SIDHO-KANHO-BIRSHA UNIVERSITY

SYLLABUS

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TWO-YEAR M.Sc. COURSE OF STUDIES

PHYSICS

2014

Syllabus for M.Sc. Course in Physics

Sidho-Kanho-Birsha University

Full Marks – 1000 (Theory papers - 650, Practical papers - 350)

Total number of lectures for a theory paper of 25 marks is 30 (25 Lectures + 5 Tutorials).
Internal assessment for papers of 25, 50 and 100 marks are 5, 10 and 20 marks, respectively.

SEMESTER I

Paper 101	Unit I: Mathematical Methods I	(25 Marks)
	Unit II: Quantum Mechanics I	(25 Marks)
Paper 102	Unit I: Classical Electrodynamics	(25 Marks)
	Unit II: Classical Mechanics	(25 Marks)
Paper 103	Unit I: Solid State Physics I	(25 Marks)
	Unit II: Electronics I	(25 Marks)
Paper 104	General Practical	(100 Marks)
	Group A - Electrical and Electronics Experiments	
	Group B - General Physics Experiments	

SEMESTER II

Paper 201	Unit I: Mathematical Methods II	(25 Marks)
	Unit II: Quantum Mechanics II	(25 Marks)
Paper 202	Unit I: Atomic and Molecular Physics	(25 Marks)
	Unit II: Nuclear Physics I	(25 Marks)
Paper 203	Unit I: Solid State Physics II	(25 Marks)
	Unit II: Electronics II	(25 Marks)
Paper 204	General Practical	(100 Marks)
	Group A - General Physics Experiments	
	Group B - Electrical and Electronics Experiments	

SEMESTER III

Paper 301	Unit I: Statistical Mechanics I	(25 Marks)
	Unit II: Computer programming and Numerical Methods	(25 Marks)
Paper 302	Unit I: Laser and Nonlinear Optics	(25 Marks)
	Unit II: Nuclear Physics II	(25 Marks)
Paper 303	**Advanced Paper - I**: (Any one unit)	(50 Marks)
	A: Advanced Electronics I	
	B: Photonics I	
	C: Condensed Matter Physics I	
	D: Nuclear Structure	
Paper 304	**Advanced Practical - I**	(50 Marks)
Paper 305	Computer Practical	(50 Marks)

SEMESTER IV

Paper 401	Unit I: Statistical Mechanics II	(25 Marks)
	Unit II: Advanced Quantum Mechanics	(25 Marks)
Paper 402	**Elective Paper**: (Any one unit)	(50 Marks)
	1: Electronics and Instrumentation	
	2: Relativity, Cosmology and Astrophysics	
	3: Dynamical Systems	
	4: Advanced Classical Electrodynamics	
Paper 403	**Advanced Paper – II**: (Any one unit)	(50 Marks)
	A: Advanced Electronics II	
	B: Photonics II	
	C: Condensed Matter Physics II	
	D: Nuclear Reaction	
Paper 404	**Advanced Practical - II**	(50 Marks)
Paper 405	**Term Paper/ Project** (Unit I)	(25 Marks)
	Grand Viva (Unit II)	(25 Marks)

SEMESTER I (Total 250 Marks)

Paper 101
Unit I: Mathematical Methods I [25 Marks]

1. Complex analysis:

(a) Recapitulation - Complex numbers, modulus, triangular inequalities, Schwarz inequality. Function of a complex variable - single and multiple-valued function, limit and continuity; Differentiation – Cauchy-Riemann equations and their applications; Analytic and harmonic function. (3 L)

(b) Complex integrals, Cauchy's theorem (elementary proof only), converse of Cauchy's theorem, Cauchy's Integral Formula and its corollaries; Series - Taylor and Laurent expansion; Classification of singularities; Branch point and branch cut; Residue theorem and its applications for evaluation of definite integrals through contour integration, evaluation of principal values of improper integrals, summation and inversion of series; Partial fraction representation and Infinite product representation. (6 L)

(c) Analytic Continuation, Asymptotic Expansion (definition), Saddle point expansion method. (2 L)

2. Differential equations:

(a) Ordinary second order linear homogeneous differential equation: Singular points; Frobenius method; Fuch's theorem; Linear independence of solutions - Wronskian, second solution. Sturm-Liouville theory; Hermitian operators; Completeness. (5 L)

(b) Special functions: Basic properties of Legendre, Bessel and Hermite functions. (2 L)

3. Vector space:
Axiomatic definition, linear independence, bases, dimensionality, inner product; Gram Schmidt orthogonalisation. Matrices and their types: Representation of linear transformations and change of base; Eigenvalues and eigenvectors; Functions of a matrix; Cayley-Hamilton theorem; Diagonalisation of matrices; Commuting matrices with degenerate eigenvalues; Orthonormality of eigenvectors. (7 L)

Books Recommended:
(1) P. Dennery and A. Krzywicki: Mathematics for Physicists.
(2) K.F. Riley et al: Mathematical Methods for Physics and Engineering.
(3) S.D. Joglekar: Mathematical Physics – The Basics and Advanced Topics.
(4) A.W. Joshi: Matrices and Tensors in Physics.
(5) E.T. Copson: Theory of functions of a Complex Variable.
(6) M. R. Spiegel et al: Complex Variables.
(7) R. Bronson and G.B. Costa: Differential Equations.
(8) M. Tenenbaum and H. Pollard: Ordinary Differential Equations.
(9) S. Lipschutz and M. Lipson: Linear Algebra.

Unit II: Quantum Mechanics I **[25 Marks]**

1. Vector spaces in quantum mechanics:
Hilbert space. Kets, bras and operators, Base bras, kets and matrix representation. Hermitian operator (definition and properties). Eigenkets as base kets. Orthogonality. Completeness. Postulates of quantum mechanics. Observable and results of its measurement. The generalized uncertainty relation. Non-commutating observables. Complete set of commuting observables. Change of basis. Unitary operators Discrete and continuous bases. Coordinate and momentum representations. Linear harmonic oscillator by operator method. Coherent states. (7 L)

2. Quantum dynamics:
Schrödinger, Heisenberg - interaction pictures and equations of motion. Schrödinger equation – coordinate and momentum representation. Evolution operator. (3 L)

3. Schroedinger equation and its applications:
The interpretation of the wavefunction. Stationary states.

(a) One dimentional problems: The delta-function potential and the Kronig Penney model.

(b) Three dimensional problems: The rigid rotator. The spherical well with impenetrable walls. Spherical square well potential. The harmonic oscillator with Heisenberg's equation of motion. (8 L)

4. Approximation methods:
Time-independent perturbation theory for non-degenerate and degenerate states. Applications to anharmonic oscillator, Stark effect in hydrogen atom, Landau levels. Variational methods for ground and excited states. Application to the ground state of helium atom. WKB approximation, tunnelling, qualitative discussion of alpha decay. (5 L)

5. Identical particles:
Symmetry under interchange. Wave functions for bosons and fermions. Slater determinant. (2 L)

Books Recommended:
(1) B.H. Bransden and C.J. Joachain: Quantum Mechanics.
(2) D.J. Griffiths: Introduction to Quantum Mechanics.
(3) S. Gasiorowicz: Quantum Physics.
(4) P.A.M. Dirac: Principles of Quantum Mechanics.
(5) L.I. Schiff: Quantum Mechanics.
(6) E. Merzbacher: Quantum Mechanics.
(7) C. Cohen-Tannoudji et al: Quantum Mechanics Vol I and II.
(8) J.J. Sakurai: Modern Quantum Mechanics.
(9) Y. Peleg at al: Theory and Problems of Quantum Mechanics.
(10) Y.K. Lim: Problems and Solutions on Quantum Mechanics.

Paper 102
Unit I: Classical Electrodynamics **[25 Marks]**

1. Electromagnetic theory:
Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance, Lorentz invariance of Maxwell's equation. Electromagnetic waves in free space. Poynting's theorem. Dynamics of charged particles in static and uniform electromagnetic fields. Transmission lines, TE and TM modes, Waveguides between parallel plates. (7 L)

2. Solution of Inhomogenous wave equation (vector and scalar potential), Green's function, retarded solution. (3 L)

3. Radiation from moving point charges:
Lienard-Wiechert potentials; Fields due to a charge moving with uniform velocity; Dipole antenna; Fields due to an accelerated charge; Radiation at low velocity; Larmor's formula and its relativistic generalisation; Radiation when velocity (relativistic) and acceleration are parallel, Bremsstrahlung; Radiation when velocity and acceleration are perpendicular, Synchrotron radiation; Cherenkov radiation (qualitative treatment only). Thomson and Rayleigh scattering. (8 L)

4. Radiation from time-dependent sources of charges and currents:
Radiation from time varying localised sources and multipole expansion in the radiation zone. (4 L)

5. Relativistic electrodynamics
Equation of motion in an electromagnetic field; Electromagnetic field tensor, covariance of Maxwell's equations; Maxwell's equations as equations of motion; Lorentz transformation law for the electromagnetic fields and the fields due to a point charge in uniform motion.

Books Recommended:
(1) D.J. Griffiths: Introduction to Electrodynamics.
(2) W.K.H. Panofsky and M. Phillips: Classical Electricity and Magnetism,
(3) J. Schwinger et al: Classical Electrodynamics.
(4) J.D. Jackson: Classical Electrodynamics.
(5) M.A. Heald and J.B. Marion: Classical Electromagnetic radiation.
(6) Ashok Das: Lectures on Electromagnetism.
(7) Satya Prakash: Electromagnetic Theory and Electrodynamics.
(8) Y.K. Lim: Problems and Solutions on Electromagnetism.

Unit II: Classical Mechanics **[25 Marks]**

1. Review of the Lagrangian and Hamiltonian formalisms:

(a) Some specific applications of Lagrange's equation: Systems with constraints and Lagrange's undetermined multiplier, Small oscillations, Normal modes and frequencies. (3 L)

(b) Legendre transforms. Hamilton's function and Hamilton's equations of motion. Simple applications. Lagrangian and Hamiltonian of relativistic particles. Principle of least action. Hamilton's principle. Euler – Lagrange equations of motion from Hamilton's principle. Hamilton's equations of motion from Hamilton's principle. Noether's theorem. (5 L)

2. Canonical transformations:
Examples. Integral invariants of Poincare. Lagrange and Poisson brackets as canonical invariants. The equations of motion in Poisson bracket notation. Infinitesimal contact transformation. Constants of the motion. Symmetry properties. Angular momentum Poisson bracket relations. Liouville's theorem. (5 L)

3. Hamilton-Jacobi theory:
The Hamilton Jacobi equation for Hamilton's principle function; The harmonic oscillator problem; Hamilton's characteristic function; Action angle variables. (4 L)

4. Rigid bodies:
Independent coordinates; orthogonal transformations and rotations (finite and infinitesimal); Euler's theorem, Euler angles; Inertia tensor and principal axis system; Euler's equations; Heavy symmetrical top with precession and nutation. (5 L)

5. Dynamical Systems:
Phase Space dynamics, Stability analysis. (3 L)

Books Recommended:
(1) H. Goldstein, C. Poole and J. Safko: Classical mechanics.
(2) A.L. Fetter and J.D. Walecka: Theoretical Mechanics of Particles and Continua.
(3) L. Landau and E. Liftshitz: Mechanics.
(4) N.C. Rana and P.S. Joag: Classical Mechanics.
(5) R. G. Takwale and P. S. Puranik: Introduction to Classical Mechanics.
(6) S.N. Biswas: Classical Mechanics.
(7) A. K. Roychaudhuri: Classical Mechanics.
(8) A.L. Fetter and J.D. Walecka: Nonlinear Mechanics.
(9) Y.K. Lim: Problems and Solutions on Mechanics.

Paper 103
Unit I: Solid State Physics I **[25 Marks]**

1. Crystal structure:

Bravais lattice - primitive vectors, primitive unit cell, conventional unit cell, Wigner-Seitz cell; Symmetry operations and classification of 2- and 3-dimensional Bravais lattices; Crystal structures: basis, crystal class, point group and space group (information only); Miller indices; Directions and planes in crystals; Inter-planar spacings; Common crystal structures: SC, BCC, FCC, NaCl, CsCl, Diamond, ZnS, and HCP structures; Reciprocal lattice and Brillouin zone; Bragg-Laue formulation of X-ray diffraction by a crystal; Interpretation of Laue equations; Ewald construction; Atomic and crystal structure factors; Explanation of experimental methods on the basis of Ewald construction; Electron and neutron diffraction by crystals (qualitative discussion only). (7L)

2. Bonding in Solids:

Bond classifications; covalent, molecular, and ionic crystals; nature of bonding; cohesive energies; hydrogen bonding. (3L)

3. Lattice dynamics and Specific heat:

Classical theory of lattice vibration under harmonic approximation; Vibrations of linear monatomic and diatomic lattices, acoustical and optical modes, long wavelength limits; Infrared absorption in ionic crystals (one-dimensional model). Adiabatic approximation (qualitative discussion); Normal modes and phonons; Inelastic scattering of neutron by phonon; Lattice heat capacity, models of Debye and Einstein, comparison with electronic heat capacity; Anharmonic effects in crystals - thermal expansion and thermal conductivity; Mossbauer effect. (7L)

4. Magnetic properties of solids:

Origin of magnetism; Diamagnetism: quantum theory of atomic diamagnetism; Landau diamagnetism (qualitative discussion); Paramagnetism: quantum theory of paramagnetism; Curie law; Hund's rules; Paramagnetism in rare earth and iron group ions; quenching of orbital angular momentum; Van-Vleck paramagnetism and Pauli paramagnetism; Ferromagnetism: Curie-Weiss law, temperature dependence of saturated magnetization, Heisenberg's exchange interaction, ferromagnetic domains; Ferrimagnetism and antiferromagnetism; Other kind of magnetic orders; Nuclear magnetic resonances, Electron-spin resonance. (8L)

Books Recommended:

(1) F.C.Phillips: An introduction to crystallography
(2) N. Ashcroft and N. Mermin: Solid State Physics
(3) M. Ali Omar: Elementary Solid State Physics
(4) C. Kittel: Introduction to Solid State Physics
(5) J. Christmaan: FundamentaL of Solid State Physics
(6) A.J. Dekker: Solid State Physics
(7) J.P. Srivastava: Elements of Solid State Physics
(8) S.P. Kuila: Essentials of Solid State Physics

Unit II: Electronics I **[25 Marks]**

1. Passive Networks:
Synthesis of two terminal reactive networks. Driving point impedance and admittance, Foster's reactance theorems. Canonic networks. (2 L)

2. Four-terminal two-port network:
Parameters for symmetrical and asymmetrical networks. Image, iterative and characteristic impedances. Propagation function. Lattice network. Bisection theorem and its application. (2 L)

3. L-C filters:
LPF, HPF, BPF and BRF type constant-k prototype filters. m-derived filters (principle only). Attenuators. T-type, Pi-type, Bridged-T type lattice attenuators. (4 L)

4. High Frequency transmission line:
Distributed parameters. Primary and secondary line constants; Telegraphers' equation. Reflection co-efficient and VSWR. Input impedance of loss-less line. Distortionless line. Cable fault location. (5 L)

5. Semiconductor Devices:
(a) p-n junction physics. Fabrication steps. Thermal equilibrium condition. Depletion capacitance. Current-voltage characteristics. Charge storage and transient behaviour. Junction breakdown. Heterojunction.
(b) Characteristics of some semiconductor devices: MOS devices, LED, Solar cell, Tunnel diode, Gunn diode and IMPATT. (9 L)

6. Multivibrators:
Astable and monostable. (3 L)

Books Recommended:
(1) J. Ryder: Networks, Line and Fields.
(2) D. Chattopadhyay and P.C. Rakshit: Electronic Circuit Analysis.
(3) J. Kennedy: Electronic Communication Systems.
(4) S.M. Zee and K.K. Ng: Physics of Semiconductor Devices.
(5) B.G. Streetman and S. Banerjee: Solid State Electronic Devices.
(6) Floyd: Electronic Devices.
(7) R.L. Boylestad and L. Nashelski: Electronic Devices and Circuit Theory.
(8) J. Milman and A. Grable: Microelectronics.
(9) R. Kar: Advanced Practical Electronics.
(10) Van Valkenberg: Electronics.

Paper 104
General Practical **[100 Marks]**

Group A – General Physics Experiments

1. Verification of Bohr's atomic theory (discreteness of the atomic orbital) of Ar atom by Franck Hertz Experiment.
2. Determination of the Lande - g factor for the DPPH sample using the Electron Spin Resonance (ESR) setup.
3. Study of temperature dependence of resistivity for a given semiconductor using Four Probe setup and determine its energy band gap.
4. Determination of Hall Coefficient of a given semiconductor sample using variable DC magnetic field.
5. Study the I-V characteristics of light emitting diodes (LEDs) and hence determine the Planck's constant along with finding the ac resistances of the LEDs (using at least four different LEDs).
6. Determination of Planck's constant by Photoelectric effect.
7. Experiments using Jamin's interferometer.
8. Experiments using Fabry-Perot Interferometer.
9. Determination of (i) wavelength of *He-Ne* laser light, (ii) the refractive index of a given transparent thin film, and (iii) refractive index of air at different pressures using Michelson's Interferometer.
10. Using a radioactive source and a Geiger-Müller (GM) counter (i) determine the plateau and optimal operating voltage of the GM counter, and (ii) perform analysis of statistical fluctuations at high count rates.
11. Using a radioactive source and a Geiger-Müller (GM) counter (i) determine the relative efficiency of the GM counter as a function of source-to-detector distance, and (ii) perform analysis of statistical fluctuations at low count rates.
12. Study of alpha scattering from metal targets and verification of the Rutherford scattering formula and identification of the target element.
13. Experiment with Laser.
14. Experiment with Optical Fibre.

Group B – Electrical and Electronics Experiments

1. Study the characteristics of a light dependent resistance (LDR)
2. Design and study of CC amplifier.
3. Study of OPAMP (IC 741) characteristics and its use as an inverting amplifier, non-inverting amplifier, adder and differential amplifier.
4. Design and study of current mirror biasing.
5. Study of the different gate characteristics using NAND gate.
6. Square wave generation using 555 timer.
7. Transistor based monostable multivibrator.
8. CE amplifier characteristic study for AC load variation with and without feedback stage.

SEMESTER II (Total 250 Marks)

Paper 201

Unit I: Mathematical Methods II **[25 Marks]**

1. Integral transform:
Fourier and Laplace transforms and their inverse transforms, Bromwich integral [use of partial fractions in calculating inverse Laplace transforms]; Transform of derivative and integral of a function; Solution of differential equations using integral transforms. (8 L)

2. Inhomogeneous differential equations: Green's function and its applications. (3 L)

3. Tensor analysis:
Coordinate transformations. Scalars. Covariant and contravariant tensors. Outer product. Inner product. Contraction. Symmetric and antisymmetric tensors. Quotient law. (4 L)

4. Group Theory:
Concept of a group, Definition and examples, Multiplication table and rearrangement theorem, Isomorphism and homomorphism, Direct product of groups, Distinct groups of a given order, Representations of a group – faithful, unfaithful, equivalent, reducible and irreducible representations. Lie groups and Lie algebra with O(2), SU(2), SO(3) and SU(3). (10 L)

Books Recommended [including books (1) to (4) from Mathematical Methods I course]**:**
(1) G.B. Arfken and H.J. Weber: Mathematical Methods for Physicists.
(2) L. Andrews and B. Shivamoggi: Integral Transforms for Engineers.
(3) M. Hamermesh: Group Theory and its Applications to Physical Problems.
(4) A.W. Joshi: Elements of Group Theory for Physicists.

Unit II: Quantum Mechanics II **[25 Marks]**

1. Generalised angular momentum**:**

Infinitesimal rotation. Generator of rotation. Commutation rules. Matrix representation of angular momentum operators. Spin. Pauli spin matrices. Eigenspinors. Electron in static magnetic field. Larmor precession. Electron in an oscillating magnetic field. Addition of two angular momenta. Simple examples. Clebsch-Gordan co-efficients. Recursion relations. (8 L)

2. Discrete and continuous space-time symmetries:

Invariance principles and conservation laws. Space translation. Time translation. Space rotation. Irreducible spherical tensor operators. Wigner-Eckert theorem (no proof) and applications. Space inversion. Time reversal. Kramers degeneracy. (5 L)

3. Time-dependent perturbation theory:

Constant and harmonic perturbations. Perturbation coupling two discrete states. Fermi's golden rule. Sudden and adiabatic approximations. Interaction of an atom with electromagnetic wave. Electric dipole radiation. (6 L)

4. Scattering theory:

Scattering amplitude. Differential and total cross sections. Integral equation for potential scattering. Green's function. Born approximation, its validity and some applications (square well potential, Yukawa potential). Method of partial waves. Phase shifts. Optical theorem. Scattering by hard sphere. Coulomb Scattering - Rutherford formula, Scattering with WKB. (6 L)

Books Recommended (including books from Quantum Mechanics I course)**:**

(1) R. Shankar: Principles of Quantum Mechanics.
(2) P.M. Mathews and K. Venkatesan: A Text Book of Quantum Mechanics
(3) A.K. Ghatak and S. Lokenathan: Quantum Mechanics.
(4) Amit Goswami: Quantum Mechanics.

Paper –202

Unit I: Atomic and Molecular Physics [25 Marks]

1. Spectra of hydrogenic atoms:
Quantum defect. Penetrating and non-penetrating orbits. Introduction to electron spin. Spin-orbit interaction and fine structure. Relativistic correction to spectra of hydrogen atom. Lamb shift. Lande *g* factor. Zeeman, Paschen-Back and Stark effects. (5 L)

2. Spectra of many electron atoms:
Independent particle model. He atom as an example of central field approximation. Central field approximation for many electron atom. Slater determinant. L-S and j-j coupling. Equivalent and nonequivalent electrons. Energy levels and spectra. Spectroscopic terms. Hunds rule. Lande interval rule. Alkali spectra. (4 L)

3. Hyperfine structure and isotopic shift, Width of spectral lines, Electron spin resonance, Nuclear magnetic resonance, Chemical shift. (3 L)

4. Molecular Electronic States:
Concept of molecular potential, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Electronic angular momenta, Approximation methods for the calculation of electronic Wave function, The LCAO approach, States for hydrogen molecular ion, Coulomb, Exchange and Overlap integral, Symmetries of electronic wavefunctions; Shapes of molecular orbital; π and σ bond; Term symbol for simple molecules. (5 L)

5. Rotation and Vibration of Molecules:
Molecular rotation: Rigid and Non-rigid rotator, Centrifugal distortion, Symmetric top molecules, Molecular vibrations: Harmonic oscillator and the anharmonic oscillator approximation, Morse potential. (4 L)

6. Spectra of Diatomic Molecules:
Transition matrix elements, Vibration-rotation spectra: Pure vibrational transitions, Pure rotational transitions, Vibration-rotation transitions, Electronic transitions: Structure, Franck-Condon principle, Rotational structure of electronic transitions, Fortrat diagram, Band head, Dissociation energy of molecules, Continuous spectra, Raman transitions and Raman spectra. (4 L)

Books Recommended:
(1) C.J. Foot: Atomic Physics.
(2) H. Haken and H.C. Wolf: The Physics of Atoms and Quanta.
(3) W. Demtroder: Atoms, Molecules and Photons.
(4) B.H. Bransden and C.J. Joachain: Physics of Atoms and Molecules.
(5) C.B. Banwell and E. McCash: Fundamentals of Molecular Spectroscopy.
(6) G. Aruldhas: Molecular Structure and Spectroscopy.
(7) V.K. Jain: Introduction to Atomic and Molecular Spectroscopy.
(8) M.C. Gupta: Atomic and Molecular Spectroscopy.
(9) Y.K. Lim: Problems and Solutions on Atomic, Nuclear and Particle Physics.

Unit II: Nuclear Physics I **[25 Marks]**

1. General properties of nuclei: (6 L)

(a) Nuclear size: Electron scattering and form factors, charge density radius and potential radius, Woods-Saxon potential, experimental methods of determination.

(b) Mass and abundance of nuclides, Nuclear binding energy, Semi-empirical mass formula and its applications to stability of nuclei and neutron star.

(c) Angular momentum and parity of nuclei. Magnetic dipole moment. Electric quadrupole moment and nuclear shape. Anomalous magnetic moments of nucleons and qualitative discussions about their origin.

2. Two nucleon system: (7 L)

(a) Bound state problem: Properties of deuteron, Schrodinger equation and its solution for ground state of deuteron, rms radius, electric quadrupole and magnetic dipole moments of deuteron. Spin and isospin dependence and the necessity of tensor forces.

(b) Scattering problem: Partial wave analysis. Phase-shift. Scattering length. Low energy n-p and p-p scattering (qualitative discussion). Singlet and triplet state. Charge symmetry and charge independence of nuclear forces. Isospin symmetry. Exchange interaction. Elementary discussion on Yukawa's theory.

3. Nuclear structure: (6 L)

(a) Shell Model: Evidence of shell structure; magic numbers; effective single particle potentials: square-well, harmonic oscillator, Wood-Saxon with spin orbit interaction. Extreme single particle model.

(b) Collective Model: Evidence of collective motion; nature of vibrational and rotational spectra – qualitative discussion in term of phonons and rigid rotators, illustrated with examples.

4. Nuclear reaction: (6 L)

(a) Direct Reaction: characteristics, types of direct reactions with examples – elastic, inelastic, transfer, stripping, pick-up, knock-on and break-up reactions. Quantum mechanical theory (qualitative).

(b) Compound Nuclear Reaction: characteristics, resonance and compound nucleus formation; one level Breit – Wigner formula; Optical model.

Books Recommended:

(1) K.S. Krane: Introductory Nuclear Physics.
(2) S.S.M. Wong: Introductory Nuclear Physics.
(3) J.L. Basdevant et al: Fundamentals in Nuclear Physics.
(4) B. Povh et al: Particles and Nuclei.
(5) B. Cohen: Concepts of Nuclear Physics.
(6) K. Heyde: Basic Ideas and Concepts in Nuclear Physics.
(7) R. Roy and B.P. Nigam: Nuclear Physics.
(8) Y.K. Lim: Problems and Solutions on Atomic, Nuclear and Particle Physics.
(9) S.N. Ghosal: Nuclear Physics.

Paper 203

Unit I: Solid State Physics II **[25 Marks]**

1. Free electron Theory: Free electron theory of electrical and thermal conductivity. Electronic specific heat. Quantized free electron theory. Fermi energy, wave vector, velocity and temperature. Density of states in one, two and three dimensions. AC conductivity and optical properties. Plasma oscillations. Hall effect. Hall coefficient in one- and two- band models. (6 L)

2. Band theory of solids:
Energy bands in solids; Periodic potential and Bloch's theorem; Kronig-Penney model; Brillouin zones; Number of states in the band; Band gap in the nearly free electron model; Tight binding method; Electron dynamics in an electric field; Effective mass of an electron in a band: concept of holes; Energy band in one dimension - reduced zone scheme; Classification of metal, semiconductor and insulator; Topology of Fermi surface - cyclotron resonance; de Haas-van Alphen effect; limitations of Band Theory - metal-insulator transitions. (8 L)

3. Semiconductors:
Intrinsic and extrinsic semiconductors; Carrier concentration; Fermi levels of intrinsic and extrinsic semi-conductor; Band gap; Direct and indirect gap semiconductors; Hydrogenic model of impurity levels. (3L)

4. Optical properties in solids:
Frenkel and Schottky defects; Colour centers and luminescence; Alloys – order-disorder phenomena. (2L)

5. Superconductivity:
Phenomenological description of superconductivity - occurrence of superconductivity, critical temperature, destruction of superconductivity by magnetic field, Meissner effect; Type-I and type-II superconductors; Heat capacity, energy gap and isotope effect; London equation, London penetration depth; Outlines of the BCS theory; Giaver tunnelling; Flux quantization and Josephson effect, High temperature superconductors. (6 L)

Books Recommended:
(1) N. Ashcroft and N. Mermin: Solid State Physics
(2) M. Ali Omar: Elementary Solid State Physics
(3) C. Kittel: Introduction to Solid State Physics
(4) J. Christmaan: FundamentaL of Solid State Physics
(5) A.J. Dekker: Solid State Physics
(6) J.P. Srivastava: Elements of Solid State Physics
(7) S.P. Kuila: Essentials of Solid State Physics

Unit II: Electronics II **[25 Marks]**

1. Op-Amp Circuits:

Characteristics of ideal and practical op-amp. Nonlinear amplifiers using op-amps. Log amplifier, anti-log amplifier, regenerative comparators. Active filters. ADC and DAC circuits. Op-amp based self-oscillator circuits. RC phase shift, Wien bridge, Non-sinusoidal oscillators. (7 L)

2. Elements of communication electronics:

Comparison among different modulation techniques. Generation of transmitted carrier and suppressed carrier type AM signals. Principles of FM and PM signal generation. Principles of detection of different types of modulated signals (TC and SC types). Modulation techniques in some practical communication systems. VSB modulation. Pulse modulation, Pulse code modulation and quantization error. (10 L)

3. Digital circuits:

Logic functions. Logic simplification using Karnaugh maps. SOP and POS design of logic circuits. MUX - DEMUX as universal building block. RS, JK and MS-JK flip-flops. Registers and counters. (8 L)

Books Recommended:

(1) R. Gaykwad: Operational Amplifier.
(2) A.S. Sedra and K.C. Smith: Microelectronic Circuits.
(3) D. Roddy and J. Coolen: Electronic Communications.
(4) R. Jain: Modern Digital Electronics.
(5) Kleitz: Digital Electronics.
(6) H. Taub and D. Schilling: Digital Integrated Electronics.
(7) R. Kar: Electronics.

Paper 204

General Practical **[100 Marks]**

Group A – Electrical and Electronics Experiments

1. Study the characteristics of a light dependent resistance (LDR)
2. Design and study of CC amplifier.
3. Study of OPAMP (IC 741) characteristics and its use as an inverting amplifier, non-inverting amplifier, adder and differential amplifier.
4. Design and study of current mirror biasing.
5. Study of the different gate characteristics using NAND gate.
6. Square wave generation using 555 timer.
7. Transistor based monostable multivibrator.
8. CE amplifier characteristic study for AC load variation with and without feedback stage.

Group B – General Physics Experiments

1. Verification of Bohr's atomic theory (discreteness of the atomic orbital) of Ar atom by Franck Hertz Experiment.
2. Determination of the Lande - g factor for the DPPH sample using the Electron Spin Resonance (ESR) setup.
3. Study of temperature dependence of resistivity for a given semiconductor using Four Probe setup and determine its energy band gap.
4. Determination of Hall Coefficient of a given semiconductor sample using variable DC magnetic field.
5. Study the I-V characteristics of light emitting diodes (LEDs) and hence determine the Planck's constant along with finding the ac resistances of the LEDs (using at least four different LEDs).
6. Determination of Planck's constant by Photoelectric effect.
7. Experiments using Jamin's interferometer.
8. Experiments using Fabry-Perot Interferometer.
9. Determination of (i) wavelength of *He-Ne* laser light, (ii) the refractive index of a given transparent thin film, and (iii) refractive index of air at different pressures using Michelson's Interferometer.
10. Using a radioactive source and a Geiger-Müller (GM) counter (i) determine the plateau and optimal operating voltage of the GM counter, and (ii) perform analysis of statistical fluctuations at high count rates.
11. Using a radioactive source and a Geiger-Müller (GM) counter (i) determine the relative efficiency of the GM counter as a function of source-to-detector distance, and (ii) perform analysis of statistical fluctuations at low count rates.
12. Study of alpha scattering from metal targets and verification of the Rutherford scattering formula and identification of the target element.
13. Experiment with Laser.
14. Experiment with Optical Fibre.

SEMESTER III (Total 250 Marks)

Paper 301
Unit I: Statistical Mechanics I [25 Marks]

1. Introduction

Objective of statistical mechanics. Transition from thermodynamics to statistical mechanics. Reviews of the ideas of macrostates, microstates, phase space and ensembles. Ergodic hypothesis, postulate of equal a priori probability and equality of ensemble average and time average. Boltzmann's postulate of entropy. Entropy of ideal gas: Sackur-Tetrode equation and Gibbs' paradox. Liouville's Theorem, Stationary ensembles. (6 L)

2. Micro-canonical and canonical ensembles

Micro-canonical ensembles. System in contact with heat reservoir in canonical ensemble, canonical partition function, Helmholtz free energy, Equilibrium properties of ideal systems: Ideal gas, Harmonic Oscillators, rigid rotator, Paramagnetism, Concept of negative temperature, fluctuation of internal energy. (6 L)

3. Grand Canonical Ensemble

System in contact with a particle reservoir, chemical potential, grand canonical partition function and grand potential, fluctuation of particle number. Chemical potential of ideal gas. (3 L)

4.Quantum statistical mechanics

Density Matrix; Quantum Liouville theorem; Statistical and quantum mechanical approach, pure and mixed states, Density matrix for stationary ensembles. Simple examples of density matrices - one electron in a magnetic field, particle in a box; Density matrix for a beam of spin 1/2 particles. Construction of the density matrix for different states (pure and mixture) and calculation of the polarization vector. (8 L)

5. Identical particles

B-E and F-D distributions. General equations of states for ideal quantum systems.(3 L)

Books Recommended:

(1) F. Reif: Fundamental of Statistical and Thermal Physics.
(2) R. Pathria and P. Beal: Statistical Mechanics.
(3) R. Kubo: Statistical Mechanics.
(4) K. Huang: Introduction to Statistical Mechanics
(5) S. Bowley: Introductory Statistical Mechanics.
(6) S. Salinas: Introduction to Statistical Mechanics.
(7) L.D. Landau and E. M. Lifshitz: Statistical Physics.
(8) P. Rudra and N. Rudra: Basic Statistical Physics.

Unit II: Computer Programming and Numerical Methods [25 Marks]

1. Elements of C Programming Language

Algorithms and flowchart, Structure of a high level language program, Features of C language, Constants and variables, Expressions, Input and output statements, Conditional statements and loop statements, Arrays, Functions, Character strings. (10 L)

2. Numerical Analysis

Approximation of numbers, Significant figures, Absolute, Relative & Percentage errors, Round off errors and significant errors. Solution of Polynomial equations – Bisection, Regula-Falsi and Newton-Raphson algorithms. Solution of a system of simultaneous equations- Gauss elimination, Gauss-Seidel algorithms. Interpolation - Newton's Forward & Backward interpolation formulae. Numerical integration – Trapezoidal formula, Simpson's $1/3^{rd}$ & $3/8^{th}$ formula, Romberg formula. Numerical solution of differential equations- Euler and Runge-Kutta formulae. Numerical solution of partial differential equations - discussion of algorithms only. (15 L)

Books Recommended:

(1) B. Gottfried: Programming with C.
(2) E. Balaguruswamy: Programming in ANSI C.
(3) H.M. Antia: Numerical Methods for Scientists and Engineers.
(4) S. Sastry: Introductory Methods of Numerical Analysis.
(5) W.H. Press et al: Numerical Recipes in C.
(6) S.A. Mollah: Numerical Analysis and Computational Procedures.

Paper 302
Unit I: Laser and Nonlinear Optics **[25 Marks]**

1. Lasers

Emission broadening, Absorption and Gain. Homogeneous broadening, Doppler broadening, Threshold requirements, Population rate equations. Population inversion. Creation of population inversion in three level and four level lasers. Pumping requirements. Laser cavity modes, Febry Perot resonator, Laser cavity modes and its properties, Q switching, Mode-Locking, Ruby Laser, He-Ne Laser, Gas Laser. CO_2 laser. Solid State Laser. Nd:YAG laser. Liquid laser. Dye laser. Semiconductor junction laser, Fiber Laser. (12 L)

2. Nonlinear Optics

Origin of nonlinearity. Nonlinear optical materials. Nonlinear polarization. Nonlinear susceptibilities. Self-focussing. Self-phase modulation. Cross-phase modulation. Second harmonic generation. Phase matching. Three-wave mixing. Parametric amplification and oscillation. (6 L)

3. Fibre optics

Dielectric slab waveguide. Modes in the symmetric slab waveguide. TE and TM modes. Modes in the asymmetric slab waveguide. Coupling of the waveguide (edge, prism, grating). Loss in optical fiber, power budget equation, time budget equation, multipath, material and waveguide dispersions, dispersion free optical fiber. (5 L)

4. Detection of optical radiation

Photon detectors (photoconductive, photo voltaic detector and photo-emissive detectors). p-i-n photodiode. APD photodiode. (2 L)

Books recommended:

(1) M. Fox: Quantum Optics.
(2) O. Svelto: Principles of lasers.
(3) P. Miloni and J. Eberly: Laser Physics.
(4) K. Thyagarajan and A.K. Ghatak: Lasers, Theory and Applications
(5) B.B. Laud: Lasers and Non-linear Optics.
(6) D. Mills: Nonlinear Optics.
(7) A. Ghatak and K. Thyagarajan: Introduction to Fibre Optics.

Unit II: Nuclear Physics II **[25 Marks]**

1. Beta and Gamma decay

Fermi's theory of beta decay. Allowed and forbidden transitions. Selection rules. Non-conservation of parity in beta decay. Detection of neutrino. Gamma–decay and selection rules (derivation of transition probabilities not required). Internal conversion. Weisskopf estimates. (5 L)

2. Introduction to experimental methods

Energy loss of charged particles and gamma rays. Ionization formula, Stopping power and range. Radiation detectors and their comparisons for different types of radiation detection: Multiwire proportional counter, Scintillation detector, Semiconductor detector. Basic ideas for energy, timing and position sensitive spectroscopy. (5 L)

3. Reactor Physics

Slowing down of neutrons in a moderator. Average log decrement of energy per collision. Slowing down power. Moderating ratio. Slowing down density. Fermi age equations. Four-factor formula. (5 L)

4. High energy physics

Types of interaction in nature. Typical strengths and timescales. Conservation laws. Charge-conjugation. Parity and Time reversal. CPT theorem, Gell-Mann-Nishijima formula. Intrinsic parity of pions. Resonances. Symmetry classification of elementary particles. Quark hypothesis. Charm, beauty and truth. Gluons. Quark-confinement. Asymptotic freedom. (10 L)

Books Recommended (including books from Nuclear Physics I course)**:**

(1) A. Das and T. Ferbel: Introduction to Nuclear and Particle Physics.
(2) J. Lilley: Nuclear Physics – Principles and Applications.
(3) G.F. Knoll: Radiation, Detection and Measurement.
(4) W.R. Leo: Techniques of Radiation Detection.
(5) J. Dodd: Ideas of Particle Physics.
(6) A. Seiden: Particle Physics.
(7) D.J. Griffiths: An introduction to Particle Physics.
(8) M.P. Khanna: Particle Physics.

Paper 303: Advanced Paper I (Any one unit) **[50 Marks]**

Unit A: Advanced Electronics I

1. IC Technology

Hybrid and monolithic IC. Semiconductor processing: Diffusion, implantation, Oxidation, Epitaxy, lithography. Si IC technology: MOS and Bipolar. Packaging and testing. (4 L)

2. Analog Integrated Circuits

Differential amplifier, OP-AMP comparator. Continuous time filters. Switched capacitance implementation of sample data filters. Analog multiplexers. PLL and frequency synthesizer. (10 L)

3. Digital Integrated Circuits

Logic families – TTL, ECL, MOS, MESFET. Design of combinational and sequential circuits – MUX, decoder/ encoder, registers, counters, gate arrays. Programmable logic devices – PAL, GAL, PLA. Programmable gate arrays. (8 L)

4. Special purpose ICs

ICs for analog communication. Digital signal processing ICs. Basic concepts of MIC, MMIC and OELC. GaAs technology. (6 L)

5. Memories

Sequential and Random access memories. RAM bipolar and MOS static and dynamic memories. Programmable memories: PROM, EPROM, EEPROM. (6 L)

6. Microprocessors and their applications

Architecture of 8 bit (8085) and 16 bit (8086) microprocessors. Addressing modes and assembly language programming of 8085 and 8086. Machine cycles and their timing diagrams. Interfacing concepts. Memory and I/O interfacing. Interrupts and interrupt controllers. Microprocessor based system design. Comparison of different microprocessors. (16 L)

Books Recommended:

(1) Geiger, Allen and Strader: VLI – Design Techniques for Analog and Digital Circuits.
(2) Gray and Meyer: Analysis and Design of Analog Integrated Circuits.
(3) A Mathur: Microprocessors.
(4) R. Gaonkar: Microprocessor Architecture, Programming and Applications with 8085/8085A.
(5) Lin and Gibson: Microprocessor.
(6) S Soelof: Applications of Analog Integrated Circuits.
(7) B. Brey: Intel Microprocessors Architecture, Programming and Interfacing.

Unit B. Photonics I

1. Coherence of light

Mutual coherence function. Complex degree of coherence. Quasi-monochromatic fields and visibility. Spatial coherence of ordinary and laser light. Photon statistics. Poissonian photon statistics. Classification of light by photon statistics. Photon statistics of thermal and laser sources. Brown-Twiss correlations. Photon bunching and antibunching. (9L)

2. Interferometry & Holography

Fabry-Perot interferometer, Mach-Zehnder interferometer, Basic holography equations; Use of coherent light in holography recording ; Advantages of holographic recording over photo graphic recording; Recording and reconstruction processes. (7L)

3. Polarization

Zones Calculus, Mueller Calculus, Poincare sphere. (4L)

4. Optical / Optoelectronic Sources

Direct band gap semiconductors for optical/ optoelectronic sources ; Principle of operation of LED and Semiconductor junction Laser diode ; Internal and External quantum efficiencies of LED, DHLED; Different types of quantum and other efficiencies of Semiconductor junction Laser diode, Equations relating the light intensity of LED and Semiconductor Laser with applied current ; Quantum well laser , Principle of operation of quantum well Laser; Quantum dot. (10L)

5. Optical/optoelectronic detectors

Vacuum photodiodes and photomultipliers; PN junction detectors and its disadvantages ; PiN detectors and its principle of operation ; Quantum efficiency of PiN detectors ; Avalanche photo detector(APD) ; Equations relating the applied light intensity with received photo current of a PiN detector and also that of a Avalanche photo detector ; Dark current of a photo detector ; Shot noise of PiN detector ; Signal to noise ratio of a photo detector; Photo conductor and its function ; Photo transistor and its principle of operation. (10L)

6. Optical modulators

Optical Q- Switching , Different processes of Q- Switching, Optical Mode locking ; Pockels effect and Kerr effect ; Electro-optic modulation by pockels materials ; Phase modulation and Amplitude modulations in Electro-optic modulators ; Modulation of light using optical Kerr effect ; Self focusing, self defocussing ; All- optical switches using Kerr effect , Optical Faraday effect. (10L)

Books Recommended:

(1) John Gower: Optical communication systems
(2) Franz and Jain: Optical Communication Systems.
(3) Gerd Keiser: Optical Fiber Communication
(4) John M. Senior: Optical Fiber Communications
(5) Selvarajan and Kar: Optical Fiber Communications
(6) Ghatak and Thyagrajan: Introduction to Fiber Optics
(7) Wilson and Hawkes: Optoelectronics
(8) Keneth E Jones: Introduction to Optical Electronics
(9) Djafer K Mynbaev and Lowell L Scheiner: Fiber Optic Communication Technology
(10)Ralf Menzel: Photonics Linear And Nonlinear Interactions Of Laser Light And Matter
(11) B. E. A. Saleh M. C. Teich: Fundamentals of Photonics

Unit C: Condensed Matter Physics I

1. Symmetry in crystals
   Crystal geometry; Point groups; Space groups - Glide planes and screw axes, Space group notations, Equivalent points; Systematic absences, Determination of crystal symmetry from systematic absences; Stereographic projections and other Standard projection of crystals. Quasicrystals: general idea, approximate translational and rotational symmetry of two-dimensional Penrose tiling, Frank-Casper phase in metallic glass. (10L)

2. Diffraction of x-rays by crystals
   Scattering of x-rays by an atom and by a three dimensional crystal; Laue interference function; Bragg equation; Ewald construction; Width of diffraction maxima; Crystal structure factor; Space group extinctions; Patterson function; Effect of temperature on the intensity of Bragg reflections; Debye-Waller factor. (10 L)

3. Many body techniques
   The basic Hamiltonian; Jelium Mode; Hatree and Hatree-Fock equation; Interacting electron gas; Hatree-Fock approximations for the electron gas; Excahnge hole and exchange energy; Static screening; Thomas Fermi approximation; Plasma Oscillations; Bohm Pines theory – Random Phase Approximation, plasma oscillations, dielectric function of an electron gas; Linhard dielectric function. (12L)

4. Ferromagnetism and Spin wave
   Spontaneous magnetic orders; Alignment of spins through Heisenberg exchange; Thermal variation of spontaneous magnetization; Spin waves; Magnons; Magnon dispersion relation; Derivation of Bloch $T^{3/2}$ Law; Magnon heat capacity. (6L)

5. Superconductivity
   Electron–electron interaction via lattice; Cooper pairing; BCS Hamiltonian and its diagonalization by Bogoliubov-Valatin transformation; ground state energy; gap equation; critical temperature; isotope effect; magnetic mechanisms of pairing; Ginzburg-Landau theory; Abrikosov vortex lattice; Josephson junction and Josephson effect; "Novel High Temperature" superconductors and applications of high T_c superconductors. (8L)

6. Liquid Crystals
   Isotropic; Nematic and Cholesteric Phases; Smectics –A and –C; Hexatic Phases; Discotic Phases; Lyotropic Liquid Crystals and microemulsions. (4L)

References:

1. V. N. Azaroff – Elements of X-ray Crystalography.
2. B. E.Warren – X-ray Diffraction.
3. O. Madelung – Introduction of Solid State Theory.
4. J. M. Ziman – Principles of the Theory of Solids
5. A. L. Fetter and J.D. Walecka – Quantum Theory of Many Particle Systems.
6. S. Raimes – Many Electron Theory.
7. N.H. March and M. Parrinello – Collective Effects in Solids and Liquids.
8. C. Kittel – Quantum Theory of Solids.
9. D. Pines – Elementary excitations in solids.
10. M. Tinkham – Introduction to Superconductivity.
11. E.B. Priestley, P.J. Wojtowich and P. Sheng: Introduction to Liquid Crystals.

Unit D: Nuclear Structure

1. Nuclear Models

(i) Nuclear shell model:
Individual particle model, Basic idea of an actual calculation (seniority scheme, qualitative discussion of cfp, diagonalization). (10 L)

(ii) Collective model (especially for odd-A nuclei):
Coupling of particle and collective motions, Ground state, beta and gamma bands (rotational). (10 L)

(iii) Nilsson model. (5 L)

(iv) Nuclei far away from the stability valley: Drip line, Extremely neutron rich nuclei, Superheavy nuclei. (5 L)

2. Microscopic Theory

(i) Occupation number representation, One and two-body operators, Matrix elements, Wick's theorem. (12 L)

(ii) Hartree-Fock approximation and HF equations. BCS model. (8 L)

Books Recommended (including books from Nuclear Physics I course)**:**

(1) K. Heyde: The Nuclear Shell Model.
(2) W. Greiner and J.A. Maruhn: Nuclear Models.
(3) S.G. Nilsson and I. Ragnarsson: Shapes and Shells in Nuclear Structure.
(4) M.A. Preston and R.K. Bhaduri: Structure of the Nucleus.
(5) M.K. Pal: Nuclear Structure.
(6) De Shalit and I Talmi: Nuclear Shell Theory.
(7) G.R. Satchler: Introduction to Nuclear Reaction.
(8) C.A. Bertulani and P. Danielewicz: Introduction to Nuclear Reactions.
(9) R. Singh and S.N. Mukherjee: Nuclear Reactions.
(10) A. de-Shalit and H. Feshbach: Theoretical Nuclear Physics vol I.

Paper 304

Advanced Practical I **[50 Marks]**

(At least 5 experiments have to be performed)

Unit A: Advanced Electronics I

1. Design and study of Active low pass filter
2. Design and study of Active band pass filter
3. Design and study of ECL OR/NOR circuit
4. Microwave characteristic study using klystron tube
5. Design and study of shift register
6. Design of analog computer to solve linear simultaneous equations using OP-AMP
7. Design and study of logarithmic and antilogarithmic amplifier.
8. Design and study of current controlled oscillator.

Unit B: Photonics I

1. Optical fiber: mode field diameter and numerical aperture, bend loss measurement;
2. Atomic spectra by constant deviation spectrometer
3. To verify the Malus law
4. Measurement of Brewster angle of a substance and hence determine the refractive index.
5. Fabry-Perot Interferometer
6. Mach-Zehnder interferometer
7. Jamin's interferometer
8. Holography: construction of the hologram and reconstruction of the object beam
9. To determine the distance between the grooves of a compact disk.
10. To find the wavelength of an unknown light source using compact disk.
11. Determination of the particle size of a material (supplied).
12. Determination of spot size and angle of divergence of a given laser source.

Unit C: Condensed Matter Physics – I

1. Determination of the spectroscopic splitting factor of a given sample using electron spin resonance (ESR) spectrometer.
2. To use nuclear magnetic resonance (NMR) for the study of solids.
3. Determination of saturation magnetization, retentivity and coercivity of given ferromagnetic samples using hysteresis loop tracer.
4. Determination of magnetic susceptibility of paramagnetic salts by Guoy Balance method.
5. Study of colour centers and thermoluminiscence of alkali halides.
6. Determination of Miller indices and lattice parameter of a polycrystalline material using X-ray diffractometer.
7. Determination of grain size and lattice strain of polycrystalline material applying MARQ2 software and Scherrer equation.
8. Determination of phase transition temperatures of a binary liquid crystal mixture at different concentrations.

Unit D: Nuclear Structure

1. Alpha particle absorption using surface barrier detectors and multichannel analyser.
2. Alpha particle spectroscopy with ^{241}Am source and calculation of branching ratio.
3. Measurement of half life of ^{40}K using beta counting.
4. Study of conversion electron spectrum of ^{57}Co.
5. Gamma spectroscopy: (a) study of energy resolution at different amplifier gains, (b) energy calibration for a fixed gain, (c) study of ^{22}Na source spectrum and determination of the activity from sum peak analysis.
6. Beta-gamma coincidence measurements: study of decay schemes and lifetime of nuclear levels.

Paper 305 **[50 marks]**
Computer Practical

Several numerical methods will be tasted in the computer lab namely, numerical differentiation and integration, solution of first-order differential equations, interpolation and extrapolation, least square fitting, Monte Carlo Technique etc.

SEMESTER IV (Total 250 Marks)

Paper 401
Unit I: Statistical Mechanics II [25 Marks]

1. Ideal Bose and Fermi Gases

Properties of ideal Bose gas: Bose-Einstein condensation. Transition in liquid He^4, Superfluidity in He^4. Photon gas, Planck's radiation law. Phonon gas, Debye's theory of specific heat of solids. Properties of ideal Fermi gas: Fermi gas at finite temperature. Review of the thermal and electrical properties of an ideal electron gas. Landau levels, Landau diamagnetism. (9L)

2. Strongly interacting systems

Ising model. Idea of exchange interaction and Heisenberg Hamiltonian. Ising Hamiltonian as a truncated Heisenberg Hamiltonian. Exact solution of one-dimensional Ising system (Matrix method). Bragg-William's approximation (Mean field theory) and the Bethe-Peierls approximation. (6L)

3. Phase transition

General remarks. Critical relations and scaling relations. Landau's order parameter theory of phase transition, Calculation of exponents from mean field theory and Landau's theory. (4L)

4. Irreversible Thermodynamics

Thermodynamic fluctuations, Flux and affinity. Onsager reciprocity theorem (proof not required). Spatial correlations in a fluid. Brownian motion. (6L)

Books Recommended

(1) S. Bowley: Introductory Statistical Mechanics (Oxford University Press).
(2) R. Pathria: Statistical Mechanics
(3 K. Huang: Introduction to Statistical Mechanics
(4) F. Mandl: Statistical Physics.
(5) H.E. Stanley: Introduction to Phase Transitions and Critical Phenomena
(6) J.M. Yeomans: Statistical Mechanics of Phase Transitions
(7) L.D. Landau and E. M. Lifshitz: Statistical Physics.

Unit II: Advanced Quantum Mechanics **[25 Marks]**

1. Relativistic quantum mechanics

The Klein-Gordon equation. Covariant notation. Probability density. Negative energy solution. The Dirac equation. Properties of the Dirac matrices. The Dirac particle in an electromagnetic field. The magnetic moment of the electron. (5 L)

2. Covariant form of the Dirac equation

Lorentz covariance. Rotation, parity and time reversal operations on the Dirac wavefunction. Conjugate Dirac spinor and its Lorentz transformation. The $\Gamma 5$ matrix and its properties. Bilinear covariants and their transformation under parity and infinitesimal Lorentz transformation. (6 L)

3. Plane wave solutions of the Dirac equation and their properties

Energy and projection operators. Dirac's hole theory. Charge conjugation. Feynman-Stuckelberg interpretation of negative energy states and the concept of antiparticles. (4 L)

4. Non-relativistic limit of the Dirac equation

Large and small components. Spin-orbit interaction from Dirac equation. Foldy-Wouthuysen transformations for a free particle and for a particle in a field. Electon in a central electrostatic potential. Hyperfine structure of hydrogenic atoms. (5 L)

5. Concept of field

Lagrangian dynamics of classical fields. Euler-Lagrange equation. Lagrangians and equations of motion of fundamental fields. Noether's theorem. Conserved currents and charges. Energy-momentum tensor and energy of fields. Second quantization of KG & Dirac equations. (5 L)

Books Recommended:

(1) J. Bjorken and S. Drell: Relativistic Quantum Mechanics.
(2) J. Sakurai: Advanced Quantum Mechanics.
(3) W. Greiner: Relativistic Quantum Mechanics.
(4) F. Gross: Relativistic Quantum Mechanics and Field Theory.
(5) M. Srednicki Quantum Field Theory

Paper 402: Elective Paper (Any one unit) **[50 Marks]**

Unit 1: Electronics and Instrumentation

1. Microwave Devices
Klystron, Reflex Klystron, magnetrons, Travelling wave tubes, Gunn, Impatt, Trapatt, transistors, GaAs-InP FET, HEMT, BARITT. (9 L)

2. Optical Devices
Laser and Laser resonator, LEDs, Photodiodes, APD, Photo conductor, Phototransistor, LIDAR. (6 L)

3. Microwave measurements
Frequency, power, impedance. (3 L)

4. Optical modulator
Electro optics modulation (amplitude and phase), Kerr modulator. (3 L)

5. Optical coupler
3db directional coupler details. (3 L)

6. Integrated optics
Basic idea. (2 L)

7. Analysis of networks and systems:
Sample data system. Z- transform, Fourier and Laplace transforms. (8 L)

8. Wave guide and transmission networks
Coaxial, rectangular and cylindrical wave guides. Resonators. Filters. Couplers. Branching networks. Antennas: dipole, array, reflectors, steering strip, microstrip and coplanar structure. (10 L)

9. Feedback control systems
Feedback system. Stability. Performance criteria. Servo systems. Automatic control principle. (6 L)

Books Recommended:
(1) P. Bhattacharya: Semiconductor optoelectronic devices.
(2) R.E. Collin: Foundations of Microwave engineering.
(3) S.Y. Liao :Microwave Devices on circuits.
(4) J. Ryder: Networks, Lines and Field.
(5) A. Papoulis: Signal Analysis.
(6) F.E. Terman: Electronic and Radio Engineering.

Unit 2: Relativity, Cosmology and Astrophysics.

1. Relativity

(i) Review of special theory of relativity

Poincare and Minkowski's 4-dimensional formulation. Geometrical representation of Lorentz transformations in Minkowski's space. Length contraction. Time dilation. Causality. Time-like and space-like vectors. Newton's second law of motion expressed in terms of 4-vectors. (4 L)

(ii) Tensor calculus

Idea of Euclidean and non-Euclidean space. Meaning of parallel transport and covariant derivatives. Geodesics and autoparallel curves. Curvature tensor and its properties. Bianchi Identities. Vanishing of Riemann-Christoffel tensor as the necessary and sufficient condition of flatness. Ricci tensor. Einstein tensor. (6L)

(iii) Einstein's field equations

Inconsistency of Newtonian gravitation with the special theory of relativity. Principles of equivalence. Principle of general covariance. Metric tensors and Newtonian Gravitational potential. Logical steps leading to Einstein's field equations of gravitation. Einstein's equation from action principle, Linearised equation for weak fields. Poisson's equation. (5L)

(iv) Applications of general relativity

Observational tests of Einstein's theory, gravitational lensing, Schwarzschild's exterior solution. Singularity. Event horizon and black holes. Isotropic coordinates. Birkhoff's theorem. static and rotating black holes (Schwarzschild and Reissner-Nordstrom). Kerr metric (derivation not required), event horizon. Kerr-Neumann Metric (no derivation). No hair theorem. Cosmic censorship hypothesis. (4L)

2. Cosmology

Cosmological principles. Weyl postulates. Robertson-Walker metric (derivation is not required). Cosmological parameters. Static universe. Expanding universe. Open and closed universe. Cosmological red shift. Hubble's law. Olber's paradox. Brief discussions on: Big bang, Early universe (thermal history and nucleosynthesis), Cosmic microwave background radiation, Particle horizon. (6 L)

PTO

3. Astrophysics

(i) Stellar Structure and Evolution:

(a) Star formation. Stellar Magnitudes. Classification of stars. H-D classification. Saha's equation of ionization. Hertzsprung-Russel (H-R) diagram.

(b) Gravitational energy, Virial theorem, Equations of stellar structure and evolution.

(c) Pre-main sequence evolution, Jeans criteria for star formation, fragmentation and adiabatic contraction, Evolution on the main sequence, Post main sequence evolution, Polytropic Models. Lane-Emden equation. Simple stellar models. Eddington's model and Homologous model, Convective and Radiative stars, Pre-main sequence contraction: Hayashi and Henyey tracks. (13 L)

(ii) Nuclear Astrophysics

Thermonuclear reactions in stars, pp chains and CNO cycle. Solar Neutrino problem. Thermonuclear reactions. Helium burning and onwards. Nucleosynthesis beyond iron, r- and s- processes. (6 L)

(iii) Stellar objects and stellar explosions

Brief discussions on: Galaxies, Nebulae, Quasars, Brown dwarfs, Red giant stars, Nova, Supernova, White dwarf and Chandrasekhar limit, Pulsars, neutron stars and black holes. (6 L)

Books Recommended:

(1) J.B. Hartle: Gravity.
(2) B. Schutz: A first course on general relativity.
(3) S. Banerjee and A. Banerjee: General Relativity and Cosmology.
(4) S. Shapiro and S. Teukolky: Black Holes, White Dwarfs and Neutron Stars.
(5) S. Weinberg: Gravitation and Cosmology.
(6) Ray D'Inverno : Introducing Einstein's Relativity.
(7) Ashok Das: Lectures on Gravitation.

(8) S. Weinberg: The first three minutes.
(9) H. Karttunen et al: Fundamental Astronomy.
(10) K. Abhyankar: Astrophysics – Stars and Galaxies.
(11) H. Reeves: Stellar evolution and Nucleosynthesis.
(12) A.C. Phillips: The Physics of Stars.
(13) Carrol & Ostile: An introduction to modern astrophysics
(14) T. Padmanabhan: Theoretical Astrophysics, vols. 1-3.
(15) M. Harwitt: Astrophysical Concepts.

Unit 3: Dynamical Systems

1. Introduction

Importance and applicability (a) One-dimensional flows

Flows on the line, Geometric way of thinking, Fixed points and stability, Examples like population growth, Linear stability analysis, Existence and uniqueness, Impossibility of oscillations, Potentials, Solving on the computer.

(b) Bifurcations

Bifurcations in one dimensional systems and their classifications, e.g, Saddle-Node, Transcritical, Normal forms, Laser threshold, Pitchfork bifurcation.

(c) Flows on the Circle

Examples and Definitions, Uniform Oscillator, Nonuniform Oscillator. (15L)

2. Two-Dimensional Flows

Linear Systems, Classification

(a) Phase Plane, Phase Portraits, Existence, Uniqueness and topological consequences, Fixed points and Linearization, Rabbit vs sheep, Conservative systems, Reversible systems, Pendulum.

(b) Limit cycles, Ruling out closed orbits, Poincare-Bendixon theorem.

(c) Bifurcations revisited : Saddle-Node, Transcritical, Pitchfork bifurcations, Hopf Bifurcation. (12L)

3. Chaos

Lorenz equation, Chaotic Waterwheel, Simple properties of the Lorenz equations, Chaos on a strange attractor, Lorenz map. (8L)

4. Irreversible processes, Fluctuations and Stochastic Dynamics

Brownian motion, Langevin equation, Applications, Fokker-Planck equation, Examples and applications. (15L)

Books Recommended:

1. S. Strogatz: Nonlinear Dynamics and Chaos
2. M.W. Hirsch et al: Differential equations, Dynamical systems and an introduction to Chaos.
3. R. Hilborn: Chaos and Nonlinear Dynamics.
4. M. Lakshmanan and S. Rajasekar: Nonlinear Dynamics.
5. Jordan and Smith: Differential Equations and Nonlinear Dynamics
6. E. Ott: Chaos in Dynamical Systems
7. Alligood, Sauer, Yorke: Chaos: An introduction to dynamical systems
8. F. Reif: Statistical and Thermal Physics
9. J.K. Bhattacharjee: Statistical Physics
10. J.K. Bhattacharjee and S. Bhattacharyya: Nonlinear Dynamics.

Unit 4: Advanced Classical Electrodynamics

1. Scattering from a free electron

Thomson scattering. Scattering from a bound electron. Rayleigh scattering. Absorption of radiation by a bound electron. Normal and anomalous dispersion. Lorentz's electromagnetic theory. Causality and dispersion relations. Kramers-Kronig relations. (10 L)

2. Magnetohydrodynamics

Magnetohydrodynamic (MHD) equations. Magnetic diffusion, viscosity and pressure. Magnetic Reynolds number. MHD flow between boundaries with crossed electric and magnetic fields. Hartman number. MHD waves. Alfven waves. (10 L)

3. Plasma Physics

Quasineutrality of a Plasma. Charged particles in homogeneous and inhomogeneous magnetic fields. Adiabatic invariance of flux through an orbit. Magnetic mirror. Plasma as a conducting fluid. Pinch effect. Instability in a pinched plasma column. Plasma oscillations. Short wavelength limit. Debye screening length. Propagation of electromagnetic waves through plasma. Effect of external magnetic field on wave propagations. Ordinary and extraordinary rays. (20 L)

4. Relativistic electrodynamics

Field invariants; Covariance of Lorentz force equation and the equation of motion of a charged particle in an electromagnetic field; The generalised momentum; Energy-momentum tensor and the conservation laws for the electromagnetic field; Relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field. (10 L)

Books Recommended (including books from Classical Electrodynamics course)**:**

(1) L.D. Landau and E.M. Lifshitz: (i) Electrodynamics of Continuous Media, and
(ii) Classical theory of fields.
(2) J. Marion: Classical Electromagnetic Radiation.
(3) C.A. Brau: Modern Problems in Classical Electrodynamics.
(4) Chen: Plasma Physics.
(5) J.A. Bittencourt: Fundamentals of Plasma Physics.

Paper 403: Advanced Paper II (Any one unit) **[50 Marks]**

Unit A: Advanced Electronics II

1.Linear modulation, Exponential modulation
FM and PM; AM and FM modulators and demodulators. (3 L)

2. Pulse Modulation and Demodulation Techniques
Sampling the rein PAM, PWM, PPM, Pulse code modulation – coding technique. Modulation and demodulation. (5 L)

3. Digital Modulation Techniques
Principles of ASK, FSK, PSK, DPSK, QPSK, MSK. Modulators and demodulators. (7 L)

4. Effect of Noise on Communication System
Characteristics of additive noise; Performance of AM, FM and PCM receivers in the face of noise. Multi-path effect. (5 L)

5. Elements of Information Theory
Information, average information, information rate, Effect of coding on average information per bit. Shanon's theorem; Channel capacity. Optimum modulation system in AWGN channel. (5 L)

6. TV Systems
Color TV standards – NTSC, PAL, SECAM; Transmission format of intensity and color signal. Transmitter and receiver systems of broadcast TV. Advanced TV. Cable TV. (5 L)

7. RADAR System
Types of RADAR (CW, MTI, FM & Chirp pulse radar), Radar system and range equation. (4L)

8. Optical Communication
Types of optical fibres, numerical aperture and pulse broadening, propagation of EM waves in planar optical wave guide, V-parameter, power associated with modes, Multiplier and demultiplexer, Fibre optic communications, direct and coherent detections, signal-to-noise ratio. LIDAR and submarine communication (idea only). (6L)

9. Satellite Communication
Orbits, Station keeping. Satellite attitude. Path loss calculation. Link equation. Multiple access techniques. Transponders. Effects of nonlinearity of transponders. (4 L)

10. Specialized Communication Systems

Mobile Communication – Concepts of cell and frequency reuse description of cellular communication, development of mobile generation 1G to 5G (idea only).

Computer communication – Types of networks. Circuit message and packet switched networks. Features of network, design and examples of ARPANET, LAN, ISDN, Medium access techniques – TDMA, FDMA, Basics of protocol. (6 L)

Books Recommended:

(1) A. Carlson: Communication Systems.
(2) S. Haykin: Communication Systems.
(3) D. Roddy and J. Coolen: Electronic Communications.
(4) Franz and Jain: Optical Communication Systems.
(5) A. Dhake: Television and Video Engineering.
(6) Gulati: Monochrome and Color TV.
(7) Kennedy and Davis; Electronic Communication Systems.
(8) Taub and Schilling: Principle of Communication Systems.
(9) B. P. Lathi: Modern Digital and Analog Communication Systems.

Unit B: Photonics II

1. Nonlinear optics

Review of Nonlinear optics, Parametric generation of light, Crystal optics, Nonlinear optics in Crystals, 2HG in KDP, Pockels cell and Pockels effect, Stimulated Raman Scattering. (5 L)

2. Non-linear Optical fiber

Step index optical fiber ; Concept of TEM modes in cylindrical fiber; Optical communication through wave guide ; Types of optical fiber ; Losses in optical fiber: Propagation of electromagnetic radiation through a planar waveguide; concept of TE and TM modes ; Propagation of electromagnetic radiation through 3-dimensional cylindrical waveguide, Dispersion in optical fiber; multi-mode dispersion, material dispersion, and wave guide dispersion; Derivation of the expressions of the three dispersions; Dispersion free fiber and dispersion compensated fiber; Propagation of electromagnetic radiation through nonlinear wave guide; Nonlinear Schrodinger equation; Optical soliton formation; Wavelength division multiplexing and demultiplexing. (16 L)

3. Optical amplifiers

Semiconductor Optical Amplifier (SOA) and its operation ; Self phase modulation, cross phase modulation , Cross gain modulation and wavelength conversion of SOA ; Erbium doped fiber amplifier (EDFA) and its principle of operation. (5 L)

4. Photonic measurement systems

Homodyne and Heterodyne detectors for phase and intensity measurements of light , Optical time domain reflectometer (OTDR). (4 L)

5. Optical devices and sensors

Principle of operation of Liquid Crystal Display; Charge Coupled Devices ; Fiber optic displacement, current , pressure and temperature sensors . optical directional coupler, optical biological sensor. (7 L)

6. Optical Communication

Optical free space communication; Components of coherent communication systems ; Coherent signal, Transmitter, transmission channel, coherent receivers; Probability error and bit error rate; Calculation of Worst-case bit error rate; maximum bit rate and bit error rate in digital communication through optical fiber; Power budget equation and Time budget equation. LIDAR, Optical free-space communication, Optical submarine communication. (8 L)

7. Optical Networks

Local area network, Broadcast and distribution network; Optical Bus topology (Single fiber and dual fiber bus topologies). (5 L)

Recommended Books :

(1) A. Yariv and P.Yeh (Oxford University Press , 2007)- Photonics : Optical electronics in modern communication.

(2) J. Wilson and J.F.B.Hawkes (Prentice Hall Europe, 1998)- Optoelectronics : An introduction .

(3) C.K. Sarkar (New Age international (p) Limited , 2004)- Opto Electronics And Fiber Optics Communication.

(4) J Franz and V K Jain (NAROSA ,1996)-Optical Communication Systems.

Unit C: Condensed Matter Physics II

1. Lattice dynamics
   Equation of motion of a vibrating lattice, Harmonic approximation; Atomic force constants; Dynamical matrix; Central and non-central forces; Dispersion relation; Vibrational properties of square and cubic lattices, Acoustic and optical modes; Quantisation of lattice vibration; Optical modes in ionic crystals; The Lyddane-Sachs-Teller relation; Polaritons; Localised lattice vibrations; Frequency distribution function, Van Hovesingularities; Thermodynamic functions of a vibrating solid in the harmonic approximation; Anharmonic interaction; Gruneisen constant, Mie-Gruneisen equation of state; Slow neutron scasttering in solids, Elastic/inelastic and Coherent/incoherent scattering. (10L)

2. Transport properties of solids
   Boltzmann transport equation and its linearization; The relaxation time approximation; Variational method for the solution of the linearized Boltzmann equation; Electron-phonon interaction; Ideal resistance in metals; Mattheissen's rule; Transport coefficients of metals and semiconductors in presence of magnetic field; Limitations of the Boltzmann transport equation; Kubo formula for electrical conductivity. (8L)

3. Optical properties of solids
   The dielectric function – the dielectric function for a harmonic oscillator, dielectric losses of electrons, Kramers-Kronig relations; Interaction of phonons and electrons with photons; Interband transition – direct and indirect transition; Absorption in insulators; Polaritons; One-phonon absorption; Optical properties of metals, skin effect and anomalous skin effect. (7L)

4. Energy bands
   Different methods of calculation of energy bands in solids – Nearly free electron model, Tight bibdibg approximation, Orthogonalised plane wave (OPW) method and Pseudo-potential methods; Phillops-Kleiman's cancellation: Qualitative discussions of band structures of semiconductor, semi-metal and insulator, Dynamics of an electron in a crystal, Effective mass tensor. (8L)

5. Density Functional Theory
   Basics of DFT, Comparison with conventional wave function approach, Hohenberg-Kohn Theorem; Kohn-Sham Equation; Thomas-Fermi approximation and beyond; Practical DFT in a many body calculation and its reliability. (7L)

6. Advanced materials/phenomena
   Spintronics, Multiferroics, Gaint magnetoresistance (GMR), Colossal magnetoresistance (CMR), La-based Perovskite, Nanostructured Materials, Carbon nanotube, and Fullerine. (5L)

7. Introduction to Experimental Techniques in Condensed Matter Physics
   Measurement of DC and AC susceptibilities, Superconducting quantum interference device (SQUID), VSMO; Electron Microscopy – Transmission Electron and Scanning Electron Microscopy; Optical spectroscopy – UV-VIS-IR and Raman Spectroscopy; Surface techniques – Atomic Force Microscopy (AFM) and Scaning Tunneling Microscopy (STM). (5L)

Recommended Books

1. M. Sachs – Solid State Theory.
2. A.O.E. Animalu – Intermediate Quantum Theory of Crystalline Solids.
3. N.W. Ashcroft and N.D. Mermin – Solid State Physics.
4. O. Madelung – Introduction of Solid State Theory.
5. J.M. Ziman – Principles of the Theory of Solids.
6. C. Kittel – Introduction to Solid State Physics.
7. W. D. Callister – Materials Science & Engineering.
8. C.N.R. Rao and B. Raveau: Colossal Magnetoresistance, Charge Density and Related Properties of Manganese Oxides.
9. J.H. Fendler: Nanoparticles and Nanostructured Films: Preparation, Characterization and Applications.
10. D. P. Woodruff and T. A. Delchar – Modern techniques of surface science.

Unit D: Nuclear Reaction

(a) Introduction (10 L)

(i) Survey of reactions of nuclei Strong, electromagnetic and weak processes, Types of reactions and Q-values, Reaction mechanisms: Energy and time scales for direct and compound reactions,

(ii) Experimental observables: Cross section, Angular distributions, Excitation functions.

(b) Models for nuclear reactions Direct reactions (20 L)

(i) Optical Model:
From Hamiltonian to cross-sections for elastic scattering; Partial waves, Phase shifts, Scattering amplitudes, S-matrix and its symmetry and reciprocity; Angular distributions, Optical potential, idea of barrier penetration.

(ii) Green functions methods:
T-matrix expression, Two potential formula, Plane-wave and distorted-wave Born series.

(iii) Connection with nuclear structure:
Reference to folded potential, Nuclear density, Inelastic excitation, Electric BE(k) and nuclear deformations, transfer reactions, Spectroscopic factors, Asymptotic normalization constant (ANC), Giant resonances, Doorway states.

(iv) Compound nuclear reactions : Statistical model, Hauser-Feshback formalism.

(v) R-matrix methods: Dispersion theory, One level formula.

(c) Heavy Ion collisions (10 L)

(i) Collisions near the Coulomb barrier: Semi-classical concepts, Elastic scattering, Coulomb excitation, Deep inelastic collisions, Fusion, Collisions near the Fermi velocity,

(ii) Collisions near the speed of light: Classifications of reactions and products. Ultra relativistic nuclear collisions: Phase diagram of nuclear matter.

(d) Nuclear Fission Spontaneous Fission, Mass energy distribution of fission fragments, Bohr-Wheeler theory, Fission isobars, Super-heavy nuclei. (6 L)

(e) Reactions involving exotic nuclei. (4 L)

Books Recommended (including books from Nuclear Physics I course)**:**

(1) W. Meyerhof: Elements of Nuclear Physics.
(2) G.R. Satchler: Introduction to Nuclear Reactions.
(3) C.A. Bertulani and P. Danielewicz: Introduction to Nuclear Reactions.
(4) R. Singh and S.N. Mukherjee: Nuclear Reactions.
(5) Jackson: Nuclear Reactions.
(6) I.J. Thompson and F.M. Nunes: Nuclear Reactions for Astrophysics.
(7) N.K. Glendenning: Direct Nuclear Reactions.
(8) A. de-Shalit and H. Feshbach: Theoretical Nuclear Physics vol II.

Paper 404

Advanced Practical II **[50 Marks]**

(At least 5 experiments have to be performed)

Unit A: Advanced Electronics

1. Design and study of Wien bridge oscillator.
2. Design and study of RC phase shift oscillator.
3. Design and study of active phase shifter.
4. Design and study of digital to analog converter.
5. Design and study of 4-bit ripple counter.
6. Design of analog computer to solve differential equation using OP-AMP.
7. Experiments on microprocessor interfacing.
8. Problems on assembly language programming using 8085 microprocessor.
9. Studies on LED and LED based circuits.

Unit B: Photonics II

1. Studies on LED and LED based circuits.
2. Characterization of quantum dot structures.
3. Atomic spectra by constant deviation spectrometer
4. Fraunhofer diffraction and Bragg diffraction using microwave
5. Determination of energy band gap of semiconductor by studying the photoluminescence spectra.
6. Synthesis of nanoparticles using laser ablation technique and study of their optical nonlinearity.
7. Study of Pockels effect.
8. Studies on PIN Photodetector and PD based circuits
9. Signal transmission employing optical communication system.

Unit C: Condensed Matter Physics - II

1. Study of the electrical properties of given thin films of different materials (metal, insulator or semiconductor) using four probe technique.
2. Study of the variation of Hall Coefficient of a given semiconductor as a function of temperature.
3. Determination of magnetoresistance of a given semiconductor for different magnetic fields.
4. Determination of the dielectric constant of a solid.
5. Measurement of absorption spectra and determination of the band gap energy and thickness of a given semiconductor film using dual beam UV-VIS spectrophotometer.
6. Determination of size and size distribution of semiconductor nanoparticles, prepared by chemical rout, by studying the optical absorption spectra using dual beam UV-VIS spectrophotometer.
7. Determination of energy band gap of semiconductor by studying the photoluminescence spectra.
8. Synthesis of nanoparticles using laser ablation technique and their characterization.

9. FTIR study of Si based oxide/carbon nanocomposites.
10. Experimental verification of tunnelling of electrons using STM spectroscopy.
11. Surface imaging of single crystalline materials using STM.

Unit D: Nuclear Reaction

1. Study of Compton scattering: (a) angle dependence of Compton shift and scattering cross section, (b) determination of the classical electron radius.
2. Beta spectroscopy using surface barrier detectors and multichannel analyser.
3. Determination of end point energy of the ^{204}Tl β spectrum from its Fermi-Kurie plot.
4. Gamma spectroscopy: (a) study of energy resolution at different shaping times, (b) Study of spectrum of ^{60}Co source and determination of the relative full energy peak efficiency.
5. Gamma spectroscopy: (a) Calibration of NaI(Tl) spectrometer and determine energies of the gamma-rays emitted from an unknown source, (b) Study of variation of energy resolution with gamma energy.
6. Gamma-gamma coincidence measurements: (a) Determination of resolving time of the coincidence setup, (b) Study of angular correlation of two positron annihilation gammas from ^{22}Na source.

Paper 405

Unit I - Project/Term paper **[25 Marks]**

Project/Term paper to be made on the basis of subject-interest of the students in different areas of Physics discipline and under the supervision of a teacher of the department. Seminar talk based on the Project/Term paper work to be conducted by the department. Record to be maintained by the department.

Unit II - Grand Viva **[25 Marks]**

Grand Viva is to be conducted by the Department. At least one external examiner should be appointed for the Grand-Viva. Students may be asked questions from any part of the MSc syllabus. However, any relevant question outside the mentioned syllabus may also be asked.

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