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SUBJECT : PHYSICS

SYLLABUS

Unit I **MATHEMATICAL PHYSICS**

Dimensional analysis: Differential equation (ordinary and partial) – order of equation – Expressions for gradient, divergence, curl and Laplacian – vector algebra and vector calculus – Gauss divergence theorem – Green's theorem – Stokes' theorem. Matrix: Cayley – Hamilton theorem, inverse of matrix – Eigen values and Eigen vectors. Polynomials: Hermite, Bessel and Legendre Functions. Special function: Beta and Gamma functions. Probability: Elementary probability theory – Random variables – Binomial – Poisson and Normal distribution. Complex variables: Analytic functions – Singular points – Cauchy's integral theorem and formula -Taylor's and Laurent's expansions, poles, Calculus of residues and evaluation of integrals. Integral transforms: Fourier series and Fourier transform and their properties.

Unit II **CLASSICAL MECHANICS**

Mechanics of particles and systems of particles: Constraints and Generalized coordinates, Law of conservation of Energy, Linear and Angular momentum, Conservative and Non-Conservative systems, Degrees of freedom, Holonomic – Nonholonomic – Scleronomic systems. Lagrangian Formalism: Lagrange equations of motion – D'Alembert's principle – Applications (Simple pendulum, Atwood's machine, Harmonic Oscillator, Electrical circuit). Hamiltonian Formalism: Hamilton's equation of motion – Cyclic co-ordinates – Hamilton's equation from variational principle, Principle of least action, Canonical transformation, Liouville's theorem. Rigid body Dynamics: Euler's angles – Moment of inertia tensor, Euler's equation of motion – Symmetrical top, Special theory of Relativity: Inertial and Non- inertial frames, Lorentz transformation, Lorentz inverse transformation, Length contraction, Time dilation, Mass invariance, Einstein's mass-energy relation.

Unit III **ELECTROMAGNETIC THEORY**

Electrostatics: Coulomb's law – Gauss's law and its application. Laplace and Poisson's equations. Magnetostatics: Biot Savart's law – Ampere's law – Magnetic scalar and vector potentials – magnetic susceptibility – Equation of continuity – Displacement current – Maxwell's equations (free space and linear isotropic media) – Electromagnetic waves – Poynting's theorem – Dielectrics: Retarded potentials – Polarization – Radiation from a linear antenna – Transmission lines and Wave guides.

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Unit IV **QUANTUM MECHANICS**

Failures of Classical mechanics – Black body radiation – Wave and particle duality – Postulates of Quantum mechanics – Wave function and properties – Expectation values – Heisenberg's uncertainty principle – Schrodinger equations (time – dependent and time- independent). Eigen value problems: Particle in a box (1D and 3D), Particle in a finite potential well & barrier, Tunnelling, Harmonic oscillator. Operators: Ladder operators, Angular momentum operator, Hydrogen atom, spin – Stern Gerlach experiment. Approximation methods: Variational principle, Time independent (1st and 2nd order) degenerate and non-degenerate perturbation theory – Time-Dependent perturbation theory – Fermi's golden rule, Identical particles. Relativistic Quantum Mechanism: Pauli's spin Matrices, Dirac and Klein Gordon equation. Commutators. Scattering theory: Scattering cross-section, Scattering by a central potential, Partial wave analysis, Breit-Wigner formula.

Unit V **THERMODYNAMICS AND STATISTICAL MECHANICS**

Laws of thermodynamics and their consequences – thermodynamic system (closed and open) – thermodynamic processes (isothermal, adiabatic, isochoric, isobaric, isotropic) – cyclic process – thermodynamic potentials (U, S, G, H) – relation between them. Specific heat – equation of state – intensive and extensive variables – The P-V diagram – Carnot cycle and its efficiency – Entropy – reversible and irreversible – T-S diagram – Equipartition theorem. Phase space – micro and macrostates – Liouville's theorem – ensembles – partition function – classical (MB distribution) – Maxwell's distribution of velocities – Kinetic Theory of gases – Pressure exerted by gas – Mean free path – Mean – RMS and most probable speed – and quantum (BE & FD distribution) statistics – applications to black body radiation – Bose Einstein condensation.

Unit VI **ATOMIC PHYSICS AND SPECTROSCOPY**

Quantum states of an electron in an atom – Hydrogen atom spectrum – Electron spin -Spin orbit coupling – Fine structure – Relativistic correction – Spectroscopic terms and selection rules – Hyperfine structure – Exchange symmetry of wave functions – Pauli's exclusion principle – Hund's rule – Periodic table – Alkali type spectra – LS and JJ Coupling – Zeeman, Paschen – Back and Stark effects. Principles of ESR, NMR, Chemical shift – Frank Condon principle – Born Oppenheimer approximation – Electronic, rotational and vibrational spectra of diatomic molecules, Selection rules.

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Unit VII **SOLID STATE PHYSICS**

Crystal Physics: Lattice, Crystal structures – Bravais lattices – Miller indices – Reciprocal lattices – Lattice Dynamics: Monoatomic, diatomic lattices – Theories of specific heat – Einstein's and Debye's model for lattice specific heat. Classical free electron theory: Drude model – Thermal conductivity – Wiedemann Franz law. Energy bands in solids: Energy bands in metals, insulators and semiconductors, E-k diagram – Density of states – Brillouin zones – Wave equation of electron in a Periodic potential. Semiconductor Physics: Types of semiconductors – Mobility – Carrier concentration of charge carriers – Bloch's theorem – Kronig – Penney model. Dielectrics: Polarization Mechanism – Clausius – Mossotti Equation – Piezo, Pyro and Ferroelectricity. Magnetism: Dia, Para, Ferro, Anti-Ferro and Ferri magnetism. Superconductivity: Meissner effect – Type I and Type II superconductivity – BCS theory – Josephson effect.

Unit VIII **NUCLEAR AND PARTICLE PHYSICS**

Nuclear properties (size, shape, charge distribution, spin and parity) – Binding energy, Nuclear force – Liquid drop model – semi – empirical mass formula, Shell model and Collective model – Deuteron, Ground state of deuteron – exicted state of deuteron – Meson theory of nuclear force – Yukawa potentials – Elementary ideas of alpha, beta and gamma decays – Radioactive decay – Fission, Fusion – Chain reaction – Nuclear reactor. Elementary particles: Classification of elementary particles, Fundamental interactions (EM, Strong, Weak, Gravitational) and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.) – Gell-Mann-Nishijima formula. Elementary particles – Classifications – Quark model, Baryons and Mesons, Parity non-conservation in weak interaction.

Unit IX **ELECTRONICS**

Semiconducting devices: Diodes – Junction diode – Rectification – Zener diode – Light Emitting Diode. Junction Transistors: common base, common emitter and common collector configurations – Static characteristics – Transistors as amplifier and oscillators – FET, JFET, MOSFET. IC: Fabrication technology, Monolithic IC Processing. 555 Timer, Phase shift, Wien bridge oscillators. Operational Amplifier (IC 741): Op-Amp characteristics, Inverting and Non-inverting Amplifiers, Adder, Subtractor, Differentiator and Integrator. Digital techniques and applications: Flip Flops, Registers – Counters. Digital integrated circuits: Logic gates, NAND and NOR – Universal building blocks – Half and Full adder. Communication Electronics: Modulation and Demodulation (AM, FM, Phase), Transmitter and Receiver, Satellite and Fiber optic communication.

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Unit X **EXPERIMENTAL PHYSICS**

Units and dimension of physical quantities – significant figures. Data interpretation and analysis, precision and accuracy, error analysis, propagation of errors, Least square fitting. Measurement of fundamental constants – e, h, c – Detection of X-rays, gamma rays, Charged particles, neutrons. Ionization chamber – proportional counter – Measurement of e/m ratio – Measurement of Hall voltage, mobility and charge carrier concentration – measurement of resistance and capacitance in series and parallel.

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