M.Sc. Physics

ourse / it paper	*Subject / Topics*	*Credit Point*	*Class Test (20%)*		*Written Exam. (80%)*	*Total Marks*
Jnit-1	Mathematical Methods	**3**	**15**		**60**	**75**
Jnit-2	Classical Mechanics	**3**	**15**		**60**	**75**
Jnit-3	Quantum Mechanics 1	**3**	**15**		**60**	**75**
Jnit-4	Electronics	**3**	**15**		**60**	**75**
Jnit-5	**Practical :** Electronics and Solid State – group A Students only Or Nuclear Physics and Optics – Group B students only	**4**	Internal Assessment-1 (Performance) **20**		Experiment in Examination **80**	**100**
T Sem.		**16**				**400**

Unit – 1: Mathematical Methods

Full Marks: 75 **Credit points: 3**

Module-I

Group Theory : Group of transformation, generators of a group, classes, subgroups, costs, factor groups, direct product, permutation groups, isomorphism and homomorphism, reducible and irreducible representation.

Analysis: Point set, neighborhood, isolated point, limit point etc. Convergence of a sequence, infinite series, absolute convergence and conditioned convergence test of convergence (ratio test, Cauchys root test, Raabes test).

Functions of Complex Variables: (a) Limit, continuity, differentiability, analyticity, necessary and sufficient condition for analytic function, Cauchy-Riemann conditions; multivaluedness of functions, singularities, branch points and cuts, Riemann sheets.

(b) Jordan curve; rectifiable arc and its length; contours; Riemanns definition of integration and the integrability of a function; Primitive function, Darboux inequality, simply and multiply connected domains.

Module-II

Complex integrals : Cauchys theorem, Cauchys integral formula; derivatives of an analytic function; Liouvillestheorem; indefinite integrals; Moreras theorem, Taylors theorem and Laurents Theorem; zeros and singularities of a function; essential singularity; limiting points of zeroes and poles; Weierstrass theorem; the point at infinity.

Calculus of Residues : Residue and evaluation of residue; Cauchys residue theorem; evaluation of definite integrals by the method of contour integration (including integration around branch cuts); evaluation of principal values of improper integrals; summation and inversion of series; partial fraction representation of meromorphic functions; infinite product representation of entire functions (MittagLeffler Expansion).

Module III

Analytic Continuation: Definition and some elementary theorems; Schwarz reflection principle; power series method of analytic continuation, Gamma and Beta functions definitions and properties, Asymptotic Expansion: Definition and some illustrations; saddle point expansion method.

Linear Ordinary Differential Equations (Second Order): Linear independence of solution; number of solutions and the Wronskian; Wronskian method of obtaining the second solution. Classification of singularities of differential equation: Ordinary points; regular and irregular singularities; series solutions about ordinary and regular singular points; convergence and analyticity properties of series solutions Fuchs theorem; Frobenius method of obtaining the second solution, self adjoint operator; the Sturm Liouville problem, boundary conditions (Dirichlet, Neumann and Cauchy Problem).

Module IV

Series solution of differential equation and Special Functions: Hyper-geometric and confluent hypergeometric functions; Legendre functions (including associated Legendre functions and spherical harmonics) Bessel functions (including spherical Bessel functions); Hankel function and modified Bessel functions. Hermite and Laguerre functions (including associated Laguerre functions); Generating functions; recursion relation; orthonormality; asymptotic behavior; graphical representation.

References:

1. Mathews and Walker: Mathematical Methods of Physics – Benjamin

2. Arfken and Weber: Mathematical methods for Physicists – Academic Press

3. Morse and Feshbach: Methods of Theoretical Physics – McGraw Hill.

4. Pipes and Harvil: Applied Mathematics for Physicists and Engineers – McGraw Hill Kogakusha.

5. Harper: Introduction to Mathematical Physics – Prentice Hall.

6. Chattopadhayay:Mathematical Methods of Physics - New Age International.

7. Courant and Hilbert: Methods of Mathematical Physics – John Wiley.

8. Smirnov: Course on Higher Mathematics – Pergamon.

9. Lang: Linear Algebra - Addison Wesley

10. Finkbeiner:Matricesand Linear transformations – Taraporevala

11. Whittaker and Watson: A Course in Modern Analysis – Cambridge

12. Copson: Theory of Functions of a Complex Variable – Oxford

13. Tichmarsh: Theory of Functions – Oxford.

Unit – 2:Classical Mechanics

Full Marks: 75 **Credit points: 3**

Module-I

Lagrangian formulation: Problems involving systems with non-holonomic constraints.

TwoBody Central Force Problem : Equivalent one body problem and effective potential; classification of orbits; differential equation for orbits; integrable power law potentials; conditions for closed and stable orbits, Bertrand's theorem, Virial Theorem, Laplace-Runge-Lenz Vector.

Hamilton's Equations of Motion : Legendre transformation; Hessian determinant; Hamiltonian and physical significance; Hamilton's action and the principle of least action; Hamilton's equations of motion and applications; action as a function and Maupertuis principle; conservation theorems; cyclic coordinates and Routh's procedure.

Module-II

Canonical Transformations : Equations of canonical transformation; generating functions; examples of canonical transformations; integral invariants of Poincare; Lagrange and Poisson brackets as canonical invariants; infinitesimal contact transformations; constants of motion and symmetry principles; generators of infinitesimal symmetry transformations.

Hamilton-Jacobi theory : Hamilton's principal and characteristic functions; Hamilton-Jacobi equations for these two functions; separation of variables in the Hamilton-Jacobi method (e.g. simple harmonic motion, Kepler problem etc.), Hamilton-Jacobi theory, geometrical optics and wave mechanics.

Module-III

Rigid Body Dynamics: Degrees of freedom; space-fixed and body-fixed set of axesand orthogonal transformation; Euler's angles; Euler's theorem on the motion of a rigid body; infinitesimal rotations. Moments of inertia; eigenvalues of the inertia tensor and principal axes transformations; Lagrange's equations of motion for a rigid body; Euler's equations of motion. Force free motion of a rigid body; heavy symmetrical top with one point fixed; precession and nutation; Larmor precession; gyroscope and asymmetrical top.

Theory of Small Oscillations: Formulation of the problem; eigenvalue equations; frequencies of free vibrations and normal coordinates; forced vibrations and the effect of dissipative forces; simple examples.

Module-IV

Mechanics of Continuous Media: Transition from discrete to continuous systems; the Lagrangian formulation; stress energy tensor and conservation theorems; Hamiltonian formulation; Poisson brackets and momentum representation; examples.

Non-linear Dynamics and Chaos : Non-linear Equations : autonomous systems; critical points; stability; Liapunov direct method; periodic solutions; Poincare Bendixon theorem; limit cycles; Lienard theorem. Non-linear Oscillation and Chaos; Perturbations and the Kolmogorov – Arnold – Moser theorem (no derivation).

Refrences :

1. Goldstein, Poole and Safko: Classical Mechanics – Addison Wesley / Narosa.
2. Landau and Lifshitz : Mechanics – Pergamon.
3. Sommerfeld:Mechanics – Academic Press.
4. Rana and Joag: Classical Mechanics – Tata-McGraw Hill.
5. Whittaker : Analytical Dynamics of Particles and Rigid Bodies – Cambridge.
6. Fetter and Walecka : Theoretical Mechanics of Particles and Continua - McGraw Hill.
7. RaychaudhuriA.K: Classical Mechanics – Oxford.
8. Simmons: Differential Equations – Tata-McGraw Hill.
9. Bhatia: Classical Mechanics – Narosa.

Unit – 3:Quantum Mechanics I

Full Marks: 75 **Credit points: 3**

Module-I

Linear Vector Space formulation : Linear vector space; linear independence of vectors; complete set of states; inner product; dual space; orthogonalisation; linear operators; Hermitian and unitary operators; eigenvectorsandeigenvalues; diagonalization of matrices and Cayley-Hamilton theorem; basic features of the states and eigenvalues of a Hermitian operator.

States and observables: States and observables of a system as vectors and operators respectively, and related discussion; commutation rules and commutator algebra; discussion on the simultaneous eigenstates of two operators; uncertainty relations;

Representations: Matrix representation of operators; change of basis; coordinate representation of states and operators; momentum eigenfunctions; box and delta function normalization; momentum representation.

Module-II

Linear harmonic oscillator: Eigenvalue problem by the operator method and related discussions.

Coherent states etc.: Coherent states; mixed states; density matrix and its properties with examples; use of the density matrix in calculating the average values.

Stationary state problems: Bound and scattering states; reflection and transmission from a potential barrier (finite square well and delta function well and barrier as examples).

Time dependent systems: Expectation values; time dependence of expectation values of observables; time evolution of states; explicit use of the dynamical equation of motion to analyze the physicsof a two state system (the ammonia molecule may be chosen as an example).

Module-III

Schrödinger, Heisenberg and Interaction pictures: Introduction to the three representations; equation of motion in Schrödinger, Heisenberg and Interaction pictures; time translation operator.

Time dependent Schrödinger equation : Single particle system; probability density and current; initial value problems; Greens function; propagator concept; free particle moving in space; Fourier transforms; Gaussian wave packet and its spreading; Ehrenfest theorem.

Module-IV

Angular momentum : Angular momentum as generator of rotation; commutation rules; eigenvalues and matrix representation; orbital angular momentum and its eigen functions; spin angular momentum; algebra of Pauli spin matrices; spin half particle in a magnetic field.

Addition of angular momenta: Clebsch Gordan coefficients; Tensor operators and Wigner-Eckart theorem (statement only).

References:

1. David Griffiths: Introduction to Quantum Mechanics-Pearson Education.
2. Schiff: Quantum Mechanics – McGraw Hill Kogakusha.
3. Merzbacher : Quantum Mechanics – John Wiley.
4. Sakurai: Modern Quantum Mechanics – Addison Wesley.
5. R.P. Feynman: Lectures on Physics, Vol. 3 – Narosa.
6. Schwabl : Quantum Mechanics – Narosa.
7. Bransden and Joachain : Introduction to Quantum Mechanics – Longmans.
8. Landau and Lifshitz : Quantum Mechanics – Pergamon.
9. Davydov: Quantum Mechanics – Pergamon.
10. Gasiorowicz: Quantum Physics – John Wiley.

Unit – 4:Electronics

Full Marks: 75 **Credit points: 3**

Module-I

Power Circuits: Regulated power supply; basic concepts; series and op-amp regulator and SMPS; SCR firing and firing angle, power control.

Integrated Circuits: Fabrication techniques of IC components and devices : LSI,VLSI.

Operational Amplifiers: subtracting amplifier; constant amplitude phase shifter; RC active filters; Instrumentation amplifiers. Non-ideal Op-Amps: Effects of i) finite loop gain, ii) finite input resistance, iii) nonzero output resistance and iv) off-setand drift; common mode rejection ration.

Amplitude Modulation and Detection: sideband, power relation; modulation index, typical amplitude modulation circuit; detection of amplitude modulated waves; envelope; average detection.

Module-II

Network Analysis: Constant k and m derived low and high pass; band pass and band elimination Filters, propagation constants, characteristic impedance for T and II sections, neper and decibel.

Noise: Different sources of noise; signal to noise ratio; definition and calculation of noise figure.

Frequency Modulation and Detection: Concepts of frequency and phase modulation, Frequency spectrum; bandwidth; reactance tube and p-n junction methods of generation of FM waves; Armstrong system; demodulation by staggered, tuned and Foster Seely discriminator circuits.

Antenna and Radar Systems : a) Antenna : Basic considerations; antenna gain; resistance, band width and beam width, high frequency antenna, b) Radio method Detection and Ranging; pulse radar; Block diagram and range equation.

Module-III

Devices: MOSFET, CMOS, UJT, SCR, Triac, Diac, IGBT.

Waveform Generators: Pulse generation and shaping by astable, monostable and bistablemultivibrators; IC555.

Digital Circuits and Systems : bistable latch, flip-flops; SR, JK, Master slave; shift registers; counters (up-down); encoder-decoder; digital to analog converter; summing and R-2R ladder type, analog to digital converter; counting and tracking; Memory cell and array.

Module-IV

Elements of Microprocessors : Basic concepts; block diagram of 8085; instruction set; memory interfacing; machine cycle and timing diagram; idea of assembly language programming.

Transmission Lines, Waveguides and Microwaves: Parallel wire and coaxial lines; transmission line equation; characteristic impedance; propagation constant; high frequency transmission lines; travelling wave interpretation; VSWR : Coefficient of reflection; principle of stub line matching; directional coupler. Rectangular waveguide; waveguide modes; resonant cavities; microwave oscillators; reflex klystron; magnetron.

References:

1. Van der Ziel : Solid State Physical Electronics – Prentice Hall India.
2. Millman and Taub: Digital and Switching Waveforms – McGraw Hill Kogakusha.
3. Taub and Schilling: Digital Integrated Electronics – McGraw Hill Kogakusha.
4. Millman and Halkias: Integrated Electronics – McGraw Hill Kogakusha.
5. Tobey, Graeme and Huelsman : operational Amplifiers – McGraw Hill Kogakusha.
6. Gaekwad : Op –Amps and Linear Integrated Circuits – Prentice Hall India.
7. Jordan and Balmain : Radiation and Radiating Systems – Prentice Hall India.
8. Kennedy : Electronic Communication Systems – Tata McGraw Hill.
9. Taub and Schilling : Principles of Communication Systems – Tata McGraw Hill.
10. Carlson : Communication Systems – Tata McGraw Hill.
11. Haykin ; Communication Systems – John Wiley.
12. Stallings : Data and Computer Communications – Prentice Hall.
13. Gaonkar : Microprocessor Architecture, Programming and Applications with 8085.
14. Ryder : Networks, Lines and Fields – Prentice Hall India.
15. Millman and Grabel : Microelectronics – McGrawHill.
16. Millman : Microelectronics – McGraw Hill.
17. Malvino and Leach :Digital Principles and Applications – Tata McGraw Hill.

18. Terman : Electronic and Radio Engineering - McGraw Hill.

19. Kraus : Antenna – McGraw Hill.

20. Reich, Ordnung and Skalnick : Microwave Principles – Affiliated East West Press.

21. Sarkar : Microwave Propagation and Technique – S. Chand.

22. Ram : Fundamentals of Microprocessors and Microcomputers – D. Rai and Sons.

23. Rafiquazzaman : Microprocessors – Prentice Hall India.

24. Malvino : Digital Computer Electronics – Tata McGraw Hill.

25. Streetman : Solid State Electronic Devices – Prentice Hall India.

Unit – 5: Practical

Full Marks: 100 **Credit points: 4**

Nuclear Physics and Advanced Optics (Group A students only)

List of Experiments:

1. (a) Determination of the Plateau region of a GM tube.

   (b) Analysis of statistical fluctuations at low and high count rates.

2. Determination of the half-life of a long lived radioactive sample (^{40}K).

3. Study of gamma absorption in Aluminium and Lead using a GM tube and determination of the mass absorption coefficient.

4. Study of beta absorption in Aluminium using a GM tube and determination of range and energy of beta particles.

5. a) Calibration of a Michelson interferometer using Na-D lines as standard.

   b) Measurement of d between Na-D lines.

   c) Determination of refractive index/thickness of a thin sheet of a transparent material.

6. Study of spectra of Hydrogen atom using a constant deviation spectrograph/spectrometer, to identify the Rydberg series and to construct its energy level diagram.

7. Study of the molecular spectra of I_2 in absorption and determination of the dissociation energy.

8. Study of emission spectra of Cu and to determine the energy diagram with possible transition.

9. Study of the Zeeman splitting of Na-D lines using a constant deviation spectroscope and Fabry-Perot etalon.

Electronics and Solid State Physics (Group B students only)

List of Experiments:

1. Construction of a power supply with semiconductor devices, zener diodes and using an emitter follower and to study its performance ripple factor, line and load regulations.

2. Construction of a single stage common emitter voltage amplifier, measurement of its gain, input and output impedances and the determination of the gain-band width product using R-C coupling.

3. Experiments on Diac, Triac, SCR and UJT.

4. Design and construction of astablemultivibrator and the study of its characteristics and performance.

5. Experiments on Modulation and demodulation.

6. Study of characteristics of FET and MOSFET and use of these as source followers.

7. To test the performance of digital gates using ICs.
8. Study of OPAMP (IC 741) characteristics and its use as an inverting amplifier, non-inverting amplifier, adder and differential amplifier.
9. Determination of Hall coefficient and carrier concentration.
10. Dielectric constant measurement as a function of temperature.