxation mechanism; spin relaxation in a quantum dots; The spin galvanic effect; Basic electron transport; Spin dependent transport; Spin dependent tunneling; Spin- polarized transport.

Module 2:

Electrochemical potential, Spin accumulation, Spin diffusion, Rashba formalism of linear spin injection, Equivalent circuit model, Silsbee-Johnson spin charge coupling. Spin injection,Spin accumulation, Spin hall effect, Silcon based spin electronic devices, Spin LEDs: Fundamentals and applications, Electron Spin filtering, Quantum spin –polarized transport.

Module 3:

Geometric spin phase, Diluted magnetic semiconductors. Nanostructures for spin electronics, Deposition techniques, micro and nanofabrication techniques. Spin- Valve and spin –tunneling devices: Read heads, MRAMS, Field Sensors, Spintronics Biosensors, Spin transistors, Magnetic bipolar diode, Magnetic bipolar transistor, Magnetic tunneling devices.

Course Outcome:

At the end of course the students should be able to

1. Explain the physical phenomena that are associated with the spintronics and its devices.
2. Can lead a way to research in spintronics materials with the basic knowledge to develop materials for spintronics application using nanotechnology.

Reference Books:

1. S.Bandyopadhyay, M.Cahay, Introduction to Spintronics, CRC Press,2008
2. D. J. Sellmyer, R. Skomski, Advanced Magnetic Nanostructures, Springer,2006
3. D.D. Awschalom, R.A. Buhrman, J.M.Daughton, S.V.Molnar and M. L. Roukes, Spin Electronics, Kluwer Academic Publisher,2004
4. M. Johnson, Magnetoelectronics, Academic Press 2004
5. S. Maekawa, Concepts in Spin Electronics, Oxford Univeresity Press,2006
6. Y. B. Xu and S. M. Thompson, Spintronics Materials and Technology, Taylor & Francis,2006

Course: Thin Film Science and Nanotechnology **Code: PPH0xExx**

L-T-P: 3-1-0 **Credit: 4**

Pre-requisite: Preliminary knowledge of Condensed Matter Physics and Quantum Mechanics

Course Objective:

1. The purpose of this course is to introduce the students about the concept of thin film science and nanotechnology.

2. This course also provides an overview about the wide applications of thin film science and nanotechnology in various technological fields.

3. The major application of nanotechnology in the field of energy science, electronic devices and healthcare have been offered.

Course content:

Introduction to thin films: Basic definitions, classification of thin films, thin film deposition methods, physical vapor deposition (PVD), physics and chemistry of PVD, chemical vapour deposition (CVD), sputtering techniques, DC and AC sputtering, Magnetron sputtering, electrochemical deposition, cathodic and anodic films, Pulse laser deposition (PLD), atomic layer deposition (ALD), Epitaxy, Molecular beam epitaxy, theory of nucleation & growth in thin films, defects, diffusion, methods of control and measurement of film thickness, low energy electron diffraction (LEED), reflected high energy electron diffraction (RHEED), applications of epitaxial films.

Characterizations of thin films:

Microstructural characterizations: Atomic force microscopy (AFM), Scanning electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM).Thickness measurement and monitoring*:* Ellipsometry, quartz crystal methods. Structural characterizations and compositional analysis: x-ray diffraction (XRD), x-ray photoelectron spectroscopy (XPS), Auger emission spectroscopy, electron dispersive x-ray spectroscopy (EDX), Optical characterizations: Photoluminescence (PL) spectroscopy, Ultraviolet-Visible-Infrared Absorption Spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), Reflectance and Transmittance spectroscopy, Raman spectroscopy. Electric properties of films: Resistivity and conductivity of thin film, four probe method, dielectric properties,

Applications of thin films: Micro and optoelectronic devices, Data storage, optical applications, Applications in electronics, electric contacts, resistors, capacitors and inductors, active electronic elements, integrated circuits;

Nanoscience and Nanotechnology: Low dimensional physics, density of state in low dimensions, zero, one and two dimensions, Quantum confinement, Energy quantization and quantum phenomena. Phenomena at nanoscale: Nanoscale electrical transport, nano-magnetics, nanoscale thermal transport. Nanomaterial systems: Metallic, semiconducting, Quantum dot and quantum superlattice, polymer, nanocomposites, carbon based nanostructures, nanowires, self-assembled nanostructures, Synthesis of nanomaterials, clusters, particles, carbon based nanomaterials, nanostructures, Characterization of nanomaterials: XRD, XPS, Raman Spectroscopy, UV-Visible spectroscopy, SEM, AFM, TEM, STM.

Applications of Nanomaterials: Applications of nanomaterials in electronic and optoelectronic devices, photonics, biotechnology, sensors, nano-electromechanical systems (NEMS).

Course Outcome:

At the end of the course, students will be able to

1. Understand the basic of Thin Films Science, Fabrication of Films and their Application
2. Understand the principles and background of nanotechnology
3. Experimental techniques for the growth of various nanomaterials
4. Application of Nanotechnology in electronic and optoelectronic devices, photonics, biotechnology, sensors etc.
5. Understand the fundamental knowledge about various Characterization Techniques for Thin Films and Nanomaterials

Books Recommended:

1. M. Ohring, The Material Science of Thin Films, Academic (1992).

2. A. Goswami, Thin Film Fundamentals, New Age (1996).

3. A. Wagendristel and Y.Wang, An introduction to Physics and Technology of Thin Films, World Scientific (1994)
4. J. George, Preparation of Thin Films, Marcel Dekker Inc (1992).
5. Nanomaterials: Synthesis, properties and Applications, Ed. A. S. Edelstein and R.C.Cammarata, IoP (UK, 1996).
6. Characterization of nanophase materials: Ed. Z.L.Wang, Willey-VCH (New York, 2002).
7. Introduction to nanotechnology, Charles P. Poole an d Frank J. Owens (Wiley-Interscience, May 2003).
8. Nanostructured Materials, Ed. Jackie Yi-Ru Ying (Academic Press, Dec 2001).
9. Nanotechnology: Basic Science and emerging technologies, Ed. Michael Wilson, K. Kannangara, G. Smith, M. Simmons, and C. Crane (CRC Press, June 2002).