FACULTY OF SCIENCES

SYLLABUS
of
Master of Science (Physics)
(Semester: I -IV)

(Under Credit Based Continuous Evaluation Grading System)

(CBCEGS)

Session: 2025-26

The Heritage Institution

KANYA MAHA VIDYALAYA JALANDHAR (Autonomous)

Kanya Maha Vidyalaya, Jalandhar (Autonomous)

SCHEME AND CURRICULUM OF EXAMINATIONS OF TWO-YEAR DEGREE PROGRAMME
(Under Credit Based Continuous Evaluation Grading System) (CBCEGS)

Master of Science (Physics)

SESSION 2025-26

SEMESTER-I

Course Code	Course Title	Course Type	Hours Per Week	Credits L-T-P	Total Credits	Marks				Examination time (in Hours)
						Total	Ext.		CA	
							L	P		
MPHL-1391	Analog and Digital Electronics	C	4	4-0-0	4	100	70	-	30	3
MPHL-1392	Mathematical Physics	C	4	4-0-0	4	100	70	-	30	3
MPHL-1393	Classical Mechanics	C	4	4-0-0	4	100	70	-	30	3
MPHL-1394	Computational Techniques	C	4	4-0-0	4	100	70	-	30	3
MPHM-1395	Introduction to Glass Science and Glass Ceramics	C	4	3-0-1	4	100	40	30	30	3+3
MPHP-1396	Electronics Lab	C	6	0-0-3	3	100	-	70	30	3
MPHP-1397	Computer Lab	C	6	0-0-3	3	100	-	70	30	3
Student may opt any one of the following Interdisciplinary courses		IDE			4	100	70		30	3
Total				**26**		**600**				
IDEC-1101	Communication Skills									
IDEM-1362	Basics of Music (Vocal)									
IDEH-1313	Human Rights and Constitutional Duties									
IDEI-1124	Basics of Computer Applications									
IDEW-1275	Indian Heritage: Contribution to the world (Credits of these courses will not be added to SGPA)									

Master of Science (Physics) SEMESTER-II

Course Code	Course Title	Course Type	Hours Per Week	Hours Per Week L-T-P	Total Credits	Total	Ext.		CA	Examination time (in Hours)
							L	P		
MPHL-2391	Quantum Mechanics-I	C	4	4-0-0	4	100	70	-	30	3
MPHL-2392	Electrodynamics-I	C	4	4-0-0	4	100	70	-	30	3
MPHL-2393	Condensed Matter Physics-I	C	4	4-0-0	4	100	70	-	30	3
MPHL-2394	Atomic and Molecular Spectroscopy	C	4	4-0-0	4	100	70	-	30	3
MPHP-2395	Condensed Matter Physics Lab -I	C	6	0-0-3	3	100	-	70	30	3
MPHP-2396	Spectroscopy Lab	C	6	0-0-3	3	100	-	70	30	3
Total				**22**		600				

	Master of Science (Physics) SEMESTER-III									
Course Code	**Course Name**	**Course Type**	**Hours Per Week**	**Credits L-T-P**	**Total Credits**	**Marks**				**Examination time (in Hours)**
						Total	**Ext.**		**CA**	
							L	**P**		
MPHL-3391	Quantum Mechanics-II	C	4	4-0-0	4	100	70	-	30	3
MPHL-3392	Electrodynamics-II	C	4	4-0-0	4	100	70	-	30	3
MPHL-3393	Condensed Matter Physics-II	C	4	4-0-0	4	100	70	-	30	3
MPHL-3394	Nuclear Physics	C	4	4-0-0	4	100	70	-	30	3
MPHP-3395	Condensed Matter Physics Lab-II	C	6	0-0-3	3	100	-	70	30	3
MPHP-3396	Nuclear Physics Lab	C	6	0-0-3	3	100	-	70	30	3
Student may opt any one of the following Interdisciplinary courses		IDE			4	100	70		30	3
Total				**22**	**22**	**600**				

IDEC-3101	Communication Skills
IDEM-3362	Basics of Music (Vocal)
IDEH-3313	Human Rights and Constitutional Duties
IDEI-3124	Basics of Computer Applications
IDEW-3275	Indian Heritage: Contribution to the world
	(Credits of these courses will not be added to SGPA)

Master of Science (Physics) SEMESTER-IV										
Course Code	**Course Name**	**Course Type**	**Hours Per Week**	**Credits L-T-P**	**Total Credits**	**Total**	**Ext.**		**CA**	**Examination time (in Hours)**
							L	**P**		
MPHL-4391	Particle Physics	C	4	4-0-0	4	100	70	-	30	3
MPHL-4392	Statistical Mechanics	C	4	4-0-0	4	100	70	-	30	3
MPHL-4393 (OPT-II)	Student may choose any two subjects from the following list of options	C	4	4	4	100	70	-	30	3
MPHL-4394 (OPT-V)		C	4	4	4	100	70	-	30	3
MPHD-4395	Project Work	C	12	0-0-6	6	100	-	70	30	3
Total credits				**22**	**22**	**500**				

OPT-I	Photonics
OPT-II	Radiation Physics
OPT-III	Reactor Physics
OPT-IV	Nanotechnology
OPT-V	Material Science
OPT-VI	Space Science

Program Specific Outcomes: M.Sc. (Physics)

After the successful completion of the program, the student will be able to do the following

PSO 1. The Master of Science in Physics program provides detailed functional knowledge of the fundamental theoretical concepts and experimental methods of physics. It will help the candidate to enhance her general competence, and analytical skills on an advanced level, and will prepare her according to the jobs needed in education, research or public administration.

PSO 2. Demonstrate a deep understanding of fundamental principles across various branches of physics including glass science and proficiency in computational tools, numerical methods, and programming languages relevant to physics.

PSO 3. The student will have the understanding of the basic concepts of classical mechanics, quantum mechanics, statistical mechanics and electricity and magnetism to appreciate how diverse phenomena observed in nature follow from a small set of fundamental laws through logical and mathematical reasoning and their applications in emerging technologies.

PSO 4. Acquire proficiency in experimental techniques, data analysis, and problem-solving in physics.

PSO 5. Demonstrate adaptability to emerging technologies and tools relevant to the field of physics and enhance communication skills for effectively presenting scientific findings and collaborating within interdisciplinary teams.

PSO 6. The student will be able to critically apply the knowledge gained during the course to scientific models and solve problems in the areas of electrodynamics, quantum mechanics, classical mechanics, statistical mechanics, glass science and advanced mathematical methods.

PSO 7. Gain expertise in various fields of Physics, and correlate relativistic principles with classical mechanics and electrodynamics.

PSO 8. General competence

The candidate will be able to

- Understand the role of physics in society and know the historical development of physics, its possibilities and limitations, and understand the value of lifelong learning.
- Gather, assess, and make use of new information.

Master of Science (Physics)
SEMESTER-I
(SESSION 2025-26)
COURSE CODE: MPHL-1391
ANALOG AND DIGITAL ELECTRONICS

COURSE OUTCOMES

After passing this course the student will be able to:

CO 1. Explain the construction and working principles of electronic devices (MOSFET, UJT, SCR) and analyze the characteristics and applications of these devices in electronic circuits.

CO 2. Explain the principles and characteristics of operational amplifiers and Identify and analyze the practical applications of OP-AMPs in various electronic circuits.

CO 3. Demonstrate proficiency in designing and analyzing digital circuits, including the use of binary and hexadecimal number systems, binary arithmetic, logic gates, Boolean algebra, and various digital components such as encoders, decoders, multiplexers, demultiplexers, parity generators, and adder-subtractor circuits.

CO 4. Apply the understanding of flip-flops, registers, etc, to design integrated digital systems, incorporating binary weighted resistor networks, ladder D/A converters, and successive approximation A/D converters.

Master of Science (Physics) SEMESTER-I
(SESSION 2025-26)

COURSE CODE: MPHL-1391

ANALOG AND DIGITAL ELECTRONICS

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Total Teaching hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT-I: Electronic Devices and semiconductor Memories

MOSFETs, construction and working of U.J.T. and SCR and their application in wave generation and power control. Types of Memories, Read/Write Memory, ROM, EPROM, EEPROM, static dynamic memory, memory cell: static RAM Memory cells, NMOS static cells.

Hours 15

UNIT-II: Electronic Circuits:

Operational amplifier (OP-AMP), OP-AMP as inverting and non-inverting, scalar, summer, integrator, differentiator. Schmitt trigger and logarithmic amplifier, Electronic analog computation circuits **Hours 15**

UNIT-III: Digital Principles:

Binary and Hexadecimal number system, Binary arithmetic, Logic gates, Boolean equation of logic circuits, Karnaugh map simplifications for digital circuit analysis, and design, Encoders & Decoders, Multiplexers and Demultiplexers, Parity generators and checkers, Adder-Subractor circuits. **Hours 15**

UNIT-IV: Sequential Circuits:

Flip Flops, Registers, Up/Down counters, D/A conversion using binary weighted resistor network, Ladder, D/A converter, A/D converter using counter, Successive approximation A/D converter. **Hours 15**

Text and Reference Books

1. Electronic Devices and Circuits by Millman and Halkias-Tata McGraw Hill, 1983.
2. Digital Principles and Applications by A.P.Malvino and D.P.Leach-Tata McGraw Hill, New Delhi, 1986.
3. Digital Computer Electronics by A P Malvino-Tata McGraw Hill, New Delhi, 1986
4. Electronic Devices and Circuit Theory 10e by Robert L. Boylestad; Louis Nashelsky 2009.

Master of Science (Physics) SEMESTER-I

(SESSION 2025-26)

COURSE CODE: MPHL-1392

MATHEMATICAL PHYSICS

COURSE OUTCOMES

On completion of this course a student will be able to:

- CO 1. gain proficiency in general coordinate transformations and algebraic operations on tensors. They will be able to demonstrate Fourier series, Fourier and Laplace transforms, applying these concepts to analyze and solve problems in wave theory and develop the capability to apply the toolsets for solving complex physics problems.
- CO 2. understand the concept of analytical functions and will apply these concepts to explore the applications in calculating real integrals.
- CO 3. gain proficiency in mathematical functions crucial in physics, including, exponential integrals functions, and differential functions making them capable of solving complex mathematical problems in various scientific disciplines.
- CO 4. develop a comprehensive understanding of group theory with a solid foundation in abstract algebra and its applications in understanding symmetries and transformations in various mathematical and physical contexts.

Master of Science (Physics) SEMESTER-I
(SESSION 2025-26)

COURSE CODE: MPHL-1392
MATHEMATICAL PHYSICS

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Total Teaching hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT-I: Coordinates systems, Fourier and Laplace transform.
Curvilinear coordinates, Differential vector operators in curvilinear coordinates, spherical and cylindrical systems, General coordinate transformation, Tensors: covariant, contra variant and Mixed, Algebraic operations on tensors, Illustrative applications.
Fourier decomposition, Fourier series and convolution theorem, Fourier transforms and its applications to wave theory. Laplace Transform, Laplace transforms of derivatives and integrals, Inverse Laplace transform, Application of Laplace Transform. **20Hours**

UNIT-II: Complex analysis.
Function of a complex variables, Analytical functions and Cauchy–Riemann conditions, Cauchy integral theorem, Cauchy integral formula, Taylor and Laurent series, singularities and residues, Cauchy residue theorem, calculations of real integrals. **10Hours**

Unit –III: Differential equations and Special Functions.
Second order differential equations, Frobenions method, Wronskian and a second solution, the Strum Liouville theorem, one dimensional Green's function. Gamma functions. The exponential integral and related functions, Bessel functions of the first and second kind, Legendre polynomials, associated Legendre polynomials and spherical harmonics, Generating functions for Bessel, Legendre and associated Legendre functions, Hermite Functions.
20Hours

UNIT-IV: Group theory:
Definition of a group, multiplication table, conjugate elements and classes of groups, direct product Isomorphism, homomorphism, permutation group, definition of the three dimensional rotation groups and SU(2) **10Hours**

Text and Reference Books
1. Mathematical Methods for Physicist by George Arfken-New York Academy,
2. Mathematical Physics by P.K. Chattopadhyay, New Age International, 1990.
3. Mathematical Methods in th Physical Sciences, 3ed Mary L. Boas

Master of Science (Physics) SEMESTER-I

(SESSION 2025-26)

COURSE CODE: MPHL-1393

CLASSICAL MECHANICS

COURSE OUTCOMES

On completion of this course a student will be able to:

CO 1. Understand the formulation of mechanics using generalized coordinates, D'Alembert's principle, and Lagrange equations of motion, particularly for conservative systems and apply the formulation to practical utilities.

CO 2. explore the equivalent one-dimensional problem, classify orbits, and delve into the Virial theorem and will be known to advanced analytical tools to model and comprehend celestial mechanics, planetary motion, and particle scattering in central force fields.

CO 3. understand Legendre transformations and Hamilton's equations of motion to explore the concepts of cyclic coordinates and associated conservation theorems, providing insights into the foundations of Hamiltonian mechanics.

CO 4. explore small oscillations, covering the eigenvalue equation, free vibrations, normal coordinates, and vibrations of a triatomic molecule.

Master of Science (Physics) SEMESTER-I
(SESSION 2025-26)
COURSE CODE: MPHL-1393
CLASSICAL MECHANICS

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT-I: Lagrangian Mechanics

Newton's laws of motion, mechanics of a system of particles, constraints, generalized coordinates D'Alembert's principle and Lagrange equations of motion for conservative systems, simple applications of Lagrangian formulation. **Variational Principles:**Hamiltons principle, some techniques of the Calculus of variations, derivation of Lagrange equations from Hamilton's principle, conservation theorems and symmetry properties. **Hours 15**

UNIT-II: Central Force Problem

Two body central force problem, reduction to equivalent one body problem, the equation of motion and first integrals, the equivalent one dimensional problem, and
classification of orbits, the Virial theorem, the differential equation for the orbit, conditions for closed orbits, the Kepler problem, scattering in a central force field (Rutherford scattering cross section formula). **Hours 15**

UNIT-III: Hamiltonian Mechanics

Legendre transformation and Hamilton equations of motion, cyclic coordinates and conservation theorems, derivation of Hamilton's equations from a variational principle, the principle of least action, simple applications of Hamiltonian formulation.

Canonical Transformations: The equations of canonical transformation, examples of canonical transformations, Poisson brackets, equations of motion, infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation, Hamilton-Jacoby theory. **Hours 15**

UNIT-IV: Rigid Body Dynamics

The independent coordinates of a rigid body, orthogonal transformation,
the Euler angles, Euler's theorem on the motion of rigid body, finite and infinitesimal rotations, rate of change of a vector, angular momentum and kinetic energy about a point for a rigid body, the inertia tensor and moment of inertia, the eigen values of the inertia tensor and the principal axis transformation. Euler's equations of motion, torque free motion of a rigid body.

Small Oscillations: Eigenvalue equation, Free vibrations, Normal Coordinates, vibrations of a triatomic molecule. **Hours 15**

Reference Books:

1. Classical Mechanics by Herbert Goldstein-Narosa Pub. House, New Delhi, 1970.
2. Mechanics by L.D. Landau-Pergamon Press, Oxford, 1982.
3. Classical Mechanics by Rana and Joag-Tata McGraw Hill, New Delhi, 1995.

Master of Science (Physics) SEMESTER-I

(SESSION 2025-26)

COURSE CODE: MPHL-1394

COMPUTATIONAL TECHNIQUES

COURSE OUTCOMES

On completion of this course a student will be able to:

- CO 1. gain knowledge about MATLAB programming languages and its need in research and development to solve various mathematical problems.
- CO 2. understand advanced skills in interpolation to apply them to effectively estimate values between known data points and apply these techniques in various mathematical and computational scenarios.
- CO 3. apply advanced computational tools for accurately approximating definite integrals and solving differential equations in diverse scientific and engineering applications.
- CO 4. expertise in finding approximate values of roots using various numerical methods such as the Bisection Method, Regula-Falsi Method, and the Newton-Raphson method, as well as the Bairstow method for polynomial root approximation.

Master of Science (Physics) SEMESTER-I

(SESSION 2025-26)

COURSE CODE: MPHL-1394

COMPUTATIONAL TECHNIQUES

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT-I: Introduction of MATLAB

Introduction: Basics of MATLAB, working with arrays, creating and printing plots, Interacting Computations: Matrices and Vectors, Matrices and Array Operations, built in functions, saving and loading data, plotting simple graphs Programming in MATLAB: Script files, function files, Compiled files, p-code, variables, loops, branches, and control flow, Input/Output, Advanced data objects, structures, cells **Hours18**

UNIT-II: Interpolation

Interpolation, Newton's formula for forward and backward interpolation, Divided differences, Symmetry of divided differences, Newton's general interpolation formula, Lagranges interpolation formula **Hours12**

UNIT-III: Numerical Differentiation and integration

Numerical integration, A general quadrature formula for equidistant ordinates, Simpson, Weddle and Trapezoidal rules, Monte- Carlo Method, Euler's method, Modified Euler's method, Runge Kutta Method. **Hours15**

UNIT-IV: Roots of Equation

Approximate values of roots, Bisection Method, Regula-Falsi Method, Newton-Raphson method, Bairstow method. Simultaneous Linear Algebraic Equations: Solution of Simultaneous Linear equations, Gauss elimination method, Gauss-Jordon method, Matrix inversion, finding eigen values and eigen vectors, matrix factorization, Curve fitting and Interpolation; polynomial curve fitting, least square curve fitting **Hours15**

Text and Reference Books

1. Getting started with MATLAB by RudraPratap-OxfordUniversityPress-2005.
2. A concise introduction to MATLAB by William JPalm III-McGrawHill-2008.
3. Numerical Mathematical Analysis by James Scarborough (Oxford and IBH),1966.
4. Elementary Numerical Analysis by S.D. Conte (McGrawHill),1965.
5. Numerical Methods for Mathematics by John. H. Methews Science and Engineering(Prentice Hall of India).

Master of Science (Physics) SEMESTER-I

(SESSION 2025-26)

COURSE CODE: MPHL-1395

Introduction to Glass Science and Glass Ceramics

COURSE OUTCOMES

On completion of this course a student will be able to:

Course Outcomes:

After completing this course a student will be able to

CO1: Select appropriate raw materials for different types of glass based on their bonding nature (metallic, covalent, ionic) and amorphous/crystalline characteristics.

CO2: Utilize temperature-enthalpy relationships to design energy-efficient thermal processing protocols in glass manufacturing industries. Enables students to predict glass formation tendencies in new compositions for applications such as solar panels, optical fibers, or biomedical devices.

CO3: learn about historical developments in glasses and glass batch preparation. They will learn about physical and thermal properties of glasses..

CO4: Will learn about the commercial applications of the glasses and role of indian industries in glass technology. They will get hands-on glass preparation

Master of Science (PHYSICS) (SEMESTER–I)
(SESSION 2025-26)
COURSE TITLE: Introduction to Glass Science and Glass Ceramics
COURSE CODE: MPHM-1395
Credits: 3-0-1 Max Marks: 100 (ESE Marks: 40 (Theory), 30 (Practical) CA: 30)
Examination Time: 3 Hours Pass Mark: 14

Instructions for the Paper Setters:

Eight questions of equal marks are to be set, two from each of the four sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section. Each question carries 8 marks.

Note: Students can use Non-Scientific calculators or logarithmic tables.

Unit 1

Classification of Materials on the basis of structure: Crystalline Vs Non. Crystalline, Nature of Bonding in Materials: Metallic, ionic, covalent and mixed bonding, amorphous materials, Definition of Glass, Glasses found in nature.

Unit 2

Enthalpy/Temperature (V-T) Diagram, Glass transition and crystallization temperature, Zachariasen Structural Theories of Glass Formation, Glass-forming oxides and the concept of glass formers, modifiers, and intermediates, Nucleation and Crystal Growth.

Unit 3

Historical development of glasses, Types of glasses, Glass Preparation methods, Determination of Physical properties and thermal characterization, glass ceramics.

Unit 4

Applications of glass and important commercial compositions, Role of Indian industries, Challenges faced, future scope, Open Problems

Reference Books:

1. Fundamentals of Inorganic Glasses by Arun K. Varshneya and John C. Mauro
2. Introduction to Glass Science and Technology by J.E. Shelby
3. Glass Science by Robert H. Doremus

Master of Science (PHYSICS) (SEMESTER–I)
(SESSION 2025-26)

Introduction to Glass Science and Glass Ceramics

Course Code: MPHM-1395 (P)

Credits: 0-0-1 **Max Marks: 30**

Examination Time: 3 Hours **Pass Mark: 11**

COURSE OUTCOMES

After successful completion of this lab, the student will be able to:

CO1: Perform batch calculations for glass preparation.

CO2: Demonstrate hands-on skills in laboratory procedures for preparation of glass and glass ceramics.

CO3: Carry out lapping and polishing of glass samples.

CO4: Understand and apply the principles of absorption spectroscopy.

Master of Science (PHYSICS) (SEMESTER–I)
(SESSION 2025-26)

Introduction to Glass Science and Glass Ceramics

Course Code: MPHM-1395 (P)

Credits: 0-0-1 **Max Marks: 30**

Examination Time: 3 Hours **Pass Marks: 11**

General Guidelines for Practical Examination

I. The distribution of marks is as follows:

i) One experiment 10 Marks

ii) Brief Theory 10 Marks

iii) Viva–Voce 5 Marks

iv) Record file 5 Marks

LIST OF EXPERIMENTS:

1. Learn the principles and methods of batch calculations for glass preparation.
2. Prepare a 10 g batch of borosilicate glass.
3. Synthesize glass–ceramics from the prepared borosilicate glass.
4. Perform lapping and polishing of glass samples.
5. Conduct absorption spectroscopy on the prepared glass specimens.

Master of Science (Physics) SEMESTER-I
(SESSION 2025-26)
COURSE CODE: MPHP-1396
ELECTRONICS LAB

COURSE OUTCOMES
After successfully completion of this lab student will be able to

CO1: Characterise and understand the applications of DIAC, TRIAC, UJT and SCR.

CO2: Investigate characteristics of MOSFET and Multivibrators.

CO3: understand experimentally working of Operational Amplifier and its applications

CO4: basics about Digital Logic circuits from logic gates to ALU.

Master of Science (Physics) SEMESTER-I

(SESSION 2025-26)

COURSE CODE: MPHP-1396

ELECTRONICS LAB

Credits: 0-0-3 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Out of 100 Marks, Continuous Assessment (based on mid-semester test/ class performance, written assignment/project work etc.) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

LIST OF EXPERIMENTS:

1. To Study the DC characteristics and applications of DIAC.
2. To study the DC characteristics and applications of SCR.
3. To study the DC characteristics and applications of TRIAC.
4. Investigation of the DC characteristics and applications of UJT.
5. Investigation of the DC characteristics of MOSFET.
6. Study of bi-stable, mono-stable and astable, multivibrators.
7. Study of Op-Amps and their applications such as an amplifier (inverting, non-inverting), scalar, summer, differentiator and integrator.
8. Study of logic gates using discrete elements and universal gates.
9. Study of encoder, decoder circuit.
10. Study of arithmetic logic unit (ALU) circuit.
11. Study of shift registers.
12. Study of half and full adder circuits.
13. Study of A/D and D/A circuits.

Master of Science (Physics)SEMESTER-I
(SESSION 2025-26)
COURSE CODE: MPHP-1397
COMPUTER LAB

COURSE OUTCOMES

After completion of this lab Student will be

CO1: familiar with various MATLAB syntaxes and techniques to carry out simple calculations.

CO2: able to develop MATLAB programs to find roots of equations.

CO3: able to apply MATLAB commands to plot simple graphs in 2D.

CO4: able to write MATLAB programs to solve numerical integration, numerical differentiation and interpolation.

Master of Science (Physics) SEMESTER-I

(SESSION 2025-26)

COURSE CODE: MPHP-1397

COMPUTER LAB

Credits: 0-0-3 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**

Out of 100 Marks, Continuous Assessment (based on mid-semester test/ class performance, written assignment/project work etc.) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

LIST OF EXPERIMENTS:
1.Determination of Roots

a) Bisection Method
b) Newton Raphson Method
c) Secant Method
2.Integration

a) Trapezoidal rule
b) Simpson1/3andSimpson3/8rules
c) Gaussian Quadrature
3.Differential Equations

a) Euler's Method
b) Runge Kutta Method

4.Interpolation

a) Forward interpolation, Backward interpolation.
b) Lagrange's interpolation.
5.Applications

a) Chaotic Dynamics, logistic map
b) One dimensional Schrondinger Equation
c) Time period calculation for a potential
d) Luminous intensity of a perfectly blackbody vs. temperature

Master of Science (Physics) SEMESTER-II

(SESSION 2025-26)

COURSE CODE: MPHL-2391

QUANTUM MECHANICS-I

COURSE OUTCOMES

This course develops concepts in quantum mechanics such that the behavior of the physical universe could be understood from a fundamental point of view. It provides a basis for further study of quantum mechanics

CO 1. The very first outcome of the course is that the student will learn the mathematical tools needed to solve quantum mechanics problems. This will include Hilbert spaces, and the theory of operator algebra and the concept that quantum states could be described in a vector space.

CO 2. The student will be able to understand the concept of time evolution and the relation between Hamiltonian and time evolution. They will be capable of learning the time evolution of quantum systems.

CO 3. The student will be able to apply the concepts of quantum mechanics to solve the one- and three-dimensional problems of quantum mechanics to understand the basics of atomic structures and the wave mechanics of these atoms.

CO 4. The student will learn the basic concepts of spin and angular momentum and the role of spherical harmonics in determining the shape of electronic clouds around the nucleus. They will also learn about applications of total angular momentum.

Master of Science (Physics) SEMESTER-II

(SESSION 2025-26)

COURSE CODE: MPHL-2391

QUANTUM MECHANICS-I

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT-I: ***Basic Formulation and quantum Kinematics:*** Stern Gerlach experiment as a tool to introduce quantum ideas, analogy of two level quantum systems with polarisation states of light. Complex linear vector spaces, ket space, bra space and inner product, operators and properties of operators .Eigen kets of an observable, eigen kets as base kets, matrix representations. Measurement of observable, compatible vs incompatible observable, commutators and uncertainty relations. Change of basis and unitary transformations. Diagonalisation of operators. Position, momentum and translation, momentum as a generator of translations, canonical commutation relations. Wave functions as position representation of ket vectors. Momentum operator in position representation, momentum Space wave function. **Hours18**

UNIT-II: ***Quantum Dynamics:*** Time evolution operator and Schrödinger equation, special role of the Hamiltonian operator, energy eigen kets, time dependence of expectation values, spin precession. Schrodinger vs. Heisenberg picture, unitary operators, state kets and observables in Schrodinger and Heisenberg pictures, Heisenberg equations of motion, Ehrenfest's theorem. Simple harmonic oscillator Energy eigenvalues and eigenvectors of SHO, Matrix representation of creation and annihilation operators, Zero-point energy; Coherent states. **Hours12**

UNIT-III: Symmetry Principles: Symmetry and conservation laws, Space time translation and rotations. Conservation of linear momentum, energy and angular momentum. Unitary transformation, Symmetry and Degeneracy, space inversion and parity. Time reversal invariance. **Hours12**

UNIT-IV: Spherical Symmetric Systems and Angular momentum*:* Schrodinger equation for a spherically symmetric potential. Orbital angular momentum commutation relations. Eigenvalue problem for L^2, spherical harmonics. Three dimensional harmonic oscillator, three dimensional potential well and the hydrogen atom. Angular momentum algebra, commutation relations. Introduction to the concept of representation of the commutation relations in different dimensions. Eigenvectors and eigenfunctions of J^2 and Jz. Addition of angular momentum and C.G. coefficients. **Hours18**

Text and Reference Books

1. Modern Quantum Mechanics by J.J. Sakurai-Pearson Educaton Pvt.Ltd.,New Delhi,2002.
2. A textbook of Quantum Mechanics by P M Mathews, K Venkatesan, MccGraw Hill Education
3. Quantum Mechanics: Concepts and Applications by N. Zettili, John Wiley & Sons.
4. Quantum Mechanics by Merzbacher JohnWiley&Sons, NewYork,1970.
5. Quantum Mechanics (2nd Ed.) by V.K. Thankappan, New Age International Publications,

Master of Science (Physics) SEMESTER-II

(SESSION 2025-26)

COURSE CODE: MPHL-2392

ELECTRODYNAMICS-I

COURSE OUTCOMES

After passing this course the students will be able to:

CO 1. Explore advanced electrostatics and delve into methods of images, multipole expansion, and solving boundary value problems using Green's function. they will be able to apply these tools for problem-solving in dielectric environments.

CO 2. Analyze magnetic moments, forces, and torques acting on magnetic dipoles within external fields. Examine the dynamics of charged particles in static and uniform electromagnetic fields.

CO 3. Investigate vector and scalar potentials, revealing the general expression for electromagnetic field energy. Understand gauge transformations, including Lorentz and Coulomb gauges.

CO 4. Explore superposition of waves in one dimension, emphasizing group velocity and the propagation of pulses in dispersive media and examine electromagnetic waves in conductive media, incorporating a simple model for conductivity.

Master of Science (Physics) SEMESTER-II
(SESSION 2025-26)
COURSE CODE: MPHL-2392
ELECTRODYNAMICS-I

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT-I: Electrostatics: Coulomb's law, Gauss's law and its applications, Scalar potential, Poisson's equation, Laplace equation. method of images, multipole expansion, Solution of boundary value problems: Green's function and its calculation for the image charge problem in the case of a sphere, uniqueness theorem. Electrostatics of dielectric media, Boundary value problems in dielectrics; molecular polarizability, electrostatic energy in dielectric media. **Hours 18**

UNIT-II: Magnetostatics: Biot and Savart's law. The differential equation of Magnetostatics and Ampere's law, magnetic vector potential and magnetic fields of a localized current distribution. Magnetic moment, force and torque on a magnetic dipole in an external field. Dynamics of charged particles in static and uniform electromagnetic fields. Magnetic materials, Magnetization and microscopic equations. **Hours 12**

UNIT-III: Time-varying fields: Electromagnetic induction. Faraday's law of induction, Energy in a magnetic field. Maxwell's displacement current, Maxwell's equations in free space and linear isotropic media; vector and scalar potential, General Expression for the electromagnetic fields energy, Gauge transformations; Lorentz gauge and Coulomb gauge. Poynting theorem, conservation laws for a system of charged particles and electromagnetic field, Equation of continuity

Hours 15

UNIT-IV: Electromagnetic Waves: Plane wave-like solutions of the Maxwell equations. Polarization, linear and circular polarization. Superposition of waves in one dimension. Group velocity. Illustration of propagation of a pulse in a dispersive medium. Reflection and refraction of electromagnetic waves at a plane surface between dielectrics. Polarization by reflection and total internal reflection. Interference, coherence, and diffraction. Waves in conductive medium, Simple model for conductivity.

Hours 15

Text and Reference Books

1. Introduction to Electrodynamics - D.J. Griffiths-Pearson Education Ltd., New Delhi,1991.
2. Classical Electrodynamics - J.D. Jackson-John & Wiley Sons Pvt. Ltd. New York, 2004.
3. Classical Electromagnetic Radiation - J.B. Marion-Academic Press, New Delhi, 1995.
4. Classical Electrodynamics: S.P. Puri, (Tata McGraw Hill, New Delhi)

Master of Science (Physics) SEMESTER-II
(SESSION 2025-26)
COURSE CODE: MPHL-2393
CONDENSED MATTER PHYSICS-I

COURSE OUTCOME

After studying this course, the students will be able to understand:

CO1: various theories related to heat capacities and significance of lattice heat capacity and phonons

CO2: about various types of lattice defects, dislocations and grain boundaries and their role in cryatal growth.

CO3: concepts related with electrical and thermal conductivities and relation between them as well as concepts of activation and hydration energies.

CO4: properties and concepts related to Dielectrics and FerroElectrics and thermodynamics of ferroelectric transitions

Master of Science (Physics) SEMESTER II
(SESSION 2025-26)
COURSE CODE: MPHL-2393
CONDENSED MATTER PHYSICS-I

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

Unit-I: Lattice Specific Heat and Elastic Constants

Different theories of lattice specific heat of solids, Einstein model of the Lattice Specific heat, Density of modes of vibration, Debye model of Lattice specific heat, Born cut-off procedure, Specific heat of metals. Elastic strain and stress components, Elastic compliance and stiffness constants, Elastic constants of cubic crystals, Elastic waves in cubic crystals.

Unit-II: Defects and Diffusion in Solids

Point defects: Impurities, Vacancies-Schottky and Frankel vacancies, Diffusion, Fick's law, Self diffusion in metals, Color centers and coloration of crystals, F-centres, V-centres, Line defects, Edge and screw dislocations, Burgers vectors, Stress field of dislocations, Grain boundaries, Low angle grain boundaries, dislocation densities, Dislocation multiplication and slips, dislocation and crystal growth.

Unit-III: Conductivity of metals and ionic crystals

Electrical conductivity of metals, Drift velocity and relaxation time, The Boltzmann transport equation, The Sommerfield theory of conductivity, Mean free path in metals, Qualitative, discussion of the features of resistivity, Mathiesson's rule. Thermal conductivity of metals, Wiedemann-Franz law. Hydration energy of ions, Activation energy for formation of defects in ionic crystals, Ionic conductivity in pure alkali halides.

Unit-IV: Dielectrics and FerroElectrics

Macroscopic field, The local field, Lorentz field, The Claussius-Mossotti relations, Different contribution to polarization: dipolar, electronic and ionic polarizabilities, Ferroelectric crystals: Classifications and their general properties, Structure and properties of BaTiO3, The dipole theory of ferroelectricity, objection against dipole theory, Thermodynamics of ferroelectric transitions.

Books:

1. Solid State Physics by A.J. Dekker-Prentice Hall, 1965.
2. An Introduction to Solid State Physics by C. Kittle-Wiley, 1958
3. Elementary Solid State Physics by Omar, Addison Welly, 1975.
4. Principles of Solid State Physics by R.A. Levey-Academic Press, 1968
5. Introduction of Solid State Physics by Ashroft-Cengage Learning, 1999

Master of Science (Physics)

SEMESTER II

(SESSION 2025-26)

COURSE CODE: MPHL-2394

ATOMIC AND MOLECULAR SPECTROSCOPY

COURSE OUTCOMES

After passing this course the students will be able to:

CO 1. Describe the atomic spectra of one and two valance electron atoms. the student will understand the relativistic corrections for the energy levels of the hydrogen atom and their effect on optical spectra and the key properties of many electron atoms

CO 2. Explain the broadening of spectral lines and the concept of Zeeman effect.

CO 3. Explain rotational, vibrational, electronic and Raman spectra of molecules.

CO 4. Explain the role of Frank Condon principle in determining electronic spectra of the molecule. The student will also learn about the dissociation and pre-dissociation energies.

Master of Science (Physics) SEMESTER-II

(SESSION 2025-26)

COURSE CODE: MPHL-2394

ATOMIC AND MOLECULAR SPECTROSCOPY

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT-I: Spectra of one and two valence electron systems

Magnetic dipole moments, Larmor's theorem, Space quantization of orbital, spin and total angular momenta, Vector model for one and two valence electron atoms, Spin-orbit interaction and fine structure of hydrogen, Lamb shift, Spectroscopic terminology, Spectroscopic notations for L-S and J-J couplings, Spectra of alkali and alkaline earth metals, Interaction energy in L-S and J-J coupling for two electron systems, Selection and Intensity rules for doublets and triplets. **15Hours**

UNIT-II: Breadth of spectral line and effects of external fields

The Doppler effect, Natural breadth from classical theory, natural breadth and quantum mechanics, External effects like collision damping, asymmetry and pressure shift and stark broadening, The Zeeman Effect for two electron systems, Intensity rules for the Zeeman effect, The calculations of Zeeman patterns, Paschen-Back effect, LS coupling and Paschen–Back effect, Lande's factor in LS coupling, Stark effect. **15Hours**

UNIT-III: Microwave and Infra-Red Spectroscopy - rigid rotator, Intensity of rotational lines, Effect of isotopic substitution, Microwave spectrum of polyatomic molecules, Microwave oven, the vibrating diatomic molecule as a simple harmonic and anharmonic oscillator, Diatomic vibrating rotator, The vibration-rotation spectrum of carbon monoxide, The interaction of rotation and vibrations, Outline of technique and instrumentation, Fourier transform Spectroscopy. **15Hours**

UNIT-IV: Raman and Electronic Spectroscopy

Quantum and classical theories of Raman Effect, Pure rotational Raman spectra for linear and polyatomic molecules, Vibrational Raman spectra, Structure determination from Raman and infra-red spectroscopy, Electronic structure of diatomic molecule, Electronic spectra of diatomic molecules, Born Oppenheimer approximation, The Franck Condon principle, Dissociation and pre-dissociation energy, The Fortrat diagram, Example of spectrum of molecular hydrogen.

Text and Reference Books

1. Atomic and molecular Spectra: Laser by Raj Kumar, Kedarnath Ram Nath
2. Fundamentals of molecular spectroscopy by C.B.Banwell-TataMcGrawHill,1986.
3. Spectroscopy Vol. I,II&III by Walker&Straughen,Chapman&Hall1976
4. Introduction to Molecular spectroscopy by G.M.Barrow-TokyoMcGrawHill,1962.
5. Spectra of diatomic molecules by Herzberg-NewYork,1944.

Master of Science (Physics) SEMESTER-II

(SESSION 2025-26)

COURSE CODE: MPHP-2395

CONDENSED MATTER PHYSICS LAB-I

COURSE OUTCOMES

Student upon completion of this course will be able to

CO 1. successfully apply the theoretical techniques presented in the course to practical problems

CO 2. Understand Hall Effect and demonstrate the concept of Pn junction g-factor using ESR, formation and analysis of Hysteresis loop.

CO 3. Demonstrate experimental determination of Energy gap using Four Probe Method and characteristics of photovoltaic cells.

Master of Science (Physics) SEMESTER-II

(SESSION 2025-26)

COURSE CODE: MPHP-2395

CONDENSED MATTER PHYSICS LAB-I

Credits: 0-0-3 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Out of 100 Marks, Continuous Assessment (based on mid-semester test/ class performance, written assignment/project work etc.) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

LIST OF EXPERIMENTS:

1. To determine Hall coefficient by Hall Effect.
2. To determine the band gap of a semiconductor using a p-n junction diode.
3. To determine the magnetic susceptibility of a material using Quink's method.
4. To determine the g-factor using an ESR spectrometer.
5. To determine the energy gap and resistivity of the semiconductor using four probe methods.
6. To trace hysteresis loop and calculate retentivity, coercivity and saturation magnetization.
7. To determine dielectric constant of a dielectric material.
8. To study the series and parallel characteristics of a photovoltaic cell.
9. To study the spectral characteristics of a photovoltaic cell.

Master of Science (Physics) SEMESTER-II
(SESSION 2025-26)
COURSE CODE: MPHP-2396
SPECTROSCOPY LAB

COURSE OUTCOMES

On successful completion of the course students will be able to:

CO 1. develop analytical, laboratory skills through laboratory which involve the application of physics to various spectroscopy systems.

CO 2. successfully apply the theoretical techniques presented in the course to practical problems

CO 3. set up the Fabry Parot interferometer, Michelson Morley interferometer, Zeeman experimental instrument and constant deviation spectrometer.

Master of Science (Physics) SEMESTER-II
(SESSION 2025-26)
COURSE CODE: MPHP-2396
SPECTROSCOPY LAB

Credits: 0-0-3 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**

Out of 100 Marks, Continuous Assessment (based on mid-semester test/ class performance, written assignment/project work etc.) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

LIST OF EXPERIMENTS:
1. To find the wavelength of monochromatic light using Febry Perot interferometer.
2. To find the wavelength of monochromatic light using Michelson interferometer.
3. To calibrate the constant deviation spectrometer with white light and to find the wavelength of unknown monochromatic light.
4. To find the wavelength of He-Ne Laser using Vernier Calliper and the grating element of the given grating.
6. To verify the existence of Bohr's energy levels with the Frank-Hertz experiment.
7. To determine the charge to mass ratio (e/m) of an electron with normal Zeeman Effect
8. To determine the velocity of ultrasonic waves in a liquid using ultrasonic interferometer
9. Particle size determination by diode laser

Master of Science (Physics)

SEMESTER III

(SESSION 2025-26)

COURSE CODE: MPHL-3391

QUANTUM MECHANICS-II

COURSE OUTCOMES

After passing this course the students will be able to:

CO 1. Explore first and second-order perturbation theory for both non-degenerate and degenerate systems. Investigate perturbation of an oscillator, anharmonic oscillator, and the variation method.

CO 2. have advanced insights into scattering phenomena, offering a comprehensive understanding of Born approximation, its limitations, and its applications in diverse physical scenarios.

CO 3. explore positive and negative energy solutions, introducing positrons. Investigate properties of gamma matrices, analyze the action of the parity operator on states, and examine magnetic moments and spin-orbit energy.

CO 4. Explore identical particles in quantum mechanics, distinguishing between Fermions and Bosons. Investigate the wave function of n-identical particles using Slater's determinant and understand the symmetrization postulates. Study exchange operators and exchange degeneracy, applying these concepts to two and three electron systems.

Master of Science (Physics) SEMESTER III

(SESSION 2025-26)

COURSE CODE: MPHL-3391

QUANTUM MECHANICS-II

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

Unit-I: Perturbation Theory

First and second order perturbation theory for non degenerate and degenerate systems, Perturbation of an oscillator and anharmonic oscillator, the variation method, First order time dependent perturbation theory, constant perturbation, Calculation of transition probability per unit time for harmonic perturbation, The Helium atom problem, Stark effect.

Unit-II: Scattering Theory

Born approximation, extend to higher orders. Validity of Born approximation for a square well potential, Optical theorem Partial wave analysis, unitarity and phase shifts. Determination of phase shift, applications to hard sphere scattering. Low energy scattering in case of bound states, Resonance scattering.

Unit-III: Relativistic Quantum Mechanics

Klein Gordon equation, Dirac Equation, Lorentz covariance of Dirac equation, Positive and negative energy solutions of Dirac equation, positrons, Properties of gamma matrices, Parity operator and its action on states, Magnetic moments and spin orbit energy.

Unit-IV: Identical Particles

Brief introduction to identical particles in quantum mechanics, Fermions and Bosons, wave function of n-identical particles and Slater's determinant, symmetrisation postulates, Exchange operators and exchange degeneracy, Application to 2 and 3 electron systems. Pauli Exclusion Principle

References :

1. Quantum Mechanics by L I Schiff-Tokyo McGraw Hill, 1968.
2. A textbook of quantum mechanics by P.M. Methews and K. Venktasen Mcgraw Hill Education, 2017
3. Introduction to Quantum Mechanics by David J. Griffiths, pearson, 2015
4. Advanced Quantum Mechanics by JJ Sakurai

Master of Science (Physics) SEMESTER III

(SESSION 2025-26)

COURSE CODE: MPHL-3392

Electrodynamics-II

COURSE OUTCOMES

After passing this course the students will be able to:

CO1: Understand different types of waveguides. The transmission of electromagnetic signals through waveguide. The attenuation and loss of signal in waveguides

CO2: Correlate Einstein's special theory of relativity with classical mechanics and electrodynamics in terms of tensor notation.

CO3: Study the fields around electric dipole, magnetic dipole and electric quadruple. The transition of signal from full wave and half wave antennas.

CO4: Understand fields due to moving charges in terms of vectors and in terms of relativistic mechanics.

Master of Science (Physics) SEMESTER III

(SESSION 2025-26)

COURSE CODE: MPHL-3392

Electrodynamics-II

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT-I

Wave Guides: Field at the surface of and within a conductor. Cylindrical cavities and waveguides, modes in a rectangular wave guide, energy flow and attenuation in wave guides. Perturbation of boundary conditions, resonant cavities, power loss in cavity and quality factor.

UNIT-II

Relativistic Formulation of Electrodynamics: Special theory of relativity, simultaneity, length contraction, time dilation and Lorentz's transformations, Structure of space-time, four scalars, four vectors and tensors, relativistic mechanics: proper time and proper velocity, relativistic energy and momentum. Relativistic electrodynamics: Magnetism as a relativistic phenomenon and field transformations. Field tensor. Recasting Maxwell equations in the language of special relativity, covariance and manifest covariance.

UNIT-III

Radiating Systems: Inhomogeneous Wave Equation for potentials: Retarded Potentials ,Fields of radiation of localized oscillating sources, electric dipole fields and radiation, magnetic dipole and electric quadrupole fields, central fed antenna, brief introduction to radiation damping and radiation reaction.

UNIT-IV

Fields of Moving Charges: Lienard Wiechert potential, field of a moving charge. Radiated power from an accelerated charge at low velocities, Larmour's power formula and its relativistic generalization; Angular distribution of radiation emitted by an accelerated charge.

Text and Reference Books:

1. Classical Electrodynamics by J.D. Jackson-John Wiley & Sons Pvt. Ltd., New York.
2. Introduction to Electrodynamics by D.J. Griffiths-Pearson Education Ltd.
3. Classical Electromagnetic Radiation by J.B. Marion-Academic Press, New Delhi.

Master of Science (Physics) SEMESTER III

(SESSION 2025-26)

COURSE CODE: MPHL-3393

Condensed Matter Physics-II

COURSE OUTCOMES

After passing this course the students will be able to:

CO 1. Condensed Matter Physics-II aim at the applications of Solid state Physics. The course should give deeper knowledge about magnetic materials.

CO 2. Make students familiar with various concepts like curie's temperature, super exchange interaction and properties of hysteresis loop.

CO 3. The students will have knowledge of superconductors and its types and how its properties can be applicable in the research field.

CO 4. Develop a knowledge and understanding of the optical properties and students will get the knowledge how these properties are beneficial in the field of research.

Master of Science (Physics) SEMESTER III
(SESSION 2025-26)

COURSE CODE: MPHL-3393

CONDENSED MATTER PHYSICS-II

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

Unit- I

Classification of magnetic materials, Origin of permanent magnetic dipoles, Diamagnetic susceptibility, Langevin diamagnetic equation, Classical theory of paramagnetism, Quantum theory of paramagnetism, Quenching of orbital angular momentum, Cooling by adiabatic demagnetization, Paramagnetic susceptibility of conduction electrons, Determination of susceptibilities of para and diamagnetic materials: Theory, Gouy method and Quincke's method

Unit - II

Ferromagnetism, Curie point and the exchange integral, Weiss molecular field, the interpretation of the Weiss field, Temperature dependence of spontaneous magnetization, Saturation magnetization at absolute zero, Ferromagnetic domains, Anisotropy energy, Transition region between domains: Bloch wall, Origin of domains, Coercivity and hysteresis, Spin waves, Quantization of spin waves, Thermal excitations of magnons, Neutron Magnetic Scattering, Ferrimagnetic Order, Curie temperature and susceptibility of ferrimagnets, Antiferromagnetism, Two sublattice model.

Unit – III

Superconductivity, zero resistivity, critical temperature, Meissner effect, Type I and Type II superconductors, specific heat and thermal conductivity, Thermodynamics of superconducting transition, London's equation, Coherence length, BCS theory of conventional superconductors, BCS ground states, Flux quantization on a superconducting ring, Duration of persistent current, Josephson effect: dc Josephson effect, ac Josephson effect, macroscopic quantum interference, Superconducting magnet and SQUID, High temperature superconductors: Structure and properties.

Unit - IV

Interaction of light with solids, Atomic and electronic interactions, Optical properties of metals and non-metals: Reflection, Refraction, Absorption, Transmission, Fundamentals of direct and indirect band gap, Exciton absorption, Free carrier absorption, Absorption process involving impurities, Photoconductivity, Luminescence, excitation and emission, Decay mechanisms, Thallium activated alkali halides, Sulphide phosphors.

Books Recommended:

1. An Introduction to Solid State Physics by C. Kittel-WielyEstem Ltd., New Delhi.
2. Solid State Physics by A.J. Dekkar-Maemillan India Ltd., New Delhi.
3. Material Science and Engineering by William D. Callister JR, Wiley
4. Elementary Solid State Physics by Omar, Addison Wesly.
5. Principles of Solid State Physics by R.A. Levy-New York Academy.

Master of Science (Physics) SEMESTER III

(SESSION 2025-26)

COURSE CODE: MPHL-3394

NUCLEAR PHYSICS

COURSE OUTCOMES

After passing this course the students will be able to:

CO 1. Explore properties of nuclei, including size, spin, parity, magnetic and quadrupole moments, and binding energy. Investigate the two-nucleon system, focusing on the deuteron problem and tensor forces. Study low-energy pp and pn scattering experiments, including the scattering length and effective range theory. Understand the spin dependence, charge independence, and charge symmetry of nuclear forces.

CO 2. understand advanced nuclear models and their applications in describing nuclear structure and behavior and Investigate the Bohr-Wheeler theory of fission and experimental evidence for the shell structure of the nucleus.

CO 3. gain advanced insights into nuclear decay mechanisms, their theoretical foundations, and experimental observations in the realm of beta and gamma decay and understand allowed and forbidden transitions, along with parity violation in beta decay.

CO 4. understand nuclear reactions, their underlying principles, and applications in the context of compound and direct mechanisms, resonance scattering, fission, and fusion.

Master of Science (Physics) SEMESTER III
(SESSION 2025-26)
COURSE CODE: MPHL-3394
NUCLEAR PHYSICS

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:
Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

Unit-I

Properties of nucleus and nuclear forces: size, spin, parity, magnetic moment, quadrupole moment and binding energy of a nucleus. Two nucleon system, deuteron problem, tensor forces, pp and pn scattering experiments at low energy, scattering length, effective range theory, spin dependence of nuclear forces, charge independence and charge symmetry of nuclear forces, exchanges forces: Bartlett, Heisenberg, Majorana forces and potentials, meson theory of nuclear forces.

Unit-II

Nuclear Models: Liquid drop model, semi-empirical mass formula, Bohr-Wheeler theory of fission, experimental evidence for shell structure of nucleus, shell model, spin-orbit coupling, applications of shell model like angular momenta, parities, magnetic moments (Schmidt lines) of nuclear ground states, collective model, nuclear vibrations spectra and rotational spectra, Nilsson model.

Unit-III

Nuclear Decay: Beta decay: Types of beta decay, neutrino hypothesis, Fermi theory of beta decay, detection of neutrino, total decay rate, comparative half-lives, angular momentum and parity selection rules in beta decay, allowed and forbidden transitions, parity violation in beta decay. Gamma decay: Multipole transitions in nuclei, angular momentum and parity selection rules in gamma decay, internal conversion, nuclear isomerism.

Unit-IV

Nuclear Reactions: Introduction to nuclear reactions, conservations laws, cross sections in terms of partial wave amplitudes, compound and direct nuclear reaction mechanisms, Breit Winger one level formula, Resonance scattering. Nuclear fission, nuclear fusion.

Reference books:

1. Nuclear Physics by R.R. Roy and B.P. Nigam-New Age International Publishers
2. Introductory Nuclear Physics by K.S. Krane-Wiley, New York
3. Nuclear Physics by G.N. Ghoshal-S. Chand and Co.

Master of Science (Physics) SEMESTER III

(SESSION 2025-26)

COURSE CODE: MPHP-3395

CONDENSED MATTER PHYSICS LAB-II

COURSE OUTCOMES

After passing this course the students will be able to:

CO 1. Understand the mechanism of domain formation in ferromagnetic materials and to

CO 2. find the energy losses in various ferromagnetic materials

CO 3. Understand the concept of Curie temperature.

CO 4. Understand the concept of charge storage mechanism in p-n junction diodes

CO 5. Understand the phonon and photon interactions in materials

CO 6. Will learn to work with the travelling, transmission and reflection of microwaves.

Master of Science (Physics) SEMESTER III
(SESSION 2025-26)
COURSE CODE: MPHP-3395
CONDENSED MATTER PHYSICS LAB-II

Credits: 0-0-3 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**

Out of 100 Marks, Continuous Assessment (based on mid-semester test/ class performance, written assignment/project work etc.) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

LIST OF EXPERIMENTS:
1. To determine the energy loss in transformer and ferrite cores using B-H curve.
2. To determine Curie temperature of ferrites.
3. To determine Stefan's constant using Boltzmann's Law.
4. To study the depletion capacitance and its variation with reverse bias in a p-n junction.
5. To determine the lattice dynamics and dispersion relation for the monatomic and diatomic lattices.
6. To find the Young's modulus of a material using ultrasonic interferometer for solids
7. Experiments with Microwaves
8. set up.

Master of Science (Physics) SEMESTER III

(SESSION 2025-26)

COURSE CODE: MPHP-3396

NUCLEAR PHYSICS LAB

COURSE OUTCOMES

After passing this course the students will be able to:

CO 1. Carry out experimental work using NaI (Tl) scintillation detector and GM counter in the field of radiation shielding and radioactive analysis of various materials.

CO 2. Understand the interaction of beta particles, alpha particles and gamma ray with matter.

CO 3. Understand the importance of statistical nature of radioactivity in the field of radioactive analysis.

CO 4. Investigate the attenuation power of various materials for alpha, beta and gamma radiation.

Master of Science (Physics) SEMESTER III
(SESSION 2025-26)
COURSE CODE: MPHP-3396
NUCLEAR PHYSICS LAB

Credits: 0-0-3 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**

Out of 100 Marks, Continuous Assessment (based on mid-semester test/ class performance, written assignment/project work etc.) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

LIST OF EXPERIMENTS:

1. Pulse-Height Analysis of Gamma Ray Spectra.
2. Energy calibration of Scintillation Spectrometer.
3. Least square fitting of a straight line.
4. Study of absorption of gamma rays in matter.
5. Study of the characteristics of a G.M. Counter.
6. Study of the Dead time of a G.M. Counter.
7. Study of absorptions of Beta Particles in Matter.
8. Window thickness of a G.M. Tube.
9. Investigation of the statistics of radioactive measurements.
10. Study of Poisson Distribution.
11. Study of Gaussian Distribution.
12. Study of absorption alpha-particles in matter.

Master of Science (Physics) SEMESTER IV
(SESSION 2025-26)
COURSE CODE: MPHL-4391
PARTICLE PHYSICS

COURSE OUTCOMES

After passing this course the students will be able to:

CO 1. classify elementary particles and explore the fundamental forces of nature. Investigate the determination of mass, lifetime, decay modes, spin, and parity of muons, pions, kaons, and hadrons. Introduce the concept of antiparticles and delve into relativistic kinematics.

CO 2. Explore isospin invariance, the Gellmann-Nishijima formula, and operations like parity and charge conjugation. Investigate processes such as positronium decay, CP violation, and Ko-Ko doublet. Understand time reversal invariance and the CPT theorem.

CO 3. Explore weak interactions, including their classification and the τ-θ puzzle. Investigate parity violation in beta and Λ-decay, and the two-component neutrino theory. Understand the GIM mechanism and delve into the CKM matrix.

CO 4. Explore global and local gauge invariance, Feynman rules, and the Higgs mechanism in the context of spontaneously broken symmetries in field theory. Investigate neutrino mass and neutrino oscillations

Master of Science (Physics) SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4391

PARTICLE PHYSICS

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

Unit-I

Elementary Particles and Their Properties: Historical survey of elementary particles and their classification, fundamental forces of nature, determination of mass, lifetime, decay mode, spin and parity of muons, pions, kaons and hadrons, introduction to antiparticles, relativistic kinematics.

Unit-II

Symmetries and Conservation Laws: Conserved quantities and symmetries, the electric charge, baryon number, lepton number, hypercharge (strangeness), the nucleon isospin, isospin invariance, isospin of particles, Gellmann-Nishijima formula, parity operation, charge conjugation, positronium decay, CP violation and $K^o - \underline{K^o}$ doublet, time reversal invariance, CPT theorem, Gellmann's eightfold way of hadrons, quark model.

Unit-III

Week Interactions: Classification of weak interactions, τ-θ puzzle, parity violation in beta decay, parity violation in Λ-decay, the two component neutrino theory, measurement of neutrino helicity (Goldhaber's experiment), the V-A interaction, weak decays of strange-particles and Cabibbo's theory, GIM mechanism, CKM matrix.

Unit-IV

Gauge theory and neutrino oscillation: Gauge symmetry, field equations for scalar (spin 0), spinor (spin ½), vector (spin-1) and fields, global gauge invariance, local gauge invariance, Feynmann rules, spontaneously broken symmetries in the field theory, Higgs mechanism, neutrino mass, neutrino oscillations.

Reference books:

1 Introduction to Elementary Particles by D. Griffiths-Wiley-VCH.
2 Introduction to High Energy Physics by D.H Perkins-Cambridge University Press.
3 Nuclear Physics by S.N. Ghoshal-S. Chand and Co.

Master of Science (Physics) SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4392

STATISTICAL MECHANICS

COURSE OUTCOMES

After passing this course the students will be able to:

CO 1. Investigate the classical ideal state, addressing the entropy of mixing and Gibbs paradox. Delve into the phase space of a classical system, understanding Liouville's theorem and its far-reaching consequences.

CO 2. Explore the canonical ensemble, covering thermodynamics, partition function, and applications like the classical ideal gas. Analyze energy fluctuations within the canonical ensemble, extending the study to a system of harmonic oscillators and statistics of paramagnetism.

CO 3. understand quantum states, statistical ensembles, and the bridge between classical and quantum statistical mechanics through the Boltzmann formula.

CO 4. Analyze the statistics of occupation numbers and the thermodynamic behavior of an ideal gas. Investigate Bose-Einstein condensation and apply it to gases of photons and phonons.

Master of Science (Physics) SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4392

STATISTICAL MECHANICS

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT-I: Classical Statistical Mechanics I

Foundations of statistical mechanics; specification of states in a system, contact between statistics and thermodynamics, the classical ideal state, the entropy of mixing and Gibbs paradox. The phase space of a classical system, Liouville's theorem and its consequences. **15 Hours**

UNIT-II: Classical Statistical Mechanics II

The microcanonical ensemble with examples. The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations in the canonical ensemble. A system of harmonic oscillators. The statistics of paramagnetism. The grand canononical ensemble, the physical significance of the statistical quantities, examples, fluctuation of energy and density. Cluster expansion of classical gas, the virial equation of state. **15 Hours**

UNIT-III: Quantum Statistical Mechanics I

Quatum states and phase space, the density matrix, statistics of various ensembles. Example of electrons in a magnetic field, a free particle in a box and a linear harmonic oscillator. Significance of Boltzamann formula in classical and quantum statistical mechanics. **15 Hours**

UNIT-IV: Quantum Statistical Mechanics II

An ideal gas in a quantum mechanical microcanonical ensemble. Statistics of occupation numbers, concepts and thermodynamical behaviour of an ideal gas. Bose Einstein condensation. Discussion of a gas of photons and phonons. Thermodynamical behaviour of an ideal fermi gas, electron gas in metals, Pauli's paramagnetism, statistical equilibrium of white dwarf stars. **15 Hours**

Text and Reference Books

1. Statistical Mechanics . Patharia Butterworth-Heineman, 1996
2. Statistical Mechanics: Kerson Huang-Wiley-1963.

Master of Science (Physics) SEMESTER IV
(SESSION 2025-26)
COURSE CODE: MPHL-4393/94 (OPT-1)

OPTICS AND PHOTONICS

COURSE OUTCOMES

After passing this course the students will be able to:

CO1: understand basic ideas about different types of waveguides.
CO2: understand basics of Gaussian Beam Propagation and electromagnetic propagation in anisotropic media
CO3: understand basics of Electro-optics and Acoustic-optics.
CO4: understand basic optoelectronics devices.

Master of Science (Physics) SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4393/94 (OPT-I)

PHOTONICS

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT I

Guided Wave Optics: Planar slab waveguides, Rectangular channel waveguides, Single and multimode optical fibers, waveguide modes and field distributions, waveguide dispersion, pulse propagation

UNIT II

Gaussian Beam Propagation: ABCD matrices for transformation of Gaussian beams, applications to simple resonators

Electromagnetic Propagation in Anisotropic Media: Reflection and transmission at anisotropic interfaces, Jones Calculus, retardation plates, polarizers

UNIT III

Electro-optics and Acousto-optics: Linear electro-optic effect, Longitudinal and transverse modulators, amplitude and phase modulation, Mach-Zehnder modulators, Coupled mode theory, Optical coupling between waveguides, Directional couplers, Photoelastic effect, Acousto-optic interaction and Bragg diffraction, Acousto-optic modulators, deflectors and scanners

UNIT IV

Optoelectronics: p-n junctions, semiconductor devices: laser amplifiers, injection lasers, photoconductors, photodiodes, photodetector noise.

Recommended Books

1. Fundamentals of Photonics by B. E. A. Saleh and M. C. Teich (2nd Edition), John Wiley (2007)
2. Photonic Devices by J-M. Liu, Cambridge (2009)
3. Photonics: Optical Electronics in Modern Communications by A. Yariv and P. Yeh, Oxford (2006)
4. Optics by E. Hecht (4thEdition), Addison-Wesley (2001)

Master of Science (Physics) SEMESTER IV
(SESSION 2025-26)
COURSE CODE: MPHL-4393 (OPT-II)
RADIATION PHYSICS

COURSE OUTCOMES

After passing this course the students will be able to:

CO 1. Investigate measurement techniques, including the free air chamber and air wall chamber. Examine absorbed dose measurement with a focus on the Bragg Gray Principle. Explore radiation dose units such as rem, rad, Gray, and sievert, including dose commitment, dose equivalent, and the concept of quality factor.
CO 2. understand various dosimetry techniques and radiation detectors, emphasizing their principles, applications, and numerical aspects for dose estimation.
CO 3. Examine the biological effects of radiation at the molecular level, distinguishing acute and delayed effects, as well as stochastic and nonstochastic effects. Evaluate permissible doses for occupational and non-occupational workers, maximum permissible concentrations in air and water, and safe handling of radioactive materials.
CO 4. Explore thermal and biological shields, addressing shielding requirements for medical, industrial, and accelerator facilities. Investigate radiation attenuation from uniform plane, line, and point sources. Apply the exponential point-kernel method.

Master of Science (Physics) SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4393 (OPT-II)

RADIATION PHYSICS

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

Unit – 1

Ionizing Radiations and Radiation Quantities: Types and sources of ionizing radiation, fluence, energy fluence, kerma, exposure rate and its measurement - The free air chamber and air wall chamber, Absorbed dose and its measurement ; Bragg Gray Principle, Radiation dose units - rem, rad, Gray and sievert dose commitment, dose equivalent and quality factor.

Unit- II

Dosimeters:

Pocket dosimeter, films, solid state dosimeters such as TLD, SSNTD, chemical detectors and neutron detectors. Simple numerical problems on dose estimation.

Unit- III

Radiation Effects and Protection:

Biological effects of radiation at molecular level, acute and delayed effects, stochastic and nonstochastic effects, Relative Biological Effectiveness (RBE), Linear energy transformation (LET), Dose response characteristics. Permissible dose to occupational and non-occupational workers, maximum permissible concentration in air and water, safe handling of radioactive materials, The ALARA, ALI and MIRD concepts, single target, multitarget and multihit theories, Rad waste and its disposal, simple numerical problems.

Unit - IV

Radiation Shielding: Thermal and biological shields, shielding requirement for medical, industrial and accelerator facilities, shielding materials, radiation attenuation calculations-The point kernel technique, radiation attenuation from a uniform plane source. The exponential point-Kernel. Radiation attenuation from a line and plane source. Practical applications of some simple numerical problems.

References :

1. Nuclear Reactor Engineering by . S. Glasstone and A. Sesonke ,Van Nostrand Reinhold.
2. Radiation Theory by Alison. P. Casart
3. Radiation Biology-Radiation Bio by A. Edward Profio /Prentice Hall.
4. Introduction to Radiological Physics and Radiation Dosimetry by F.H. Attix -Wiley-VCH.

Master of Science (Physics) SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4393/94 (OPT-III)

REACTOR PHYSICS

COURSE OUTCOMES

After passing this course the students will be able to:

CO1. Understand neutron behavior and diffusion in various mediums, with practical applications and theoretical foundations.

CO2. Explore the mechanics of elastic scattering in neutron interactions. Analyze the energy distribution of thermal neutrons, including concepts like average logarithmic energy decrement, slowing-down power, and moderating ratio in a medium.

CO3. Understand neutron multiplication and reactor design principles, with practical applications in diverse reactor configurations. Analyze the advantages and disadvantages of heterogeneous assemblies. Examine various types of reactors, with special reference to Indian reactors, and provide a brief discussion of their design features.

CO4. Explore advanced concepts in reactor physics, including breeding ratio, breeding gain, and doubling time. Investigate the principles of Fast Breeder Reactors (FBRs) and dual-purpose reactors. Understand the concept of fusion reactors. Analyze the role of delayed neutrons and reactor period, utilizing the Inhour formula, and addressing excess reactivity, temperature effects, and fission product poisoning.

Master of Science (Physics)

SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4393/94 (OPT-III)

REACTOR PHYSICS

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

Interaction of Neutrons with Matter in Bulk:

Thermal neutron diffusion, Transport and diffusion equations, transport mean free path, solution of diffusion equation for a point source in an infinite medium and for an infinite plane source in a finite medium, extrapolation length and diffusion length-the albedo concept.

Hours 15

Moderation of Neutron:

Mechanics of elastic scattering, energy distribution of thermal neutrons, average logarithmic energy decrement, slowing down power and moderating ratio of a medium. Slowing down density, slowing down time, Fast neutron diffusion and Fermi age theory, solution of age equation for a point source of fast neutrons in an infinite medium, slowing down length and Fermi age. **Hours 15**

Theory of Homogeneous Bare Thermal and Heterogeneous Natural Uranium Reactors

Neutron cycle and multiplication factor, four factor formula, neutron leakage, typical calculations of critical size and composition in simple cases, The critical equation, material and geometrical bucklings, effect of reflector, Advantages and disadvantages of heterogeneous assemblies, various types of reactors with special reference to Indian reactors and a brief discussion of their design feature. **Hours 15**

Power Reactors Problems of Reactor Control

Breeding ratio, breeding gain, doubling time, Fast breeder reactors, dual purpose reactors, concept of fusion reactors, Role of delayed neutrons and reactor period, In hour formula, excess reactivity, temperature effects, fission product poisoning, use of coolants and control rods.

Hours 15

References:

1. The elements of Nuclear reactor Theory by Glasstone & Edlund-VamNostrand, 1952.
2. Introductions of Nuclear Engineering by Murray-Prentice Hall, 1961.

Master of Science (Physics) SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4393/94 (OPT-IV)

NANOTECHNOLOGY

Course Outcomes :

After completion of this course the students will be able to :

CO1: understand basic ideas of nanotechnology and synthesis techniques of nanomaterials.

CO2: understand the basics of various characterisation techniques for nano materials.

CO3: understand the preparation methods and applications of Carbon Nanotubes and other Carbon based materials.

CO4:understand properties of Nanosemiconductors and their applications as Nano sensors.

Master of Science (Physics) SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4393/94 (OPT-IV)

NANOTECHNOLOGY

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

Unit-I: Introduction and Synthesis of Nanomaterials

Introduction, Basic idea of nanotechnology, nanoparticles, metal Nanoclusters, Semiconductor nanoparticles, Physical Techniques of Fabrication, inert gas condensation, Arc Discharge, RF plasma, Ball milling, Molecular Beam Epitaxy, Chemical Vapour deposition, Electro deposition, Chemical Methods-Metal nanocrystals by reduction, Photochemical synthesis, Electrochemical synthesis, Sol-gel, micelles and microemulsions, Cluster compounds. Lithographic Techniques-AFM based nanolithography and nanomanipulation, E-beam lithography and SEM based nanolithography, X ray based lithography. **(Hours 15)**

Unit-II: Characterization Techniques

X-ray diffraction, data manipulation of diffracted X-rays for structure determination, Scanning Probe microscopy, Scanning Electron microscopy, Transmission Electron Microscopy, Scanning Tunneling Microscopy, Optical microscopy, FTIR Spectroscopy, Raman Spectroscopy, DTA, TGA and DSC measurements **(Hours 15)**

Unit-III:Carbon Nanotubes and other Carbon based materials

Preparation of Carbon nanotubes, CVD and other methods of preparation of CNT, Properties of CNT; Electrical, Optical, Mechanical, Vibrational properties etc. Application of CNT; Field emission, Fuel Cells, Display devices. Other important Carbon based materials; Preparation and Characterization of Fullerence and other associated carbon clusters/molecules, Graphene preparation, characterization and properties, DLC and nano diamonds. **(Hours 15)**

Unit-IV:Nanosemiconductors and Nano sensors

Semiconductor nanoparticles-applications; optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, carrier injection, polymers-nanoparticles, LED and solarcells, electroluminescence. Micro and nanosensors; fundamentals of sensors, biosensor, microfluids, MEMS and NEMS, packaging and characterization of sensors. **(Hours 15)**

References:

1. Solid State Physics: J.P. Srivastva-Prentice Hall, 2007.
2. Introduction to nanoscience and Nanotechnology: K.K. Chattopadhyay and A.N. Banerjee- PHI Learning Pvt. Ltd. 2009
3. Nanotechnology Fundamentals and Applications: Manasi Karkare, I.K.- International Publishing House, 2008.
4. Nanomaterials: B. Viswanathan- Narosa, 2009.
5. Encyclopedia of Nanotechnology: H.S. Nalwa-American Scientific Publishers, 2004.
6. Introduction to Nanotechnology: Charles P. Poole Jr. and Franks J. Qwens,-John Wiley &

Sons, 2003.
7. Nanostructures and Nanomaterials, Synthesis, Properties and Applications: Guoahong Cao- Imperial College Press, 2004.
8. Springer Handbook of Nanotechnology: Bharat Bhushan-Springer, 2004.
9. Science of Engineering Materials: C.M. Srivastva and C. Srinivasan-New Age International, 2005.
10. The Principles and Practice of electron Microcopy: Ian. M. Watt-Cambridge University Press, 1997.
11. Ultrasonic Testing of Materials: J.K. Krammer and H.K. Krammer-Springer Verlag, 1996.
12. Physical Properties of Carbon Nanotube: R. Satio, G. Dresselhaus and M. S. Dresselhaus-Imperial College Press, 1998.
13. Sensors Vol. 8, Micro and Nanosensor Technology: H. Meixner and R. Jones (Editor)-John Wiley and Sons, 2000.

Master of Science (Physics) SEMESTER IV
(SESSION 2025-26)
COURSE CODE: MPHL-4394 (OPT-V)
MATERIAL SCIENCE

COURSE OUTCOMES

After passing this course the students will be able to:

CO1: Explore advanced aspects of thin film technology, covering film deposition methods (PVD, CVD, Spray pyrolysis, Sputtering), modes of growth, and film microstructures (epitaxial, polycrystalline). Gain in-depth knowledge for diverse applications in this specialized field.

CO2: Gain advanced understanding of polymers, covering polymerization, stress-strain behavior, and thermosets/thermoplasts. Explore characteristics, applications, and processing of ceramics, glasses, and refractories. Acquire specialized knowledge for diverse applications in polymer and ceramic materials.

CO3: Acquire proficiency in material characterization using spectroscopic techniques such as NMR, and Photoluminescence spectroscopy. Master advanced microscopy methods, including Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM).

CO4: understand the preparation of carbon based materials and analyse fundamental principles governing the preparation and diverse properties of various carbon nanomaterials, including carbon nanotubes, fullerenes, graphene, and related carbon clusters.

Master of Science (Physics) SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4394 (OPT-V)

MATERIAL SCIENCE

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**

Examination Time: 3 Hours **Pass Marks: 25**

Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT I

Thin Film Technology: Classification of Thin films configurations; Film deposition method: Physical vapor deposition, Chemical vapor deposition, Spray pyrolysis, Sputtering (RF, DC); Modes of film growth by vapor deposition: from vapor to adatoms, from adatoms to film growth, growth modes based on surface energies; film microstructure: Epitaxial films, polycrystalline films.

UNIT II

Polymers & Ceramics: Characteristics, Application and Processing of polymers; Polymerization, Polymer types: Stress- Strain behaviour, melting and glass transition, thermosets and thermoplasts; Characteristics, Application and Processing of Ceramics.

UNIT III

Characterization Techniques: Spectroscopic techniques: NMR & Photoluminescence spectroscopy for characterization of materials. Transmission electron microscopy (TEM), Scanning electron microscopy (SEM), X-ray diffraction, data manipulation of diffracted X-rays for structure determination; X-ray fluorescence spectrometry for element detection with concentration;

UNIT IV

Carbon nanomaterials: Carbon Nanotubes and other Carbon based materials: Preparation of Carbon nanotubes, CVD and other methods of preparation of CNT, Properties of CNT; Electrical, Optical, Mechanical, Vibrational properties etc. Application of CNT, Graphene preparation, characterization and properties

References:

1. Thin Film Materials-Stress, defect, formation and surface evolution: L.B. Freund and S.Suresh-Cambridge.
2. Thin Film Phenomena :K.L. Chopra-Mc Graw Hill Book, Comp.,1979.
3. Thin Film fundamentals: A. Goswami-New age International, 2007
4. Material Science and Engg :W.D. Callister-John Wiley, 2001
5. Elements of X-ray Diffraction (3rd edition) : B.D. Cullity, S.R. Stock-Prentice Hall, 2001.
6. X-ray Fluorescence spectroscopy: R. Jenkins-Wiley Interscience, New York, 1999.
7. Methods of Surface Analysis : J.M. Walls- Cambridge University Press, 1989.
8. The principles and Practice of Electron Microscopy: Ian M. Watt-Cambridge University Press, 1997
9. Modern techniques for surface science: D.P.Woodruff andT.A. Delchar-CambridgeUniv. Press, 1994.

Master of Science (Physics) SEMESTER IV

(SESSION 2025-26)

COURSE CODE: MPHL-4393/94 (OPT-VI)

SPACE SCIENCE

COURSE OUTCOMES:

After completion of this course the students will be able to

CO1: understand Hydrostatics, Emission mechanisms and Excitation mechanisms of the atmosphere of Earth.
CO2: understand the behaviour and properties of different layers of ionosphere
CO3: understand the Ionospheric Irregularities and disturbances and response of ionosphere to radio waves
CO4: know about the Sun and its active regions.

Master of Science (Physics) SEMESTER IV
(SESSION 2025-26)
COURSE CODE: MPHL-4393/94 (OPT-VI)
SPACE SCIENCE

Credits: 4-0-0 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**
Teaching Hours: 60

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Note for the Paper Setters:

Eight questions of equal marks are to be set, two in each of the four Sections (A-D). Questions of Sections A-D should be set from Units I-IV of the syllabus respectively. Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any Section. Each question carries 14 marks.

UNIT I

Hydrostatics, Heating of the upper atmosphere, Variations in the earth's atmosphere, Model atmosphere, The earth’s exosphere.
Emission mechanisms, Airglow, Aurora, Morphology, Excitation mechanism, Auroral spectra.

UNIT II

Ionosphere: Ion-electron pair production, Ion-kinetics, Equilibrium, Ionospheric regions (D,E,F_1), Variations in these regions.
F_2 region: Formation of F_2-layer, Continuity equation, F_2-region anomalies, Thermal properties of the F_2-region.

UNIT III

Ionospheric Irregularities and disturbances: Spread-F, Travelling ionospheric disturbances, Perturbation by electromagnetic and corpuscular radiation, Ionospheric and magnetic storms.
Propagation of radio waves through the ionosphere, Appleton Hartee equation. Faraday rotation.

UNIT IV

The Sun: Interior, A model, Outer atmosphere: Photosphere, Chromosphere, Transition region, Corona
Active Regions: Development and structure, Loops, Internal motions, Sunspots: Classification, Structure and evolution of sunspots, Solar cycle, Prominences, Solar flares (descriptive only).

References:

1. Fundamentals of Aeronomy, R.C. Whitten & I.G. Poppoff, John Wiley & Sons Inc. 1971.
2. Priest, E.R., Solar Magnetohydrodynamics, D. Reidel Pub. Company, 1987
3. Introduction to Space Physics, Kivelson, M.G. and Russell, C.T., Cambridge University Press, 1996

Master of Science (Physics) SEMESTER IV
SESSION 2025-26
Course Code: MPHD-4395
Course Title: Project Work

Course Outcomes:

Students will be able to

CO 1. Apply their theoretical knowledge and skills to solve practical problems related to research fields

CO 2. Analyze complex problems, identify gaps, and propose innovative solutions and make informed decisions.

CO 3. Work effectively in teams and gain the ability to contribute to group goals.

CO 4. effectively communicate their findings, both orally and in written form through presenting research results and technical details

CO 5. analyze, and synthesize information from multiple sources

Master of Science (Physics) SEMESTER IV
SESSION 2025-26
Course Code: MPHD-4395
Course Title: Project Work

Credits: 0-0-6 **Maximum Marks: 100 (ESE:70, CA: 30)**
Examination Time: 3 Hours **Pass Marks: 25**

The student may choose any one research problem from the following fields to complete her project work:
1. Material Science
2. Computational Physics
3. Nuclear Physics
4. Advanced Theoretical Physics
5. Radiation Physics
6. Electronics

Note:
Evaluation committee will consist of following members:
1. External examiner
2. HOD, PG Department of Physics and Guides of the students

Evaluation will be based on the content of the presentation and the presenter's delivery, ultimately aiming to determine how well the project's objectives and outcomes are communicated and understood.