Syllabus for RET in Physics

Mathematical Method

Calculus of Residues : Residue and evaluation of residue; Cauchys residue theorem; evaluation of definite integrals by the method of contour integration (including integration around branch cuts); evaluation of principal values of improper integrals; summation and inversion of series; partial fraction representation of meromorphic functions; infinite product representation of entire functions (Mittag Leffler Expansion).Analytic Continuation: Definition and some elementary theorems; Schwarz reflection principle; power series method of analytic continuation. Complex Mapping. Conformal Transformation.

Eigenfunction methods for differential equations: Sets of functions. Some useful inequalities Adjoint, self-adjoint and Hermitian operators Properties of Hermitian operator. Reality of the eigenvalues; orthogonality of the eigenfunctions; construction of real eigenfunctions, Sturm–Liouville equations Valid boundary conditions; putting an equation into Sturm–Liouville form.

Integral Transforms: Fourier transform, Laplace transforms; Parsevals theorem and convolution theorem; partial differential equation and its classification; Solution of partial and ordinary differential equation by above transformations. Green's Functions:Inhomogeneous differential equation (Poisson equations, wave equation,etc.); Green's Functions, definition and properties (for self adjoint differential operators only)computation of Green's function, direct computation, eigenfunction expansion, integral transform method.

Group Theory: Abstract groups: subgroups, classes, cosets, factor groups, normal, subgroups, direct product of groups; Examples, Homomorphism &isomorphism. Representations: reducible and irreducible, unitary representations, Schur's lemma and orthogonality theorems, characters of representation, direct product of representations. Introduction to continuous groups: Lie groups, rotation and unitary groups. Representation of SO(3), SU(2), SU(3) and SO(3,1).

Tensors : Coordinate transformation, Jacobian determinant, definition of tensors; contravariant, covariant and mixed tensors; tensor algebra, Riemannian Geometry, signature requirement, metric tensor, invariant volume, associated tensors, parallel transport, covariant differentiation, Christoffel symbols; Geodesics, Ricci identity, Riemann –Christoffel curvature tensors, curved space, Bianchi identity, Ricci tensor, vanishing of the curvature tensor as a condition of flatness. Gradient, divergence, curl and Laplacian in terms of tensors.

Classical Mechanics

Lagrangian and Hamiltonian formalisms: Study of different systems. Legendre transforms. Hamilton's canonical equations and their applications. Lagrangian and Hamiltonian for relativistic particles, free and forced vibrations problems in Small Oscillations.

Central force: Review of central force problems. Conditions for closed and stable orbits, Bertrand's theorem, Virial Theorem, Laplace-Runge-Lenz Vector.

Canonical Transformations : Equations of canonical transformation; generating functions; examples of canonical transformations; integral invariants of Poincare; Lagrange and Poisson brackets as canonical invariants; infinitesimal contact transformations; constants of motion and symmetry principles; generators of infinitesimal symmetry transformations. **Hamilton-Jacobi theory :** Hamilton's principal and characteristic functions; Hamilton Jacobi equations for these two functions; separation of variables in the Hamilton-Jacobi method (e.g. simple harmonic motion, Kepler problem etc.), Hamilton-Jacobi theory, geometrical optics and wave mechanics.

Non linear dynamics: Non-linear Equations, autonomous systems; critical points; stability; Liapunov direct method; periodic solutions; Poincare Bendixon theorem; limit cycles; Lienard theorem

Rigid body dynamics: Lagrange's equations of motion for a rigid body; Euler's theorem on the motion of a rigid body; infinitesimal rotations. Euler's equations of motion. Force free motion of a rigid body; heavy symmetrical top with one point fixed; precession and nutation; Larmor precession; gyroscope and asymmetrical top , condition for Fast and sleeping top.

Mechanics of Continuous Media: Transition from discrete to continuous systems; the Lagrangian formulation; stress energy tensor and conservation theorems; Hamiltonian formulation; Poisson brackets and momentum representation; examples.

Quantum mechanics

Linear Vector Space formulation: The Linear Vector Space, Dimension and Basis of a Vector Space, concept of state vectors, Time Evolution of the state vectors, basis functions, inner product; dual space; principle of superposition of states, change of basis, Ket vector and its characteristics, Bra vector and its characteristics, orthonormility, completeness condition and closure property.

Hilbert Space and operators: The Hilbert Space, linear Operators, Hermitian Adjoint, Hermitian operator, Time Evolution Operator, Fundamental postulates of Quantum mechanics, eigenvalue equation,, Projection Operators, Commutator Algebra, Parity Operator, Uncertainty Relation between Two Operators, Functions of Operators, Expectation values, Square-Integrable Functions: Wave Functions, Eigenvalues and Eigen vectors of an Operator.

Representations: Representation in Discrete Bases, Representation in Continuous Bases, Matrix Representation of Kets, Bras, and Operators, Position Representation, Momentum Representation, Connecting the Position and Momentum Representations, Schrödinger Equation and Wave Packets, Stationary States: Time-Independent Potentials, the Conservation of Probability.

Schrödinger, Heisenberg and Interaction pictures: Introduction to the three representations; equation of motion in Schrödinger, Heisenberg and Interaction pictures; time translation operator. Time Evolution of Expectation Values.

Harmonic oscillator with operator algebra: Creation and annihilation operators, Oscillator algebra, Hamiltonian of harmonic oscillator in terms of creation and annihilation operators, Number operator, solution of energy eigenvalues, Selection rule, solution of wave functions, Coherent state, Coherent state as a normalized state, Coherent state is a state of minimum uncertainty product of position and momentum.

Mixed states; density matrix and its properties with examples; use of the density matrix in calculating the average values, Greens function; propagator concept.

Rotations: Infinitesimal Rotations, Finite Rotations, Properties of the Rotation Operator Euler Rotations, Angular momentum as generator of rotation, Representation of the Rotation Operator Rotation Matrices and the Spherical Harmonics.

Angular Momentum: Introduction to Orbital Angular Momentum, General Formalism of Angular Momentum, Geometrical Representation of Angular Momentum, commutation rules; eigenvalues and eigen functions of angular momentums, Matrix Representation of Angular Momentum, Spin Angular Momentum, algebra of Pauli spin matrices; spin half particle in a magnetic field and spinors; properties of the spherical harmonics.

Addition of Angular Momenta: Addition of Two Angular Momenta, General Formalism, Calculation of the Clebsch–Gordan Coefficients.

Electronics

Power Circuits: Regulated power supply; basic concepts; series regulator using BJT and op-amp regulator; SMPS; D.C / D.C converter; Power control by SCR.

Integrated Circuit Fabrication: Monolithic Integrated-circuit technology, Planner process, fabrication of BJT, MOSFET, diodes, Integrated-circuit resistors, capacitors.

Semiconductor Devices: MOSFET, CMOS, Power MOS, UJT, SCR, triac, diac, IGBT.

Operational Amplifiers: Instrumentation amplifiers, Practical integrator and differentiator, Log and anti-log amplifier, Multiplier and Divider, RC active filters-first and second order low pass and high pass filter, band pass and band elimination filter.

Network Analysis: Constant k low pass, high pass; band pass and band elimination filters, m derived filters, propagation constants, characteristic impedance for T and Π sections, neper and decibel.

Noise: Different sources of noise; signal to noise ratio; definition and calculation of noise figure.

Amplitude Modulation: basic concepts of modulation, sidebands; double sideband, single sideband and carrier suppressed mode of transmission; power relation; modulation index, typical circuits for generation and detection of amplitude modulated waves; envelope and average detection, generation and detection of suppressed carrier type AM signals. VSB AM and QAM technique in TV broadcasting.

Angle Modulation: Concepts of frequency and phase modulation, Frequency spectrum; bandwidth; reactance tube and p-n junction methods of generation of FM waves; Armstrong system; demodulation by staggered tuned and Foster Seeley discriminator circuits, equivalence between PM and FM.

Digital circuits: Encoders, Decoders, tri-state devices, A/D converters-parallel comparator, Successive Approximation, Dual-slope.

Elements of Microprocessors : Review of 8085 μP, functions of ALU, Flags, ALE and different registers; instruction set; Assembly language programming; machine cycle; op-code fetch, memory read, memory write and timing diagram; Memory: FF or Latch as storage elements; array of memory elements; addressing of registers; memory map and address lines, absolute and partial decoding and multiple address ranges.

Transmission Lines, Waveguides and Microwaves oscillators: Parallel wire and coaxial lines; transmission line equation; characteristic impedance; propagation constant; high frequency transmission lines; travelling wave interpretation; VSWR; Coefficient of reflection;

principle of stub line matching; directional coupler; Rectangular waveguide; waveguide modes; resonant cavities; reflex klystron; magnetron.

Instrumentation methods

Linear and nonlinear curve fitting, chi-square test.

Particle detectors **:** Principle of Gas filled detector, ionization chamber, scintillation detector and Solid state detectors , Energy Measurements, Signal processing; Multi channel analyzer; Time of flight technique; Coincidence measurements true-to-chance ratio; time resolution.

Counting Statistics and Error Prediction: Characterization of Data, Statistical Models, Application of Statistical Models, Error Propagation, Optimization of Counting Experiments, Limits of Detectability.

Structural and optical properties characterization of materials (XRD, FTIR, UV, PL)

Production and measurement of high vacuum: pumps and gauges

Very High and very low Temperature production and measurement: High temperature furnaces, Cryogenics (brief idea), different thermometers

High magnetic fields production and measurement: superconducting coil magnet, pulse magnetic field, vibrating sample magnetometer, SQUID

Electrodynamics and plasma

Electromagnetic Fields : Maxwell's equations & Pointing's theorem (mention only), Conservation of linear and angular momentum - Maxwell's stress tensor, scalar and vector potentials, gauge transformations-Lorentz gauge and Coulomb gauge, the inhomogeneous wave equations - solution of inhomogeneous wave equations by Green's function; retarded and advanced solutions; Multipole expansion of localized charge distributions, Magnetic monopole.

Multipole Radiations: Electric and magnetic dipole field and radiation of a localized oscillating source; Hertz potential and corresponding field equations; Multipole expansion of the electromagnetic field; Electric quadrupole radiations; Sources of multipole radiation-multipole moments.

Moving Charge: Lienard-Wiechert potentials, the field of a uniformly moving point charge; convection potential and virtual photons.

Radiation from an Accelerated Charge : Fields of an accelerated charge; angular and frequency distributions of the emitted radiation; special cases of acceleration-parallel and perpendicular (circular orbit) to velocity; Larmor's formula and its relativistic generalization; Bremsstrahlung; Cerenkov radiation; radiation reaction; electromagnetic mass.

Scattering: Radiation damping; scattering by a free electron; scattering and absorption of radiation by a harmonically bound electron; scattering of electromagnetic waves from a system of charges, coherent and incoherent Bragg diffraction.
Magneto-hydrodynamics and Plasma Physics : Conducting fluid in a magnetic field; freezing in of lines of force; MHD equations; magnetic pressure; magnetic viscosity; pinch effect; Alfven waves; plasma oscillations; screened potential and Debye length.

Advanced Quantum Mechanics

Approximation methods: Variational method for stationary state problems; Time - independent perturbation theory -non-degenerate and degenerate cases; Time-dependent perturbation theory -transition amplitude; constant and harmonic perturbations; Fermi's golden rule; WKB approximation; Adiabatic and sudden approximations; Applications.

Scattering theory: Scattering amplitude; differential and total cross-sections; Scattering in a spherically symmetric potential partial -wave analysis; phase shift its evaluation; Born approximation; hard sphere scattering.

Symmetries: Symmetry operations as unitary and anti-unitary transformations; conservation laws from invariance principles; Discrete symmetries; reflection, inversion and parity; intrinsic parity; time reversal; Kramers degeneracy.

Quantum Computation: Bits and Qubits; Quantum Cryptography; Bloch sphere representation of a Qubit, Multiple Qubits; Quantum Circuits: Single Qubit Gates, Multiple Qubit Gates, Design of Quantum Circuits; Quantum Teleportation; Experimental realization of Quantum Teleportation; Quantum Computation; Logical Operations on Quantum Registers; A real Quantum Computer.

Relativistic Quantum Mechanics: Klein-Gordon Equation: Continuity equation and indefinite norm; free particle solutions; negative energy-momentum solutions and their interpretation, non-relativistic reduction and interpretation of Klein-Gordon equation; the charged Klein-Gordon field; the interaction of a spin-0 particle with an electromagnetic field; spin of the KG particle; invariance properties.

Dirac equation: the conjugate Dirac equation; continuity equation; non-relativistic correspondence; spin; helicity and magnetic moment of the Dirac particle. Lorentz covariance for the Dirac particle; gamma matrices, their different representations and properties; bilinear covariant; free particle solutions and their representation; negative energy solutions and hole theory; positron.

Statistical Mechanics

Review: Random Walk, phase space, phase points, Phase trajectory, Ensemble, Liouville's equation, Gibbs paradox; Free energy, entropy.

Stationary ensembles: Micro canonical, canonical and grand canonical ensembles. Partition function and statistical definition of thermodynamic quantities; computation of partition functions of some standard systems- ideal gas, Harmonic oscillators, rigid rotators, Para magnetism.; relation between density of states and partition function; spin ½ system and negative temperature; grand canonical ensemble and its partition function; chemical potential; dependence of different thermodynamic quantities on the number of particles; energy fluctuations in the canonical ensemble and the equivalence of the canonical and the microcanonical ensembles; density fluctuations in the grand canonical ensemble and its equivalence to the canonical ensemble. Partition function and distribution for perfect gas.

Density Matrix: Quantum mechanical and statistical averaging, quantum Liouville equation, Density matrix for stationary ensembles. Construction of density matrix, Polarization vector, Pure and Mixed states, Application to a free particle in a box, an electron in a magnetic field, beam of spin ½ particles.

Quantum Statistics: Fermi and Bose distributions; quantum gas in equilibrium; quantum gases of elementary particles; number density and chemical potential; energy density, equation of state and different thermodynamic quantities; relativistic quantum gas; black body radiation and Planck's law; degenerate Bose gas; lattice specific heat and phonons; Bose condensation and super fluidity; quantum liquid with Bose-type spectrum, example of liquid He; degenerate Fermi gas; degeneracy pressure; specific heat of degenerate Fermi gas; Riemann's $\xi(z)$ and integrals of quantum statistics : relativistic degenerate electron gas; high temperature dense matter; white dwarfs and neutron stars.

Real Gas: Free energy; virial equation of state; second virial coefficient and Joule Thomson expansion; inversion temperature, model calculation and van der Waals equation of state.

Ising Model: One dimensional and three dimensional Ising Model, Bragg-William approximation, Bethe-Peierl approximation, Specific heat, high temperature expansion.

Phase Transitions: Liquid-gas, order-disorder, ferroelectric and ferromagnetic transitions; critical points; Ehrenfest's classification; order parameter; continuous and discontinuous transactions; Landau's theory of continuous transitions; continuity of entropy; discontinuity of specific heat; singularities of order parameter and partition function; generalized susceptibility; mean field theory; critical exponents; scaling and fluctuations of order parameter.

Atomic and Molecular Spectroscopy

Atomic Spectroscopy : One electron atom : Hydrogen spectrum; spectral series limit and term values; Ritz combination principle; summary of Bohr-Somerfield model; semi-classical treatments of relativistic corrections and spin-orbit interaction; Thomas correction; non-relativistic limit of Dirac equation; existence of intrinsic spin and anomalous magnetic moment; Dirac – Coulomb problem; relativistic spin-orbit and Darwin terms; correction to Bohr-Somerfield term values; fine structure constant; Lamp-Rutherford splitting; evaluation of integrals $< r^{1/k} >_{nl}$; features of alkali spectrum; double structure; Born Heisenberg approximation; induced dipole field; quantum defects Rydberg and Ritz terms; X-ray spectrum and screening.

Many Electron atoms: Schrödinger equation for many electrons system; central field approximation; product function and Hartee equation; Pauli exclusion principle; Slater determinant; Hartree-Fock approximation; exchange integral; Koopmans theorem, Aufbau principle and the periodic table, Electronic configuration; multiplicity of terms; Russel Saunders coupling; Hunds rule; Lande interval rule; j-j coupling; land g factor, Thomas Fermi approximation.

Atoms in External Electric and Magnetic Fields: Zeeman and Paschen Back effects; Stark effect in hydrogen. Electron-Nucleus interaction: Effect of nuclear spin; hyperfine structure of atomic spectrum; ^{133}Cs clock.

Molecular structure and Spectra: Adiabatic approximation and separation of electronic and nuclear motions; Hund-Mülliken and exchange integral; covalent bond of homonuclear molecules; hybridization and directed valence bond of carbon.

Electronic terms in molecules: Relation between atomic and molecular terms. Vibrational and rotational structures of singlet terms in diatomic molecules; anharmonicity and rotation vibration coupling; angular part of a singlet wave function for a diatomic molecule; multiplet structures in diatomic molecules and Hund's schemes; symmetry of molecules; Λ doubling.

Rotational and Vibrational Energy Levels: Quantization of rotation of a rigid body; rotational spectrum and bond length measurements; rotation-vibration spectrum; Frank Condon principle; Condon parabola; Fortrat diagram P, Q and R branches; band head; fine structure. Fluorescence and phosphorescence; photo dissociation; Raman spectrum.

LASER: basic principle of laser; interaction of atomic system and radiation-density matrix of two-level systems; atomic susceptibility; line shape; saturation; spontaneous and induced transitions; gain coefficient; homogeneous and inhomogeneous broadening; beam stability; optical resonators and resonance frequency; oscillation condition; threshold inversion; oscillation frequency; power output.

Specific Laser Systems: Semiconductor diode laser; quantum well laser; free electron laser.

Solid State Physics

Crystal symmetry and diffraction: Macroscopic and microscopic symmetry elements, Point groups, Space groups, Equivalent points, Braggs Law; in reciprocal lattice and Brillouin Zones, Laue derivation of amplitude of scattered wave; Equivalence of Bragg's law and Laue's condition, Ewald construction Geometrical structure factor and atomic form factor, Structure factor calculations of some novel metals and compounds with SC, BCC, FCC, HCP, NaCl, ZnS and diamond crystal structures,

Imperfection in solids: Different types of defects and dislocation, point defects and line defects, Frenkel and Schottky defects, defects by non-stoichiometry; electrical conductivity of ionic crystals; classifications of dislocations; role of dislocations in plastic deformation and crystal growth. Luminescence and phosphors, decay mechanisms, thermoluminiscence, thalium activated alkali halides; Colour centers and photoconductivity; electron compounds; Excitons.

Crystal Binding: General considerations about bonding: ionic bonds, covalent bond, van der Walls-Fluctuating dipole forces-or molecular bonding, metallic bonding, hydrogen bonds.

Transport Properties: Boltzmann transport equation; electrical conductivity of metals and alloys; thermal conductivity of metals and insulators; Wiedemann-Franz law; isothermal Hall effect; quantum Hall effect.

Energy bands in solids: The Bloch theorem; Bloch functions; Review of the Kronig-Penney model; Brillouin zones; Band gap in the nearly free electron model;The tight binding model; Empty lattice band; Number of states in a band; Effective mass of an electron in a band: concept of holes; Classification of metal, semiconductor and insulator; Electronic band structures in solids - Nearly free electron bands; Tight binding method – application to a simple cubic lattice; Band structures in copper, GaAs and silicon; Topology of Fermi-surface; Electron dynamics in an electric field.Cyclotron resonance and determination of Effective mass. Concept of hole.

Magnetic properties of solids: Semiclassical treatment of paramagnetism for J=1/2, Brillouin function-van Vleck paramagnetism; ground state of an ion and Hund's rules; crystal field splitting and quenching of orbital momentum; Pauli Spin Paramagnetism of Metals; ferromagnetism in insulators; spontaneous magnetization; exchange interactions; antiferromagnetic order; ferrimagnetism; Colossal and Giant magnetoresistance.

Dielectric relaxation: Dielectric solid in static and alternating electric fields; losses; relaxation times; Complex dielectric constant and dielectric losses, relaxation time; Debye equations; Cases of distribution of relaxation time; Cole - Cole distribution parameter; Dielectric modulus; Ferro-electricity; different models and thermodynamic treatment of phase change. Thermo-electricity; electrets.

Phenomenological description of superconductivity: Occurrence of superconductivity; destruction of superconductivity by magnetic field; Thermodynamics of superconductivity; Gibbs free energy; entropy; heat capacity; qualitative description of formation cooper pair and outline of BCS theory and BCS Hamiltonian; energy gap and its experimental evidences; Giaver tunnelling; Flux quantisation; a.c. and d.c. Josephson effect; Vortex state (qualitative discussions); High T_c superconductors (information and qualitative description).

Nuclear Physics

Basic nuclear properties: mass; Change; parity; isospin; binding energy; separation energy.
Nuclear size: Rutherford scattering, electron scattering and form factors, charge density radius and potential radius, Wood-Saxon potential, experimental methods of determination.
Static Electric and Magnetic Moments of a Nucleus; magnetic dipole and electric quadrupole moments. experimental determination.
Liquid Drop Model: properties of the model; the semi-empirical mass formula and its application to considerations of nuclear stability, Degenerate Fermi Gas Model applications.
Nuclear Disintegrations: Nuclear Emission: Penetration of potential barrier; nature of barrier for neutrons, protons and alpha particles; Gamow's theory of alpha disintegration and

calculation of reduced widths and decay half-lives. Beta Decay- Fermi theory; Kurie plot ; log fτ values, classification and selection rules; Gamma disintegration and selection rule.

Interaction of charged particles with matter: ionization formula, range-energy relationship, charged particle detectors, energy measurement and identification of charged particles.

Deuteron: Properties of the deuteron; ground and excited states of deuteron with square-well potential; deuteron radius and probability.

Scattering Problem: **n-p** scattering at low energies; effective range formula and scattering length, shape-independent approximation; modification of effective range for deuteron bound state; scattering by hard sphere and finite square-well potential. **p-p scattering** at low energies; identity of particles, antisymmetrization of wavefunction; comparison with n-p scattering; interference between nuclear and Coulomb forces; effective range. **n-n scattering**; charge-independence and charge symmetry, mirror nuclei, exchange forces and saturation, repulsive core; Relative stability of the n-n, n-p, and p-p systems.

Structure of Complex Nuclei: **Shell Model**: Evidence of shell structure; magic numbers; effective single particle potentials (square-well and harmonic oscillator); extreme single-particle model- its successes and failures in predicting ground state spin, parity and magnetic moments; Nordheim's rules; Schmidt limits, anomalous magnetic moments of nucleons and qualitative discussions about their origin. **Collective Model**: Evidence of collective motion; nature of vibrational and rotational spectra; qualitative discussion in terms of phonons and rigid rotators; quadrupole moments of deformed even-even nucleus.

Nuclear Reactions: Classification; conservation principles; kinematics and Q-values; exoergic and endorgic reactions; threshold energy, Experimental setup; cross sections – elastic, inelastic, reaction, total; principle of detailed balance; Partial wave method of calculating cross sections.

Compound Nuclear Reactions: characteristics; resonance and compound nucleus formation; one level Breit Wigner formula;

Direct Reactions: characteristics; types of direct reactions with examples elastic, inelastic, transfer, stripping, pick-up, knock on and break-up reactions (qualitative discussion with example).

Nuclear Fission: Spontaneous and induced fissions; elementary discussion of Bohr-Wheeler theory; barrier penetration and decay rates in fission; mass distribution of decay products; fission isomers.

Nuclear Fusion and thermo nuclear reaction: Source of energy in stars, Nucleo-synthesis.

Elementary Particle Physics and quantum field theory

Brief history of particle discovery, Relativistic Kinematics and Mandelstam variables. parity; charge conjugation and charge parity; G-parity, time reversal invariance and the principle of detailed balance; CPT theorem (statement only) and its consequences; strangeness; Gell-Mann Nishijima formula,; hypercharge; Properties of Charged Pions and Muons decay modes: measurement of charge, spin, parity, lifetime of pions and muons,

Methods of determination of mass, spin, parity and other quantum numbers of other particles (Principles only). quark structure of baryons and mesons; charm, beauty and truth prediction of Ω; mass formula; baryon and meson resonances , quarkonium; Pauli principle and the colour of quarks. Gluons as mediators in quark quark interaction. Role of Neutrino in parity non-conservation in beta decay; Wu's experiment, Muon Decay and time dilation, Different types of neutrinos.

Quantum Mechanics of Fields and Many Particle Systems (Second Quantization) Identical particles: Bosons and Fermions; Symmetric and antisymmetric many body wave functions.

Method of Second Quantization : Lagrangian formalism; Noethers theorem; in-variance under transformations and operator requirements; quantization of a field obeying Schrödinger's equation; quantum conditions for boson and fermion fields; occupation number representation and Fock space; method of writing one and two body operators in the second quantized notation. Quantization of Klein-Gordon Field:Single component free Hermitian scalar field; plane wave and spherical wave decompositions; energy, momentum and displacement operators; symmetry of states; non-hermitian scalar field; charge operator; particles and antiparticles.

Quantization of Dirac Field: Plane wave representation; quantum conditions; energy and momentum operators; positivity of energy; current and charge operators symmetrisation.

Quantization of the Electromagnetic Field:Maxwell's equations and the electromagnetic field tensor; quantization in the radiation gauge; transverse photon.

Interacting Fields: Brief discussion; quantized electromagnetic field interacting with a classical source; application to atomic transition probabilities; scattering of radiation (Compton Effect); S matrix and the evolution operator.