**Unit I: Mathematical Methods of Physics**

- Dimensional Analysis
- Vector Algebra and Calculus
- Linear Algebra: Matrices, Cayley-Hamilton theorem, eigenvalues and eigenvectors
- Differential Equations: Linear ODEs (first and second order)
- Special Functions: Hermite, Bessel, Laguerre, and Legendre functions
- Fourier Series and Laplace Transforms
- Complex Analysis:
    - Analytic functions
    - Taylor and Laurent series
    - Poles and residues
    - Evaluation of integrals
- Probability Theory:
    - Random variables
    - Binomial, Poisson, and Normal distributions
    - Central Limit Theorem

**Unit II: Classical Mechanics**

- Newton's laws
- Dynamical systems and phase space dynamics
- Stability analysis
- Central force motion
- Two-body collisions: Lab and center-of-mass frames
- Rigid body dynamics: Moment of inertia tensor
- Non-inertial frames and pseudo forces
- Variational principle
- Generalized coordinates
- Lagrangian and Hamiltonian formalisms
- Equations of motion and conservation laws
- Cyclic coordinates
- Periodic motion: Small oscillations and normal modes
- Special Theory of Relativity:
    - Lorentz transformations
    - Relativistic kinematics and mass-energy equivalence

**Unit III: Electromagnetic Theory**

- Electrostatics:
    - Gauss's 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 in linear isotropic media)

- Boundary conditions at interfaces
- Scalar and vector potentials; gauge invariance
- Electromagnetic Waves:
    - In free space, dielectrics, and conductors
    - Reflection, refraction, and polarization
    - Fresnel's laws
    - Interference, coherence, and diffraction
- Charged Particle Dynamics in static and uniform EM fields

**Unit IV: Quantum Mechanics**

- Wave-particle duality
- Schrödinger equation (time-dependent and time-independent)
- Eigenvalue Problems: Particle in a box, harmonic oscillator
- Quantum tunneling
- Wave functions in coordinate and momentum space
- Commutators and Heisenberg uncertainty principle
- Dirac notation
- Central Potential Problems:
    - Orbital angular momentum and its algebra
    - Spin and addition of angular momenta
    - Hydrogen atom
    - Stern–Gerlach experiment
- Perturbation Theories:
    - Time-independent and applications
    - Variational method
    - Time-dependent perturbation and Fermi's Golden Rule
- Selection rules
- Identical particles, Pauli exclusion principle, spin-statistics connection

**Unit V: Thermodynamics and Statistical Physics**

- Laws of thermodynamics and consequences
- Thermodynamic potentials
- Maxwell's relations
- Chemical potential
- Phase equilibrium
- Phase space: Microstates and macrostates
- Statistical Ensembles:
    - Microcanonical, canonical
- Note: The portion starting from "noise reduction, shielding…" appears misclassified and belongs to Electronics (moved below).

**Unit VI: Electronics and Experimental Methods**

- Semiconductor Devices:

    - Diodes, junctions, transistors, FETs
    - Homo- and hetero-junction devices
    - Optoelectronic devices: Solar cells, photodetectors, LEDs
- Operational Amplifiers and applications
- Digital Electronics:
    - Registers, counters, comparators
    - A/D and D/A converters
- Microprocessors and microcontrollers: Basics
- Data Interpretation & Analysis:
    - Precision and accuracy
    - Error propagation
    - Least squares fitting (linear and nonlinear), chi-square test
- Transducers:
    - Measurement of temperature, pressure/vacuum, magnetic fields, vibration, optical/particle detection
- Measurement & Control Techniques:
    - Signal conditioning, impedance matching, amplification (Op-amp, instrumentation amp, feedback)
    - Filtering and noise reduction
    - Shielding and grounding
- Fourier transforms, Lock-in detection, Boxcar integrator, modulation techniques
- High-frequency devices (generators and detectors)

**Unit VII: Atomic and Molecular Physics**

- Quantum states of electrons in atoms
- Electron spin; spectra of helium and alkali atoms
- Relativistic corrections for hydrogen atom
- Hyperfine structure and isotope shifts
- LS and JJ coupling schemes
- Zeeman, Paschen–Back, and Stark effects
- Resonance Phenomena:
    - Electron spin resonance (ESR)
    - Nuclear magnetic resonance (NMR), chemical shift
- Franck–Condon principle
- Born–Oppenheimer approximation
- Molecular Spectra:
    - Electronic, rotational, vibrational, and Raman spectra
    - Selection rules
- Lasers:
    - Spontaneous and stimulated emission
    - Einstein A and B coefficients
    - Optical pumping, population inversion, rate equations
    - Resonator modes, coherence length

**Unit VIII: Condensed Matter Physics**

- Crystal structure: Bravais lattices, reciprocal lattice
- Diffraction and structure factor
- Bonding in solids
- Elastic properties; phonons and lattice specific heat
- Free electron theory and electronic specific heat
- Response and relaxation phenomena
- Drude model of electrical and thermal conductivity
- Hall effect, thermoelectric power
- Electron motion in periodic potential; band theory
- Metals, insulators, semiconductors
- Superconductivity (type I and II), Josephson junctions
- Superfluidity
- Crystal defects and dislocations
- Ordered phases of matter:
    - Translational and orientational order
    - Liquid crystals
    - Quasicrystals

**Unit IX: Nuclear and Particle Physics**

- Nuclear Structure:
    - Size, shape, charge distribution
    - Spin and parity
    - Binding energy, semi-empirical mass formula
    - Liquid drop model
- Nuclear Forces:
    - Nucleon–nucleon potential
    - Charge independence and symmetry
    - Deuteron problem
- Shell model: Validity and limitations
- Nuclear spectra (rotational)
- Nuclear Decays:
    - Alpha, beta, gamma decays and selection rules
- Nuclear reactions: Compound nucleus, direct reactions
- Particle Physics:
    - Fundamental forces
    - Classification of particles; quantum numbers (charge, spin, parity, isospin, strangeness)
    - Gell-Mann–Nishijima formula
    - Quark model: Baryons and mesons
    - C, P, T symmetries
    - Parity violation in weak interactions
    - Relativistic kinematics in particle reactions