St. Xavier's College (Autonomous)
Syllabus for Research Entrance Test (RET) in Physics

Mathematical Methods

Vector Calculus : Gradient, Divergence & Curl, Divergence & Stokes theorem.
Differential Equations: Second order ordinary differential equations with non-constant coefficients. Inhomogeneous Differential Equations and Green's Function. Integral transforms. Complex variables theory: Cauchy-Riemann equations, Application of Residue Theorem.
Tensor Analysis: Index notation, Transformation laws, Quotient theorem.
Group Theory: Discrete groups, Basic notions of group representations and symmetries, Lie groups and Lie algebras : SU(2) as a case study.

Classical Physics

Classical Mechanics: Conservation Principles, Calculus of Variations, Lagrangian and Hamiltonian Dynamics, Poisson Brackets. Canonical Transformations, Action-angle variables, Small oscillations. Rigid bodies: Moment of Inertia Tensor, Euler equations of motion.
Electrodynamics: Maxwell's equations, Scalar and Vector potentials, Gauge transformations. Green's function for wave equation. Radiation from electric dipole and accelerated charges, Retarded potentials, Larmor formula.
Special Relativity: Lorentz-transformation, Four vectors and relativistic dynamics. Lagrangian for a point relativistic particle in an electromagnetic field.

Quantum Physics

Quantum Mechanics: Formalism: Vector Space, Operators, Time evolution (pictures), Angular momentum, Identical Particles. Bound State problems in 1D, Harmonic Oscillator, Hydrogen atom problem, Coulomb Potential. Scattering theory, Born Approximation. Approximate methods: Variational method, First order time independent perturbation theory. Time dependent perturbation and Fermi Golden rule. Relativistic theory: Klein Gordon and Dirac Equations, Elementary notions on Scalar fields and simple applications of Noether's theorem.
Solid State Physics: Crystallography: Crystallographic point group, Bragg-Laue formulation of X-Ray Diffraction, Schottky defects. Lattice vibrations: Phonon heat capacity (Einstein's and Debye's theory), Band theory of solids: Bloch equation, effective mass of electrons and holes, Fermi surfaces. Dielectric and Magnetic properties of solids. NMR and ESR (essential ideas only). Superconductivity: BCS theory, High Tc Superconductors (qualitative).

Atomic and Molecular Physics: Hydrogenic wavefunctions, Interaction with Radiation: Induced absorption and emission, Transition rates and selection rules. Fine structure splitting. Zeeman, Paschen-Back and Stark effects. Molecular Structure: bond length and dissociation energy of diatomic molecules. Molecular Rotational, Vibrational and Raman spectra of diatomic molecules. LASER: Spontaneous & Stimulated emissions, Einstein's A & B coefficients.
Nuclear and Particle Physics: Basic Properties: Size, Shape, Charge distribution, Parity, Isospin, Binding. Properties of Deuteron. Meson theory of nuclear Interactions. Fermi theory of beta decay, Nuclear models and Nuclear reactions. Symmetries and Conservation laws of particle interactions, Classification of hadrons, SU(2) and SU(3), Strange particles, CP violation, CPT invariance, elementary ideas about electroweak interactions and QCD.

Thermal Physics
Kinetic theory : Maxwell's velocity distribution, mean free path & transport phenomena.
Thermodynamics : Laws of Thermodynamics, Entropy, Phase Transition.
Statistical Mechanics: Microcanonical, Canonical and Grand Canonical Ensembles, Quantum Mechanical ensemble theory: Density matrix, Maxwell, Fermi-Dirac and Bose-Einstein Statistics. He-3 and He-4 (introductory ideas).

Electronics
Semiconductor Physics: Current components & Transistor biasing , junction band diagrams, Amplifiers (Class A, AB, B), Oscillators (RC, Hartley, Colpitts, Wien Bridge), h-parameters.
Devices: BJT, FET and MOSFETs, Tunnel Diodes, UJT and SCR. Analog Circuits: OPAMPS, Comparators and Multivibrators. Digital Circuits: Basic gates and Boolean Algebra, K-map simplifications, A/D, D/A conversion, Counters and Multiplexers. Microprocessors.

Computation & Laboratory Techniques
Algorithms involving iteration and choice. Fortran / Python / C (any one) implementation of root finding techniques (iteration, bisection, Newton-Raphson) for non linear equations in one variable, integration (Simpson and Trapezoidal rules) and Solution of ordinary differential equations (Euler and modified Euler).
Estimation & propagation of errors in experiments.

Format of RET Examination

Part A : Written Examination
Full Marks : 100
Type of questions : Multiple choice questions
Duration of Exam : 2 hours

Part B : Interview
Full Marks : 50