APPLIED MATHEMATICS

Analysis:
Elementary set theory, finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, supremum, infimum. Sequences and series, convergence, limsup, liminf. Bolzano Weierstrass theorem, Heine Borel theorem. Continuity, uniform continuity, differentiability, mean value theorem. Sequences and series of functions, uniform convergence. Riemann sums and Riemann integral, Improper Integrals. Monotonic functions, types of discontinuity, functions of bounded variation, Lebesgue measure, Lebesgue integral. Functions of several variables, directional derivative, partial derivative, derivative as a linear transformation, inverse and implicit function theorems. Metric spaces, compactness, connectedness.Normed linear Spaces.Spaces of continuous functions as examples.

Linear Algebra:
Vector spaces, subspaces, linear dependence, basis, dimension, algebra of lineartransformations. Algebra of matrices, rank and determinant of matrices, linear equations. Eigenvalues and eigenvectors, Cayley-Hamilton theorem.Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms. Inner product spaces, orthonormal basis. Quadratic forms, reduction and classification of quadratic forms

Complex Analysis:
Algebra of complex numbers, the complex plane, polynomials, power series,transcendental functions such as exponential, trigonometric and hyperbolic functions. Analytic functions, Cauchy-Riemann equations. Contour integral, Cauchy‟s theorem, Cauchy‟s integral formula, Liouville‟s theorem, Maximum modulus principle, Schwarz lemma, Open mapping theorem. Taylor series, Laurent series, calculus of residues.Conformal mappings, Mobius transformations.

Algebra:
Permutations, combinations, pigeon-hole principle, inclusion-exclusion principle, derangements. Fundamental theorem of arithmetic, divisibility in Z, congruences, Chinese Remainder Theorem, Euler‟s Ø- function, primitive roots.Groups, subgroups, normal subgroups, quotient groups, homomorphisms, cyclic groups, permutation groups, Cayley‟s theorem, class equations, Sylow theorems. Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domain, principal ideal domain, Euclidean domain. Polynomial rings and irreducibility criteria. Fields, finite fields, field extensions, Galois Theory.

Topology: Basis, dense sets, subspace and product topology, separation axioms, connectedness and compactness.

Ordinary Differential Equations (ODEs):
Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs. General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green‟s function.

Partial Differential Equations (PDEs):
Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs. Classification of second order PDEs, General solution of higher order PDEs with constant coefficients, Method of separation of variables for Laplace, Heat and Wave.

Numerical Analysis:
Numerical solutions of algebraic equations, Method of iteration and Newton-Raphson method, Rate of convergence, Solution of systems of linear algebraic equations using Gauss elimination and Gauss-Seidel methods, Finite differences, Lagrange, Hermite and spline interpolation,Numerical differentiation and integration, Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

Fluid Mechanics:
Real and Ideal fluids, Basic flow concepts, Viscosity, Laminar and Turbulent flows, Reynolds Number, Eulerian and Lagrangian description of fluid motion, steady and unsteady flows, Couette-Poiseuille flows. Equations of mass and momentum (Euler equation).

Probability and Distributions:
Descriptive statistics, exploratory data analysis. Sample space, discrete probability, independent events, Bayes theorem. Random variables and distribution functions (univariate and multivariate), Binomial, Poisson, Normal distributions, expectation and moments. Independent random variables, marginal and conditional distributions.

Operations Research:
Linear programming problem, simplex methods, duality. Elementary queuing and inventory models. Jobsequences, Game theory, Steady-state solutions of Markovian queuing models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space, M/G/1.

APPLIED PHYSICS

Mathematical Method of Physics:
Vector Algebra and vector calculus; Linear algebra, matrices, Cayley Hamilton theorem, eigenvalue problems; Linear differential equations; Special functions (Hermite , Bessel, Laguerre and Legender); 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; Elementary probability theory, random variables, binomial, Poisson and normal distributions.

Electromagnetic theory:
Electrostatics: Gauss" Law and its applications; Laplace and Poison equations, boundary value problems; Magnetostatics: Biot–savart law, Ampere"s theorem, electromagnetic induction; Maxwell"s equations in free space and linear isotropic media; boundary conditions on fields at interface; Scalar and vector potential; Gauge invariance; Electromagnetic wave in free space, dielectrics, and conductors; Reflection and refraction, polarization, Fresnel"s Law, interface, coherence, and diffraction; Dispersion relations in plasma; Lorentz invariance of Maxwell"s equations; Transmission lines and wave guides.

Quantum Mechanics:
Wave-particle duality; Wave function in coordinate and momentum representation; Commutators and Heisenberg"s uncertainty principle; Matrix representation; Dirac"s bra and ket notation; Schroedinger equation (time-dependent and time-independent); Eigenvalue problem 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; Time dependent perturbation theory and Fermi"s Golden Rule; Selection Rules; Semi-classical theory of radiation; 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.

Thermodynamic and Statistical Physics:
Laws of thermodynamics and their consequence; Thermodynamic potentials, Maxwell relations; Chemical potential, phase equilibria; 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; Principle of detailed balance; Blackbody radiation and Planck"s distribution law; Bose-Einstein condensation; Random Walk and Brownian motion; introduction to nonequilibrium processes; Diffusion equations.

Electronics:
Semiconductor device physics, including diodes, junctions, transistors, field effect devices, homo and hetero junction devices, device structure, device characteristics, frequency dependence and applications; Optoelectronics devices, including solar cells, photodetectors, and LEDs; Highfrequency
devices, including generators and detectors; Operational amplifiers and their
applications; Digital techniques and applications (registers, counters, comparators, and similar circuits); A/D and D/A converters; Microprocessors and microcontroller basics.

Experimental Techniques and data analysis:
Data interpretation and analysis; Precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and nonlinear curve fitting, chi-square test; Transducers (temperature,

pressure/vacuum, magnetic field, vibration, optical, and particle detectors), measurement and control; Signals conditioning and recovery, impedance matching, amplification (Op-amp based, instrumentation; amp feedback), filtering and noise reduction, shielding and grounding; Fourier transforms; lock-in detector, box-in car integrator, modulation techniques.

Atomic and Molecular Physics:

Quantum stats of an electron in an atom; Electro spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Relativistic corrections for energy levels of hydrogen; 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.

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; response and relaxation phenomena; 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-l and type-ll superconductors, Josephson Junctions; Defects and dislocations; Ordered phase of matter, translational and orientational order, kinds of liquids crystalline order; Conducting polymers; Quasicrystals.

Inorganic Chemistry

1. Chemical periodicity

2. Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules (VSEPR Theory).

3. Concepts of acids and bases, Hard-Soft acid base concept, Non-aqueous solvents.

4. Main group elements and their compounds: Allotropy, synthesis, structure and bonding, industrial importance of the compounds.

5. Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms.

6. Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications.

7. Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis.

8. Cages and metal clusters.

9. Analytical chemistry- separation, spectroscopic, electro- and thermoanalytical methods.

10. Bioinorganic chemistry: photosystems, porphyrins, metalloenzymes, oxygen transport, electron- transfer reactions; nitrogen fixation, metal complexes in medicine.

11. Characterisation of inorganic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques.

12. Nuclear chemistry: nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis.

Physical Chemistry:

1. Basic principles of quantum mechanics: Postulates; operator algebra; exactly-solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling.

2. Approximate methods of quantum mechanics: Variational principle; perturbation theory up to second order in energy; applications.

3. Atomic structure and spectroscopy: term symbols: many-electron systems and antisymmetry principle.

Power Systems

4. **Organic reactive intermediates:** Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes.

5. **Organic reaction mechanisms** involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.

6. **Common named reactions and rearrangements** – applications in organic synthesis.

7. **Organic transformations and reagents:** Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic). Chemo, regio and stereoselective transformations.

8. **Concepts in organic synthesis:** Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups.

9. **Asymmetric synthesis:** Chiral auxiliaries, methods of asymmetric induction –substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution – optical and kinetic.

10. **Pericyclic reactions** – electrocyclisation, cycloaddition, sigmatropic rearrangements and other related concerted reactions. Principles and applications of photochemical reactions in organic chemistry.

11. **Synthesis and reactivity** of common heterocyclic compounds containing one or two heteroatoms (O, N, S).

12. **Chemistry of natural products:** Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids.

13. **Structure determination** of organic compounds by IR, UV-Vis, ^1H & ^{13}C NMR and Mass spectroscopic techniques.