Course Descriptions of all PHY courses & a few relevant BITS courses

PHY F212 Electromagnetic Theory I 3 0 3

Review of mathematics - scalar and vector fields, calculus of scalar and vector fields in Cartesian and curvilinear coordinates, Dirac delta function; Electrostatics - electric field, divergence & curl of electric field, electric potential, work and energy in electrostatics, conductors, electric dipole; Electrostatics in Matter - polarization and field of a polarized object, electric displacement, linear dielectrics; Magnetostatics - Lorentz force law, Biot-Savart law, divergence & curl of magnetic field, magnetic vector potential, magnetic dipole; Magnetostatics in matter - magnetization and field of a magnetized object, the H-field, linear & non-linear magnetic media; Electrodynamics - electromotive force, electromagnetic induction, Maxwell's equations in free space, plane wave solutions of Maxwell's equations in free space.

PHY F213 Optics 3 0 3

Geometrical optics - light as rays, Fermat's principle, matrix methods in ray tracing; scalar wave theory of light, spatial and temporal coherence, theory of diffraction - Fresnel & Fraunhoffer diffraction, diffraction at rectangular and circular aperture, diffraction around opaque objects; crystal optics - electromagnetic wave propagation in anisotropic media, birefringence, e-m waves in nonlinear media, elements of nonlinear optics; scattering of light – Thomson and Rayleigh scattering; elements of modern optics - lasers and applications, holography, fiber optics, Fourier optics.

PHY F214 Electricity, Magnetism, and Optics Lab 0 2 2

This lab will consist of experiments on electromagnetism, optics and lasers.

PHY F215 Introduction to Astronomy and As-trophysics 3 0 3

Introduction and scope, telescopes, distance and size measurements of astronomical objects, celestial mechanics, the Sun, planets, planet formation, interstellar medium, star formation, stellar structure, stellar evolution, star clusters - open clusters, globular clusters, the Milky-Way galaxy, nature of galaxies - normal and active galaxies, Newtonian cosmology, cosmic microwave background radiation, the early universe.

PHY F241 Electromagnetic Theory II 3 1 4

Maxwell's equations in matter, boundary conditions on electric and magnetic fields; energy of e-m fields and Poynting's theorem, linear momentum and angular momentum of e-m fields, Maxwell's stress tensor; electromagnetic waves in dielectric media – reflection, refraction and transmission at interfaces; wave propagation in metals – absorption and dispersion; guided waves; potential formulation of e-m fields, retarded potentials & Jefimenko's equations, Lienard-Weichert potentials and fields of a moving point charge; dipole radiation & radiation due to point charges; special theory of relativity, relativistic mechanics, relativistic electrodynamics.

PHY F242 Quantum Mechanics I 3 0 3

Origin of the quantum theory - black body radiation, photoelectric effect, Compton scattering, electron diffraction, Bohr model of hydrogen atom, Frank-Hertz experiment, Bohr- Sommerfeld quantization condition; notion of wave function, statistical interpretation of the wave function, issues of normalization, the Heisenberg uncertainty relation; Schrodinger equation, stationary states and time independent Schrodinger equation, energy eigenvalues and eigenfunctions, one-dimensional problems – potential wells, potential barriers, the harmonic oscillator; Hilbert space formalism – state vectors, Dirac's bra-ket notation, observables as Hermitian operators, eigenvalues and eigenstates of Hermitian operators, the measurement postulate.

PHY F243 Mathematical Methods of Physics 3 0 3

Tensor analysis in Cartesian and curvilinear coordinates; linear vector spaces, linear transformations and theory of matrices; functions of a complex variable, contour integration and applications; elements of calculus of variation; series solution of ordinary differential equations, special functions, Sturm-Liouville theory; Fourier integral; partial differential equations of physics, solution of partial differential equations by separation of variables method, the Green function method.

PHY F244 Modern Physics Lab 0 2 2

This lab will consist of experiments on modern physics and electromagnetism.

PHY F266 Study Project 3

These courses include projects which are oriented towards readings from published literature or books about new fron-tiers of development or analysis of available database.

These courses are normally available to students in second or higher levels. These courses must terminate with project reports.

PHY F311 Quantum Mechanics II 3 0 3
Hilbert space formalism (continued from QM-I) - operators and their matrix representations, change of basis, position and momentum representations, commuting and noncommuting observables, the generalized uncertainty relation; the time evolution operator and Schrodinger equation, Schrodinger and Heisenberg picture, simple harmonic oscillator using operator method; angular momentum operators and their commutation relations, eigenvalues and eigenvectors of angular momentum, spherically symmetric potentials, the hydrogen atom; time independent perturbation theory, WKB approximation, variational method; time dependent perturbation theory, interaction of atom with classical radiation field; identical particles.

PHY F312 Statistical Mechanics 3 0 3
Review of Thermodynamics - First and the second law of thermodynamics, reversible and irreversible processes, entropy, absolute temperature, thermodynamic potentials ; Statistical description of macroscopic systems - micro and macro states, phase space distribution, Liouville theorem, microcanonical ensemble, statistical definition of temperature, pressure and entropy; Canonical ensembles, probability distribution in canonical ensemble, partition function and calculation of thermodynamic quantities, equipartition and virial theorems, Maxwell velocity distribution, paramgnetism, harmonic oscillators, polyatomic molecules; Grand canonical ensembles - probability distribution in grand canonical ensemble, grand partition function, calculation of thermodynamic quantities; Quantum statistics - indistinguishable particles, Bose-Einstein and Fermi-Dirac distribution, classical limit, photon statistics, Planck distribution; Ideal Fermi gas - equation of state of ideal Fermi gas, free electron gas in metals, Pauli paramagnetism, Landau diamagnetism, statistical equilibrium of white dwarf stars; Ideal Bose Gas - equation of state, Bose-Einstein condensation.

PHY F313 Computational Physics 3 0 3

Review of programming language - C/C++, Matlab and Mathematica; Functions and roots - Newton-Raphson method, rate of convergence, system of algebraic equations; Numerical integration - Romberg integration, Gaussian quadrature; Ordinary differential equations - Euler Method, Runge-Kutta method, predictor-corrector method, system of equations; Partial differential equations - boundary value problems, finite difference method, finite element method; discrete and fast Fourier transform; Eigen-value problems; Monte-Carlo method - random numbers, sampling rules, metropolis algorithm.

PHY F315 Theory of Relativity 3 0 3

Special theory of relativity : Experimental background and postulates of the special theory, Lorentz transformation equations and their implications, space-time diagrams, Four vectors, tensors in flat space-time, relativistic kinematics and dynamics, relativistic electromagnetism. General theory of relativity : Principle of equivalence, gravitational red shift, geometry of curved space-time, Einstein field equation, spherically symmetric solution of field equation.

PHY F341 Solid State Physics 3 0 3

Crystal structure - direct and reciprocal lattice, Brillouin zone, X-ray diffraction and crystal structure; free electron theory of metals; periodic potential and band theory of solids, the tight-binding approximation; lattice vibration and thermal properties; semiconductors - energy band gap in semiconductors, carrier density of intrinsic and extrinsic semiconductors, the p-n junction; magnetism – paramagnetism and diamagnetism, spontaneous magnetism, magnetic ordering; super conductivity-basic properties, the London equation, elements of BCS theory.

PHY F342 Atomic and Molecular Physics 3 0 3

Interaction of electromagnetic field with atoms - transition rates, dipole approximation, Einstein coefficients, selection rules and spectrum of one electron atom, line intensities and shapes, line widths and lifetimes; one electron atoms - fine and hyperfine structure, interaction with external electric and magnetic fields; two electron atoms - para and ortho states, level scheme, ground and exited states of two electron atoms; many electron atoms - central field approximation, Thomas –Fermi model, Hartree- Fock method, L-S coupling and j-j coupling; Molecular structure - Born-Oppenheimer approximation, rotation and vibration of diatomic and polyatomic molecules, electronic structure and spin, rotational, vibrational and electronic spectra of diatomic molecules, nuclear spin.

PHY F343 Nuclear and Particle Physics 3 0 3
Bethe-Weizsacker mass formula, nuclear size, mirror nuclei, electric multipole moments, Spherically and axially symmetric charge distribution, electric quadrupole moment, nuclear magnetic moment, nuclear decay, alpha and beta decay processes, nuclear fission, Bohr-Wheeler theory, two-body problem, deuteron wave function with central and

PHY F344 Advanced Physics Lab 0 3 3

This lab will consist of experiments on solid state physics, spectroscopy and nuclear physics.

noncentral potential, electric quadrupole moment & magnetic moment, exchange forces, low energy nucleon-nucleon scattering, scattering length, effective range theory, spin dependence of n-p scattering, magic numbers, independent particle model, collective model. Mesons and baryons, antiparticles, neutrinos, strange particles, eightfold way, quark model, intermediate vector bosons, four fundamental forces, basic vertices and charactesitics of quantum electrodynamics, quantum flavordyamics and quantum chromo dynamics, decays and conservations laws, basic ideas of standard model of particle physics, qualitative discussion of current issues in particle physics.	
PHY F376 Design Project 3 These courses are intended to impart training in design of product/ process or other artifact to the students in the discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports.	**PHY F377 Design Project 3** Same as PHY F376
PHY F366 Lab Project 3 These courses include projects involving laboratory investigation or laboratory development in the students discipline or interdisciplinary areas. These courses are normally available to students in third or higher levels. These courses must coterminate with project reports	**PHY F367 Lab Project 3** Same as PHY 367
PHY F412 Introduction to Quantum Field Theory 3 1 4 Klein-Gordan equation, SU(2) and rotation group, SL(2,C) and Lorentz Group, antiparticles, construction of Dirac Spinors, algebra of gamma matrices, Maxwell and Proca equations, Maxwell's equations and differential geometry; Lagrangian Formulation of particle mechanics, real scalar field and Noether's theorem, real and complex scalar fields, Yang-Mills field, geometry of gauge fields, canonical quantization of Klein-Gordan, Dirac and Electromagnetic field, spontaneously broken gauge symmetries, Goldstone theorem, superconductivity.	**PHY F413 Particle Physics 3 1 4** Klein-Gordan equation, time-dependent non-relativistic perturbation theory, spinless electron-muon scattering and electron-positron scattering, crossing symmetry, Dirac equation, standard examples of scattering, parity violation and V-A interaction, beta decay, muon decay, weak neutral currents, Cabibo angle, weak mixing angles, CP violation, Weak isospin and hypercharge, basic electroweak interaction, Lagrangian and single particle wave-equation, U(1) local gauge invariance and QED, non-abelian gauge invariance and QCD, spontaneous symmetry breaking, Higgs mechanism, spontaneous breaking of local SU(2) gauge symmetry.
PHY F414 Physics of Advanced Materials 3 1 4 Review of fundamentals of crystallography, structural properties of crystals, polymers and glasses, processes involved in materials preparation, viz., diffusion, phase diagrams, advanced techniques to prepare low dimensional systems and thin films, kinetics of phase transformations, Mechanical, structural, thermal and electrical characterization of advanced materials, e.g., high Tc superconductors, superionic conductors, conducting polymers, dielectrics, ferroelectric materials, polycrystalline semiconducting materials, magnetic semiconductors, magneto resistance and GMR materials, shape memory alloys.	**PHY F416 Soft Condensed Matter Physics 3 1 4** Forces, energies, timescale and dimensionality in soft condensed matter, phase transition, mean field theory and its breakdown, simulation of Ising spin using Monte Carlo and molecular dynamics, colloidal dispersion, polymer physics, molecular order in soft condensed matter – i) liquid crystals ii) polymer, supramolecular self assembly.
PHY F415 General Theory of Relativity and Cosmology 3 1 4 Review of relativistic mechanics, gravity as geometry, descriptions of curved space-time, tensor analysis, geodesic equations, affine connections, parallel transport, Riemann and Ricci tensors, Einstein's equations, Schwarzschild solution, classic tests of general theory of relativity, mapping the universe, Friedmann-Robertson-Walker (FRW)	**PHY F417 Experimental Methods of Physics 3 1 4** Vacuum techniques, sample preparation techniques, X-ray diffraction, scanning probe microscopy, scanning electron microscopy, low temperature techniques, magnetic measurements, Mossbauer and positron annihilation spectroscopy, neutron diffraction, Rutherford backscattering, techniques in nuclear experimentation, high energy accelerators.

cosmological model, Friedmann equation and the evolution of the universe, thermal history of the early universe, shortcomings of standard model of cosmology, theory of inflation, cosmic microwave background radiations (CMBR), baryogenesis, dark matter & dark energy.	
PHY F418 Lasers and Applications 3 1 4 Properties of laser light, theories of some simple optical processes, basic principles of lasers, solid-state lasers, gas lasers, semiconductor lasers, free electron lasers, liquid, dye and chemical lasers, dynamics of laser processes, advances in laser physics, Q-switching, modelocking (active and passive), saturable absorbers, Kerr lens mode locking, non-linear optics, laser spectroscopy, time resolved spectroscopy, multi-photon spectroscopy.	**PHY F419 Advanced Solid State Physics 3 1 4** Schrodinger field theory (second quantized formalism), Bose and Fermi fields, equivalence with many body quantum mechanics, particles and holes, single particle Green functions and propagators, diagrammatic techniques, application to Fermi systems (electrons in a metal, electron – phonon interaction) and Bose systems (superconductivity, superfluidity).
PHY F420 Quantum Optics 3 1 4 Quantization of the electromagnetic field, single mode and multimode fields, vacuum fluctuations and zero-point energy, coherent states, atom - field interaction – semiclassical and quantum, the Rabi model, Jaynes-Cummings model, beam splitters and interferometry, squeezed states, lasers.	**PHY F421 Advanced Quantum Mechanics 3 1 4** Symmetries, conservation laws and degeneracies; Discrete symmetries - parity, lattice translations and time reversal; Identical particles, permutation symmetry, symmetrization postulate, two-electron system, the helium atom; Scattering theory - Lippman-Schwinger equation, Born approximation, optical theorem, eikonal approximation, method of partial waves; Quantum theory of radiation - quantization of electromagnetic field, interaction of electromagnetic radiation with atoms; relativistic quantum mechanics.
PHY F422 Group Theory and Applications 3 1 4 Basic concepts – group axioms and examples of groups, subgroups, cosets, invariant subgroups; group representation , unitary representation, irreducible representation, character table, Schur's lemmas; the point symmetry group and applications to molecular and crystal structure; Continuous groups – Lie groups, infinitesimal transformation, structure constants; Lie algebras, irreducible representations of Lie groups and Lie algebras; linear groups, rotation groups, groups of the standard model of particle physics.	**PHY F423 Special Topics in Statistical Mechanics 3 1 4** The Ising Model – Definition, equivalence to other models, spontaneous magnetization, Bragg- William approximation, Bethe-Peierls Approximation, one dimensional Ising model, exact solution in one and two dimensions; Landau's mean field theory for phase transition – the order parameter, correlation function and fluctuation-dissipation theorem, critical exponents, calculation of critical exponents, scale invariance, field driven transitions, temperature driven condition, Landau-Ginzberg theory, two-point correlation function, Ginzberg criterion, Gaussian approximation; Scaling hypothesis – universality and universality classes, renormalization group; Elements of nonequilibrium statistical mechanics – Brownian motion, diffusion and Langevin equation, relation between dissipation and fluctuating force, Fokker-Planck equation.
PHY F424 Advanced Electrodynamics 3 1 4 Review of Maxwell's equations – Maxwell's equations, scalar and vector potentials, gauge transformations of the potentials, the electromagnetic wave equation, retarded and advanced Green's functions for the wave equation and their interpretation, transformation properties of electromagnetic fields; Radiating systems – multipole expansion of radiation fields, energy and angular momentum of multipole radiation, multipole radiation in atoms and nuclei, multipole radiation from a linear, centre-fed antenna; Scattering and diffraction – perturbation theory of scattering, scattering by gases and liquids, scattering of EM waves by a sphere, scalar and vector diffraction theory, diffraction by a circular aperture; Dynamics of relativistic particles and EM fields – Lagrangian of a relativistic charged particle in an EM field, motion in uniform, static electromagnetic fields, Lagrangian of the EM fields, solution of wave equation in covariant form, invariant Green's functions; Collisions, energy loss and scattering of a charged particle, Cherenkov radiation, the Bremsstrahlung; Radiation by moving charges – Lienard-Wiechert potentials and fields, Larmor's formula and its relativistic generalization; Radiation damping – radiative reaction force	**PHYF425 Advanced Mathematical Methods of 3 1 4 Physics** Course description is to be developed.

from conservationof energy, Abraham-Lorentz model.	
PHY F426 Physics of Semiconductor Devices 3 1 4 Course description is to be developed.	**PHY F427 Atmospheric Physics 3 0 3** Course description is to be developed.
PHY F491 Special Projects 3 This is an unstructured open-ended course where under the overall supervision of an instructor-in-charge, batches of students will be attached to different instructors. Each batch will work on a specific time-bound project which is of basic or peripheral concern of his discipline. Each student must submit a project report as a culmination of his endeavour and investigation. The instructor- in-charge will determine the choice of the project and also whether or not the project report is to be submitted jointly by a group or individually by a student. The course will aim to evaluate student's actual ability to use the fundamentals of knowledge and to meet new unknown situations as demonstrated by the students' interaction with the instructors and instructor-in-charge and aggregated in the project report. The instructor-in- charge may assign specific hours for formal brain-storming sessions.	**PHY G511 Theoretical Physics 5** Calculus of Variations and its applications to Lagrangian and Hamiltonian Dynamics, Thermodynamics and Geometric Optics and Electrodynamics. Geometric and Group theoretic foundations of Hamiltonian Dynamics, Hamilton-Jacobi Theory, Integrability and Action-Angle Variables, Adiabatic Invariants, Transformation (Lie) Groups and Classical Mechanics. Modern Theory of Phase Transitions and Critical Phenomenon: Thermodynamics and Statistical Mechanics of Phase Transitions, General Properties (eg Scaling, Universality, Critical exponents) and Order of Phase Transitions; Introduction to Landau-Ginzburg (Mean Field Theory) theory for Second Order Phase Transitions, the Ising Model and some Examples, Phase Transitions as a *symmetry-breaking* phenomenon.
PHY G513 Classical Electrodynamics 4 Review of Electrostatics, Magnetostatics, and solution of Boundary Value Problems. Method of Images. Maxwell equations for time dependent fields, Propagation of electromagnetic waves in unbounded media. Waveguides & Cavity Resonators. Absorption, Scattering and Diffraction, Special Relativity, Covariant formulation of Classical Electrodynamics. Dynamics of charged particles in electromagnetic fields. Radiation by moving charges and Cerenkov Radiation.	**PHY G514 Quantum Theory and Applications 4** Mathematics of linear vector spaces, Postulates of Quantum Mechanics, Review of exactly solvable bound state problems, WKB methods, Angular momentum, Spin, Addition of angular momenta, Systems with many degrees of freedom, Perturbation theory, Scattering theory, Dirac equation.
PHY G515 Condensed Matter Physics I 4 Free electron models, Reciprocal lattice, Electrons in weak periodic potential, Tight-binding method, Semiclassical model of electron dynamics, Theory of conduction in metals, Theory of harmonic crystals, Anharmonic effects, Semiconductors, Diamagnetism and paramagnetism, Superconductivity.	**PHY G516 Statistical Physics & Applications 4** Liouville's theorem, Boltzmann transport equation, H-Theorem; Postulate of statistical Mechanics; Temperature; Entropy; Micro-canonical, Canonical, Grand-canonical ensembles - Derivation, calculation of macroscopic quantities, fluctuations, equivalence of ensembles, Applications, Ideal gases, Gibbs Paradox; Quantum mechanical ensemble theory; Bose-Einstein statistics –derivation, Bose Einstein condensation, applications; Fermi-Dirac Statistics – derivation, applications - Equation of state of ideal Fermi gas, Landau Diamagnetism, etc; Radiation; Maxwell-Boltzmann statistics; Interacting systems – cluster expansion, Ising model in 1-d & 2-d; Liquid Helium, phase transitions and renormalization group.
PHY G517 Topics in Mathematical Physics 4 Functions of complex variables, special functions, fourier analysis, Sturm-Liuoville theory, partial differential equation with examples, Greens functions, Group theory, differential forms, approximation methods in solutions of PDE's, vector valued PDE's.	**PHY G521 Nuclear and Particle Physics 5** Course description for the above course is to be developed.

PHY G531 Selected Topics in Solid State Physics -5

Schrodinger Field Theory (2nd Quantized formalism), Bose and Fermi fields, equivalence with many body quantum mechanics, particles and holes, Single particle Green functions and propagators, Diagrammatic techniques, Application to Fermi systems electrons in a metal, electron-phonon interaction) and Bose systems (superconductivity, superfluidity).

PHY G541 Physics of Semiconductor Devices 5

Electrons and Phonons in Crystals; Carrier dynamics in semiconductors; Junctions in semiconductors (including metals and insulators); Heterostructures; Quantum wells and Low-dimensional systems; Tunnelling transport; Optoelectronics properties; Electric and magnetic fields; The 2d Electron gas; Semiconductor spintronic devices

PHY F316 Musical Acoustics 3 0 3

Mathematical description of sound waves; physicalsound production by vibrations in different dimensions; perception of music by the human ear and brain, the scientific meaning of psycho-acoustic concepts of pitch, loudness and timbre; Fourier analysis as a tool for characterizing timbre; musical scales, harmonics and tones; musical instruments with plucked, bowed and struck strings, wood-wind instruments, reed instruments and the human voice, percussions instruments such as tympani, and drums; engineering for sound reproduction in transducers, mikes, amplifiers and loudspeakers; sound spectrum analysis; basics of signal processing for electronic music production, filtration and enhancement; rudiments of room and auditorium acoustics ; hands-on work and projects.

BITS F317 Theoretical Neuroscience 3 0 3

Introduction to nervous system: Neurons; centraland peripheral nervous systems; nerves; ganglions;brain areas; Neural circuits – few examples; Single neuron modelling: Electrical properties of a neuron; Action potential; Integrate and fire models; Conductance based models - Hodgkin-Huxley model, Morris-Lecar model; Cable equation; Multicompartment models for dendrites; Models for synapses; FitzHugh-Nagumo model; Networks of neurons: Feed forward network; Recurrent networks; Excitatory-Inhibitory networks; Stochastic networks; Encoding and decoding: Firing rate; Spike-train statistics; Receptive fields; Reverse correlation methods; Static nonlinearities; Discrimination; Population decoding; Spike-train decoding; Shannon entropy; Mutual information; Entropy maximization and information; Current trends in theoretical neuroscience.

BITS F316 Nonlinear Dynamics & Chaos 3 0 3

Chaos – definitions, characteristics, and measures; Examples of chaotic systems; Nonlinear dynamics and chaos – state space, Poincare sections, Iterated maps, Period-doubling; Quasi-periodicity, Intermittency, fractals; computer simulations of chaotic systems; Selected topics and applications of chaos theory; Examples will be drawn from different disciplines in science, engineering, and social sciences.

BITS F386 Quantum Information & Computation 3 0 3

History and scope, introduction to quantum information, quantum bits (qubits), quantum parallelism, teleportation etc. Basic ideas of quantum systems, two-state systems, evolution of states, superposition, entanglement, quantum measurement, decoherence. Basic ideas of computation theories and models, computational resources, complexity. Quantum Gates: single qubit, multiple qubit gates, controlled gates, universal gates, measurement. Quantum algorithms, Deutsch', Shor's and Grover's Algorithms, quantum circuits. Quantum Fourier Transform and applications, Quantum Search Algorithm. Physical Implementation of quantum computation. Compression and transmission of quantum information, quantum noise, error-correction, coding and cryptography, complexity, fault-tolerant computation.

PHY F378 Plasma Physics and its Applications

Introduction to plasma physics. Motion of single charged particles in Electric and Magnetic fields. Fluid description of plasma and study of waves in plasmas, Theory of instabilities in plasma, A Kinetic theory description of plasma and some basic plasma phenomenon, Applications of plasma physics to plasma based accelerators, plasma based energy radiation sources, magnetic confinement fusion, laser-plasma interaction, astrophysical plasma, and studying plasma physics using computer simulation.

Quantum Mechanics For Engineers 3 0 3

Wave particle duality; Schrödinger wave equation; probability and current densities; position and momentum operators; state space; expectation values of operators; commuting operators, Uncertainty relations; orthogonality and completeness of eigenfunctions; one dimensional potential problems; reflection and transmission; harmonic oscillator; time dependent Schrödinger equation; time evolution of stationary states; group velocity; crystals; one electron approximation; Kronig-Penny model; Bloch's theorem; density of states; effective mass; band structure calculations; nanostructures: quantum wire, quantum well, quantum dots

Advanced Quantum Field Theory 3 0 3

Diagrammatics : Feynman diagrams & rules in Phi^4, Tree and loop amplitudes, Combinatorics of Feynman diagrams ; Loop diagrams : Computing amplitudes in Phi^4 - loops and divergences, Regularizations (cut-off, Pauli-Villars, Dimensional), Renormalization of mass, Coupling and field, Scheme dependence, Subdivergences,

Renormalizability and power counting ; S-matrix : Schwinger-Dyson equations, LSZ , Optical theorem ; Path integrals : Path integral techniques in QM, Computing amplitudes, PI for fermions, Grassman integrals; Saddle-point & Effective action ; Gauge theories : FP quantisation of gauge-fields - abelian & non-abelian, Ghost fields, QED and QCD lagrangians ; QED : Bhabha, Moller, Compton scattering, Ward identity, Anomalies, Fujikawa method, topological index ; Renormalization group: Renormalization group flow, Beta and Gamma functions, Relevant, irrelevant, marginal operators; Critical exponents ; QCD : e^+ e^- scattering, DIS, Asymptotic freedom, Jets, collinear divergences; Drell-Yan processes ; Non-perturbative states : Solitons, Instantons, Monopoles.	