Physics

Unit-I : Mathematical Physics and Classical Mechanics

1.*Vector calculus, tensors and complex variables* :
Vector calculus, Gauss theorem and Stokes theorem. Lorentz transformations and four vectors, Covariant and contravariant tensors, transformation properties of tensors, direct product and contraction of tensors. Cauchy's theorem, Cauchy's integral formula, classification of singularities, branch point and branch cut, Residue theorem, evaluation of integrals using residue theorem.

2. *Special functions :*
Basic properties and solutions (series expansion, recurrence and orthogonality relations) of Bessel, Legendre, Hermite differential equations. Beta and Gamma function, Fourier series , Dirac delta function, Laplace and Fourier transform.

3. *Hamilton's principle:*
Hamilton's principle, Lagrange's equation from Hamilton's principle, Solution of Lagrange's equation of motion for simple harmonic oscillator. Hamilton's equations of motion, canonical equations from variational principle, principle of least action

4. *Canonical transformation*:
Generating function and Legendre transformation, Lagrange and Poisson's brackets, conservation theorems in Poisson bracket formalism, Jacobi identity.

5. *Coupled oscillations*:
Theory of coupled oscillation, normal modes, energy relation and transfer.

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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.

2. *Maxwell's equations*:
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 a 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 wavelength limit, Rayleigh scattering,

5. *Transients and A.C.circuits*:
   Growth and decay of current in d.c. circuit containing LR, CR and LCR. Alternating current circuits containing LR, CR and LCR, Resonance.

Unit-III: Quantum Mechanics

1. *Wave packet and Schrödinger's equation*:
   Gaussian wave packet, spreading of wave packet, Schrödinger's equation, probability interpretation of wave function, expectation values, coordinate and momentum representation, **x** and **p** in these representations, stationary states, eigen states, Ehrenfest theorem, Quantum virial theorem. linear independence and linear dependence, expansion theorem, ortho-normality and completeness conditions.
2. *Operator method in Quantum Mechanics*:
   Operator algebra, eigenfunctions and eigenvalues of Hermitian operator, formulation of Quantum Mechanics in vector space language, uncertainty product of two non commuting Hermitian operators, one dimensional harmonic oscillator, matrix representation of operators, Schrodinger, Heisenberg and interaction pictures. Potential well (Finite, infinite) in one dimension, potential step.
3. *Angular momentum*:
   Angular momentum algebra, addition of two angular momenta $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$. Clebsch–Gordon coefficients, examples, matrix representation of $j_1 = \frac{1}{2}$ and $j_2 = 1$. Spin angular momentum, Pauli spin matrices and their properties, eigenvalue and eigenfunction,
4. Radial solution of Hydrogen atom and its wave function in the ground state.
5. *Approximation methods*:
   Time independent perturbation theory, first and second order correction to energy and eigenfunctions, application to one electron system, Zeeman effect, linear Stark effect.

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

1. *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. Canonical ensemble: Expression for entropy, canonical partition function, Helmholtz free energy, energy fluctuation, Maxwell Boltzmann distribution law.
2. *Digital Circuits* :
   Logic fundamentals, Boolean theorem, Logic gates-RTL,DTL,TTL, RS flip-flop, JK flip-flop, Boolean algebra, De Morgan theorem, AND, NAND, NOT, OR, NOR gates, Logic Circuits.
3. *Lattice Dynamics*:
   Classical theory of lattice vibration under harmonic approximation, vibration of linear mono atomic and diatomic lattices, acoustic 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.

4. *Free electron theory and superconductivity*:
   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. Superconductivity, Meissner effect, London equation.
5. *Band Theory of Solids and Magnetic Properties of Solids*:
   Nearly free electron model, effective mass of electron in the band, concept of holes, classification of metal, semiconductor and insulator, intrinsic and extrinsic semiconductors, intrinsic carrier concentration, Quantum theory of diamagnetism, paramagnetism, Langevin theory of 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, magnetic dipole 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, explanation of nuclear fission, Bethe-Weizsacker binding energy/mass formula, 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 Nuclear fission: Experimental features, spontaneous fission, liquid drop model, barrier penetration and Alpha decay.
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 consequences of time reversal invariance, charge conjugation, G-parity, statement of CPT theorem and its consequences, Hadron classification by isospin and hypercharge, SU(2) symmetry groups, algebras and generators; Elementary idea of SU(3) symmetry and Quark model, need for color.