Deen Dayal Upadhyaya Gorakhpur University Gorakhpur
M.Sc. Physics
Entrance Examination Syllabus

Unit-I: Mathematical Physics & Newtonian Mechanics

Vector Algebra: Coordinate rotation, reflection and inversion as the basis for defining scalars, vectors, pseudo- scalars and pseudo-vectors. Component form in 2D and 3D. Addition, subtraction, dot product, wedge product, cross product and triple product of vectors. Position, separation and displacement vectors.

Vector Calculus: Geometrical and physical interpretation of vector differentiation, Gradient, Divergence and Curl. Vector integration, Line, Surface (flux) and Volume integrals of vector fields. Gradient theorem, Gauss-divergence theorem, Stoke-curl theorem, Greens theorem and Helmholtz theorem. Dirac delta function.

Coordinate Systems: 2D & 3D Cartesian, Spherical and Cylindrical coordinate systems, basis vectors, transformation equations. Displacement vector, arc length, area element, volume element, gradient, divergence and curl in different coordinate systems. Components of velocity and acceleration in different coordinate systems. Examples of non-inertial coordinate system and pseudo-acceleration.

Introduction to Tensors: Principle of invariance of physical laws. Coordinate transformations for general spaces of nD, contravariant, covariant & mixed tensors and their ranks, 4-vectors. Index notation and summation convention. Symmetric and skew-symmetric tensors. Invariant tensors, Kronecker delta and Epsilon (Levi Civita) tensors. Examples of tensors in physics.

Dynamics of a System of Particles: Newton's axioms of motion. Dynamics of a system of particles, centre of mass motion, conservation laws. Rotating frames of reference, pseudo forces, Coriolis force. Angular momentum, Torque, Rotational energy and the inertia tensor. Rotational inertia for simple bodies. Translational and rotational motion of a rigid body. Elasticity, Elastic constants, bending of beam and torsion of cylinder.

Motion of Planets & Satellites: Two particle central force problem, reduced mass, relative and centre of mass motion. Newton's law of gravitation, gravitational field and gravitational potential. Kepler's laws of planetary motion. Motions of geo-synchronous & geo-stationary satellites. Global Positioning System (GPS).

Wave Motion: Simple harmonic motion. Damped and forced oscillations, Quality factor. Composition of simple harmonic motion, Lissajous figures. Differential equation of wave motion. Plain progressive waves. Principle of superposition of waves, stationary waves, phase and group velocity. Fourier series and Fourier coefficients.

Unit-II: Thermal Physics & Semiconductor Devices

Zeroth & First Law of Thermodynamics: Zeroth law and temperature. First law, internal energy, heat and work done. Relation between C P and C V. Carnot's engine, efficiency and Carnot's theorem. Efficiency of internal combustion engines.

Second & Third Law of Thermodynamics: Different statements of second law, Clausius inequality, entropy. Entropy. Third law of thermodynamics and unattainability of absolute zero. Thermodynamical potentials, Maxwell's relations, conditions for feasibility of a process and equilibrium of a system. Clausius- Clapeyron equation, Joule- Thompson effect.

Kinetic Theory of Gases: Kinetic model of gas laws. Maxwell's law of distribution of velocities. Degrees of freedom, law of equipartition of energy.

Theory of Radiation: Blackbody radiation, spectral distribution. Planck's law, Wien's distribution law, Rayleigh-Jeans law, Stefan- Boltzmann law and Wien's displacement law from Planck's law.

DC & AC Circuits: Growth and decay of currents in RL circuit. Charging and discharging of capacitor in RC, LC and V RCL circuits. Network Analysis. Thevenin's and Norton's theorems. AC Bridges - measurement of inductance (Maxwell's and Anderson's bridges) and measurement of capacitance (Schering's and de Sauty's bridges).

Semiconductors & Diodes: P and N type semiconductors, Fermi level. PN junction diode, Forward & reverse bias. Zener diode, Tunnel, Light Emitting, Point Contact and Photo diodes. Half and Full wave rectifiers, Ripple factor, rectification efficiency and voltage regulation. Filter circuits and voltage regulated power supply.

Transistors: Bipolar Junction PNP and NPN transistors. CB, CE & CC configurations; characteristics; current, voltage & power gains; transistor currents. Base width modulation, base spreading resistance & transition time. DC Load Line analysis and Q-point stabilisation. Voltage Divider Bias circuit for CE amplifier. Qualitative discussion of RC coupled amplifier.

Electronic Instrumentation: Multimeter: Measurement of dc voltage, dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. Cathode Ray Oscilloscope: Applications of CRO to study the waveform and measurement of voltage, current, frequency & phase difference.

Unit-III: Electromagnetic Theory & Optics

Electrostatics: Electric force between two charges. Electric field, Electric potential and Gauss law. Electric dipole. Electric polarization, auxiliary field D, electric susceptibility and permittivity.

Magnetostatics: Magnetic force between two current elements. Magnetic field, Magnetic potential and Ampere's circuital law. Magnetic fields in matter, magnetisation, auxiliary field H, magnetic susceptibility and permeability.

Time Varying Electromagnetic Fields: Faraday's laws of electromagnetic induction and Lenz's law. Displacement current, equation of continuity and Maxwell-Ampere's circuital law. Self and mutual induction. Maxwell's equations and their physical significance.

Electromagnetic Waves: Electromagnetic energy density, Poynting vector. Plane electromagnetic waves in dielectrics, dispersive & non- dispersive media. Reflection and refraction of electromagnetic waves, law of reflection, Snell's law, Fresnel's formulae.

Interference: Spatial & temporal coherence. Fresnel's Biprism and Lloyd's Mirror. Parallel thin film, wedge shaped film and Newton's Ring experiment. Michelson and Fabry-Perot.

Diffraction: Fresnel's and Fraunhofer's class of diffraction. Fresnel's Half Period Zones and Zone plate. Fraunhofer diffraction at a single slit, N-slits and Diffracting Grating. Resolving Power of Optical Instruments - Rayleigh's criterion and resolving power of telescope.

Polarisation: Polarisation by dichronic crystals, birefringence, Nicol prism, retardation plates. Analysis of polarized light. Optical Rotation and Half Shade & Biquartz polarimeters.

Lasers: Characteristic of Lasers. Qualitative analysis of Spatial and Temporal coherence. Conditions for Laser action and Einstein's coefficients. Ruby and He-Ne Lasers.

Unit-IV: Modern Physics & Electronics

Relativity-Experimental Background: Michelson-Morley experiment, null result. Einstein's postulates of special theory of relativity. Structure of space & time in Relativistic mechanics and derivation of Lorentz transformation equations and its Consequences.

Relativity-Relativistic Kinematics: Concept of Simultaneity; Transformation of Length; Transformation of Time; Transformation of Velocity; Transformation of Acceleration; Transformation of Mass. Relation between Energy & Mass and Energy & Momentum.

Inadequacies of Classical Mechanics: Particle Properties of Waves: Spectrum of Black Body radiation, Photoelectric effect, Compton effect, Max Planck's Quantum hypothesis. Wave Properties of Particles: Louis de Broglie's hypothesis of matter waves, Davisson-Germer's experiment and Thomson's experiment.

Introduction to Quantum Mechanics: Matter Waves: Mathematical representation, Wavelength, Concept of Wave group, Group velocity, Phase velocity. Wave Function: Functional form, Normalisation of wave function, Orthogonal & Orthonormal wave functions and Probabilistic interpretation of wave function based on Born Rule.

Transistor Biasing: Faithful amplification & need for biasing. Stability Factors and its calculation for transistor biasing V circuits for CE configuration: Fixed Bias, Emitter Bias, Collector to Base Bias &, Voltage Divider Bias. Discussion of Emitter-Follower configuration.

Amplifiers: Classification of amplifiers (Class A, B, AB, C & D), Stages, Coupling methods (RC, Transformer, Direct & LC couplings), Nature of amplification (Voltage & Power amplification) and Frequency capabilities (AF, IF, RF & VF). RC coupled voltage amplifier and Transformer coupled power amplifier. Calculation of Amplifier Efficiency for Class A Series-Fed, Class A Transformer Coupled, Class B Series-Fed and Class B Transformer Coupled amplifiers.

Feedback & Oscillator Circuits: Positive and negative feedback. Voltage Series, Voltage Shunt, Current Series and Current Shunt feedback connection types. Estimation of Input Impedance, Output Impedance, Gain, Stability, Distortion, Noise and Band Width for Voltage Series negative feedback. Oscillator Circuits: Use of positive feedback for oscillator operation. Barkhausen criterion for self-sustained oscillations. Feedback factor and frequency of oscillation for RC Phase Shift oscillator and Wein Bridge oscillator. Qualitative discussion of Reactive Network feedback oscillators: Hartley & Colpitt oscillators.

Introduction to Fiber Optics: Basics of Fiber Optics, step index fiber, graded index fiber, light propagation through an optical fiber, acceptance angle & numerical aperture, qualitative discussion of fiber losses and applications of optical fibers.

Unit-V: Classical Mechanics & Statistical Mechanics

Constrained Motion: Degrees of Freedom and Configuration space. Constrained system, Forces of constraint and Constrained motion. Generalised coordinates, Transformation equations and Generalised notations & relations. Virtual work and D'Alembert's principle.

Lagrangian Formalism: Lagrangian for conservative & non-conservative systems, Lagrange's equation of motion, Comparison of Newtonian & Lagrangian formulations, Cyclic coordinates, and Conservation laws. Simple examples based on Lagrangian formulation.

Hamiltonian Formalism: Phase space, Hamiltonian for conservative & non-conservative systems, Hamilton's equation of motion, Comparison of Lagrangian & Hamiltonian formulations, Cyclic coordinates, and Construction of Hamiltonian from Lagrangian.

Central Force: Equation of motion, Orbit, Bound & unbound orbits, stable & non-stable orbits, closed & open orbits and Bertrand's theorem. Motion under inverse square law of force and Kepler's laws. Laplace-Runge- Lenz vector (Runge-Lenz vector).

Macrostate & Microstate: Macrostate, Microstate, Number of accessible microstates and Postulate of equal a priori. Phase space, Phase trajectory, Volume element in phase space, Quantisation of phase space and number of accessible microstates for free particle in 1D, free particle in 3D & harmonic oscillator in 1D.

Concept of Ensemble: Concept of ensemble, postulate of ensemble average and Liouville's theorem. Micro Canonical, Canonical & Grand Canonical ensembles. Thermodynamic Probability, Postulate of Equilibrium and Boltzmann Entropy relation.

Distribution Laws: Number of accessible microstates, probability & number of particles in ith state at equilibrium for Maxwell-Boltzmann, Bose-Einstein & Fermi- Dirac statistics. Comparison of statistical distribution laws. Boltzmann's Canonical Distribution Law, Boltzmann's Partition Function, Law of Equipartition of energy and relation between Partition function and Thermodynamic potentials.

Applications of Statistical Distribution Laws: Photons in a black body cavity and derivation of Planck's Distribution Law. Application of Fermi-Dirac Distribution Law: Free electrons in a metal, Fermi energy, Fermi energy at absolute zero, Kinetic energy of Fermi gas at absolute zero and concept of Density of States (Density of Orbitals).

Unit-VI: Quantum Mechanics & Spectroscopy

Operator Formalism: Operators: Review of matrix algebra, special operators, operator algebra and operators corresponding to various physical-dynamical variables. Commutators: commutator algebra and commutation relations among position, linear momentum & angular momentum and energy & time.

Eigen & Expectation Values: Eigen equation for an operator, eigen state (value) and eigen functions. Linear superposition of eigen functions and Non-degenerate & Degenerate eigen states. Expectation value pertaining to an operator and its physical interpretation. Hermitian Operators, Prove of the hermitian nature of various physical-dynamical operators.

Uncertainty Principle & Schrodinger Equation: Commutativity & simultaneity. Non commutativity of operators as the basis for uncertainty principle. Uncertainty principle for various conjugate pairs of physical- dynamical parameters. Time independent & time dependent Schrodinger equation. Interpretation of equation of continuity in Schrodinger representation, and Equation of motion of an operator in Schrodinger representation.

Applications of Schrodinger Equation: Application to 1D Problems: Infinite Square well potential (Particle in 1D box), Finite Square well potential, Potential step, Rectangular potential barrier and 1D Harmonic oscillator. Application to 3D Problems: Infinite Square well potential (Particle in a 3D box) and the Hydrogen atom. Direct solutions of Hermite, Associated Legendre and Associated Laguerre differential equations to be substituted.

Vector Atomic Model: Bohr and Bohr-Sommerfeld atomic models, spectrum of Hydrogen atom: H-alpha line. Modification due to finite mass of nucleus and Deuteron spectrum. Vector atomic model, Stern-Gerlach experiment included, various quantum numbers for single & many valence electron systems. LS & jj couplings, spectroscopic notation for energy states, selection rules for transition of electrons and intensity rules for spectral lines. Fine structure of H-alpha line on the basis of vector atomic model.

Spectra of Alkali & Alkaline Elements: Screening constants for s, p, d & f orbitals; sharp, principle, diffuse & fundamental series; doublet structure of spectra and fine structure of Sodium D line.

X-Rays & X-Ray Spectra: Nature & production, Continuous X-ray spectrum & Duane-Hunt's law, Characteristic X-ray spectrum & Mosley's law, Characteristic X-ray spectrum.

Molecular Spectra: Electronic, vibrational and rotational energies of Molecules. Quantisation of vibrational energies, transition rules and pure vibrational spectra. Quantisation of rotational energies, transition rules, pure rotational spectra and determination of inter nuclear distance. Rotational-Vibrational spectra; transition rules; fundamental band. P, Q, R

Unit-VII: Solid State Physics & Nuclear Physics

Crystal Structure: Lattice, Basis & Crystal structure. Lattice translation vectors, Primitive & non-primitive cells. Symmetry operations, Point group & Space group. 2D & 3D Bravais lattice. Parameters of cubic lattices. Lattice planes and Miller indices. Simple crystal structures - HCP & FCC, Diamond, Cubic Zinc Sulphide, Sodium Chloride, Cesium Chloride.

Crystal Diffraction: X-ray diffraction and Bragg's law. Laue, Rotating crystal and Powder methods. Scattered wave amplitude. Reciprocal lattice, Reciprocal lattice vectors. Diffraction conditions, Ewald's method and Brillouin zones. Reciprocal lattice to SC, BCC & FCC lattices.

Crystal Bindings: Classification of Crystals on the Basis of Bonding - Ionic, Covalent, Metallic, van der Waals (Molecular) and Hydrogen bonded. Crystals of inert gases, Attractive interaction (van der Waals- London) & Repulsive interaction, Equilibrium lattice constant, Cohesive energy and Compressibility & Bulk modulus. Ionic crystals, Cohesive energy, Madelung energy and evaluation of Madelung constant.

Lattice Vibrations: Lattice vibrations for linear mono & di atomic chains, Dispersion relations and Acoustical & Optical branches. Qualitative description of Phonons in solids. Lattice heat capacity, Dulong-Petit's law and Einstein's theory of lattice heat capacity. Fermi energy, Density of states, Heat capacity of conduction electrons, Paramagnetic susceptibility of conduction electrons and Hall effect in metals.

Band Theory: Qualitative idea of Bloch theorem, Kronig-Penney model, Effectice mass of an electron & Concept of Holes & Classification of solids on the basis of band theory.

Nuclear Forces & Radioactive Decays: Mass, binding energy, radii, density, angular momentum, magnetic dipole moment vector, electric quadrupole moment tensor. Nuclear Forces: Characteristic of nuclear force and Deuteron ground state properties. Radioactive Decays: Nuclear stability, beta minus decay, beta plus decay, alpha decay, gamma decay & electron capture, fundamental laws of radioactive disintegration and radioactive series.

Nuclear Models & Nuclear Reactions: Liquid drop model and Bethe-Weizsacker mass formula. Single particle shell model. Nuclear Reactions: Bethe's notation, Conservation laws, Cross-section of nuclear reaction, nuclear fission and fusion(qualitative), Nuclear reactors.

Accelerators & Detectors: Theory, working and applications of Van de Graaff accelerator, Cyclotron and Synchrotron. Detectors: Theory, working and applications of GM counter, Semiconductor detector, Scintillation counter and Wilson cloud chamber.

Elementary Particles: Fundamental interactions & their mediating quanta. Concept of antiparticles. Classification of elementary particles based on intrinsic-spin, mass, interaction & lifetime.

Unit-VIII: Analog & Digital - Principles & Applications

Semiconductor Junction: Fermi energy, Electron density in conduction band, Hole density in valence band, Drift of charge carriers (mobility & conductivity), Diffusion of charge carries and Life time of charge carries in a semiconductor. Work function in metals and semiconductors. Barrier potential, Barrier width and Junction capacitance (diffusion & transition) for depletion layer in a PN junction. Current (diode equation) and Dynamic resistance for PN junction.

Transistor Modeling: Transistor as Two-Port Network. Notation for dc & ac components of voltage & current. Quantitative discussion of Z, Y & h parameters and their equivalent two-generator model circuits. h-parameters for CB, CE & CC configurations. Analysis of transistor amplifier using the hybrid equivalent model and estimation of Input Impedance, Output Impedance and Gain (current, voltage & power).

Field Effect Transistors: JFET: Construction (N channel & P channel); Configuration (CS, CD & CG); Operation in different regions (Ohmic or Linear, Saturated or Active or Pinch off & Break down); Important Terms (Shorted Gate Drain Current, Pinch Off Voltage & Gate Source Cut-Off Voltage); Expression for Drain Current (Shockley equation); Characteristics (Drain & Transfer); Parameters (Drain III Resistance, Mutual Conductance or Transconductance & Amplification Factor); Biasing w.r.t. CS configuration (Self Bias & Voltage Divider Bias); Amplifiers (CS & CD or Source Follower); Comparison (N & P channels and BJTs & JFETs).

MOSFET: Construction and Working of DE-MOSFET (N channel & P channel) and E- MOSFET (N channel & P channel); Characteristics (Drain & Transfer) of DE-MOSFET and E- MOSFET; Comparison of JFFET and MOSFET.

Number System: Number Systems: Binary, Octal, Decimal & Hexadecimal number systems and their inter conversion. Binary Codes: BCD, Excess-3 (XS3), Parity, Gray, ASCII & EBCDIC Codes and their advantages & disadvantages. Data representation.

Binary Arithmetic: Binary Addition, Decimal Subtraction using 9's & 10's complement, Binary Subtraction using 1's & 2's compliment, Multiplication and Division.

Logic Gates: Truth Table, Symbolic Representation and Properties of OR, AND, NOT, NOR, NAND, EX- OR & EX-NOR Gates. Implementation of OR, AND & NOT gates (realization using diodes & transistor). De Morgan's theorems. NOR & NAND gates as Universal Gates. Application of EX-OR & EX- NOR gates as pairty checker. Boolean Algebra. Karnaugh Map.

Combinational & Sequential Circuits: Combinational Circuits: Half Adder, Full Adder, Parallel Adder, Half Substractor, Full Substractor. Data Processing Circuits: Multiplexer, Demultiplexer, Decoders & Encoders. Sequential Circuits: SR, JK & D Flip-Flops, Shift Register (transfer operation of Flip-Flops), and Asynchronous & Synchronous counters.