

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-501 **Course Title:** Numerical Analysis and Computational Techniques

L-T-P: 2-0-2

Credits: 3

Subject Area: PCC

Course Outlines: Review of computer programming. Linear system of simultaneous equations, nonlinear algebraic equation, curve fitting, roots of transcendental equation, interpolation, data analysis and statistics. Finite difference method, Numerical integration and differentiation, Monte-Carlo simulation, ordinary differential equation, partial differential equation methods.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-503

Course Title: Fabrication and Characterization Techniques

L-T-P: 3-0-0

Credits: 3

Subject Area: PCC

Course Outlines: Lithographic techniques: Patterning, various kinds of resists, Spin Coating, Thermodynamics of Material Growth, Kinetics and Nucleation; Grain growth, Physical Vapor Deposition: Evaporation, Pulsed Laser Deposition, Nano-fabrication Techniques: Bottom-up and top-down approaches, Electrospraying, Sol-Gel. Dry and wet etching techniques. Structural characterization: X-ray Diffraction, X-ray Reflectivity, RHEED, Microstructural characterization: Optical Microscopy: Scanning Electron Microscopy, Atomic Force Microscopy, Transmission Electron Microscope, Electrical and Transport Characterization, Chemical characterization, Thermal characterization, Optical Characterization: Ellipsometer, Spectrometric characterization: IR, Raman and X-ray photo spectrometer.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-505 **Course Title:** Laboratory Work in Solid State Electronic Materials

L-T-P: 0-0-6

Credits: 3

Subject Area: PCC

Course Outlines: Four Probe Technique for resistivity measurement, Mapping and analysis of the resistivity of thin films and bulk samples, Ionic conductivity measurement of solid state materials, Hall coefficient of n- and p- type semiconductors, Dielectric constant, Curie temperature of ferroelectric material, Verification of Bragg's condition by X-ray diffractometer, Thermoluminescence study in alkali halides crystals, solar cell characteristics, magnetoresistance of semiconductors, coercivity, saturation magnetization and retentivity of ferromagnetic materials, laser diode characteristics, superconductivity measurements, Determination of Lande's 'g' factor, C-V characteristics of various solid-state devices and materials

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-507

Course Title: Semiconductor Device Physics

L-T-P: 3-1-0

Credits: 4

Subject Area: PCC

Course Outlines: Physics of Semiconductors; P-N junction, Metal-Semiconductor junction and Bipolar Junction Transistors; Field Effect Transistors: Junction Field Effect Transistor, Metal Semiconductor Field Effect Transistor, High Electron Mobility Transistors, Metal Oxide Semiconductor Field Effect Transistors (Ideal and real MOS capacitors, Threshold Voltage, C-V curve, Current-Voltage Characteristics of Enhancement Mode MOSFET); Tunnel Devices: Tunnel Diode, MIS tunnel devices, MIM tunnel diodes, Hot Electron Transistors, Resonant Tunneling Diodes; IMPATT Diodes, BARITT Diode, TUNNETT Diode; Single Electron Transistors .

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-509

Course Title: Science and Technology of Thin Films

L-T-P: 3-0-0

Credits: 3

Subject Area: PCC

Course Outlines: Vacuum components and systems, Thin film deposition techniques, Physical vapour Deposition Techniques including Sputtering, Pulsed Laser Deposition, Molecular Beam Epitaxy and Chemical Vapour deposition, different methods to study structural, Chemical, Electrical and Magnetic properties of thin films, Applications of thin films.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-511

Course Title: Laboratory Work in Photonics

L-T-P: 0-0-6

Credits: 3

Subject Area: PCC

Course Outlines: Mode-field diameter, bend loss and cut-off wavelength of a single mode fiber, numerical aperture, and refractive index profile of a multi-mode fiber, refractive index profiling of a planar waveguide by prism coupling method, acousto-optic effect, electro-optic effect, Characterization of light emitting diode, laser diode, photo-voltaic solar cell, photodetectors, and optocoupler, thin films deposition by thermal evaporator and spin coating, thin film characterization by spectro-photometer, optical time domain reflectometry.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-513

Course Title: Optical Electronics

L-T-P: 3-1-0

Credits: 4

Subject Area: PCC

Course Outlines: Anisotropic medium, wave and ray refractive indices, index ellipsoid, fundamentals of lasers, lasers rate equations, resonator cavity, Q-switching and mode locking, solid state lasers, gas lasers, fiber lasers, semiconductor lasers, salient features of optical fibers, electro-optic effect, longitudinal and transverse configurations, acousto-optic effect, RamanNath and Bragg diffraction, acousto-optic devices, nonlinear optical effects, second harmonic generation, frequency conversion, optical parametric amplifier, self-focussing, self-phase modulation, stimulated Raman and Brillouin scattering.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-521

Course Title: Quantum Mechanics – I

L-T-P: 3-1-0

Credits: 04

Subject Area: PCC

Course Outlines: Foundations of non-relativistic quantum mechanics, Matrix formulation and applications, Harmonic Oscillator, Angular momentum algebra, Quantum scattering theory, Approximate solution methods in Quantum mechanics.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-523

Course Title: Advanced Mathematical Physics

L-T-P: 3-1-0

Credits: 4

Subject Area: PCC

Course Outlines: Review of complex analysis. Fourier and Laplace transforms. Solutions of differential equations: Review of some differential equations relevant to Physics and their solutions (special functions): Legendre, associated Legendre, Hermite, Laguerre, associated Laguerre, Bessel and Hypergeometric equations. Beta and Gamma functions. Solutions of inhomogeneous differential equations and Green's functions. Symmetry and transformations: Tensor calculus. Representation theory of groups and applications in physics.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-525

Course Title: Classical Electrodynamics

L-T-P: 3-1-0

Credits: 4

Subject Area: PCC

Course Outlines: Maxwell's Equations, Scalar and Vector Potentials, Gauge transformations, Poynting theorem; Electromagnetic waves in conducting and non-conducting medium; Multipole expansion of electromagnetic fields, Multipole Moments; Lienard-Wiechert potentials, Fields produced by a charged particle in uniform and arbitrary motion, Radiation from an accelerated charged particle with collinear velocity and acceleration; Synchrotron radiation, Cherenkov radiation, Thomson scattering; Covariant formulation of vacuum electrodynamics: space-time symmetry of the field equations, four-vector potential, Electromagnetic field-tensor and its invariants, Lorentz Force equation in a covariant form.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-527

Course Title: Classical Mechanics

L-T-P: 3-1-0

Credits: 3

Subject Area: PCC

Course Outlines: Holonomic and nonholonomic constraints, D'Alembert's principle and Lagrange's equation of motion, Calculus of variations, Cyclic coordinates, conservation laws, relativistic and covariant formulation, Hamilton's equation of motion, Principle of least action, Canonical transformations, Symplectic approach, Poisson brackets, Angular momentum, Symmetry groups and Liouville's theorem, Hamilton-Jacobi equations of motion, harmonic oscillations, action-angle variables, Kepler problem, Adiabatic invariants.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-529

Course Title: Atomic, Molecular and Laser Physics

L-T-P: 3-0-0

Credits: 3

Subject Area: PCC

Course Outlines: Atomic Spectroscopy, Spectra of one and two electron systems, Electron spin and magnetic moment, Fine structure splitting, Lamb shift, hyperfine structure and isotope shifts, exotic atoms, Many-electron atoms, L-S and J-J coupling, Hund's rules, atoms in electric and magnetic fields, X-ray spectra. Molecular spectra of diatomic molecules, Born-Oppenheimer approximation, Raman effect, Characteristics of laser light, Optical amplification, Population inversion, Basic concepts of 2-, 3- and 4-level systems, optical resonator, characteristics of semiconductor and gas lasers.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**NAME OF DEPARTMENT/CENTRE/SCHOOL:** Department of Physics**Subject Code:** PHT-506 **Course Title:** Superconducting Qubits-based Quantum Computing**L-T-P:** 3-0-0**Credits:** 3**Subject Area:** STAR

Course outlines: Quantum states in Hilbert space, EPR paradox, Schrödinger wave equation and its incompleteness, Superposition, entanglement, Quantum Confinement, Fundamentals of Superconductivity, Cooper pairs, and Josephson tunneling. Bits and Qubits, Josephson Quantum dot-junction-based Superconducting quantum qubits, charge qubits, flux qubits and phase qubits, Transmon qubit, and hybrid qubits. Quantum circuits Quantum gates X-gate (bit flip, Not), Z-gate (phase flip), H-gate and T gate, controlled-NOT, qubits gates and quantum Circuits, Shor's Algorithm, and Grover's Algorithm code, Superconducting qubits-based quantum computers fabrication, advantages based on coherence time, operation fidelities and Error's correction, Di-Vincenzo Criteria, Possible array of Superconducting Quantum Qubits, and Challenges ahead in Quantum computing.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-531

Course Title: Condensed Matter Physics

L-T-P: 3-0-0

Credits: 3

Subject Area: PCC

Course Outlines: Free electron theories: Drude and Sommerfeld models, Geometry of solids: crystal structure, X-ray and neutron diffraction, reciprocal lattice, Brillouin zone, Band theory of solids, Bloch's theorem, Lattice dynamics, lattice specific heat, Magnetism: Larmor diamagnetism, Curie paramagnetism, Weiss molecular field theory of ferro and antiferromagnetism, Superconductivity: Meissner effect, heat capacity, isotope effect, type-I and type-II superconductors, London theory, elementary BCS theory.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-533

Course Title: Statistical Mechanics

L-T-P: 3-0-0

Credits: 3

Subject Area: PCC

Course Outlines: Review of classical statistical mechanics; Quantum statistical mechanics: FD and BE statistics and their applications in physics; Phase transitions and applications: spontaneous symmetry breaking, order parameter, critical phenomena, Landau theory of phase transitions, Ising model; Stochastic processes: random walk and its applications.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-535

Course Title: Laboratory Work

L-T-P: 0-0-6

Credits: 3

Subject Area: PCC

Course Outlines: Hall effect, Four Probe method, PN junction, random nature of nuclear radiation, G.M. tube characteristics, distribution of the size of Aerosol, attenuation of laser radiation in varying atmospheric condition, precipitation rate of water using rain gauge, numerical aperture of a fiber, laser beam characteristics, elliptically and circularly polarized light, flip flop, relaxation oscillator, Schmitt trigger, binary/BCD up-down counter.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-537

Course Title: Elements of Nuclear and Particle Physics

L-T-P: 3-0-0

Credits: 3

Subject Area: PCC

Course Outlines: Two nucleon interaction, nuclear models, spin-orbit interaction and magic numbers, Nuclear reactions: conservation laws, angular distributions and cross sections, direct and compound reactions, elementary particles and conservation of baryon number, strangeness, colour, quarks and gluons, SU(2) and SU(3) groups, SU(3) flavour symmetry, V-A theory of β -decay, Klein-Gordon and Dirac equation, Gauge theory: the electromagnetic, weak and strong interactions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-539

Course Title: Physics of Earth's Atmosphere

L-T-P: 2-0-0

Credits: 2

Subject Area: PCC

Course Outlines: Atmospheric Evolution, Solar radiation, present atmospheric constituents, Thermodynamics of Atmosphere, Humidity variables, Moist air, adiabatic expansion of unsaturated air, various lapse rates, Atmospheric absorption and greenhouse effect, Atmospheric aerosols, Plasma, Ionosphere, Chapman theory of layer production, electron, ion and neutral temperatures in the thermosphere, airglow and auroral emissions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHL-555

Course Title: Optical Communication System

L-T-P: 3-1-0

Credits: 4

Subject Area: PEC

Course Outlines: Analogue vs digital communication, Elements of digital communication system, Communication channels (Wireline, Fiber-optic, Wireless, Underwater acoustic and storage channels) and their characteristics, Mathematical models for communication channels, Digital modulation and demodulation schemes, Introduction to quantum communication.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHL-559

Course Title: Photonic Sensors

L-T-P: 3-1-0

Credits: 4

Subject Area: PEC

Course Outlines: Basics of photonic sensors, characteristics and performance parameters, Basic optical sensors and interrogation scheme, Evanescent waves and plasmonic sensors, Fiber optic sensors: FBGs and LPGs, interferometric sensors, gyroscope, Distributed sensors, reliability issues in photonic sensing, Enhanced sensor schemes, Quantum sensing and metrology

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHL-561

Course Title: Silicon Photonics

L-T-P: 3-1-0

Credits: 4

Subject Area: PEC

Course Outlines: Metal Oxide Semiconductor (MOS) Transistors (Qualitative analysis and review), CMOS Processing Technology and its relevance to photonic devices and circuits, Silicon Photonic waveguides with focus in SOI platform, Coupling of light from- and to photonic waveguides, Resonant and Non-resonant Passive Devices, Active Silicon Photonic Devices.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHL-563 **Course Title:** Guided Wave Photonic Components and Devices

L-T-P: 3-0-2

Credits: 4

Subject Area: PEC

Course Outlines: Photonic waveguides and their modal analysis; Guided wave devices including directional coupler, MZI, Gratings, AWG; Optical fibers and fiber-based components; Circulators, isolators, and filters; Optical amplifiers; Photonic waveguides in quantum communication and sensing.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHL-901

Course Title: Physics and Technology of Ion Sources

L-T-P: 3-1-0

Credits: 4

Subject Area: PEC

Course Outlines: Review of charged particle dynamics; Gas discharge fundamentals; Classification of ion sources; Transverse and longitudinal particle beam dynamics; Beam optics with and without space charge; Extraction systems for ion sources; Types of ion sources- Penning Ionization Gauge (PIG), Electron Cyclotron Resonance (ECR), Vacuum arc, Duoplasmatron, Radio Frequency (RF), and SNICS ion source (Source of Negative Ions by Cesium Sputtering); Vacuum technology for ion sources, Beam diagnostics for ion sources.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHC-543

Course Title: Computational Physics

L-T-P: 2-0-2

Credits: 3

Subject Area: PCC

Course Outline: Review of computer programming. Linear system of simultaneous equations, nonlinear algebraic equation, curve fitting, roots of transcendental equation, interpolation, data analysis and statistics. Numerical integration and differentiation, Monte-Carlo simulation, Numerical methods for solving ordinary- and partial- differential equations; Applications drawn from various fields of physics.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHC-545

Course Title: Semiconductor Devices and Applications

L-T-P: 3-0-0

Credits: 3

Subject Area: PCC

Course Outline: Energy bands, Intrinsic and extrinsic semiconductors, Density of states, Law of mass action, Direct and indirect band gaps, Carrier transport: Drift, Diffusion, Hall effect, Carrier generation, Recombination, Lifetime, Continuity equation, and Haynes–Shockley experiment, Schottky junctions, Ohmic contacts, p–n junction, Energy band diagram, Junction breakdowns, Diode theory, Tunnel diodes, LEDs, Photodiodes, Solar cells, Heterojunctions, Transistors: BJTs, JFETs, MOSFETs, and Gunn diodes.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHC-547

Course Title: Quantum Mechanics-II

L-T-P: 3-0-0

Credits: 3

Subject Area: PCC

Course Outline: Time-independent Perturbation Theory: Non-degenerate and degenerate perturbation theory and their applications, Time-dependent Perturbation Theory: harmonic perturbation, Fermi-golden rule, quantization of the electromagnetic field, Identical Particles: Indistinguishability, two-particle system: Helium atom, Hartree and Hartree-Fock methods. Relativistic Quantum Mechanics: Klein-Gordon equation and its applications, Dirac theory of electron, spin of the electron, Dirac equation for free particles and Hydrogen atom.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHL-534

Course Title: Nuclear Astrophysics

L-T-P: 3-0-0

Credits: 3

Subject Area: PEC

Course Outline: General characteristics of thermonuclear reactions, cross sections, stellar reaction rates, S-factor, rates at elevated temperatures, non-resonant and resonant rates, neutron, charged particle, and photon induced reactions, pp chain, CNO cycle, Helium burning, Creation and survival of ^{12}C , other stellar cycles, abundance calculations, Nucleosynthesis in massive stars, s – process, r – process, Indirect methods in nuclear astrophysics, Nuclear Astrophysics databases, and experimental facilities worldwide.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHL-540

Course Title: Quantum Theory of Solids

L-T-P: 3-0-0

Credits: 3

Subject Area: PEC

Course Outline: Quantum many body techniques: second quantization, many body Hamiltonian in second quantized form, Hartree-Fock Theory, Green's function, Magnetism (using second quantized notation): Heisenberg model, spin waves, ferromagnetic and antiferromagnetic magnon, Superconductivity (using second quantized notation): BCS theory, Bogoliubov transformation, Plasma oscillations in free electron gas.