Syllabus with effect from the Academic Year 2024-2025

<table>
<tr><th colspan="8">Structure for MSc Physics – Semester - IV</th></tr>
<tr><th>Course Type</th><th>Course Code</th><th>Course Name</th><th>Teaching hours/week</th><th>Credit</th><th>Internal Marks</th><th>External Marks</th><th>Total Marks</th></tr>
<tr><td rowspan="3">Core</td><td>PH-541</td><td>Advanced Quantum Mechanics</td><td>04</td><td>04</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>PH-542</td><td>Atomic and Molecular Physics</td><td>04</td><td>04</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>PH-543</td><td>Statistical Mechanics</td><td>04</td><td>04</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td rowspan="4">Elective (Any one course can be taken)</td><td rowspan="4">PH-544</td><td>Elective 1: Micro and Nano Electronics</td><td>04</td><td>04</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Elective 2: Properties of Materials</td><td>04</td><td>04</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Elective 3: Simulation Techniques for computational Physics</td><td>04</td><td>04</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Elective 4: Nuclear Reactions</td><td>04</td><td>04</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td></td><td>PH-545</td><td>Practical</td><td>12</td><td>06</td><td>50</td><td>100</td><td>150</td></tr>
<tr><td>Skill based course</td><td>PH-546</td><td>Remote Sensors</td><td>02</td><td>02</td><td>20</td><td>30</td><td>50</td></tr>
<tr><td colspan="3" align="right">Total</td><td>30</td><td>24</td><td>190</td><td>410</td><td>600</td></tr>
</table>

Course Name	PH-541:Advanced Quantum Mechanics
Course Code	PH-541
Course Type	Core
Course Outcome (CO)	(1) By studying the course student will be able to deal time dependent perturbation and relativistic theory. (2) Students will study the approximation methods treating Hamiltonians that depend explicitly on time. (3) Students will study the quantum mechanical treatment of the scattering of a particle by a potential. (4) Students will train to solve the relativistic wave equations. (5) Students will study the Dirac Particle in different potentials.

Course Content	
Unit 1	**Time-Dependent Perturbation Theory** The Pictures of Quantum Mechanics: The Schrödinger Picture, The Heisenberg Picture, The Interaction Picture; Time-Dependent Perturbation Theory: Transition Probability, Transition Probability for a Constant Perturbation, Transition Probability for a Harmonic Perturbation; Adiabatic and Sudden Approximations: Adiabatic Approximation, Sudden Approximation; Interaction of Atoms with Radiation: Classical Treatment of the Incident Radiation, Quantization of the Electromagnetic Field, Transition Rates for Absorption and Emission of Radiation, Transition Rates within the Dipole Approximation, The Electric Dipole Selection Rules, Spontaneous Emission.
Unit 2	**Scattering Theory** Scattering and Cross Section: Connecting the Angles in the Lab and CM frames, Connecting the Lab and CM Cross Sections; Scattering Amplitude of Spinless Particles: Scattering Amplitude and Differential Cross Section, Scattering Amplitude; The Born Approximation: The First Born Approximation, Validity of the First Born Approximation; Partial Wave Analysis: Partial Wave Analysis for Elastic Scattering, Partial Wave Analysis for Inelastic Scattering; Scattering of Identical Particles.
Unit 3	**Relativistic Wave Equations** Generalization of the Schrödinger Equation, The Klein-Gordon Equation: Plane Wave Solutions; Charge and Current Densities, Interaction with Electromagnetic Fields; Hydrogen-Like Atom, Non-relativistic Limit; The Dirac Equation: Dirac's Relativistic Hamiltonian, Position Probability Density; Expectation Values, Dirac Matrices, Plane Wave Solutions of the Dirac Equation; Energy Spectrum
Unit 4	**The Dirac Equation** The Spin of the Dirac Particle, Significance of Negative Energy States; Dirac Particle in Electromagnetic Fields, Relativistic Electron in a Central Potential: Total Angular Momentum, Radial Wave Equations in Coulomb Potential, Series Solutions of the Radial Equations: Asymptotic Behaviour, Determination of the Energy Levels, Exact Radial Wave Functions; Comparison to Non-Relativistic Case, Electron in a Magnetic Field—Spin Magnetic Moment, The Spin Orbit Energy.

Reference Books	
1.	Quantum Mechanics: Concepts and Applications: Nouredine Zettili, A John Wiley and Sons Ltd.,Second Edition, (2004).
2.	A text book of Quantum Mechanics: P. M. Mathews and K. Venkatesan, Tata McGraw Hill Education Private Limited, Second Edition, (2011).
3.	Quantum Mechanics: L. I. Schiff, McGraw-Hill Inc., US, Third Edition, (1968).
4.	Introduction to Quantum Mechanics: David Griffiths, Pearson Education; Second Edition, (2015).
5.	Quantum Mechanics: A. K. Ghatak and S. Lokanathan Macmillan-India, Fifth Edition, (2004).
6.	Quantum Mechanics: Claude Cohen-Tannoudji, Bernard Diu, Franck Laloe Vol. I & II, Wiley-CH, (1997).

Course Name	PH-542:Atomic and Molecular Physics
Course Code	PH-542
Course Type	Core
Course Outcome (CO)	(1)The objective of the course is to provide requisite intellectual understanding in the field of atomic and molecular physics. (2) To learn the fine structure of hydrogenic atom and small corrections involved in it. (3) The students will understand the basic idea of central field approximation and general properties of central potential and conclude by considering corrections. (4) To study the general nature of molecular structure showing how the rotational, vibrational and electronic motions can be treated independently. (5) To understand the analysis of rotational spectra of diatomic molecules and how electric dipole transitions are modified when spin dependent interactions are considered.

Course Content	
Unit 1	**One-electron atoms: fine structure and hyperfine structure** Fine structure of hydrogenic atoms, Energy shifts, Fine structure splitting, Fine structure of spectral lines, Intensities of fine structure lines, The Lamb shift, Hyperfine structure and isotopic shifts, Magnetic dipole hyperfine structure, Electric quadrupole hyperfine structure, Isotope shifts.
Unit 2	**Two-electron atoms and many-electron atoms** Schrödinger equation for Two-electron atoms: Para and ortho states, Spin wave functions and the role of the Pauli exclusion principle, Level Scheme of two-electron atom, Independent particle model. The Zeeman Effect, The Stark effect, Quantum mechanical explanation of normal Zeeman effect, Anomalous Zeeman effect, Paschen Back effect, Stark effect. Many electron atoms: The central field Approximation, Spin and the Pauli exclusion principle, Spin-orbitals and Slater determinants, Slater determinants, Electron state in a central field: Configurations, shells and subshells, Degeneracies.
Unit 3	**Molecular structure** The Thomas-Fermi model of the atom: Fermi electron gas, The Hatree-Fock method and the self-consistent field: The Hatree-Fock equations, Physical interpretation of the Hartree-Fock equations, Koopmans' theorem, Corrections to the central field approximation: Correlation effects. Born-Oppenheimer separation for diatomic molecules, The rotation and vibration of diatomic molecules, The electronic spin and Hund's cases, Hund's cases (a), (b), (c), (d) and (e), Spin uncoupling, Λ-doubling, The structure of polyatomic molecules: Rotational structure, Vibrational structure and Electronic structure, Water molecule, Methane, ethylene and acetylene molecules, Benzene molecule and non-locallised orbitals.
Unit 4	**Molecular spectra and applications of atomic and molecular physics** Molecular spectra, Rotational spectra of diatomic molecules, Vibrational-rotational spectra of diatomic molecules, Electronic spectra of diatomic molecules: Vibrational structure of electronic spectra, Rotational structure of electronic spectra, Frank-Condon

	principle, Dissociation and Predissociation, Fluorescence and phosphorescence, Spin-dependent interactions and electric dipole transitions, Nuclear spin, Inversion spectrum of ammonia. Nuclear magnetic resonance, Rabi molecular beam apparatus, Ramsey's method of separated oscillatory fields, Paramagnetic resonance in bulk samples, Nuclear magnetic resonance in bulk samples, Chemical shifts, Atom optics: Focusing of atomic beams, focusing using static electromagnetic fields, Focusing by using light forces, Focusing by using a Fresnel zone plate. Atom mirrors: Reflection from surfaces, Reflection from an evanescent light wave, Atomic beam splitters: Diffraction from micro-fabricated structures, Photon recoil beam splitter, Sudden transition due to field gradients, Atoms in cavities and ions in traps: one-atom maser, one-atom laser, Ion in traps: Paul trap or radio-frequency trap, Penning trap, Quantum jumps of single ion, Crystallisation of laser-cooled ions in a trap.

Reference Books	
1.	Physics of Atoms and Molecules: B. H. Bransden and C.J. Joachain, Second Edition, Pearson, (2003).
2.	Modern Physics: R. Murugeshan, Seventeenth Edition, S. Chand & Company Pvt. Ltd (2014).
3.	Concepts of Modern Physics: Arthur Beiser, Sixth Edition, McGraw Hill, (2003).

Course Name	PH-543: Statistical Mechanics
Course Code	PH-543
Course Type	Core
Course Outcome (CO)	(1) Students will comprehend the unique properties of ideal Bose and Fermi gases. (2) Students will gain proficiency in the Ising model, exchange interaction, and Heisenberg Hamiltonian. They will apply these concepts to precisely analyze one-dimensional lattice systems. (3) Students will grasp the fundamentals of phase transitions, critical phenomena, and the dynamics involved. They will apply Mayer's theory and understand critical indices and Lee-Yang's theory. (4) Students will acquire a deep understanding of thermodynamic fluctuations, spatial correlations in fluids, and Brownian motion. They will apply theoretical models to explain diverse physical phenomena. (5) After completion of this course, students will possess a comprehensive understanding of ideal quantum systems, strongly interacting models, phase transitions, and fluctuations, applying these concepts to real-world phenomena.

Course Content	
Unit 1	**Ideal quantum systems:** a. Properties of ideal Bose gas: Bose-Einstein condensation: Transition in liquid He4, Superfluidity in He4. Photon gas: Planck's radiation law. Phonon gas: Debye's theory of specific heat of solids. b. Properties of ideal Fermi gas: Review of the thermal and electrical properties of an ideal electron gas. Landau levels, Landau diamagnetism. White dwarf and Neutron stars.
Unit 2	**Strongly interacting systems:** Ising model. Idea of exchange interaction and Heisenberg Hamiltonian. Ising Hamiltonian, zeroth and first order approximations, Exact treatment of one dimensional lattice.
Unit 3	**Phase transition** General remarks. Phase transition and critical phenomena. Critical indices. Mayer's theory of condensation, The theory of Lee and Yang, dynamical model of phase transitions.
Unit 4	**Fluctuations** Thermodynamic fluctuations. Spatial correlations in a fluid. Brownian motion: Einstein-Smoluchowski's theory, Langevan theory of Brownian motion, Fokker-Planck equation.

Reference Books	
1.	Statistical Mechanics: R.K. Pathria and P.D. Beale, Butterworth-Heinemann,Oxford, Third Edition, (2011).
2.	Statistical Mechanics: K. Huang, Wiley Eastern, New Delhi, (1987).
3.	Statistical Mechanics by F. Schwabl, Springer-Verlag, Berlin, (2006).
4.	Statistical Mechanics: B.K. Agarwal and M. Eisner, Wiley Eastern, New Delhi,Second Edition, (2011).

5	Elementary Statistical Physics: C. Kittel, Wiley, New York, (2004).
6	Statistical Mechanics: S.K. Sinha, Tata McGraw Hill, New Delhi, (1990)

Course Name	PH-544: Elective 1: Micro and Nano Electronics
Course Code	PH-544
Course Type	Elective 1
Course Outcome (CO)	(1) Student will learn Micro and Nano-electronics as a field of energy which deals with study and manufacturing of small (Micro and Nano electronics design and components. (2) Student will learn most advance Micro and Nano technologies like NMOS, CMOS, BIFET-BIMOS- BICMOS, ECL and I^2L technologies. (3) Student will learn modern architectures for PROM, EPROM, PAL, PLA and CCD memories. (4) Student can shape up their carrier in Integrated circuit (VLSI) design and manufacturing sector. This is an emerging sector for Gujarat as well as for our country.

Course Content	
Unit 1	**Micro Electronic Devices** Electronics and Microelectronics, Classification of Semiconductor Devices. Depletion and Enhancement MOSFET, NMOS, Physical behaviour of NMOS, Volt-Ampere Characteristics, Comparison of NMOS, for NMOS, Small Signal model of NMOS, NMOS amplifier with small signal analysis, NMOS as analog Switch, CMOS devices, CMOS small signal model, BIFET-BIMOS and BICMOS circuits.
Unit 2	**Micro electronic Technologies** NMOS Inverter, NMOS-NAND, NOR Gates, their architecture and Truth Tables, Propagation Delay of an NMOS, CMOS Inverter, CMOS – NAND, NOR and Transmission Gate with their architectures and operation, Emitter Coupled Logic (ECL) circuits, ECL advantages and limitations, Integrated Injection Logic (I^2L). Comparison of Logic families.
Unit 3	**Solid State Memories** Classification of memory, Limitations of ROM, Programmable ROM (PROM) and their architecture, Limitations of PROM, Erasable ROM (EPROM), FAMOS, Limitations of EPROM, Electrical Erasable PROM (EEPROM), Programmable Array Logic (PAL), Programmable Logic Array (PLA), Flash Memory Devices, Manufactures of Memory Devices, Charge Coupled Device (CCD) and their charge transfer, CCD structures, CCD organisations (Serpentine and LARAM).
Unit 4	**Nano Electronics** Challenges going to sub 100 nm MOSFETS, Nano MOS based Devices-Multiple Gate MOSFETS, FIN FETS, Verticals MOSFETS, Carbon Nano tube based Devices – CNFET, Characteristics. Spintronics, spin based Devices – Spin FET, Quantum Dots, Single Electron Devices, Flexible Devices.

Reference Books	
1.	Microelectronics: J. Millmann and A. Grable, Sixteenth Reprint, Mc Graw Hill, (2005).
2.	Microelectronics–Circuits Theory and Application: A. S. Sedra and K.C. Smith, Oxford University Press, Sixth Edition, (2013).
3.	Microelectronics–An Integrated Approach: Roger T Howe, Charles G. Sodini, Pearson Education, First Edition, (2006).
4.	Microelectronic Devices: Dipankar Nagchoudhuri, Pearson Education,

	Second Edition (2002).
5.	Technology of Quantum Devices: Manjieh Razeghi, Springer
6.	Physics of Quantum Well Devices: B. R. Nag, Springer, (2002)
7.	SWAYAM–Microelectronics: Devices to Circuits: Prof. S. Dasgupta 60 Lectures – 12 week (NPTEL).
8.	Nano electronics and Nano systems–From Transistors to Molecular: J. Dienstuhi, Springer, International Edition, Second Edition, (2008).
9.	Fundamentals of Nano electronics: George W. Hanson, Pearson Education, First Edition, (2009).

Course Name	PH-544: Elective 2: Properties of Materials
Course Code	PH-544
Course Type	Elective 2
Course Outcome (CO)	(1) Students will learn the general and distinguished properties of modern materials. (2) Students will learn the fundamental properties of materials like Dielectric, Mechanical, Electrical and Nonlinear optical properties with modern experimental aspects for these properties (3) Students can correlate the data available through different modern characterization tools with theories and interpret them for new structures or performances of new materials. (4) Students are able to work in variety of industries such as Automation industry, ceramic, Composite, Polymer and optoelectronic related industries.

Course Content	
Unit 1	**Dielectric Properties** Dielectric Behaviour, Dipole moment and Polarization, Polarization of an Electric Field, Frequency Dependence of Dielectric Constant, Effect of Temperature on Dielectric Constant, Dielectric Losses, Dielectric Breakdown, Dielectric Materials Practical Dielectrics.
Unit 2	**Mechanical Properties** Common terms, Atomic Model of Elastic Behaviour, Fundamental Mechanical Properties, Factors affecting Mechanical Properties, Mechanical tests – Brine" Hardness Test, Vicker's Hardness Test Rock well Hardness Test, Knoop's Hardness Test, Rebound Hardness Test, MOG's Hardness Test, Comparison of Various Tests, Deformation of Materials.
Unit 3	**Electrical Semiconductor Properties** Commonly used Conducting Materials, High resistivity Materials, Different Types of Bond structures, Electron Mobility, Electronic and Ionic Conduction, Insulation. Properties of Insulation Materials, Semiconductor, Intrinsic and Extrinsic Semiconductors, Semiconductor Devices, Application of semiconductors.
Unit 4	**Non Linear Optical Properties** Non linearity in Physics, Light Propagation in anisotropic media, The linear susceptibility, Second Harmonic Generation in KDP and in LBO. Third order nonlinear Process, High harmonic generation. The DC Kerr effect and Kerr Cell. The Optical Kerr Effect.

Reference Books	
1.	Elements of Materials Science and Engineering: Lawrence H. Van Vlack, Pearson Education, Sixth Edition, (2006).
2.	Materials Science and Metallurgy: U.C. Jindal, Atish Mozumder, Pearson Education, Third Edition, (2013).
3.	Engineering Materials (Polymers, Ceramics and Composites) : A. K. Bhargava, PHI

	Learning Private Ltd., Fourth Edition, (2010)
4.	Materials Science – An Intermediate Test: William F. Hosfold, Cambridge University Press, First Edition, (2007.)
5.	Materials Science and Engineering: A First Course: V. Ragavan, Prentice– Hall of India Private Ltd., Fifth Edition, (2005).
6.	Materials Science and Metallurgy: Parashivamurthy K. I., Pearson Education, First Edition (2012).
7.	Introduction to Nonlinear optics: Geoffrey, New Cambridge University Press, First Edition, (2011).

Course Name	PH-544: Elective 3: Simulation Techniques for computational Physics
Course Code	PH-544
Course Type	Elective 3
Course Outcome (CO)	(1) Students will master computational materials science, employing diverse techniques for modelling, simulation, and analysis in materials research. (2) Students will understand and apply computational materials science concepts, including random-walk simulations and modelling materials with long-range potentials. (3) Learners will grasp inter-atomic potentials and electronic structure methods, enabling them to simulate various materials and systems accurately using density functional theory. (4) Participants will master molecular dynamics fundamentals, including numerical integration, initial conditions, and analysis techniques for simulating atomic systems and materials research. (5) Students will proficiently utilize the Monte Carlo method to simulate materials, understand ensemble averages, and apply it to various systems in materials research.

Course Content	
Unit 1	**Random walk and Simulation of finite systems** Modelling and simulation, What is meant by computational materials science and engineering?, Scales in materials structure and behaviour, How to develop models, Random-walk model of diffusion, Connection to the diffusion coefficient, Bulk diffusion, A random-walk simulation, random walk models for materials, Sums of interacting pairs of objects, Perfect crystals, cutoffs, periodic boundary conditions, Implementations, Long-ranged Potentials.
Unit 2	**Inter-atomic Potentials and Electronic Structure Methods** The cohesive energy, Inter-atomic Potentials, Pair Potentials, Ionic materials, Metals, Covalent solids, System with mixed bonding, what we can simulate, Determining parameters in potentials, Quantum mechanics of multi-electron systems, Early density functional theories, The Hohenberg-Kohn theorem, Kohn-sham method, The exchange correlation functional pseudo-potentials, Use of density functional theory, Ab initio molecular dynamics, Car-Parinello simulation scheme.
Unit 3	**Molecular dynamics** Basics of molecular dynamics for atomic systems, Numerical Integration of Newton's equations, Conservation laws, examining the reliability of a simulation, Connection to thermodynamics, Initial conditions, Steps in an MD simulation, An example calculation, Potential cutoffs, Analysis of molecular dynamics simulations, "Lennard-Jonesium" as a model for materials, Spatial correlation functions, Time correlational Functionals, Molecular dynamics in other ensembles, velocity rescaling, Accelerated dynamics, Limitation of molecular dynamics, Molecular dynamics in materials research.
Unit 4	**The Monte Carlo method** Introduction, Ensemble averages, The Metropolis Algorithm (MA), Sampling in MA, Updating the energy in MA, The Ising model, metropolis Monte Carlo simulations of Ising model, Example simulation of Ising model, other sampling

	methods for the Ising model, Monte Carlo for atomic Systems, simulations of atoms in the canonical (NVT) ensemble other ensembles, Time in Monte Carlo simulations, Assessment of the Monte Carlo method, Uses of Monte Carlo method in materials research.

Reference Books	
1.	Introduction to Computational Materials Science: Fundamentals to Applications: R. Lesar, Cambridge University Press, (2013).
2.	An Introduction to Computational Physics: T. Pang, Cambridge University Press, Second Edition, (2006).
3.	Computational Physics Problem solving with Python: R. H. Landau, Manuel J. Páze, and Cristian C. Bordeianu, Third edition, Wiley-VCH, (2015).
4.	Computational Problems for Physics: With Guided Solutions Using Python: R. H. Landau, M. J. Páez, CRC Press, Taylor & Francis Group,(2018).
5.	Computational Physics: Nicholas Giordano, Hisao Nakanishi, Second Edition, Pearson Prentice Hall, (2006).

Course Name	PH-544: Elective 4-Nuclear Reactions
Course Code	PH-544
Course Type	Elective 4
Course Outcome (CO)	(1) At the end of the course, the students will be able to study different types of nuclear reactions and apply conservation laws to get the reaction cross-sections during them (2) The students will learn the detail study of Neutron Physics. (3) The students will understand nuclear fission, fission reactors and related Parameters (4) The students will learn nuclear fusion. (5) The student will be able to learn about thermonuclear weapons.

Course Content	
Unit 1	**Nuclear Reactions I** Introduction, types of reactions and conservation laws, observables, conservation laws, energetics of nuclear reactions, isospin, reaction cross-sections, experimental techniques, Coulomb scattering, nuclear scattering, scattering and reaction cross-sections.
Unit 2	**Nuclear Reactions II** Ghoshal experiment, Compound nucleus reactions, Resonance Reactions, Direct reaction, Heavy-Ion Reactions, Super heavy elements, Pre-equilibrium reaction mechanism, Complete and incomplete fusion reactions, Optical Model.
Unit 3	**Neutron Physics** Introduction, neutron sources, absorption and moderation of neutrons, neutron detectors, neutron reactions and cross-sections, neutron capture, interference and diffraction with neutrons.
Unit 4	**Nuclear Fission and Nuclear Fusion** Nuclear Fission: Introduction, Why nuclei fission, Characteristics of Fission, mass distribution of fragments, number of emitted neutrons, radioactive decay processes, fission cross-sections, Energy in fission, controlled fission reactions, fission reactors, a natural fission reactor, fission explosives. Nuclear Fusion: Basic fusion processes, characteristics of fusion, solar fusion, controlled fusion reactors, thermonuclear weapons.

Reference Books	
1.	Introductory Nuclear Physics: K. Krane, Wiley India Pvt. Ltd. (1988).
2.	Nuclear Physics: S. N. Ghoshal ,S. Chand and Co. Pvt. Ltd., Revised enlarged edition (2014).
3.	Introduction to Nuclear and Particle Physics by Mittal, Gupta and Verma, PHI Learning Pvt. Ltd., 3rd edition (2017).
4.	Nuclear Physics: D. C. Tayal, Himalaya Publishing House (2017).
5.	Radiation Detection and Measurement: G. F. Knoll.
6.	Nuclear Radiation Detectors: S. S. Kapoor and V. S. Ramamurthy.

Course Name	PH-545: Practical
Course Code	PH-545
Course Type	Core
Course Outcome (CO)	(1) Students will develop proficiency in a range of experimental techniques encompassing multiple beam interferometry, particle size analysis, spectroscopy, and electronic properties (2) Students will acquire versatile experimental skills while studying solar cells, electron spin resonance, ultrasonic interferometer etc. (3) Students will be trained to learn thermal properties of materials, determine g-factor of proton.

Course Content	
	Group A
1.	To study two beam interference using Mach-Zehnder Interferometer.
2.	To determine the particle size of lycopodium powder.
3.	To determine the refractive indices for the O-ray and the E-ray using quartz/calcite.
4.	To confirm the de Broglie equation for wavelength.
5.	Experiment using Quantum Efficiency Apparatus.
	Group B
6.	To measure 'h' by Solar Cell.
7.	To determine the wavelength of Balmer series in the visible region from hydrogen emission.
8.	To study Electron Spin Resonance.
9.	To study ultrasonic Interferometer.
10.	To study Frank-Hertz experiment.
	Group C
11.	To study damping effect in various media.
12.	To find coefficient of thermal expansion of Copper, Aluminium and Brass using their pipes.
13.	Study of black body radiation.
14.	Determination of proton spin and nuclear g-factor using NMR.
15.	To study the I-V characteristics of CdS photo-resistor at constant irradiance.
	Group D (Elective Paper 1)
16.	Characteristics of SCR, MOSFET, IGBT and power transistors (1 PE)
17.	Determination of NMOS and PMOS characteristics.
18.	Design of a Voltage reference and Simple Cascade Current mirror.
19.	Determination of NMOS Device parameters (V_{TO}, K, λ).
20.	Design of CMOS inverter and measure its delay, Noise Margin and power.

Group D (Elective Paper 2)	
16.	To investigate the elastic and plastic extension of metal wires.
17.	Measurement of Vicker's and Mho hardness using micro hardness tester.
18.	To study thermal conductivity of aluminium and copper at a constant temperature gradient.
19.	To determine the electrical conductivity of aluminium and copper by plotting a current-voltage characteristic curve.
20.	To measure the transition temperature of a high temperature superconductor.
Group D (Elective Paper 3)	
16.	Write a PYTHON program to perform the simulation of Random walk.
17.	Write a PYTHON program to perform the simulation of Radioactive decay.
18.	Write a PYTHON program to perform the simulation of Molecular dynamics.
19.	Write a PYTHON program to perform the simulation of Scattering by central potential.
20.	Write a PYTHON program for integration using Monte Carlo Method.
Group D (Elective Paper 4)	
16.	To estimate efficiency of the G. M. detector for (a) gamma source and (b) beta source.
17.	To study backscattering of beta particles.
18.	To study activity of a gamma source (Absolute Method).
19.	To study production and attenuation of bremsstrahlung.
20.	To determine the resolving time.

Course Name	PH-536:Skill based course- Remote Sensors
Course Code	PH-536
Course Type	Skill based course
Course Outcome (CO)	(1) At the end of the course, the students will be able to learn classification of Sensors. (2) To study various sensor parameters. (3) To understand the optical IR sensors in detail

Course Content	
Unit 1	**Remote Sensors- An Overview** Classification of Remote Sensors, Selection of Sensor Parameter, Spatial Resolution, Spectral Resolution, Location of spectral band, Radiometric Resolution, Radiometric Quality, Temporal Resolution, Performance Specification.
Unit 2	**Optical Infrared Sensors** Quality of Image in Optical Systems, Imaging mode, Photographic Camera, Photographic films, Characterizing film, Distortion in Photographs, Television cameras, Opto-mechanical scanner, Scanning Systems, Collecting Optics, Spectral Dispersion System, Detectors.

Reference Books	
1.	Fundamentals of Remote Sensing : George Joseph and C. Jeganathan, Third Edition, Universities Press
2.	Comprehensive remote sensing: Sunling Liang, Volume I, Missions and Sensors, Elsevier.
3.	Fundamentals of Remote Sensing : S C Bhatia, Atlantic Publishers and Distributors (P) Ltd.
4.	Introduction to Remote Sensing, James B. Campbell, Randolph H. Wynne, and Valerie A. Thomas, Floyd, F. Sabins Jr.: Sixth Edition.
5.	Remote Sensing Principles and Interpretation: Wavel and PrInc, (2020).
6.	Remote Sensing and Image interpretation: Lillesand and Kiefer, John Wiley (2015).
7.	Manual of Remote Sensing Vol. I&II, American Society of Photogrammetry, Second Edition.
8.	Introduction to modern photogrammetry: E. Mikhail, J. Bethel, J. McGlone, India: Wiley(2001).