515. Physics

UNIT I- Mathematical Physics and Statistical Physics

Mathematical Physics

Linear differential equations; Special functions (Hermite, Bessel, and Legendre); Fourier and Laplace transforms; Error analysis, propagation of errors,least square fitting, curve fitting-linear and polynomial regression analysis Elements of computational techniques: roots of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, solution of first order differential equations using Runge-Kutta method; Finite difference methods;

Statistical Physics

Phase space, micro- and macrostates; ensembles, Liouville's theorem. Microcanonical, canonical and grand-canonical ensembles and partition functions; Free Energy and connection with thermodynamic quantities; First- and second-order phase transitions; Classical and quantum statistics, ideal Fermi and Bose gases; Principle of detailed balance; Blackbody radiation and Planck's distribution law; Bose-Einstein condensation; Random walk and Brownian motion;

Unit II- Classical Mechanics, Quantum Mechanics and Electromagnetic Theory

Classical Mechanics

Newton's laws; Phase space dynamics, stability analysis; Central-force motion; Two-body collisions, scattering in laboratory and centre-of-mass frames; Rigid body dynamics, moment of inertia tensor, non-inertial frames and pseudoforces; Variational principle, Lagrangian and Hamiltonian formalisms and equations of motion; Poisson brackets and canonical transformations;

Quantum Mechanics

Basic principles of Quantum mechanics -Dirac's bra and ket notation; Schroedinger equation (time-dependent and time-independent); Eigenvalue problems such as particle-in-a-box, harmonic oscillator, etc.; Uncertainity principle; Orbital angular momentum, Time-independent perturbation theory and applications; Variational method; WKB approximation; Time dependent perturbation theory and Fermi's Golden Rule; Selection rules; Elementary theory of scattering, phase shifts, partial waves, Born approximation; Relativistic quantum mechanics: Klein Gordon and Dirac equations.

Electromagnetic Theory

Electrostatics: Gauss' Law and its applications; Laplace and Poisson equations,; Magnetostatics: Biot-Savart law, Ampere's theorem, electromagnetic induction; Maxwell's equations in free space and linear isotropic media; boundary conditions on fields at interfaces; Scalar and vector potentials; Gauge invariance; Electromagnetic waves in free space, dielectrics, and conductors; Reflection and refraction, polarization, Fresnel's Law, Radiation from moving charges, dipoles and retarded potentials.

UNIT III- Atomic & Molecular Physics and Nuclear Physics

Atomic & Molecular Physics

Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Hyperfine structure and isotopic shift; width of spectral lines; LS & JJ coupling; Zeeman, Paschen Back & Stark effect; X-ray spectroscopy; Electron spin resonance, Nuclear magnetic resonance,

chemical shift; Rotational, vibrational, electronic, and Raman spectra of diatomic molecules; Frank – Condon principle and selection rules; Spontaneous and stimulated emission, Einstein A & B coefficients; Lasers, optical pumping, population inversion, rate equation; Modes of resonators and coherence length

Nuclear Physics

Basic nuclear properties: size, shape, charge distribution, spin and parity; Interaction of chargesd particles with matter; Range-Energy relation; Interaction of r-radiation with matter, Photoelectric effect, Compton effect and pair production;

Binding energy, semi-empirical mass formula; Liquid drop model; Fission and fusion;

UNIT IV- Solid State Physics and Electronics

Solid State Physics

Bravais lattices; Reciprocal lattice, diffraction and the structure factor; Bonding in solids; phonons, lattice specific heat; Free electron theory and electronic specific heat; Drude model of electrical and thermal conductivity; Hall effect and thermoelectric power; Diamagnetism, paramagnetism, and ferromagnetism; Electron motion in a periodic potential, band theory of metals, insulators and semiconductors; Superconductivity, type – I and type - II superconductors, Josephson junctions; Defects and dislocations; Ionic conductivity and diffusion

Electronics

Semiconductor devices including diodes, transistors, field effect transistors and their characteristics; Regulated power supply; RC coupled amplifier ; Sinusoidal Oscillators Optoelectronic devices - solar cells, photodetectors, and LEDs;Wave form generators Operational amplifiers and their applications; Digital techniques and applications (registers, counters, comparators and similar circuits); A/D and D/A converters; Microprocessor and microcontroller basics. Amplitude and Frequency Modulation.

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