III Semester Syllabus

Department Name: Physics

Semester - III

Course Title: Thermal and Statistical Physics	**Course Code:** 23PHHCT31
Total Contact Hours: 60 Hours	**No. of Credits:** 04
Internal Assessment Marks: 30	**Duration of SEE :** 03 Hours
SEE Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Apply the basic ideas in thermodynamics and statistical mechanics to physical situations.
2. Use various partition functions to determine thermodynamic potentials.
3. Apply various distribution functions to physical systems.
4. Analyse thermodynamical systems using fluctuations and related phenomenon.
5. Analyse phase equilibria in various thermodynamical situations.

Unit	Description	Hours
1	**Basic thermodynamics and statistical concepts** Laws of thermodynamics and their consequences, Thermodynamic potentials, Maxwell's relations and their applications, Microscopic and Macroscopic states, Phase space and μ-space, Chemical potential (qualitative), Ergodic hypothesis and Liouville's theorem (proof). Probability distribution – Binomial, Poisson and Gaussian distributions, Ensemble – Probability distributions in Microcanonical, canonical and grand canonical ensembles. (1,2,4)	12
2	**Classical statistics** Concept of partition function, Partition function of a system of particles, The translation partition function, Gibbs paradox – Sacker-Tetrode equation, Boltzmann equipartition theorem, Rotational partition function, Vibrational partition function, Electronic partition function, Maxwell-Boltzmann distribution – velocity & energy, Deduction of average speed, mean square speed and most probable speed by Maxwell-Boltzmann distribution. (Ref. 2,3,4)	12
3	**Quantum statistics** The symmetry and anti symmetry of the wave functions, Bosons and Fermions, Bose-Einstein and Fermi-Dirac distributions. Ideal Bose systems: Photon gas – Radiation pressure, Radiation density and emissivity, Bose-Einstein condensation, Phonon gas - specific heat of solids by Einstein and Debye's theories. Ideal Fermi Systems: Fermi energy, Mean energy of Fermions at T=0K, Fermi Gas in Metals, Atomic nucleus as an ideal Fermion gas, Electronic specific heat in metals, Pauli paramagnetism, (Ref. 1,4)	12

4	**Fluctuations and Irreversible thermodynamics** Fluctuations in canonical, grand canonical and microcanonical ensembles. The Brownian motion and Langevin equation. Random walk, diffusion and the Einstein relation for mobility. Onsager reciprocity relations. Thermoelectric phenomena. (Ref. 2,4)	12
5	**Phase Equilibria** Equilibrium conditions, First- and second-order phase transitions, phase diagram, Ising model, Clausius-Clapeyron equation, Liquid-Vapour equilibria: vapour pressure curve, Heat capacity of vapour in equilibrium, Compressibility of vapour; Sublimation curve; Phase transition in ferromagnetic materials, Liquid helium, Chemical equilibrium, Saha-Ionisation formula. (Ref.1,4)	12

References:

1. Fundamentals of Statistical Mechanics by B.B. Laud, New Age International Pvt. Ltd., Second Edition, 2012.
2. Statistical Mechanics and Properties of Matter by E.S.R. Gopal, Ellis Horwood Limted Chichester Publisher, 1974.
3. Thermal Physics by by S.C. Garg, R.M. Bansal and C.K. Ghosh, Mc Graw Hill Education (India) Private Limited, 2012.
4. Fundamentals of Statistical Mechanics and Thermal Physics by F. Reif, Mc Graw Hill Book Company, New York.

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Department Name: Physics

Semester - III

Course Title: Analytical Techniques and Instrumentation	**Course Code:** 23PHHCT32
Total Contact Hours: 60 Hours	**No. of Credits:** 04
Internal Assessment Marks: 30	**Duration of SEE :** 03 Hours
SEE Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Explain the fundamentals of analytical Instrumentation techniques.
2. Analyse vibrations of molecules using IR and Raman spectroscopic techniques.
3. Analyse atomic absorption, emission & photoluminescence of chemical species using absorption and emission spectroscopy.
4. Analyse the crystalline and morphological features of chemical species using spectroscopic techniques.
5. Determine electrical, magnetic, nuclear and thermal properties of chemical species using suitable techniques.

Unit	Description	Hours
1	**Fundamentals of Analytical Instruments:** Types of chemical analysis, Elements of analytical instrument, Sensors and transducers, Classification of transducers, Performance characteristics of Transducers, Smart sensors, Signal processing in analytical instruments, Read out systems, types of instrumental methods, classification of analytical instruments. Performance requirements of analytical instruments: Errors in chemical analysis, Types of Errors, Accuracy and precision, Significant figures, Application of statistical methods, Signal to noise ration. Sensitivity, Selectivity, Specificity, Resolution, Range, Limit of detection, Linearity. (Ref: 1)	12
2	**Infrared and Raman Spectroscopy:** Infrared Absorption Spectroscopy: Range of Infrared Radiation, Modes of vibrations, Basic components of IR spectrophotometers (Radiation sources, monochromators, slits, mirrors, sample cells, sampling substance, and detectors) Types of IR spectrophotometers: Optical null method and Ratio recording method; sample handling techniques, Fourier transform infrared spectrometer. (Ref: 1,2) Raman Spectroscopy: Raman effect: Principle, characteristic properties of Raman lines, Raman spectrometer (Sources, sample chamber, Detectors), PC based Raman spectrometer, FT Raman spectrometer, Applications, comparison between Raman and Infrared Spectroscopy. (Ref: 1,2)	12

3	**Absorption and Emission Spectroscopy:** UV-Visible Absorption spectroscopy: Beer-Lamberts law, construction and working of single and double beam absorption spectrometers, applications. Atomic absorption spectroscopy: Principle, Instrumentation (Radiation sources, Burners and flames, Atomization, Optical system, Electronic system, Sampling system), Applications. Atomic emission spectrophotometer: Instrumentation, Plasma excitation sources (Direct coupled plasma, Inductively coupled plasma, Microwave induced plasma). Photoluminescence: Principles of fluorescence and Phosphorescence, Instrumentation of spectrofluorimeter (Ref: 1-6)	12
4	**X-ray, Electron and Ion spectroscopy:** X-ray Diffraction: Bragg's law, X-ray diffraction methods and associated instrumentation, Applications. Electron spectroscopy: Auger Electron Spectroscopy (AES), Scanning Electron Microscopy (SEM); Transmission Electron Microscopy (TEM). Scanning Tunneling Electron Microscopy (STEM), Atomic Force Microscopy (AFM). Ion Spectroscopy: Secondary Ion Mass Spectroscopy (SIMS), Ion Scattering Spectroscopy (ISS). (Ref: 1-4)	12
5	**Electric, Magnetic and Thermal techniques:** Measurement of high and low electrical resistivity: DC and AC four probe technique, two probe techniques, errors in the measurement, impedance considerations and accuracy, Instrumentation of impedance analyzer. Impedance, dielectric constant and dielectric loss measurements using impedance analyzers. Vibrating-sample magnetometer (VSM), Nuclear Magnetic Resonance spectrometer (NMR), Electron Spin Resonance (ESR). Thermo-analytical instruments: Thermogravimetric analysis (TGA), Differential thermal analysis, Differential scanning calorimetry (DSC). (Ref: 1-4)	12

References:

1. Handbook of Analytical Instruments, R.S. Khandpur, 3rd Edition, Tata McGraw-Hill, (2015).
2. Instruments Methods of Chemical Analysis, Chatwal and Anand, Himalaya Publishing House, (2019).
3. Instrumental Method of Analysis, Willard, Merritt, Dean and Settle, CBS Publishers and Distributors, Delhi (1986).
4. Principles of Instrumental Analysis, 7th Edition, D. A. Skoog, F. J. Holler, S. R. Crouch, Cengage India Private Limited, (2020).
5. Methods of Experimental Physics, Dudley Williams, Academic press, New York, (1976).
6. Experimental Spectroscopy, Sawyer, Prentice-Hall publisher, (1946).

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Department Name: Physics

Semester - III

Course Title: Advanced Condensed Matter Physics	**Course Code:** 23PHSCT31A
Total Contact Hours: 60 Hours	**No. of Credits:** 04
Internal Assessment Marks: 30	**Duration of SEE :** 03 Hours
SEE Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Determine physical parameters of solids using reciprocal lattice and band structure models.
2. Determine transport properties of solids using related theories.
3. Analyse dielectric and optical properties of solids using basic principles of physics.
4. Analyse magnetic properties of solids using various theories/models.
5. Explain properties of superconductors based on classical and quantum concepts.

Unit	Description	Hours
1	**Reciprocal Lattice and Band structure in Solids:** Concept of Reciprocal lattice, Method of Construction, Reciprocal Lattice Vectors, Properties of Reciprocal lattice, Expression for length of Reciprocal lattice vector in terms of interplanar spacing, Reciprocal lattice to SC, BCC and FCC, Bragg's law in Reciprocal Lattice, Brillouin Zones and their construction, Brillouin Zone of BCC and FCC Lattice. (Ref.1 & 2) Nearly free electron model – origin and magnitude of energy gap; Tight Binding Model – Band width and effective mass in linear lattice and cubic lattice; Augumented Plane Wave (APW) method of band structure calculation. (Ref. 2, 3 & 4)	12
2	**Transport Properties:** Boltzmann transport equation, Boltzmann Transport Equation for Electrons and Lorentz solution, Chamber's Equation, Sommerfeld's theory of electrical conductivity, Thermal conductivity of metals and Widemann –Franz law, Criticism of Sommerfeld's theory, Relaxation time, Mean free path, The additive Nature of Resistivity – Mathiessen's rule, Thermoelectric effects, Magneto-resistance. (Ref.5)	12
3	**Dielectric and Optical Properties:** **Static Fields:** Macroscopic description of static dielectric constant, Static electronic and ionic polarisabilities of molecules, Orientational polarization, Static dielectric constant of gases, Internal field according to Lorentz, Static dielectric constant of solids – Clausius-Mosotti formula. **Alternating fields:**	12

	Complex dielectric constant and dielectric losses, Dielectric losses and relaxation time, Classical theory of electronic polarization and optical absorption. (Ref. 6)	
4	**Magnetic Properties** Classification of magnetic materials, Atomic origin of magnetism, Langevin diamagnetism, Paramagnetism - Classical and quantum theories; Magnetism in metals – Spin-paramagnetism, diamagnetism; Ferromagnetism in insulators – Curie-Weiss law, Molecular field theory, Antiferromagnetism and ferrimagnetism, Ferromagnetism in metals, Ferromagnetic domains – Hysteresis curve, Principle and Theory of Paramagnetic resonance and Nuclear magnetic resonance. (Ref. 3 & 4).	12
5	**Superconductivity** Review of superconductivity, Heat Capacity, Energy gap, Microwave and Infrared Properties, Isotope Effect, Thermodynamics of Superconducting Transition, Electrodynamics of Superconductors - London Equations, Coherence Length, BCS theory of Superconductivity, BCS Ground State, Flux quantization in a Superconducting Ring, Duration of Persistent Currents, Single Particle Tunneling, Josephson Tunneling – DC and AC Josephson Effect, Macroscopic Quantum Interference. (Ref. 2)	12

References:

1. Solid State Physics by R. K. Puri & V. K. Babbar, S. Chand Publications.
2. Introduction to Solid State Physics by C. Kittel, Wiley Eastern Ltd
3. Elementary Solid State Physics by M. Ali Omar, Pearson Education.
4. Elements of Solid State Physics by J.P Srivastava, PHI Learning Pvt. Ltd.
5. Solid State Physics by S.L. Gupta and V. Kumar, K. Nath & Co.
6. Solid State Physics by A. J. Dekker, McMillan and Co. Ltd.

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Department Name: Physics

Semester - III

Course Title: Advanced Nuclear Physics	**Course Code:** 23PHSCT31B
Total Contact Hours: 60 Hours	**No. of Credits:** 04
Internal Assessment Marks: 30	**Duration of SEE :** 03 Hours
SEE Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Analyse structure of nuclei using various models.
2. Analyse two nucleon systems and nuclear reactions.
3. Explain fundamentals of heavy ion physics.
4. Use neutron physics to describe various nuclear processes. .
5. Apply various nuclear techniques in advanced nuclear physics.

Unit	Description	Hours
1	**Nuclear Models** **Shell model:** Evidences for shell structure, energy levels according to harmonic oscillator intermediate potentials - effect of spin-orbit interaction. Shell model Prediction of ground state spin, parity of odd-A nuclei and odd-odd nuclei - Nordheim's rules, magnetic moments of odd-A nuclei Schmidt limits. **Collective model:** Introduction, Nuclear deformations and collective motions of nucleons. Vibrational model- Vibrational excitation and vibrational energy levels for even-even nuclei, rotational model- Nuclear rotational motion and rotational energy spectra for even-even and odd A nuclei. **Fermi gas model**: Fermi energy of nucleons, Fermi momentum and level density; nuclear matter. **(Ref. Roy and Nigam, D C Tayal, R D Evans)**	12
2	**Two nucleon systems**: The ground and Excited states of deuteron, tensor nature of nuclear force and its range. Neutron-proton scattering at low energies, scattering length, Effective range theory in n-p scattering, proton-proton scattering at low energies, Analysis of n-p and p-p scattering, high energy n-p and p-p scattering. Interpretation of n-p and p-p scattering. **Nuclear reactions**: Nuclear reactions and cross sections, partial wave analysis of nuclear reactions-expressions for scattering and reaction cross sections and their interpretations - shadow scattering. Resonance theory of scattering and absorption. Breit-Wigner formula for l=0. **Compound nucleus model:** model and continuum theory of cross-section. **(Ref. Roy and Nigam, D C Tayal)**	12

3	**Optical model** - mean free path - optical potential and optical model parameters, optical model at low energy, Kapur-Pierls dispersion formula for potential scattering and experimental results. **Direct Reactions**: Transfer reactions - semiclassical description. Theory of stripping and pickup reactions, Plane wave Born approximation (PWBA) - its predictions of angular distributions - modifications - distorted wave Born approximation (DWBA) - spectroscopic factors and their significance. **Heavy Ion Physics**: Special features of heavy ion reactions. Qualitative treatment of remote electromagnetic interaction Coulomb excitations; close encounters, grazing collisions and particle transfer. Direct and head on collision, compound nucleus and quasi molecule formation. **(Ref: Roy and Nigam, Mermier and Sheldon Vol. II)**	12
4	**Neutron Physics:** Introduction, Properties of neutron, Classification of neutrons according to energy - neutron sources. Ultrafast neutrons, Neutron detectors, Neutron detection from nuclear reactions. BF3 counters, He-3 proportional counters, fission detectors, activation method for neutron flux measurement. Recoil counters, neutron time of flight technique. Slow neutron detection through nuclear reaction and induced radio activity, slow neutron cross section measurements, neutron monochromators. Review of Nuclear fusion process, Controlled thermonuclear reactions. Hydromagnetic equations. Magnetic pressure, pinch effect, magnetic confinement systems for controlled thermonuclear fusion.**(Ref: S N Ghoshal and Zweifel P F)**	12
5	**Nuclear techniques:** X-ray Fluorescence (XRF) - Basic principle, instrumentation and application, Neutron Activation Analysis (NAA) - Basic Principle, Instrumentation and application, Proton Induced X-ray Emission (PIXE) - Basic Principle, Instrumentation and application, Positron annihilation - Basic Principle, Sources, Experimental details, angular correlation of annihilation radiation and Fermi momentum of conduction electron in metals, Ion beam analysis-Rutherford back scattering. **(Ref. H R Verma)**	12

References:

1. Nuclear Physics: R R Roy and B P Nigam, John Wiley & Sons, Inc., 1967.
2. Nuclear Physics: D C Tayal, Himalaya Publishing House, Fifth Edition, 2015.
3. The Atomic Nucleus: R D Evans, Tata McGraw Hill Edition, 1955.
4. Physics of Nuclei and Particles: P Mermier and E Sheldon, Volume-II, Academic Press, Inc., 1969.
5. Atomic and Nuclear Physics: S N Ghoshal, S. Chand & Company Pvt. Ltd., 2014.
6. Zweifel P F, 'Reactor Physics', International student Edn. (McGraw Hill, 1973).
7. H R Verma, Atomic and Nuclear Analytical Methods: XRF, Mössbauer, XPS, NAA and Ion-Beam Spectroscopic Techniques. Springer.

Department Name: Physics

Semester - III

Course Title: Materials Science	**Course Code:** 23PHSCT31C
Total Contact Hours: 60 Hours	**No. of Credits:** 04
Internal Assessment Marks: 30	**Duration of SEE :** 03 Hours
SEE Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

At the end of the course the student will be able to:

1. Explain the basics of engineered materials and their properties.
2. Analyse the behavior of elastic and plastic materials.
3. Analyse the behavior of ferroelectric, ferrite, polymer and Nano - materials.
4. Describe the applications of different materials in science and technology.

Unit	Description	Hours
1	**Introduction to Engineering Materials :** Materials Science and Engineering, Classification of Engineering Materials, Levels of Structure, Structure - Property Relationships in Materials. Equilibrium and Kinetics: Stability and Metastability, Basic Thermodynamic functions, The statistical nature of entropy, The kinetics of thermally activated processes. Review of ionic, covalent and molecular bindings, bond angle, bond length and bond energy, lattice energy - Madelung constant cohesive energy, vander Waal's Interaction- Lennard- Jones Potential, closed packed structure-packing efficiency and density of materials.	12
2	**Elastic and plastic behaviour of materials:** Atomic model of elastic behaviour-rubber like Elasticity-anelastic behaviour, viscoelastic behaviour, fracture of materials-Ductile and brittle fracture – Ductile brittle transition, Protection against fracture. Plastic deformation by slip-shear strength of perfect and real crystals- CRSS ratio, Maximum stress to move dislocation, Methods of strengthening crystalline materials against plastic deformation-strain hardening, grain refinement, solid solution strengthening, precipitation strengthening.	12
3	**Ferroelectrics and Ferrites:** Ferroelectrics: General properties of ferroelectrics, classification and properties of representative ferroelectric crystals, theory of ferroelectricity, piezo and pyro electric properties, dielectric constant with temperature and frequency,	12

	hysteresis loop. Ferrites: definitions and types of ferrites with examples, structure of cubic ferrite, saturation magnetization, molecular field theory, hexagonal ferrite, influence of temperature and field on magnetic behaviour, domains, hysteresis, and applications of ferrites.	
4	**Elements of polymer science**: Monomers- Polymers- classification of polymers, synthesis of polymers-chain polymerization, step polymerization, Industrial polymerization methods, Average molecular weight- weight, number & viscosity, size of polymer molecule. Microstructure of polymers- chemical, geometric, random, alternating and block polymers. Phase transition-Polymer melting and glass transition, stereo isomerism, degree of crystallinity. Process of plastic materials: Moulding- compression, injection, blow, extrusion, spinning.	12
5	**Nanomaterials:** Introduction, size effect: quantum confinement effect, Different form of nanostructures, idea of 2-d, 1-d and 0-d nanostructures, Synthesis of nanomaterials, Physical Methods of Synthesis: High Energy Ball Milling, Physical Vapour Deposition, Laser Ablation, Electric Arc Deposition; Chemical Methods of Synthesis: Synthesis of Metal and Semicondctor Nanoparticles by Colloidal Route, Sol-Gel Method, Hydrothermal Synthesis; Biological Methods of Synthesis: Synthesis Using Microorganisms, Synthesis Using Plant Extracts.	12

References:

1. Elements of Materials Science and Engineering, H. Lowrence, V. Vlack, Addison Wesley, (1975).
2. Introduction to Ceramics, W. D. Kingery, H. K. Bower, D. R. Uhlmann, 2nd Edition, Wiley, (1976).
3. Foundations of Materials Science and Engineering, W. F. Smith, J. Hashemi, 5th Edition, McGraw Hills International Edition, (2009).
4. Materials Science and Engineering, V. Ragharan, 5th Edition, Prentice Hall, (2011).
5. Structure & Properties of materials- Rose, Shepard, Wulff, Wiley, (1987).
6. Polymer Science, V. R. Gowariker, N.V. Vishwanathan, Joydev Shreedhar, John Wiley and Sons, Inc. (1987).
7. Text of Polymer Science, Fred. W. Billmeyer, 3rd Edition, John Wiley and Sons, Inc. (1984).
8. Nanotechnology: Importance and applications, M H Fulekar, I. K. International Pvt. Ltd., (2010).
9. A Textbook of Nanoscience and Nanotechnology, T. Pradeep, McGraw Hill Education, (2017).
10. Nanotechnology: Principles and Practices, 3rd Edition, Sulabha K. Kulkarni, Springer International Publishing, (2015)

Department Name: Physics

Semester - III

Course Title: Radiation Physics	**Course Code:** 23PHSCT32A
Total Contact Hours: 60 Hours	**No. of Credits:** 04
Internal Assessment Marks: 30	**Duration of SEE :** 03 Hours
SEE Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Describe the basics of radiation physics.
2. Analyse interaction of radiation with matter.
3. Measure radiation and related quantities with appropriate units.
4. Describe the importance of radiation protection.
5. Identify electronics/electronic components required in radiation field.
6. Explain the industrial applications of radiation.

Unit	Description	Hours
1	**Basic Radiation Physics:** Atomic and nuclear structure – Rutherford's and Bohr's atomic models, nucleus and its constituents, isotopes, isobars and isomers. Electromagnetic radiation – Ionising and non-ionising radiations. Radioactivity – Radioactive decay, decay constant, half-life, biological half-life, types of ionising radiations (alpha, beta, and gamma radiations) and radioisotopes. Radiation sources – Natural and artificial radioactive sources.	12
2	**Interaction of Radiation with Matter:** Interaction of radiation with matter: Interaction - stopping power - energy loss characteristics, particle range - energy loss in thin absorbers. Scaling laws. Interaction of fast electrons - specific energy loss. Electron range and transmission curves. Interaction of gamma rays - interaction mechanisms - photoelectric absorption, Compton scattering and pair-production. Gamma ray attenuation - attenuation coefficients, absorber mass thickness, cross sections. Interaction of neutrons - general properties - slow down interaction, fast neutron interaction, neutron cross sections. Radiation exposure and dose – dose equivalent.	12
3	**Radiation Measurements, Quantities, Units and Protection:** Basic principles of radiation detection - GM detectors, scintillation detectors, semiconductor detectors, solid state nuclear track detectors (SSNTD) and thermo luminescent dosimeters (TLD).Radiation quantities and units – Activity, radiation exposure, absorbed dose, equivalent dose and effective dose. Linear energy transfer	12

	(LET). Radiation protection - Objectives of radiation protection, committees and regulatory bodies concerned with risk estimates and radiation protection, occupational exposure, as low as reasonably achievable (ALARA), protection of the embryo/fetus, Exposure of members of the public (non-occupational).	
4	**Nuclear Electronics:** Preamplifier circuits, linear and pulse amplifier, pulse shaping, pulse stretching. Wilkinson type analog to digital converter. Pulse discriminators - coincidence and anticoincidence circuits - memories, single and multichannel analysers – on-line data processing - time to amplitude converter - charge sensitive amplifier. Basic principles of measurement techniques such as collimation, shielding, geometry and calibration.	12
5	**Industrial Applications:** Non-Destructive Testing: automobile industry - thickness of metal sheets, pipeline corrosion; aircraft industry - checking flaws in jet engines; mineral analysis. Sealed source applications: industrial radiography, gauging applications - density, moisture, level, thickness monitoring gauges. Radio tracer techniques: Leak and block detection, flow rate and mixing measurements. Gamma Radiation Processing Plants: sterilization of medical products, irradiation of food materials. Enhancing Material Quality: hardening plastics by cross linking, heat resistant wire and cables by irradiation, radiation vulcanisation of natural rubber for better quality. Electrostatic control applications.	12

References:

1. Knoll G F, Radiation Detection and Measurement', II Edn. (John Wiley, 1989).
2. Ghoshal S N, 'Atomic and Nuclear Physics', Vol. I & II (S Chand & Company, 1994).
3. Segre E, 'Nuclei and Particles', II Edn. (Benjamin, 1977).
4. Eisenbud M. Environmental Radioactivity, Academic Press Inc. (London) Ltd., 24-28 Oval Road, London NW1 7DX, 1987.
5. Patel S B, 'Nuclear Physics - An Introduction' (Wiley Eastern, 1991).
6. Krane K S, 'Introductory Nuclear Physics' (John Wiley, 1988).
7. Roy R K and Nigam P P, 'Nuclear Physics - Theory and Experiment' (Wiley Eastern Ltd., 1993).
8. Kapoor S S and Ramamurthy V S, 'Radiation Detectors' (Wiley Eastern, 1986).

Department Name: Physics

Semester - III

Course Title: Optical Spectroscopy	Course Code: 23PHSCT32B
Total Contact Hours: 60 Hours	**No. of Credits:** 04
Internal Assessment Marks: 30	**Duration of SEE :** 03 Hours
SEE Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Analyse UV and visible spectroscopy of molecules.
2. Analyse fluorescence spectroscopy of molecules.
3. Explain time domain and frequency domain techniques for lifetime measurements.
4. Describe the working of Refractometry, Polarimetry, and Circular Dichroism instrumentation.
5. Explain the development of holograms and theory of non-linear optics.

Unit	Description	Hours
1	**Ultraviolet and Visible Spectroscopy:** Origin and theory of ultraviolet spectra, Beer-Lambert's law, Types of transitions in inorganic and organic molecules ($\sigma \to \sigma^*$, $n \to \sigma^*$, $\pi \to \pi^*$, $n \to \pi^*$), The shape of UV absorption curves, Transition probability, Chromophore and related terms: Bathochromic and Hypsochromic shift; Hyperchromic, Hypochromic effect; Auxochrome, Effect of conjugation, solvent effects, Choice of solvents, Instrumentation: construction and working of single and double beam spectrophotometers, Applications.	12
2	**Fluorescence Spectroscopy:** Fluorescence, Jablonski Diagram, Characteristics of Fluorescence Emission, Fluorescence Lifetimes and Quantum Yields, Fluorescence Anisotropy, Timescale of Molecular Processes in Solution, Molecular Information from Fluorescence: Emission Spectra and the Stokes Shift, Quenching of Fluorescence, Fluorescence Polarization or Anisotropy, Resonance Energy Transfe;, Intrinsic or Natural Fluorophores, Extrinsic Fluorophores, DNA Probes, Chemical Sensing Probes and Special Probes, other Fluorescent Proteins, Long-Lifetime Probes: Lanthanides, Transition Metal–Ligand Complexes, Proteins as Sensors. Construction and working of Spectrofluorometer: Light Sources, Monochromators, Optical Filters, Detectors.	12
3	**Time Domain and Frequency Domain Lifetime Measurements:** Overview of Time-Domain and Frequency-Domain Measurements, Meaning of the Lifetime or Decay Time, Phase and Modulation Lifetimes, Examples of	12

	Time-Domain and Frequency-Domain Lifetimes, Construction and Working of Time-Correlated Single-Photon Counting Instrument, Applications of TCSPC, Theory of Frequency-Domain Fluorometry, Frequency-Domain Instrumentation.	
4	**Refractometry, Polarimetry, and Circular Dichroism:** Refractometry: Refractive index, Effect of wavelength and temperature on RI, Instrumentation of Abbe Refractometer, Applications. Polarimetry: Optical activity, types of molecules analyzed by polarimetry, Instrumentation of Polarimeter, Applications. Circular Dichroism Spectroscopy: Circularly polarized light, Optically active molecules, Optically rotator dispersion, Circular dichroism and Instrumentation for measurements, Applications.	12
5	**Holography and Non-linear optics:** Principle of holography, Recording of the Hologram, Reconstruction of the Image, some distinguishing characteristics of holographs - practical applications of holography. Harmonic generation - second harmonic generation - phase matching - third harmonic generation Z scan technique - optical mixing - parametric generation of light - self focusing of light, Electro-optic effect.	12

References:

1. Instruments Methods of Chemical Analysis, Chatwal and Anand, Himalaya Publishing House, (2019).
2. Handbook of Analytical Instruments, R.S. Khandpur, 3rd Edition, Tata McGraw-Hill, (2015).
3. Fundamentals of Molecular Spectroscopic, C N. Banwell and E. M. McCash, Tata McGraw-Hill Publishing Co., Ltd., New Delhi, 5th Edition, (2008).
4. Principles of fluorescence spectroscopy, Joseph R Lakowicz, 3rd Edition, Springer, New York, (2006).
5. Lasers & Nonlinear Optics, Laud B B, New Age International (P) Limited, Publishers, (2011).
6. Nonlinear Optics-Basic Concepts, Mills D L, Narosa Publishing, (1991).

Department Name: Physics

Semester - III

Course Title: Renewable Energy Physics	**Course Code:** 23PHSCT32C
Total Contact Hours: 60 Hours	**No. of Credits:** 04
Internal Assessment Marks: 30	**Duration of SEE :** 03 Hours
SEE Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Explain the fundamentals of renewable energy.
2. Identify different renewable energy sources.
3. Analyse different solar electric systems.
4. Analyse the performance of wind energy systems.
5. Explain the biomass energy systems.

Unit	Description	Hours
1	**Introduction to renewable energy:** Introduction, Definition of Power and energy, difference between power and energy, Importance of Energy Consumption as Measure of Prosperity, Per Capita Energy Consumption, Classification of Energy Resources; Conventional Energy Resources - Availability and their limitations; Non-Conventional Energy Resources – Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario.	12
2	**Energy Sources:** Conventional energy sources: Hydro Electric, Thermal, Nuclear, Non-Conventional Energy sources Bio-mass, geo-thermal, solar, wind energy, ocean energy, wave energy, advantages and disadvantages, challenges. Commercial energy sources, fossil-fuels coal, oil, natural gas, hydroelectric power, nuclear, Non-commercial energy sources, wood, animal wastes, agricultural waste, cost of raw materials, transport problems, issues.	12
3	**Solar Electric Systems:** Solar Thermal Electric Power Generation – Solar Pond and Concentrating Solar Collector (parabolic trough, parabolic dish, Central Tower Collector). Advantages and Disadvantages; Solar Photovoltaic – Solar Cell fundamentals, characteristics, classification, construction of module, panel and array. Solar PV Systems – stand-alone and grid connected; Applications – Street lighting, Domestic lighting and Solar Water pumping systems.	12

4	**Wind and Hydrogen Energy:** Introduction, Wind and its Properties, History of Wind Energy, Wind Energy Scenario – World and India. Basic principles of Wind Energy Conversion Systems (WECS). Hydrogen Energy: Relevance in relation to depletion of Fossil fuels and Environmental considerations. Hydrogen Production: Solar hydrogen through Photo electrolysis and Photocatalytic process. Physics of material characteristics for production of solar hydrogen.	12
5	**Biomass Energy:** Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies, Urban waste to Energy Conversion, Biomass Gasification, Biomass to Ethanol Production, Biogas production from waste biomass, factors affecting biogas generation, types of biogas plants – KVIC and Janata model; Biomass program in India.	12

References:

1. Non-Conventional Sources of Energy, Rai, G. D, Khanna Publishers, 4th Edition, 2007
2. Non-Conventional Energy Resources, Khan, B. H., Tata Mc Hills, 2nd Edition.
3. Fundamentals of Renewable Energy Systems, Mukherjee, D and Chakrabarti, S., New Age International Publishers, 2005.

Department Name: Physics

Semester - III

Course Title: Research Methodology	**Course Code:** 23PHSEC31
Total Contact Hours: 30 Hours	**No. of Credits:** 02
Internal Assessment Marks: 50	**Duration of SEE : -** No SEE
SEE Marks: - No SEE	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Identify types of research and sources for selection of a research problem.
2. Explain methods of data collection.
3. Write a technical paper with representing data in terms of plots and figures.
4. Perform data analysis using various statistical tools.

Unit	Description	Hours
1	**Introduction to Research:** Nature and importance of research - Aims, Objectives and Principles, Fundamental research vs. applied research with examples, Qualitative vs Quantitative research with examples, Theoretical research vs. experimental research with examples. Selection of a research problem and Sources of literature – Journals, Conferences, Books. Types of sources: Literature Survey engines - Scopus, web of Science, Google Scholar, PubMed, NCBI, Scihub, etc. How to read a research paper?, Science citation index: Citations, h-index, i10 index, impact factor.	07
2	**Methods of Data Collection:** Data Collection Methods - Framing a hypothesis, designing controlled experiments, choosing the sample-size, sampling bias, importance of independent replicates, conducting an experiment, maintaining a lab notebook to record observations, Identifying experimental errors. Case studies on well-designed experiments vs. poorly designed experiments. Correlations vs. Causation , Good laboratory Practices.	07
3	**Data analysis (Practical):** Data Presentation and Writing: Technical presentation, technical writing, Formatting citations ; MS Excel/ origin for plotting the data (pie chart, plots, bar charts) **Analysis using software tools:** Descriptive Statistics: Mean, standard deviation, variance, plotting data and understanding error-bars. Curve Fitting: Correlation and Regression. Distributions: Normal Distribution, Gaussian distribution, skewed distributions, Inferential Statistics: Hypothesis testing and understanding p-value, Parametric tests: Student's t-test, ANOVA, Tests to analyse categorical data: Chi-square test.	16

References:

1. C.R. Kothari, Research Methodology: Methods and Techniques, II Ed. New Age International Publishers, (2009).
2. Shanthibhushan Mishra, Shashi Alok, Handbook of Research Methodology, I Ed, 2017, Edu creation Publishers.
3. Basic Statistical Tools in Research and Data Analysis (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5037948/).
4. Introduction to statistical methods with MATLAB (MATLAB and Simulink Training (mathworks.com)).

Department Name: Physics

Semester - III

Course Title: Space Research Programs in India and Abroad	**Course Code:** 23PHOET31
Total Contact Hours: 30 Hours	**No. of Credits:** 02
Internal Assessment Marks: 10	**Duration of SEE : 2** Hours
SEE Marks: 40	

Course Outcomes (COs): At the end of the course, students will be able to:

1. Explain basic ideas of space missions.
2. Recognise major space centers and space scientists in the World.
3. Explain the contributions of ISRO for space missions.
4. Explain the applications of satellite.

Unit	Description	Hours
1	**Introduction to Space Missions** Rockets, types and their applications, Orbits - Different types of orbits, Artificial satellites – basic idea and their applications, Introduction to Space Missions, Beginning of Space Missions - World and India, Applications of Space Research, Space crafts, Launching Vehicles. Major Space Centres in the World (at least 10) – brief idea about their location, establishment, capabilities and achievements.	10
2	**Indian Space Research Organisation (ISRO)** About ISRO and its Goals, History of Creation. General Satellite Programmes: The IRS series, The INSAT series. Gagan Satellite Navigation System, Navigation with Indian Constellation (NavIC), Other satellites. Launch vehicles: Satellite Launch Vehicle (SLV), Augmented Satellite Launch Vehicle (ASLV), Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV). Experimental Satellites: Details and applications (Any Five)	10
3	**Applications of satellites and Success Stories of Space missions** Earth Observation Satellites: Details and applications (Any Five), Communication satellites: Details and applications (Any Five), Application of satellites in agriculture, communication, weather forecasting, exploration of natural resources and Global positioning system (GPS). Success stories: Apollo 11, Chandrayaan 1, Mars Orbiter Mission (MoM). Proposed space programmes of NASA and ISRO.	10

References:

1. https://www.britannica.com/topic/NASA
2. https://www.isro.gov.in/

Department Name: Physics

Semester - III

Course Title: Elementary Astrophysics	**Course Code:** 23PHOET32
Total Contact Hours: 30 Hours	**No. of Credits:** 02
Internal Assessment Marks: 10	**Duration of SEE :** 2 Hours
SEE Marks: 40	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Explain the basics of astrophysics and telescopes.
2. Identify stars and its parameters based on their spectra.
3. Identify various types of galaxies.
4. Describe the structure and evolution of the universe.

Unit	Description	Hours
1	**Basics of Astrophysics and Telescopes:** Scales and Dimensions, Night Sky, Constellations, Earth, Sun, and the Solar System, Retrograde Motion of Planets, Sidereal Time. Basic Optics, Types of telescopes. Telescope mounting systems. Optical telescopes, Infrared, Ultraviolet, X-ray and Gamma-ray telescopes. Schmidt telescopes.	10
2	**Stars, Stellar Spectra, and Classification:** Stellar Spectra, Harvard Classification of Stellar Spectra, Saha Equation, HR Diagram, Star Clusters and Association, Distance and Age Determination of Clusters Using Color-Magnitude Diagram, Solar System, Solar Atmosphere (Photosphere, Chromosphere, Corona).	10
3	**Galaxies and the Universe:** The Milky Way – our galaxy, Classification of galaxies, Origin and evolution of galaxies, Measuring galaxy properties, The distances to other galaxies, The structure of the Universe, The evolution of the Universe.	10

References:

1. Introduction to Stellar Astrophysics, E. Bohm-Vitense, 3rd Volume, CUP, 1989.
2. Astrophysics and Stellar Astronomy, T.L. Swihart, Wiley 1968.
3. An Introduction to Astrophysics Baidyanath Basu, PHI.
4. A Text book of Astrophysics and Cosmology, V.B. Bhatia, New Age.
5. Stars and Galaxies, K.D. Abhyankar, University Press.
6. An introduction to Astrophysics and Cosmology by Andrew Norton – 2016

Department Name: Physics

Semester - III

Course Title: Thermal and Statistical Physics Lab	**Course Code:** 23PHHCP31
Total Contact Hours: 60 Hours	**No. of Credits:** 02
Internal Assessment Marks: 20	**Duration of SEE :** 04 Hours
SEE Marks: 30	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Design an experiment / a computation technique in statistical physics.
2. Conduct an experiment / perform a computation in statistical physics.
3. Analyse data and interpret the results related to statistical physics.

<u>List of Experiments</u>

1. Study of Binomial distribution.
2. Study of Poisson distribution.
3. Study of Gaussian Distribution.
4. Study of variation of MB, BE and FD statistics at different temperatures- Computation.
5. Study of Bose-Einstein condensation - Computation.
6. Study of theories of specific heat – Computation.
7. Specific Heat in Metals.
8. Debye temperature of solids.
9. Study of Black body Radiation.
10. Measurement of Planck's constant.
11. Study of Seeback and Peltier effects.
12. Fourier analysis studies.
13. Measurement of Magnetic susceptibility.
14. Measurement of Curie temperature (Magnetic/Electrical).
15. Measurement of thermal conductivity.

Note:

1. Minimum of EIGHT computations must be carried out.
2. Experiments may be added as and when required with the approval of BoS.

References:

1. University Practical Physics by D.C. Tayal, Himalaya Publishing House, First Millenium Edition, 2000.
2. Advanced Practical Physics for students by B.L. Flint and H.T. Worsnop, Asia Publishing House, 1971.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, Kitab Mahal, 11th Edition, 2011.
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers, 4th Edition, 1985.

Department Name: Physics

Semester - III

Course Title: Analytical Techniques & Instrumentation Lab	**Course Code:** 23PHHCP32
Total Contact Hours: 60 Hours	**No. of Credits:** 02
Internal Assessment Marks: 20	**Duration of SEE :** 04 Hours
SEE Marks: 30	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Design an experiment / a computation technique to measure material properties.
2. Conduct an experiment / perform a computation to measure material properties.
3. Analyse data and interpret the results related to material properties.

List of Experiments

1. Determination of 'g' factor using Electron spin resonance spectrometer.
2. Fourier analysis of different complex waves, existence of different harmonics and measure their relative amplitudes.
3. Study of the Dispersion relation for "Mono-atomic Lattice". Determination of the Cut-off frequency and Comparison with theory.
4. Study of the Dispersion relation for the Di-atomic Lattice, Acoustical mode and Energy Gap. Comparison with theory.
5. Measurement of numerical aperture and acceptance angle of the given optical fibre.
6. Determination of Dielectric constant of given liquid.
7. Determination of Dielectric constant of given solid.
8. Measurement of Dipole moment of Organic molecules by Solvatochromic technique-computation.
9. Identification of type of vibrations in organic molecules by IR spectroscopic technique and determination of force constant-computation.
10. Design of simple pendulum experiment using ExpEyes kit.
11. Simulation of range of heavy ions in materials using SRIM software.

12. Determination of lattice constant of a given powder XRD pattern of a sample.
13. Determination of size of the NPs using Debye-Scherrer method.

Note:

1. Minimum of EIGHT computations must be carried out.
2. Computations may be added as and when required with the approval of BoS.

References:

1. University Practical Physics by D.C. Tayal, Himalaya Publishing House, First Millenium Edition, 2000.
2. Advanced Practical Physics for students by B.L. Flint and H.T. Worsnop, Asia Publishing House, 1971.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, Kitab Mahal, 11th Edition, 2011.
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers, 4th Edition, 1985.