INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT / CENTRE: Department of Physics

1. **Subject Code:** PHI-101 **Course Title:** Physics-I
2. **Contact Hours/Week: L:** 3 **T:** 1 **P:** 2/2
3. **Exam Duration (Hrs.): Theory:** 3 **Practical:** 0
4. **Relative Weightage: CWS:** 15-30 **PRS:** 20 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn **7. Subject Area:** BSC
8. **Pre-requisite:** Nil
9. **Objective:** To provide basic knowledge and applications of Electromagnetic Theory and Quantum Mechanics.

10. Details of the Course:

S.No.	Contents	Contact Hours
1.	**Electromagnetic Theory:** Vector algebra and vector calculus, electrostatics and related Maxwell equations in differential form, magnetostatics and related Maxwell equations in differential form, boundary conditions, time-dependent fields and Maxwell's equations, wave equation, EM waves in free space and lossless dielectric, reflection and transmission at the interface (normal incidence)	21
2.	**Quantum Physics:** Black body radiation, Planck's radiation law, Compton effect, Frank-Hertz experiment, Davisson-Germer experiment, wave-particle duality, basic postulates of Quantum mechanics, Schrödinger wave equation, 1D problems (1-D box, linear harmonic oscillator, potential step, potential barrier	21
Total		**42**

11. Suggested Books:

S.No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Matthew N. O. Sadiku, "Elements of Electromagnetics", Oxford University Press, 7th edition.	2021
2.	David J. Griffiths, Introduction to Electrodynamics, Prentice Hall of India, 4th edition.	2015
3.	Arthur Beiser, "Concepts of Modern Physics", Tata McGraw Hill, 6th edition.	2003
4.	Robert Eisberg, Robert Resnick, "Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles", Wiley, 2nd edition	1985

List of Experiments:

1. To study the variation of a magnetic field of paired coils in Helmholtz arrangement and verify the principle of superposition of magnetic field.
2. Determination of reverse saturation current I0 and material constant of PN junction also determine the energy band gap.
3. To determine the resistivity of a semiconductor as a function of temperature and to estimate its band gap using the four-probe method.
4. Measure the surface tension using the 'break-away' method and determine the density of the material of the ring.
5. To determine the first excitation potential of a gas by the Frank-Hertz Experiment.
6. To determine Planck's Constant and work function using the photoelectric effect.
7. To study the single slit diffraction by laser light and determine slit width.
8. To determine the wavelength of sodium light by Newton's Ring.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Mathematics

1. **Subject Code:** MAI-101 **Course Title**: Mathematics I
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS: 0** **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Autumn **7. Subject Area:** BSC
8. **Prerequisite:** NIL
9. **Objective:** To provide the essential knowledge of basic tools of Differential Calculus, Integral Calculus, Vector Calculus and Matrix Algebra.

10. **Details of the Course**

S. No.	Contents	Contact Hours
1.	**Matrix Algebra:** Elementary operations and their use in getting the rank, inverse of a matrix and solution of linear simultaneous equations. Orthogonal, symmetric, skew-symmetric, Hermitian, skew-Hermitian, normal and unitary matrices and their elementary properties. Eigenvalues and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix.	8
2.	**Differential Calculus:** Limit, continuity and differentiability of functions of two variables, Euler's theorem for homogeneous equations, Tangent plane and normal. Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Error approximations. Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers	12
3.	**Integral Calculus:** Review of curve tracing and quadric surfaces, Double and Triple integrals, Change of order of integration. Change of variables. Gamma and Beta functions. Dirichlet's integral. Applications of Multiple integrals such as surface area, volumes, centre of gravity and moment of inertia..	12
4.	**Vector Calculus:** Differentiation of vectors, gradient, divergence, curl and their physical meaning. Identities involving gradient, divergence and curl. Line and surface integrals. Green's, Gauss and Stoke's theorem and their applications.	10
	Total	**42**

11. **Suggested Books:**

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Kreyszig, E., "Advanced Engineering Mathematics", 10th Ed., Wiley India Pvt. Ltd	2015
2.	Jain, R. K. and Iyenger, S. R. K., "Advanced Engineering Mathematics", 5th Ed., Narosa Publishing House.	2017
3.	Thomas, G. B., Hass, J., Heil, C. and Weir M. D., "Thomas' Calculus", 14th Ed., Pearson Education	2018

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Mathematics

1. **Subject Code:** MAI-102 **Course Title**: Mathematics II
2. **Contact Hours:** **L:** 3 **T:** 1 **P:** 0
3. **Examination Duration (Hrs.):** **Theory:** 3 **Practical:** 0
4. **Relative Weightage:** **CWS:** 20-35 **PRS: 0** **MTE:** 20-30 **ETE:** 40-50 **PRE:** 0
5. **Credits:** 4 **6. Semester:** Spring **7. Subject Area:** BSC
8. **Prerequisite:** NIL
9. **Objective:** To introduce the basic concepts of linear algebra, probability and statistics.

10. **Details of the Course**

S. No.	Contents	Contact Hours
1.	**Vector Spaces:** Vector spaces (over the field of real numbers), subspaces, spanning set, linear independence, basis and dimension. Linear transformations, range and null space, rank-nullity theorem, matrix of a linear transformation.	8
2.	**Inner Product Spaces:** Inner-product spaces, Gram-Schmidt process, orthonormal basis; spectral theorem for real symmetric matrices, singular value decomposition; low-rank approximation.	6
3.	**Probability and distributions:** Concept of probability, random variables and their probability distributions, expectation, moments and moment generating functions, Chebyshev's inequality.	6
4.	**Special distributions:** (Discrete): Binomial, Poisson, Negative binomial, and Geometric distributions. (Continuous): Uniform, Exponential, Gamma, and Normal distributions.	5
5.	**Bivariate random variables:** Joint, marginal, and conditional distributions, statistical independence. Distributions of functions of random variables. Correlation and regression.	6
6.	**Sampling Distributions:** Random sampling and sampling distributions, law of large numbers, central limit theorem.	3
7.	**Estimation:** Point estimation, unbiased estimators, maximum likelihood estimation. Interval estimation, interval estimation of mean, variance and proportion for normal populations.	4
8.	**Testing of Hypothesis:** Simple and composite hypothesis, Type I and Type II errors, power of a test. Hypothesis testing for mean, variance and proportion for normal populations.	4
	Total	**42**

11. **Suggested Books:**

S.No.	Name of Authors/Book/Publisher	Year of Publication / Reprint
1.	Axler, S., "Linear Algebra Done Right", 3rd Ed., Springer Nature.	2015
2.	Strang, G., "Linear Algebra and Its Applications" 4th Ed., Cengage India Private Limited.	2005
3.	Hogg, R. V., Mckean, J. and Craig, A. T., "Introduction to Mathematical Statistics", 8th Ed., Pearson Education India	2021
4.	Rohatgi, V. K. and Saleh, A. K. Md. E., "An Introduction to Probability and Statistics" 2nd Ed., Wiley India	2008
5.	Miller, I. and Miller, M., "John E. Freund's Mathematical Statistics with Applications", 8th Ed., Pearson Education India	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE /SCHOOL: Department of Physics

1. Subject Code: PHC-101 **Course Title**: Computer Programming

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory:** 3 **Practical:** 0

4. Relative Weightage: **CWS:** 10-25 **PRS:** 25 **MTE:** 15-25 **ETE:** 30-40 **PRE:** 0

5. Credits: 4 **6. Semester:** Autumn **7. Subject Area:** PCC

8. Pre-requisite: Nil

9. Objective: To introduce the fundamentals of programming for scientific and engineering applications.

10. Details of the Course:

S. No.	Contents	Contact Hours
1.	Introduction to computer hardware and software, Memory, Storage media, Operating system, Top programming languages, Compilers, Interpreters, Installing the required software, Client-server architecture, Remote login, Popular IDEs	4
2.	Data types, variables and assignment, Operators and their precedence, Type conversion, Input and output, Formatted output, Arrays and pointers or tuples and lists.	4
3.	Subprograms or functions, Return values, Optional and keyword parameters, Inline function, Scope of variables among various program blocks, File i/o, Plotting graphs.	6
4.	Decision structures and Boolean logic, Repetition structures, Nested structures, Break/exit, and continue/cycle. Avoiding infinite loops. Vectorization highlighting time complexity and optimization.	6
5.	Numerical Integration: Riemann sum, Trapezoidal and Simpsons rules and their composite forms, Gauss quadrature, Higher dimensional integrals, Monte-Carlo techniques.	6
6.	Interpolation: Linear, Lagrange interpolating polynomial, Piece-wise interpolation, Numerical derivatives using difference formulae and interpolated values.	4

7.	Solving transcendental equations: Root bracketing, Bisection method, Newton's method, Secant method.	4
8.	Solving ordinary differential equations: Euler method, Runge-Kutta methods, higher-order ODEs in vectorized form.	8
	TOTAL	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publisher	Year of Publication/Reprint
1.	**"Python Crash Course, 3e, A Hands-On, Projects-Based Introduction to Programming":** Eric Matthes, No Starch Press.	2023
2.	**"Learning Python, 5e":** Mark Lutz, O'Reilly Media, Inc.	2013
3.	**"Object Oriented Programming with C++, 5e":** E. Balaguruswamy, Tata McGraw Hill Education.	2011
4.	**"Computer Programming In Fortran 90 and 95":** V. Rajaraman, Prentice Hall of India.	2006
5.	**"Introductory Methods of Numerical Analysis, 5e":** S.S. Sastry, Prentice Hall of India.	2012
6.	"Introduction to Coding Theory": R.M. Roth, Cambridge University Press.	2006
7.	**"Numerical Recipes: The Art of Scientific Computing , 3e":** W.H. Press, **S.A.** Teukolsky, W.T. vetterling and B.P. Flannery, Cambridge University Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-202 **Course Title:** Mathematical Physics

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Complex analysis: Complex variables, analytic functions and singularities, Cauchy Reimann conditions and harmonic functions, complex integration and associated theorems, calculus of residues. Laplace and Fourier transforms. Beta, Gamma functions. Series solution of ODE and special functions: power series and Frobenius series method, special functions: Legendre, Hermite polynomials, Bessel's functions, generating functions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-203 **Course Title:** Thermal and Statistical Physics

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline: Condition of equilibrium and constraints, pressure, temperature, chemical potential, internal energy, heat and entropy, laws of thermodynamics, PV, PT, TS diagram, Enthalpy, Helmholtz & Gibb's functions, Maxwell's thermodynamic relations, phase transitions, inversion curve, Liquefaction of gases, Microstates, phase space, Liouville's theorem, equal a priori probability, Connection between statistics and thermodynamics, Microcanonical and Canonical ensemble, Gibbs paradox, M-B, B-E and F-D statistics, Blackbody radiation.

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-204 **Course Title:** Quantum Mechanics-I

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Schrodinger equation, expectation value, observables and operators, commutation relations, Dirac notation; Schrodinger, Heisenberg and Dirac pictures; 1D problems: tunnelling through multiple barriers: resonant tunnelling, simple harmonic oscillator, raising and lowering operators, 2D Problems: electron gas in a magnetic field, Landau levels, 3D problems: symmetry and conservation laws in quantum mechanics, central potential, hydrogen atom, angular momentum and spherical harmonics, time independent non-degenerate perturbation theory.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-205 **Course Title:** Digital Electronics

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Basic logic gates and circuits, Boolean laws, Karnaugh map representation, Multiplexers, Demultiplexers, Encoders, Decoders, Parity generators, Digital ICs, TTL and CMOS logics, Binary, Octal and Hexadecimal systems, Addition and subtraction in different systems, J-K, R-S, T, D, J-K Master-Slave flip-flops, Registers, Counters, D/A and A/D conversions, Schmitt trigger ICs, 555timer.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-206 **Course Title:** Applied Optics

L-T-P: 3-0-2 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Fermat's Principle, ray equation, matrix method in paraxial optics, unit planes, nodal planes, Huygen's principle, interference by division of wavefront and amplitude, Fraunhofer diffraction, single, double and multiple slit diffraction, Fresnel diffraction, zone plate, Polarization and double refraction, analysis of polarized light, Brewster's law, Malus's law, quarter and half wave plates, optical activity, holography, salient features of optical fiber.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-207 **Course Title:** Physics Lab – II

L-T-P: 0-0-4 **Credits**: 2 **Subject Area**: PCC

Course outlines: The experiments include: Callendar and Barne's method, Four Probe Method, Maxwellian velocity distribution, Searl's Experiment, Specific Heat Measurement, P-V Isotherms of Ethane gas, Stefan Boltzmann Law, Planck's constant 'h' by photo voltaic cell, Solar Cells Characterization, Thermal Measurements of Metals. Logic gates with TTL ICs, De- Morgan's Law, Flip-flop, interfacing 7-segment display using IC 7447, multiplexer and de- multiplexer, half and full subtractor, half and full adder.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-301 **Course Title:** Atomic and Molecular Spectroscopy

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline: Atomic Spectroscopy: electron spin and magnetic moment, spectra of hydrogen and hydrogen-like atoms: fine-structure splitting, Lamb shift, hyperfine structure and isotope shifts; atoms in electric and magnetic fields, Rydberg atoms, exotic atoms. Many-electron atoms, Helium spectra, angular momentum coupling schemes, equivalent and non-equivalent electrons Hund's rules, X-ray spectra; Molecular Spectroscopy: rotational spectra, vibrational spectra, and vibration-rotation spectra; electronic spectra; transitions and selection rules; basics of Raman spectra.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-302 **Course Title:** Condensed Matter Physics

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline:

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-314 **Course Title:** Statistical Mechanics

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline:

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

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHC-303 **Course Title:** Signals and Systems

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PEC

Course Outline: Introduction to Signals and Systems, Mathematical Representation of Signals, System Properties, Continuous & Discrete Time LTI Systems, Convolution, Fourier Series and Transform, System Analysis using Laplace Transform and Z-transform, Sampling Theory, Modulation and Filtering, State-Space Representation, Feedback Systems, Physics-Inspired Case Studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHC-306 **Course Title:** Microprocessors and Microcontroller

L-T-P: 2-0-2 **Credits:** 3 **Subject Area:** PCC

Course Outline: Microcomputer systems; Intel 8085 microprocessor: Architecture, assembly language programming; interfacing with memory, I/O and peripheral devices, interrupts; Intel 8051 microcontroller: Architecture, programming in assembly and C; timers, serial communication and interrupts; interfacing with I/O and peripheral devices; modern microcontrollers and development boards (introductory exposure).

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHC-308 **Course Title:** Quantum Electronics and Devices

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outline: Quantum Mechanics, light matter interaction, quantum theory of evaluation of transition rates and Einstein's coefficients, line broadening mechanisms, Laser rate equations, ultimate linewidth of a laser, optical resonators, Q-switching, mode locking, selective laser systems, acousto-optic modulation, electro-optic modulation and devices, 2^{nd} and 3^{rd} order nonlinear optical effects and devices based on these effects, applications.

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, Sympletic 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: 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/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-351 **Course Title:** Fundamentals of AI/ML

L-T-P: 2-0-0 **Credits:** 2 **Subject Area:** PCC

Course Outline: Introduction: AI vs Machine Learning, ethics and societal impact, basic ML tasks, overview of various ML paradigms; Mathematics for ML: Linear algebra, probability theory, classical optimization techniques, Bayesian statistics; Supervised Learning algorithms; Unsupervised Learning algorithms; Artificial Neural Networks; Applications of AI/ML: case studies relevant to physics.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHL-305 **Course Title:** Fiber and Integrated Optics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outline: Modes of a planar waveguide, TE and TM modes, symmetric and asymmetric waveguides, analysis of 2-D waveguides, optical fiber waveguide, propagation characteristics of an optical fiber, integrated-optic waveguide components, directional coupler, modulators, multiplexer, de-multiplexer, arrayed waveguide grating.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHL-504 **Course Title:** Fiber and Nonlinear Optics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outline: Salient features of an optical fiber, modes of a waveguide, scalar modes of an optical fiber, attenuation, pulse dispersion, splice loss, fiber fabrication, fused fiber coupler, fiber- based components, 2nd order nonlinear effects, second harmonic generation, parametric down conversion, sum frequency generation, 3rd order nonlinear effects, self-focusing, 4-wave mixing, optical phase conjugation.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-101 **Course Title:** Experimental Techniques in Quantum Materials

L-T-P: 0-1-3 **Credits:** 2 **Subject Area:** TEB

Course Outline: Electrical transport: Van-der Pauw method for measurement of Resistivity, Hall effect, Magnetoresistance measurements, Electron Spin Resonance (ESR) Spectrometry, Characterization of dielectric constant of materials, Scanning Tunnelling Microscopy (STM) technique.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-102 **Course Title:** Advanced Experimental Techniques in Quantum Materials

L-T-P: 1-1-3 **Credits:** 4 **Subject Area:** TEB

Course Outline: Growth & characterization of quantum materials: Vapour deposition techniques, Thin film growth, Layer transfer process, X-ray diffraction and reflectivity measurements, Elemental analysis, Device fabrication process using lithography and evaporation techniques, Electrical, optical and magneto-transport measurements on quantum materials, Magneto-optic Kerr effect (MOKE) magnetometry.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-103 **Course Title:** Experimental Techniques in Laser Physics

L-T-P: 0-1-3 **Credits:** 2 **Subject Area:** TEB

Course Outline: Measurement of real and imaginary refractive indices of semiconductors and metal films using Spectroscopic Ellipsometer, Deposition of oxide and metal thin films using Pulsed Laser Deposition and Thermal Evaporation techniques and characterization, Modulation characteristics of a laser, Characteristics of photodiode/optical receiver, BER measurements for an optical link.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-104 **Course Title:** Advanced Experimental Techniques in Photonics

L-T-P: 1-1-3 **Credits:** 4 **Subject Area:** TEB

Course Outline: Study of Laser Emission Spectroscopy: Spontaneous and Stimulated Emission, Localized Surface Study of Plasmonic properties of Thin Films, Surface Enhanced Raman Spectroscopic of nano-plasmonic thin films.

List of Experiments:

1. Study of ASE spectrum of erbium-doped fiber by Optical spectrum analyser.
2. Characterization of fiber Bragg gratings using Fiber Bragg Grating (FBG) Interrogator
3. Emission spectrum of Rhodamine 6G: Effect of pump energy.
4. Study of the Fabry-Perot mode of a low-quality cavity
5. Fabrication of nanoplasmonic films and estimation of electromagnetic enhancement factor in SERS.
6. Study of surface plasmon resonance on Kretschmann configuration

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-105 **Course Title:** Experimental Techniques in Gamma Spectroscopy

L-T-P: 0-1-3 **Credits:** 2 **Subject Area:** TEB

Course Outline: Synthesis of scintillators using different methods for gamma spectrometry, Measurement of coincident gamma rays using compact data acquisition system, GEANT4 simulation toolkit for generating gamma spectrum, Trace analysis with High-purity Germanium (HPGe) detector and digital data acquisition setup, and exploration of reaction simulations, Measurement of gamma rays through the proton activation, Irradiation of materials using Gamma irradiation chamber.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-106 **Course Title:** Experimental Techniques in Charged Particle Spectroscopy

L-T-P: 1-1-3 **Credits:** 4 **Subject Area:** TEB

Course Outline: Synthesis of scintillator detectors (plastic and inorganic) for charged particle spectroscopy using solution growth and 3D printing methods, Experiments with different types of photo sensors (PMT, SiPM, APD), measurement of range of alpha particles using alpha spectrometer, alpha spectroscopy using semiconductor detectors, conversion electron spectroscopy, pulse shape discrimination, Software tools to study the response of materials for charged particles (SRIM and GEANT4), accelerator based charged particle spectroscopy.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-107 **Course Title:** Methods and Experiments in Atmospheric and Space Physics

L-T-P: 0-1-3 **Credits:** 2 **Subject Area:** TEB

Course Outline: Atmospheric structure, classification based on temperature, pressure, hydrostatic equation, Atmospheric stability, nucleation processes, collision and coalescence, diffusional growth of a rain droplet, formation of clouds and cloud classification.

Practical: Rain Gauge, Atmospheric attenuation, Aerosol size distribution, Flame photometer, Derivation of atmospheric parameters from weather maps.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-108 **Course Title:** Advanced Experimental Techniques in Atmospheric and Space Physics

L-T-P: 1-1-3 **Credits:** 4 **Subject Area:** TEB

Course outline: Earth's upper atmosphere, ionosphere, chapman layer, measurement of electron density, temperature in ionosphere, satellite-based payloads for the observation of earth's upper atmosphere. Lorentz system for atmospheric convection.

Practical: Measurement of Solar constant, Electric field simulation, Design and development of sensor-based modules for the measurement of atmospheric parameters, Numerical simulation of atmospheric models.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-109 **Course Title:** Principles of Electroceramic Processing & Fabrication

L-T-P: 0-1-3 **Credits:** 2 **Subject Area:** TEB

Course outline: Solid State Synthesis, Hydrothermal Synthesis, Coprecipitation Method, and Ball Milling of electroceramic materials—particle characterization; Sintering dynamics; Microstructural control.

Practical: Solid State Synthesis, Hydrothermal Synthesis, Coprecipitation Method, Ball Milling, X-Ray Diffraction, SEM, Sintering Dynamics, Thermal Analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-110 **Course Title:** Advanced Techniques of Electroceramic Characterization

L-T-P: 1-1-3 **Credits:** 4 **Subject Area:** TEB

Course outline: Advanced structural techniques (X-ray diffraction (XRD), electron tomography, microstructural analysis (FESEM). Electrical, Magnetic, and Thermal property evaluations involving advanced dielectric spectroscopy, impedance analysis, and thermal analysis. Emphasis on linking nanoscale phenomena to macroscopic properties for innovations in energy storage systems.

Practical: X-Ray Diffraction, SEM, Dielectric vs Temperature, Impedance Vs Temperature, UV-Vis Spectroscopy, P-E Loop.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHT-111 **Course Title:** Theoretical & Computational Techniques

L-T-P: 0-1-3 **Credits:** 2 **Subject Area:** TEB

Course Outline: Analytical techniques for solving differential equations in mathematical physics, Contour integration methods, Symbolic computation using computer algebra packages, Numerical solutions of Maxwell equations in simple geometries, Numerical diagonalization methods and solution of Schrödinger equation.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Physics

Subject Code: PHT-112 **Course Title:** Advanced Computational Techniques

L-T-P: 1-1-3 **Credits:** 4 **Subject Area:** TEB

Course Outline: Shell-scripting; Parallel Programming; Introduction to HPC; Molecular Dynamics Simulations; Monte Carlo simulations; Applications of advanced numerical simulations in problems of contemporary interest.