Teaching and Examination scheme

Master of Science Two-Year (Four Semester Degree Course)
M.Sc. Sem- I (Physics Major Subject)

Level 6.0

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs) Theory	Tut	Prac	Total Credit	Evaluation Scheme			
				Th	Tu	P		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
1	DSC	Mathematical Physics	M-PH111T	4	--	--	4	3	60	40	50
		Electrodynamics	M-PH112T	4	--	--	4	3	60	40	50
2	DSE	1. Numerical Methods 2. Solid State Electronics	M-PH113T M-PH114T	4	--	--	4	3	60	40	50
3	DSC/DSE	Lab	M-PH115P	--	--	12	6	6	180	120	150
4	RM	Research Methodology	M-PH116T	4	--	--	4	3	60	40	50
Total				**16**	**--**	**12**	**22**		**420**	**280**	**--**

M.Sc. Sem- II (Physics Major Subject)

Level 6

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs)			Total Credit	Evaluation Scheme			
				Theory	Tut	Prac					
				Th	Tu	P		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
1	DSC	Quantum Mechanics - I	M-PH121T	4	--	--	4	3	60	40	50
		Classical Mechanics	M-PH122T	4	--	--	4	3	60	40	50
2	DSE	1. Molecular Modelling and Simulations 2. Applied Digital Electronics	M-PH123T M-PH124T	4	--	--	4	3	60	40	50
3	DEC/DSE	Lab	M-PH125P	--	--	12	6	6-8	180	120	75
4	OJT/FP	Internship / Apprenticeship/Field Project (Related to DSC)	M-PH126P	--	--	8	4	--	--	200	100
Total				**12**	**--**	**20**	**22**		**360**	**440**	**-**

M.Sc. Sem- III (Physics Major Subject)

Level 6.5

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs)			Total Credit	Evaluation Scheme			
				Theory	Tut	Pract					
				Th	Tu	P		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
1	DSC	Paper 1:- Quantum Mechanics -II	M-PH231 T	4	--	--	4	3	60	40	50
		Paper 2:- Statistical Physics	M-PH232 T	4	--	--	4	3	60	40	50
2	DSE	1. Atomic Molecular Physics 2. Material Science	M-PH233 T M-PH234 T	4	--	--	4	3	60	40	50
3	DSC/ DSE	Lab	M-PH235 P	--	--	12	6	6-8	180	120	150
4	RP	Research Project /Dissertation (Core)	M-PH236 P	--	--	8	4	--	--	200	100
Total				**12**	**--**	**20**	**22**		**360**	**440**	**-**

M.Sc. Sem- IV (Physics Major Subject)

Level 6.5

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs)			Total Credit	Evaluation Scheme			
				Theory	Tut	Prac					
				Th	Tu	P		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
1	DSC	Solid State Physics	M-PH241T	4	--	--	4	3	60	40	50
		Nuclear and Particle Physics	M-PH242T	4	--	--	4	3	60	40	50
2	DSE	1. Photonics 2.Nanoscience and Nanotechnology	M-PH243T M-PH244T	4	--	--	4	3	60	40	50
3	DSC/DSE	Lab	M-PH245P	--	--	8	4	6-8	120	80	100
4	RP	Research Project /Dissertation (Core)	M-PH246P	--	--	12	6	--	--	300	150
Total				**12**	**--**	**20**	**22**		**300**	**500**	**-**

Table showing total marks in theory and Practical semester wise

Semester	Theory	Practical	Total Marks
I	400	300	700
II	300	500	800
III	300	500	800
IV	300	600	900
Total	**1300**	**1900**	**2200**

Total Credits: Cumulative
Cumulative Credits required for PG in Major Subject (One Year PG Degree) = 44

Cumulative Credits required for PG in Major Subject (Two Year PG Degree) = 88

Abbreviations: On Job Training (Internship/Apprenticeship): OJT, Research Methodology: RM, Research Project: RP

Master of Science Two-Year (Four Semester Degree Course)
M.Sc. Sem- I (Physics Major Subject)

Level 6.0

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs)			Total Credit	Evaluation Scheme			
				Theory	Tut	Prac					
				Th	Tu	P		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
1	DSC	Mathematical Physics	M-PH111T	4	--	--	4	3	80	20	40
		Electrodynamics	M-PH112T	4	--	--	4	3	80	20	40
		Lab	M-PH113P	--	--	12	6	6	100	50	75
2	DSE	3. Numerical Methods 4. Solid State Electronics	M-PH114T	4	--	--	4	3	80	20	40
3	RM	Research Methodology	M-PH115T	4	--	--	4	3	80	20	40
Total				**16**	**--**	**12**	**22**		**420**	**130**	**--**

M.SC. –I SEMESTER - I

DSC: Paper-I: Course Code: M-PH111T

MATHEMATICAL METHODS FOR PHYSICS

Credit: 4

Marks- 60 (Credit 4, 4h/week) Time- 60 hours

OBJECTIVES:

1. To disseminate the concepts of mathematical physics regarding co-ordinate system.
2. To disseminate the concepts Laplace Transform, and Inverse transform.
3. To disseminate the fundamental knowledge of Linear vector space
4. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students gain knowledge of co-ordinate system, tensors, vector space, Laplace Transform, and Inverse transform.
2. They understand the special functions, their polynomial, and applications.
3. They apply the knowledge to solve problems based on above properties to strengthen their basics.

Unit I **15 hrs.**

Curvilinear co-ordinate Systems, Physical ideas about gradient, divergence, and Curl, Fourier Series: Definition, Dirichlet's condition, Convergence, Fourier Integral and Fourier transform, Convolution theorem, Parseval's identity, Applications to the solution of differential equations.

Unit II **15 hrs.**

Laplace transform of elementary functions – Inverse Laplace transforms – Methods of finding Inverse Laplace transforms – Heaviside expansion formula – Solutions of simple differential equations.

Unit III **15 hrs.**

Linear vector spaces - linear independent bases, Dimensionality, inner product, matrices, linear transformation, Matrices- Inverse, Orthogonal and Unitary matrices, Cayley Hamilton theorem, eigen vectors and eigen value problem, Diagonalization, Complete orthonormal sets of function.

Unit-IV **15 hrs.**

Linear differential equations, Special Function- Laguerre, Hermite, Legendre polynomials, Special Bessel's function, Spherical harmonics, Generating Function and recursion relations, differential and integral form.

References:

1. Mathematical Physics: A.W.Joshi

2. Mathematical Physics: H.K.Dass

3. Vector analysis – Newell

M.SC. –I SEMESTER - I
DSC: Paper II: Course Code: M-PH112T

ELECTRODYNAMICS

Credit: 4

Marks- 60 (Credit 4, 4h/week) **Time- 60 hours**

Course Objectives:

- To provide students with a solid understanding of the fundamental concepts and principles of electrostatics and magnetostatics.
- To introduce students to Maxwell's equations and their applications in time-varying fields.
- To develop students' ability to apply mathematical tools and techniques to solve problems in electrodynamics.
- To familiarize students with electromagnetic wave equations and the behavior of electromagnetic waves in different media.
- To explore the concepts of radiation emission and the interaction of electromagnetic fields with matter.
- To enable students to analyze and interpret electromagnetic phenomena and their practical applications in various fields.
- To cultivate critical thinking, problem-solving skills, and the ability to apply electrodynamics principles to real-world scenarios.

Program Outcomes:

By the end of the course, students should be able to:

- Understand and apply the principles of electrostatics and magnetostatics, including Gauss's law, Ampere's law, boundary conditions, and the Biot-Savart law.
- Solve boundary value problems and apply uniqueness theorems and the method of images in electrostatics and magnetostatics.
- Comprehend Maxwell's equations, including the differential form of Gauss's law and Ampere's law, and their applications in time-varying fields.
- Analyze and solve problems related to electromagnetic potentials, including scalar and vector potentials.
- Understand the energy, force, and momentum relations in electromagnetic systems and apply Poynting's theorem.
- Comprehend electromagnetic wave equations and analyze the behavior of electromagnetic waves in different media, including reflection, refraction, and the skin effect.
- Understand gauge transformations and apply them in different gauges.
- Analyze radiation emission phenomena, including the radiation of electric dipoles, magnetic dipoles, and moving charges.
- Apply electrodynamics principles to analyze the radiation and fields of oscillating sources and antennas.
- Interpret and evaluate electromagnetic phenomena and their practical applications in various fields, such as electrical engineering, telecommunications, and optics.
- The provided reference books offer additional resources and perspectives to further enhance students' understanding of electrodynamics, and they can be used as supplementary materials for the course.

Unit-I: Electrostatics and Magnetostatics: 15 hrs.

Dirac delta function, Gauss's law and applications, Differential form of Gauss's law, Poisson and Laplace's equations, Electrostatic potential energy, Boundary conditions, Uniqueness theorems, Method of images, Multipole expansion.

Biot-Savart law, Ampere's law, Differential form of Ampere's law, Vector potential, Magnetic field of a localized current distribution, Boundary conditions.

Unit-II: Time varying fields and Energy, force, momentum relations: 15 hrs.

Faraday's law, Maxwell's displacement current, Maxwell's equations, Maxwell's equations in matter, Scalar and vector potentials,

Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy.

Unit-III: Electromagnetic wave equations: 15 hrs.

Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Normal and Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth.

Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator,

Unit IV: Radiation emission: 15 hrs.

Electric dipole, electric quadrupole and magnetic dipole radiation, Radiation by a moving charge: Lienard-Wiechert potentials of a point charge, Larmor's formula, Angular distribution of radiation. Fields and radiation of a localized oscillating source, radiation from a half wave antenna, radiation damping.

Reference Books

1. Introduction to Electrodynamics: David Griffiths (PHI)
2. Electrodyanamics J. D. Jackson
3. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat (Narosa)
4. Classical theory of fields, Landau &Lifshitz
5. Electrodynamics, W. Panofsky and M. Phillips
6. Electromagnetism and Classified Theory, A. D. Barut, Dover
7. Electromagnetic theory and Electrodynamics, by Satya Prakash, KedarNath and Co.Meerut.
8. Electromagnetics by B.B.Laud, Willey Eastern.
9. Electrodynamics by Kumar Gupta and Singh.

M.SC. –I SEMESTER - I
DSC: Course Code: M-PH113P

PRACTICAL

OBJECTIVES:

1. Provide opportunities for scientific study, experimentally.
2. To disseminate the practical knowledge of various computational methods and programming
3. To disseminate the practical knowledge of simple computer language and syntax
4.

OUTCOMES:

1. They become skilful to design and perform experiments with good accuracy.
2. Students develop experimental skills in programming to execute computational methods.
3. They analyse experimental limitations and precautions.
4. They become skilful to design and perform experiments with good accuracy.

List of Practical:

Numerical Methods

1. Introduction to SCILAB: Variables and syntax
2. Introduction to SCILAB: Loops, arrays, conditions
3. Largest and smallest numbers
4. Bisection Method
5. Newton-Raphson Method
6. Matrix multiplication
7. Lagrange Interpolation
8. Linear Least Squares Fit
9. Simpson's rule integration
10. Runge - Kutta Method

M.SC. –I SEMESTER - I
DSE: Paper III: Course Code: M-PH114T

NUMERICAL METHODS

Credit: 4

OBJECTIVES:

1. To disseminate the knowledge of various computational methods and programming
2. To disseminate the knowledge of simple computer language and syntax
3. Provide opportunities for scientific study, experimentally.

OUTCOMES:

1. Students develop experimental skills in programming to execute computational methods.
2. They analyse experimental limitations and precautions.
3. They become skilful to design and perform experiments with good accuracy.

UNIT I **15 hrs.**

SCILAB for numerical computation and visualization. Basics of SCILAB: real numbers in double precision; arithmetics with SCILAB; how to use scripts and functions; vectors and matrices; line plots; and logical variables, conditional statements, loops.

UNIT II **15 hrs**.

Root finding technique to determine the roots, or zeros, of a given function. Root-finding methods: including the Bisection method, Newton's method, and the Secant method. Order of convergence for these methods. SCILAB code using Newton's method,

Fundamentals of quadrature, Trapezoidal rule and Simpson's rule; use of the SCILAB. Linear Interpolation. Linear least squares.

UNIT III **15 hrs.**

Gaussian elimination with large matrices, The LU decomposition algorithm must then incorporate permutation matrices. Count the number of required operations for Gaussian elimination, forward substitution, and backward substitution, Power method for eigenvalues of a matrix, Gaussian elimination to solve a system of nonlinear differential equations using Newton's method.

UNIT IV **15 hrs.**

Numerical integration of ordinary differential equations (ODEs). Euler method, and the Runge-Kutta methods, solving systems of ODEs. We will show how to use the SCILAB functions, and how to solve a two-point boundary value ODE.

References:

1. Introductory Methods of Numerical Analysis: S S Sastry
2. Computer Oriented Numerical Methods: V Rajaraman

M.SC. –I SEMESTER - I

DSE: Paper III: Course Code: M-PH114T

SOLID STATE ELECTRONICS

Credit: 4

Marks- 60 (Credit 4, 4h/week) **Time- 60 hours**

OBJECTIVES:

To provide the basic and advanced knowledge physics of electronics as various electronic devices and circuits are useful in the measurement of various physical parameters at master and research level**.**

OUTCOMES:

1. Students gain knowledge of Energy bands and charge carriers in semiconductor, diode, transistors, various rectifiers and integrated circuits.
2. They understand the importance of biasing of various circuits, to improve the efficiency and prevent the monitory losses.
3. They apply the knowledge to design small projects based on electronics helpful for the improvement in their depth of knowledge.

Unit I: **15hrs**

Energy bands and charge carriers in semiconductor: Formation of energy bands, Classification of solids on the basis of energy band structure, direct and indirect semiconductor, intrinsic and extrinsic materials, Fermi level and fermi distribution function applied to semiconductors, Electron and hole concentration at equilibrium.

Fabrication of p-n junction: grown junction, alloyed junction, diffused junction, ion implementation, contact potential, forward and reverse biased junction: qualitative description of current flow at a junction, reverse breakdown: Zener breakdown, avalanche breakdown, capacitance of p-n junction

Unit II: **15hrs**

Transistor biasing and thermal stabilization: Fabrication of transistor, Charge transport in BJT, Amplification with BJT and relation between $\alpha, \beta \ and \ \gamma$, operating point, bias stability, self-bias, emitter bias, voltage divider bias, stabilization against variation in I_{CO}, V_{BE} and β i.e. S, S', S'', CB and CC configurations in brief and CE configuration: input and output characteristics, CE cutoff and saturation region, typical transistor junction voltage values, Ebers-Moll model, Switching operation: Cutoff, Saturation, switching cycle, frequency limitations of transistor

Unit III: **15hrs**

Semiconductor discrete devices - special types of diodes: Zener diode, varactor diode, Schottky, MOS diodes, tunnel diode, photodiode, solar cells, LED, diode laser, IR emitters, LCDs, thermistors,

Junction field effect transistor (JFET), Metal-oxide-Semiconductor field effect transistor (MOSFET), unijunction transistor (UJT) and silicon controlled rectifier (SCR), phototransistor

Unit IV: **15hrs**

Integrated circuits: fabrication and characteristics- Integrated circuit technology, basic monolithic IC, epitaxial growth, masking and etching, diffusion of impurities, transistor for monolithic circuits, monolithic diodes, integrated resistors, integrated capacitors and inductors, monolithic circuit layout, Isolation methods, wafer of monolithic circuit testing, wire bonding and packaging

Reference books:

Milliman, J. Halkias, “integrated elctronics”, Tata McGraw Hill
Boylestad & Nashelsky, “Electronic devices & circuit theory”, PHI
Ben G. Streetman, “Solid state electronics devices”, PHI

M.SC. –I SEMESTER - I

RM: Paper IV: Course Code: M-PH115T

RESEARCH METHODOLOGY

Credit: 4

Course Objective:

1. To provide necessary knowledge, skills, and understanding of the research process in physics.
2. To familiarize students with various research methodologies, techniques, and tools commonly used in physics research.
3. To foster critical thinking, scientific reasoning, and ethical conduct in physics research.

Course Outcomes:

By the end of the research methodology course for physics, students should be able to:

1. Understand the nature and significance of research in physics, and appreciate its role in advancing scientific knowledge and technological advancements.
2. Design research studies, experiments, simulations, or theoretical models appropriate for addressing research questions in physics.
3. Develop skills in scientific writing, including writing research proposals, reports, and scientific papers following accepted standards and formats.
4. Understand the ethical considerations and responsible conduct of research in physics, including principles of intellectual property, authorship, and collaboration.

By achieving these course outcomes, students will be well-prepared to engage in independent research projects, pursue advanced studies in physics, or contribute to the scientific community through their research endeavours.

Syllabus

Unit I **15 Hours**

Scientific methods and their applications in physics research, Types of research in physics: experimental, theoretical, and computational, Formulation of Research Problem, Recognizing research questions and objectives, Review of literature and identifying gaps in knowledge, Developing hypotheses and research proposals, Research Design and Planning.

Unit II **15 Hours**

Selecting appropriate research methodologies and techniques, Designing experiments, simulations, or/and theoretical models, Identifying data collection methods and instruments.

Data Collection and Analysis: Techniques for collecting experimental, observational, or simulation data, Data processing, reduction, and analysis, Statistical methods and tools for analysing data in physics research, Data visualization and plotting techniques.

Experimental Techniques and Instrumentation: Principles of experimental physics, Laboratory safety and ethics, Handling and calibration of experimental equipment, Propagation of Errors.

Unit III **15 Hours**

Scientific Writing and Communication: Writing research proposals, reports, and scientific papers, scientific ethics and plagiarism, Policy for use of AI in paper writing, Presentation skills and effective communication of research findings.

Unit IV **15 Hours**

Research Presentation and Evaluation: Preparing and delivering effective research presentations, Peer review process and scientific evaluation, critically evaluating scientific literature and research findings.

Research Ethics and Responsible Conduct: Ethical considerations in physics research, Intellectual property and patents, Professional conduct, responsible authorship, and collaboration Research.

Reference Books

1. "Research Methodology: A Step-by-Step Guide for Beginners" by Ranjit Kumar
2. "Research Methodology: Methods and Techniques" by C.R. Kothari
3. Simplifying Physics Mathematics Research Methodology, Rajan Iyer
4. Research Methods for Science, M. P. Marder, Cambridge University Press, 2011
5. Research Methodology Techniques and Trends, Y. K. Singh and R. B. Bajpai, APH Publishing Corporation House, 2008.
6. Data Reduction and Error Analysis for the Physical Sciences 3rd Ed. by Philip R Bevington& D Keith Robinson, McGraw – Hill (2003)
7. Numerical Methods by Balagurusamy, Tata McGraw – Hill (2000)
8. "Computational Physics: Problem Solving with Python" by Rubin H. Landau, Manuel J. Paez, and Cristian C. Bordeianu
9. "Statistical Data Analysis for the Physical Sciences" by Adrian Bevan
10. LATEX for Engineers and Scientists by David J Buerger, McGraw Hill Pub. Co., NY, 1990.

M.Sc. Sem- II (Physics Major Subject)

Level 6

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs) Theory Th	Tut Tu	Prac P	Total Credit	Evaluation Scheme: Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
1	DSC	Quantum Mechanics - I	M-PH121T	4	--	--	4	3	80	20	40
		Classical Mechanics	M-PH122T	4	--	--	4	3	80	20	40
		Lab	M-PH123P	--	--	12	6	6	100	50	75
2	DSE	3. Molecular Modelling and Simulations 4. Applied Digital Electronics	M-PH124T	4	--	--	4	3	80	20	40
3	OJT/FP	Internship / Apprenticeship/Field Project (Related to DSC)	M-PH125P	--	--	8	4	--	80	20	50
Total				**12**	**--**	**20**	**22**		**420**	**130**	**-**

M.SC. –I SEMESTER - II
DSC: Paper I: Course Code: M-PH121T

QUANTUM MECHANICS-I

Credit: 4

Marks- 60 **Time- 60 hours.**

OBJECTIVES:

1. To disseminate the concepts of quantum mechanics with respect to initial development and various representations
2. To disseminate the fundamental knowledge of angular and generalized angular momenta.
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students gain knowledge of quantum mechanics with respect to initial development and various representations.
2. They the fundamental knowledge of angular and generalized angular momenta.
3. Apply the knowledge to solve problems based on above properties to strengthen their basics.

Unit- I **15 hrs.**

Time dependent and time-independent Schrodinger equation, continuity equation, wave packet, admissible wave functions, and stationary states. Formalism of wave mechanics, expectation values, quantum mechanical operators for position and momentum in the coordinate representation, Construction of quantum mechanical operators for other dynamical variables from those of position and momentum, Ehrenfest's theorem, momentum eigen functions in the coordinate Representation, box normalization and Dirac delta function. Coordinate and momentum representations, Schrodinger equation in momentum representation,

Unit-II **15 hrs.**

Brief revision of linear vector spaces, inner or scalar product, Schwarz inequality, state vectors, general formalism of operator mechanics vector, operator algebra, commutation relations, eigen values and eigen vectors, Hermitian operators degeneracy, orthogonality eigenvectors of Hermitian operators, noncommutativity of two operators and uncertainty in the simultaneous measurements of the corresponding dynamical variables, the fundamental expansion postulate, representation of state vector, Dirac's bra-ket notations. Matrix representation of operators, change of basis, unitary transformations, quantum dynamics, Schrodinger, Heisenberg, and interaction picture.

Unit-III **15 hrs.**

Solution of Schrodinger equation for simple problems, 1-D Square well, step and barrier potentials, 1-D harmonic oscillator, zero-point energy. harmonic oscillator problem by operator method.
Angular momentum operator, commutation relations, expression for L^2 operator in spherical polar coordinates, Role of L^2 operators in central force problem, eigen value problem for L^2 , separation of Schrodinger equation in radial and angular parts, solution of radial equation for hydrogen atom, 3-d square well potential, parity of wave function, parity operator.

Unit-IV **15 hrs.**

Generalized angular momentum, raising, and lowering operators, matrices for J2, Jx, Jy, Jz operators, Pauli spin matrices, Addition of angular momenta, Clebich-Gordon Coefficient, spin angular momentum, spin momentum functions.

References:

1. Quantum mechanics: L.I.Schiff
2. Quantum mechanics: Mathews and Venkatesan
3. Quantum mechanics :Ghatak and Loknathan
4. Quantum mechanics: B.Craseman and J.D.Powell
5. Modern quantum mechanics: J.J.Sakurai
6. Quantum Theory D. Bohm, (Asia Publishing House)

M.SC. –I SEMESTER - II
DSC: Paper II: Course Code: M-PH122T

CLASSICAL MECHANICS

Credit: 4

Marks- 60 **Time- 60 hours.**

OBJECTIVES:

1. To disseminate the deep knowledge of Newtonian, Lagrangian and Hamiltonian of the classical particles
2. To disseminate the fundamental knowledge of rigid dynamics and central force motion
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students understand the Newtonian, Lagrangian and Hamiltonian equations of the classical particles.
2. They understand the basics of rigid dynamics and central force motion.
3. Apply the knowledge to solve problems based on above properties to strengthen their basics.

Unit-I **15 hrs.**

Survey of elementary principles of mechanics of a particle, Dynamical systems, Phase space dynamics, stability analysis, constraints & their classifications, D'Alemberts Principle, Variational Principle, Lagrange's equation, Hamilton's Principle

Unit-II **15 hrs.**

Conservation theorems and symmetry properties, Hamiltonian formalism, Hamilton's equations, Routh's procedure for cyclic coordinates, conservation laws Canonical transformations, Poisson brackets and Poisson theorems, Hamilton-Jacobi Theory

Unit-III **15 hrs.**

Central force motion, reduction to one body problem, equations of motions and first integrals, classification of orbits for inverse square central forces. Two body collisions, Rutherford scattering in laboratory and centre-of-mass frames.

Unit-IV **15 hrs.**

Rigid body dynamics, Euler's angles, Euler's theorem, moment of inertia tensor, eigen values and principal axis transformation, non-inertial frames and Pseudo forces, Periodic motion, small oscillations, normal modes.

References:

1. Classical Mechanics: H. Goldstein
2. Classical Mechanics: N.C.Rana and P.S.Joag

M.SC. –I SEMESTER - II

DSC: Course Code: M-PH123P

PRACTICAL

Credit: 6

1. Determination of e/m by Thomson method.
2. Determination of e/m by Busch's helical beam method.
3. Study of paramagnetic to ferromagnetic phase transition.
4. Study of Paramagnetic salt by Guoy's balance
5. Differential scanning Calorimetry
6. Determination of Plank's constant.
7. Determination of Stephan's constant.
8. Generation of Random Numbers
9. Simulation of Random walk problem in 1D and 2D
10. Simulation of MB, FD and BE statistics.
11. Numerical solution of particle in a box.
12. Simulation of Maxwell's velocity distribution.

M.SC. –I SEMESTER - II
DSE: Paper III: Course Code: M-PH124T
MOLECULAR MODELLING AND SIMULATIONS

Credit: 4

OBJECTIVES:

1. To disseminate the knowledge of Modelling and Simulation
2. To disseminate the practical knowledge of Modelling and simulation tools
3. Provide opportunities for scientific study of molecular systems

OUTCOMES: After the course completion student will be able to,

1. Preform classical molecular simulations
2. Preform quantum mechanical simulations
3. Determine electronic and mechanical properties of molecules

Part I: Particle and Continuum Methods

Unit I **15hrs**

1 Introduction, Continuum modelling and solution approaches
2 Statistical mechanics,
3 Basics of molecular dynamics and Monte Carlo
4 Visualization and data analysis
5 Mechanical properties

Unit –II **15hrs**

1 Multi-scale modelling paradigm
2 Modelling chemical interactions
3 Application to modelling brittle materials
4 Reactive potentials and applications
5 Applications to biophysics

Part II: Quantum Mechanical Methods

Unit III **15hrs**

1. Basics of quantum mechanics
2. The Many-Body Problem
3. From many-body to single-particle
4. Quantum modelling of molecules
5. Applications of quantum modelling

Unit IV **15hrs**

1. Hydrogen Storage, Atoms to Molecules
2. From atoms to solids
3. Quantum modelling of solids: Basic properties
4. Advanced properties of materials
5. Solar Photovoltaics

References

1. Daan Frenkel_ Berend Smit - Understanding molecular simulation from algorithms to applications (2002, Academic Press) - libgen.lc
2. Tamar Schlick, Molecular Modeling and Simulation An Interdisciplinary Guide. Springer
3. Herma Cuppen, Introduction in Molecular Modeling (dictaat.pdf (ru.nl)
4. Alan Hinchliffe, Molecular Modelling for Beginners UMIST, Manchester, Willey
5. DAVID S. SHOLL and JANICE A. STECKEL DENSITY FUNCTIONAL THEORY A Practical Introduction Willey
6. Wolfram Koch, Max C. Holthausen, A Chemist’s Guide to Density Functional Theory

M.SC. –I SEMESTER - II
DSE: Paper III: Course Code: M-PH124T
APPLIED DIGITAL ELECTRONICS

Credit: 4

OBJECTIVES:

1. To disseminate the knowledge of Logic circuits
2. To disseminate the practical knowledge of Binary counters
3. Provide opportunities for scientific study, memory devices

OUTCOMES:

After the course completion student understand

1. How to design logic gates and circuits Logic circuits
2. Construction and working of Binary counters
3. Memory devices, their working and design.

Unit I **15 hrs.**

Binary and decimal number systems, NOT, OR, AND gates using transistor, truth tables and Boolean equations of NAND, NOR & EXOR gates, Binary addition and subtraction, 2's compliment representation, Representing decimal numbers as 2's complements, Binary addition and subtraction, multiplication and division using 2's compliments. De Morgan's theorems, Duality theorem, SOP and POS methods, Karnaugh maps upto 4 variables, Multiplexers (4:1 and 8:1) and Demultiplexers (1:4 and 1:8), half adder and full adder

Unit II **15 hrs.**

Flip-flops: RS ff using NOR and NAND gates, Clocked RS ff, D-ff, JK-ff, JKMS-ff, Clock waveform, IC 555 and its application as astable and monostable multivibrator, Shift registers: SISO (4 bit using D-ff), SIPO, PISO, PIPO (4 bit using RS ff), Ring counter (4 bit using D-ff), Asynchronous counters, UP/DOWN counters, Synchronous counters, MOD-3, MOD-5 and MOD-7 counters

Unit III **15 hrs.**

D/A converters: variable resistor network, binary ladder, A/D converters: counter type, Single slope-pulse width or voltage to time, Dual slope

Semiconductor memories: ROM, RAM, EPROM, EEPROM, Flash memory, DRAM, SRAM, SDRAM, F-RAM and MRAM

Unit IV **15 hrs.**

Integrated circuit technologies: TTL: Two input TTL NAND, Two input TTL NOR gates, Inverter, TTL input and output profile, concept of open collector gates, Need of three state TTL devices, three state buffer

CMOS: Two input TTL NAND, Two input TTL NOR gates, Inverter

Comparison of TTL and CMOS technologies (advantages and disadvantages)

Introduction to PLDs: Simple Programmable Logic Devices (SPLDs), Complex Programmable Logic Devices (CPLDs) and Field-Programmable Gate Arrays (FPGAs).

Reference books:

Digital Principles and Applications by Malvino & Leach: Mc Graw Hill publication
Digital Fundamentals by Thomas Floyd and R. P. Jain: PEARSON education
Digital Electronics by Kale, Gokhale and Dharmadhikari: Das Ganu Publication

M.SC. –I SEMESTER - II

Course Code: M-PH125P

Internship / Apprenticeship/Field Project (Related to DSC)

Credit: 4

OBJECTIVES:

1. To disseminate the Internship experience
2. Provide opportunities for scientific projects

OUTCOMES:

1. Students develop experimental skills in research
2. They analyze experimental limitations, precautions and future scope

Internship

Each student has to take a part time internship in the field of science and technology.

M.Sc. Sem- III (Physics Major Subject)

Level 6.5

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs)			Total Credit	Evaluation Scheme			
				Theory	Tut	Pract					
				Th	Tu	P		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
1	DSC	Paper 1:- Quantum Mechanics -II	M-PH231T	4	--	--	4	3	80	20	40
		Paper 2:- Statistical Physics	M-PH232T	4	--	--	4	3	80	20	40
		DSC Lab	M-PH233P	--	--	12	6	6	100	50	75

2	DSE	2. Atomic Molecular Physics 2. Material Science	M-PH234T	4	--	--	4	3	80	20	40
3	RP	Research Project /Dissertation (Core)	M-PH235P	--	--	8	4	--	50	50	50
Total				**12**	**--**	**20**	**22**		**390**	**160**	**-**

M.SC. –II SEMESTER - III

DSC: Paper I: Course Code: M-PH231T

QUANTUM MECHANICS-II

Credit: 4

Marks- 60 **Time- 60 hours.**

OBJECTIVES:

1. To disseminate the concepts of quantum mechanics with respect perturbation, variational WKB techniques
2. To disseminate the fundamental knowledge of identical particles and scattering
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students gain knowledge of respect perturbation, variational WKB techniques
2. They the fundamental knowledge of identical particles and scattering
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Time independent perturbation theory, first order perturbation theory applied to nondegenerate states, second order perturbation extension to degenerate state, Application of perturbation theory to the ground state energy, He atom (calculation given in Pauling and Wilson), Normal and anomalous Zeeman effect, First order Stark effect in the ground and first excited states of H atom and second order Stark effect of H atom, an-harmonic oscillator.

Unit II **15 hrs.**

Time dependent perturbation theory, transition rate, Fermi Golden rule, constant perturbation harmonic in time, radiative transitions, absorption, and induced emission, atomic radiation, dipole approximation, Einstein's atomic radiation, Einstein's A and B coefficients and their calculations. Approximation methods: W. K. B. method and its application to barrier penetration. Variational principle and its application to simple cases like ground state of He atom and deuteron in Yukawa potential.

Unit III **15 hrs.**

System of identical particles, exchange and transposition operators, totally symmetric and antisymmetric wave function and their expressions for a system of non-interacting particles, statistics of systems of identical particles, Relation of statistics with spin, Ortho and para states of the helium atom and their perturbation by Coulomb repulsion. Hamiltonian of a molecule, Born-Oppenheimer approximation, outline of Heitler-London theory of the hydrogen molecule. Scattering theory, scattering cross-section in laboratory and centre of mass system, scattering by a central potential, Partial wave method, phase shifts and their importance, scattering by a square well potential and a perfectly rigid sphere, resonance scattering.

Unit IV **15 hrs.**

Relativistic wave equation, the Klein-Gordon equation, and initial difficulties in interpreting its solutions, Dirac's relativistic equation, Dirac's matrices, explanation of the spin of the electron, equation for an electron in an electromagnetic field and explanation of the magnetic moment due to the electron spin, spin-orbit interaction, solution for hydrogen atom in Dirac's theory, negative energy states and their qualitative explanations.

References:

1. E. Merzbacher, Quantum Mechanics (Wiley and Sons-Toppon)
2. J. L. Powell and B. Crasemann, Quantum mechanics (B I Publications)
3. L. I. Schiff, Quantum Mechanics (McGraw-Hill)
4. Quantum Mechanics: Aruldhas
5. Pauling and Wilson, Introduction to Quantum Mechanics
6. A.K. Ghatak and Lokanathan, Quantum Mechanics (Macmillan, India)
7. Quantum Mechanics: 500 problems with Solutions: Aruldhas (PHI)

M.SC. –II SEMESTER - III

DSC: Paper II: Course Code: M-PH232T

STATISTICAL PHYSICS

Credit: 4

Marks- 60 **Time- 60 hours.**

OBJECTIVES:

1. To disseminate the importance of statistical mechanics
2. To solve the problems in classical and quantum domains by using statistical mechanics
3. Provide opportunities for scientific study and creativity.

OUTCOMES:

1. Students should be able to apply statistical tools to solve the problems in Physics
2. Students should be able identify the connection between statistical mechanics and thermodynamics
3. Students should be able to compare and apply Classical and quantum distributions

Unit I **15 hrs.**

Scope and aim of statistical mechanics, mean values, standard deviation, variance, probability distribution, binomial, Poisson and Gaussian distributions, Maxwell velocity distribution, momentum, and energy distribution, Microstates and macrostates, phase space

Unit II **15 hrs**

Postulate of equal a priori probability, Ergodic hypothesis, Liouville's theorem, Statistical equilibrium, ensembles (micro-canonical, canonical, and grand-canonical), partition function, free energy and connection with thermodynamic quantities, barometric formula, ideal gas, Gibbs paradox, equipartition theorem.

Unit III **15 hrs**

Fundamentals of quantum statistical mechanics, Symmetry of wave functions, BE and FD Statistics, Boltzmann limit of Bosons and Fermions, Ideal Bose system: Bose-Einstein condensation, Bose temperature, specific heat from lattice vibration, Debye model

Unit IV **15 hrs.**

Ideal Fermi system: Fermi energy as a function of temperature, Fermi temperature, mean energy of fermions at absolute zero, atomic nucleus as an ideal fermion gas, Fermionic condensation, Fermi gas in metals, Electronic specific heat

Text and Reference Books:

1. Fundamentals of Statistical Physics: B. B. Laud

2. Statistical and Thermal Physics: F. Reif

3. Statistical Mechanics: Loknathan and Gambhir

4. Statistical Physics: Landau and Lifshitz

M.SC. –II SEMESTER - III

DSC: Course Code: M-PH233P

PRACTICAL

Credit: 6

M.SC. –II SEMESTER - III

DSE: Paper III: Course Code: M-PH234T

ATOMIC AND MOLECULAR PHYSICS

Credit: 4

Marks- 60 **Time- 60 hours.**

OBJECTIVES:

1. To disseminate the knowledge of atomic spectra like electron spin, helium and alkali spectra NMR spectra
2. To disseminate the fundamentals of rotational and vibrational and electronic spectra
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain deep knowledge of atomic spectra like electron spin, helium and alkali spectra NMR spectra
2. They gain knowledge of rotational and vibrational and electronic spectra
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Quantum states of an electron in an atomic Electron spin, spectrum of hydrogen, Helium and alkali atoms, Relativistic corrections for energy levels of hydrogen; Basic principles of interaction of spin and applied magnetic field. Concepts of NMR spectroscopy concepts of spin-spin and spin-lattice relaxation, chemical shift; spin-spin coupling between two and more nuclei; chemical analysis using NMR. Mossbauer effect-Recoil less emission of gamma rays, chemical shift, magnetic hyperfine interaction

Unit II **15 hrs.**

Electron spin resonance, experimental setup, hyperfine structure and isotopic shift, width of spectral lines, LS & JJ coupling, Zeeman, Paschen Back & Stark effect. Spontaneous and Stimulated emission, Einstein A & B Coefficients; LASERS, optical pumping, population inversion, rate equation, modes of resonators and coherence length, Role of resonant cavity, three and four level systems, Ammonia MASER, ruby, He-Ne, CO2, dye and diode lasers, Lasers applications

Unit III **15 hrs.**

Rotational, vibrational and Raman spectra of diatomic molecules, Quantum theory, Molecular polarizability, Intensity alteration in Raman spectra of diatomic molecules, Experimental setup for Raman spectroscopy in the structure determination of simple molecules. polyatomic molecules, symmetric top asymmetric top molecules. Hunds rule.

Unit IV **15 hrs.**

Electronic spectra of diatomic molecules, Born Oppenheimer approximation, Vibrational Coarse structure of electronic bands, intensity of electronic bonds, Franck Condon principle, and selection rules, dissociation and pre dissociation, dissociation energy, rotational fine structure of electronic bands. General treatment of molecular orbitals, Hund's coupling cases.

References:

1. Molecular Spectroscopy: - Jeane L. McHale.
2. Mossbauer spectroscopy –M. R. Bhide.
3. NMR and Chemistry – J. W. Akitt.
4. Structural Methods in inorganic chemistry, E.A V.Ebsworth, D. W. H.Rankin, S.Crdock.
5. Introduction to Atomic Spectra – H. E. White.
6. Fundamental of Molecular Spectroscopy – C. B. Banwell.
7. Spectroscopy Vol. I, II and III, Walker and Straghen.
8. Introduction to Molecular Spectroscopy – G. M. Barrow.
9. Spectra of diatomic molecules – Herzberg.
10. Molecular spectroscopy – Jeanne L. McHale.

M.SC. –II SEMESTER - III

DSE: Paper III: Course Code: M-PH234T

MATERIALS SCIENCE

Credit: 4

Marks- 60 **Time- 60 hours.**

OBJECTIVES:

1. To disseminate the deep knowledge of phase diagram, phase transformation
2. To disseminate the fundamental knowledge of diffusion in solids, synthesis, processing of materials and structure determination
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students understand the phase diagram, phase transformation
2. They understand the basics of diffusion in solids, processing of materials and structure determination.
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Equilibrium and kinetics: Stability and metastability, Basic thermodynamic functions, Statistical nature of entropy, Kinetics of thermally activated process.

Phase diagrams: The phase rule, free energy composition diagram, correlation between free energy and phase diagram, calculation of phase boundaries, thermodynamics of solutions, single component system (water), two component system containing two phases and three phases, Binary phase diagrams having intermediate phases, Binary phase diagrams with eutectic system. Lever principle, maximum, minimum, super lattice, miscibility gap, microstructure changes during cooling, application to zone refining.

Unit – II **15 hrs.**

Phase transformations: Time scale for phase changes, peritectic reaction, eutectoid and eutectic transformations, order disorder transformation, transformation diagrams, dendritic structure in alloys, transformation on heating and cooling, grain size effect on rate of transformation at constant temperature and on continuous cooling, grain size effect on rate of transformation, nucleation kinetics, growth kinetics, interface kinetics leading to the crystal growth.

Unit-III **15 hrs.**

Diffusion in solids: Fick's laws and their solutions, the Kirkendall effect, mechanism of diffusion, temperature dependence of diffusion co-efficient, self-diffusion, interstitial diffusion, the Snoek effect in diffusion, diffusion in ionic crystals, diffusion path other than the crystal lattice, thermal vibrations and activation energy, diffusion of carbon in iron.

Concept of Synthesis: Concept of equilibrium and nonequilibrium processing and their importance in materials science. Synthesis of materials: Physical method – Bottom up: cluster beam evaporation, Ion beam deposition, Gas evaporation, Chemical method – Hydrothermal, combustion, bath deposition with capping techniques and top down: Ball milling. Thermal decomposition – reduction methods.

UNIT-IV 15 hrs.

Processing of materials: Metallic, non-metallic and other materials. Only basic elements of powder technologies, compaction, sintering calcination, vitrification reactions, with different example, porosity. Quenching: concept, glass formation.

Diffraction techniques: Electron and neutron diffraction. Interpretation of x-ray powder diffraction patterns, Identification & quantitative estimation of unknown samples by X-ray powder diffraction technique.

Microscopic techniques: TEM, SEM & STEM, AFM and XPS.

References:

1. Vanvellak: Materials Science.
2. V. Raghvan: Materials Science.
3. D. Kingery: Introduction to ceramics.
4. R. E. Reedhil: Physical metallurgy.
5. Kittel: Solid state physics, Vth edition.
6. M. A. Azaroff: Elements of crystallography
7. Chemical approaches to the synthesis of inorganic materials, C. N. R. Rao Wiley Eastern Ltd.1994.
8. Materials Science and Engineering – An Introduction, W. D. Callister, Jr. John Wiley & Sons,1991.
9. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa, Academic Press (1998).

M.SC. –II SEMESTER - III

Course Code: M-PH235P

RESEARCH PROJECT/ DISSERTATION (core)

Credit: 4

OBJECTIVES:

3. To disseminate the research skill
4. Provide opportunities for scientific projects

OUTCOMES:

3. Students develop experimental skills in research
4. They analyze experimental limitations, precautions and future scope

Project Work (Theoretical/Experimental work, Thesis submission and Defence)

Each student has to take a part time project for the duration of one semester (3rd semester) in the field of Physics under the supervision of assigned faculty. Student's M.Sc project thesis will be reviewed and he/she has to defense his/her thesis by giving 30 min seminar+Viva on the project results in front of the Examiners.

M.Sc. Sem- IV (Physics Major Subject)

Level 6.5

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs)			Total Credit	Evaluation Scheme			
				Theory	Tut	Prac		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
				Th	Tu	P					
1	DSC	Solid State Physics	M-PH241T	4	--	--	4	3	80	20	40
		Nuclear and Particle Physics	M-PH242T	4	--	--	4	3	80	20	40
		DSC Lab	M-PH243P	--	--	8	4	4-6	80	20	50
2	DSE	1. Photonics 2.Nanoscience and Nanotechnology	M-PH244T	4	--	--	4	3	80	20	40
3	RP	Research Project /Dissertation (Core)	M-PH245P	--	--	12	6	--	75	75	75
Total				**12**	**--**	**20**	**22**		**395**	**155**	**-**

M.SC. –II SEMESTER - IV

DSC: Paper II: Course Code: M-PH241T

SOLID STATE PHYSICS

Credit: 4

Marks- 60 **Time- 60 hours.**

OBJECTIVES:

1. To disseminate the concepts of solid state physics
2. To disseminate the fundamental knowledge of 1D, 3D crystal lattice and various phenomenon in solids
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students gain knowledge of concepts of solid state physics
2. They the fundamental knowledge of 1D, 3D crystal lattice and various phenomenon in solids
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

UNIT I: Density of states, k-space, Origin of energy gap, Bloch theorem, Kronig- Penney model, Construction of Brillouin zones, Extended and reduced zone schemes, Effective mass of an electron, Tight binding approximation, Magnetism: Quantum theory of paramagnetism, Magnetism of iron group and rare earth ions, Exchange interactions, Pauli paramagnetic susceptibility.

UNIT II: Concept of lattice mode of vibration, phase velocity, group velocity of harmonic waves, Harmonic approximation, Lattice vibrations of linear monoatomic chain, Lattice vibrations of linear diatomic chain, Dispersion relations, Acoustic and optical phonons, Theories of lattice specific heat: Einstein model and Debye model, Born procedure, anharmonicity and thermal expansion.

UNIT III: Electron moving in 1-D and 3-D potential wells, Quantum state and degerneracy, Electrical conductivity of metals, Thermal conductivity of metals, Relaxation time and mean free path, electrical resistivity of metals, Free carrier concentration in semiconductors, Fermi level and carrier concentration in semiconductors, Effect of temperature on mobility and electrical conductivity of semiconductor, Hall effect in conductors and semiconductors.

UNIT IV: Phenomenon of Superconductivity, Type I and Type II superconductors, Meissener effect, isotope effect, London equations, London penetration depth, Coherence length, Two fluid model of superconductivity, Elements of BCS theory, Tunnelling, DC Josephson effect, AC Josephson effect, SQUID, High TC superconductors (elementary)

References:

1. Solid State Physics, Charles Kittel, John Willey & Sons
2. Materials Science and Engineering: V. Raghavan
3. Solid State Physics: S. O. Pillai (New Age International 2006)
4. Solid State Physics, by Abdul Ali Omar, Pearson Publication, Delhi

5. Solid State Physics, by Saxena, Gupta, Mandal, Pragati prakashan
6. Introduction to solids by Azaroff, Wiley publication
7. Solid state physics by Singhal

M.SC. –II SEMESTER - IV

DSC: Paper II: Course Code: M-PH242T

NUCLEAR AND PARTICLE PHYSICS

Credit: 4

Marks- 60 **Time- 60 hours.**

Objectives:

1. To disseminate the knowledge of nuclear properties, decay processes and elementary particles

2. To disseminate the fundamental knowledge of nuclear eraction mechanism, various terminologies and working of nuclear reactors, and nuclear accelerators

3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain knowledge of various nuclear properties, decay processes, elementary particles

2. They gain knowledge of nuclear reaction mechnism and different types of nuclear reactions

3. Studnets gain the knowledge of nuclear accelerators

3. They can apply the knowledge to solve problems to strengthen their concepts

Unit I: Basic Nuclear Properties and Nuclear Models **15 Hours**

Nuclear properties: Nuclear Radius & its determination by Rutherford scattering, electron scattering & mirror nuclei method, Nuclear mass, Nuclear quantum numbers, Angular momentum, nuclear dipole moment, electric quadruple moment, Nuclear Binding, average binding energy and its variation with mass number, Semi empirical mass formula & its applications, Liquid drop model: assumptions, achievements, Bohr Wheeler theory of fission, Failure and limitations of liquid drop model, Nuclear shell model: spin orbit coupling, nuclear magic numbers, experimental evidences of magic numbers, Extreme single particle shell model, significance, achievements and limitations, magnetic moment and Schmidt lines.

Unit II: Nuclear Decay Reactions **15 Hours**

Radioactive decay, Unit of Radioactivity, laws of successive transformation, dosemetry, Alpha Decay: Velocity of Alpha Particles, Disintegration Energy, Range-Energy Relationship, Geiger-Nuttal Law, Gamow theory, Beta decay: Fermi theory of β- decay, Kurie plot, Angular momentum and parity, selection rules, allowed and forbidden transitions, non conservation of parity in β- decay, Origin of Beta Spectrum-Neutrino Hypothesis, Gamma decay: Decay Scheme of 137Cs &60Co Nuclei, Internal Conversion, Internal Pair Creation.

Unit III: Nuclear Reaction Dynamics, Nuclear Reactors, Accelerators **15 Hours**

Nuclear reactions: conservation laws, mechanism, and cross section, compound nucleus, direct reactions, partial wave analysis, Fission and Fusion Reactions, Reactors: Fission Chain Reaction, Four Factor Formula, Multiplication Factor, General Properties and Concepts of Nuclear Reactors, Reactor Materials, Types of Reactors, Reactors Developed in India, Accelerators: Classificaqtion and applications in various fields, Cyclotron, Betatron, Light Hydron Collidor (LHC)

Unit IV: Elemetary Particles 15 Hours

Classification of elementary particles, Basic interactions in nature, quantum numbers associated with elemetray particles: charge, mass, spin, parity, iso-spin, strangeness etc. Gellmann-

Nishijima formula, Symmetry theories, Gell-Mann-Okubo mass formula, Charge conjugation, Parity inversion, Time reversal, CPT theorem, Quark theory: Classification scheme, Quantum chromodynamics, Grand unification theory, Higg's Boson.

References:

1. Nuclear Physics, D.C.Tayal,(Himalaya Publishing House, Mumbai)

2. Introduction to Elementary Particles, D. Griffiths, 2nd Ed., Academic Press, 2008.

3. Introductory Nuclear Physics, S.S.M. Wong, 2nd Ed., Wiley VCH, 2004

4. Nuclear Physics, Kaplan, Addison Wesley, (Indian Ed., from Narosa Publishing House,

New Delhi), 2002.

5. Introduction to nuclear physics , S.B Patel

6. Concept of Nuclear Physics, B.L. Cohen, McGraw-Hill, 2003.

7. Nuclear & Particle Physics: An Introduction, B. Martin, Willey, 2006.

8. Atomic and Nuclear Physics, S.N. Ghoshal, S. Chand

M.SC. –II SEMESTER -IV

DSC: Course Code: M-PH243P

PRACTICAL

Credit: 6

M.SC. –II SEMESTER - IV
DSe: Paper II: Course Code: M-PH244T

PHOTONICS

Credit: 4

Marks- 60 **Time- 60 hours.**

Objectives:

1. To disseminate the knowledge of fundamental optics concepts

2. To disseminate the fundamental knowledge of Fourier optics techniques and near field optics principles
3. Provide opportunities for scientific study and creativity

Program Outcomes (POs):

- **Optical Principles:** Understand fundamental optics concepts.
- **Fourier Optics Proficiency:** Master Fourier optics techniques.
- **Near Field Application:** Apply near field optics principles.
- **Advanced Photonics:** Grasp advanced photonics topics.
- **Problem-solving Skills:** Develop strong research and problem-solving abilities.

Unit I **15h**

Fundamentals of Modern Optics: Wave propagation, wave particle duality, Derivation of Kramers - Kronig relations and their physical significance, Electromagnetic fields in homo and inhomogeneous dispersive media, diffraction theory, Polarization of light. Numerical problems.

Unit II **15h**

Fourier Optics: Plane waves, spatial frequency, Optical Fourier Transform, Diffraction of light, special function in Photonics and their Fourier transform, convex lens and its function, Image formation, spatial filters, Holography, Applications of Holography, Numerical problems

Unit III **15h**

Near field optics: Near field and far field light, evanescent waves, generation and properties of evanescent waves, quantum confinement of light, Application in Near field microscopy: Photon tunnelling microscope, scanning near field optical microscope, Numerical problems.

Unit IV **15h**

Quantum optics: Radiation pressure of laser light, Optical Tweezers and its applications, Laser cooling of atoms: fundamentals and advances, Experimental realization of Bose Einstein Condensate, Application of B E condensate, Concept of Atom laser, Numerical problems.

REFERENCES:

1. Keigo Iizuka, “Elements of PHOTONICS Vol. 1 (In free space and special media) and 2 (for fiber and integrated optics),” Wiley Series in Pure and Applied Optics.

2. Eugene Hecht, “Optics (International Edition),” Addison Wesley, (2003).

3. F G Smith, T A King and D Wilkins, “Optics and Photonics: An Introduction,” John Wiley & Sons, Ltd, San Francisco, USA, (2007).

4. David J. Griffiths, “Introduction to Electrodynamics (3rd edition),” Pearson Publishers.

5. Born and Wolf, “Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light,” Cambridge University Press.

6. Joseph W Goodman, “Introduction to Fourier Optics,” McGraw-Hill.

7. Hand Book/Optics, Vol. 1-IV, Optical Society of India, McGraw Hill.

8. Fundamental and review research articles on all units

M.SC. –II SEMESTER - IV

DSe: Paper II: Course Code: M-PH244T

NANOSCIENCE AND NANOTECHNOLOGY

Credit: 4

Marks- 60 **Time- 60 hours.**

OBJECTIVES:

1. To disseminate the deep knowledge of nanoscience
2. To disseminate the fundamental knowledge of synthesis, characterization and applications of nanoparticles
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students understand the nanoscience fundamentals
2. They understand the basics knowledge of synthesis, characterization and applications of nanoparticles
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Introduction to Nanoscience: Free electron theory (qualitative idea) and its features, Idea of band structure, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, dots, Factors affecting to particle size, Structure property relation, Size dependence properties. Determination of particle size, Increase in width of XRD peaks of nano-particles, Shift in photoluminescence peaks, Variation on Raman spectra of nano-materials.

Unit II: **15 hrs.**

Synthesis of Nanomaterials: Physical methods**:** High energy Ball Milling, Melt mixing, Physical vapour deposition, Ionised cluster beam deposition, Laser ablation, Laser pyrolysis, Sputter deposition, Electric arc deposition, Photolithography.

Chemical methods**:** Chemical vapour deposition, Synthesis of metal & semiconductor nanoparticles by colloidal route, Langmuir-Blodgett method, Microemulsions, Sol-gel method, Combustion method, Wet chemical method

Unit III: **15 hrs.**

Nanomaterials Characterizations: X-ray diffraction, UV-VIS spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy, Transmission Electron Microscopy, Scanning Electron Microscopy, Scanning Tunnelling Electron Microscopy, Atomic Force Microscopy, Vibration Sample Magnetometer, Spintronics

Unit IV: **15 hrs.**

Special Nanomaterials and Properties: Carbon nanotubes, porous silicon, Aerogels, Core shell structures. Self-assembled nanomaterials. Metal and semiconductor nanoclusters Mechanical, Thermal, Electrical, Optical, Magnetic, Structural properties of nanomaterials

References:

1. Nanotechnology: Principles &Practicals. Sulbha K. Kulkarni, Capital Publishing Co.New Delhi.

2. Nanostructures & Nanomaterials Synthesis, Properties & Applications**.** Guozhong Cao, Imperials College Press London.

3.Nanomaterials: Synthesis, Properties & Applications**.** Edited by A.S. Edelstein &R.C.Commorata.Institute of Physics Publishing, Bristol & Philadelphia.

4. Introduction to Nanotechnology. C.P. Poole Jr. and F. J.Owens, Wiley Student ed.

5. Nano: The Essentials. T. Pradeep , McGraw Hill Education.

6. Handbook of Nanostructures: Materials and Nanotechnology. H. S. Nalwa Vol 1- 5, Academic Press, Bostan.

7. Hand Book of Nanotechnology, Bhushan

8. Nanoscience and Technology: Novel Structure and Phenomena. Ping and Sheng

M.SC. –II SEMESTER - IV

Course Code: M-PH245P

RESEARCH PROJECT/ DISSERTATION (core)

Credit: 4

OBJECTIVES:

5. To disseminate the research skill
6. Provide opportunities for scientific projects

OUTCOMES:

5. Students develop experimental skills in research
6. They analyze experimental limitations, precautions and future scope

Project Work (Theoretical/Experimental work, Thesis submission and Defence)

Each student has to take a part time project for the duration of one semester (4^{th} semester) in the field of Physics under the supervision of assigned faculty. Student's M.Sc project thesis will be reviewed and he/she has to defense his/her thesis by giving 30 min seminar+Viva on the project results in front of the Examiners.