SYLLABUS
For
MASTER PROGRAM (MSc.)
In
PHYSICS
(Batch 2025 Onwards)
Under
The National Education Policy, 2020 (NEP 2020)

DEPARTMENT OF PHYSICS
(A DST-FIST & UGC-SAP Assisted Department)
University of Kashmir
(NAAC Accredited A+)
Hazratbal, Srinagar, Kashmir, J&K-190006

(Approved in Borad of Post Graduate Studies (BOPGS) held on 05th May 2025)

M.Sc. Physics Programme Objectives (PEO):

This two-year M.Sc. Physics programme equips graduates with advanced expertise in theoretical, experimental, and computational physics, preparing them for impactful careers in academia, research, and industry. The programme's objectives are:

1. **PEO1 (Advancement in Research and Academia):** Graduates will gain a rigorous foundation in physics, enabling them to pursue Ph.D. programmes or research positions at leading global institutions. Their proficiency in theoretical, experimental, and computational physics, combined with a 6-month research internship/dissertation, will empower them to contribute to scientific innovation.

2. **PEO2 (Impact in Scientific and Technical Fields):** Graduates will develop a scientific mindset and apply their analytical skills, specialized knowledge, and practical experience (gained through dissertations/internships) to excel in research and development (R&D) roles across physics, interdisciplinary sciences, and emerging technology sectors.

3. **PEO3 (Adaptability and Proficiency in Diverse Settings):** Through laboratory work, projects, seminars, and internships, graduates will acquire problem-solving, data analysis, and scientific reasoning skills to thrive in academia, industry, or government roles.

4. **PEO4 (Commitment to Professional Excellence):** Graduates will uphold scientific integrity, engage in lifelong learning, and communicate complex concepts effectively. Courses in Python programming, computational physics, and numerical analysis will prepare them for careers as data scientists, interdisciplinary researchers, and technology leaders in evolving scientific fields.

Programme Outcomes (POs):

Upon completion, graduates will demonstrate the following competencies:

1. **PO1 (Mastery of Core and Advanced Physics):** Expertise in Classical Mechanics, Quantum Mechanics, Electrodynamics, Statistical Mechanics, and specialized fields including: Condensed Matter Physics, Nuclear and Particle Physics, Quantum Information Theory, Astrophysics and Atmospheric Physics, Electronics and Energy Studies, Nanophysics and Spintronics.

2. **PO2 (Experimental and Technical Skills):** Design, conduct, and analyze experiments using advanced laboratory equipment; accurately interpret data while identifying and addressing experimental uncertainties.

3. **PO3 (Mathematical and Computational Proficiency):** Apply advanced mathematics (complex analysis, differential equations) and computational tools (simulations, programming, data analysis) to model and solve complex physics problems.

4. **PO4 (Analytical and Critical Thinking):** Formulate complex physics problems, apply quantitative and theoretical frameworks, and critically evaluate physical systems with logical rigor.

5. **PO5 (Research and Innovation):** Conduct comprehensive literature reviews, identify research gaps, and execute independent projects (dissertation/internship). Graduates will begin their journey as researchers, contributing to cutting-edge scientific advancements under faculty mentorship.

Course Structure – Semester-I

Course Type	Course Code	Course Name	Credits
Core Course (C) /Laboratory (L)	MPHYCMP125	Mathematical Physics -I	4
	MPHYCQM125	Quantum Mechanics-I	4
	MPHYCCM125	Classical Mechanics	4
	MPHYLLB125	Lab-I	4
		Total Core/Laboratory Credits	**16**
Discipline Centric Elective Course (D)	MPHYDEC125	Electronics-I	2
	MPHYDAP125	Atmospheric Physics	2
	MPHYDCP125	Communication Physics	2
	MPHYDNM125	Physics of Nanomaterials	2
	MPHYDMS125	Materials Science	2
		Total Discipline Centric Elective Credits	**6**
Total Credits Semester-I			**22**

- No. of Core Course (C) /Laboratory (L) to be opted = 04 (12 Credits Theory + 04 Credits Lab) = **16** credits
- No. of Discipline Centric Elective Papers to be opted = 03 (02 Credits each) = **06** Credits
- Total No. of Credits = **22** Credits

Course Structure – Semester-II

Course Type	Course Code	Course Name	Credits
Core Course (C) /Laboratory (L)	MPHYCQM225	Quantum Mechanics-II	4
	MPHYCCE225	Classical Electrodynamics	4
	MPHYCSM225	Statistical Mechanics	4
	MPHYLLB225	Lab-II	4
		Total Core/Laboratory Credits	**16**
Discipline Centric Elective Course (D)	MPHYDAA225	Astrophysics-I	2
	MPHYDEC225	Electronics-II	2
	MPHYDEM225	Electronic Instrumentation and Measurements	2
	MPHYDMP225	Mathematical Physics-II	2
	MPHYDQI225	Quantum Information Theory	2
	MPHYDES225	Energy Studies	2
	MPHYDRM225	Research Methodology-I	**2**
		Total Discipline Centric Elective Credits	**6**
Seminar(Y)	MPHYYSM225	Seminar-I	2
		Total Seminar(Y) Credits	**2**
Total Credits Semester-II			**24**

- No. of Core Course (C) /Laboratory (L) to be opted = 04 (12 Credits Theory + 04 Credits Lab) = **16** credits
- No. of Discipline Centric Elective Papers to be opted = 03 (02 Credits each) = **06** Credits
- No. of Seminar(Y) to be opted = 01 (02 Credits each) = **02** Credits
- Total No. of Credits = **24** Credits

Course Structure – Semester-III

Course Type	Course Code	Course Name	Credits
Core Course (C)	MPHYCNP325	Nuclear & Particle Physics	4
	MPHYCCM325	Condensed Matter Physics	4
	MPHYCAM325	Atomic and Molecular Physics	2
		Total Major Core Credits	**10**
Discipline Centric Elective Course (D)	MPHYDLP325	Laser Physics	2
	MPHYDME325	Microwave Electronics	2
	MPHYDHE325	High Energy Physics	2
	MPHYDAA325	Astrophysics-II	2
	MPHYDSC325	Superconductivity	2
	MPHYDQF325	Quantum Field Theory	2
	MPHYDRP325	Radiation Physics	2
	MPHYDIS325	Introduction to Spintronics	2
	MPHYDRM325	Research Methodology-II	2
		Total Discipline Centric Elective Credits	**12**
Seminar (Y)	MPHYYSM325	Seminar-II	2
		Total Research Methodology Credits	**2**
Total Credits Semester-III			**24**

- No. of Core Course (C) = 03 (10 Credits Theory) = **10** credits
- No. of Discipline Centric Elective Papers to be opted = 06 (02 Credits each) = **12** Credits
- No. of Seminar(Y) to be opted = 01 (02 Credits each) = **02** Credits
- Total No. of Credits = **24** Credits

Course Structure – Semester-IV

Course Type	Course Code	Course Name	Credits
Dissertation (DI)	MPHYIDI425	Dissertation/Internship	24
Total Credits Semester-IV			**24**

- Dissertation/Internship (DI) = **24** credits
- Total No. of Credits = **24** Credits

Total credit distribution for the Four semesters

	C/L	D	Y	DI	Total credits (semester wise)
Semester-I	16	6	0	0	**22**
Semester-II	16	6	2	0	**24**
Semester-III	10	12	2	0	**24**
Semester-IV	0	0	0	24	**24**
Total credits (Courses type)	**42**	**20**	**8**	**24**	**94**

Types of Courses:

- C - Core Course (C)
- L - Laboratory (L)
- D - Discipline Centric Elective Course (D)
- Y - Seminar (Y)
- DI - Dissertation (DI)

Semester I

Semester I					
Course Code	**Course Title**				**Type of Course**
MPHYCMP125	**Mathematical Physics I**				**C**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**4**	**0**	**0**	**4**	**4**

Course Objective: The course on Mathematical Physics is intended to equip the students with the mathematical tools and techniques used to solve problems in Physical Sciences. The topics covered in this course include Complex Analysis, Gamma and Beta functions, Mathematical series and their convergence, Ordinary and partial Differential equations and their solutions, Special Functions and their properties and uses in solving problems in Physics.

Course Outcomes (COs): By the end of the course, a student should have gained enough knowledge and skills to

1. Understand the role of complex analysis in solving problems in theoretical Physics
2. Clarify the notion of singularities, Taylor and Laurent series, and calculus of residues
3. Apply complex analysis for evaluation of a wide class of integrals in addition to other useful tools for Physics students
4. Understand the utility of Gamma and Beta functions
5. Create and manipulate infinite series alongwith the convergence tests
6. Formulate problems in Physics in terms of differential equations
7. Solve the frequently encountered differential equations in Physics
8. Understand various methods of obtaining solutions of ODEs and PDEs and demonstrating practical use of these methods
9. Develop an understanding of the widely used special mathematical functions in Physics
10. Provide a detailed treatment of the various kinds of Bessel functions, Legendre/ Associated Legendre, Lagueree/Associated Lagueree, Hermite functions and the likes
11. Derive and discuss the various properties of special functions including orthogonality and normalization, recurrence relations, generating functions and their uses

Unit-I

Review of Complex variable Theory; Laurent Series, Singularities; Calculus of residues, Evaluation of Definite Integrals, Evaluation of Sums.
Schwarz Reflection Principle; Conformal Mapping; Rodrigue’s Formula; Generating Functions for the commonly used polynomials in Physics.

Unit-II

The Gamma Function; Definitions, Simple Properties, Factorial and Double factorial, Digamma and Polygamma Functions, Stirlings Series. The Beta Function, Legendre duplication formula. Infinite series; Convergence tests, Riemann Zeta Functions. Dirac Delta function and its properties.

Unit-III

Partial differential equations (PDEs) and their reduction to ordinary differential equations (ODEs), First and Second order ODEs, Series Solution and its limitations, Other (Wronskian double integral) Solution. Inhomogeneous ODEs, Nonlinear Differential Equations

Unit-IV

Bessel functions of integral order; Recurrence Relations, Integral representation, Orthonormality, non-integer order, Bessel Series. Definitions of the Bessel functions of Second and Third kind; Recurrence relations. Modified Bessel functions. Spherical Bessel functions.
Legendre functions; Properties and Recurrence relations, Upper and Lower bound, Orthonormality. Associated Legendre functions. Spherical Harmonics. Angular Momentum.
Hermite functions; Recurrence relations, Orthonormality, Simple Harmonic Oscillator. Laguerre and Associated Laguerre Polynomials; Properties, Radial Schrodinger equation.

Text Books:

Mathematical Methods for Physicists (7th Ed. by G. B. Arfken and H. J. Weber and F. E. Harris (Academic Press)

References:

1. Mathematical Methods For Students of Physics and Related Fields by Sadri Hassani (Springer)
2. Mathematics for Physicists by Philippe Dennery (Dover)
3. Advanced Engineering Mathematics by Michel Greenberg (Prentice Hall)
4. Mathematical Methods for Physics and Engineering by Riley, Hobson and Bence (Cambridge)
5. Advanced Engineering Mathematics by E Kreyzig (Wiley)

Semester I					
Course Code	**Course Title**				**Type of Course**
MPHYCQM125	**Quantum Mechanics-I**				**C**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**3**	**1**	**0**	**4**	**4**
Course Objective: Upon successful completion of this course, students will be able to articulate fundamental quantum mechanical principles, solve the Schrödinger equation for various potentials, analyze angular momentum and symmetries in quantum systems, and apply these concepts to understand atomic phenomena like the hydrogen atom.					
Course Outcomes (COs): By the end of this course, students will be able to: 1. Develop a foundational understanding of quantum mechanics through key experiments, mathematical representations, and operator formalism. 2. Solve the Schrödinger equation for various quantum systems and analyze quantum effects such as tunneling and energy quantization. 3. Apply symmetry principles, including rotational symmetry and group theory, to understand angular momentum in quantum systems. 4. Analyze motion in a central potential, with a focus on the hydrogen atom, spherical waves, and quantum mechanical scattering.					

UNIT-I

The Double-Slit Experiment and Stern-Gerlach Experiment. Kets, Bras, and Operators. Matrix Representations. Measurements, Observables, and Uncertainty Relations. Change of Basis: Unitary operators. Position, Momentum, and Translation. Wave Functions in Position and Momentum. Quantum Dynamics: Time-Evolution and the Schrodinger Equation. The Schrodinger Versus the Heisenberg Picture.

UNIT-II

Schrodinger's Wave Equation: Fundamental properties, Current density, General Properties of motion in one dimension. Classical Limit of Schrodinger equation. Potential well, Harmonic oscillator. Transmission and Reflection coefficients: Delta function potential. Tunnelling through a Barrier.

UNIT-III

Angular momentum, Rotation as Group. O(3) and SU(2). Eigenvalues and eigenfunctions of angular momentum. Symmetries and their Consequences. Parity and time reversal invariance. Addition of angular momentum, Clebsch-Gordon Coefficients, Symmetry Relations of CG coefficients, Evaluation of CG coefficients. Matrix representation of the rotation operators.

UNIT-IV

Motion in a centrally symmetric field, Spherical waves, Infinite Spherical Well, Resolution of a plane wave. Fall of a particle to the Centre, Motion in a coulomb field: Hydrogen atom.

TEXTBOOK:

1. J. J. Sakurai, Modern Quantum Mechanics, Third Edition(Cambridge University Press).

REFERENCES:

1. Non-Relativistic Quantum Mechanics: L. D. Landau and E. M. Lifshitz, Permagon Press.
2. Principles of Quantum Mechanics: R. Shankar, Springer-Verlag.

Semester I					
Course Code	**Course Title**				**Type of Course**
MPHYCCM125	**Classical Mechanics**				**C**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**4**	**0**	**0**	**4**	**4**

Course Objective (CO):

- To develop a comprehensive understanding of advanced classical mechanics, moving beyond Newtonian formalism to Lagrangian and Hamiltonian mechanics.
- To equip students with the mathematical tools and conceptual frameworks necessary to analyze complex dynamical systems.
- To enable students to apply variational principles and canonical transformations to solve sophisticated problems in mechanics.
- To provide a foundation for further studies in advanced physics, including quantum mechanics and statistical mechanics, where these formalisms are essential.

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

1. **Formulate and solve problems using the Lagrangian approach,** including identifying generalized coordinates and forces, applying d'Alembert's principle, and deriving and solving the Euler-Lagrange equations for various physical systems like pendulums and particles in electromagnetic fields.
2. **Apply variational calculus and Hamiltonian dynamics to analyze mechanical systems,** including understanding the principle of least action, deriving Hamilton's equations, and interpreting phase space dynamics and Liouville's theorem.
3. **Utilize canonical transformations, Poisson brackets, and Hamilton-Jacobi theory** to solve advanced problems in theoretical mechanics, including analyzing central force motion and understanding action-angle variables.
4. **Analyze oscillatory motion in complex systems,** including damped and coupled oscillators, and extend Lagrangian and Hamiltonian formalisms to continuous systems.

Unit - I

The Lagrangian Approach to Mechanics: degrees of freedom, constraints and generalized coordinates, virtual displacement, virtual work and generalized force, d'Alembert's principle and the generalized equation of motion, the Lagrangian and the Euler Lagrange equation of motion, the Hamiltonian, cyclic coordinates and canonical momenta, applications; double pendulum, spherical pendulum, particle in electromagnetic field.

Unit - II

Variational calculus and Hamiltonian dynamics: the variational calculus and the Euler equation, the principle of least action and the Euler Lagrange equation, constraints in variational dynamics.
Hamiltonian dynamics: Legendre transformations, Hamilton's equations, conservation laws, phase space and Liouville's theorem.

Unit - III

Theoretical Mechanics: canonical transformations and generating functions, symplectic notation, Poisson Brackets (PB); the angular momentum PB relations, invariance of PBs under canonical transformations, action-angle variables and adiabatic invariance, the Hamilton Jacobi (HJ) Equation; HJ equation for Hamilton's characteristic function, separation of variables, particle motion under central force

Unit - IV

Oscillations: the simple harmonic oscillator; the damped harmonic oscillator, the damped simple and damped harmonic oscillator, coupled simple harmonic oscillators; couple pendulum, general method of solution.
Lagrangian and Hamiltonian of continuous systems: transition from discrete to continuous systems, the Hamiltonian formulation.

Text Books:

1. Classical Mechanics by Goldstein, Poole and Safko (Pearson Education)

2. Mechanics by Landau and Lifshitz

Reference Books:

1. Analytical Mechanics by L. N. Hand and J. D. Finch (Cambridge University Press)

Semester I					
Course Code	**Course Title**				**Type of Course**
MPHYCLB125	**Course Lab: I**				**Laboratory**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**0**	**0**	**4**	**4**	**4**

Course Objective:

- The students will have a good foundation in the fundamentals related to the experiments included in this course and their advanced applications.
- Make predictions about expected measurements, data, and results.
- Share experimentation responsibility with other group members .
- Describe the experimental goals, process, data, results, and conclusions in a lab and
- To learn how to report their results in the form of a report.
- After completion of this course students will be able to design and carry out scientific experiments

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

1. **Execute diverse physics experiments proficiently,** accurately collecting and analyzing data related to concepts in electronics, optics, thermodynamics, and modern physics.
2. **Interpret experimental results in the context of relevant physical theories,** identify sources of error, and draw valid conclusions.
3. **Collaborate effectively in a laboratory setting** and communicate experimental procedures, findings, and analyses clearly through well-structured reports.
4. **Design and troubleshoot basic experimental setups** and apply fundamental laboratory techniques to investigate physical phenomena.

List of Experiments:

S.No	Expt-No.	Aim/Objective	CREDIT	LAB
1	**Expt-01:**	(ESR)To measure the Landé g factor for the free electron in DPPH as predicted by quantum mechanics.	2	I

2	**Expt-02:**	Design and realize to analyze the frequency response of an op – amplifier under inverting and non - inverting configuration for a given gain.	2	I
3	**Expt-03:**	To study the variation in current flowing in circuit containing a LDR due to variation in intensity of light source and the distance from LDR also to Study LDR as an dark sensor.	2	I
4	**Expt-04 :**	To study the characteristics of half wave, full wave and bridge rectifier with and without filter and calculate the ripple factor, rectification efficiency and % regulation.	3	I
5	**Expt-05:**	To measure the relative permittivity (εr) of $BaTiO3$ at a series of temperatures and using these data obtain the Curie temperature Tc of barium Titanate.	3	I
6	**Expt-06:**	To determine Speed of Sound in air Using Phase change/ Lissajous Figures and show that the speed increases when the temperature is increased.	3	I
7	**Expt-07:**	To determine the plateau and optimal operating voltage of a Geiger-Müller counter. To determine the resolving time(dead time) of a GM counter and verify the Inverse square relationship between the distance and intensity of radiation:	3	I
8	**Expt-08:**	Obtain IV Characteristics of zener diode & also observe zener as a voltage regulator. Calculate its load & line regulation.	2	I
9	**Expt-09:**	To Determine the wave length of a laser light using diffraction grating and narrow slit(or thin wire) and determining the grating radial spacing of the CD.	2	I

10	**Expt-10:**	To measure the ratio of charge/mass (e/m) by Helical method, for electrons and to learn about phenomena of electric and magnetic deflection and application of vector product.	2	I
11	**Expt-11:**	To perform No load and Load characteristics of Solar Panel and study charging of batteries with and without Solar Panel.	3	I
12	**Expt-12:**	Implementation of the given Boolean function using logic gates in both sop and pos forms. Design and realization of logic gates using universal gates.	3	I
13	**Ept-13**	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency.	3	I

Semester I					
Course Code	**Course Title**				**Type of Course**
MPHYDEC125	**Electronics-I**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO):

- To gain a deeper understanding of linear and digital electronic circuits, to be able to Conceptualize, implement, and actualize both linear and digital electronics circuits.
- The course will enable students to have deep understanding of electronic devices and applications.
- Study the design and implementation of analog and digital circuits.

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

1. Analyze the working principles and applications of various types of diodes including Schottky, varactor, and photodiodes.
2. Design and implement basic analog electronic circuits such as rectifiers and filters using diodes and operational amplifiers.
3. Differentiate between various diode models and apply them appropriately in circuit analysis.

Unit-I:

Junction Diodes: Diode structure, Diode equation, Diode Specifications, Peak Inverse Voltage (PIV) and bias circuits, Diode Models: The Ideal Diode Mode, The Practical Diode Model, Complete Diode model, Bridge Rectifier with filter, Metal semiconductor junctions- Schottky barriers; Rectifying contacts; Ohmic contacts; Typical Schottky barriers Schottky Diode, Switching diodes, Varactor Diodes, Photodiodes

Unit-II:

Electronic filters: Filters In Electronics Circuits, Passive Filters: low pass and high pass filters; RC bandpass filter; Band reject Filter. Disadvantages of passive filters. Introduction to operational Amplifiers, Filter Design and Analysis with an Operational Amplifiers, First and Second-order Low Pass Active Filter, First and Second-order high Pass Active Filter.

Books Recommended:

1. R. Boylestad and L. Nashelski: Electronic Devices and Circuit Theory
2. J. Millman and C. Halkias: Integrated Electronics
3. B.G. Streetman, S. Banerjee: Solid State Electronic Devices
4. H. Taub and D. Schilling: Digital Integrated Electronics
5. P. Bhattacharyya: Semiconductor Optoelectronic Devices
6. S.M. Sze: Physics of Semiconductor Devices
7. A. P. Malvino and A. Brown, *Digital Computer Electronics*.

Semester I					
Course Code	**Course Title**				**Type of Course**
MPHYDAP125	**Atmospheric Physics**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO):

- To provide students with a foundational understanding of the structure and composition of the Earth's atmosphere.
- To introduce the fundamental physics of radiation and its interaction with atmospheric constituents.
- To develop the ability to analyze Earth's energy balance and understand mechanisms of atmospheric heating and cooling.
- To impart knowledge on atmospheric aerosols, their physical and optical properties, and their role in climate systems.

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

1. Describe the composition, vertical structure, and key variable constituents of the atmosphere.
2. Explain the fundamental physics of radiation and its interaction with atmospheric components
3. Analyze the energy budget of the Earth's surface and atmospheric heating/cooling mechanisms.
4. Identify and classify atmospheric aerosols based on their physical and optical properties.
5. Evaluate the impact of aerosols on radiation and climate, including their hygroscopic growth and chemical composition.

Unit I:

Atmospheric Structure and Radiation: Origin, Composition, and Mean Structure of the Atmosphere, Vertical Profiles of Pressure and Density, Variable Constituents and Vertical Temperature Structure Fundamental Physics of Radiation:, Solar and Terrestrial Radiation, Radiation Laws (Planck's Law, Stefan-Boltzmann Law, Wien's Law), Absorption, Emission, and

Scattering in the Atmosphere, Schwarzschild's Equation, Radiation in the Earth-Atmosphere System: Geographical and Seasonal Distribution, Radiative Heating and Cooling of the Atmosphere, Surface Energy Budget, Mean Annual Heat Balance

Unit II:

Atmospheric Aerosols and Optical Properties: Introduction to Atmospheric Aerosols,Characterization of Aerosols,Physical and Optical Properties of Aerosols: Size Distribution, Refractive Indices, Absorption and Scattering of Radiation by Aerosols.

Key Optical Properties of Aerosols: Single Scattering Albedo, Aerosol Optical Depth, Aerosol Phase Function, Hygroscopic Growth and Mixing State of Aerosols, Vertical Distribution in the Atmosphere, Chemical Composition of Aerosols and their Role in Climate.

Text Books:

1. Wallace, J. M., & Hobbs, P. V. (2006). *Atmospheric Science: An Introductory Survey*. Academic Press.
2. Salby, M. L. (2012). *Physics of the Atmosphere and Climate*. Cambridge University Press.
3. Houghton, J. (2009). *The Physics of Atmospheres*. Cambridge University Press.

Reference Books:

1. Ramanathan, V., & Crutzen, P. J. (2003). *Atmospheric Aerosols and Climate*. Science.
2. Seinfeld, J. H., & Pandis, S. N. (2016). *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*. Wiley.
3. Satheesh, S. K., Moorthy, K. K., & Babu, S. S. (2017). *Atmospheric Aerosols: Properties and Climate Impacts*. Springer.

Semester I					
Course Code	**Course Title**				**Type of Course**
MPHYDCP125	**Communication Physics**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO): This course aims to introduce fundamentals of Communication Electronics

- To study the basic concepts regarding Digital Communication
- To impart knowledge about Satellite Communication

Course Outcomes (COs): Upon completion of the course, the student will be able

1. Understand Digital Communication.
2. Identify Network organization.
3. Satellite Communication and their significance
4. UnderstandingtheCommunicationElectronicstocreateascientifictemperament
5. Apply the knowledge of Digital Communication systems.

Unit-I

Digital Communication: Fundamentals of digital communication systems. Characteristics of data transmission system such as Band-Width requirement, speeds, SNR, cross talk, echo suppressors, distortion equalizer, Digital codes, Bar dot code, binary code, ASCII code (EBCDIC), Hollerith code, Error detection, constant ratio codes, Redundant codes, parity check codes, Communication system using modem interfacing, Network organization.

Unit-II

Satellite Communication: Introduction to radar systems, fundamental radar range equation, basic pulsed radar. Satellite frequencies, orbits(geostatic, equatorial/polar, Synchronous) station keeping, satellite attitude, transmission path, path loss, noise considerations, satellite system.

REFERENCE:

1. Electronic communications –Rooddy–Coolen (PHI)electronic
2. Communication Systems–George Kennedy (TMH)
3. Principles of Electronic Communication System–Louis Frenzel
4. Communication Electronics–Katre
5. Telecommunication switching systems &Network–T.Vishwanathan.(PHI)

Semester I					
Course Code	**Course Title**				**Type of Course**
MPHYDNM125	**Physics of Nanomaterials**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (COs):

- To introduce students to the fundamental principles of nanoscience and nanomaterials, focusing on the impact of size at the nanoscale.
- To develop a quantum mechanical understanding of low-dimensional systems such as quantum wells, wires, and dots.
- To equip students with analytical tools to study electronic structure, density of states, and quantum confinement effects in nanomaterials.

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

1. **Explain key concepts of nanoscience** including size-dependent properties, crystal structures, and surface-to-volume effects.
2. **Describe quantum confinement** and related physical scales such as Bohr radius, Fermi energy, and the Kubo gap.
3. **Apply quantum mechanics** to model particles in quantum wells, wires, and dots using the Schrödinger equation.
4. **Analyze electronic structure and density of states** in low-dimensional systems and heterostructures using effective mass theory.

Unit I:

Introduction to Nanoscience, Definitions, historical context, and societal impact. Key questions in nanoscience: size-dependent properties, synthesis (brief overview), and applications.
Crystal Structure and Symmetry, Bravais lattices, unit cells, Miller indices. Common nanostructure crystal systems: FCC, BCC, zinc blende, wurtzite. Surface-to-volume ratio and its implications for catalysis.

Length Scales in Nanoscience, de Broglie wavelength, Bohr radius, excitons. Confinement regimes: strong, intermediate, weak. Fermi energy, Fermi velocity, Kubo Gap, mean free path, Drude–Lorentz Model, and charging energy.

Unit II:

Wave Mechanics and the Schrödinger Equation, Free particles, bound particle (quantum well), and optical absorption in quantum wells. Model problems: particle in a box (1D, 2D, 3D) applied to quantum wells, wires, and dots. Harmonic oscillator and finite potential wells.

Density of States (DOS), DOS for bulk, quantum wells, wires, and dots. Joint density of states (JDOS) and optical transitions. Heterostructures and Band Engineering, Band alignment, heterostructures, and their applications. Effective mass approximation and effective mass theory in heterostructures.

Textbooks:

1. C. P. Poole Jr. and F. J. Owens – *Introduction to Nanotechnology*, Wiley
2. G. Cao and Y. Wang – *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, World Scientific
3. K. K. Chattopadhyay and A. N. Banerjee – *Introduction to Nanoscience and Nanotechnology*, PHI Learning

Reference Books:

1. M. A. Ratner and D. Ratner – *Nanotechnology: A Gentle Introduction to the Next Big Idea*, Pearson
2. C. Binns – *Introduction to Nanoscience and Nanotechnology*, Wiley
3. B. S. Murty, P. Shankar, B. Raj, B. B. Rath, and J. Murday – *Textbook of Nanoscience and Nanotechnology*, Springer

Semester I					
Course Code	**Course Title**				**Type of Course**
MPHYDMS125	**Materials Science**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO):

- To understand the fundamental principles of crystal growth, including nucleation mechanisms (homogeneous/heterogeneous) and growth theories (KSV, BCF, periodic bond chain).
- To analyze the role of defects (point defects, dislocations, grain boundaries) in determining material properties and microstructure.
- To explore advanced characterization techniques (XRD, spectroscopy, microscopy, thermal analysis) for studying crystal structure, composition, and behavior.
- To apply theoretical and experimental knowledge in materials science for technological applications involving single and polycrystalline materials.

Course Outcomes (COs): After completing this course, students will be able to:

1. Explain crystal growth mechanisms, nucleation theories, and the influence of defects on material properties.
2. Use characterization tools (XRD, SEM, TEM, spectroscopy, thermal analysis) to analyze crystal structure and properties.
3. Interpret experimental data to correlate microstructure with mechanical, electrical, and thermal behavior of materials.
4. Apply crystal growth and characterization concepts to real-world material design and optimization problems.

Unit 1.

Crystal Growth Phenomena: The significance of single crystals, Nucleation and Crystal growth, Theories of nucleation- Gibb's Thomson equation – kinetic theory of nucleation, the energy of formation of the spherical nucleus- homogenous and heterogeneous nucleation - kinetics of crystal growth, singular and rough faces, KSV theory, BCF theory - periodic bond chain theory, Point defects, dislocations, grain boundaries, Formation, texture, and anisotropy Polycrystalline Materials, Grain boundary effects on mechanical/electrical properties.

Unit 2.

Characterization Methods: Introduction to materials characterization techniques; Power X-ray Diffraction, Spectroscopic methods- UV-visible and vibrational spectroscopy- Infrared and Raman, Electron spectroscopies - X-ray photoelectron spectroscopy, Ultra-violet photoelectron spectroscopy, Auger electron spectroscopy; Optical microscopy, Electron microscopy- SEM, TEM; Scanning Probe Microscopies: STM, AFM; Thermal analysis- TGA, DTA, DSC.

Books:

1. H.E.Buckley, Crystal growth. John Wiley & Sons, New York,1981.
2. D.Elwell and H.J.Scheel, Crystal growth from high-temperature solution. Academic Press, New York,1995.
3. Crystal Growth for Beginners: Fundamentals of Nucleation, Crystal Growth, and Epitaxy by Ivan V. Markov (World Scientific, 3rd Ed., 2017, ISBN 978-9813143858).
4. R.A.Laudise, The growth of single crystals. Prentice Hall, Englewood,1970.
5. P. Ramasamy and P.Santhanaraghavan, Crystal growth processes and methods. KRU Publications, 2000.
6. Introduction to Crystallography by Donald E. Sands (Dover Publications, 1994, ISBN 978-0486678399).
7. Physics and Chemistry of Materials, Joel I. Gersten, Frederick W. Smith, Willey
8. Theory of Dislocations by John P. Hirth & Jens Lothe (Oxford Univ. Press, 1982, ISBN 978-0894646172).
9. Materials Characterization: Modern Methods and Applications ed. by Narottam P. Bansal (Wiley, 2016, ISBN 978-1118896093).
10. Materials Science and Engineering: An Introduction by Callister & Rethwisch (Wiley, 10th Ed., 2018, ISBN 978-1119405498).

Semester II

Semester II					
Course Code	**Course Title**				**Type of Course**
MPHYCQM225	**Quantum Mechanics-II**				**C**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**4**	**0**	**0**	**4**	**4**

Course Objective (CO): Upon successful completion of this course, students will be able to:

- **Apply Approximate Methods in Quantum Mechanics**: Utilize time-independent and time-dependent perturbation theory, variational methods, and the WKB approximation to solve quantum mechanical problems, including tunneling phenomena.
- **Analyze Quantum Scattering Theory**: Understand scattering processes, derive scattering amplitudes and cross-sections, and apply methods such as the Born approximation, Eikonal approximation, and partial wave analysis.
- **Understand Many-Body Quantum Systems**: Describe identical particle systems, apply symmetry principles, and use second quantization techniques to analyze bosonic and fermionic systems, as well as transitions in semi-classical radiation theory.
- **Formulate Relativistic Quantum Mechanics**: Solve the Klein-Gordon and Dirac equations, interpret probability densities, analyze spin and negative energy solutions, and explore the non-relativistic limits of relativistic wave equations.

Course Outcomes (COs): After completing this course, students will be able to:

1. **Implement Perturbative and Approximate Methods**: Apply perturbation theory, variational methods, and the WKB approximation to real-world quantum mechanical problems such as the Stark and Zeeman effects.
2. **Solve Scattering Problems in Quantum Mechanics**: Derive and interpret the Lippmann-Schwinger equation, perform partial wave analysis, and analyze bound states, resonances, and absorption in quantum collisions.
3. **Utilize Quantum Statistics and Second Quantization**: Develop symmetric and antisymmetric wavefunctions, analyze collision processes of identical particles, and apply second quantization to weakly interacting many-body systems.
4. **Develop a Foundation in Relativistic Quantum Mechanics**: Solve the Klein-Gordon and Dirac equations for free particles, understand the concept of spin in relativistic systems, and interpret negative energy solutions.

UNIT-I

Time-independent perturbation theory: Non-degenerate & degenerate cases, Applications such as linear harmonic oscillator, Zeeman effect, Stark effect, Perturbation of the type X^2, X^3, X^4. Variational method and its applications, WKB approximation: Solution of bound state and Tunnelling problems.

Time-dependent perturbation theory: Harmonic perturbation, Fermi's golden rule, Adiabatic and sudden approximation.

UNIT-II

Scattering Matrix: Bound States and Resonances. Collision in 3-D and scattering, Laboratory and CM reference frames, Scattering amplitude, differential and total scattering cross sections. Lippman-Schwinger Equation. Born and Eikonal Approximation. Partial Wave Analysis: Low energy Scattering, Bound states and Resonance scattering. Complex potential and absorption.

UNIT-III

Identical particles, Symmetric and antisymmetric wave functions, Spin and Statistics. Collision of identical particles; Spin angular momentum. Second Quantization: Weakly interacting Bosonic and Fermionic systems.

Semi classical theory of radiation, Transition probability for absorption and induced emission, Electric dipole and forbidden transitions

UNIT-IV

Relativistic QM: The Klein-Gordon equation, Free particle solutions, probability density & probability current density, interpretation of negative energy solutions of the K-G equation. The Dirac equation, Free particle solutions, Probability density and probability density current for the free particle Dirac equation, Spin of an electron, Interpretation of negative energy states. Non-relativistic limit of KG and Dirac Equations.

Text Books:

1. J. J. Sakurai, Modern Quantum Mechanics, Pearson Publications
2. W. Greiner, Relativistic Quantum Mechanics, Springer-Verlag.

Semester II					
Course Code	**Course Title**				**Type of Course**
MPHYCCE225	**Classical Electrodynamics**				**C**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**4**	**0**	**0**	**4**	**4**

Course Objective (CO): Upon successful completion of this course, students will be able to:

- **Apply Advanced Electrostatic Methods:** Utilize Green's functions, uniqueness theorems, and the method of images to solve boundary-value problems in electrostatics for different geometries.
- **Analyze Electrodynamics in Various Media:** Understand and apply Maxwell's equations in free space and dielectric media, including boundary conditions, charge distributions, and energy conservation principles.
- **Describe Electromagnetic Wave Propagation:** Analyze wave propagation in different media, solve wave equations, and understand waveguides, gauge transformations, and radiation from moving charges.
- **Understand Relativistic Electrodynamics:** Utilize tensor notation and four-vector formalism to describe electromagnetic fields under Lorentz transformations, and analyze charged particle motion in external electromagnetic fields.

Course Outcomes (COs): After completing this course, students will be able to:

1. **Solve Complex Electrostatic Problems:** Apply mathematical techniques such as Green's functions, boundary-value problem-solving, and multipole expansion to determine electrostatic potentials in various configurations.
2. **Derive and Interpret Maxwell's Equations:** Formulate and analyze Maxwell's equations in different coordinate systems, understand their implications in dielectric and conducting materials, and apply conservation laws like Poynting's theorem.
3. **Analyze Electromagnetic Wave Behavior:** Investigate wave propagation in free space and matter, solve wave equations for waveguides, and understand energy-momentum transfer in electromagnetic radiation, including dipole radiation.
4. **Apply Relativistic Electrodynamics:** Use four-vector notation, field tensors, and covariant forms of Maxwell's equations to study transformations of electric and magnetic fields and predict the motion of charged particles in electromagnetic fields.

UNIT-I

Electrostatics: Gauss Law and Scalar Potential. Poisson's and Laplace's equation, Boundary Conditions. Green's theorem, Uniqueness theorem, Formal solution of boundary-value problem, Green's functions, Electrostatic potential energy. Method of images:Point-charge and grounded conducting sphere, Point charge and conducting sphere in uniform field, Method of inversion, Green's function for sphere, Conducting sphere with hemi-spheres at different potentials. Boundary value problems in cylindrical co-ordinates, Expansion of Green's function in spherical co-ordinates, Mixed boundary conditions, charged conducting disc.

UNIT-II

Multipole expansion and energy of charge distribution. Gauss Law in dielectrics. Induced and bound charges. Boundary Value problems in presence of linear dielectrics. Vector potential and multipole expansion. Boundary conditions and calculation of vector field. Maxwell's equations in free space and linear isotropic media, Boundary conditions on the fields at interfaces, Charge and energy, Poynting's theorem and Conservation of Energy and momentum.

UNIT-III

Electromagnetic waves: Waves in one-dimension, Electromagnetic waves in vacuum and matter, Energy and momentum in electromagnetic waves, Wave Guides and modes in a rectangular wave guide. Scalar and Vector potentials, Gauge transformations, Coulomb and Lorentz Gauge, Maxwell's equations in terms of potentials, Retarded potentials, Lienard-Wiechert potentials, fields of a moving point charge, Electric and Magnetic dipole radiation, power radiated by a point charge.

UNIT-IV

Four-Vectors in Electrodynamics, Transformation of electric and magnetic fields under Lorentz transformations, Field Tensor, Electrodynamics in tensor notation, Relativistic potentials, Covariant form of Maxwell's equations, Lorentz force on a relativistic charged particle. Lagrangian and Hamiltonian for a relativistic charge particle in external electromagnetic fields. Motion in uniform, static, magnetic field, Motion in combined uniform, static, electric and magnetic fields, Particle drifts in non-uniform magnetic fields.

Text Books:

1. Classical Electrodynamics: J. D. Jackson, Wiley Press
2. Electrodynamics: D. J. Griffiths, Pearson Edition.

References:

1. Classical Theory of Fields: L. D. Landau and E. M. Lifshitz, Permagon Press
2. Classical Electrodynamics: J. Schwinger, John Wiley Press
3. Modern Electrodynamics: A. Zhangwll, Cambridge University Press.

Semester II					
Course Code	**Course Title**				**Type of Course**
MPHYCSM225	**Statistical Mechanics**				**C**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**4**	**0**	**0**	**4**	**4**

Course Objective (CO):

- To introduce the fundamental principles and formalism of statistical mechanics, and their connection with thermodynamic behavior.
- To provide a detailed understanding of classical and quantum statistical distributions and ensembles.
- To enable the application of statistical mechanics to a variety of physical systems including ideal and interacting gases, and phase transitions.
- To develop the ability to derive macroscopic thermodynamic properties from microscopic models.

Course Outcomes (COs): After completing this course, students will be able to:

1. Understand and apply the concepts of microcanonical, canonical, and grand canonical ensembles.
2. Derive thermodynamic quantities from partition functions using appropriate statistical frameworks.
3. Analyze quantum systems using Bose-Einstein and Fermi-Dirac statistics.
4. Evaluate statistical behavior of ideal and degenerate gases and understand deviations from ideal gas laws.
5. Interpret phase transitions and critical phenomena using statistical mechanics.

Unit - I

Statistical Distributions; Statistical independence, Liouvilles theorem, Significance of energy, Statistical Matrix, Statistical Distributions in quantum Statistics, Microcanonical, Canonical and Grand Canonical ensemble, Partition Function, Calculation of Statistical Quantities, Energy and Density Fluctuations.

Unit - II

Gibbs distribution, Maxwellian distribution, Probability distribution for an Oscillator, Free energy in the Gibbs distribution,

Gibbs distribution for rotating bodies and for a variable number of particles, Derivation of thermodynamics relations from the Gibbs distribution.

Unit - III

Fermi distribution, Bose distribution, Fermi and Bose gases of elementary particles, Degenerate electron gas, Specific heat of degenerate electron gas, Weak fields, Strong fields, Relativistic degenerate electron gas, Degenerate Bose gas, Black body Radiation.

Deviation of gases from the ideal state, Expansion in powers of density, Relationship of the virial coefficients.

Unit - IV

Conditions for phase equilibrium; the Clapeyron-Clausius formula, Critical point, Law of Corresponding states, Phase transitions of the second kind, Discontinuity of Specific heat, Effect of an external field on a phase transition, Change in symmetry in a phase transition of the second kind, Fluctuations of the order parameter, Critical indices, scale invariance.

Text Books:

1. Statistical Physics, Landau and Lifshitz, Butterworth-Heineman, An imprint of Elsevier, Linacre House, Jordan Hill, Oxford OX2 8DP, UK

Reference Books:

1. Statistical Mechanics by K Huang
2. Statistical and Thermal Physics by F. Reif
3. Statistical Mechanics by Pateria
4. Fundamentals of Statistical Mechanics by B. B. Laud
5. Thermodynamics and Statistical Mechanics by Greiner, Neise and Stocke

Semester II					
Course Code	**Course Title**				**Type of Course**
MPHYCLB225	**Lab: II**				**Laboratory**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**0**	**0**	**4**	**4**	**4**

Course Objective (CO):

- The students will have a good foundation in the fundamentals related to the experiments included in this course and their advanced applications.
- Make predictions about expected measurements, data, and results.
- Share experimentation responsibility with other group members.
- Describe the experimental goals, process, data, results, and conclusions in a lab and
- To learn how to report their results in the form of a report.
- After completion of this course students will be able to design and carry out scientific experiments

Course Outcomes (COs): After completing this course, students will be able to:

1. Design and conduct physics experiments with appropriate instrumentation and techniques.
2. Analyze experimental data, interpret results, and assess measurement uncertainties.
3. Work collaboratively in a lab environment and effectively communicate experimental outcomes through written reports.

List of Experiments

S.No	Expt-No.	Aim/Objective	Credit	Lab
1	**Expt-14:**	Design and realize an op – amp based first order Butterworth (a) low pass (b) high pass and (c) band pass filters for a given cut off frequency/frequencies to verify the frequency response characteristic.	3	II

2	**Expt-15**:	The aim of this experiment is to determine that V_H, the Hall Voltage, is proportional to BI, the applied magnetic field times the applied current. Also for a Ge crystal, we measure R_H, along with the carrier concentration, mobility, and the electrical conductivity.	3	II
3	**Expt-16:**	DESIGN i) a 450KHZ CLOCK USING NAND/NOR GATES ii) a 4 bit Adder / Subtractor.	3	II
4	**Expt-17 :**	To determine the characteristics of an UJT 2n2646 at various Base to base Voltages and determine η and to construct and study UJT as a relaxation oscillator of a given frequency.	3	II
5	**Expt-18:**	Obatin γ -ray energy spectra of Cs-137,Co-60 and Na-22, identify the processes taking place. Calibration of a spectrometer for a particular gamma-ray energy ant to compute the energy resolution of the NaI detector at various energies.	2	II
6	**Expt-19:**	Simplify any given Boolean function (f) using the k-map method and implement your result using minimum NAND/NOR gates?	3	II
7	**Expt-20:**	To calculate the band gap energy (Eg) in Germanium (Ge) semiconductor by four point probe resistivity measurement method.	3	II
8	**Expt-21:**	To determine the velocity of ultrasonic waves in liquids and measure their adiabatic compressibility.	2	II
9	**Expt-22:**	To determine the velocity of ultrasonic waves in liquids and measure their adiabatic compressibility.	2	II
10	**Expt-23:**	Measurement of Magnetic Susceptibility of Paramagnetic sample(liquid/solution) by QUINCKE'S TUBE METHOD.	3	II

11	**Expt-24:**	UV- VIS Absorption spectrometery of some compounds	3	II
12	**Expt-25:**	Quantitatively study transverse normal Zeeman effect by observing the splitting of the rings due to magnetic field resolved by Fabry-Perot etalon using a CMOS camera and evaluate the value of Bohr’s magneton (μB). Observe thepolarization of the rings using a polarizer	3	II
13	**Expt-26**	To be able to use of common electronic test and measurement instruments, such asoscilloscopes, mustimeters, function generators, and soldering equipment.	2	II

<table>
<tr><td colspan="6">Semester II</td></tr>
<tr><td>Course Code</td><td colspan="4">Course Title</td><td>Type of Course</td></tr>
<tr><td>MPHYDAA225</td><td colspan="4">Astrophysics-I</td><td>D</td></tr>
<tr><td>Prerequisite</td><td>L</td><td>T</td><td>P</td><td>Contact Hours/Week</td><td>Credits</td></tr>
<tr><td>NA</td><td>2</td><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="6">Course Objective (CO): The aim of teaching is to understand
● Astrophysical processes and systems, ranging from stars, galaxies and the whole universe.
● To explore the properties of stellar systems, galaxies, and the large-scale structure of the universe.
● To introduce key observational tools and physical principles underlying modern astrophysics.</td></tr>
<tr><td colspan="6">Course Outcomes (COs): After completing this course, students will be able to:
1. Interpret and apply the principles of stellar structure and evolution, including the use of the H-R diagram and stellar classification systems.
2. Analyze the physical processes governing stellar interiors, including hydrostatic equilibrium, energy transport, and nuclear energy generation.
3. Explain the formation, life cycle, and end states of stars such as white dwarfs, neutron stars, and black holes.</td></tr>
</table>

UNIT – I

Spectral classification, Stellar distances, Absolute magnitude and distance modulus, The H-R diagram of stars.

Stellar interiors: equation of conservation of mass, hydrostatic equilibrium, thermal equilibrium and energy transport, Equation of State, Stellar Opacity, Stellar Energy Sources. Application of virial theorem to isothermal spheres. Polytropic model, Laneemden’s equation, Central temperature and pressure.

UNIT – II

Evolution of stars, interstellar dust and gas, Jean's criteria for stability, formation of stars, Evolution of stars on the basis of HR diagram, Binary stars, masses of binary stars, Fate of massive stars, Supernovae, White dwarfs, Chandershker limit, neutron stars, Pulsars, black holes.

Text books

1. Steller Structure by Chanderskher
2. Modern Astrophysics by B.W.Carroll and D.A.Ostlie Addison-Weslet Publishing

Reference Books:

1. Astronomy by R. H. Baker
2. G. Abell: Exploration of the Uiverse.

<table>
<tr><th colspan="6">Semester II</th></tr>
<tr><td>Course Code</td><td colspan="4">Course Title</td><td>Type of Course</td></tr>
<tr><td>MPHYDEC225</td><td colspan="4">Electronics-II</td><td>D</td></tr>
<tr><td>Prerequisite</td><td>L</td><td>T</td><td>P</td><td>Contact Hours/Week</td><td>Credits</td></tr>
<tr><td>Electronics-I</td><td>2</td><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="6">Course Objective (CO):
● Study the design and implementation of analog and digital circuits.
● Students will be able to formulate the concepts of operational amplifier, electronic filters and identify major properties of these circuits</td></tr>
<tr><td colspan="6">Course Outcomes (COs): After completing this course, students will be able to:
1. Explain the operation and applications of special purpose diodes and devices such as tunnel diode, SCR, Gunn diode, and UJT.
2. Design and analyze multivibrator circuits including astable, monostable, and bistable configurations.
3. Apply Boolean algebra and Karnaugh map techniques to simplify and implement digital logic circuits.</td></tr>
</table>

Unit-I:

Special purpose devices: Tunnel diode, Silicon Control Rectifier, Special-Purpose Diodes, Gunn diode, Pin Diode, UJT and Programmable UJT. Multivibrators: Astable Multivibrator, Monostable Multivibrator and Bistable Multivibrator, Schmitt Trigger.

Unit-II:

Digital Electronics: Fundamentals of Digital Electronics, Boolean Algebra, Rules and properties of Boolean Algebra, Boolean Laws, Demargon's Laws, Realization of Boolean expressions using logic gates., Sum of Product (SOP) form, Product of Sum (POS) form, K-Map simplification, Karnaugh Map simplification exercises.

Books Recommended:

1. R. Boylestad and L. Nashelski: Electronic Devices and Circuit Theory
2. J. Millman and C. Halkias: Integrated Electronics
3. B.G. Streetman, S. Banerjee: Solid State Electronic Devices
4. H. Taub and D. Schilling: Digital Integrated Electronics
5. P. Bhattacharyya: Semiconductor Optoelectronic Devices
6. S.M. Sze: Physics of Semiconductor Devices
7. A. P. Malvino and A. Brown, *Digital Computer Electronics*

Semester II					
Course Code	**Course Title**				**Type of Course**
MPHYDEM225	**Electronic Instrumentation and Measurements**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO): Course Outcomes: This course will enable the students to

- Impart with the knowledge of generalized measurement systems.
- Learn the characteristics of various types of measurement systems and errors in measuring instruments
- Use of Digital Multimeters and CRO for measurements.
- Analyze and interpret different signal generator circuits for the generation of various waveforms
- Understand the working of radiation detectors and applications.

Course Outcomes (COs): After completing this course, students will be able to:

1. Identify different types of measurement errors and calculate uncertainties in experimental data.
2. Operate digital multimeters and oscilloscopes for accurate electronic measurements.
3. Explain the working of various signal generators and their applications in instrumentation.
4. Describe the types, working principles, and applications of radiation detectors and associated instrumentation.

Unit-I:

Measurement and Errors: Introduction, Significance of measurements, methods of measurements, instruments and measurement systems, The Uncertainty of Measurements, Experimental Errors, Precision and Accuracy, Types of Errors: Statistical and Systematic, Statistical Uncertainties in Measured Quantities, Propagation of Uncertainty. Reporting

Uncertainties. Resolution and Significant figures, Measurement error combinations(relevant problems).

Unit-II:

Digital Measuring Instruments: Digital Measuring Instruments, Resolution and sensitivity of Digital meters, General specification of DVM, Introduction, Block diagram of a Basic Digital Multimeter DMM, Measurements with DMM, Oscilloscopes : Introduction, Basic principles, CRT features, Block diagram and working of each block, Typical CRT connections, Dual beam and dual trace CROs, Electronic switch. Measurements with analog oscilloscope.

Unit-III:

Signal Generators: Special Oscilloscopes: Delayed time-base oscilloscopes: Need for a time delay & delayed-time base system. Digital storage oscilloscopes: Basic DSO operation only. Introduction, Fixed and variable AF oscillator, Standard signal generator, Modern laboratory signal generator, AF sine and Square wave generator, Function generator, Square and Pulse generator ,Segmental Displays: Seven segmental display, dot matrices, LED, LCD

Unit-IV:

Radiation Detectors: Radiation Detector ,Type of Detectors, Gaseous Ionization Detectors, Geiger Counter, Types of Radiations ,Alpha Radiation, Beta Radiation, Gamma Radiation . Photomultiplier Tube Construction & Working Principle, Solid state detectors (Si and HPGe), Scintillation Counter: Working Principle of Scintillation Counter, Types of Scintillation Counter, Scintillator Detector Materials, NaI Scintillation Detector and its Application. Measurement of energy and time using electronic signals from the detectors and associated instrumentation, Signal processing; Multi Channel Analyzer

Books Recommended:

1. Electronic Instrumentation by H. S. Kalsi, TMH, 2004.
2. Electronic Instrumentation and Measurements by David A Bell

3. Electrical and Electronic Measurements and Instrumentation by A. K. Sawhney, 17th Edition
4. Principles of Measurement Systems by John P. Beately, 3rdEdition, Pearson Education, 2000 2.
5. Modern Electronic Instrumentation and Measuring Techniques by Cooper D & A D Helfrick, PHI, 1998.

Semester II					
Course Code	**Course Title**				**Type of Course**
MPHYDMP225	**Mathematical Physics-II**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO): Upon successful completion of this course, students will be able to:

- Apply Green's Function Techniques: Solve differential equations using Green's functions in one and multiple dimensions, including applications to boundary value problems in physics.
- Analyze Partial Differential Equations (PDEs): Understand the role of Green's functions in solving second-order PDEs in various coordinate systems and apply them to Dirichlet and Neumann boundary conditions.
- Understand Group Theory in Physics: Utilize group representations, character theory, and orthogonality relations to classify eigenfunctions and analyze symmetries in physical systems.
- Apply Lie Groups and Representations: Explore continuous groups, Lie groups, their representations, and Casimir operators to study symmetries and conservation laws in quantum mechanics and field theory.

Course Outcomes (COs): After completing this course, students will be able to:

1. Construct and Utilize Green's Functions: Develop Green's functions for second-order linear differential operators and apply them to solve inhomogeneous differential equations in different dimensions.
2. Solve Boundary Value Problems: Apply Green's function methods to Dirichlet and Neumann-type boundary conditions in various coordinate systems, including spherical coordinates.
3. Apply Group Representation Theory: Analyze group representations, construct character tables, and classify eigenfunctions using Schur's Lemmas and orthogonality relations.
4. Interpret and Use Lie Groups in Physics: Understand the structure of Lie groups, their role in symmetries of physical systems, and apply Casimir operators to classify irreducible representations.

UNIT-I

Green's Functions in One Dimension: Calculation of Green's Functions for simple differential operators, Green's Functions for Second order Linear Differential Operators (SOLDOs), Self Adjoint SOLDOs, Generalized Green's identity. Multidimensional Green's Functions: Second-Order PDEs in m Dimensions, Inhomogeneous BC. Multidimensional GFs and Delta Functions, Spherical Coordinates in m Dimensions, Green's Function for the Laplacian. Dirichlet's and Neuman type Problems.

UNIT-II

Group representations, Characters, Construction of Representations, Invariances of functions, Operators and classification of eigenfunctions, Unitary Representation, Hilbert space, Irreducible Representation, Schur's Lemas, Orthogonality Relations, Analysis of Representations. Continuous Groups: Summary of results for discrete groups. Lie groups, examples, Isomorphism. Casimer Operators.

Text Book:

Mathematical Physics: A Modern Introduction to Its Foundations, Sadri Hassani, Springer Press.

Semester II					
Course Code	**Course Title**				**Type of Course**
MPHYDQI225	**Quantum Information Theory**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO): Upon successful completion of this course, students will be able to:

- Understand Fundamental Concepts of Quantum Mechanics and Information: Explain the postulates of quantum mechanics, quantum entanglement, Bell inequalities, and the density operator formalism, including Bloch sphere representation and measurement techniques.
- Analyze Quantum Channels and Entanglement Measures: Utilize operator sum representation, purification techniques, and distance measures such as trace distance and fidelity to quantify quantum states and entanglement.
- Explore Quantum Communication and Information Theory: Understand key quantum communication protocols such as quantum teleportation, superdense coding, and entanglement distribution, along with the implications of the No-Cloning theorem.
- Apply Quantum Algorithms and Information Measures: Implement quantum algorithms such as Deutsch-Jozsa and Quantum Fourier Transform, analyze Shannon and von Neumann entropies, and evaluate quantum channel capacities using mutual information.

Course Outcomes (COs): After completing this course, students will be able to:

1. Describe and Manipulate Quantum States: Represent quantum states using density matrices, apply projective and POVM measurements, and analyze entanglement through Schmidt decomposition and entanglement measures.
2. Evaluate Quantum Channels and Operations: Utilize purification techniques, operator sum representation, and distance measures to study quantum channels and their effects on quantum states.
3. Apply Quantum Information Protocols: Demonstrate the working principles and optimality of quantum teleportation, superdense coding, and entanglement distribution while understanding the role of entropy in quantum information.
4. Implement and Analyze Quantum Algorithms: Develop quantum circuits for fundamental quantum algorithms such as Deutsch-Jozsa and Quantum Fourier Transform, and analyze their computational advantages over classical counterparts

UNIT-I

Postulates of quantum mechanics, qubits, composite quantum systems, Quantum entanglement, Bell Inequality. Density Operator: General properties, Bloch sphere representation, projective measurement, POVM, Schmidt decomposition, reduced density operator. Operator sum representation and its applications. Distance Measures: Norms, Trace Distance and its properties, Fidelity and its properties, relation between Trace Distance and Fidelity. Entanglement measures. Purification: Purification of a density operator, isometric extension of single qubit channels.

UNIT-II

No-Cloning theorem. Quantum Circuits. Entanglement distribution, super dense coding, quantum teleportation, optimality of these protocols, unit source capacity region. Shannon and von Neumann Entropies: Basic properties, Data Processing Inequalities, coding theorems, channel capacities. Mutual Information. Quantum Algorithms: Parallelism, Deustch-Jozsa, Quantum Fourier Transform and its applications.

Text Book:

1. Quantum Computation and Quantum Information: M. A. Nielson and I. Chaung , Cambidge University Press.

References:

1. Quantum Information Second Edition (Cambridge University Press): Mark Wilde
2. Quantum Information Theory: Mathematical Foundations (Springer) : M. Hayashi
3. Lecture Notes by John Preskill (Caltech USA)
4. http://theory.caltech.edu/~preskill/ph219/index.html#lecture

Semester II					
Course Code	**Course Title**				**Type of Course**
MPHYDES225	**Energy Studies**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO) This course aims to:

- Introduce students to the scientific and engineering principles underlying energy production, storage, and utilization.
- Develop a foundational understanding of both conventional and renewable energy systems along with sustainability considerations.
- Familiarize students with emerging energy technologies and advanced storage mechanisms for efficient energy management.

Course Outcomes (CLO): After completing this course, students will be able to:

1. Understand fundamental and advanced concepts of energy production, storage, and management.
2. Explore conventional and renewable energy technologies and their applications.
3. Analyze advanced energy storage systems and emerging energy technologies.
4. Evaluate the sustainability and efficiency of various energy systems.

UNIT I:

Fundamentals and Conventional Energy Systems

Energy Fundamentals: Concepts of energy, power, and work, Thermodynamics: Laws, entropy, energy conversion, Energy density and efficiency, energy components: Battery, Capacitor, Inductor, Thermal Storage, Flywheel, SMES (Superconducting Magnetic Energy Storage), Gravitational Potential System.

Conventional Energy Sources: Fossil fuels: Coal, oil, natural gas, Combustion processes and emissions, Nuclear energy: Fission and fusion, Reactor design and safety measures, Waste management and disposal

Renewable Energy Sources: Solar energy: Photovoltaics, solar thermal systems, Wind energy: Wind turbines and power generation, Hydropower: Dams, tidal and wave energy, Biomass and biofuels: Production and utilization, Geothermal energy: Power plants and direct heating,

UNIT II:

Advanced Energy Storage and Emerging Technologies

Advanced Energy Storage Systems: Electrochemical storage: Lead-acid, lithium-ion, sodium-ion, flow batteries, Supercapacitors: High-capacitance energy storage, Mechanical storage: Flywheels, compressed air energy storage, Thermal storage: Molten salts, phase-change materials

Emerging Energy Technologies: Hydrogen energy systems: Production, storage, fuel cells, Magnetic energy storage: Superconducting Magnetic Energy Storage (SMES) systems, Energy harvesting: Piezoelectric, thermoelectric, electromagnetic, Smart and microgrid technologies: Integration and optimization

Text Books:

1. Energy Systems Engineering: Evaluation and Implementation by Francis M. Vanek and Louis D. Albright, Publisher: McGraw-Hill Education
2. Fundamentals of Thermodynamics by Richard E. Sonntag and Claus Borgnakke, Publisher: Wiley
3. Renewable Energy: Power for a Sustainable Future by Godfrey Boyle, Publisher: Oxford University Press
4. Waste to Energy by Sethi Amrinder Singh, Publisher : LAP Lambert Academic Publishing

Reference Books:

1. Solar Energy: Principles and Possibilities by G. N. Tiwari, Publisher: Narosa Publishing House
2. Nuclear Reactor Physics by Weston M. Stacey, Publisher: Wiley-VCH
3. Hydrogen and Fuel Cells: Emerging Technologies and Applications by Bent Sørensen, Publisher: Academic Press (Elsevier)
4. Smart Grids: Fundamentals and Technologies in Electricity Networks by Stuart Borlase, Publisher: CRC Press

Semester II					
Course Code	**Course Title**				**Type of Course**
MPHYDRM225	**Research Methodology-I**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO):

- To introduce students to the fundamental principles of scientific research.
- To develop skills in literature review, data analysis, and research ethics.
- To provide practical guidance on academic writing, publishing, and presentations.
- To familiarize students with contemporary research tools and software in physics.

Course Outcomes (COs): After completing this course, students will be able to:

1. Formulate research problems by conducting effective literature reviews and identifying knowledge gaps.
2. Apply appropriate research tools, statistical methods, and software for data analysis and visualization.
3. Demonstrate ethical research practices and prepare scientific documents such as theses, papers, and proposals for academic publishing.

Unit 1:

Fundamentals of Research Methodology: Introduction to Research in Physics: Definition and objectives of research. Types of research: Experimental, theoretical, computational. Research process and methodology. Literature Review and Research Problem Formulation: The Importance of literature review in scientific research. Sources of scientific information: Journals, books, databases (Scopus, Web of Science, arXiv, Shodganga). Identifying research gaps and defining research problems.

Research Design and Methodology: Experimental vs. computational vs. theoretical research design. Data collection methods in physics research. Sampling techniques and statistical considerations. Handling uncertainties and error analysis\Research Ethics and Scientific Integrity: Ethical considerations in scientific research. Plagiarism and academic misconduct.

Unit 2:

Research Tools, Data Analysis, and Scientific Communication: Software for data analysis: Excel, Origin, Mathematica. LaTeX for scientific writing. Reference management tools: Mendeley and EndNote. Simulation tools in physics research (e.g., DFT calculations, Monte Carlo methods)

Scientific Writing and Presentation Skills: Structure of a research paper: Abstract, introduction, methodology, results, and discussion. Writing a thesis/dissertation. Conference presentations and poster design. Writing research proposals and grant applications.

Publishing and Peer Review Process: Citation metrics: Impact factor, h-index, citation analysis.

Recommended Books and References:

1. C.R. Kothari, Research Methodology: Methods and Techniques, New Age International.
2. Peter Pruzan , Research Methodology The Aims, Practices and Ethics of Science , Springer
3. P.R. Bevington & D.K. Robinson, Data Reduction and Error Analysis for the Physical Sciences, McGraw-Hill.
4. J. Pallant, SPSS Survival Manual: A Step by Step Guide to Data Analysis, McGraw-Hill.
5. Selected research papers and journal articles.

Semester II					
Course Code	**Course Title**				**Type of Course**
MPHYSSM225	**Seminar-I**				**Y**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**0**	**0**	**2**	**2**	**2**

Course Objective (CO):

- The Seminar-I course is designed to provide students with foundational research exposure, critical thinking skills, and effective communication practices through an in-depth seminar presentation on a focused topic in physics. The course aims to:
- Develop Conceptual Clarity: Strengthen understanding of core theoretical concepts relevant to the seminar topic.
- Build Research Competence: Train students in literature review methods, scientific inquiry, and data interpretation.
- Enhance Analytical Thinking: Encourage students to engage with open-ended questions and apply physics concepts to new or emerging areas.
- Improve Communication Skills: Foster the ability to present scientific content clearly and confidently, both in writing and orally.
- Promote Independent Learning: Guide students to take initiative, manage their research timelines, and self-evaluate their progress.

Course Outcomes (COs): Upon completion of Seminar-I, students will be able to:

1. Understand and Articulate Key Concepts: Demonstrate depth of knowledge in a specific area of physics through seminar presentations.
2. Conduct Preliminary Research: Identify relevant scientific literature, extract key findings, and synthesize information.
3. Present Scientifically: Deliver well-organized and logically coherent seminar presentations to academic peers and faculty.
4. Engage in Scientific Discourse: Respond to questions and critiques effectively during the viva voce.
5. Lay the Foundation for Future Projects/Internships: Set the stage for more comprehensive research work in the subsequent semester (e.g., Seminar-II/Internship Dissertation).

Seminar Guidelines

- Each student will select a specific topic in physics in consultation with an assigned faculty supervisor.
- Students are expected to carry out a comprehensive literature survey, compile findings, and organize them into a seminar report.
- The seminar presentation will be conducted in front of students and departmental faculty.
- Evaluation is based on content understanding, quality of presentation, clarity of presentation, engagement with the audience, and ability to answer questions.
- Successful completion of Seminar-I is a prerequisite for continuation into the next phase (i.e. Seminar-II in third semester and internship/dissertation in the fourth semester.

Semester III

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYCNP325	**Nuclear and Particle Physics**				**C**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**4**	**0**	**0**	**4**	**4**

Course Objective (CO):

- **Understanding Nuclear Forces:** To explore nuclear forces and their origins through concepts like deuteron properties and Yukawa theory.
- **Analyzing Nuclear Models:** To evaluate various nuclear models, including shell models, and understand their applications and limitations in explaining nuclear structure.
- **Elementary Particles and Their Interactions:** To study fundamental particles, their quantum properties, and the principles governing their interactions.
- **Feynman Calculus and Quantum Field Theory:** To introduce Feynman calculus for analyzing particle decays and scattering phenomena.
- **Electroweak Theory and Beyond:** To examine electrodynamics and chromodynamics, focusing on advanced concepts such as symmetry breaking and Higgs mechanism.
- Students will develop an understanding of the fundamental concepts related to hadrons, quark-gluon plasma (QGP), and the conditions under which these phases occur.

Course Outcomes (CO): Upon successful completion of this course, students will be able to:

1. **Comprehension of Nuclear Interactions:** Students will demonstrate an understanding of nuclear forces and the interactions responsible for nuclear stability and decay processes.
2. **Critical Evaluation of Nuclear Models:** Students will be able to critically analyze and apply different nuclear models to various systems and predict their behavior.
3. **Application of Quantum Numbers:** Students will identify and utilize quantum numbers of elementary particles to solve complex problems involving particle interactions.
4. **Mastery of Feynman Diagrams:** Students will proficiently use Feynman diagrams to describe particle decay and scattering processes, demonstrating application of the Golden Rule for decay rates.
5. **Integration of Advanced Theoretical Concepts:** Students will integrate concepts from electroweak theory and quantum chromodynamics to solve problems related to fundamental forces and particle interactions.
6. **Research and Analytical Skills:** Students will develop research skills necessary to explore contemporary issues and advancements in nuclear and particle physics, fostering a continuous learning mindset.

Unit - I

Nuclear Forces and Two Nucleon System: Deuteron, Deuteron Magnetic Dipole Moment, Deuteron Electric quadrupole Moment, Tensor force and deuteron D-state, Yukawa theory of nuclear forces, Properties of nucleon-nucleon force, Meson theory of nucleon-nucleon force.

Nuclear Interaction and Decays: Weak Interaction, Fermi Theory of Beta decay, Gamow theory of alpha decay.

Unit - II

Nuclear Models: Liquid drop model. semi-empirical mass formula (applications), Magic numbers, closed shells, single-particle shell model, its validity and limitations, Evidence of shell structure, Fermi gas model, Collective motion: rotational states. Nuclear deformations.

Rutherford scattering, Mott scattering, Properties of Nuclei: Electron scattering form factor, Charge radius and charge densities, Nucleon form factor, High energy lepton scattering (Deep inelastic scattering).

Unit - III

Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Eight folded way, Gellmann- Nishijima formula. baryons and mesons, Quark model, Standard model. Parity (non-conservation in weak interaction), charge conjugation and CPT invariance, CP violation. Application of symmetry arguments to particle reactions. Relativistic collisions, classical collisions, Examples and applications.

Unit - IV

Feynman calculus: Decays and scattering, Decay rates, Cross sections, The Golden Rule (for decays), Two particle decays. Feynman rules for a Toy Theory, Muon deacy and pion decay.

Electrodynamics and Chromodynamics of Quarks: Quark-Quark, Quark-Antiquark, Pair annhilation in QCD, Asymptotic Freedom, Spontaneous symmetry breaking, Higgs mechanism.

Text Books:

1. Introduction to elementary particles by David J. Griffiths, John Wiley and Sons.
2. Introduction to Nuclear Physics by Samuel S. M. Wong.

Reference Books:

1.Introduction to high energy physics by D. H. Perkins
2. Introductory Nuclear Physics by David Halliday and Robert Resnick.
3.The Standard Model of Particle Physics by David Griffiths.
4. An Introduction to the Physics of Nuclear Reactions by M. H. McCarthy.

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYCCM325	**Condensed Matter Physics**				**C**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**4**	**0**	**0**	**4**	**4**

Course Objective (CO): The course outcomes cover a broad spectrum of topics in solid-state physics, crystallography, solid state-quantum mechanics, and the behaviour of materials in different dimensional systems, offering students a comprehensive understanding of the subject matter.

Course Outcomes (COs): After completing this course, students will be able to:

1. Understand crystal lattices planes, and directions within a crystal structure.
2. Analyze crystallographic point groups and their practical applications.
3. Explain the diffraction of waves by crystals, including scattered wave amplitude and Fourier Analysis of a crystal.
4. Apply reciprocal lattice concepts to diffraction techniques, such as diffraction conditions in reciprocal space, Brillouin zones, crystal structure factor, and atomic scattering factor.
5. Analyse electrons in a periodic lattice, emphasizing the origin of energy gaps.
6. Apply the Bloch theorem and understand Bloch modes and Schrodinger wave equation in reciprocal space.
7. Comprehend the Tight Binding Approximation and its relevance.
8. Analyse Fermi surfaces of solids and associated experimental methods.
9. Explain experimental methods like De Hass-van Alfen effect and cyclotron resonance.
10. Understand the electronic structure of a two-dimensional electron gas and integral quantum Hall-effect.
11. Analyse one-dimensional systems including DOS, 1D sub-bands, and Van-Hove singularities and their practical applications.
12. Explain conductance quantization and the Landauer formalism.
13. Understand resonant tunnelling and the behaviour of two potential barriers in series.

Unit-I

Crystal lattice; crystal planes and directions. Crystal symmetry, crystallographic point groups, non-centrosymmetric points, and their applications. Space groups, diffraction of waves by crystals, scattered wave amplitude, Fourier Analysis of a crystal. Reciprocal lattice and its applications to diffraction techniques, Bragg's law in reciprocal space. Diffraction condition in reciprocal space, Brillouin zones, Crystal Structure Factor, and Atomic Scattering Factor. Calculation of atomic scattering factor for ground state hydrogen.

Unit-II

Specific heat: The Einstein and Debye models; Lattice waves; One-dimensional monoatomic lattice; Density of states of a lattice; The concept of phonons. Drude model, the quantum mechanical free electron model, electrons in a periodic lattice, and the origin of energy gaps. Bloch's theorem, Bloch modes, and the Schrödinger wave equation in reciprocal space; Kronig-Penney model, Tight binding approximation. Band structure of Intrinsic semiconductors. The Fermi surface of solids; Experimental methods: the de Haas-van Alphen effect and cyclotron resonance.

Unit-III

Low-dimensional electron systems: One-dimensional systems; density of states (DOS), 1D sub-bands, Van Hove singularities and their applications; electron motion in a uniform magnetic field; Landau levels; the electronic structure of a two-dimensional electron gas and the integral quantum Hall effect (IQHE). Conductance quantisation and the Landauer formalism. Resonant tunnelling, two potential barriers in series. Zero-dimensional systems: quantised energy levels of semiconductor nanocrystals.

Unit-IV

Ferromagnetism: Weiss's theory of ferromagnetism, the Curie-Weiss law for susceptibility, Heisenberg model and molecular field theory. Ising model in one-dimensions. Spin waves and magnons, Dispersion relation. Specific heat of ferromagnets at low temperature, Bloch $T^{3/2}$ law. Formation of domains, Bloch wall energy. Ferroelectricity: Classification of ferroelectric crystals, Landau's theory of the ferroelectric phase transition. Phonon softening and ferroelectricity, Soft-mode theory. Applications of ferroelectric materials.

Text Books:

1. Introduction to Solid State Physics, Charles Kittel, John Wiley and Sons
2. Elementary solid-state physics by Ali Omer , Pearson Publications
3. The physics of low dimensional semiconductors: An introduction by John H. Davis, Cambridge University Press.
4. Quantum Mechanics for Nanostructure by Dmitry I. Sementsov, Nizami Z. Vagidov, and V. V. Mitin,, Cambridge University Press.

References:

1. Modern course in quantum theory of solids by Fuxuang Han, Wiley Scientific.
2. Solid state physics by Neil W. Ashcroft and N. David Mermin, Black Well Pub.

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYCAM325	**Atomic and Molecular Physics**				**C**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**4**	**0**	**0**	**4**	**4**

Course Objective (CO):

- Apply quantum mechanics to understand and predict atomic energy level structures in hydrogenic and multi-electron atoms.
- Evaluate the role of fine and hyperfine interactions in determining atomic spectra and selection rules.
- Identify and explain molecular transitions, and analyze the vibrational and rotational spectra of diatomic molecules.
- Compare classical and quantum mechanical explanations of the Raman Effect and apply it to molecular spectroscopy.
- Use spectroscopic data to extract physical information about atomic and molecular structure and understand its applications in physics and chemistry.

Course Outcomes (COs): After completing this course, students will be able to:

1. Explain the fine and hyperfine structures of one-electron atoms using quantum mechanical principles.
2. Analyze the effects of external electric and magnetic fields (Stark and Zeeman effects) on atomic spectra.
3. Solve the Schrödinger equation for two-electron atoms and describe electron correlation and spin configurations.
4. Differentiate between L–S and j–j coupling schemes and apply Hund's rules to determine atomic term symbols.
5. Interpret vibrational, rotational, and Raman spectra of diatomic molecules using classical and quantum theories.

Unit I:

One-electron atoms: Fine structure of hydrogenic atoms, energy shifts, the Lamb shift, hyperfine structure, Zeeman effect (normal and anomalous), Stark effect, selection rules, and transition probabilities. Two-electron atoms: The Schrödinger equation for two-electron atoms, spin wave functions and the role of the Pauli exclusion principle, electron correlation effects, L–S coupling and j–j coupling, possible terms of a multi-electron configuration in L–S coupling, Hund's rules, fine structure of terms in L–S coupling, Landé interval rule.

Unit II:

Rotation and vibration of diatomic molecules, the Born–Oppenheimer approximation, Franck–Condon principle, electronic transitions in molecules, vibrational progressions. Raman Effect: Classical theory and quantum mechanical theory of Raman Effect, rotational and vibrational–rotational Raman spectroscopy, polarization of Raman lines, resonance Raman effect, application of Raman spectroscopy in structural analysis.

Textbooks:

1. Physics of Atoms and Molecules by B. H. Bransden and C. J. Joachain, 2nd Ed.
2. Spectra of Atoms and Molecules by Peter F. Bernath, Oxford University Press
3. Atoms and Molecules by Mitchel Weissbluth

References:

1. Fundamentals of Molecular Spectroscopy by C. N. Banwell
2. Introduction to Molecular Spectroscopy by G. M. Barrow

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYDLP325	**Laser Physics**				**Electrive**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO):

- Demonstrate knowledge of fundamental laser principles and their physical basis.
- Apply rate equations and threshold conditions to analyze laser action.
- Identify the structural and operational features of different types of lasers.
- Evaluate the coherence, intensity, and spectral characteristics of laser beams.
- Understand the practical applications of lasers in fusion technology and isotope separation.

Course Outcomes (COs): After completing this course, students will be able to:

1. Understand the processes of absorption, spontaneous emission, and stimulated emission.
2. Analyze the Einstein coefficients and transition probabilities of atomic systems.
3. Explain the concept of population inversion and rate equations for laser systems.
4. Describe the characteristics and operational principles of various laser systems.
5. Discuss the properties and practical applications of laser beams in science and technology.

Unit-I

Absorption, spontaneous and stimulated emission, Einstein coefficients, transition probability and lifetime of an atom in an excited state, population inversion, laser rate equations: the three level and four level systems, line broadening mechanism, shape and width of spectral lines, optical resonators: quality factor, losses inside the cavity, threshold conditions, Schawlow-Townes condition, transverse and longitudinal mode selection.

Unit-II

Laser systems: He-Ne laser, CO_2 laser, four level solid state lasers, dye lasers, Ar^+ laser, excimer lasers, properties of laser beam: directionality, monochromaticity, intensity, coherence (temporal and spatial), applications of lasers: laser induced fusion, isotope separation.

Textbooks:

1) Lasers: Theory and Applications by K. K. Thyagarajan and A. K. Ghatak
2) Laser and Non-linear Optics by B. B. Laud

Reference Books:

1) Optical Electronics – Ajoy Ghatak and K. Thyagarajan
2) Principles of Lasers – Orazio Svelto
3) Fundamentals of Photonics – B.E.A. Saleh and M.C. Teich
4) Laser Fundamentals – William T. Silfvast

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYDME325	**Microwave Electronics**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO):

- To study the basic idea about Microwave frequencies application and measurement techniques
- To know about microwaves tubes and their working

Course Outcomes (COs): After completing this course, students will be able to:

1. Understanding basics about microwaves
2. Having insight about the parameters about microwaves
3. Knowing about working about Microwave tubes
4. Becoming familiar about application

Unit-I

Basic Idea: Microwave frequency, Difficulties of conventional devices at microwave frequencies, Microwave devices and systems, Ground wave, sky wave, Line of sight propagation. Applications of microwaves.

Microwave transmission lines: Primary parameters RLGC, Transmission line equation and its solution, Characteristic impedance and propagation constant, Low loss transmission line, Line impedance under load, Reflection and Transmission coefficient, Standing wave Ratio, Smith Chart, Impedance matching,

Unit-II

Klystrons: Velocity modulation and bunching, Output powers, Reflex klystron, multicavity klystron (qualitative).

Travelling Wave Tube: Slow waves structures, Amplification process, Axial electric field, wave modes, gain consideration, .

Magnetron : Cylindrical magnetron, linear magnetron, coaxial magnetron, Voltage tunable magnetron, Inverted coaxial magnetron, Forward cross field and backward cross field magnetron.

Gunndiode: Gunneffect Gunn oscillation

Books:

1. Microwave Devices and circuits: S.Y.Liao.PHI
2. Microwave and Radar Engineering 3rd edition: M. Kulkarni. Umesh Publication, New Delhi Microwaves: Introduction to Circuits Devices and Antennas: M.L. Sisodia and Vijay Laxmi gupta. New Age Publications.

Reference Books:

1. Microwave electronics: A. D. Grigoriev, V. A. Ivanov, S. I. Molokov. Springer Microwave electronic devices: T.G. Roer. Springer
2. Microwave Electronics: Measurement and Materials Characterization: L. F. Chen, C. K. Ong, C. P. Neo, V. V. Varadan and V. K. Varadan. Wiley

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYDHE325	**High Energy Physics**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO):

- **Understanding Fundamental Concepts:** Students will develop an understanding of the fundamental concepts related to hadrons, quark-gluon plasma (QGP), and the conditions under which these phases occur.
- **Exploration of Heavy Ion Collisions:** Students will explore the significance of heavy ion collisions in high-energy physics and the experimental techniques involved in studying these phenomena.
- **Analysis of Experimental Data:** Students will learn to analyze and interpret data from various high-energy physics experiments, understanding the implications of findings related to QGP and hadronic matter.
- **Investigating Phase Transitions:** Students will examine the phase transitions between hadronic matter and quark-gluon plasma, exploring their characteristic and theoretical implications.
- **Application of Theoretical Models:** Students will apply theoretical models, such as the MIT Bag model, to real-world scenarios in high-energy physics.

Course Outcomes (CO): After completing this course, students will be able to:

1. **Comprehensive Knowledge: S**tudents will be able to explain the properties of quark-gluon plasma and hadronic matter, as well as the significance of phase transitions in high-energy environments.
2. **Critical Thinking**: Students will demonstrate critical thinking skills in evaluating different experimental results and methodologies used in the study of heavy ion collisions.
3. **Effective Communication**: Students will effectively communicate complex concepts related to heavy ion collisions and QGP both verbally and in written format.
4. **Skill Development**: Students will gain practical skills in using simulation tools and data analysis software relevant to high-energy physics research.
5. **Research Orientation**: Students will be prepared to engage in advanced research projects or graduate studies in the field of high-energy physics, particularly focusing on experimental and theoretical aspects of quark-gluon plasma.

Unit I

Heavy ion collisions and formation of Quark Gluon Plasma, Overview of different experiments at high energy: Compressed Baryonic Matter (CBM) at FAIR, A Large Ion Collider Experiment (ALICE), A Toroidal LHC Apparatus (ATLAS), Compact Muon Solenoid (CMS) at CERN. Solenoidal Tracker at RHIC (STAR). Discoveries of High energy experiments.

Unit II

MIT Bag model of hadrons, Equation of state for Hadronic phase and Quark Gulon Plasma, Quark-Hadron phase transition, Quark Gluon Plasma at High Temperature scenario, High Baryon Density scenario, QGP signatures: J/Psi suppression and production in Quark Gluon Plasma, Dilepton production in QGP, Photon production in Quark Gluon Plasma and Strangeness enhancement.

Text Books:

1. Introduction to High Energy Physics by Donald H. Perkins.
2. Introduction to High-Energy Heavy-Ion Collisions by Cheuk-Yin Wong (Oak Ridge National Laboratory, USA).
3. The CBM Physics Book by B. Friman, C. Höhne, J. Knoll, S. Leupold, J. Randrup, R. Rapp, P. Senger.

Reference Books:

1. QCD and Heavy Ion Collisions by Miklos Gyulassy et al.
2. Quarks and Leptons: An Introductory Course in Modern
3. Particle Physics by F. Halzen and J. D. Martin.
4. Introduction to elementary particles by David J. Griffiths, John Wiley and Sons.

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYDAA325	**Astrophysics-II**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO):

- Going through Friedman model Students will acquire knowledge about where the Universe came from and where it's headed.
- After finishing the course student is expected to account for the theoretical basis for our modern cosmological view of the universe.

Course Outcomes (COs): After completing this course, students will be able to:

1. Understand the large-scale structure and dynamics of galaxies, including the Milky Way, and explain phenomena such as rotation curves and the missing mass problem.
2. Apply fundamental concepts of cosmology, including the Friedman model and Robertson-Walker metric, to describe the origin, evolution, and fate of the Universe.
3. Explain the thermal history of the Universe and interpret the significance of Cosmic Microwave Background Radiation (CMBR).

UNIT – I

The Milky way Galaxy, size and shape, Rotation curves of the Galaxy, Missing mass problem, Radio observation, star counts, interstellar extinction, Hubble's classification of galaxies.
Stellar dynamics; types of forces on a star in the stellar system, Tidal radii, star - star encounter, time of relaxation, determination of time of relaxation, application to Galaxy & star cluster. Masses of double galaxies, Masses of cluster of galaxies by virial theorem observational determination of masses.

UNIT – II

Cosmology; cosmological principle, Newtonian cosmology, deceleration parameters critical density, Robertson walker equation and its properties, solution of Robertson-Walker equations. Einstein field equation in cosmology, Energy tensor of Universe, solution of Friedman's equation, Einstein de-sitter model, open model, particle horizon, Event horizon.

Thermal History of the Universe; Temperature red shift relation, distribution in the early Universe, relativistic and non-relativistic limits, decoupling of matter and radiation, Cosmic microwave background radiation (CMBR), isotropy and anisotropy of CMBR.

Text Books:

1. Introduction to Cosmology By J. V. Narliker
2. Modern Astrophysics by B.W. Carroll and D. A. Ostlie, Addison Wesley Publishing Co.

Reference Books:

1. Structure Formation in the Universe by T. Padmanabhan, Cambridge University
2. Stellar Dynamics by S.Chandersakher
3. Stellar Evolution by Kippenhahn

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYDSC325	**Superconductivity**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO): The course aims to provide an overview of superconductivity and its importance, the unusual properties of the superconducting state, theories of superconductivity and its vast applications and future directions.

Course Outcomes (COs): After completing this course, students will be able to:

1. Describe superconductivity and its unusual properties
2. Understand the basic superconductor parameters and the characteristic lengths
3. Understand the classical aspects of superconductors, alongwith their thermodynamic and magnetic properties
4. Understand the Superconducting Quantum Interference, the Josephson effect and its applications
5. Understand the models and theories of superconductivity alongwith their limitations and drawbacks
6. Develop an understanding of the Hi Temperature superconductors, in particular the Cuprate family.
7. Know the challenges in developing a complete theory of Hi Temperature superconductvity
8. Have an understanding of the numerous applications of superconductivity
9. Have an idea of what is in store for future superconductivity research

Unit - I

The superconducting state, Basic properties of the superconducting state: Zero resistance, Critical temperature, The Meissner effect (Perfect diamagnetism), Flux quantization, Isotope effect, Critical magnetic fields, Type-I and Type-II superconductors, Critical Current, Penetration depth, Coherence length, Thermodynamics of transition, First and Second order transitions, Entropy, specific heat, Energy gap, The Josephson effects.

Unit - II

Models and theories: Two fluid model, London equations, Ginzburg-Landau theory, main results of Bardeen Cooper and Schrieffer (BCS) theory: Instability of the Fermi Surface in the presence of attractive Interaction between electrons, Electron distribution in the ground state of a Superconductor, Critical temperature, Energy gap, Origin of the attractive interaction. Introduction to Hi TC superconductivity.

Applications: SQUIDS, Magnetic Shielding, Power Transmission, Energy Storage devices, and Medical Applications.

Text Books:

1. A. C. Rose-Innes, Introduction to superconductivity (Pregamon Press)

Reference Books:

1. C. P. Poole, Handbook of superconductivity (Academic Press 2000)
2. Andre Mourchakine, Room temperature superconductivity (Cambridge 2004)
3. Jeffery W. Linn, High temperature superconductivity (Springer Verlag 1990)
4. T. V. Rama krishnan and C. N. Rao, Superconductivity today (Wiley 1992)
5. M. Tinkham, Introduction to superconductivity (McGraw Hill, 2004)

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYDQF325	**Quantum Field Theory**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO): Upon successful completion of this course, students will be able to:

- Understand Lorentz Invariance and Field Quantization: Analyze the Lorentz invariance of the Dirac equation, identify bilinear invariants, and apply canonical quantization to scalar, Dirac, and electromagnetic fields.
- Apply Lagrangian Formulation and Symmetry Principles: Utilize Noether's theorem to derive conserved quantities, explore PCT symmetries, and understand the mechanisms of symmetry breaking and the Higgs mechanism.
- Compute Scattering Processes Using QED: Derive the S-matrix expansion using Wick's theorem, apply Feynman rules to QED processes such as electron-electron scattering, Compton scattering, and scattering by an external field.
- Analyze Higher-Order Corrections and Gauge Invariance: Understand loop corrections in quantum electrodynamics, including the Lamb shift and vacuum polarization, and explore the implications of gauge invariance in particle interactions.

Course Outcomes (COs): After completing this course, students will be able to:

1. Demonstrate Lorentz Invariance in Quantum Fields: Prove the Lorentz invariance of the Dirac equation and construct bilinear invariants, while applying canonical quantization to different fields.
2. Apply Noether's Theorem to Quantum Systems: Derive conserved currents from symmetry principles and analyze the impact of symmetry breaking and the Higgs mechanism in quantum field theory.
3. Use Feynman Diagrams for Scattering Calculations: Construct and interpret Feynman diagrams, apply Wick's theorem, and compute cross-sections for QED processes such as electron-electron and Compton scattering.
4. Analyze Radiative Corrections in QED: Understand and compute loop corrections, such as vacuum polarization and the Lamb shift, and explore the role of gauge invariance in renormalization.

UNIT-I

Lorentz Invariance of Dirac equation. Bilinear invariants. Lagrangian formulation and Noether's theorem. Canonical quantisation and particle interpretation: Scalar field, Dirac field. Electromagnetic field. Radiation Gauge quantization. PCT symmetries. Symmetry Breaking and Higgs Mechanism.

UNIT-II

The S-matrix expansion and Wick's theorem. Feynman diagrams and Rules. Yukawa interaction: decay of a scalar. Cross section for QED processes: Electron-electron scattering. Consequence of gauge invariance. Compton scattering, Scattering by an external field. Idea of Loop diagrams: Lamb Shift and Vacuum Polarization.

Text Book:

1. A first book of quantum field theory, Lahiri and Pal, Narosa Publishing House
2. Quantum Field Theory, Lewis H Ryder, Cambridge University Press.

References:

1. Quantum Field Theory and Standard Model, M. D. Schwartz, Cambridge University Press
2. S Wienberg, Quantum theory of fields, Vol I. Cambridge University Press.
3. Quantum Field Theory, Claude Itzkyson, Cambridge University Press.

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYDRP325	**Radiation Physics**				**D**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**2**	**0**	**0**	**2**	**2**

Course Objective (CO) The primary objective of this course is to provide students with a comprehensive understanding of the fundamental principles of radiation physics as applied to medical and radiation protection fields. Students will learn about the types of radiation, their interactions with matter, dosimetric quantities, and the principles of radiation detection and measurement. The course aims to equip students with the knowledge necessary to understand radiation safety, protection laws, and the functioning of various radiation detection devices, enabling them to apply this knowledge in clinical and research settings.

Course Outcomes (CLO): After completing this course, students will be able to:

1. Explain the basic concepts of electromagnetic and particle radiation, including ionizing and non-ionizing radiation, and understand their interactions with matter such as photoelectric effect and Compton scattering.
2. Understand and calculate dosimetric quantities such as exposure, dose, dose equivalent, Kerma, and absorbed dose, and comprehend their relationships and significance in radiation protection.
3. Describe the principles and functioning of various radiation detection and measurement devices, including ionization chambers, GM counters, scintillation detectors, TLDs, and OSLDs.
4. Apply radiation safety measures and adhere to radiation protection laws and regulations to ensure safe handling and use of radiation sources.
5. Demonstrate the ability to monitor and assess radiation exposure using different survey meters and personal monitoring devices.
6. Analyze and interpret dosimetric data to evaluate radiation risks and ensure compliance with safety standards in medical and industrial environments.

UNIT I:

Dosimetric concepts and quantities: Electromagnetic Radiation, Ionizing and Non-Ionizing Radiation, Radiation Units, Exposure and Dose, Dose equivalent Unit, Particle flux, X Rays and Gamma Rays, their interaction with matter, Photoelectric and Compton effect, Exposure, Roentgen, photon fluence and energy fluence, Kerma and absorbed dose, stopping power, relationship between the dosimetric quantities, Safety measures, Radiation Protection laws.

Unit - II

Principles of radiation detection: Radiation monitoring, Area survey meters, Ionization chambers, proportional counters, neutron area survey meters, GM survey meters, scintillation detectors, Personal monitoring, film badge, TLD.

Properties of personal monitors, Radiophtoluminesce glass dosimetry system, OSLD. Principles of Radiation detection, properties of dosimeters, Theory of gas filled Detectors.

Text Books:

1. The physics of radiation therapy by F. M. Khan, 3rd Ed. Lippincott Williams and Wilkins, USA, 20003

Reference Books:

1. The Physics of radiology by H. E. Jones and J. R. Cunnigham, Charles C. Thomas, New York 2002
2. Fundamental physics of radiology by W. J. Meredith and J. B. Massey, John Wright and Sons UK, 2002
3. Medical radiation physics by W. R. Handee, Yearbook medical publishers Inc. London, 2003

Semester III					
Course Code	Course Title				Type of Course
MPHYDIS325	Introduction to Spintronics				D
Prerequisite	L	T	P	Contact Hours/Week	Credits
Condensed Matter Physics	2	0	0	2	2

Course Objective (CO): The objective of this course is to provide students with a comprehensive understanding of the physical principles underlying spin-based phenomena in materials, and to explore their applications in cutting-edge spintronic devices. The course aims to bridge fundamental concepts with real-world technologies, encouraging analytical thinking, interdisciplinary learning, and research orientation. By engaging with theoretical models, experimental insights, and recent innovations, students will develop the ability to analyze, design, and evaluate spintronic systems relevant to both academic research and industrial applications.

Course Outcomes (COs): After completing this course, students will be able to:

1. Evaluate the operation and performance of various spintronic devices, including spin valves, magnetic tunnel junctions, and spin transistors.
2. Interpret emerging concepts in spintronics such as topological insulators, skyrmions, and spin Hall effects through recent literature.
3. Design and present a project that investigates a novel concept, material, or application in magnetism or spintronics using research-based learning.

Unit I:

Fundamental Principles of Spintronics: Overview of Spintronics, Basics of magnetostatics and magnetism, The discovery and quantum mechanical nature of spin, Spin and orbital angular momenta, Fundamental magnetic interactions including exchange, dipole-dipole, and anisotropy, Classification of magnetic materials such as paramagnetism, diamagnetism, ferromagnetism, and antiferromagnetism, Band magnetism in transition metals, Surface and interface magnetism, Spin-orbit physics at interfaces, Micromagnetics and magnetization dynamics, Magnetic domain walls and their dynamics

Unit II:

Spin Transport and Device Applications: Electronic and spin transport in metals, spin-dependent tunneling effects, spin transfer and pumping phenomena, current-driven magnetization dynamics, spin dynamics in complex magnetic textures, emerging applications in spintronic devices, spin valve and magnetic tunnel junctions (MTJs), spin field-effect transistors (SpinFETs), giant magnetoresistance (GMR) and tunneling magnetoresistance (TMR), spin transfer torque and spin-orbit torque phenomena

Textbooks:

1. Spintronics: Materials, Devices, and Applications by Kaiyou Wang, Meiyin Yang, Jun Luo; 1st Editon; ISBN: 978-1-119-69895-1, Pages 336, Publisher: Wiley; Publishing Year 2022.

References:

1. Introduction to Spintronics by Supriyo Bandyopadhyay and Marc Cahay; 2nd Editon; Publisher: CRC Press; ISBN-13: 978-0367656447 (2015).
2. Spintronics Handbook: Spin Transport and Magnetism by Evgeny Y. Tsymbal and Igor Žutić; Edition: 2nd (Multi-volume); Publisher: CRC Press; Pub Date: 2021-03-31 (3-Vol Paperback Set); ISBN-13: 978-0367777876 (3-Vol Paperback Set).
3. Fundamentals of Magnetism and Spintronics by Atowar Rahman; Latest Edition: 1st; Publisher: Zorba Books; Pub Date: 2022-08-16; ISBN-13: 978-9393029799.
4. Spintronics for Next Generation Innovative Devices edited by Katsuaki Sato, Eiji Saitoh; Latest Edition: 1st; Publisher: John Wiley & Sons, Inc.; Pub Date: 2015-09-18; ISBN-13: 978-1118751916; (Wiley Series in Materials for Electronic & Optoelectronic Applications).
5. Spintronics: Fundamentals and Applications" by David D. Awschalom, David Loss, and Nathaniel Samarth, Reviews of Modern Physics, Volume 76, Page 323-410 (2004)

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYDRM325	Research Methodology-II				D
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
Research Methodology-I	1	0	1	2	2

Course Objective (CO): The primary objectives of this course are to:

- Equip students with advanced skills in data analysis, interpretation, and visualization techniques essential for scientific research.
- Develop proficiency in applying statistical methods such as regression analysis, hypothesis testing, and goodness-of-fit tests to experimental data.
- Introduce programming tools, particularly Python and Jupyter Notebook, for efficient data handling, analysis, and curve fitting.
- Foster the ability to critically analyze data, interpret results accurately, and communicate findings effectively using graphical and statistical techniques.

Course Outcomes (COs):

1. Upon successful completion of this course, students will be able to:
2. Collect, analyze, and interpret data using various statistical techniques, including regression analysis, error analysis, and hypothesis testing.
3. Apply curve fitting and data visualization methods to represent experimental data graphically and extract meaningful insights.
4. Demonstrate proficiency in programming with Python, including data manipulation, statistical analysis, and plotting using libraries such as NumPy and Matplotlib.
5. Utilize Jupyter Notebook for performing comprehensive data analysis, hypothesis testing, and nonlinear curve fitting of experimental data.
6. Critically evaluate statistical results, assess the significance of tests, and communicate findings effectively in research reports.

UNIT-I

Data Analysis and Interpretation: Sources of data collection include primary and secondary data. Methods of collecting primary data, Measurement scales and sources of error, Statistical analysis techniques: Mean, standard deviation, regression analysis. Data interpretation and analysis involve understanding precision and accuracy, error analysis, least squares fitting, linear and nonlinear regression, and correlation analysis.

Curve fitting and data visualization techniques. Hypothesis testing methods include T-tests and F-tests, along with tests of significance. The significance of goodness-of-fit tests, such as the Chi-square test, is also examined.

UNIT-II

Programming: Introduction to Python

Introduction to Python, Anaconda, Jupyter Notebook, Python Basics including data types, variables, arrays, functions, dictionaries, loops, and conditional statements. Working with Files, NumPy & Matplotlib.

Python Programming for Data Analysis:

Data Analysis in Jupyter Notebook. Statistical Analysis & Hypothesis Testing, Curve Fitting (Linear Fitting and non-linear Fitting).

Recommended Literature

1. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (2014), J. W. Creswell, Sage Publications
2. Data Reduction and Error Analysis for the Physical Sciences (2003), Philip R. Bevington & D. Keith Robinson, McGraw-Hill
3. Statistical Treatment of Experimental Data (2013), H. D. Young, McGraw-Hill Book Company Inc
4. Python for Data Analysis, 2nd Edition (2017), Wes McKinney, O'Reilly Media, Inc.
5. Learn Python the Hard Way (2019), S. Wróbel, Addison-Wesley Professional
6. Applied Regression Analysis (1998), N. R. Draper & H. Smith, John Wiley & Sons

Web Resources:

1. Jupyter Notebook: https://jupyter.org
2. NumPy: https://numpy.org
3. Matplotlib: https://matplotlib.org

Additional Books:

1. Data Reduction and Error Analysis for the Physical Sciences, 3rd Edition, Philip R. Bevington & D. Keith Robinson, McGraw-Hill (2003)
2. Numerical Methods, Balagurusamy, Tata McGraw-Hill (2000)
3. Numerical Analysis, 2nd Edition, Francis Scheid, McGraw-Hill (2009)
4. Numerical Mathematical Analysis, James B. Scarborough
5. Numerical Methods for Scientists and Engineers, K. Sankara Rao, 3rd Edition, PHI

Semester III					
Course Code	**Course Title**				**Type of Course**
MPHYSSM325	**Seminar-II**				**Y**
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	**0**	**0**	**2**	**2**	**2**

Course Objective (CO):

- Seminar-II aims to deepen students' exposure to contemporary research developments and cutting-edge topics in physics. This course is structured to:
- Bridge Academic Learning and Research Practice: Connect foundational knowledge from Seminar-I with real-world research and industry trends.
- Familiarize with Current Trends: Introduce students to recent advances in various physics subfields (e.g., quantum technologies, nanomaterials, astrophysics, condensed matter, etc.).
- Promote Critical Analysis: Encourage students to analyze current research papers and synthesize key ideas for academic discussion.
- Refine Scientific Communication: Further develop students' ability to present technical content to a knowledgeable audience.
- Prepare for Internships/Projects: Equip students with an informed perspective for upcoming internships, dissertations, or industry placements.

Course Outcomes (COs): Upon completion of Seminar-II, students will be able to:

1. Identify and Explore Emerging Topics: Demonstrate awareness of modern research themes and their significance in contemporary physics.
2. Engage with Scientific Literature: Critically read and interpret current research papers, preprints, or review articles.
3. Synthesize and Present Knowledge: Deliver structured presentations that integrate complex information clearly and effectively.
4. Communicate Research Significance: Articulate the broader implications of a topic in both academic and applied contexts.
5. Transition Smoothly to Research/Industry: Enter internships or research projects with contextual knowledge and preparation.Lay the Foundation for Future Projects/Internships:

Set the stage for more comprehensive research work in the subsequent semester (e.g., Seminar-II/Internship Dissertation).

Seminar-II Guidelines

- Topic Selection: Each student, in consultation with a faculty mentor, will choose a topic aligned with current research trends in physics.
- Literature Review: Students must survey recent journal publications, conference proceedings, and scientific preprints.
- Seminar Report: A concise but well-organized seminar report (8–10 pages) summarizing the selected topic must be submitted before presentation.
- Presentation and Viva: Students will present their findings before an evaluation committee and respond to questions during the viva session.
- Continuity to Internship/dissertation work: Topics may be selected to align with potential fourth-semester internship or dissertation work.

Semester-IV

Semester IV					
Course Code	**Course Title**				**Type of Course**
MPHYIDI425	Dissertation/Internship				DI
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**
NA	0	0	24	24	24
Course Objective (CO):					

Course Outcomes (COs): After completing this course, students will be able to:

1. Demonstrate research aptitude and methodological skills in their chosen area
2. Develop and present a comprehensive research report or dissertation
3. Critically analyze research findings and communicate results effectively

Dissertation/Internship evaluation Guidelines	
Internal Assessment by Supervisor	**4 Credits**
Ongoing evaluation based on research progress, commitment, and adherence to academic timelines, conducted by the designated supervisor	
Mid-Semester Evaluation/Attendance	**4 Credits**
Interim assessment organized by the department/supervisor to evaluate the Regularity and attendance, research approach, methodology, and preliminary findings. May involve an external expert.	
Internship Dissertation	**6 Credits**
Assessment of the quality, structure, and originality, of the dissertation/report submitted at the conclusion of the internship. Evaluated by a panel including external examiners. **Note:** A plagiarism report, along with the dissertation, should be submitted to the department and allowed plagiarism percentage will be governed as per the university Plagiarism Policy.	
Final Presentation and Viva Voce	**10 Credits**
A comprehensive evaluation based on the final presentation and viva voce examination, conducted by a committee comprising supervisor, HOD, internal and external experts.	