MPAT-2017 (Paper-II)

Subject: Physics

SECTION A

I. Classical Mechanics Newton's law, 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 pseudo forces; Variational principle, Lagrangian and Hamiltonian formalisms and equations of motion; Poisson brackets and canonical transformations; Symmetry, invariance and conservation laws, cyclic coordinates; Periodic motion, small oscillations and normal modes; Special theory of relativity, Lorentz transformations, relativistic kinematics and mass-energy equivalence.

II. Mathematical Methods of Physics

Dimensional analysis, Vector algebra and vector calculus; Linear algebra, matrices, Linear differential equations; Special functions (Hermite, Bessel, Laguerre and Legendre); Fourier series, Fourier and Laplace transforms; Elements of complex analysis; Laurent series-poles, residues and evaluation of integrals; Elementary ideas about tensors; Introductory group theory, SU(2), O(3); 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.

III. Electronics Circuit theorems, DC and AC circuit analysis; Semiconductor devices, physical structure, static and dynamic characteristics and applications of p-n junction diodes, transistor, FET and MOSFET; Gain and phase frequency response of single and cascade amplifiers and applications; Wave shaping and timing circuits; Optoelectronic devices including solar cells, photo-detectors and LEDs; High-frequency devices including generators and detectors; Operational amplifiers and their applications; Digital techniques and applications (registors, counters, comparators and similar circuits); A/D and D/A converters.

SECTION B

I. Thermodynamic and Statistical Physics Laws of thermodynamics and their consequences; Thermodynamic potentials, Maxwell relations; Chemical potential; Phase space, micro and macrostates; 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; Blackbody radiation and Planck's distribution law; Bose-Einstein condensation.

II. Condensed Matter Physics Bravais lattices; Reciprocal lattice, diffraction and the structure factor; Bonding of solids; Elastic properties, phonons, lattice specific heat; Free electron theory and electronic specific heat ; Drude model of electrical and thermal conductivity; Normal and Umklapp processes; Electron motion in a periodic potential, band theory of metals, insulators and semiconductors; Direct and Indirect band gaps and transitions; Hall effect; Diamagnetism, paramagnetism and ferromagnetism; Magnetic domains, domain walls; Spin wave, magnons; Mossbauer effect; Superconductivity, type I and type – II superconductors, Josephson junctions.

III. Electromagnetic Theory Electrostatics: Gauss' Law and its applications; Laplace and Poisson equations, boundary value problems; Magnetostatics: Biot-Savart law, Ampere's theorem, electromagnetic induction; Maxwell's equations in free space and linear isotopic 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, interference, coherence and diffraction; Dispersion relations in plasma; Lorentz invariance of Maxwell's equations; Dynamics of charged particles in static and uniform electromagnetic fields; Radiation from moving charges, dipoles and retarded potentials.

SECTION C

I. Quantum Mechanics

Wave-particle duality; Wave functions in coordinate and momentum representations; Commutators and Heisenberg's uncertainty principle; Matrix representation; Dirac's bra and ket notation; Schroedinger equation (time-dependent and time-independent); Eigen value problems such as particle-in-a-box, harmonic oscillator, etc.; Tunneling through a barrier; Motion in a central potential; Orbital angular momentum, Angular momentum algebra, spin; Addition of angular momenta; Hydrogen atom, spin-orbit coupling, fine structure; Time-independent perturbation theory and applications; Variational method; WKB approximation; Elementary theory of scattering, phase shifts, partial waves, Born approximation; Identical particles, Pauli's exclusion principle, spin-statistics connection; Relativistic quantum mechanics; Klein Gordon and Dirac equations.

II. Atomic & Molecular Physics

Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Relativistic corrections for energy levels of hydrogen; Hyperfine structure; width of spectral lines; Zeeman, Paschen Back & Stark effect; 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; Modes of resonators and coherence length.

III. Nuclear and Particle Physics

Basic nuclear properties: size, shape, charge distribution, spin and parity; Binding energy, semi-empirical mass formula; Liquid drop model; Fission and fusion; Nature of the nuclear force, form of nucleonnucleon potential; Charge-independence and charge-symmetry of nuclear forces; Isospin; Deuteron problem ; Shell structure, single-particle shell model, its validity and limitations; Rotational spectra; Elementary ideas of alpha, beta and gamma decays; Nuclear reactions, compound nuclei and direct reactions; Particle detectors proportional counter, G.M. Counter, scintillation detector; Accelerators – linear accelerator, cyclotron, synchrotron and Betatron; Classification of fundamental forces; Elementary particles (quarks, baryons, mesons, leptons); Spin and parity assignments, isospin, strangeness; GellMann-Nishijima formula; C, P and T invariance and applications of symmetry arguments to particle reactions, parity non-conservation in week interactions; Relativistic kinematics.