Physics

Unit-I : Mathematical Physics and Classical Mechanics

1.Vector calculus andcomplex variable :

Vector Calculus, Gauss theorem and Stokes theorem.

Cauchy's theorem, Cauchy's integral formula, classification of singularities, branch point and branch cut, Residue theorem, evaluation of integral using residue theorem.

2. Special functions :

Basic properties and solutions (series expansion, recurrence and orthogonality relations) of Bessel, Legendre, Hermite, Hypergeometric, Confluent hypergeometric and Laguerre functions,

3. Hamilton's principle:

Hamilton's principle, Lagrange's equation from Hamilton's principle,Solution of Lagrange equation of motion for Simple harmonic oscillator. Hamilton'

equations of motion, canonical equations from variational principle, principle of least action

4. Canonical transformation:

Generating function and Legendre transformation, Integral invariant of Poincare, Lagrange and Poisson's brackets, infinitesimal canonical transformation, conservation theorems in Poisson bracket formalism, Jacobi Identity.

5. Coupled oscillations:

Theory of coupled oscillation, Normal modes, Energy relation and transfer.

Unit-II: Classical Electrodynamics

1. Electrostatics and Magnetostatics:

Scalar and vector potential, Gauge transformation, multipole expansion of (i) scalar potential and electrostatic energy due to static charge distribution, (ii) vector potential due to stationary current distribution, Electrostatic and magnetostatic energy, Poynting's theorem, Maxwell's stress tensor.

2. Maxwell's electromagnetic equations-wave equation in conducting medium. Reflection of electromagnetic waves (normal and oblique incidence) from (i) dielectric and (ii) metallic interface.

3. Relativistic electrodynamics:

Equation of motion in an electromagnetic field, electromagnetic field tensor, covariance of Maxwell's equation, Maxwell's equations as equations of motion, Lorentz transformation laws for electromagnetic field, and the fields due to point charge in uniform motion.

4. Radiation, scattering and diffraction:

Field due to localized oscillating source, electric dipole, magnetic dipole, electric quadrupole field radiation, centre-fed linear antenna with sinusoidal current, scattering by a small dielectric sphere in long wave length limit, Raleigh scattering,

5. Radiation from moving Charge:

Lienard Wiechert potential, Field due to a charge moving with velocity, field due to accelerated charge, radiation at low velocities, total power radiated by the accelerated charge, Larmor 's formula and its relativistic generalization, angular distribution of radiation from an accelerated charge, Thomson scattering.

Unit-III: Quantum Mechanics

1. Wave packet:

Gaussian wave packet, spreading of wave packet, coordinate and momentum representation, **x** and **p** in these representation, Dirac delta function,

2. Operator method in Quantum Mechanics:

Formulation of Quantum Mechanics in vector space language, uncertainty product of two arbitrary operators, one dimensional harmonic oscillator by operator method. Matrix representation of operators, Schrodinger, Heisenberg and interaction pictures. Dirac bracket notation.

3. Three dimensional potential well, Radial solution of Hydrogen atom and its total wave function .

4. Angular momentum:

Angular momentum algebra, addition of two angular momenta $j_1=1/2$, $j_2=1/2$. Clebsch–Gordon Coefficients, examples, matrix representation of $j_1=1/2$ and $j_2=1$. Spin angular momentum, Pauli spin matrices and their properties, eigen value and eigen function,

5. Approximation methods:

Time independent perturbation theory, First and second order correction to energy and eigen functions, Degenerate perturbation theory, application to one electron system, Zeeman effect, linear Stark effect.

WKB approximation- connection formulae, barrier penetration and α-decay.

Variational method- He atom as an example.

Time dependent perturbation theory- interaction picture, transition probability, constant and harmonic perturbation, Fermi Golden rule, electric dipole radiation, selection rule.

Unit-IV: Condensed matter Physics, Statistical Mechanics and Electronics

1. Objectives of Classical Statistical Mechanics:

Microstates, macro states, phase space, Liouville's theorem, concept of ensembles, Ergodic hypothesis, postulates of equal a priory probability, Boltzmann's postulates of entropy, micro canonical ensemble, entropy of ideal gas, Gibb's paradox, Sakur-Tetrode equation,

Canonical ensemble:

Expression for entropy, canonical partition function, Helmholtz free energy, energy fluctuation,

Grand canonical ensemble:

Grand canonical partition function, chemical potential, density fluctuation, chemical potential of an ideal gas.

2. Digital Circuits

Logic fundamentals, Boolean theorem, Logic gates-RTL,DTL,TTL, RS flipflop, JK flip-flops

Boolean algebra, De Morgan theorem, AND,NAND,NOT,NOR gates(CMOS,NMOS), MOS circuits, two phase inverter, dynamic MOS shift register.

3. Lattice Dynamics:

Classical theory of lattice vibration under harmonic approximation, vibration of linear mono atomic and diatomic lattices, acoustical and optical modes, optical properties of ionic crystal in the infrared region, normal modes and phonon, inelastic scattering of neutron by phonon, lattice heat capacity, models of Debye and Einstein, An-harmonic effects in crystals-thermal expansion and thermal conductivity.

Free Electron Theory:
Free electron theory of metal, one dimensional infinite potential well. Electron gas in three dimension, density of states, electronic specific heat, electrical conductivity and Wiedeman-Franz law, Hall effect, cyclotron resonance.
4. Band Theory of Solid:
Nearly free electron bands, effective mass of electron in the band, concept of holes, classification of metal, semiconductor and insulator, intrinsic and extrinsic semiconductors, intrinsic carrier concentration,
5. Magnetic Properties of Solids:
Quantum theory of diamagnetism, paramagnetism, Pauli Paramagnetism, Ferromagnetism, Curie-Weiss law.

Unit-V: Nuclear and Particle Physics.
1. Nuclear Properties:
Basic nuclear properties: nuclear size, nuclear radius and charge distribution, nuclear form factor, mass and binding energy, Angular momentum, parity and symmetry, Magneticdipole moment and electric quadrupole moment,
2. Two body bound state;
Properties of deuteron, Schrodinger equation and its solution for ground state of deuteron, rms radius, spin dependence of nuclear forces, electromagnetic moment and magnetic dipole moment of deuteron and the necessity of tensor forces.
3. Beta-decay :
β- emission and electron capture, Fermi's theory of allowed β-decay, Selection rules for Fermi and Gamow-Teller transitions, Parity non-conservation and Wu's experiment.
Liquid drop model, Bethe-Weizsacker binding energy/mass formula, Fermi model, Shell model and Collective model.
4. Nuclear Reactions and Fission.
Different types of reactions, Quantum mechanical theory, Resonance scattering and reactions, Breit-Wigner dispersion relation; Compound nucleus formation and break-up Optical model; Principle of detailed balance, Transfer reactions. Nuclear fission: Experimental features, spontaneous fission, liquid drop model, barrier penetration, statistical model, Super-heavy nuclei.
5. Particle Physics:
Basic forces, classification of elementary particle, Gellmann-Nishijima scheme,meson and Baryon octet, isospin, strangeness, spin ,parity, Lepton and baryon number. conservation, parity conservation and non conservation , time reversal and consequence of time time reversal invariance, charge conjugation, G-parity, Statement of CPT theorem and its consequences,
Hadron classification by isospin and hypercharge, SU(2) and SU(3) Groups, algebras and generators;Elementary idea of SU(3) symmetry and Quarks model, need for Color;