DEPARTMENT OF PHYSICS
JAMIA MILLIA ISLAMIA, NEW DELHI

Jamia Millia Islamia, a Central University, was founded at Aligarh in 1920 during the Khilafat and Non-Cooperation Movements in response to Gandhiji's call to boycott government supported educational institutions. The Jamia moved from Aligarh to Delhi in 1925. Since then, it has been continuously growing, always improving its methods, and branching out from time to time to meet new needs. Jamia Millia Islamia was made a Central University in 1988.

The Department of Physics was created in 1971. The strength of the faculty in the Department, at present, is 20.

The Department offers a 2 year (4 semesters) postgraduate course M.Sc. (Physics) with the following three specializations : (i) Materials Science; (ii) Lasers and Spectroscopy; and (iii) Theoretical Physics. For the M.Sc. Course in Physics, 35 students are admitted every year.

The Department also has a full-fledged Ph.D. Program as part of the ongoing research.

DEPARTMENT OF PHYSICS
JAMIA MILLIA ISLAMIA, NEW DELHI
M.Sc. Physics

Paper Code	Topic	M.Marks	Periods per week	Credits
	Semester I			
PHM101	Classical Mechanics	100	L 3 T 1 P 0	4
PHM102	Quantum Mechanics I	100	L 3 T 1 P 0	4
PHM103	Mathematical Physics	100	L 3 T 1 P 0	4
PHM104	Electronics	100	L 3 T 1 P 0	4
PHM105	Lab. I	150	L 0 T 0 P 12	6
	Semester II			
PHM201	Condensed Matter Physics I	100	L 3 T 1 P 0	4
PHM202	Quantum Mechanics II	100	L 3 T 1 P 0	4
PHM203	Electrodynamics	100	L 3 T 1 P 0	4
PHM204	Numerical Methods & Computer Lab.	100	L 2 T 0 P 4	4
PHM205	Lab. II	150	L 0 T 0 P 12	6
	Semester III			
PHM301	Atomic and Molecular Physics	100	L 3 T 1 P 0	4
PHM302	Nuclear and Particle Physics	100	L 3 T 1 P 0	4
PHM303	Condensed Matter Physics II	100	L 3 T 1 P 0	4
PHM304	Spl. paper I	100	L 3 T 1 P 0	4
PHM305	Lab. III	100	L 0 T 0 P 8	4
	Semester IV			
PHM401	Statistical Mechanics	100	L 3 T 1 P 0	4
PHM402	Spl. paper II	100	L 3 T 1 P 0	4
PHM403	Spl. paper III	100	L 3 T 1 P 0	4
PHM404	Spl. paper IV	100	L 3 T 1 P 0	4
PHM405	Project	200	L 0 T 8 P 0	8

SPECIALIZATIONS		
Materials Science	**Laser & Spectroscopy**	**Theoretical Physics**
PHM304M Physics of Novel Materials	PHM304L Laser Physics	PHM304T Advanced Mathematical Physics
PHM402M Growth & imperfections of Materials	PHM402L Photonics	PHM402T General Relativity
PHM403M Characterization of Materials	PHM403L Quantum Optics	PHM403T Particle Physics
PHM404M Physics & Technology of Semiconductor Devices	PHM404L Laser Spectroscopy	PHM404T Quantum Field Theory

CLASSICAL MECHANICS

Code PHM101 **Max. Marks 100**

UNIT 1 : Newtonian mechanics and its limitations. Constrained motion. Constraints and their classification. Principle of virtual work. D' Alembert's principle. Generalised coordinates. Deduction of Lagrange's equations from D' Alembert's Principle. Generalised momenta and energy. Cyclic or ignorable coordinates. Rayleigh' s dissipation function. Integrals of motion. Symmetries of space and time with conservation laws. (8 lectures)

UNIT 2 : Central force. Definition and properties of central force. Two-body central force problem. Stability of orbits. Conditions for closure. General analysis of orbits. Kepler's laws. Kepler's equation. Artificial satellites. Rutherford scattering. (10 lectures)

UNIT 3 : Principle of least action. Hamilton's principle. The calculas of variations. Derivation of Hamilton's equations of motion for holonomic systems from Hamilton's principle. Hamilton's principle and characteristic functions. (8 lectures)

UNIT 4 : Canonical Transformations. Generating functions. Poisson bracket. Poisson's Theorem. Invariance of PB under canonical transformations. Angular momentum PBs. Hamilton-Jacobi equation. Connection with canonical transformation. Problems. (12 lectures)

UNIT 5 : Small Oscillations. Normal modes and coordinates. Problems. (6 lectures)

REFERENCES

1. Classical Mechanics by N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991)
2. Classical Mechanics by H. Goldstein (Addison Wesley, 2000)

QUANTUM MECHANICS I

Code PHM102 **Max. Marks 100**

UNIT 1 : Mathematical tools Brief introduction to origins of quantum Physics. Wave packets. Dirac notation. Operators, their eigenvalues and eigenfunctions, orthonormality, completeness and closure. Generalized Uncertainty Principle. Unitary transformations, change of basis. Matrix Representation of operators. Continuous basis, position and momentum representation and their connection. Parity operator. (15 lectures)

UNIT 2 : Fundamental Concepts of Quantum Mechanics Basic postulates of quantum mechanics. Measurement. Time evolution of system's state. Discrete and continuous spetra in 1-D. Solution of 1-D harmonic oscillator using matrix mechanics. (12 lectures)

UNIT 3 : Angular Momentum Orbital, Spin and total angular momentum operators. Pauli spin matrices, their Commutation relations. Eigenvalues and eigenfunctions of L2 and Lz. (10 lectures)

UNIT 4 : Identical Particles Many particle systems, systems of identical particles, exchange degeneracy, symmetrization postulate, construction of symmetric and anti-symmetric wave functions from unsymmetrized functions. The pauli exclusion principle. (8 lectures)

REFERENCES

1. Franz Schwabl : Quantum Mechanics
2. J. J. Sakurai : Modern Quantum Mechanics
3. N. Zettili : Quantum Mechanics
4. P. A. M. Dirac : Priciples of Quantum Mechanics
5. Bohm : Quantum Mechanics

MATHEMATICAL PHYSICS

Code PHM103 **Max. Marks 100**

UNIT 1 : Review of Basic Methods Real and complex numbers; Euclidean space; Differentiability; Series and convergence. Function of a complex variable; Analytic functions; Cauchy's theorem; calculus of residues and applications. Advanced vector calculus; multiple integrals. (10 lectures)

UNIT 2 : Linear Differential Equations & Special Functions Series solutions of ordinary differential equations; ordinary, regular and irregular singular points; Gamma function; Special functions (Legendre, Bessel, Laguerre, Hermite); Hypergeometric and confluent hypergeometric functions. (12 lectures)

UNIT 3 : Partial Differential Equations and Green Function Method Classification of PDE's and boundary conditions; method of separation of variables; Green function method for Laplace, Poisson, wave, Klein-Gordon and heat equations; solutions of boundary value problems using Fourier series and Bessel functions. (10 lectures)

UNIT 4 : Elements of Group Theory Definitions and examples of a group; subgroup, cosets, conjugate classes, invariant subgroups and factor group; isomorphism and homomorphism; Permutation groups; Representations of a group, Reducible and irreducible representations, orthogonality relations; Topological groups and Lie groups, SO(2), SO(3), Lorentz group, Generators of U(n) and SU(n), SU(2), SU(3). (8 lectures)

UNIT 5 : Integral Equations Homogeneous and Inhomogeneous equations, Method of successive approximations, Hilbert-Schmidt method. (5 lectures)

REFERENCES

1.Mathews and Walker, Mathematical Methods of Physics, Addison Wesley Publishing.
2.G B Arfken, Mathematical Methods for Physicists, Academic Press.
3.S Hassani, Mathematical Physics, Springer-Verlag, New York.
4.P Dennery & A Krzywicki, Mathematics for Physicists, Dover Publications, New York.
5.M Hammermash, Group Theory and its Applications to Physical Problems.
6.R Courant and D Hilbert, Methods of Mathematical Physics, Vol I & II.
7.Morse and Feshback, Mathematical Physics, Vol I & II.

ELECTRONICS

Code PHM104 **Max. Marks 100**

UNIT 1 : Semiconductor Devices I Semiconducting Materials, conduction in semiconductors, Charge densities in a semiconductors, PN junction, space charge and electric field distribution at junctions, forward and reverse biased conditions, Space charge capacitance, varactor diode, Zener and avalanche breakdowns, zener diodes, Schottky barrier, tunnel diode, photodiode, LED, p-n-p-n devices and their characteristics, SCR. (16 Lectures)

UNIT 2 : Semiconductor Devices II Transistors: Bipolar junction Transistor (BJT), Ebers Moll Model, Analysis of CE amplifier using h-parameters, The T-network equivalent circuit, constants of CB and CE amplifier using emitter, base, collector resistance, Biasing technique to BJT, stabilization factor, temperature stabilization, operating point, fixed bias, emitter feedback bias, voltage feedback bias. Field-Effect Transistors (FET) and MOSFET: Structure, Working, Derivations of the equations for I-V characteristics under different conditions. (16 Lectures)

UNIT 3 : Feedback Principle Negative feedback, effect of negative feedback on input/output resistances and voltage gain, gain stabilization, effect of negative feedback on band width, voltage series feedback, voltage shunt feedback applied to BJT. (6 Lectures)

UNIT 4 : Microwave Electronics Microwaves, Principle of velocity modulation and bunching of electrons, Basic principles of two cavity klystrons and Reflex Klystrons, operation of magnetrons, characteristics of microwave diode. (7 Lectures)

REFERENCES

1. John D. Ryder, Electronic Fundamentals and Applications.
2. Millman and Halkins; Electronic Devices and Circuits
3. Ben G. Streetman : Solid State Electronic Devices
4. Ramabhadran S. Electronics
5. Boylested and Nashelsky; Electronics Devices and Circuit theory
6. Millman J. and Taub, H; Pulse, Digital and Switching Waveforms
7. S.W. Amos; Fundamental of Transistor
8. W.J. Reich; Microwave Principle.
9. K.L. Gupta; Microwaves
10. G.J.Wheeler; Introduction to Microwave.
11. S.M. Sze; Semiconductor Devices- Physics and Tecnology.

PHYSICS LAB I

Code PHM105 **Max. Marks 150**

LIST OF EXPERIMENTS

1. Design & Study of Common Emitter Amplifier
2. Study of Operational Amplifier IC-741 : summer, inverting/non-inverting amplifier, differentiator, integrator
3. Active filters using op-amp
4. Study of IC - 555 as astable, monostable and bistable multivibrator
5. UJT - characteristics and it's applications as relaxation oscillator
6. SCR - characteristics and it's applications as switching device
7. Study of Optoelectronic Devices
8. Study of Phase Shift Oscillator
9. Study of Negative & Positive Feedback Amplifier
10. FET - I/V characteristics, biasing and it's application as an amplifier
11. MOSFET - I/V characteristics, biasing and it's application as an amplifier
12. Study of Pulse Amplitude Modulation (PAM) & Demodulation
13. A/D and D/A converter
14. Design & study of regulated and stabilized power supply.
15. Design & study of triangular wave generator.

CONDENSED MATTER PHYSICS I

Code PHM201 **Max. Marks 100**

UNIT 1 : Bonding in crystals: covalent, ionic, metallic, hydrogen bond, van der Waal's bond and the Madelung constant. Crystalline solids, unit cell, primitive cell, Bravais lattices, Miller indices, closed packed structures. Atomic radius, lattice constant and density. Connection between orbital symmetry and crystal structure. Scattering from periodic structures, reciprocal lattice, Brillouin Zones.

UNIT 2 : Free electrons in solids, density of states, Fermi surface, Fermi gas at T=0 K, Fermi statistics, specific heat capacity of electrons in metals, thermionic emission of electrons from metals.

UNIT 3 : Electronic band structure in solids, Electrons in periodic potentials, Bloch's Theorem, Kronig-Penney model, Nearly free electron model, Tight-binding model : density of states, examples of band structures. Fermi surfaces of metals and semiconductors. (12 lectures)

UNIT 4 : Transport properties: Motion of electrons in bands and the effective mass, currents in bands and holes, scattering of electrons in bands, Boltzman equation and relaxation time, electrical conductivity of metals, thermoelectric effects, the Wiedemann-Franz Law. (11 lectures)

UNIT 5 : Lattice dynamics of atoms in crystals, vibrations of monoatomic and diatomic linear chains, acoustic and optical phonon modes, density of states, thermal properties of crystal lattices, thermal energy of the harmonic oscillator, specific heat capacity of the lattice, Debye theory of specific heats. (11 lectures)

REFERENCES

1. Hook and Hall : Solid State Physics
2. Kittel : Introduction to Solid State Physics
3. Ibach and Luth : Solid State Physics
4. H. M. Rosenberg : Introduction to the Theory of Solids
5. Blakemore : Solid State Physics
6. Ashcroft and Mermin : Solid State Physics

QUANTUM MECHANICS II

Code PHM202 **Max. Marks 100**

UNIT 1 : Approximation methods for stationary systems Time independent perturbation theory. Perturbation of non-degenerate states: first and second order perturbation. Perturbation of a harmonic osscilator. Perturbation of degenerate states, removal of degeneracy. Zeeman and Stark effects. Variational and WKB methods. (9 lectures)

UNIT 2 : Approximation methods for non-stationary systems Scroedinger, Heisenberg and interaction pictures, Equations of Motion. Constatnt and harmonic perturbation. Discrete and continuous case, transition probability. Fermi golden rule. Adiabatic and sudden approximations. (8 lectures)

UNIT 3 : Scattering Theory Scattering of a wave packet. The differential and total Cross section. The Born approximation. Partial waves and phase shifts. The Lippman Schwinger equation. Definition and properties of S-matrix, T matrix. Optical theorem. (10 lectures)

UNIT 4 : Relativistic Quantum Mechanics Klein-Gordon and Dirac equations, properties of Dirac matrices. Lorentz and CPT invariance of Dirac equation. Non-relativistic reduction of the Dirac equation. Central forces and the hydrogen atom. (8 lectures)

UNIT 5 : Solutions to Dirac equation Free particle solution, hydrogen atom in dirac's theory, Dirac electron in constant magnetic field, Foldy-Wouthuysen transformation, Hole theory. (8 lectures)

REFERENCES

1. Franz Schwabl : Quantum Mechanics
2. Eugen Merzbacher : Quantum Mechanics
3. N. Zettili : Quantum Mechanics
4. P. M. Mathews and K. Venkatesan: Quantum Mechanics
5. P. A. M. Dirac : Priciples of Quantum Mechanics

ELECTRODYNAMICS

Code PHM203 **Max. Marks 100**

UNIT 1 : Maxwells equations. Continuity Equation. Lorentz force. Poynting theorem. Conservation of energy and momentum. Scalar and vector potentials. Gauge transformations. Coulomb and Lorentz gauge.

UNIT 2 : Generalized functions. Grenn's functions for Poisson, Helmholtz and Wave equations. Retarded and Advenced solutions for Maxwell's equations. Jefimencko formulas for fields for charge and current distriubutions. Lienard-Wiechert Potentials. Electromagnetic field of a moving point charge. Feynman formulas.

UNIT 3 : Review of Special Theory of Relativity. Lorentz transformations. Energy and momentum. Covariant formulation of electrodynamics. Transformation of electromagnetic fields. Lorentz group. Infinitesimal generators. Lie algebra of Lorentz group. Action Principle. Stess-energy tensor.

UNIT 4 : Equations of motion of a point charge in electromagnetic fields. Radiations emitted by an accelerated charge. Energy radiation formula and radiative reaction.

REFERENCES

1. Classical Electrodynamics : J.D.Jackson, III Ed. 1999.
2. Classical Theorey of Fields : Landau & Lifshitz
3. Introduction to Electrodynamics: D. J. Griffiths
4. Feynman Lectures on Physics : Vol II
5. Foundations of Electromagnetic Theorey : Reitz, Milford and Christy
6. Classical Charged Particle : Rohrlich

NUMERICAL METHODS & COMPUTER LAB

Code PHM204 **Max. Marks 100**

UNIT 1 : Introduction to operating systems, computer programming (FORTRAN and/or C, C++) and graphics (gnuplot, xmgrace etc.).

UNIT 2 : Summation of finite and infinite series, root finding techniques (bisection, secant, Newton-Raphson methods), Sorting, interpolation, extrapolation, regression, modelling of data (least square fit etc.).

UNIT 3 : Matrices (addition, multiplication, eigenvalues, eigenvectors, inversion, diagonalization, solution of simultaneous equations).

UNIT 4 : Numerical integration (trapezoidal, Simpson, Gauss quadrature etc.).

UNIT 5 : Solution of differential equations (Euler and RK methods).

UNIT 6 : Simulation techniques (Monte Carlo, Molecular Dynamics, Ising model, percolation, cellular automata, Diffusion limited aggregation), fractals and nonlinear dynamics.

REFERENCES

1. V. Rajaraman, Computer Programming in Fortran 77.
2. V. Rajaraman, Computer Programming in Fortran 90/95.

PHYSICS LAB II

Code PHM 205 **Max. Marks 150**

LIST OF EXPERIMENTS

1. G.M. Tube Characteristics & Absorption Coefficient
2. Nuclear exp.
3. Study of high energy interaction in nuclear emulsion
4. Study of Hall effect in semiconductors:
(a) Determination of Hall voltage and Hall coefficient, and
(b) Determination of the mobility of charge carriers and the carrier concentration.
5. Study of Magnetic Susceptibility of $MnCl_2$
6. Study of Fourier Analyser
7. To determine dissociation Energy of Iodine Molecule
8. To determine the Ionisation Potential of Argon with the help of Frank Hertz Tube
9. To study of Hysteresis loop curve of Magnetic Materials
10. To study Magnetoresistance of Semiconductor
11. To study conductivity of a Semiconductor using Four Probe method
12. Determination of the energy gap of a semiconductor by four probe method.
13. To determine the response of silicon solar cells and the effect of prolonged irradiation, and to calculate the efficiency and fill factors of a variety of solar cells.
14. To determine :
a. the velocity of ultrasonic waves in a liquid and,
b. the compressibility of the liquid.
15. Study of electron spin resonance (ESR) spectrum of a paramagnetic substance.

ATOMIC AND MOLECULAR PHYSICS

Code PHM301 **Max. Marks 100**

UNIT 1: Review of Solution of Schroedinger's equation for Coulomb field and Hydrogen atom, dipole approximation, spectroscopic terms and selection rules, intensities of spectral lines. (8 lectures)

UNIT 2: Fine structure of Hydrogen like atoms: spin-orbit interaction, relativistic correction, Lamb shift. Interaction with external fields: Zeeman, Paschen-Back and Stark effects. (12 lectures)

UNIT 3: The LS-coupling approximation, J-J coupling, hyperfine structures. The central field approximation: the central field, Thomas Fermi-potential, alkali atom spectra, Na doublet. (10 lectures)

UNIT 4: Born-Oppenheimer Approximation, Rotational, Vibrational, Rotational-Vibrational and Electronic spectra of Di-atomic molecules, Selection rules, Frank-Condon principle, Raman spectra, NMR, ESR. (10 lectures)

UNIT 5: Lasers : Spontaneous and stimulated emission, optical pumping, population inversion, rate equations, properties of laser beams: temporal and spatial coherence, simple description of Ammonia maser, $C0_2$ and He-Ne lasers. (5 lectures)

REFERENCES

1. B.H. Bransden & C.J. Joachain : Physics of Atoms and Molecules
2. G.K. Woodgate : Elementary Atomic Structure, Mc Graw-Hill
3. H.S. Mani & G.K. Mehta : Introduction to Modem Physics, East West Press
4. G. Herzberg : Molecular Spectra
5. C.N. Banwell : Fundamentals of Molecular Spectroscopy.
6. W. Demtroder : Laser Spectroscopy
7. O. Svelto : Principle of Lasers
8. K. Shimoda : Introduction to Laser Physics

NUCLEAR AND PARTICLE PHYSICS

Code PHM302 **Max. Marks 100**

UNIT 1 : Basic Nuclear Concepts Mass, Charge, and Constituents of the nucleus, Nuclear size and distribution of nucleons, Energies of nucleons in the nucleus, Angular momentum, Parity and symmetry, Magnetic dipole moment and electric quadrupole moment, Energy levels and mirror nuclei. (5 Lectures)

UNIT 2 : Nuclear Forces Characteristics of nuclear forces -Range and strength, Simple theory of two nucleon system -deuterons, Spin states of two nucleon system, Effect of Pauli's exclusion principle, Magnetic dipole moment and electric quadrupole moment of deuteron -The tensor forces. (7 Lectures)

UNIT 3 : Experimental Methods of Nuclear & Particle Physics Interaction of charged particles with matter. Stopping power and range. Detectors for energetic charged particles; Solid State or Semiconductor detector. (8 Lectures)

UNIT 4 : Particle Accelerators Need for accelerator of charged particles, Classification of types of accelerators, Proton Synchrotron, Betatron; Alternating gradient accelerator, Colliding beam accelerator. (5 Lectures)

UNIT 5 : Elementary particles Classification and properties of elementary particles -Leptons, Baryons, mesons particles and antiparticles excited states and resonances. Various types of interactions gravitational, electromagnetic, weak and strong interactions and their mediating quanta, Conservation rules in fundamental interactions. Charge symmetry and charge independence, Parity and charge conjugation, Conservation of parity and its violation in different types of interactions. Strange particles, associated production, strangeness and decay modes of charged Kaons, Isospin and its conservation. Idea of eight fold way and quarks. (20 Lectures)

REFERENCES

1. Segre : Nuclei and Particles
2. Cohen : Nuclear Physics
3. Enge : Nuclear Physics
4. Marmur and Sheldon : Physics of Nuclei and Particles

CONDENSED MATTER PHYSICS II

Code PHM303 **Max. Marks 100**

UNIT 1 : Review of free electron theory, nearly free electron approximation, Wannier functions, LCAO approximation, effective mass tensor, Dielectric constant of metals and insulators. (08 Lectures)

UNIT 2 : Optical properties of materials, optical constants-Kramers-kronig relations, polarons, excitons. Electronic interband and intraband transitions, relation between optical properties and band structure, reflectance, diffraction, dispersion, photoluminescence, electroluminescence. Hartree-Fock approximation, screening, plasmons. (10 lectures)

UNIT 3 : Magnetism: Diamagnetism (including Landau diamagnetism) and Paramagnetism including van Vleck and Langevin paramagnetism), Exchange interaction of free electrons, Band model of Ferromagnetism, superexchange, double exchange, Hubbard model, Antiferromagnetism, Neel temperature, spin-waves, 2D electron gas in a magnetic field :Quantum Hall Effect. Landau levels. Degeneracy. Fractional quantum Hall effect. (15 lectures)

UNIT 4 : Fundamental phenomena of superconductivity, Meissner effect, London euation, Type I and type II superconductors. Ginzburg-Landau Theory, Coopers pairing and BCS theory. BCS wavefunctions, Josephson Effect, SQUIDS. Weakly interacting Bose gas, Superfluidity. (12 lectures).

REFERENCES

1. O. Madelung: Introduction to Solid State Theory
2. Ibach and Luth : Solid State Physics
3. Ashcroft and Mermin : Solid State Physics
4. Kittel : Introduction to Solid State Physics
5. C. Kittel: Quantum Theory of Solid.

PHYSICS OF NOVEL MATERIALS

Code PHM304M **Max. Marks 100**

UNIT 1 : Quantum Well Structures: electron confinement in infinitely deep square well, confinement in one and two dimensional well, idea of a quantum well structure, quantum dots, quantum wires. (10 lectures)

UNIT 2 : Carbon nanotubes: carbon nanotubes and other carbon materials, bonding between carbon atoms, single and multiwalled nanotube growth and characterization, electronic structure, crsytal structure, junctions and defects of nanotubes. Electronic structure, transport, optical properties, thermal and mechanical properties of nanotubes. Electron spectroscopy and scanning probe microscopy of nanotubes. Applications of carbon nanotubes. (15 lectures)

UNIT 3 : Non-carbon nanostructures : semiconductor heterostructures, synthesis of nanomaterials using chemical techniques. (10 lectures)

UNIT 4 : MEMS (microelectromechanical systems) and NEMS (nanoelectromechanical systems), nanomachines and applications. (10 lectures)

REFERENCES

1. D. Bimberg, M.Grundman, N.N. Ledentsov: Quantum Dot Heterostructures
2. M.S. Dresselhaus, G. Dresselhaus, Ph.Avouris: Carbon Nanotubes: Synthesis,Structure, Properties and Applications
3. Mott and Davis: Electronics in Non-crystalline materials
4. Elliot: Physics of Amorphous materials
5. A. V. Narlikar : Superconductivity
6. O. Madelung : Introduction to Solid State Theory

LASER PHYSICS & SPECTROSCOPY

Code PHM304L **Max. Marks 100**

UNIT 1 : Stimulated Absorption, Stimulated Emission and spontaneous Emission : Absorption and Gain Coefficient. Radiative Lifetime and Spontaneous Transition Probabilities. Saturation: Saturation of Absorption. Gain Saturation. Widths and Profiles of Spectral Lines: Homogeneous and Inhomogeneous Broadening. Natural Linewidth. Doppler Width. Collision Broadening of Spectral Lines. (8 Lectures)

UNIT 2 : Basic principles of LASERS Laser Amplification. Laser Oscillation. Optical and Electrical Pumping. Optical Resonators. Optimization of Favourable Losses in Resonators. Resonance Frequencies of Optical Resonators. Laser Modes. Rate Equations for Three-Level and Four-Level Lasers. Steady State Output. CW and Transient Laser Behaviour. Single-Mode Operation. Q-Switching. Mode Locking. (15 Lectures)

UNIT 3 : LASER systems and their applications Types of Lasers. Solis State lasers, Gas Lasers, Dye Lasers, Semiconductor Lasers, Excimer Lasers. Applications of Lasers. (8 lectures)

UNIT 4 : Doppler limited Absorption and Fluorescence Spectroscopy with lasers- Sensitive methods of Absorption Spectroscopy: Intracavity Absorption, CRDS, Fluorescence Excitation Spectroscopy and LIF, Ionization Spectroscopy. Non- linear Spectroscopy. Saturation Spectroscopy, Polarization Spectroscopy, Multiphoton Spectroscopy. Doppler- Free Techniques in Spectroscopy. Laser Raman Spectroscopy: Non-linear Raman Spectroscopy, CARS, Resonant CARS. Time-Resolved Laser Spectroscopy. (15 lectures)

REFERENCES

1. K.Shimoda : Introduction to Laser Physics; (Springer-Verlag)
2. O. Svelto : Principles of Lasers (plenum Press)
3. D.C. OShea, W.R. Callen & W.T. Rhodes. Introduction to Lasers and their Applications (Addison-Wesley)
4. W Demtrder. Laser Spectroscopy A Basic Concepts and Instrumentation (SpringerVerlag)
5. A. Corney : Atomic and Laser Spectroscopy (Clarendon Press)
6. Thyagarajan and Ghatak : Lasers- Theory and Applications

ADVANCED MATHEMATICAL PHYSICS

Code PHM304T **Max. Marks 100**

UNIT 1: Group and representations Definitions and examples of group, Useful theorems, Subgroups, Schur's lemma, Conjugate classes, Invariant subgroups, Factor groups, Homomorphism, Direct Products, Permutation group, Young tableaux, reducible and irreducible representations, Rotation(O(2) and O(3)) groups, Poincare (O(1,3)) group. (10 lectures)

UNIT 2: Lie groups I Generators, Lie algebras, Jacobi identity , adjoint representation, Simple algebras and groups, Tensor operators, Wigner- Eckart theorem, SU(2) and SU(3) groups, roots and Weights, Simple roots, Dynkin diagrams, Cartan matrix. (8 lectures)

UNIT 3: Differential Geometry Metric Spaces, Introduction to general topolog: Topological spaces, some example of topologies on a finite set, Compact spaces, homeomorphism, Differentiable Manifolds: Main definitions, Tangent Spaces, Vector Fields, Integral Curves and Flows, Cotangent Vectos, General Tensors and n- forms, DeRham Cohomology. (10 lectures)

UNIT 4: Fiber Bundles Bundles in general: Definition, idea of a cross-section,pull-back operation, Universal bundles, Principal Fibre bundles,Vector bundles, Connections in a bundles, Parallel Transport.(9 lectures)

UNIT 5: Lie Groups II Basic ideas,Lie Algebra of a Lie group, Left- Invariat Forms, Transfomation Groups, Infinitesimal Transfomations. (8 lectures)

REFERENCES

1. Lie Algebra in Particle Physics. Howard Georgi, ABP.
2. Modern Differential Geometry for Physicists. Chris J Isham, WS
3. An Introduction to Differential Geometry. T.J Willmore,OUP.
4. Geometry, Topology and Physics. M. Nakahara. Adam Hilger, Bristol.
5. Lie Groups, Lie Algebras and Some of their Applications. R.Gilmore, John Wiley.

PHYSICS LAB III

Code PHM305 **Max. Marks 150**

LIST OF EXPERIMENTS

1. Microwave Diffraction/interference/polarization
2. Fuel Cell
3. Experiments with Phoenix kit
4. e/m by Thompson's method
5. Hydrogen spectrum
6. He spectrum
7. Determination of elastic constants by ultrasonics using Pizo Electric Crystal.
8. Michelson interferometer
9. Transition temperature in ferrites.
10. Determination of Zeeman splitting of mercury field.
11. Determination of Plank's constant
12. Study of electret.
13. NMR

STATISTICAL MECHANICS

Code PHM401 **Max. Marks 100**

UNIT 1 : Statistical basis of thermodynamics The macroscopic and the microscopic states, phase space, trajectories and density of states, Liouville's theorem, ensemble theory, the principle of maximum entropy, contact between statistical mechanics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox. (10 lectures)

UNIT 2 : Canonical and grand-canonical ensembles Classical canonical ensemble, partition function, calculation of statistical quantities, Energy fluctuations. The grand canonical ensemble, particle number fluctuation. Entropy in grand canonical ensemble, thermodynamic potentials. (12 lectures)

UNIT 3 : Quantum Statistical Mechanics Postulates of quantum statistical mechanics, density matrix, statistics of ensembles. Statistics of indistinguishable particles, Maxwell-Boltzmann, Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein condensation. (10 lectures)

UNIT 4 : Phase transitions Type of phase transitions, first and second order phase transitions. Ising model, mean-field theories of the Ising model in two and three dimensions, exact solution in one dimension. Connection of Ising model to lattice gas and binary alloy models. Landau theory of phase transition, Landau free energy for second and first order transitions, critical exponents and universality classes. (12 lectures)

REFERENCES

1. Statistical and Thermal Physics, by F. Reif
2. Statistical.Mechanics, by K. Huang
3. Statistical Mechanics, R K Pathria
4. Statistical Mechanics, R. Kubo
5. Statistical Physics, Landau and Lifshitz
6. Thermodynamics and Statistical Mechanics, Greiner, Neise and Stocker
7. Statistical Physics by F. Mandl

GROWTH AND IMPERFECTIONS OF MATERIALS

Code PHM402M **Max. Marks 100**

UNIT 1 : Experimental Methods of Crystal Growth Crystal growth from solution, melt and vapour; Flux and Hydrothermal method, Bridgman-Stockbarger and Czochralski method, Float zone andZone refining techniques, purification of materials. (11 Lectures)

UNIT 2 : Kinetics of Crystal Growth Nucleation kinetics, Homogenous and heterogenous nucleation theories of crystal growth, Koesel's theory, The Diffusion theory, Bulk diffusion model, BCF bulk diffusion model, Growth mechanism, Screw dislocation mechanism of crystal growth and polytypism, Experimental verification. (11 lectures)

UNIT 3 : Atomic Packings in Crystals Close packing of spheres, Axial ratio and lattice constants, Voids in close-packing, Coordination of voids, Rules governing the packings of atoms, Effect of radius ratio, Application of Pauling rules to actual structures, Representation of closest packings polymorphic and polytypic structures, Polytypic notations, Stacking faults in fcc, hcp crystals. (11 lectures)

UNIT 4 : Atomic Imperfections in Crystals Point imperfection in ionic crystals, Line imperfection, Edge and Screw dislocation, Burgers vector and Burger's circuit, Dislocation motion, Energy of dislocation, Slip planes and slip directions, Perfect and imperfect dislocations, Dislocation reaction, Surface imperfections, Grain boundary, Tilt and Twist boundary. (12 lectures)

REFERENCES

1. R.A. Laudise: The Growth of Single Crystal.
2. J.J. Gilman: The Art & Science of growth crystals.
3. L.V. Azroff: Introduction to Solids.
4. A.J. Dekker: Solid State Physics.
5. A.R. Verma and P. Krishna: Polytypism and polytypism in crystals.
6. V. Raghavan: Material Science and Engineering
7. Ibach & Luth: Solid State Physics
8. Kittel: Introduction to Solid State Physics
9. M.A. Wahab: Solid State Physics (Structure and properties of Materials)
10. M.A. wahab: Essential of Crystallography

PHOTONICS

Code PHM402L **Max. Marks 100**

UNIT 1 : Review of Optics: Optical components, Planar and Spherical boundaries and Lenses, Graded index components. Matrix optics: matrices of simple optical components, Wave Optics: Complex representation of monochromatic wave and Helmholtz equation, Fresnel approximation of the spherical wave : Parabolodal wave, Transmission through optical components, Multiple beam Interference. Fabry-Perot Interferometer. Polychromatic light - Fourier decomposition. (12 Lectures)

UNIT 2 : Fourier Optics: Propagation of light in free space- transfer function of free space, Optical Fourier Transform, Diffraction Integral, Fourier transform using a lens, image formation and spatial frequency filtering. Holography: Fourier Transform Holography. (7 Lectures)

UNIT 3 : Polarization of Light, Optics of anisotropic media: The index ellipsoid, Birefringence, Optical activity and Faraday effect. Polarization devices: Wave retarders, rotators and optical isolators. Electro-optics: Pockels and Kerr Effect- Electro-optics of Anisotropic media, Phase and amplitude modulators, Photorefractive materials. Acousto-optics: Accousto-optics- Bragg diffraction and acousto-optic devices. (11 Lectures)

UNIT 4 : Non-linear Optics: Non-linear optical media, second order non-linear optics-SHG, Three wave mixing. Third order non-linear optics, THG and self phase modulation, Coupled wave theory of three-wave mixing. Four wave mixing and Optical Phase conjugation. Frequency conversion, Parametric Amplification and Oscillation. Self focusing of light. Optical Bistability: Bistable Systems, Principle of optical bistability, Bistable Optical devices. (15 Lectures)

REFERENCES

1. A. Ghatak and K. Thyagarajan : Optical Electronics (Cambridge University Press)
2. Fundamentals of Photonics: B.E.A. Saleh and M.C. Teich
3. A. Yariv : Quantum Electronics (Wiley, New York)
4. M. Young : Optics and Lasers (Springer Verlag)

GENERAL RELATIVITY

<u>**Code PHM402T**</u> <u>**Max. Marks 100**</u>

Unit 1 : Review and Introduction Gravitational and Inertial mass. Equivalence Principle. Special relativity. Minkowski space-time. Einstein's argument of 1907 on slowing down of clocks in gravitational fields. (5 lectures)

Unit 2 : Tensor Calculus Vector and tensor fields. Parallel transport. Connection coefficients. Metric tensor. Covariant derivative. Geodesic equation. Riemann curvature tensor. Symmetry properties of Riemann tensor. Bianchi identity. Ricci and Einstein tensor. Einstein equation. (10 lectures)

Unit 3 : Gravity in Simple Situations Motion along a geodesic. Newtonian approximation. Gravitational redshift. Einstein equation in vacuum. Schwarzschild solution. Planetary motion and precession of the perihelion. Bending of light by a gravitating body. (10 lectures)

Unit 4 : Weak Fields Stress-energy tensor for a perfect fluid. Solution of Einstein equation for weak fields. Energy psuedo-tensor for the gravitational field. Gravi-magnetic effects. Gravitational waves. (10 lectures)

Unit 5 : Special Topics Action principle for gravitational and matter fields. Schwarzschild solution extension in Kruskal-Szekeres coordinates. Kerr solution. Black holes. (10 lectures)

<u>REFERENCES</u>

1. J.B.Hartle : Gravity
2. S.Weinberg : Gravitation and Cosmology.
3. L.D.Landau and E.M.Lifshitz : The Classical Theory of Fields.
4. R.M.Wald : General Theory of Relativity
5. C.W.Misner, K.S.Thorne and J.A.Wheeler : Gravitation
6. Pankaj Sharan : Spacetime, Geometry and Gravitation

CHARACTERISATION OF MATERIALS

Code PHM403M **Max. Marks 100**

UNIT 1 : Optical methods of structure determination Optical microscopy, Raman spectroscopy, Photoluminescence, Scanning Electron Microscopy (10 Lectures).

UNIT 2 : Surface Scanning Techniques AFM, Electron Diffraction, TEM, STM, Low Energy Electron Diffraction, Reflection High Energy Electron Diffraction (10 Lectures).

UNIT 3 : Surface analytical techniques Auger electron spectroscopy, X-Ray photoelectron spectroscopy, SIMS, Rutherford backscattering (10 Lectures).

UNIT 4 : X-Ray Diffraction Studies Diffraction phenomena as applied to Solid State problems, scattering and absorption of X-rays, neutrons and electrons. X-ray method for orienting crystals. Applications of XRD. Diffraction from regular and faulted closed packed structures. Broadening of diffraction spots due to defects. Line prifile analysis, crystal structure analysis, measurement of intensities of X-ray reflection (15 Lectures).

REFERENCES

1. Woodruff and Delchar : Experimental techniques of surface science
2. Ashcroft and mermin : Solid State Physics
3. S.R.Elliot : Amorphous Materials
4. L.C.Feldman and J.W.Mayer : Fundamentals of surfaces and thin film analysis
5. M.M.Wofson : An introduction of X-ray crystallography
6. J.C.Anderson : Use of films in Physical investigations
7. W.K.Chu : Rutherford backscattering Spectroscopy

QUANTUM OPTICS

Code PHM403L **Max. Marks 100**

UNIT 1 : Quantum theory of radiation : Quantization of free em fields, fockstates, lambshift, quantum beats, concept of photons, coherent and squeezed states of lights, quantum distribution theory and partially coherent radiation. (16 Lectures)

UNIT 2 : First and second-order coherence, HBT effect, photon bunching and anti bunching, Poissonian and sub-poissonian light, photon counting and photon statistics, Atom-field interaction : semi classical theory and quantum theory, coherent trapping, electromagnetically induced transparency and lasing without inversion. (16 Lectures)

UNIT 3 : Quantum theory of damping : density operator method and langevin approach, quantum theory of laser, squeezing of light in nonlinear optical process, Atom optics : mechanical effects of light, atomic interferometry, quantum noise in an atomic interoferometer, limits to laser cooling. (6 Lectures)

UNIT 4 : Introductory ideas on EPR paradox, Bells inequality, QND measurements and two photon interferometry. (7 Lectures)

REFERENCES

1. Elements of quantum optics : Meytre-Sergent
2. Quantum optics : M.O.Scully and M.S. Zubairy
3. Optical coherence and quantum optics : Mandel and Wolf
4. Laser physics : Sargent,Scully and Lambs

PARTICLE PHYSICS

Code PHM403T **Max. Marks 100**

UNIT 1 : Invariance Principles and Symmetries Charge conjugation, time reversal and partity , CPT theorem, Quark model and color and flavour quantum numbers, Weak isospin and hypercharge. (10 lectures)

UNIT 2 : Introduction to Gauge Theories Abelian and non-abelian gauge theories, Spontaneous symmetry breaking, Goldstone theorem, Higgs phenomenon. (10 lectures)

UNIT 3 : Standard Model Historical introduction to Fermi theory and current algebra, Weinberg-Salam model, Basic Lagrangian, neutral current, GIM mechanism, KM matrix and CP violation. (10 lectures)

UNIT 4 : Strong Interactions Basic Lagrangian of QCD and its symmetries, Asymptotic freedom, Deep inelastic scattering. (10 lectures)

UNIT 5 : Some Special topics Anamolies, supersymmetry, string theory. (5 lectures)

REFERENCES

1. Perkins: Introduction to High Energy Physics (Addison-Wesley 3rd Edition)
2. Greiner & Muller: Gauge Theory of Weak Interactions (Springer)
3. Cheng Lee: Gauge Theory and Particle Physics (Cambridge)

MATERIALS LAB

Code PHM404M **Max. Marks 100**

1. To study the strength, hardness and conductivity of the materials.

2. To grow single crystal of NaCI from solution and take its Laue photograph. Index this photograph using Gonomonic projection.

3. To take Debye Scherrer pattern of a given polycrystalline material and determination of their "d" values from the powder lines.

4. Setting of single crystal using Goniometer and detennination of the identity period of a given crystal using Rotation method.

5. To find the wave length of K-absorption edge of Zr using Mo target and Bent crystal spectrograph.

6. Study of superconductivity

7. Study of the Molumine scene of F-centres in alkali halide crystals.

LASER LAB

Code PHM404L **Max. Marks 100**

1. Absorption spectrum of benzene.
2. Fluoroscence spectrum of a dye.
3. To study the Raman effect and to find the values of Raman frequencies for a substance.
4. Determination of power distribution in a laser beam spot size and the divergence of the beam.
5. Holography.
6. Electrooptic modulation.
7. Optical fibre.
8. Acousto-optic modulation.
9. Fabry-Perrot interferometer
10. Mach-Zehnder interferometer
11. Diffraction of light.
12. Polarization of light.

QUANTUM FIELD THEORY

Code PHM404T **Max. Marks 100**

UNIT 1 : Canonical Quantization Canonical quantization of neutral scalar, Charged scalar, spin 1/2 and massive spin-1 fields, Fock space and observables. Field commutation, anti-commutation relations. (12 lectures)

UNIT 2 : Interacting Fields Interaction picture. Normal product. Wick's theorem. Feynman propagator. S-matrix. Feynman rules and diagrams. (9 lectures)

UNIT 3 : Quantum Electrodynamics Quantization of electromagnetic field. Gupta-Bleuler condition. Indefinite metric. Feynman diagrams of QED. (8 lectures)

UNIT 4 : Scattering (tree level) in QED Tree level calculations of Moller, Bhabha, Compton and Scattering in external field. (8 lectures)

UNIT 5 : Special topics 1-loop corrections and renormalization. RG equations. (8 lectures)

REFERENCES

1. S.S. Schwebber : Introduction to Relative Quantum Field Theory (Inter science 1961)
2. Bogolinbov & Shirkov : Introduction to Quantized Field Theory
3. Bjorken & Drell : Relativistic Quantum Mechanics
4. Bjorken & Drell : Quantum Field Theory
5. Itzyksen & Zuber : Quantum Field Theory (Mc Graw Hill)

PROJECT

<u>**Code PHM405**</u> <u>**Max. Marks 100**</u>

Guidelines for Project in M.Sc. Course:

1. Projects would be allotted to III Sem students which have to be carried out and completed in Sem IV.

2. A list of projects will be finalized and announced by the Department. The students will have an option to select the project in their field of interest.

3. The project will comprise of the following:

a. Study of background material

b. Collection of data, procurement and fabrication of experimental set up and writing of computer programs if needed.

c. Giving a preliminary seminar in the III sem for the purpose of internal assessment whose weightage would be 50 marks (2 credits).

d. Writing a dissertation or project report. This will be submitted by the students at the end of IV semester.

4. The Final evaluation of the project work completed will be done by external and internal examiners appointed by the Board of Studies on the basis of an oral presentation and the submitted Project-Report. The weightage of the final evaluation would be 80 percent.