Course Scheme of M.Sc. in Physics (effective from academic session 2017-18)

The program has following three specializations:

- Nuclear Science and Technology
- Electronics
- Materials Technology

Program Objectives:

- To understand the underlying physics in respective specializations, and, be able to teach and guide successfully.
- To introduce advanced ideas and techniques that are applicable in respective fields.
- To develop human resource with a solid foundation in theoretical and experimental aspects of respective specializations as a preparation for career in academia and industry.

Program Outcomes:

Students will have understanding of

- Fundamentals and advancements in nuclear physics and their applications in the area of nuclear reactors, accelerators, and medicine.
- Fundamentals and advancements in electronics, microprocessors, and their applications in electronic devices and microwave and optical fiber communications.
- Fundamentals and electromagnetic properties of materials, their characterization techniques, as well as advancements in the area of nanomaterials.

Scheme of Courses

With three specializations:

- Nuclear Science and Technology
- Electronics
- Materials Technology

FIRST SEMESTER

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PPH101	CLASSICAL MECHANICS	3	1	0	3.5
2.	PPH103	QUANTUM MECHANICS	3	1	0	3.5
3.	PPH104	MATHEMATICAL PHYSICS	3	1	0	3.5
4.	PPH108	DIGITAL SYSTEMS AND MICROPROCESSORS	3	1	0	3.5
5.	PPH109	COMPUTATIONAL METHODS IN PHYSICS	3	0	0	3.0
6	PPH106	PHYSICS LAB I	0	0	4	2.0
7	PPH107	PHYSICS LAB II	0	0	6	3.0
8	PHU003	PROFESSIONAL COMMUNICATION	2	1	0	2.5
		Total	**17**	**5**	**10**	**24.5**

SECOND SEMESTER

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PPH204	ELECTRODYNAMICS	3	1	0	3.5
2.	PPH203	ATOMIC AND MOLECULAR PHYSICS	3	1	0	3.5
3.	PPH302	NUCLEAR PHYSICS	3	1	0	3.5
4.	PPH102	STATISTICAL MECHANICS	3	1	0	3.5
5.	PPH201	CONDENSED MATTER PHYSICS	3	1	0	3.5
6.	PPH211	PHYSICS LAB III	0	0	4	2
7.	PPH212	PHYSICS LAB IV	0	0	4	2
		Total	**15**	**5**	**12**	**21.5**

SUMMER INTERNSHIP **2.0 Cr**

THIRD SEMESTER

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PPH312	ADVANCED QUANTUM MECHANICS	3	1	0	3.5
2.	PPH301	PARTICLE PHYSICS	3	1	0	3.5
3.	PPH303	SEMICONDUCTOR PHYSICS	3	1	0	3.5
4.	PPH308	INSTRUMENTATION AND EXPERIMENT DESIGN	3	1	0	3.5
5.	PPH319	PHYSICS LAB V	0	0	4	2
6.	PPH320	PHYSICS LAB VI	0	0	4	2
7.		SPECIALIZATION PAPER – I	3	1	0	3.5
8.	PPH391	SEMINAR				2.0
		Total	**15**	**5**	**12**	**23.5**

FOURTH SEMESTER

S. No.	**Course No.**	**Course Name**	**L**	**T**	**P**	**Cr**
1.		SPECIALIZATION PAPER – II	3	1	0	3.5
2.		SPECIALIZATION PAPER – III	3	1	0	3.5
3.	PPH491	DISSERTATION				10.0
		Total	**6**	**2**	**0**	**17**

LIST OF SPECIALIZATION PAPERS

SPECIALIZATION-NUCLEAR SCIENCE AND TECHNOLOGY

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PPH324	NUCLEAR REACTOR PHYSICS	3	1	0	3.5
2.	PPH436	ADVANCED NUCLEAR PHYSICS	3	1	0	3.5
1.	PPH435	RADIATION TECHNOLOGY	3	1	0	3.5

SPECIALIZATION-ELECTRONICS

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PPH448	OPTICAL FIBER COMMUNICATION	3	1	0	3.5
2.	PPH421	ANALOG ELECTRONICS	3	1	0	3.5
3.	PPH438	MICROWAVE THEORY AND TECHNIQUES	3	1	0	3.5

SPECIALIZATION-MATERIALS TECHNOLOGY

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PPH449	STRUCTURE AND PROPERTIES OF MATERIALS	3	1	0	3.5
2.	PPH422	NANO-MATERIALS	3	1	0	3.5
3.	PPH423	CHARACTERIZATION TECHNIQUES	3	1	0	3.5

Total Number of Credits: 88.5

NOTE:

Course No (i.e. Module No.) PPH301 bears the following information:
P (of **P**PH301) indicates the course/module is for PG Programme
PH (of P**PH**301) indicates the course is for physics.

L –T – P indicates the per week contact hours for Lecture, Tutorial and Practical component (in hours) and Cr indicates the credit related to that course. Credit is calculated as sum of lecture hours (per week) and half of the contact hours pertaining to tutorial and laboratory engagement

PPH101 CLASSICAL MECHANICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To apprise the students of Lagrangian and Hamiltonian formulations and their applications.

Newtonian Mechanics: One and many particle system; conservation of linear and angular momentum, work energy theorem,

System of Particles: Constraints, D'Alembert principle, Principle of virtual work, Degree of freedom, Generalized coordinates and momenta, Lagrange's equation and application of linear harmonic oscillator, Simple pendulum and central force problems, Cyclic coordinate, Symmetries and conservation laws, Hamiltonian, Lagrange's equation from Hamilton's Principle, Principle of least action derivation of equation of motion; variation and end points.

Central Force: Reduction of two body problem into single body problem. Definition and characteristics of central force; Closure and stability of circular orbits. General analysis of orbits: bounded and unbounded orbits, Kepler's law of motion, Scattering in center of mass and laboratory frame of reference, Rutherford scattering.

Rigid Body Dynamics: Euclerian angle, Inertia tensor, principal moment of inertia. Euler's equation of motion of a rigid body, Force free motion of a symmetrical top.

Canonical Transformation: Canonical transformation, Legendre Transformation, Generating functions. Conditions for a transformation to be canonical, Hamilton-Jacobi equation, Hamilton's principle and characteristics functions, Action and action angle variables

Wave Motion: Small oscillations, Normal modes and normal coordinates. Examples: Two coupled pendulums and Vibration of linear tri-atomic molecule, Dispersion relation.

Course learningoutcomes: Students will have achieved the abilityto:

1. describeLagrangian and Hamiltonian formulations.
2. solve problems on motion under central force, rigid body dynamics, and periodic motions.
3. apply the theory of small oscillations in different areas of physics e.g., molecular spectra, acoustics, vibrations of atoms in solids, coupled mechanical oscillators and electrical circuits.

Recommended Books

1. *Rana, N.C. and Joag, P.S., Classical Mechanics, Tata McGraw-Hill, (1991).*
2. *Goldstein, H., Classical Mechanics, Pearson Education, (2007).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH103 QUANTUM MECHANICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To understand the basic subtleties of quantum mechanical ideas and use Schrodinger equation and various approximation methods to predict properties of simple and composite quantum systems.

Introduction to Quantum mechanics: Experimental background and inadequacy of classical Physics, Complimentary principle**.**

Schrödinger wave equation: Development of wave equation, Schrödinger's time dependent and independent wave equation, Interpretation and normalization of wave function, Probability current density, Expectation value and Ehrenfest theorem. Wave packet. Generalized uncertainty principle.

Solution of Schrödinger equation: Constant potential in one dimension: Potential Step, Rectangular Potential Barrier and tunneling, Linear Harmonic Oscillator, Rigid Rotator and Hydrogen atom.

Angular momentum in Quantum mechanics: General solution to the Eigen value problem of angular momentum J and the angular momentum matrices, Eigenvectors for spin ½ particles, Addition of two angular momenta, Clebsch-Gordan coefficient, System of identical particles, Indistinguishability principle, Symmetry of wave functions, Connection of symmetry with spin and statistics.

Perturbation theory: Time independent perturbation theory: (1) Non degenerate case: First order perturbation, second order perturbation, Perturbation of an oscillator. (2) Degenerate case: Removal of degeneracy in second order, Zeeman Effect without electron spin, first order Stark effect in Hydrogen.

Time dependent perturbation theory: The equation of motion in interaction picture, Transition probability And Fermi-Golden Rule, Selection Rules.

WKB Approximation: Method, The connection formule, Tunneling through a potential barrier**.**

Introduction to theory of Scattering: Total and Differential Scattering cross section, Partial wave and Phase shift, Optical Theorem, Born approximation and scattering by one dimensional Potential barrier, and Coulomb Field.

Course learningoutcomes: Students will have achieved the ability to:

1. explain the probabilistic and non-local nature of quantum world
2. calculate the physical properties (position/momenta/energies) of quantum systems using Schrodinger equation
3. apply different approximation methods for understanding complex quantum phenomena.

Recommended Books

1. *Schiff, L.I., Quantum Mechanics, McGraw Hill (2008).*

2. *Ghatak, A. and Loknathan, S., Quantum Mechanics, MacMillan (2004).*
3. *Thankapan, V.K., Quantum Mechanics, New Age International (2004).*
4. *Sakurai, J.J., Advanced Quantum Mechanics, Pearson Education (2007).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH104 MATHEMATICAL PHYSICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To impart knowledge about various mathematical tools employed to study physics problems.

Complex Variables: Introduction, Cauchy-Riemann conditions, Cauchy's Integral formula, Laurent expansion, Singularities, Calculus of residues.

Differential Equations: Ordinary Differential Equations, First order homogeneous and non-homogeneous equation with variable coefficients, Second order homogeneous and non-homogeneous equation with constant coefficients, Second order homogeneous and non-homogeneous equation with variable coefficients, Partial differential equations of theoretical physics, Separation of variables, Series solutions.

Special Function: Bessel functions of first and second kind, Generating function, orthogonality; Legendre functions: generating function, Recurrence relations and special properties, Orthogonality; Hermite functions, Laguerre functions.

Fourier series and Fourier Transforms: Fourier series, Dirichlet conditions, applications, Gibbs phenomenon, Fourier transforms, Development of the Fourier integral, and Fourier transforms of derivatives.

Tensors: Scalar, Vector and tensor quantities, Contravariant and covariant tensors, Addition, multiplication and contraction of tensors, Application of tensors in coordinate transformations.

Group Theory: Concept of group, Character tables of discrete groups, Lie groups, generators, U(1), SU(2), SU(3).

Course learningoutcomes: Students will have achieved the ability to:

1. use complex numbers and variables.
2. solve differential equations of various types.
3. describe special functions and their recurrence relations
4. do fourier expansion and use Fourier transforms to understand tensors
5. explaintensor and its basic operations
6. describe the basics of Group Theory

Recommended Books:

1. *Arfken G. and Weber H.J., Mathematical Methods for Physicists, Academic Press, (2005).*
2. *Rajput B. S., Mathematical Physics, Pragati Prakashan, (2002).*
3. *Boas M.L. Mathematical Methods in the Physical Sciences, John Wiley & Sons, New York, (1983).*
4. *Harper C. Analytical Mathematics in Physics, Prentice Hall, (1999).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH108 DIGITAL SYSTEMS AND MICROPROCESSORS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To provide theoretical knowledge in Op-Amps, basic digital systems, and 8085 Microprocessor.

Operational Amplifiers: Operational Amplifier, Differential Amplifier, Transfer and frequency characteristics, Compensation in Operational Amplifiers, Application of OP-AMP as adder, Multiplier, Differentiator, Integrator, Log and Antilog Amplifier, Application of Operational Amplifier to analogue computation.

Digital systems: Standard gate assemblies. Binary Address, Parallel and Serial operations, Half Adder, Full Adder, J-K Flip-flop, Shift Register, Up and Down Counters, Synchronous and Asynchronous counters, Decoder, Multiplexer, Encoder, Read Only Memory, Random Access Memory, Applications of ROM and RAM, Digital Display, Seven segment display, Sequence generator. Memory Storage cell (both Bipolar and MOS RAM), Read, Write and Address operations (both Bipolar and MOS RAM), Digital to Analog Converters, Weighted resistor and 2R Ladder type, analog to digital Converters.

Microprocessors: An Introduction to Microprocessor, Microcomputers and assembly language. Bus interfacing, Bus organized computers, SAP-1, SAP-2 and SAP-3, Machine language, ASCII code. 8085 Microprocessor architecture, Microprocessor initiated operations. Internal data operations, 8085 registers, externally initiated operations, Memory mapping and memory classification. Simple microcomputer system, Microprocessor communication and bus timings.8085 machine cycles. Memory interfacing with 8085, Interfacing I/O devices, Introduction to 8085 assembly language programming. 8085 instructions. General purpose programmable peripheral devices. Microprocessor Applications, Recent trends in microprocessor technology, Introduction to 8086 microprocessor and 8051 microcontroller.

Course learning outcomes: Students will have achieved the ability to:

1. design circuits for various mathematical operations using Op-Amps
2. explain the working and design of various flip-flops,encoder/decoders, multiplexers, registers and counters.
3. describe the working and design of ROM, RAM, Memory storage cell and the various read and write operations.
4. explain the working and design of various A/D and D/A convertors.
5. explain various components and working of the 8085 microprocessor and their peripheral devices.

Recommended Books:

1. *Mano M., Digital Logic and computer Design, PHI (2004).*
2. *Tocci R. J., Digital Systems-Principles and Applications, Prentice Hall of India, (2002).*

3. *Gaonkar R. S., Microprocessor Architecture, Programming and Applications, Prentice-Hall (2002).*
4. *MalvinoA.P. and Brown A., Digital Computer Electronics, Prentice-Hall, (1999).*
5. *Mathur A.P., Introduction to Microprocessors, McGraw-Hill Publishing Co., (1980).*

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weightage (%)**
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH109 COMPUTATIONAL METHODS IN PHYSICS

L	T	P	Cr
3	0	0	0

Course Objectives: To learn computer programming using FORTRAN 90, solve physics problems through different numerical techniques and use computer programming for simulation and data analysis

Introduction: Role of computers in physics; Numerical analysis, modeling and simulation; Flow charts; Introduction to computer programming in Fortran 90**,** Integer and Floating point arithmetic**,** Operators and Expressions, While, Do-While, For loops, Arrays and Strings, Functions, I/O with files**.**

Root Finding Methods: Methods for determination of zeroes of linear and nonlinear algebraic and transcendental equations: Secant Method, False Position, Newton-Raphson Method; Convergence of solutions; Solution of simultaneous linear equations, Gauss Elimination, pivoting, iterative method

Interpolation and Approximation: Introduction to interpolation, Lagrange approximation, Newton polynomials, Curve fitting by least squares, Polynomial least squares and cubic splines fitting.

Numerical Differentiation and Integration: Numerical differentiation, Quadrature, Simpson's rule, Gauss's quadrature formula, Newton – Cotes formula.

Random Variables and Monte Carlo Methods: Random numbers, Pseudo-random numbers, Monte Carlo integration: Moment of inertia, Monte Carlo Simulations: Buffen's needle experiment, Importance of sampling, Random Walk

Differential Equations: Euler's method, Runge Kutta methods, Finite difference method, Finite difference equations for partial differential equations and their solution.

Course Outcomes: Students will be able to

1. write computer programs using FORTRAN 90
2. use different numerical methods to solve problems using computer programs.
3. simulate physical systems using Monte Carlo Method.

Recommended Books:

1. *Mathews, J.H., Numerical Methods for Mathematics, Science and Engineering, Prentice-Hall, (2000).*
2. *Rajaraman, V., Computer programming in Fortran 90 and 95, Prentice-Hall of India, (2008).*
3. *Salaria, R.S., Programming in Fortran, Khanna Publishing, (2008).*
4. *William H. Press, , Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, Numerical Recipes: The Art of Scientific Computing, Cambridge University Press, (2007)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH106 PHYSICS LAB I

L	T	P	Cr
0	0	4	2

Course Objectives: To experimentally realize digital electronics circuits and expose the student to working of 8085 microprocessor.

List of Experiments:

1. Study the mathematical operations and frequency response of the given operational amplifier.
2. Study the input and output characteristics of a differential amplifier.
3. To construct logic gates AND, NOT, EX-NOR and EX-OR using NANAD gates and verify their truth tables.
4. To design and construct multiplexer and demultiplexer and verify their truth tables.
5. To study the fundamentals of basic memory units and to become familiar with various types of flip-flops and verifying the Truth tables of Flip- Flops.
6. To study BCD to binary decoder and encoder
7. To study binary to seven segment decoder.
8. To design various flip-flops (R-S, D-, T-, J-K, J_K master slave) using gates and verify their truth tables.
9. To design and construct Half/Full adder and subtractor circuits.
10. To study the working of a 4-bit comparator and adder/subtractor chips.
11. To construct and study various ripple counters using J-K flip-flops.
12. To construct and study various synchronous counters using J-K flip-flops.
13. To construct and study various registers using J-K flip-flops.
14. To study 4-bit and 8-bit DAC for various V_{ref}.
15. To study and understand the working of the given 4-bit ADC.
16. To perform various mathematical, logical and jump operations for 8 bit numbers using 8085 microprocessor
17. To perform various mathematical, logical operations and jump operations for 16 bit numbers using 8085 microprocessor
18. To write a program to arrange an array of data in ascending/descending order using 8085 microprocessor.

Course learningoutcomes: Students will have achieved the ability to:

1. design and evaluate various Op-Amp circuits for mathematical operations.
2. design and evaluate various counters and registers.
3. evaluate basic components of the digital circuits like flip-flops, adder, encoders etc.
4. write and execute programs for solving simple problems using 8085 microprocessor.

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Lab Evaluation	100

PPH107 PHYSICS LAB II

L	T	P	Cr
0	0	6	3

Course Objective: The student is able to use computer programming for simulation and data analysis.

Laboratory Assignments:

1. To find mean, standard deviation and frequency distribution of an actual data set from any physics experiment.
2. To determine Wien's constant using bisection method and false position method.
3. To solve Kepler's equation by Newton-Raphson method.
4. To solve van der Waals gas equation for volume of a real gas by the method of successive approximation.
5. To interpolate a real data set from an experiment using the Lagrange's method, and Newton's method of forward differences and cubic splines.
6. To fit the Einstein's photoelectric equation to a realistic data set and hence calculate Planck's constant.
7. To find the area of a unit circle by Monte Carlo integration.
8. To simulate the random walk.
9. To study the motion of an artificial satellite by solving Newton's equation for its orbit using Euler method.
10. To study the growth and decay of current in RL circuit containing (a) DC source and (b) AC using Runge Kutta method, and to draw graphs between current and time in each case.

Course Outcomes: Students will be able to

1. write computer programs using FORTRAN 90
2. use different numerical methods to solve problems using computer programs.
3. simulate physical systems using Monte Carlo Method.

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Lab Evaluation	100

PHU003 PROFESSIONAL COMMUNICATION

L	T	P	Cr
3	1	0	3.5

Course Objective: To provide the students with essential skills required for effective communication, and, to apprise them of business communication and its role in corporate environment.

Essentials of Communication: Meaning, Definition, process, feedback, emergence of communication as a key concept in the corporate and global world, impact of technological advancements on communication.

Channels of Communication: Formal and Informal: Vertical, horizontal, diagonal, and grapevine.

Methods and Modes of Communication: Verbal and nonverbal, Verbal Communication: Characteristics of verbal communication, Non-verbal Communication: Characteristics of non-verbal communication, kinesics, proxemics and chronemics.

Barriers to Communication: Physical, semantic, language, socio-cultural, psychological barriers, Ways to overcome these barriers.

Listening: Importance of listening skills, cultivating good listening skills.

Written Communication: Business letters, memos, minutes of meeting, notices, e-mails, agendas and circulars.

Technical Report Writing: Types of Reports, contents of reports. Formatting, writing styles and documentation.

Presentations: Principles of effective presentation, power-point presentation, video and satellite conferencing.

Interviews and Group Activities: Personal interviews, group discussion and panel discussion

Creative writing: Paragraph and Essay writing, Book reviews, Movie Reviews, Editorials and articles.

Paper writing: Styles of paper writing: Short Communication, Review papers and Research papers, Referencing styles: MLA, Chicago Style and APA.

Course Outcomes: Students will have understanding of

1. the use proper writing techniques relevant to the present day technological demands, including anticipating audience reaction,
2. how to write effective and concise letters and memos,
3. how to prepare informal and formal reports,
4. how to proofread and edit copies of business correspondence
5. how to develop interpersonal skills that contribute to effective personal, social and professional relationships

Recommended Books:

1. *Lehman, C.M., DuFrene, D.D.,,and Walker, R, B-BCOM - An Innovative Approach to Learning and Teaching Business Communication. Cengage Learning New Delhi, 2011.*
2. *McMurrey, A.M and Buckley, J., Handbook for Technical Writing, Cengage Learning, New Delhi, 2008.*
3. *Lesikar, R.V and Flately, M.E., Basic Business Communication-Skills for Empowering the Internet Generation, Tata McGraw-Hill Publishing Company Limited. New Delhi, 2005.*

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weightage (%)**
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH204 ELECTRODYNAMICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To apprise the students regarding the concepts of electrodynamics and Maxwell equations and use them various situations

Boundary Value Problems: Uniqueness Theorem, Dirichlet or Neumann Boundary conditions, Formal solution of Electrostatic &Magnetostatic Boundary value problems.

Time Varying Fields and Maxwell Equations: Faraday's Law of induction, Displacement current, Maxwell equations, scalar and vector potentials, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, Conservation of energy, Complex Poynting's Theorem.

Electromagnetic Waves: Wave equation, Plane waves in free space and isotropic dielectrics, Polarization, Energy transmitted by a plane wave, Waves in conducting media, Skin depth. Reflection and Refraction of electromagnetic waves at plane interface, Fresnel's amplitude relations. Reflection and transmission coefficients, Polarization by reflection. Brewster's angle, Total internal reflection, EM wave guides, TE, TM and TEM waves, Rectangular wave guides. Energy flow and attenuation in wave guides, Cavity resonators.

Radiation from Localized Time Varying Sources: Solution of the inhomogeneous wave equation in the absence of boundaries. Fields and Radiation of a localized oscillating source, Electric dipole and electric quadrupole fields, Centre fed linear antenna.

Charged Particle Dynamics: Non-relativistic motion in uniform constant fields and in a slowly varying magnetic field. Adiabatic invariance of flux through an orbit, Relativistic motion of a charged particle.

Course learning outcomes: Students will have achieved the ability to:

1. use Maxwell equations in analysing the electromagnetic field due to time varying charge and current distribution.
2. describe the nature of electromagnetic wave and its propagation through different media and interfaces.
3. explain charged particle dynamics and radiation from localized time varying electromagnetic sources.

Recommended Books:

1. *Griffiths, D.J., Introduction to Electrodynamics, Dorling Kingsley, (1998).*
2. *Jackson, J.D., Classical Electrodynamics, Wiley Eastern, (1999).*
3. *Puri, S.P., Classical Electrodynamics, Tata McGraw Hill, (1999).*
4. *Jordan, E.C. and Balmain, K.G., Electromagnetic Wave and radiating systems, Prentice Hall of India, (2007).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH203 ATOMIC AND MOLECULAR PHYSICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: Objective of this course is to learn atomic, molecular and spin resonance spectroscopy.

One Electron Atom: Vector model of a one electron atom, Quantum states of an electron in an atom, Hydrogen atom spectrum, Spin-orbit coupling, Relativistic correction, Hydrogen fine structure, Spectroscopic terms, and Hyperfine structure.

Two valance Electron Atom: Vector model for two valance electrons atom, LS coupling, Pauli Exclusion Principle, Interaction energy for LS coupling, Lande interval rule, jj coupling, interaction energy for jj coupling.

Atom in Magnetic Field: Zeeman Effect, Magnetic moment of a bound electron, Magnetic interaction energy in weak field. Paschen-Back effect, Magnetic interaction energy in strong field.

Molecular Spectroscopy: Rotational and vibrational spectra of diatomic molecule, Raman Spectra, Electronic spectra, Born-Oppenheimer approximation, Vibrational coarse structure, Franck-Condon principle, Rotational fine structure of electronic-vibration transitions. Electron spin and nuclear magnetic resonance spectroscopy.

Course learning outcomes: Students will have achieved the ability to:

1. describe the atomic spectra of one and two valance electron atoms.
2. explain the change in behavior of atoms in external applied electric and magnetic field.
3. explain rotational, vibrational, electronic and Raman spectra of molecules.
4. Describe electron spin and nuclear magnetic resonance spectroscopy and their applications..

Recommended Books:

1. *White, H.E., Introduction to Atomic Spectra, McGraw Hill, (1934).*
2. *Banwell, C.N. and McCash, E.M., Fundamentals of molecular spectroscopy, Tata McGraw Hill, (2007).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH302 NUCLEAR PHYSICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To impart knowledge about basic nuclear physics properties and nuclear models for understanding of related reaction dynamics.

Nuclear Size and Shape: Scattering and electromagnetic methods for determining the nuclear radius, Wave mechanical properties of nucleus and statistics, Nuclear angular momentum and Parity, Electric and magnetic moments, nuclear shapes, Nuclear excited states.

Nuclear Forces: Types of nuclear potentials, Ground and excited states of deuteron, Exchange forces and mass formula, n-p scattering at low energies, Partial wave analysis, Scattering length, Spin dependence of n-p scattering, effective range theory in n-p scattering, p-p scattering at low energy, Meson theory of nuclear forces.

Nuclear Models: Liquid drop model, Coupling of angular momenta, Extreme single particle model and analysis of its predictions, Spin-orbit coupling, Magnetic moment, Electric quadrupole moment, Collective picture, Single particle states in deformed Nucleus.

Nuclear decays & Nuclear Reactions: Type of reactions, reaction cross section, conservation laws, Q-values and its significance, Coulomb excitation, compound nucleus, energy of excitation, Breit-Wigner formula, Nuclear Resonance phenomena, Direct reactions.

Course learningoutcomes: Students will have achieved the ability to:

1. explain the ground state properties of the nucleus for study of the nuclear structure behavior.
2. explain the deuteron behavior at ground and excited states.
3. apply deuteron physics and the Nucleon-Nucleon scattering for explaining the nuclear forces.
4. demonstration of the shell model and collective model descriptions.
5. applyvarious aspects of nuclear reactions in view of compound nuclear dynamics.

Recommended Books

1. *Roy, R.R. and Nigam, B.P., Nuclear Physics, New Age International Ltd., (2001).*
2. *Tayal, D. C., Nuclear Physics, Himalaya Publication home, (2007).*
3. *Kaplan Irving, Nuclear Physics, Narosa Publishing House, (2000).*
4. *Krane, K.S. Nuclear Physics, Wiley India Pvt. Ltd., (2008).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH102 STATISTICAL MECHANICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To understand the properties of macroscopic systems using the knowledge of the properties of individual particles.

The Statistical Basis of Thermodynamics: The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution.

Ensemble Theory: Phase space and Liouville's Theorem, The microcanonical ensemble theory and its application to ideal gas of monatomic particles, Partition function, Classical ideal gas in canonical ensemble theory, Energy fluctuations, Equipartition and virial theorems, A system of harmonic oscillators as canonical ensemble, Thermodynamics of magnetic systems and negative temperatures, The grand canonical ensemble and significance of statistical quantities. Classical ideal gas in grand canonical ensemble theory. Density and energy fluctuations.

Ideal Bose Systems: Basic concepts and thermodynamic behavior of an ideal Bose gas, Bose-Einstein condensation, Discussion of gas of photons (the radiation fields) and phonons (The Debye field), Liquid helium and super fluidity.

Ideal Fermi Systems: Thermodynamic behavior of an ideal Fermi gas, Discussion of heat capacity of a free-electron gas at low temperatures, Pauli paramagnetism

Course learningoutcomes: Students will have achieved the ability to:

1. find the connection between statistics and thermodynamics.
2. differentiate between different ensemble theories used to explain the behavior of the systems.
3. differentiate between classical statistics and quantum statistics.
4. explain the statistical behavior of ideal Bose and Fermi systems.

Recommended Books

1. *Pathria, R.K., Statistical Mechanics, Butterworth-Heinemann, (1996).*
2. *Reif, F., Fundamentals of Statistical and Thermal Physics, Waveland, (2008).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH201 CONDENSED MATTER PHYSICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To study some of the basic properties of the condensed phase of matter especially solids.

Crystal Structure: Fundamental types of lattices-two and three dimensional lattice types, SC, BCC and FCC unit cells, Miller indices, Diffraction of x-rays by crystals, Scattered wave amplitude-Fourier analysis, Reciprocal lattice vectors, Diffraction conditions, Laue equations, Brillouin Interpretation, Structure factor and Atomic form factors.

Electrical Conductivity and Free Electron Fermi gas: Drude theory, DC conductivity, Hall effect and magneto-resistance, AC conductivity, thermal conductivity, Fermi-Dirac distribution, Free electron gas in three dimension, thermal properties of an electron gas, Wiedemann-Franz law.

Lattice Vibrations and Thermal Properties: Vibration of lattice with monoatomic and diatomic basis: Dispersion relation, optical and acoustical branches. Quantization of elastic waves: Phonon, Classical theory of Specific heat. Average energy of harmonic oscillator, Phonon Density of states. Einstein and Debye models of specific heat. Electronic contribution to specific heat. Anharmonic effect: thermal expansion, Phonon collision process, Thermal conductivity.

Concept of Energy Band: Nearly free electron model and origin of energy gap, magnitude of gap, Bloch function, Kronig-Penny model, Wave equation of electron in periodic potential, Bloch theorem and crystal momentum, Classification of metal, insulator and semiconductors.

Dielectrics: Dielectric properties of insulators, Types of polarizations, Local field, Claussius-Mossotti equation, Dielectric constant and loss.

Magnetism: Types of magnetism, Susceptibility, Permeability and their relation. Diamagnetism: Langevin Quantum theory of Diamagnetism. Paramagnetism: Quantum Theory, Paramagnetism of rare earth and iron group ions, Crystal field Splitting and quenching of orbital angular momentum. Paramagnetism of conduction electrons**.** Ferromagnetism, Ferrimagnetism and Antiferromagnetism: Curie point and exchange integral, saturation magnetization. Ferromagnetic Domains and their origin.

Superconductivity: Superconductivity, critical temperature, Meissner effect, Destruction of superconductivity by magnetic field, Type I and type II superconductors, Isotope effect, energy gap, London equation, London penetration depth, BCS theory of superconductivity, Coherence length.

Course learning outcomes: Students will have achieved the ability to:

1. differentiate between different Lattice types and explain the concepts of reciprocal lattice and crystal diffraction.
2. predict electrical and thermal properties of solids and explain their origin.
3. explain the concept of energy bands and effect of the same on electrical properties.
4. describe the dielectric properties of insulators.
5. explain various types of magnetic phenomenon, physics behind them, their

properties and applications.

6. explain superconductivity, its properties, important parameters related to possible applications.

Recommended Books

1. *Kittel, C., Introduction to Solid State Physics, John Willey, (2007).*
2. *Omar, M.A., ElementarySolid State Physics, Pearson Education, (1999).*
3. *Srivastava, J.P., Elements of Solid State Physics, Prentice Hall of India, (2008).*
4. *Ashcroft, N.W. and Mermin, N.D., Solid State Physics, Cengage Learning, (2008).*
5. *Dekker, A.J., Solid State Physics, Macmillan, (2003).*

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weightage (%)**
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH211 PHYSICS LAB III

L	T	P	Cr
0	0	4	2

Course Objectives: To expose the students to various detectors in nuclear and particle physics so that they can investigate various relevant aspects and be confident to handle sophisticated instruments and analyze the data.

List of Experiments:

1. Dead time of a Geiger Muller (GM) Counter (Two source method)
2. Dead time of a Geiger Muller (GM) Counter (Absorber method)
3. To determine the operating voltage of a PMT and to find the photo peak efficiency of a NaI (Tl) crystal of given dimension for ϒ rays of different energies.
4. To calibrate a ϒ ray spectrometer and to determine the energy of a given gamma ray source
5. Pulse height ϒ ray spectrum with multi-channel analyzer.
6. Energy resolution of a NaI (Tl) detector.
7. To verify the inverse square law with ^{137}Cs source.
8. To study the Compton scattering using ϒ rays of suitable energy.
9. To study the time resolution of a coincidence setup.
10. To determine ϒ ray attenuation coefficient for different metals.
11. To study the relationship between thickness of absorber and backscattering using GM counter.
12. To study the shielding effect of radiation penetrability.
13. To study anisotropy of ϒ ray cascade emission in ^{60}Co source.
14. To determine the half-life of a radioactive sample.
15. Simple simulations in FOARTRAN90 for nuclear physics.
16. Studies on the Electric Spin Resonance spectrum of the given DPPH sample and determination of Lande*g* factor.
17. Studies on the NMR spectrum of ethylbenzenein $CDCl_3$and obtain the ^{1}H NMR spectrum and obtain the chemical shift and mutiplicity.

Course learning outcomes: Students will have achieved the ability to:

1. operate a GM counter and Scintillation counter with MCA.
2. determination of mass abs coeff for the given material, variation of resolution with energy and activity of the given gamma source.
3. determine $1/r^2$ law and the decay statistics for the given beta and gamma sources.
4. design and run simulations for nuclear physics problems in FORTRAN90.

5. handle nuclear materials and nuclear safely management.
6. analyze and interpret experimental data using graphs

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Lab Evaluation	100

PPH212 PHYSICS LAB IV

L	T	P	Cr
0	0	4	2

Course Learning Objective(s): To experimentally realize the structural, optical, magnetic and electric behavior of condensed matters.

List of Experiments:

1. Determination of lattice constant and crystal structure of given powder sample using X-ray diffraction method.
2. Dynamics of mono and diatomic lattices.
3. Investigation of Hall Voltage as a function of current and magnetic field and determination of Hall Coefficient and carrier concentration of the given sample of semiconductor.
4. Study of magneto resistance behavior of semiconductors/manganites.
5. Investigation of Four probe and two probe resistance measurement and determination of contact resistance.
6. Investigation of B-H curve: (i) to determine the value of permeability and coercivity of ferrite sample. (ii) to distinguish between soft and hard ferrites.
7. Investigation of ferroelectric behavior of $BaTiO_3$.
8. To determine the Curie temperature of given ferrite sample.
9. To determine the dielectric constant of PCB laminate.
10. To determine the Young's modulus of brass using ultrasonic interferometer.
11. Studies on the thermoluminescence of KCl/KBr single crystal sample and determination of activation energy and color centers.
12. Determination of Tc for the given superconductivity material.

Course learning outcomes: Students will have achieved the ability to:

1. determine the lattice parameters and crystallite size for a given compound
2. measure Hall coefficient, resistance and magnetoresistance of a given semiconductor.
3. calculate the Curie temperature and energy loss of a ferrite sample.
4. investigate the B-H curve of ferrites and distinguish between hard and soft ferrites on the basis of coercivity.
5. measure the dielectric constant of a dielectric material.
6. determine the Young's modulus of a given metal/metal alloy using ultrasonic interferometer.

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Lab Evaluation	100

PPH312 ADVANCED QUANTUM MECHANICS

L	T	P	Cr
3	**1**	**0**	**3.5**

Course Objectives: To impart knowledge of advanced quantum mechanics for solving relevant physical problems.

Relativistic Quantum Mechanics: Klein-Gordon equation, Dirac equation and its plane wave solutions, solution of Klein Gordan equation for a particle with Coulomb potential, significance of negative energy solutions, spin angular momentum of the Dirac particle. The non-relativistic limit of Dirac equation, Dirac equation for a particle in a central field, fine structure of hydrogen atom, Lamb shift.

Field Quantization: Classical field theory, Lagrangian and Hamiltonian formalism of a particle in an electromagnetic field, Second quantization, Concepts and illustrations with Schrödinger field.

Relativistic Quantum Field Theory: Quantization of a real scalar field and its application to one meson exchange potential. Quantization of a complex scalar field, Dirac field and e.m. field, Commutation relations.

Interaction: Yukawa interaction, Coupling of electron and electromagnetic field, Global and guage invariance Feynman diagrams, Feynman rules, Feynman graphs for Compton and e-e scattering, Path integration method: Wick's Theorem. Scattering matrix.

Course learning outcomes: Students will have achieved the ability to:

1. explain the relativistic quantum mechanical equations, namely, Klein-Gordon equation and Dirac equation
2. describe second quantization and related concepts.
3. explain the formalism of relativistic quantum field theory.
4. draw and explain Feynman graphs for different interactions

Recommended Books:

1. *Mathews, P.M. and Venkatesan K.A., Textbook of Quantum Mechanics, Tata McGraw Hill (2004).*
2. *Thankappan, V.K., Quantum Mechanics, New Age International (2004).*
3. *Sakurai, J.J., Advanced Quantum Mechanics, Pearson Education (2007).*
4. *Bethe, H.A. and Jackiew, R., Intermediate Quantum Mechanics, Perseus Book Group (1997).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH301 PARTICLE PHYSICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To impart the knowledge of fundamental particles, fundamental interaction and the range and strength of these interactions with the concept of particle antiparticle or matter antimatter.

Introduction: Fermions and bosons, Particles and antiparticles, Quarks and leptons, Yukawa picture, Types of fundamental interactions - electromagnetic, weak, strong and gravitational, HEP Units, Bound states of quarks, Hadron, Mesons and Baryons.

Invariance Principles and Conservation Laws: Interactions and fields in particle physics, Classical and quantum pictures Invariance in classical mechanics and in quantum mechanics types of symmetries and their breaking, Parity, Pion parity, Charge conjugation, Time reversal invariance, CP violation, CPT theorem.

Hadron-Hadron Interactions: Cross section and decay rates, Pion spin, Isospin, Two-nucleon system, Pion-nucleon system, Strangeness and Isospin, and Hypercharge.

Static Quark model of Hadrons: The Eightfold way, Meson nonet, Baryon octet, Baryon Decuplet, hypothesis of quarks, SU (3) symmetry, Quark spin and color, Quark-antiquark combinations.

Weak Interactions: Classification of weak interactions, Fermi theory, Parity non-conservation in β-decay, Helicity of neutrino, Experimental verification of parity violation.

Course learning outcomes: Students will have achieved the ability to:

1. explain the need of standard model and its limitations and the properties of QCD.
2. draw Feynman diagrams and to check if interactions are allowed or forbidden.
3. use the quark model for understanding the properties ofhadrons e.g. neutrons and protons.
4. describeweak interactions between quarks and how that is responsible for β decay, inverse beta decay.
5. explain the symmetry in baryon decuplets and octets for JP states.

Recommended Books

1. *Perkins, D.H., Introduction to High Energy Physics, Cambridge University Press, (2000).*
2. *Hughes, I.S., Elementary Particles, Cambridge University Press, (1991).*
3. *Close, F.E., Introduction to Quarks and Partons, Academic Press, (1979).*
4. *Segre, E., Nuclei and Particles, Benjamin-Cummings, (1977).*
5. *Khanna, M.P., Introduction to Particle Physics, Prentice-Hall of India, (2004).*

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weightage (%)**
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH303 SEMICONDUCTOR PHYSICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To give knowledge about semiconductor physics and discus working and applications of basic devices, including p-n junctions, BJTs and FETs.

Semiconductors: Energy Band and Charge Carriers: Energy bands in semiconductors, Types of semiconductors, Charge carriers, Intrinsic and extrinsic materials. Carrier concentration: Fermi Level, Electron and hole concentration equilibrium, Temperature dependence of carrier concentration, Compensation and charge neutrality. Conductivity and mobility, Effect of temperature, Doping and high electric field.

Optical Excitation in Semiconductor: Optical absorption, carrier generation, Carrier life time, diffusion length and photo conductivity, Direct and indirect recombination and trapping, Photoconductive devices. Diffusion of carriers, Einstein relation, Continuity equation, Carrier injection, Diffusion length. Haynes-Shockley experiment.

Junctions: p-n junction and contact potential, Fermi levels, Space charge, Reverse and Forward bias, Zener and Avalanche breakdown. Capacitance of p-n junction, Schottky barriers; Schottky barrier height, C-V characteristics, current flow across Schottky barrier: thermionic emission, Rectifying contact and Ohmic contact.

Field Effect Transistors: JEFT amplifying and switching, Pinch off and saturation, Gate control, I-V characteristics. MOSFET, Operation, MOS capacitor, Debye screening length, Effect of real surfaces; Work function difference, Interface charge, Threshold voltage and its control, MOS C-V analysis and time dependent capacitance. Output and transfer characteristics of MOSFET.

Bipolar Junction Transistors (BJT): Fundamentals of BJT operation. Minority carrier distribution, Solution of diffusion equation in base region, Terminal current, Current transfer ratio, Ebers-Moll equations, Charge control analysis. BJT switching: Cut off, Saturation, Switching cycle.

Photonics: LED: Radiative transition, Emission spectra, Luminous efficiency and LED materials, Solar cell and photodetectors: Ideal conversion efficiency, Fill factor, Equivalent circuit, V_{oc}, I_{sc} and Load resistance, Spectral response. Reverse saturation current in photodetector.

Course learning outcomes: Students will have achieved the ability to:

1. explain the basic properties of semiconductors including the band gap, charge carrier concentration, doping and charge carrier injection/excitation.
2. explain the working, design considerations and applications of various semiconducting devices including p-n junctions, BJTs and FETs.
3. describe the working and design considerations for the various photonic devices like photodetectors, solar-cells and LEDs

Recommended Books

1. *Streetman, B. and Banerjee, S., Solid State Electronics, Prentice Hall India, (2006).*
2. *Sze, S.M., Physics of Semiconductor Devices, John Wiley, (1981).*

3. *Tyagi, M.S., Introduction to semiconductor materials and devices, John Wiley, (2000).*
4. *Mishra, Umesh K. and Singh, Jaspreet, Semiconductor Device Physics and Design, Springer, (2008).*
5. *Pierret, R.F., Semiconductor Device Fundamentals, Pearson Education Inc., (2006).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH308 INSTRUMENTATION AND EXPERIMENT DESIGN

L	T	P	Cr
3	1	0	3.5

Course Objectives: To understand, analyze and implement the fundamental experimentation.

Data Interpretation and Analysis: Precision and accuracy, Errors in measurements: Statistical and systematic, Error analysis, Propagation of errors. Frequency distributions, Probability distributions: mean and variance, Probability densities: Normal distribution, Log-Normal distributions. Curve Fitting: least square method, Linear and non linear, Chi-square test.

Transducers: Sensors and Transducers: Temperature, Pressure, Vibration, Magnetic Field, Force and Torque, Optical.

Measurements: Resistance: DC Measurements: Wheatstone Bridge, The Kelvin Bridge, Potentiometers, AC Measurements: Inductor and capacitor equivalent circuits, AC operation of a Wheatstone bridge, Capacitance Measurement: The resistance ratio bridge, The De Sauty Bridge, Wein Bridge. Inductance Measurement: The Maxwell Bridge, Parallel Inductance bridge, Anderson bridge. Voltage Measurement: AC and DC, Current Measurement: AC and DC. Resistivity Measurement: 2-probe, 4-probe and Van-der-Paw measurements.

Signal Conditioning and Noise: Signal Conditioning, Analog signal conditioning: Operational amplifiers, Instrumentational amplifiers, precision absolute value circuits, True RMS to DC converters. Phase sensitive detection: Lock in amplifier, Box-car integrator, Spectrum analyzer. Noise in Circuits: Probability Density Functions, The Power Density Spectrum, Sources of noise, Noise limited resolution of Op-amp, minimum resolvable DC current, Coherent interference and its sources, Ground loops and their prevention. Introduction to Digital signal conditioning. The Fast Fourier Transformer, Sampling time and Aliasing, Voltage and Current sources.

Course learningoutcomes: Students will have achieved the ability to:

1. to analyze and fit the experimental data. Different kind of errors coming in data will also be analyzed.
2. explain principle, theory and application of various sensors and transducers.
3. explain the basic principle and importance of the different AC and DC measurement techniques.
4. explain the concepts of signal conditioning and noise analysis.

Recommended Books

1. *Sayer, M., Mansingh, A., Measurement, Instrumentation and Experiment Design in Physics and Engineering, Prentice Hall of India (2000).*
2. *Northrop, Robert, B., Introduction to Instrumentation and Measurements, CRC, Taylor & Frances (2005).*
3. *Murthy, D.V.S., Transducers and instrumentation, Prentice Hall of India (2008).*
4. *Johnson, Richard A., Miller and Freund's Probability and Statistics for Engineers, Dorling Kingsley (2005)*
5. *Horowitz P. and Hill, W., The Art of Electronics, Cambridge University Press (2006)*
6. *Helfrick, A.D., Cooper, W.D., Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall of India (2007).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH319 PHYSICS LAB V

L	T	P	Cr
0	0	4	2

Course Objectives: To expose students to common semiconductor devices and their evaluation techniques.

List of Experiments:

1. To determine the resistivity and the band-gap of the given semiconductor sample using four probe technique.
2. Determine the Hall coefficient for given semiconductor and determine the dopant density and mobility for majority charge carriers.
3. Determine the band-gap of the given p-n junction using reverse saturation current.
4. Study the forward and reverse characteristics of given p-n junctions (at least 2) and determine materials constants, bandgap, variation of junction capacitance and the nature of the junction (abrupt/linearly graded).
5. Study the characteristics of a Zener diode, LDR and VDR.
6. Static characteristics and 90^0 phase control of a Silicon Controlled Rectifier (SCR)
7. To study the input and the output characteristics of the given bipolar junction transistor (CE, CB and CC).
8. To study the switching characteristics of a transistor (NPN& PNP).
9. Study the static drain and transfer characteristics (dynamic resistance of drain, mutual conductance and amplification factor) of a JFET at a given operating point.
10. To study MOSFET as output power amplifier and plot the static drain characteristics.
11. Gain and frequency characteristics of a double stage RC coupled BJT amplifier.
12. Study the spectral output of the given lamp and use it to determine the intensity and spectral response of the given solar cell.
13. Study the I-V characteristics of the given solar cell.
14. Study the characteristics of the given photodiode and phototransistor.

Course learning outcomes: Students will have achieved the ability to:

1. evaluate some basic properties of semiconductor devices including resistivity, band gap, hall coefficient, light dependent resistance and voltage dependent resistance.
2. determine the behaviour of p-n junction including Zener diodes and SCR
3. evaluate the behaviour of FETs and BJTs
4. evaluate the working and spectral characterizations of solar cells
5. test and compare the theoretical concepts learned in the class with hands on experiments
6. analyze and interpret experimental data using graphs

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Lab Evaluation	100

PPH320 PHYSICS LAB VI

L	T	P	Cr
0	0	4	2

Course Objectives: To expose students to some simple experiments and evaluation techniques in particle physics, fiber optics, materials characterization and electronics.

List of Experiments:

1. Determine Planck's constant.
2. Use computer programming for simple particle physics simulations.
3. Analyze the given Bubble chamber data.
4. Characterization of response of linear variable detector (LVDT) sensor.
5. Study the I-V characteristics of a solar cell and determination of its performance parameters.
6. To determine the acceptance angle and numerical aperture (NA) of a single mode optical fiber.
7. To determine the mode field diameter (MFD) of a single mode optical fiber.
8. To determine the bending loss in optical fiber.
9. Microstructure analysis of a metallic sample
10. Determination the composition of the given binary alloy by cooling curve method.
11. Determine the microhardness of the given sample.
12. To study and construct various clipping and clamping circuits.
13. To study and constructastable, bistable and monostablemultivibrators using discreet components/IC555 chip.
14. Study various aspects of amplitude and frequency modulation.
15. To construct logic gates OR, AND, NOT, NOR, NAND gates using discrete components and verify their truth tables

Course learning outcomes: Students will have achieved the ability to:

1. use computer programming for solving problems in particle physics.
2. determine the performance parameters for the given solar cell.
3. perform and analyze simple experiments involving optical fibers.
4. determine the composition of the given binary alloy, analyze the microstructure and microhardness of the given sample.
5. construct and analyze simple circuits. Use CRO, multimeters, signal generators, power source, etc. for electronics measurement and circuit evaluation.
6. analyze the experimental data and evaluate it for accuracy.

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Lab Evaluation	100

PPH391 SEMINAR

L	T	P	Cr
0	0	0	2

Course Objective: This course is focused to facilitate student to gain skills of collecting, interpreting and presenting information of interest through seminar and report presentation.

Course Learning Outcomes (CLOs):

The student will be able to

- Identify and understand assumptions and arguments that exist in the national and international literature in the identified area of work/topic
- evaluate and synthesize evidence in order to draw conclusions based on research gaps
- ask meaningful questions and originate plausible research and technical gaps and the implications of the expected outcomes

Evaluation Scheme:

1. Oral Presentation: A powerpoint presentation and discussion therein that will highlight the strength of the presenter in the concept, background, literature and gap/lacunae related to identified area/topic

   Max. Marks: 40

2. Report Writing: A technical report that will highlight the student's strengths in concept and literature base on the identified area/topic; and capability to present the information in appropriate scientific formats.

   Max. Marks: 60

PPH491 DISSERTATION

L	T	P	Cr
0	0	0	10

Course Objective:

This course is focused to facilitate student to carry out extensive research and development project or technical project at place of work through problem and gap identification, development of methodology for problem solving, interpretation of findings, presentation of results and discussion of findings in context of national and international research. The overall goal of the dissertation is for the student to display the knowledge and capability required for independent work.

Course Learning Outcomes (CLOs):

The student will be able to

- gain in-depth knowledge and use adequate methods in the major subject/field of study.
- create, analyze and critically evaluate different technical/research solutions
- clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for these findings
- identify the issues that must be addressed within the framework of the specific dissertation in order to take into consideration

PPH324 NUCLEAR REACTOR PHYSICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To impart primary but wide theoretical knowledge about nuclear reactor and related topics.

Neutron moderation: Inelastic scattering, Elastic collisions, moderating ratio, slowing down Density, Resonance escape, Moderatos.

Fission Process and diffusion theory: Prompt neutrons, Fast fission, Fission energy, Thermal utilization, Fission products, Chain reaction, Multiplication factor, Leakage of neutrons, Critical size, Diffusion and slowing down theory, Homogenous and heterogeneous reactors.

Materials for Nuclear Reactors: Fuel materials, Moderator and Reflectors, Cladding materials, Coolants and control Rods.

Type of Power reactors: Boiling water reactors, Pressurized water reactors, Pressurized heavy water reactors, Light water cooled graphite moderated reactors, Gas cooled reactors, Advanced gas cooled reactors, High temperature gas cooled reactors and liquid metal cooled reactors and Fast breeder reactors, Plasma production and its diagnosis, status of fusion reactors

Fuel and waste management: Fuel management schemes, Fuel composition, Fuel cycle cost and waste management.

Course Outcomes: Students will be able to

1. study the neutron moderation process
2. apply diffusion theory for fusion-fission dynamics
3. select materials relevant for reactor design and energy production
4. categorize different nuclear reactors
5. analyze fuel and waste management

Recommended Books:

1. *Glasstons, Sammuel and Sesonske, Alexander, Nuclear reactor Engineer, CBS Publishers & Distributors, (2004).*
2. *Lamarshs, J.R., Introduction to Nuclear Reactor Theory, Addison-Wesley Publishing Co., 1966.*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	40
3	Sessionals (May include assignments/quizzes)	25

PPH448 OPTICAL FIBER COMMUNICATION

L	T	P	Cr
3	1	0	3.5

Course objectives: The course aims at imparting in-depth knowledge of optical fiber communication

Optical fibers and fabrication: Introduction, Light propagation through optical fiber, Fiber materials, Fiber fabrication, Mechanical properties of fibers.

Signal degradation in optical fibers: Attenuation, Signal distortion in optical waveguides, Pulse broadening in graded index waveguides, Mode coupling, Design optimization of single-mode fibers.

Power launching and coupling: **S**ource-to-fiber launching, fiber-to-fiber joints, LED coupling to single-mode fibers, Fiber splicing, Optical fiber connectors.

Photodetectors: The pin photodetector, Avalanche photodiodes, Photodetector noise, Detector response time, Structures for In GaAs APDs, Temperature effect on avalanche gain.

Optical amplifiers and Optical receiver: Fundamental receiver operation, Pre-amplifier types,Optical amplifiers, Semiconductor optical amplifiers, Erbium-doped fiber amplifiers, Amplifier noise, System applications.

Optical networks: Basic networks, SONET/SDH, WDM Networks, Nonlinear effects on network performance, Performance of WDM + EDFA systems, Solitons, Optical CDMA, Ultrahigh capacity networks.

Measurements: Measurement standards, Test equipment, Attenuation measurements, OTDR field applications, Eye patterns, Optical spectrum analyzer applications.

Course Outcomes: Students will have achieved the ability to:

1. describe basics of optical fiber, its fabrication and sources of attenuation the requisite inputs for optical fiber communication
2. elaborate the methods of power launching and coupling and working of photodetectors.
3. explain the mechanism and use of optical amplifiers and optical receiver.
4. analyze optical networks and their performance.
5. calculate attenuation and dispersion in optical fibers and identify fiber-fault location.

Recommended Books

1. *Keiser, G., Optical Fiber Communications, McGraw-Hill International. (2000).*
2. *Seniors, J.M., Optical Fiber Communications – Principles and Practice, Prentice-Hall of India, (1996).*
3. *Cherin, A.H., An Introduction to Optical Fibers, McGraw Hill Book Company, (1983).*
4. *Yariv, A., Quantum Electronics, Wiley, (1989).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH449 STRUCTURE AND PROPERTIES OF MATERIALS

L	T	P	Cr
3	1	0	3.5

Course Objective(s): To give comprehensive exposure to the students regarding various engineering materials; crystalline, non- crystalline materials, crystal structure and their defects; the concept of phase and different type of phase diagrams.

Materials Classification: Engineering materials and their classification: metals/ceramics/composites, Intrinsic and extrinsic, Structure sensitive and Structure insensitive properties. Structure-property-processing co-relationship as a theme of materials science.

Structure of Solids: Bravais lattice and reciprocal lattice concept; Metallic, ionic and covalent solids; Crystal structures of NaCl, CsCl, Diamond cubic, Zinc Blende, Wurtzite, Rutile, Flourite, Fullerenes, Spinel, Perovskite etc.,

Non-crystalline Structures: General features and classification, Structure models for amorphous materials-microcrystalline chain and ring model, Molecular model. Structure and properties of metallic glass and amorphous semiconductors.

Crystal Imperfections: Point imperfections, Burger vector, Dislocations (edge and screw) Properties of dislocation, Generation of dislocation, Partial dislocation, Stacking faults, Motion of dislocations (climb, cross-slip), Strain hardening and recovery, and Surface imperfections, Structure of high, Low angle and twin boundaries.

Diffusion: Diffusion mechanisms, Fick’s rules of diffusion, Factors that influence diffusion

Phase diagrams: Phase rule and phase diagrams, Unary and binary systems, Solid solutions, Hume Rothery rules, Intermediate phases and compounds, , Isomorphous and eutectic systems, Lever rule, Various phase reactions, Introduction to different phase diagrams, Ternary system, Cooling curve and its use for drawing phase diagrams, Zone refining.

Thermal Properties: Lattice vibrations, vibrations of simple lattice-optical and acoustic phonons, Heat capacity, Thermal expansion, Thermal conductivity thermal stress in materials with example and characteristics in metals and non-metals.

Optical Behavior: Interaction of radiation with matter (metals and non-metals), Phosphorescence, luminescence and optical active materials, Structure property relationship in anisotropic media.

Mechanical Behaviour of Materials: Elastic, inelastic viscoelastic properties, stress-strain relation

Failure of Materials: Brittle and ductile fracture, Creep failure, Fatigue, Development of creep and fatigue resistant materials, Brittle failures in ceramics, Glasses and polymers.

Dislocations and Strengthening Mechanisms: characteristics of dislocations, stress field around a dislocation, generation of dislocation, dislocation movement, slip systems, strengthening.

Course learning outcomes: Students will have achieved the ability to:

1. differentiate betweendifferent type of materials, and their structures.
2. explain thestructural dependence of properties

Recommended Books:

1. *Smallman, R.E., and Bishop, R.J., Metals and Materials, Butterworth-Heinemann, Oxford University Press, (1995).*
2. *Raghvan, V., Materials Science & Engineering, Prentice-Hall of India, (1998).*
3. *Callister, W.D., Materials Science & Engineering: An Introduction, Wiley & Sons, (2001).*
4. *Smith, W., Principles of Materials Science and Engineering., McGraw Hill, (1990).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH436 ADVANCED NUCLEAR PHYSICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To impart knowledge about nuclear deformations, properties and nuclear models for understanding of related reaction dynamics. Beside this, students will be exposed to heavy ion physics and nuclear astrophysics.

Nuclear deformations: Effect of quadrupole deformations and higher multipole deformations, Nuclear orientation effect, deformed magic shells and related nuclear aspects, Importance of Exotic nuclear systems, halo shapes and bubble effect.

Collective Model of Nucleus: Collective model Hamiltonian, nuclear wave function for even-even nuclei and odd-A nuclei, Rotation-vibrational coupling, Nilsson model, Cranking shell model.

Heavy-Ion Physics: Total Hamiltonian function, Scattering of deformed nuclei, Fusion fission dynamics, Radioactive ion beams, tightly and loosely bound interactions, Nuclear isomers, Nuclear Molecules, Nuclear Dynamics at Intermediate and high energies, Relativistic heavy ion collisions

Nuclear Astrophysics: Hot big bang cosmology,Stellar nucleosynthesis, energy production in stars, pp chain, CNO cycle.

Course learning outcomes: Students will have achieved the ability to:

1. explain nuclear deformation and related orientation effects
2. collective description of nuclear behavior.
3. to examine dynamics of heavy-ion reactions
4. basic aspects of astrophysics

Recommended Books:

1. *Pal, M.K., Theory of Nuclear Structure, East-West Press Delhi, (1983).*
2. *Preston M. A. and Bhaduri R. K., Structure of Nucleus Addison-Wesley, (2000).*
3. *Lilley J.S., Nuclear physics principles and applications John Wiley & sons Ltd., (2007).*
4. *Krane K.S. Nuclear Physics, Wiley India Pvt. Ltd., (2008).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH421 ANALOG ELECTRONICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To introduce students to entire circuit designs, and to provide in-depth theoretical base of Digital Electronics.

Linear Wave Shaping: High Pass RC circuits: Its response to step, Pulse, Square wave, Ramp, exponential waveforms, It's application as a Differentiator. Low pass RC Circuit: Its response to step, pulse, Square wave, Ramp, Exponential wave forms, It's application as an integrator.

Clipping and comparators Circuits: Non Linear Wave Shapers, Diode Clippers, Positive and Negative Clippers, Combinational and Biased clippers, Transistor Clipper. Application of clipping circuits as comparators.

Clamping and Switching Circuits: Operation of Clamping Circuits, Clamping Circuit theorem, Practical Clamping Circuit theorem, Operation of Transistor as a switch.

Logic Systems: Basic Concepts of dc positive and negative logic systems, Dynamic logic systems, OR gate and AND gate, NOT gate, NAND gate, EX-OR gate, NOR gate & their applications, Response to input pulse operation. TTL (transistor transistor logic) and DTL (diode transistor logic)

Multivibrators: Solid state switching circuits, A bistablemultivibrator-basic concepts of its operation. Symmetrical and Unsymmetrical triggering, Applications (brief). Monostable Multivibrator - basic concepts of its operation, quantitative discussion of quasi-stable state, Applications, Astablemultivibrator - basic concepts of operation, Applications.

Negative Resistance Devices and their applications: The negative resistance characteristic,Basic circuit principles,The tunnel diode – its characteristics and applications (brief) , Backward diode, Four-layer diode, SCR – its characteristics and applications (brief).

Course learning outcomes: Students will have achieved the ability to:

1. design linear wave shaping circuits and also use them as differentiator and integrator.
2. design an appropriate circuit for clipping wave forms.
3. explain practical clamping circuits.
4. design appropriate multivibrators for various applications.
5. design logic gates using TTL and DTL.
6. explain the working of various negative resistance devices.

Recommended Books:

1. *Millman, J. and Taub, H., Pulse Digital and Switching Wave forms, Tata McGraw Hill, (1991).*
2. *Boylestad, R.L. and Nashelsky, L., Electronic Devices and Circuit Theory, Prentice Hall of India, (2007).*
3. *Bell, D.A., Electronics Devices and Circuits, Oxford University, (2008).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH422 NANO-MATERIALS

L	T	P	Cr
3	1	0	3.5

Course Objectives: Understand (i) the influence of dimensionality of the object at nanoscale on their properties; (ii) size and shape controlled synthesis of nanomaterials and their future applications in industry.

Introduction to Nanomaterials: Features of nanosystems, Characteristic length scales of materials and their properties, Density of states in 1-D, 2-D and 3-D bands, Variation of density of states and band gap with size of crystal.

Quantum Size Effect: Electron confinement in infinitely deep square well, Confinement in one dimensional well, Idea of quantum well structure, Formation of quantum well, Quantum dots and quantum wires.

Synthesis Methods: Top-down and bottom-up approach, cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques, mechanical milling, chemical methods and self-assembly

Properties of Nanomaterials: Size and shape dependence of optical, electronic, photonic, mechanical, magnetic and catalytic properties.

Nanomaterials and their applications: Nanoparticles, Nanocoatings and Nanocomposites, Nanotubes, Fullerenes, Thin film chemical sensors, gas sensors, biosensors, Carbon fullerenes and Carbon nanotubes, Thin film chemical sensors, biosensors, Solar cells, Drug deliveries and optoelectronic devices.

Course learning outcomes: Students will have achieved the ability to:

1. explain the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale.
2. choose appropriate synthesis technique to synthesize quantum nanostructures of desired size, shape and surface properties.
3. correlate properties of nanostructures with their size, shape and surface characteristics.
4. appreciate enhanced sensitivity of nanomaterial based sensors and their novel applications in industry.

Recommended Books:

1. *Bimerg, D., Grundmann, M., and Ledentsov, N.N., Quantum Dot Heterostructures, John Wiley (1999).*
2. *Poole,C.P., Owens,F.J., Introduction to NanotechnologyJohn Wiley &Sons (2003)*
3. *Jain, K.P., Physics of Semiconductor Nanostructures, Narosa (1997).*
4. *Fendler, J.H., Nano particles and Nano-structured Films, John Wiley &Sons (1998).*
5. *Timp, G., Nanotechnology, Springer-Verlag (1999).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH435 RADIATION TECHNOLOGY

L	T	P	Cr
3	1	0	3.5

Course Objectives: To impart knowledge in depth about nuclear radiation, its detection, nuclear spectrometry and related aspects

Interactions of Nuclear Radiations: Origin and energy spectra, Brief discussion of interactions of gamma rays, Electron and heavy charged particles with matter, Different types of neutron sources, Interaction of neutron with matter, Neutron detectors.

Nuclear Radiation Detector: Gas filled detectors; Ionization chamber, Proportional counter and GM counter, Scintillation detector, semiconductor detector, Radiation exposure & monitoring.

Nuclear Spectrometry and Applications: Measurement of nuclear energy levels, spins, parities, moments, internal conversion coefficients, Angular correlation, Perturbed angular correlation, measurement of g-factor and hyperfine fields.

Mossbauer Effect: Positron annihilation, particle and photon induced x-ray emission, Elemental concentration analysis by charged particles and neutron activation analysis, Diagnostic nuclear medicine, Therapeutic nuclear medicine.

Safety Aspects: Radiation dose unit, Safety limits, Dose calculations, Design consideration of simple shields.

Course learning outcomes: Students will have achieved the ability to:

1. describe nuclear radiation interactions.
2. explain the working of various radiation detectors.
3. explain various aspects of nuclear spectrometry
4. explain the recoilless nuclear resonance fluorescence
5. identify the concepts of radiation doses and related safety measures

Recommended Books:

1. *Knoll G. F., Radiation Detection and Measurement, John Wiley & Sons, (2010).*
2. *Singuru R. M., Introduction to experimental nuclear physics, Wiley Eastern Publications, (1987).*
3. *Muraleedhara V. Nuclear radiation Detection, measurement and Analysis, Narosa Publishing House, (2009).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH438 MICROWAVE THEORY AND TECHNIQUES

L	T	P	Cr
3	1	0	3.5

Course Objectives: To build up the concept from basics of microwave communications t**o** modern applications

Microwave Transmission. Basics, Concept of Mode: TEM, TE and TM Modes and their characteristic, Losses and concept and microwave impedance.

Microwave Transmission Lines. Coaxial Line, Rectangular Waveguide, Circular waveguide, Stripline and Microstrip Line.

Microwave Network Analysis and Measurements: Equivalent Voltages and currents for non-TEM lines, Network parameters and Scattering Parameters for microwave Circuits. Power, Frequency and impedance measurement, Network Analyser and measurement of scattering parameters.

Microwave Devices. Active component: Diodes, transistors, oscillators and mixers. Passive component: Directional coupler, Power divider, Magic tree, attenuator and resonator. Low power microwave devices: Gun diodes. High power microwave devices: Travelling wave tubes (TWT), Magnetron and klystron.

Microwave Systems and applications: Radar, Cellular Phone., Satellite Communication, Electromagnetic interference / Electromagnetic Compatibility (EMI / EMC) as modern application.

Course learning outcomes: Students will have achieved the ability to:

1. describe microwave transmission modes and transmission lines.
2. analyze microwave networksand measure their measurements parameters.
3. explain the working of various microwave devices
4. Identify themodern day applications of microwaves.

Recommended Books:

1. *David, M. Pozar, Microwave Engineering, Wiley India, (2012).*
2. *Ramo, S., Whinnery, J.R., and Duzer, T.V., Fields and Waves in Communication Electronics, Wiley India.*
3. *Collin, R.E., Foundations for Microwave Engineering, IEEE Press.*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25

PPH423 CHARACTERIZATION TECHNIQUES

L	T	P	Cr
3	1	0	3.5

Course Objective(s): To introduce the students to the principles of optical and electron microscopy, X-ray diffraction and various spectroscopic techniques

Introduction: Need of materials characterization and available techniques.

Optical Microscopy: Optical microscope - Basic principles and components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarised light, Hot stage, Interference techniques), Stereomicroscopy, Photo-microscopy, Colour metallography, Specimen preparation, Applications.

Electron Microscopy: Interaction of electrons with solids, Scanning electron microscopy Transmission electron microscopy and specimen preparation techniques, Scanning transmission electron microscopy, Energy dispersive spectroscopy, Wavelength dispersive spectroscopy.

Diffraction Methods: Fundamental crystallography, Generation and detection of X-rays, Diffraction of X-rays, X-ray diffraction techniques, Electron diffraction.

Surface Analysis: Atomic force microscopy, scanning tunneling microscopy, X-ray photoelectron spectroscopy.

Spectroscopy: Atomic absorption spectroscopy, UV/Visible spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy.

Thermal Analysis: Thermo gravimetric analysis, Differential thermal analysis, Differential Scanning calorimetry, Thermo mechanical analysis and dilatometry.

Course learning outcomes: Students will have achieved the ability to:

1. apply appropriate characterization techniques for microstructure examination at different magnification level and use them to understand the microstructure of various materials
2. choose and appropriate electron microscopy techniques to investigate microstructure of materials at high resolution
3. determine crystal structure of specimen and estimate its crystallite size and stress
4. use appropriate spectroscopic technique to measure vibrational / electronic transitions to estimate parameters like energy band gap, elemental concentration, etc.
5. apply thermal analysis techniques to determine thermal stability of and thermodynamic transitions of the specimen.

Recommended Books:

1. *Li, Lin, Ashok Kumar Materials Characterization Techniques Sam Zhang; CRC Press, (2008).*
2. *Cullity, B.D., and Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall, (2001).*

3. *Murphy, Douglas B, Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Liss, Inc. USA, (2001).*
4. *Tyagi, A.K., Roy, Mainak, Kulshreshtha, S.K., and Banerjee, S., Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series), Volumes 49 – 51, (2009).*
5. *Wendlandt, W.W., Thermal Analysis, John Wiley & Sons, (1986).*
6. *Wachtman, J.B., Kalman, Z.H., Characterization of Materials, Butterworth-Heinemann, (1993).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes)	25