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 DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: PHC-112 Course Title: **Atomic and Nuclear Physics**

2. Contact Hours: **L: 3** **T: 0** **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: **3** 6. Semester: **Spring** 7. Subject Area: **PCC**

8. Pre-requisite: **NIL**

9. Objective of Course: To introduce the concepts in atomic and nuclear physics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Atomic Spectroscopy-I:** Bohr's model of H atom, Sommerfeld' extension of the Bohr's model, Qualitative results of the solution of Schrödinger equation of H-atom, fine structure splitting: spin-orbit interaction and relativistic corrections; Lamb shift, hyperfine structure and isotope shifts	08
2.	**Atomic Spectroscopy-II:** Many-electron atoms, Pauli exclusion principle, angular momentum coupling schemes, equivalent and non-equivalent electrons, Hund's rules, ground state configurations of elements in periodic table; atoms in magnetic fields, X-ray spectra	08
3.	Basic ideas of laser and its properties, Maxwell-Boltzmann distribution, Einstein's A and B coefficients, Ruby Laser and He-Ne laser	05
4.	Nuclear shape, size, radii; Basic properties of nuclear force; Mass defect and binding energy; Liquid drop model; Semi empirical mass formula; Evidence of shell structure and magic numbers.	08
5.	Radioactivity and its applications; Basics of α, β and γ decays; Nuclear reactions; Kinematics; nuclear fission and fusion.	09
6.	Basics of detectors and accelerators; Industrial, analytical and medicinal applications.	04
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Bransden B H and Joachian C J, "Physics of Atoms and Molecules", 2nd Ed. Prentice Hall	2012
2.	Haken H and Wolf H C, "The Physics of Atoms and Quanta", 6th Ed. Springer	2007
3.	Herzberg G, "Molecular Spectra and Molecular Structure: Spectra of Diatomic Molecules", Dover Books on Physics	2010
4.	Lilley J S, "Nuclear Physics", John Wiley and Sons	2001
5.	Ghoshal S N, "Nuclear Physics", S Chand and Company Ltd.	2000
6.	Povh B, Rith K, Scholz C and Zetsch F, "Particles and Nuclei", 2nd Ed. Springer	1999
7.	Heyde K, "From Nucleons to the Atomic Nucleus", Springer	1998
8.	Krane K S, "Introductory Nuclear Physics", Wiley India	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/ CENTRE/SCHOOL: Department of Physics

Subject Code: PHC 114 **Course Title:** Physics Lab-I

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

Course Outlines:

List of Experiments

1. Verification of Stefan's law of radiation using a bulb (electrical method).
2. To study the performance of a Torque Transducer.
3. Verification of Faraday and Lenz's law of induction by measuring the induced voltage as a function of time.
4. To study the variation of the magnetic field with the position of paired coils in Helmholtz arrangement along the axis of the coils carrying current.
5. To determine e/m (specific charge) for an electron by magnetron method.
6. To determine Stefan's constant using vacuum tube Diode EZ-81.
7. To study the characteristics of a Linear Variable Differential Transformer (LVDT).
8. Surface tension
9. To verify Stoke's Law
10. Pressure Measurement using strain Gauge Transducer
11. LDR Characteristics.
12. Thermal Expansion.
13. To Determine Plank's Constant by measuring radiation.
14. To study the normal modes and resonance of a coupled pendulum.
15. To determine the spring constant of the coupling spring in a coupled pendulum.
16. To calculate the time period of a coupled pendulum (T_0, T_1, T_B and ν_B, degree of coupling)
17. To determine the mass susceptibility of a para-magnetic material by Quincke's method
18. To determine the value of Planck's constant by measuring radiation in a fixed spectral range.
19. To determine the wavelength of sodium light by Newton's ring.
20. To determine the electronic charge by Millikan's oil drop experiment.
21. To study the V-I Characteristics of LDR, LED, Solar cell, photo transistor.
22. Quarter wave plate.
23. Malus law.
24. Brewster's angle.
25. Single slit diffraction.
26. Double slit diffraction.

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-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-212 **Course Title:** Physics Lab-III

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

Course Outlines: Cornu's method, Nodal slide, diffraction grating, Newton's Rings, Polarimeter, Hydrogen Spectra, the Lande g factor, Brewster's Angle, Fresnel bi-prism, Double slit diffraction, dispersive power of prism, e/m by Thomson Method, e/m by Magnetron method, Millikan's Oil Drop Experiment.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-214 **Course Title:** Optics

L-T-P: 3-0-0 **Credits:** 3 **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-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-304 **Course Title:** Nuclear Physics & Applications

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

Course Outline: Nuclear shape, size, radii, matter and charge distributions, Nuclear force, Semi empirical mass formula, Single particle Shell Model, alpha-, beta-, and gamma- decays, Nuclear reactions, Kinematics, Direct and Compound nuclear reactions, Nuclear fission and fusion, Nuclear detectors, Nuclear reactors, Accelerators, Source of stellar energy.

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-315 **Course Title:** Physics Lab – IV

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

Practical: Ultrasonic Michelson Interferometer, Quantum cryptography, B-H Curve, Potentiometric error detector, Velocity of ultrasonic waves, I-V characteristics of LDR, Graphical LCD module, Quantum Eraser, Zeeman effect, High Resistance by Leakage Method Using Ballistic Galvanometer, Young's Modulus of a wire by optical Lever Method using Laser diode.

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.

NAME OF DEPARTMENT/CENTRE/SCHOOL: Department of Physics

Subject Code: PHC-318 **Course Title:** Physics Lab – V

L-T-P: 0-0-6 **Credits:** 3 **Subject Area:** PCC

Course Outline:

Hall effect, Four Probe method, PN junction, random nature of nuclear radiation, O.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-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: 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.