

SEMESTER-1

TOPICS TO BE COVERED: CLASSICAL MECHANICS, EXPERIMENTAL PHYSICS, MATHEMATICAL PHYSICS, ATOMIC AND MOLECULAR PHYSICS LAB: BASIC PHYSICS LABORATORY-I

CLASSICAL MECHANICS

Lagrangian formulation: Generalized coordinates, Lagrange's equations of motion, cyclic coordinates, integrals of motion, Jacobi integrals, energy conservation, symmetry, Galilean invariance. 15hrs

Hamiltonian formulation: conservative systems, Hamilton's function and Hamilton's equation of motion, phase space, Poisson brackets 10hrs

Hamilton-Jacobi Theory: action-angle variables, Liouville's theorem, examples. 7hrs

Variational principle: variational principle, applications, shortest distance problem, brachistochrone. 9hrs

Rotational motion: Rotating frame of reference, inertial forces in rotating frames, effects of coriolis force, Foucault's pendulum, Larmor's precession 11hrs

Central force: Two body central force problem, Kepler's problems, virial theorem 8hrs

Reference Books :

1. Classical Mechanics by H.Goldstein, Narosa Publishing Home,, New Delhi.
2. Classical Dynamics of Particles and Systems by Marion and Thomtron, Third Edition, Horoloma Book Jovanovich College Publisher.
3. Classical Mechanics by P.V.Panat, Narosa Publishing Home,, New Delhi.
4. Classical Mechanics by N.C.Rana and P.S.Joag, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
5. Introduction to Classical Mechanics by R.G.Takawale and P.S.Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
6. Classical Mechanics by J.C.Upadhyaya, Himalaya Publishing House.

EXPERIMENTAL PHYSICS I

Sensors : Characteristics, sensitivity, reproducibility ; Sensors for displacement, velocity, acceleration, strain, temperature, pressure, magnetic field. 5Hrs

Measuring physical properties:

Mechanical Properties: Elastic modulus: Static and dynamic methods Viscosity: Flow and damping methods. Surface Tension:

Thermal Properties: Specific heat: Adiabatic and relaxation calorimetry Thermal expansion: Interference, capacitance and LVDT methods. Thermal conductivity of good and poor conductors. Thermal diffusivity using periodic heating. Phase transitions using differential scanning calorimeter. 10hrs

Electrical Properties:

Resistance: Two probe and four probe methods. DC and AC methods. High resistance by leakage.

Inductance: Self and mutual.

Capacitance: Bridge technique

Magnetic field: Search coil, Magneto resistance and Hall probe methods

Magnetic susceptibility: AC susceptibility and Vibration sample magnetometer

Ferromagnetic material: B-H curve

10hrs

Vacuum techniques:

Pumps for producing high vacuum ; pumping speed, conductance. Gauges for measuring low pressures, Leaks and leak detection. 5hrs

Thin film coating:

Evaporative coating, DC and plasma sputtering, Laser ablation Techniques for measuring thickness of film 10hrs

Low temperature techniques:

Properties of cryogenic fluids; bath cryostat and continuous flow Cryostat; Cryogenic refrigerators; temperature measurement; a cryostat for resistivity measurement. 10hrs

High pressure techniques: High pressure cell for resistivity measurement. Measurement of high pressures Diamond anvil cell for very high pressures 10hrs

Reference Books:

1. Experimental Physics: R.A. Dunlap, Oxford University Press 1988
2. The Art of Experimental Physics, Dietz Preston, Eric S. Dietz, Barnes and Noble, 2001
3. An Introduction to Experimental Physics, Colin Cooke, London; UCL Press (Pennsylvania)
4. Cryogenics and Property Measurements at Low Temperatures, R.Srinivasan, A.K. Ray Chaudhari and S. Kasturirangan, Allied Publishers.
5. Manual on the Experiments with IAS kit by R.Srinivasan

MATHEMATICAL PHYSICS

Complex analysis: analytical functions, Cauchy-Riemann conditions, Cauchy's theorem, Taylor and Laurent series, calculus of residues, contour integrations, introduction to analytic continuation and Riemann surfaces 15hrs

Linear algebra: vector spaces, basis and dimensions, linear operators, matrices, eigenvalues and eigenvectors, inner product, orthogonality, self adjoint and unitary transformations, diagonalization 13hrs

Special functions: Legendre, Hermite functions, generating function, recurrence relations, Bessel's function of 1st kind, spherical Bessel function, spherical harmonics 12hrs

Fourier analysis: Fourier series, Fourier integral and transform, convolution theorem, Parseval's identity, applications to solving differential equations, Laplace transform and applications to differential equations 15hrs

Introduction to Group Theory: Symmetry, Translation, Rotation groups, Continuous groups, orthogonal groups, Unitary groups and their applications (qualitative)

5 hrs

Reference Books :

1. Complex Variables and Applications - J.W.Brown, R.V.Churchill - (7 Edition)- Mc-Graw Hill - Ch. 2 to 7.
2. Complex Variables - Seymour Lipschutz
3. Mathematics of Classical and Quantum Physics - Byron, Fuller Dover (1992)
4. Mathematical methods for Physicists - Arfken & Weber - 6 Edition-Academic Press- N.Y.
5. Linear Algebra - Seymour Lipschutz, Schaum Outlines Series- Mc-Graw Hill edition
6. Mathematics for Physical Sciences - Mary Boas, John Wiley & Sons
7. Mathematical Methods of Physics - Mathews & Walker - 2 Edition- Pearson Edition
8. Fourier Series - Seymour Lipschutz, Schaum Outlines Series
9. Laplace Transform - Seymour Lipschutz, Schaum Outlines Series
10. Mathematical Methods in Classical and Quantum Physics - Tulsi Das, S.K.Sharma- University Press India.
11. Mathematical Methods in Physics - Butkov Addiddion Wesley Publishers.
12. Advanced Engineering Mathematics, E. Kreyszig, 7 Edition, New Age International
13. Matrices and Tensors in Physics, A. W. Joshi, 3 Edition, New Age International

ATOMIC AND MOLECULAR PHYSICS

Atoms: Terms for equivalent & non-equivalent electron atom, Hyperfine structure, Width of spectral line, Nuclear spin, Normal & anomalous Zeeman effect, Paschen - Back effect, Lamb Shift, Schrodinger Wave equation for two electron system, Helium atom, central field approximation.

12hrs

Molecules: Rotational & Vibrational spectra for diatomic molecules, Electronic spectra of diatomic Molecule, Vibrational coarse structure, Vibrational analysis of band system, Frank-Condon principle, Dissociation energy & dissociation products, Rotational fine structure of electronic vibration transitions, Electronic angular momentum in diatomic molecule.

12Hrs

Raman Spectroscopy: Classical and quantum theory, pure rotational Raman spectra, vibrational Raman spectra, polarization of light and the Raman effect, Structure determination from Raman and Infra red spectroscopy, Techniques and instrumentation.

9Hrs

NMR Spectroscopy: Nuclear spin magnetic moment, Interaction of nuclear magnet with external magnetic field, NMR spectrometer, chemical shift, spin spin coupling splitting of NMR signals, Applications.

7hrs

ESR Spectroscopy: Electron spin interaction with external magnetic field, Simple ESR Spectrometer, ESR spectrum, Applications.

5hrs

Solids: Laue theory of X-ray diffraction, Geometrical structure factor, Atomic scattering factor, calculations for bcc, fcc & diamond structure.

5hrs

Nuclear Quadrapole Resonance: Electric field gradient, principle of NQR, transitions for axially symmetric and non symmetric systems, NQR instrumentation, Applications.

5 hrs

Mossbauer Effect: Recoilless emission and absorption, Experimental technique, instrumentation, isomer shift, Quadruple and magnetic hyperfine interaction, Applications.

5 Hrs

Reference books :

1. Atomic spectra & atomic structure, Gerhard Hertzberg : Dover publication, New york Recent edition.
2. Molecular structure & spectroscopy, G.Aruldas; Prentice - Hall of India, New Delhi(2001)
3. Fundamentals of molecular spectroscopy, Colin N.Banwell & Elaine M.McCash, Tata McGraw -Hill publishing company limited, Fourth edition(2002).
4. Solid State Physics, A.J.Dekker, Macmillan India Ltd. (2005)
5. Quantum Physics of atoms, molecules, solids nuclei & particles, Robert Eisberg, Robert Resnick, Second edition, John Wiely & sons(Asia) Ltd.(1985)
6. Solid State Physics, Charles Kittel , John Willey & sons
7. Material Science & Engineering, V.Raghavan, Prentice -Hall of India, New Delhi (2001)

I Semester

General	Analog Electronics
Comparison of capacitances	Op-amp inverting-non inverting amplifier
Stefans constant	Summing and difference amplifier
Thermal relaxation	Integrator and Differentiator
Cu-Constantine Thermocouple and Si diode	Wien bridge oscillator
Thermal and electrical conductivity of copper	Phase shift oscillator
High resistance by leakage	Precision rectifier (Half and Full wave)
Passive filters	Schmitt trigger
AC bridges	Second order LP, HP, BP and BR filters
Absorption spectrum of KMnO_4	Square wave generator
	Voltage to frequency converter

SEMESTER-II
TOPICS TO BE COVERED: ELECTRODYNAMICS, NUMERICAL TECHNIQUES,
STATISTICAL PHYSICS, QUANTUM MECHANICS
LAB: ELECTRONICS (ANALOGUE)

ELECTRODYNAMICS

Multipole expansions and material media : Multipole expansions for a localised charge distribution in free space, Linear quadrupole potential and field, static electric and magnetic fields in material media, Boundary conditions.

4hrs

Time varying fields : Time dependents field, Faraday's law for stationary and moving media, Maxwell's displacement current, Differential and Integral forms of Maxwell's equations, Maxwell's equations for moving medium.

6hrs

Energy, Force and Momentum relations in electromagnetic fields : Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy, Conservation laws.

6hrs

Electromagnetic wave equations : Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth.

8hrs

Inhomogeneous wave equations : Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator, Solutions of inhomogeneous wave equations by Fourier analysis, Hertz potential and its use in computation of radiation fields, Dipole radiation, Radiation energy and Radiation resistance.

15hrs

Relativistic Kinematics: Experimental basis for special theory of relativity (Michelson - Morley experiment), 2 Lorentz transformations, Relativistic velocity addition, Mass- Energy relation ($E=mc^2$).

6hrs

Covariance and Relativistic Mechanics: Minkowski's space-time diagram, light cone, Four vectors, Lorentz transformation of Four vectors, Some tensor relations useful in special relativity, Minkowski's force.

10hrs

Covariant formulation of electrodynamics: Four vector potential, Electromagnetic field tensor, Lorentz force on a charged particle.

5hrs

Reference Books:

1. Introduction to Electrodynamics, (3 Edition) by David J.Griffith.
Publication :Prentice-Hall of India, New Delhi
2. Introduction to Electrodynamics, by A.Z.Capri and P.V.Panat Narosa Publishing House
3. Classical electricity & Magnetism, by Panofsky and Phillips, Addison Wesley
4. Foundations of Electromagnetic theory, by Reitz & Milford, World student series Edition.
5. Classical Electrodynamics, by J.D.Jackson, 3 Edition John Wiley.
6. Electromagnetic theory and Electrodynamics, by Satya Prakash, Kedar Nath and co.Meerut.
7. Special theory of Relativity, by Robert Resnick.
8. Electromagnetics by B.B.Laud, Willey Eastern.
9. Matrices and Tensors in Physics, A. W. Joshi, 3 Edition, New Age International

NUMERICAL TECHNIQUES

Solution of linear systems: Gauss, Gauss-Jordan elimination, matrix inversion and LU decomposition. Eigen values and Eigenvectors. Applications.	10hrs
Interpolation and Curve fitting: Introduction to interpolation, Lagrange approximation, Newton and Chebyshev polynomials. Least square fitting, linear. Application in Physics problems.	10hrs
Numerical Differentiation and Integration: Approximating the derivative, numerical differentiation formulas, introduction to quadrature, trapezoidal and Simpson's rule, Applications.	10hrs
Solution of ODE: Initial value and boundary value problems, Euler's and Runge-,Kutta methods, Finite difference method. Applications in Chaotic dynamics, Schrodinger equations.	10hrs
Montecarlo Techniques	5hrs
Fourier transforms, time series analysis, correlation, convolution	5hrs
Errors: Its sources, propagation and analysis	5hrs
Computer essentials (essential LINUX commands, vi editor, compiler (f77, cc), plotting (GNUplot)), computer representation of numbers	5hrs

Reference Books:

1. K. E. Atkinson, Numerical Analysis, John Wiley (Asia) (2004).
2. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw Hill (2002).

References:

1. J. H. Mathews, Numerical Methods for Mathematics, Science, and Engineering, Prentice Hall of India (1998).
2. S. S. M. Wong, Computational Methods in Physics, World Scientific (1992).
3. W. H. Press, S. A. Teukolsky, W. T. Verlling and B. P. Flannery, Numerical Recipes in C, Cab ridge (1998).
4. S. E. Koonin: *Computational Physics*, Benjamin/Cummings (Menlo Park, CA) 1986

Online texts :

- Numerical Recipes online: <http://library.lanl.gov/numerical/bookfpdf.html>
- P. Pacheco's User Guide to MPI: <ftp://math.usfca.edu/pub/MPI/mpi.guide.ps>
- MPI online at NERSC: <http://www.nersc.gov/nusers/help/tutorials/mpi/intro/print.php>
- S. E. Koonin's Computational Physics Fortran codes: <http://www.computationalphysics.info>
- W. Krauth's Introduction to Monte Carlo: <http://www.lps.ens.fr/~krauth/budapest.pdf>

STATISTICAL PHYSICS

Statistical Description of System of Particles : Specification of the state of the system, Macroscopic and Microscopic states, Phase space, Statistical ensemble, Postulate of equal a priori probability, Probability calculations, Behaviour of density of states, Liouville's theorem(Classical), Quasi-static processes.

5hrs

Statistical Thermodynamics : Equilibrium conditions and constraints, Distribution of energy between systems in equilibrium, Approach to thermal equilibrium, Temperature, Heat reservoir, Sharpness of the probability distribution, Dependence of the density of states on the external parameters, Equilibrium between interacting systems.

8hrs

Classical Statistical Mechanics : Micro-canonical ensemble, System in contact with heat reservoir, Canonical ensemble, Applications of canonical ensembles (Paramagnetism, Molecule in an ideal gas, Law of atmosphere), System with specified mean energy, Calculation of mean values and fluctuations in a canonical ensemble, Connection with thermodynamics, Grand-canonical ensemble, Physical interpretation of a, Chemical potential in the equilibrium state, Mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand partition function.

8hrs

Applications of Statistical Mechanics: Classical partition functions and their properties, Calculations of thermodynamic quantities, Ideal monoatomic gas, Gibbs paradox, Equipartition theorem and its Simple applications. i) Mean kinetic energy of a molecule in a gas ii) Brownian motion iii) Harmonic Oscillator iv) Specific heat of solid. Maxwell velocity distribution , Related distributions and mean values.

12hrs

Quantum Statistics of Ideal Gases: Symmetry of wave functions, Quantum distribution functions, Boltzmann limit of Boson and Fermion gases, Evaluation of the partition function, Partition function for diatomic molecules, Equation of state for an ideal gas, The quantum mechanical paramagnetic susceptibility.

11hrs

Ideal Bose System : Photon gas - i) Radiation pressure ii) Radiation density iii) Emissivity iv) Equilibrium number of photons in the cavity. Einstein derivation of Planck's law, Bose-Einstein Condensation, Specific heat, Photon gas - Einstein and Debye's model of solids.

8hrs

Ideal Fermi System : Fermi energy, Mean energy of fermions at absolute zero, Fermi energy as a function of temperature , Electronic specific heat, White - Dwarfs, Compressibility of Fermi gas, Pouli's paramagnetism, A relativistic degenerate electron gas.

8hrs

Reference Books :

1. Fundamentals of Statistical and Thermal Physics, - F.Reif, McGraw - Hill, International Edition (1985)
2. Fundamentals of Statistical Mechanics, B.B.Laud, New Age International Publication (2003)
- nd
3. Statistical Mechanics, R.K.Pathria, Butterworth Heinemann(2 Edition)
- nd
4. Statistical Mechanics,K.Huang, John Willey & Sons (2 Edition)
5. Statistical Mechanics,Satya Prakash, Kedar Nath Ram Nath Publication (2008)
6. Statistical Mechanics by Loknathan and Gambhir.

QUANTUM MECHANICS - I

Revision of the following topics with emphasis on problem solving : Inadequacy of classical Physics, wave packets and uncertainty relations. Schrodinger wave equation and probability interpretation, Concepts of probability, Simple one dimensional problems - wells, barriers and harmonic oscillator (One and three dimensional).

15hrs

Postulates of quantum mechanics :Representation of states and dynamical variables, observables, self-adjoint operators, eigen functions and eigen values, degeneracy, Dirac delta function, Completeness and closure property, Physical interpretation of eigen values, eigen functions and expansion co-efficients, eigen values and eigen functions of momentum operator. Hilbert space, Dirac's bra and ket notation, dynamical variables and linear operators, projection operators, unit operator, unitary operator, matrix representation of an operator, change of basis, unitary transformation. Eigen values and eigen functions of simple harmonic oscillator by operator method.

20hrs

Angular Momentum : Eigen values and eigen functions of L and Lz operators, ladder operators L+ and L-, Pauli theory of spins(Pauli's matrices), angular momentum as a generator of infinitesimal rotations, matrix representation of J in $|jm\rangle$ basis. Addition of angular momenta, Computation of Clebsch-Gordon co-efficients in simple cases ($J_1=1/2, J_2=1/2$) Central forces with an example of hydrogen atom.

15hrs

Evolution of system with time : Constants of motion, Schrodinger and Heisenberg picture, Heisenberg's matrix mechanics for harmonic oscillator .

10hrs

Reference books:-

- 1) A Text-book of Quantum Mechanics by P.M.Mathews and K.Venkatesan.
- 2) Quantum mechanics by A.Ghatak and S.Lokanathan
- 3) Quantum Mechanics by L.I.Schiff
- 4) Modern Quantum mechanics by J.J.Sakurai
- 5) Quantum Physics by R. Eisberg and R.Resnick
- 6) Introduction to Quantum Mechanics by David J.Griffiths
 - 7) Introductory Quantum mechanics by Granier, Springer Publication.
 - 8) Introductory Quantum Mechanics, Li boff, 4 Edition, Pearson Education Ltd.
- 9) Introduction to Quantum Physics by Claud Cohen-Tannoudji, Bernard Diu, Frank Laloe, 3rd Edition, Herman and John Wiley, Ltd.

II Semester

Digital Electronics	C Programming
RS flip flop and decade counter	Basics on LINUX commands.
Astable and monostable multivibrator, Voltage controlled oscillator: IC 555	Matrix multiplication
DAC: Weighted resistors and R-2R network	Euler's Method for solving Differential Equations
Amplitude Modulation and demodulation	Runge Kutta method
Pulse amplitude modulation and demodulation	Simpson's 1/3 and 2/3 method
ADC- IC0804	Planetary orbits using Leap Frog algorithm
Multiplexer and demultiplexer	Solutions od ODEs
Phase Lock Loop IC 565	Random number generation
Calibration of LIA	Determination of value of π using Monte Carlo method
Measurement of low Resistance using LIA	Simulation of diffraction as FT
Measurement of mutual inductance using LIA	Fibonacci series
Frequency multiplication	

SEMESTER-III

**TOPICS TO BE COVERED: QUANTUM MECHANICS-II, SOLID STATE PHYSICS,
MODERN OPTICS, NUCLEAR AND PARTICLE PHYSICS
LAB: ELECTRONICS (DIGITAL)**

QUANTUM MECHANICS - II

Approximation Methods : i) Time-independent Perturbation theory: Non degenerate and degenerate cases (upto second order). Applications: Zeeman effect, Stark effect, anharmonic oscillator. stnd ii) Time-dependent Perturbation theory: Transition amplitude 1 and 2 order, selection rules, constant perturbation(1st order). Fermi's golden rule, Harmonic perturbation, Interaction of atom with em radiation, dipole approx. Einstein coefficient for spontaneous emission. iii)Variational method: Basic principles and applications to particle in box, SHO, hydrogen atom, helium atom. (qualitative approach.)

30hrs

WKB approximation : Qualitative development and condition for validity of this approx., Bohr's quantization condition, applications to tunnelling such as a-particle, field emission. 6hrs

Theory of Scattering : i) Kinematics: Differential and total cross sections, scattering amplitudes using Green's function scattering by symmetric potential, mutual scattering of two particles, Centre of Mass frame, Laboratory frame.

ii) Dynamics - a) Born approximation, Validity of Born Approx., Application to square well potential and Yukawa potential. b) Partial wave analysis, phase shift, scattering amplitudes in terms of phase shift, optical theorem, scattering by square well potential and perfectly rigid sphere.

16hrs

Symmetry in Quantum Mechanics : Symmetry Parity, Identical particles, symmetric and antisymmetric wave functions, Slater determinant, spin functions for system with more than one electron. 8hrs

Reference Books :

- 1.A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, Tata McGraw Hill
- 2.Quantum Mechanics by A.Ghatak and S.Lokanathan, Macmillan India Ltd.
- 3.Quantum Mechanics by L.I.Schiff, McGraw Hill
- 4.Modern Quantum Mechanics by J.J.Sakurai
- 5.Quantum Physics by R.Eisberg and R.Resnick(Wiley and Sons)
- nd
- 6.Introduction to quantum mechanics by D.I.Griffiths (Pearson Education)(II Edition)
- 7.Introduction to Quantum Physics by Claud Cohen-Tannoudji, Bernard Diu, Frank Laloe, 3rd Edition, Herman and John Weily, Ltd.

NUCLEAR AND PARTICLE PHYSICS

Nuclear properties: radius-electron scattering method and mirror nuclei, size, mass, spin, moments, abundance of nuclei, binding energy, excited states.

Nuclear forces: deuteron, n-p, n-n and p-p interaction, nature of nuclear force.

10hrs

Nuclear Models: liquid drop, shell and collective models.

Nuclear decay and radioactivity: radioactive decay, alpha-Gamow's theory, beta-Fermi's theory of beta decay and gamma decays, radioactive dating.

12hrs

Nuclear reactions: conservation laws, energetics, isospin, reaction cross section, Coulomb scattering, nuclear scattering, scattering cross section, compound nucleus, direct reactions, resonance reactions.

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0hrs

Particle accelerators and detectors: electrostatic accelerators, cyclotron, synchrotron, linear accelerators, colliding beam accelerators, gas-filled counters, scintillation detectors, semiconductor detectors.

10hrs

Elementary particles: forces, quantum numbers, mesons and Yukawa's hypothesis, pions, CPT theorem, strange mesons and baryons, production and decay of resonances, CP violation in K decay.

9hrs

Particle physics: Symmetries and conservation laws, Feynman diagrams, Gell-MannNishijima relation, Quark model, coloured quarks and gluons, quark dynamics, standard model.

9hrs

Reference Books:

1. K. S. Krane, Introductory Nuclear Physics, John Wiley (1988).
2. R. R. Roy and B. P. Nigam, Nuclear Physics: Theory and Experiment, New Age (1967).
3. A. Das and T. Ferbel, Introduction to nuclear and particle physics, John Wiley (1994).
4. I. S. Hughes, Elementary Particles, Cambridge (1991).
5. F. Halzen and A. D. Martin, Quarks and Leptons, John Wiley

SOLID STATE PHYSICS

Crystal physics: Symmetry operations; Bravais lattices; Point and space groups; Miller indices and reciprocal lattice; Structure determination; diffraction; X-ray: Rotating anode X ray generator. Detection techniques including image plate for detection. Bragg Diffraction law: Laue camera, and a typical Laue Pattern Powder diffraction camera and use in finding lattice parameters, electron and neutron; Crystal binding; Defects in crystals; Point and line defects.

15hrs

Lattice vibration and thermal properties: Einstein and Debye models; continuous solid; linear lattice; acoustic and optical modes; dispersion relation; attenuation; density of states; phonons and quantization; Brillouin zones; thermal conductivity of metals and insulators.

8hrs

Electronic properties: Free electron theory of metals; electrons in a periodic potential; Bloch equation; Kronig-Penny model; band theory; metal, semiconductor and insulators; bandgap; intrinsic and extrinsic semiconductors, Hall Effect, p-n junction.

10hrs

Dielectrics: Polarizability; Clausius-Mossotti formula; Dielectric constant; ferroelectrics.

8hrs

Magnetism: Diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism and ferrimagnetism.

10hrs

Superconductivity: Meissner effect; London equations; coherence length; type-I and typeII superconductors.

7hrs

Reference Books:

1. H. P. Myers, Introduction to Solid State Physics, Viva books (1998).
2. M.A. Omar, Elementary Solid State Physics, Addison-Wesley (1975).
3. C. Kittel, Introduction to Solid State Physics, John Wiley (1996).
4. A. J. Dekker, Solid State Physics, Macmillan (1986).
5. N. W. Ashcroft and N. D. Mermin, Solid State Physics, HBC Publ., (1976).

MODERN OPTICS

Geometric optics: Eikonal equations, Fermat's principle and applications to laws of reflection and refraction. Paraxial optics, ABCD matrix description of lenses, mirrors, etc.

Aberrations: Wavefront aberration coefficients, Transverse ray coefficients, spherical aberration, coma, astigmatism, field curvature, distortions and aberration reduction.

Dispersion: phase and group velocity, material dispersion, normal and anomalous dispersion, chromatic aberration. 20hrs

Fourier techniques: Fourier analysis, Fourier transforms, diffraction of light, Kirchoff's diffraction theory. Fourier transformation by propagation, lenses and their description in Fourier transformation and imaging. Spread functions, modulation transfer functions, convolution, etc.

20hrs

Diffraction theory of image formation, optical data processing, Coherence, classical coherence functions, autocorrelation function and time coherence. Spatial coherence, mutual coherence functions, visibility of fringes. 10hrs

Crystal optics: double refraction. Polarization and anisotropy of wave propagation in crystals, dielectric and optical indicatrix, uniaxial and biaxial crystals. 10hrs

Reference Books:

1. Max Born and Emil Wolfe, Principles of Optics, Pergamon Press, 6th Edition (1985).
2. M.V. Klein and T.E. Furtak, Optics, 2nd edition, John Wiley (1986).
3. R.S. Sirohi, Wave Optics and Applications, Orient Longman (1992)
4. A.K. Ghatak and K. Thyagarajan, Contemporary Optics, Plenum Pub. Co. (1978).
5. J.R. Mayer-Arendt M.D. Introduction to Classical and Modern Optics, 2nd Edition, Prentice Hall (1988).
6. R.S. Sirohi and M.P. Kothiyal, Optical Components, Systems and Measurement Techniques, Marcell Dekker (1991).
7. R.D Guenther, Modern Optics, John Wiley (1990)
8. P. Hariharan, Optical Holography, Cambridge University Press (1984).
9. Ghatak, A. K, Modern Optics,
10. D. Casasent, (ed), Optical Data Processing, Springer Verlag (1978).

III Semester	
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Optics	Nuclear and Solid State Physics
Ultrasonic interferometer	Curie- Weiss law
Michelson interferometer	Thermal diffusivity of brass
Wavelength of laser using diffraction grating	GM counter characteristics and inverse square law
Size of Lycopodium particles	Determination of mass attenuation coefficient of brass and lead
Fabry Perot Interferometer	Calibration of gamma ray spectrometer
Study of Elliptically polarized light	Determination of energy of unknown source using Gamma ray spectrometer
Faraday rotation	
Edser Butler method to determine thickness of Mica sheet	
Study of Hardinger fringes	

SEMESTER-IV
TOPICS TO BE COMPLETED: EXPERIMENTAL TECHNIQUES-II, ELECTIVE-I,
ELECTIVE-II, PROJECT
LAB: PHYSICS LAB-II

EXPERIMENTAL PHYSICS-II

Spectroscopic techniques: IR absorption to study molecular vibrations and rotations, band gap of semiconductors, superconducting energy gap. Visible and UV absorption for the study of electronic energy levels, defects in solids etc. Raman Effect for the study of molecular vibrations and vibrations in solids.

15hrs

Main constituents of spectrometers: Source, dispersing element and detector. IR, UV, Visible absorption spectra, Description of a Raman spectrometer and typical Raman Spectra.

NMR and EPR Spectrometers: Principles of operation. Components of the spectrometer. Typical NMR, ESR spectra and applications.

10hrs

X ray Diffraction Techniques and electron microscope techniques: Rotating anode X ray generator and synchrotron sources. Detecting techniques including image plate for detection. Bragg Diffraction law: Laue camera, and a typical Laue Pattern Powder diffraction camera and use in finding lattice parameters.

15hrs

Transmission and scanning Electron microscopes and applications.

5hrs

Surface probe techniques: Principle AFM, STM, MFM., Applications

10hrs

Nuclear Physics: Radiation Detectors: gas filled detectors, ionization chambers, proportional counters, scintillation detectors, photomultiplier tubes.

5hrs

Reference Books:

1. Molecular Spectroscopy- An Introduction, Jagmohan, Narosa Publication
2. Introductory Raman Spectroscopy, John R. Ferraro and Kazuo Nakamoto, 2004
3. Electron Paramagnetic Resonance – Elementary Theory And Practical Applications, John A. Well, James R. Bolton and John E. Wertz John Wiley and Sons, 1994
4. Basics of X ray Diffraction and its applications, K. Ramakanth Hebbar, IK International Pvt Ltd.
5. Electron microscopy and analysis, Peter J Goodhew, John Humphreys, Richard Beanland, 3rd edition, 2000
6. Scanning probe Microscopy and Spectroscopy Theory and Applications, Second Edition Edited by Dan Bonnell, Wiley VCH, 2001
7. Scanning Probe Microscopy – The Lab on a tip, Ernst Meyer, Hans J. Hug, Roland Bennewitz, Springer Verlag New York, 2003
8. Introduction to nuclear science, Bryan J.C., Lavoisier Libraire 2008

ELECTIVE-I (ASTROPHYSICS)

An introduction to contemporary Astronomy: Optical, Infrared, Ultraviolet, Radio, X-ray and Gamma Ray Astronomy, Observational Techniques: Optical Telescopes, Radio telescopes, Detectors for X-ray and Gamma rays

5hrs

Radiative Processes: Thermal radiation, Thermal bremsstrahlung, Synchrotron radiation

10hrs

The Stars: The equation of hydrostatic equilibrium, Virial theorem, the internal temperature of the sun, the energy generation in the centre, nuclear reactions, Eddington's theory of the stars, Mass-luminosity relation, the life time of the stars of different masses, the solar neutrinos. 10hrs

The evolution of stars: The H-R diagram and the main sequence, The evolution of stars, the end states of stars, white dwarfs, the Chandrashekar limit, Neutron stars, Supernovae, Black holes.

10hrs

The Milky Way galaxy: The composition of galaxies, the classification of galaxies, the interstellar medium, atomic and molecular clouds, the 21 cm radiation, the rotation curve of galaxies, Dark matter in galaxies

10 hrs

The Universe: Clusters of galaxies, Active Galactic Nuclei, The Big bang cosmology, the Cosmic Background Radiation, The expansion rate of the universe, A review of current problems and ideas

10 hrs

The Solar System, Extra solar planets

5hrs

References:

1. Physical Universe, Shu F.H., University Science Books, 1982
2. An Invitation to Astrophysics, T. Padmanabhan, World Scientific, 2006
3. Structure and Evolution of Stars, Martin Schwarzschild, Princeton University Press, 1958
4. The Sun, Stix M., Springer-Verlag, 1989
5. The Physics of Fluids and Plasmas, Arnab Rai Choudary, Cambridge University Press, 1998
6. An Introduction to Galaxies and Cosmology, Edited by Mark H. Jones and Robert J. Lambourne, Cambridge University Press, 1998
7. Galactic Astronomy, Binney and Merrifield, Princeton Series in Astrophysics, 1998
8. Galaxies in the Universe, Sparke & Gallagher, Cambridge Univ. Press, 2000
9. High Energy Astrophysics Vol-I &II, Longair M., Cambridge Univ. Press, 1992
10. Introduction to Cosmology, Ryden B., Cambridge Univ. Press, 2002

ELECTIVE-II (SOFT CONDENSED MATTER PHYSICS)

Overview of systems and experimental techniques

2 hrs

Liquid crystals: definition and classification; different types of mesogenic molecules

Nematics: orientational order parameter; Maier-Saupe theory of the nematic-isotropic transition; elasticity; Freedericksz transition; liquid crystal displays; defects; chiral nematics, thermochromic materials

Smectics: elasticity; thermal fluctuations, quasi-long-range order; ferroelectricity

Experimental techniques: calorimetry; polarizing optical microscopy; x-ray and neutron scattering

16 hrs

Colloids: Forces between colloidal particles-DLVO theory; steric stabilization; hard sphere colloids; depletion forces; colloidal crystals; colloidal liquid crystals – Onsager theory of nematic-isotropic transition

Experimental techniques: static and dynamic light scattering

12 hrs

Polymers: ideal chain in a solution - Gaussian model; real chains- excluded volume, Flory theory; osmotic pressure of a polymer solution; light, x-ray and neutron scattering by polymer solutions; viscoelasticity.

Phase separation in polymer mixtures – Flory-Huggins theory; copolymers

Biopolymers- DNA, proteins

14 hrs

Amphiphiles: the hydrophobic effect; thermodynamics of self-assembly; different types of self-assembled structures; elasticity and thermal fluctuation of membranes; phase behaviour of concentrated solutions; microemulsions; cell membranes

Optical microscopy techniques-phase contrast, differential interference contrast, fluorescence, laser scanning confocal microscopy

16 hrs

References:

1. Introduction to soft matter, Ian W. Hamley, John Wiley, 2000.
2. Soft condensed matter, Richard A L Jones, Oxford master series in condensed matter physics, Oxford university press, 2002.
3. Structured fluids, Thomas A Witten, Oxford university press, 2004.
4. Principles of condensed matter physics, P M Chaikin and T C Lubensky, Cambridge university press, 1995.
5. Light and electron microscopy, E M Slayter and H S Slayter, Cambridge university press, 1992

EXPERIMENTAL PHYSICS-II

1. AC susceptibility measurement and verification of Curie-Weiss law for a paramagnetic material with the lock-in-amplifier.
2. Study of percolation using electrical conductivity.
3. Measurement of Boltzmann's constant using noise.
4. Optical coherence using laser pointer
5. Pumping speed of a rotary pump and measurement of conductance.
6. Preparation of a thin film and measurement of resistance down to 77 K.
7. Measuring superconducting transition in a HTS material.
8. Point contact tunnelling and measuring band gap of a semiconductor.

ASTROPHYSICS

1. Introduction to optical astronomy- Basic Photometric data reduction using IRAF
2. Introduction to Radio Astronomy-Introduction to HI 21cm Radio data reduction using AIPS
3. Study of variable stars
4. Determination of the orbital parameters of Mars

SOFT CONDENSED MATTER PHYSICS

1. Electro-optic switching of a Nematic liquid crystal
2. Electro-convective instability of a Nematic liquid crystal