

Syllabus of M.Sc. (Physics) Course

PAPER-I(PHL-501) Mathematical physics

CREDITS: 4
Time: 3 hours

Vector spaces and matrices: linear independence, bases, dimensionality, inner product, linear transformations, matrices, inverse, orthogonal and unitary matrices. Independent elements of a matrix, eigenvalues and eigenvectors, diagonalization, complete orthonormal sets of functions.

Function of a complex variable: Analytic functions, Cauchy-Reimann conditions, Elementary functions of Z , Cauchy's integral theorem, Cauchy's integral formula, Taylor and Laurent series, Residues, Residue theorem, Jordan's lemma, Evaluation of real definite integrals.

Second order linear ODE's: series solution (Frobenius's method). The Wronskian and the second solution. Solution of Legendre, Bessel, Hermite and Laguerre equations. Generating functions and recurrence relations.

Integral transforms, Laplace transform (LT), first and second shifting theorems, Inverse LT by partial fractions, L T of derivatives and integral of a function. Fourier series (FS) FS of arbitrary period, Half-wave expansions, partial sums; Fourier integral And transforms; F T of delta function.

Text and Reference Books:

T.L.Chow	Mathematical Methods for Physicists
G. Arfken	Mathematical Methods for Physics
A. W. Joshi	Matrices and Tensors for Physicists
E. Ereyszig	Advanced Engineering Mathematics
Mary L. Boas	Mathematics for Physicists

Paper II (PHL-502)
Classical Mechanics

CREDITS :4

Time :3 Hours

Constraints and their classification, D'Alemberts principle, generalized coordinates, Lagrangian equation, and its applications, Hamilton's principle and derivation of Lagrange's equations from Hamilton's principle, symmetries and conservation laws.

Reduction to equivalent one body problem , the equation of motion and first integrals, the equivalent one – dimensional problem and the classification of orbits, the differential equation for orbits, the Kepler's problem(inverse square law), scattering in central force field.

The Euler's angles, rate of change of a vector, the Coriolis force and its applications, Legendre transformation and Hamilton's equation of motion, cyclic coordinates, the equations of canonical transformation, examples of canonical transformation, Poission's brackets, Poission's theorem.

Hamilton-Jacobi equation for Hamilton's principal function, Harmonic Oscillator problem, stable and unstable equilibria, elementary idea of small oscillations, normal modes and coordinates , free vibrations of a linear triatomic molecule.

Reference books :

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|------------------------------|---|
| N.C.Rana and P.S.joag | Classical mechanics, Tata McGraw-hill,1991 |
| H.Goldstien | Classical mechanics, Addison Wesley,1980 |
| A.Sommerfeld | Mechanics, (acadmic press,1952) |
| I. Perceival and D. Richards | Introduction to dynamics, Cambridge Univ. Press,1982. |
| Kiran C.Gupta | Classical Mechanics |

Paper III (PHL-503)
Quantum Mechanics-I

CREDITS :4
Time: 3hours

The Schrodinger equation: Time dependent and time independent forms, Probability current density, expectation values, Ehrenfest's theorem, Gaussian wave packet and its spreading. Exact statement and proof of the uncertainty principle, Time independent equation, eigenvalues and eigenfunctions, Degeneracy and orthogonality. Applications of Schrodinger equation for 1 d Box, Tunneling problem & Linear Harmonic Oscillator.

Operator formalism in quantum mechanics, Hermitian operators and their properties, Vector representation of States-Bra and Ket algebra, relationship between kets and wave functions, Linear harmonic oscillator problem, coherent states, annihilation and creation operators, Matrix representation of an operator, Unitary transformation.

The angular momentum operators and their representation in spherical polar coordinates, solution of Schrodinger equation for spherically symmetric potentials, spherical harmonics, Hydrogen atom. Angular momentum matrices and Pauli spin matrices.

Time independent perturbation theory: Nondegenerate case, first and second order perturbations, Degenerate case, removal of degeneracy in second order. First order Stark effect in hydrogen, The Variational Method: expectation value of the energy, application to excited states, ground state of helium.

Text and Reference Books :

L.I.Schiff	Quantum Mechanics , McGraw-Hill
S.Gasiorowicz	Quantum Physics , Wiley
B.Craseman and J.D. Powell	Quantum Mechanics, Addison Wesley
A.P.Messiah	Quantum Mechanics
J.J.Sakurai	Modern Quantum Mechanics
Mathews and Venkatesan	Quantum Mechanics
Ghatak & Loknathan	Quantum Mechanics
Cohen Tannoudji	Quantum Mechanics

Paper VII (PHL-504)
Electronics

CREDITS :4
Time: 3 Hours

The junction field Effect Transistor: Basic structure & Operation, pinch off voltage, single ended geometry of JFET, volt – ampere characteristic, Transfer Characteristics.

MOSFET: Enhancement MOSFET, Threshold Voltage, Depletion MOSFET, comparison of p & n channel FET,s. JFET low frequency common source amplifiers.

Differential Amplifier: Circuit configuration, dual input balanced output different amplifier, D.C. & A.C. analysis, Inverting and Non-inverting inputs, CMRR – constant current bias level translator.

Operational Amplifier: Block diagram, open loop configuration, inverting & non-inverting amplifier, OP-AMP with negative feedback – Voltage series feedback, Effect of feedback on closed loop voltage gain, Input resistance, output resistance, band width, output offset voltage.

OP-AMP Application : DC and AC amplifier, summing, scaling and Averaging amplifier, Integrator, Differentiator, Electronic analog computation comparator

Oscillators: principles, Types, frequency stability, Phase shift oscillator, Wein bridge oscillator, LC tunable oscillator, Square wave, Triangular wave and pulse generator (Monostable & Astable, multivibrators)

Digital operation of system: Introduction to OR, AND & NOT gates Ex-OR gate, De Morgan's Laws, NOR & NAND DTL Logic, Binary adder, Digital Comparator, Decoder/Demultiplexer, Data selector/Multiplexer-Encoder, ROM and its applications.

Flip-Flops : R-S, J-K, Master slave, T & D type flip flop, shift Register, Synchronous & Asynchronous Counter.

Text and Reference Books:

M.Sayer and Mansingh	Measurement, Instrumentation And Experimental Design in Physics and Engineering	Prentice Hall, India (2000)
Ajoy Ghatak and K. Thyagarajan	Optical Electronics	Cambridge Univ. Press
Ramakanth A. Gayakwad	OP-Amps & Linear integrated Circuits	Second Edition, 1991
A.P. Malvino and Donald	Principals and applications	Tata Megraw-Hill

P.Laach
J.Millman, CC.HaLkias Integrated Electronics

Company, New Delhi 1993
Tata MagGraw Hall

Paper V (PHL-506)
Solid State Physics

CREDITS :4
Time: 3hours

Crystalline solids, unit cells and direct lattice, two and three-dimensional Bravais lattices, closed packed structures.

Interaction of X-rays with matter, absorption of X-rays. Elastic scattering from a perfect lattice. The reciprocal lattice and its applications to diffraction techniques. The Laue, powder and rotating crystal methods, crystal structure factor and intensity of diffraction maxima. Extinctions due to lattice centering, Brillouin zone.

Dispersion relation for one dimensional lattice vibration in monatomic and diatomic basis: acoustical and optical modes. Quantisation of elastic waves, phonon momentum, in elastic scattering by phonons. Free electron fermi gas: energy levels and density of orbitals, the Fermi-Dirac distribution, free electron gas in 3-dimensions, electronic specific heat of a metal.

Electrons in a periodic lattice: Bloch theorem, band theory, and classification of solids, effective mass. Tight bonding, cellular and pseudopotential methods. Fermi surface, de Haas van Alphen effect, cyclotron resonance, magneto resistance, quantum Hall effect.

Basic Properties of Superconductors, Critical Temperature, Meissner Effect, Transport Behavior, Types of Superconductors and Concept of λ and ξ , Ginzburg Landau Theory, Hard Type-II Superconductors and Critical Current Density, Some introduction to High Temperature Superconductors

Diamagnetism, Theory of Para-Magnetism: Vanveleck Theory and Pauli theory of Paramagnetism.

Theory of Ferromagnetism: Weiss, Heisenberg Model and Molecular field Theory, Curie Weiss law of Susceptibility, and concept of Spin Waves. Ferri and Antiferro-magnetic order. Domains and Bloch-wall energy.

Text and Reference Books:

Verma and Srivastava	Crystallography for Solid-State Physics
Azaroff	Introduction to Solids
Omar	Elementary Solid-State Physics
Aschroft & Mermin	Solid State Physics
Kittel	Solid State Physics
Chaikil & Lubensky	Principles of Condensed Matter Physics
Hans & Liith	Condensed Matter Physics
M.Tinkham	Introduction to Superconductivity

Paper VI (PHL-507)
Atomic & Molecular Physics

CREDITS :4
Time: 3 hours

Two electron systems : - Interaction energy in L S and J J coupling, Atomic states arising due to different electronic configuration (L S coupling only). Spectrum of Helium and Heisenberg's resonance. Hyperfine structure of spectral lines: Isotope effect, nuclear spin and hyperfine multiplet.

The diatomic molecule as a Rigid Rotator & Harmonic Oscillator, Energy levels and Infrared spectra. Raman Effect : Quantum theory, The Raman Spectrum of the Rigid Rotator and of the Harmonic Oscillator. The diatomic molecule as Non-rigid Rotator and Anharmonic Oscillator: Energy levels and I R spectrum. Raman Spectra for the Non-rigid Rotator and Anharmonic Oscillator.

The diatomic molecule as a Vibrating Rotator: Energy levels, Infrared spectrum and Raman Spectrum. Thermal distribution of Quantum states: Intensities in rotation- vibration spectra, symmetry properties of the rotational levels: Influence of nuclear spin, Isotope effect on vibration and rotation spectra.

Electronic band spectra: Electronic energy & total energy, resolution of the eigenfunction (Born-Oppenheimer approximation) & total energy, Vibrational structure of Electronic transitions. Rotational structure of Electronic bands: The branches (P,Q,R) of a band, Band-head formation. Intensities in Electronic bands: Intensity distribution in the vibrational structure, The Franck-Condon principle (absorption & emission)

Text and Reference Books:

H.E. White (T)	Introduction to Atomic spectra
C.B. Banwell (T)	Fundamental of molecular spectroscopy
Walkar & Stranughen	Spectroscopy vol. I II III
G.M.Barrow	Introduction to molecular spectroscopy
Herzberg	Spectra of diatomic molecules
Jeanne L McHale	Molecular spectroscopy
J.M.Brown	Molecular spectroscopy

P.F.Bemath
J.M.Holkas

Spectra of atoms and molecules
Modern spectroscopy

Paper I (PHL-508)
Statistical Mechanics

CREDITS :4
Time: 3 Hours

Foundations of statistical mechanics, specification of states of a system, concept of phase space and ensemble contact between statistics and thermodynamics, equipartition theorem, classical ideal gas, entropy of mixing and Gibb's paradox.

Microcanonical ensemble, phase space, trajectories and density of states, Liouville's theorem, Boltzmann H Theorem. Canonical and grand canonical ensembles, partition function. Calculation of statistical quantities, Energy and density fluctuations.

Density matrix, statistics of ensembles, statistics of undistinguishable particles, Maxwell – Boltzmann, Fermi-Dirac and Bose – Einstein statistics, properties of ideal Bose – Einstein and Fermi-Dirac gases, Bose Einstein condensation, Laser cooling of atom as an example of Bose Condensate. Planck's radiation formula (Black body Radiation)

Cluster expansion for a classical gas, Virial equation of state, Ising model, mean – field theories of the Ising model in one dimension and Exact solution in one dimension.

Landau theory of phase transition, critical indices, scale transformation and dimensional analysis.

Text and Reference Books:

F. Reif	Statistical and Thermal
K.Huang	Statistical Mechanics
R.K.Pathria	Statistical Mechanics
R.Kubo	Statistical Mechanics
Landau and Lifshitz	Statistical Physics
ESR Gopal	Statistical Mechanics
S.K. Ma	Statistical Mechanics
Eugene Stanley	Critical Phenomena & Phase Transitions

Paper VIII (PHL-509)
Physics of Lasers

CREDITS :4
Time: 3 Hours

Spontaneous & Stimulated Emission, Stimulated absorption, Relationship of Einstein's coefficient, Ideas of Light amplification by an atomic system. Cavity radiations and modes (one, two and three dimensions), Important properties of Laser, Spatial and temporal coherence (Experimental evidence).

Origin of Line shape function, Broadening of spectral line: Homogeneous (natural and collisional) and Inhomogeneous (Doppler) broadening mechanisms, Threshold condition for oscillation, Laser oscillation and amplification in a homogeneous broadened transition and its Gain saturation.

Laser oscillation and amplification in an inhomogeneous system, Multi-mode oscillation, Spatial hole burning (Lamb dip), Efficiency of laser (various factors), Population inversion & rate equations for three and four level laser systems. Variation of Laser power around threshold. Optimum output coupling.

Gaussian beam and its properties Physical description of Lowest order modes, Preliminary considerations of optical resonator, Energy stored in optical resonators, Different types of resonators. Different types of losses in optical resonators (Diffraction losses, coating losses, transmission losses).

Text and Reference Books:

Laser Electronics, J.T.Verdeyen, Prentice Hall (1995)

Lasers & Electro-Optics : Fundamental & Engineering C.C.Davis, Cambridge (1996)

Lasers Fundamentals By W.T. Silfvast, Cambridge (1996)

Principles of Lasers, O.Svetto, Plenum (1989)

Laser Physics, L.V.Tarasov, Mir (1983)

Quantum Electronics, A.Yavir, John Wiley (1992)

Laser: Theory & Applications, A. Ghatak & Tayagrajan, Macmillan India

Introduction to Laser Physics, K. Shimoda, Springer (1986)

Lasers & non-Linear Optics, B.B.Laud

Paper IV (PHL-511)
Quantum Mechanics-II

CREDITS :4
Time: 3hours

WKB Approximation: The WKB method for one-dimensional problems, Application to barrier penetration, The WKB method for three dimensional problems.

Time-dependent perturbation theory: harmonic perturbation; Fermi's golden rule, adiabatic and sudden approximations.

Basic concept of scattering, Scattering amplitude, differential and total scattering cross sections, scattering by spherically symmetric potentials, partial waves and phase shifts, scattering by a perfectly right sphere and by square well potential. Born approximation and its application to scattering of electrons by atom. Neumann equation and its solution, Neumann series and Bessel function.

Identical particles : Symmetric and antisymmetric wave functions, distinguishability of identical particles, the exclusion principle, the connection with statistical mechanics, collisions of identical particles, Spin angular momentum : connection between spin and statistics, spin matrices and eigenfunctions. Spin functions for a many electron system. Atomic levels of Helium atoms as an example of two electron system.

Semiclassical theory of radiation: Transition probability for absorption and induced emission, Electric dipole and forbidden transitions, selection rules.

Relativistic quantum mechanics : The Klein – Gordon equation, the Dirac equation, probability current density, plane wave solutions.

Text and Reference Books :

L.I.Schiff	Quantum Mechanics , McGraw-Hill
S.Gasiorowicz	Quantum Physics , Wiley
B.Craseman and J.D. Powell	Quantum Mechanics, Addison Wesley
A.P.Messiah	Quantum Mechanics
J.J.Sakurai	Modern Quantum Mechanics
Mathews and Venkatesan	Quantum Mechanics
Ghatak & Loknathan	Quantum Mechanics

Cohen Tannoudji

Quantum Mechanics

Paper-II (PHL-512)
Electrodynamics and Plasma Physics

CREDITS :4
Time: 3 hours

Energy stored in an electric and magnetic fields. Maxwell's equations, power flow in an electromagnetic field and pointing theorem. Electromagnetic waves in a homogeneous medium-solution for free space conditions. Uniform plane waves, the wave equations for a conducting medium, Sinusoidal time variations, Maxwell's equations using phasor notation. Wave propagation in a loss less medium, wave propagation in a conducting medium, wave propagation in a good dielectric.

Polarization : Linear, elliptical and circular Polarization, Direction cosines.

Reflection and refraction of plane waves: Reflection by a perfect conductor – normal and oblique incidence. Reflection by a perfect dielectric – normal and oblique incidence. Power loss in a plane conductor.

Dispersion and Scattering; Coherent and Incoherent Scattered Light, Polarization of Scattered Light, Dispersion in Solids, Liquids and gases.

Wave Equation for Vector and Scalar Potential and Solution Retarded Potential and Lienard – Wicchert Potential, Electric and Magnetic fields due to a Uniformly Moving Charge and An Accelerated Charge, Linear and Circular Accelerating and angular Distribution of Power Radiated, Bremsstrahlung, Synchrotron Radiation and Cerenkov Radiation, Reaction Force of Radiation.

Elementary Concepts: Derivation of moment Equations from Boltzmann Equation, Plasma Oscillations, Debye Shielding, Plasma Parameters, Magnetoplasma, Plasma Confinement. Waves Guides: Rectangular, Parallel Plane & Dielectric Slab Wave guide, Concept of Cut off frequency, Lippman Fringes, TE, TM & TEM modes.

Text and Reference Books:

Panofsky and Phillips	Classical Electricity and Magnetism
Bittencourt	Plasma Physics
Chen	Plasma Physics
Jackson	Classical Electrodynamics
Griffiths	Electromagnetic Theory
Jordan & Balme	Electromagnetic Waves

Kenneth S.Kiane, Ghoshal	Introductory Nuclear Physics Atomic & Nuclear Physics Vol. 2	Wiley, New York, 1988
P.H.Perkins	Introduction to High Energy	Addison-Esley, London,1982
Shirokov Yudin	Nuclear Physics Vol. 1 & 2	MirPublishers, Moscow,1982
D. Griffiths	Introduction to Elementary Particles	Harper and Row, New York,1987
H.A. Enge	Introduction to Nuclear Physics	Addison-Wesley, 1975
G.E.Brown and A.D. Jackson	Nucleon-Nucleon Interaction	North-Holland, Amsterdam, 1976
S.de Benedetti	Nuclear Interaction	John Wiley & Sons, New York,1964
M.K.Pal	Theory of Nuclear Structure	Affiliated East-West, Madras, 1982
Y.R.Waghmare	Introductory Nuclear Physics	Oxford-IBH, Bombay, 1981
J.M.Longo	Elementary Particles	Me Graw-Hill, New York, 1971
R.D.Evans	Atomic Nucleus	Me Graw Hill, New York, 1955
I.Kaplan	Nuclear Physics, 2 nd Ed.	Narosa, Madras, 1989
B.L. Cohen	Concepts of Nuclear Physics	TMGH, Bombay, 1971
R.R.Roy and B.P.Nigam	Nuclear Physics	Wiley-Eastern Ltd., 1983

Paper IV (PHL-514)
Computational Methods & Programming

CREDITS :4
Time: 3 hours

Elementary information about Digital Computer Principles, Compilers, Interpreters and Operating system. Fortran programming, Flow charts, Integer and Floating Point Arithmetic, Expressions, built in functions, executable and non-executable statements, assignment, control and input-output elements, Subroutines and functions, Operation with files. Manipulation of complex numbers, statistical analysis of data, and various formula based programming.

Methods for determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, convergence of solutions. Solution of simultaneous linear equations, Gaussian elimination, pivoting, iterative Method, matrix inversion, Stability analysis of above techniques. Algorithm of the above methods based on fortran language.

Eigenvalues and eigenvectors of matrices, Power and Jacobi Method.

Finite differences, interpolation with equally spaced and unevenly spaced points. Curve fitting, Polynomial least squares and cubic Spline fitting. Stability and error analysis.

Numerical differentiation and integration, Newton-Cotes formulae, error estimates, Gauss method.

Fortran Algorithm on above formula.

Random variate, Monte Carlo evaluation of Integrals, Methods of importance sampling, Random walk and Metropolis method.

Numerical solution of ordinary differential equations (introduction to second and higher order, Euler and Runge Kutta method, Predicto and corrector method. Elementary ideas of solution of partial differential equations and different techniques to solve second order partial differential equations.

Error analysis of all methods.

Text and Reference Books:

Sastry	Introductory Methods of Numerical Analysis
Rajaraman	Numerical Analysis
Rajaraman	Fortran Programming

Vetterling
Binder & Herman

Numerical Recipes
Monte Carlo Simulatio

Teukolsky Press and Framney

Paper V (PHL-516(i))
Physics of Nano Materials
(Special Paper I : Condensed Matter Physics, Group-I)

CREDITS :4

Time: 3 hours

Free electron theory (qualitative idea) and its features, Idea of band structure, Metals, insulators and semiconductors, Density of state in bands, Variation of density of states with energy, Variation of density of state and band gap with size of crystal.

Electron confinement in infinitely deep square well, confinement in one and two dimensional well, Idea of quantum well structure, Quantum wires and dots.

Different methods of preparation of nanomaterials, Bottomup: Cluster beam evaporation, Ion beam deposition, Chemical bath deposition with capping techniques and Top down: Ball Milling.

Determination of particle size, Increase in width of XRD peaks of nano-particles, Shift in photoluminescence peaks, Variation in Raman spectra of nano-materials.

Text and Reference Books:

GAn-Moog Chow, Kenneth E.Gonsalves	Nanotechnology Molecularly Designed materials	American Chemical Society John Wiley & Sons, 1998
D. Bimerg M. Grundmann and N.N.Ledenstoy	Quantum dot heterostructures	
B.C. Crandall	Nano technology: Molecular Speculations on global abundance	MIT Press, 1996
John H. Davies	Physics of low dimensional Semiconductors	Cambridge Univ. Press, 1997
K.P. Jain	Physics of semiconductor nano Structures	Narosa 1997
Harvey C. Hoch,	Nano fabrication and bio system:	Cambridge Univ. Press, 1996

Harold G. CRAichead and
Lynn Jelinski
Ed. J.H.Fendler

Integrating materials science
engineering science and biology
Nano Particles and nano structured
Films; Preparation characterization
and applications John Wiley & Sons 1998

Paper VI (PHL-516(iii))
Condensed Matter Physics: Materials Science
(Special Paper II : Condensed Matter Physics, Group-I)

CREDITS :4
Time: 3 hours

Defects in Lattice: Point Defects (Schottky and Frenkel Defects) and their Thermodynamics, Colour Centres: F, M, R, Vr and H centres, Polaron and excitons. Line Defects: Dislocations : Screw and Edge Dislocations. Grain boundaries, twinning etc. The Mechanism of Plastic Deformations in Solids and its applications in different type of Crystal Structures FCC, BCC, HCP.

Mechanism of plastic deformation in solids, Stress and strain fields of screw and edge dislocations. Elastic energy of dislocations. Forces between dislocations, stress needed to operate Frank-Read source, dislocations in fcc, hcp and bcc lattices. Partial dislocations and stacking faults in close-packed structure.

Experimental Technique to observe the defects in Lattice: Electron Microscopy, and XRD. Optical Techniques:PI, FTIR and Raman. Experimental methods of observing dislocations and stacking faults, Electron microscopy: Kinematical theory of diffraction contrast and lattice imaging. General properties of ferroelectric materials. The dipole theory of ferroelectricity. Thermodynamics of ferroelectric transitions. Ferroelectric transitions. Ferroelectric domains.

Materials Synthesis: Crystal Growth, Thin Film Deposition techniques: Thermal Evaporation, e-beam Evaporation, dc & Rf Sputtering, PLD, MOCVD etc.

Study of surface topography by multiple-beam interferometry, Conditions for accurate determination of step height and film thicknesses (Fizeau fringes). Electrical conductivity of thin films, difference of behaviour of thin films from bulk, Boltzmann transport equation for a thin film (for diffused scattering)

Electronic properties of alkali halides: Optical and thermal electronic excitation, upper filled band and the conduction band, exciton-hole interaction, influence of lattice defects on electronic levels, non-stoichiometric crystals containing excess metal, transformation of F. Centres into F'. Centres, photoelectric effect in alkali halides.

Ferro-electric and Dielectric Materials Dipole Theory of Ferroelectricity, : Piezoelectricity, Pyroelectricity, Kerr Effects, Ferro-electric Domain.

Magnetic Materials and their Applications: Metal-Insulator Transition (Mott Insulator)

Exchange Interaction: Super exchange, Indirect (RKKY) Exchange Interaction and Zener Exchange.

CMR Materials.

Text and Reference Books:

Azaroff	X-ray Crystallography
Weertman & Weertman	Elementary Dislocation Theory
Verma & Srivastava	Crysgtallography for Solid State Physics
Kittel	Solid State Physics
Azaroff & Buerger	The Powder Method
Blueger	Crystal Structure Analysis
Thomas	Transmission Electron Microscopy
Tolansky	Multiple Beam Interferometry
Heavens	Thin Films
Chopra	Physics of Thin Films

Paper VII (PHL-517(i))
Opto-Electronics
(Special Paper III : Optics & Spectroscopy, Group-II)

CREDITS :4
Time:3 hours

Pumping Processes: Optical pumping, conversion efficiency, and electrical pumping, Physical description of discharge. Excitation by Resonant energy transfer, Physical description, Excitation mechanism applications and structure of He-Ne, Ruby, Nd:YAG, Dye laser and CO₂ laser.

Index ellipsoid, Pockel's and Kerr effects, Pockel effect in KDP crystal: Longitudinal and elementary idea of transverse configuration, Elementary idea of magneto-optic effect and acousto-optic effect, Design of Q switching laser (theory), Theory of mode locking. Methods for Q-Switching and mode locking: electro-optic effect and acousto-optic effect.

Introduction to nonlinear optics, Maxwell's equation in nonlinear medium, Steady state and transient nonlinear optical effects (Brief idea), Slowly varying envelope approximation, Three wave mixing phenomenon: Second harmonic generation and Parametric amplification. Four wave mixing phenomenon: Brillouin scattering, Optical phase conjugation and Optical bistability (elementary idea)

Advantage of lasers in spectroscopy, High sensitivity methods of absorption spectroscopy; frequency modulation, intracavity absorption (using single mode and multi-mode operation), Fluorescence excitation spectroscopy, photoacoustic spectroscopy, laser induced fluorescence, Idea of laser magnetic Resonance.

Text and Reference Books:

Laser Electronics, J.T. Verdeyen, Prentice Hall (1995)

Lasers & Electro-Optics: Fundamental & Engineering C.C.Davis, Cambridge (1996)

Lasers Fundamentals by W.T. Silfvast, Cambridge (1996)

Principles of Lasers, O. Svelto, Plenum (1989)

Laser Physics, L.V.Tarasov, Mir (1983)

Quantum Electronics, A Yavir, John Wiley (1992)

Laser: Theory & applications, A. Ghatak & Tayagrajan, Macmillan India

Introduction to Laser Physics, K. Shimoda, Springer (1986)
Lasers & non-linear Optics, B.B.Laud

Paper VIII (PHL-517(ii))
Fiber Optics and Optical Communication
(Special Paper IV : Optics & Spectroscopy, Group-II)

CREDITS :4
Time: 3 hours

The Semiconductor Laser Diode and light Emitting Diode: General description, Laser structure, Excitation Mechanism (Modes and threshold conditions, resonant frequencies, single mode lasers, modulation of diodes, temperature effects), Light source linearity.

Principle of fiber optics: Ray optics and wave propagation, Fiber types: step index and graded index fiber structures, Concepts of Mode field diameter, Numerical Aperture and propagation modes. Attenuation in fibers: units, absorption, scattering losses, bending losses, core and cladding losses.

Mode theory for circular wave guides: Wave guide equations, Wave equations for Single mode fibers, Modal equation, Modes in Single mode fibers, Linearly polarized modes, Power flow in Single mode fibers. Signal distortion in optical wave-guides: Group delay, material & wave guide dispersion, mode coupling. Design optimization & Fiber Characterization: Fiber optic materials and characteristics comparison of coaxial cable and optical fibers. Optical time domain reflectometry (OTDR) as a loss measurement method. Source to fiber power launching: Source outputs pattern, Power coupling calculation, Equilibrium NA, Lensing scheme for coupling improvement: Non-imaging microsphere, LD to fiber coupling. Idea of connectors, couplers and splicing.

Principles of photodetection, Semiconductor photodetectors, Optical receivers. Noise, S/N ratio for optical power and signal currents, Background radiation, Johnson noise, Dark current shot noise, 1/f noise, Combined effect of all the noise sources. Digital signals and bit Error Rates.

Fundamentals of modulation schemes, Modulation spectral, Analog, Pulse, and Digital modulation schemes.

Direct detection method & heterodyne detection receivers, Homodyne detection optical receiver, Modulation parameter converters.

Elementary idea of Electro-optic modulation, Acousto-optic modulation. Modulation of semiconductor devices. Design issues in an fiber optics communication Link: Power budget, Time budget, Optical repeaters and amplifiers, The optical-fiber laser. Idea of soliton propagation in optical fibers.

Spatial filter: Concepts and its applications, Holograms: Construction, reconstruction, classifications and applications of holography. Laser Raman Spectroscopy: Basic consideration, linear, Non-linear and stimulated Raman Spectroscopy. Elementary idea of CARS and Self focusing phenomena.

Text and Reference Books:

Optical communication, M. Mukunda Rao, Universities Press (2000)
Optical Communication, Components & Systems, J.H. Frang & V.k. jain, Narosa (2001)
Essentials of Optoelectronics, Alan Rogers, (Chapman & Hall), 1997
Optical Communication System, W.K.Pratt. (1968)
Optical Fiber Communication by G.Keiser, 2nd ed. Mc GRaw Hill
Fundamental of Opto-electronics by C.R.Pollock, Irwin (1995)
Laser Electronics, J.T.Verdeyen, Prentice Hall (1995)
Lasers and Electro-Optics: Fundamental & Engineering C.C.Davis, Cambridge (1996)
Lasers fundamentals by W.T. Silfvast, Cambridge(1996)
Principles of lasers, O.Svetto, Plenum (1989)
Laser Physics, L.V.Tarasoy, Mir (1983)
Quantum Electronics, A.Yavir, John Wiley (1992)
Fundamentals of Photonics, Saleh & TEich, John Wiley (1992)
Laser: Theory & Applications, A. Ghatak & TAyagrajan Macmillan India
Introduction to Laser Physics, K.Shimoda, Springer (1986)
Lasers & non-linear Optics, B.B.Laud

PHL-516(iii)
CONDENSED MATTER PHYSICS
(Special Paper: Condensed Matter Physics, Group-I)

CREDITS :4
Time: 3 hours

External symmetry elements of crystals. Concept of point groups. Influence of symmetry on physical properties: Electrical conductivity. Space groups, derivation of equivalent point positions (with examples from triclinic and monoclinic systems), experimental determination of space group.

Principle of powder diffraction method, interpretation of powder photographs, analytical indexing: Ito's method. Accurate determination of lattice parameters – least-square method. Applications of powder method. Oscillation and Buerger's precession methods. Determination of relative structure amplitudes from measured intensities (Lorentz and polarization factors), Fourier representation of electron density. The phase problem, Patterson function.

Structure and symmetries of liquids, liquid crystals and amorphous solids. Aperiodic solids and quasicrystals; Fibonacci sequence, Penrose lattices and their extension to 3-dimensions. Special carbon solids; fullerenes and tubules; formation and characterization of fullerenes and tubules. Single wall and multi-wall carbon tubules. Electronic properties of tubules.

Carbon nanotubule based electronic devices. Definition and properties of nanostructured materials. Methods of synthesis of nanostructured materials. Special experimental techniques for characterization of nanostructured materials. Quantum size effect and its application.

Text and Reference Books:

Azaroff: X-ray Crystallography

Weertman & Weertman: Elementary Dislocation Theory

Verma & Srivastava: Crystallography for Solid State Physics

Kittel: Solid State Physics

Azaroff & Buerger: The Powder Method

Buerger: Crystal Structure Analysis

M.Ali Omar: Elementary Solid State Physics

The physics of Quasicrystals, Eds. Steinhardt and Ostlund

Handbook of Nanostructured Materials and Nanotechnology (Vol. 1 to 4) Ed. Hari Singh Nalwa

PHL-516(ii)
EXPERIMENTAL TECHNIQUES
(Special Paper: Condensed Matter Physics, Group-I)

CREDITS :4
Time: 3 hours

Optical Methods of Structure determination, optical microscopy, scanning electron microscopy (SEM), internal reflection spectroscopy, X-ray fluorescence.

Detailed study of spectroscopic techniques: NMR, ESR, Photoacoustic Spectroscopy. Electron Microprobe analysis.

Surface Analytical Techniques: Electron spectroscopies – Auger, XPS (ESCA), UV-photoemission and inverse photoemission, Electronic Structure determination using Synchrotron radiation sources. X-ray absorption techniques EXAFS, NEXAFS. Thermal Desorption Spectrometry, SIMS (secondary ion mass spectroscopy), RBS (Rutherford Backscattering Spectroscopy). Low energy electron diffraction.

Scanning Probe Techniques: (STM) Scanning Tunneling Microscopy, (AFM) Atomic Force Microscopy STS (Scanning Tunneling Spectroscopy.)

Text and Reference Books:

R. Ueda and J.B.Mullin	Crystal Growth and Characterisation
Woodruff and Delchar	Experimental Techniques of Surface Science
Ibach and Luth	Solid State Physics
Ibach	Solid Surfaces
Prutton	Solid Surfaces
Zangwill	Physics at Surfaces.

MPH-516(iv)
ELECTRONIC DEVICES & SMART MATERIALS
(Special Paper: Condensed Matter Physics, Group-I)

CREDITS :4
Time:3 hours

Solar Energy:

Fundamental of photovoltaic Energy Conversion Physics and Materials Properties Basic to Photovoltaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers. Types of Solar Cells, p n junction solar cell, Transport Equation, Current Density, open circuit voltage and short circuit current, Brief descriptions of single crystal silicon and amorphous silicon solar cells, elementary ideas of advanced solar cells e.g. Tandem Solar Cells. Solid Liquid Junction Solar Cells, Nature of Semiconductor, Electrolyte junction, Principles of Photoelectrochemical Solar cells.

Microwave Devices:

Tunnel diode – Principle of Operation, Microwave characteristics, Transfer Electronic devices, Gunn Effect Diodes, Avalanche Transist Time Devises: impact Diode-Physical structure, Principle of operation, Power out & efficiency. Parametric devices-Physical structure, Non-Linear reactance, parametric amplifier & applications.

Superionic Conductors:

Introduction, Types of ionic solids, Superionic materials. Classification of superionic materials: Alkali metal ion conductors, silver ion conductors. Copper ion conductors proton conductors, B – alumina, composite electrolytes, ion conducting glasses and polymers. Basic concepts: jump mechanisms, ionic conductivity and diffusion coefficient. Defect concentration in pure crystals and doped crystals, impurity – vacancy association. Application of superionic conductors on solid state batteries, fuel cells, electrochromic display devices, gas sensors.

Engineering Magnetic Materials:

Magnetising processes. Hysteresis loops and energy product. Magnetic anisotropies. Soft magnetic materials: Iron and steel, permalloys, metallic glasses, ferrites. Hard magnetic materials: Alnico, hard ferrites, rare earth compounds, bonded magnets. Materials for antenna, inductor and transformer cores. Materials for permanent magnets. Magnetic recording fundamentals. Particulate and thin film recording media. Recording heads: ferrite heads, metal – in – gap heads, thin film heads and magnetoresistive heads. Fundamentals of magneto – opto recording. Magneto – optic recording media and heads. Introduction to magnetic bubbles.

Text and Reference Books:

Nanophase materials: Synthesis, Properties and applications – R.V. Siegel and G.C. Hadjipanayis, Kluwer Publishers, 1994

High Temp. Superconductors – E.S.R. Gopal & S.V. Subramanyam (Wiley Eastern Ltd., 1989)

Studies of High T_c superconductors Vol. 1 -6 –A.V. Narlikar, Nova Science Publishers USA, 1990

Physics of High T_c superconductors – J.C. Philips, Academic Press, 1989

Superionic Solids, Principles and Application – S. Chandra, North Holland, 1981

Encyclopaedia of Applied Physics G.L. Trig Vol. 9, G.L. Trigg, V.CH Publishers, 1994

Materials science and Technology – A comprehensive Treatment – Vol. 3a and 3B, R.W. Cahn, P. Hassen and E.J.Kraurer, VCH Publishers, Germany, 1992

Electron Microscopy in the study of Materials, P.J. Grundy and G.A.Jones, Edward Arnold Publishers, 1976

Thin Film Fundamentals, A. Gosswami, New Age International, 1996

PHL-517(iii)
NON LINEAR OPTICS
(Special Paper: Optics & Spectroscopy, Group-II)

CREDITS :4
Time:3 hours

Introduction to nonlinear optics. Maxwell's eqs. in nonlinear medium, an harmonic oscillator, nonlinear polarization & susceptibilities. Steady-state & transient nonlinear optical effects, slowly varying envelope approximation.

Three wave mixing phenomena, sum & difference frequency generation, phase matching conditions, parametric amplification and oscillation single resonant parametric oscillator, Second Harmonic Generation, second harmonic generation conversion efficiency.

Four wave mixing phenomena degenerate four wave mixing, Cascaded nonlinearities in & second-order media stimulated Raman & Brillouin scattering shortpulse generation. Two photon absorption Optical phase conjugation (OPC), of photorefractive effect and their applications, Optical logic group velocity dispersion.

Self focusing phenomena and its applications, optical soliton, Interaction between ideal two level atom and coherent field (semiclassical approach), induced dipole moment, brief idea about transient coherent effects. Selection criteria of nonlinear optical materials optical breakdown.

Text and Reference Books:

The Principle of Nonlinear Optics, Y.R.Shen, John Wiley, 1984.

Quantum Electronics, A. Yariv, J. Wiley, 1989.

Nonlinear Optics: Basic Concepts, D.L. Mills, Narosa, 1991.

Laser & Electro Optics: Fundamentals & Engineering, C.C.Davis, 1996.

Fundamentals of Photonics, Saleh & Teich, J. Wiley, 1992.

PHL-517(iv)
APPLIED OPTICS
(Special Paper: Optics & Spectroscopy, Group-II)

CREDITS :4
Time: 3 hours

Diffraction: Integral theorem of Helmholtz & Kirchhoff diffraction formula (Sommerfeld radiation condition, Kirchhoff's boundary conditions, obliquity factor). Fresnel-Kirchhoff approximate formula, Approximations for Fraunhofer and Fresnel diffractions, Fraunhofer diffraction by circular apertures, Fresnel diffraction by a square aperture. A thin lens as a phase transformation.

Fourier Transforming properties of lenses (object placed against the lens, object placed in front of the lens, object placed behind the lens). Spatial frequency filtering and its applications. Frequency response of a coherent imaging system (impulse response function, coherent transfer function), frequency response of incoherent imaging system (optical transfer function & its relation to CTF, modulation transfer functions).

Crystal structure of important anisotropic materials; index ellipsoid, Pockel & Kerr effects, Pockel effect in KDP crystal (longitudinal & transverse configurations), general consideration of modulated design. Magneto-optic effect in diamagnetic media.

The strain optic tensor, Raman-Nath & Bragg regimes of diffraction. Theory of Raman-Nath diffraction, diffraction. Introduction to Holography, the wavefront-reconstruction problem (recording of amplitude & phase), classification of holograms, hologram as a diffraction grating & zone plate, Fresnel Hologram & Fourier transform holograms. Application of holography.

Text and Reference Books:

Introduction to Fourier Optics, J.W. Goodman, McGraw Hill.
Engineering Optics, K. Jizuka, Springer, 1987
Contemporary Optics, Ghatak & Thyagrajan, Macmillan, 1981
Modern Optics, R. Gaenther, J. Wiley, 1990
Optical Electronics, Ghatak & Thyagrajan, Cambridge, 1991
Quantum Electronics, A. Yariv, John Wiley, 1989
Laser & Electro Optics: Fundamentals & Engineering C.C. Davis 1986.
Optical Electronics, A. Yariv, J. Wiley.

PHL-518(i)
COMPUTER TECHNIQUES AND COMPUTER SIMULATION
(Special Paper: Theoretical Physics, Group-III)

CREDITS :4
Time: 3 hours

Differentiation & Integration

Differential equation (PDE&ODE) Composite Integration methods, Romberg Integration double Integration, Multi-step Methods for solving Initial Value ODE, Stability Analysis of multi-step methods, Ferrite element method for solving boundary value ODE, Multidimensional integration by MC method Runge-Kutta method for order first degree ODE, Methods for solving Elliptic, Hyperbolic & Parabolic PDE & its application to Physical problems.

Computations of Function

Bessel function, Legendre function, Laguerre Function, Hermite Function, Hypergeometric function, Gamma function Beta Function. Application to Physical & chemical Problems.

Simulation & Algorithm

Molecular Dynamics with application to elementary problems, chaotic motion of dynamical systems, Many particle system, MC simulation to generate Paramagnetic to Ferromagnetic phase diagram, Kawasaki & Glauber Kinetics, Introduction to Density functional theory based simulation.

Programming Language C/c⁺⁺

Tutorial Introduction on C, I/o variables & expressions, Arrays, Functions, Operators, Control statements, Functions & Program structure Pointers, Library Function, Syntax, File management in C, the preprocessor.

UNIX Operating systems

Introduction, login, password electronic mail & on-line help, using of editors, File & directories, Manipulation of files directories, Concepts of shell, Information processing (Grep, find & shell Scripts) File management Commands & others (WC, sort lp, chmod), programming using unix command.

Text and Reference Books:

Sastry Introduction Methods of Numerical Analysis

Rajaraman
Rajaraman
Vetterling
Binder & Herman

Numerical Analysis
Fortran Programming
Numerical Recipes
Monte Carlo Simulation

Teukolsky Press and Framney

PHL-518(ii)
ADVANCED QUANTUM MECHANICS
(Special Paper: Theoretical Physics, Group-III)

CREDITS :4
Time: 3 hours

Relativistic Quantum mechanics

Dirac equation, Free particle solution of Dirac equation, Covariant form of Dirac equation, γ (gamma) matrices and their anticommutation relations, Dirac equation in the presence of an electromagnetic field, central field, spin angular momentum, spin orbit interaction energy, energy levels of the hydrogen atom, negative energy states and explanation in terms of Dirac's hole theory.

Elements of field quantization

Coordinates of the field, classical lagrangian equation, classical Hamiltonian equation, Quantization of the field, Quantization of the nonrelativistic Schrodinger field using commutation relations, lagrangian and Hamiltonian density, The creation, destruction and number operators, Quantization of the non relativistic Schrodinger field using anti commutation relations.

Quantization of the relativistic wave equations. Quantization of Klein Gordon equation and the complex Klein Gordon equation, Dirac Eq, Lagrangian and Hamiltonian equation, quantum equations, The N representation, negative energy states and positrons, Anticommutation relation at different times

Quantum Electrodynamics

Maxwell's equations, Lorentz condition and Gauge transformations, quantization of maxwell's equations, transversality condition

Text and Reference Books:

Quantum mechanics, by L.I. Schiff, Mc Graw Hill
Quantum field theory, F. Mandl and G. Shaw

PHL-518(iii)
THEORETICAL NUCLEAR PHYSICS
(Special Paper: Theoretical Physics, Group-III)

CREDITS :4
Time : 3 hours

Single Particle Models:

Spherical single particle orbits, Harmonic oscillator single particle Hamilton and wavefunctions, The spin orbit coupling, Pairing and extreme single particle model, Predictions of ion magnetic and quadrupole moments, Configuration mixing, the deformed shell model of Nilsson.

Collective Models:

The signature of collectivity of states, The quadrupole moments, The electromagnetic transitions, The electric dipole transitions, Electric quadrupole transitions, Harmonic vibrations of the nuclear surface, Quantum mechanics of the rotor, The space fixed and the body fixed coordinate systems, The rotation-vibration model.

The Interacting Boson Model:

The description of nuclear collective motion in terms of bosons, Operators and definitions, The Lie algebra $U(6)$, The most general IBM Hamiltonian, The $U(5)$ limit and vibrational spectra.

Formulation of special relativity in Minkowski space, four vector covariant forms, s , t and u variables (Mandelstam variables) and their importance in scattering problems.

$SU(3)$, Classification of hadrons and quark model, Gell-Mann Okubo mass formula and its application to mass spectra of particles, Concept of colour quantum number, Basic features of quantum chromodynamics and comparison with quantum electrodynamics (only qualitatively)

Text and Reference Books:

Theory of Nuclear Structure by M.K.Pal (Affiliated East-West)

Nuclear models by J.M.Eisenberg and Walter Greiner (North Holland)

Simple models of Complex nuclei by Igal Talmi (Harvard Academic Publishers)

N.P.by R.R.Roy and B.P. Nigam (Wiley Eastern)
Elementary Particles by I.S. Hughes (Cambridge University Press)
Elementary Particle Physics by S.Gasiorwics (John Wiley Sons)

PHL-518(iv)
ENVIRONMENTAL PHYSICS
(Special Paper: Theoretical Physics, Group-III)

CREDITS :4
Time: 3 hours

Essentials of Environmental Physics

Structure and thermodynamics of the atmosphere. Composition of air. Greenhouse effect and enhanced Greenhouse effect. Transport of matter, energy and momentum in nature. Stratification and stability of atmosphere. Law of motion, hydrostatic equilibrium. General circulation of the tropics. Elements of weather and climate of India.

Solar and Terrestrial radiation

Physics of radiation. Interaction of light with matter. Rayleigh and Mie scattering. Laws of radiation (Kirchoffs law, Planck's law, Wien's displacement law, etc.). Solar and terrestrial spectra. UV radiation problem. IR absorption energy balance of the earth atmosphere system.

Environmental Pollution and Degradation

Elementary fluid dynamics. Diffusion. Turbulence and turbulent diffusion. Factors governing air, water and noise pollution. Air and water quality standards. Waste disposal. Heat island effect. Land and sea breeze. Puffs and plume. Gaseous and particulate matters. Wet and dry deposition. Stability and vertical motion of air. Horizontal motion of air and water. Pressure gradient forces. Viscous forces. Inertia forces. Reynolds number.

Environmental change, and Remote Sensing and Global and Regional Climate

Energy sources and combustion processes. Renewable sources of energy. Solar energy, wind energy, bio-energy, hydropower, fuel cells, nuclear energy. Forestry and bio-energy. Energy balance-a zero-dimensional Greenhouse model. Global climate models.

Text and Reference Books

Egbert Boeker & Rienk Van Grondelle: Environmental Physics (John Wiley).

J.T.Houghton: The Physics of Atmosphere (Cambridge University Press, 1977).

J.T. widell and J. Weir: Renewable Energy Resources (Elbs, 1988).

Sol Wieder: An Introduction of Solar Energy for scientists and Engineers (John Wiley 1982).

R.N. Keshavamurthy and M. Shankar Rao: The Physics of Monsoons (Allied Publishers 1992).
K.L.Kumar: Engineering Fluid Mechanics (S.Chand, 1994).
Landau & Lifshitz: Fluid Mechanics, Pergamon Press (2000).