

# **FACULTY OF SCIENCES**

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

**(Under Continuous Evaluation System)**

**Session: 2021-22**



**The Heritage Institution**

**KANYA MAHA VIDYALAYA  
JALANDHAR  
(Autonomous)**

# Kanya Maha Vidyalaya, Jalandhar (Autonomous)

## SCHEME AND CURRICULUM OF EXAMINATIONS OF TWO YEAR DEGREE PROGRAMME

### Master of Science (Physics)

Session 2021-22

| <b>Master of Science (Physics)</b> |                                 |             |            |      |    |    |                             |
|------------------------------------|---------------------------------|-------------|------------|------|----|----|-----------------------------|
| <b>SEMESTER-I</b>                  |                                 |             |            |      |    |    |                             |
| Course Code                        | Course Name                     | Course Type | Marks      |      |    |    | Examination time (in Hours) |
|                                    |                                 |             | Total      | Ext. |    | CA |                             |
|                                    |                                 |             |            | L    | P  |    |                             |
| MPHL-1391                          | Analog and Digital Electronics  | C           | 100        | 80   | -  | 20 | 3                           |
| MPHL-1392                          | Mathematical Physics            | C           | 100        | 80   | -  | 20 | 3                           |
| MPHL-1393                          | Classical Mechanics             | C           | 100        | 80   | -  | 20 | 3                           |
| MPHL-1394                          | Computational Techniques        | C           | 100        | 80   | -  | 20 | 3                           |
| MPHP-1395                          | Electronics Lab                 | C           | 100        | -    | 80 | 20 | 3                           |
| MPHP-1396                          | Computer Lab                    | C           | 100        | -    | 80 | 20 | 3                           |
| <b>Total</b>                       |                                 |             | <b>600</b> |      |    |    |                             |
| <b>Master of Science (Physics)</b> |                                 |             |            |      |    |    |                             |
| <b>SEMESTER-II</b>                 |                                 |             |            |      |    |    |                             |
| Course Code                        | Course Name                     | Course Type | Total      | Ext. |    | CA | Examination time (in Hours) |
|                                    |                                 |             |            | L    | P  |    |                             |
|                                    |                                 |             |            |      |    |    |                             |
| MPHL-2391                          | Quantum Mechanics-I             | C           | 100        | 80   | -  | 20 | 3                           |
| MPHL-2392                          | Electrodynamics-I               | C           | 100        | 80   | -  | 20 | 3                           |
| MPHL-2393                          | Condensed Matter Physics-I      | C           | 100        | 80   | -  | 20 | 3                           |
| MPHL-2394                          | Atomic & Molecular Spectroscopy | C           | 100        | 80   | -  | 20 | 3                           |
| MPHP-2395                          | Condensed Matter Physics Lab -I | C           | 100        | -    | 80 | 20 | 3                           |
| MPHP-2396                          | Spectroscopy Lab                | C           | 100        | -    | 80 | 20 | 3                           |
| <b>Total</b>                       |                                 |             | <b>600</b> |      |    |    |                             |

| <b>Master of Science (Physics)</b><br><b>Semester-III</b> |  |             |       |          |    |    |                             |
|---|--|-------------|-------|----------|----|----|-----------------------------|
| Course Code   | Course Name  | Course Type | Marks |          |    |    | Examination Time (in Hours) |
|   |  |             | Total | External |    | CA |                             |
|   |  |             |       | L        | P  |    |                             |
| MPHL-3391   | Quantum Mechanics-II   | C           | 100   | 80       | -- | 20 | 3                           |
| MPHL-3392   | Electrodynamics-II   | C           | 100   | 80       | -- | 20 | 3                           |
| MPHL-3393   | Condensed Matter Physics-II  | C           | 100   | 80       | -- | 20 | 3                           |
| MPHL-3394   | Nuclear Physics  | C           | 100   | 80       | -- | 20 | 3                           |
| MPHP-3395   | Condensed Matter Physics Lab-II  | C           | 100   | --       | 80 | 20 | 3                           |
| MPHP-3396   | Nuclear Physics Lab  | C           | 100   | --       | 80 | 20 | 3                           |
| <b>Master of Science (Physics)</b><br><b>Semester-IV</b>  |  |             |       |          |    |    |                             |
| MPHL-4391   | Particle Physics   | C           | 100   | 80       | -- | 20 | 3                           |
| MPHL-4392   | Statistical Mechanics  | C           | 100   | 80       | -- | 20 | 3                           |
| MPHL-4393<br>(OPT-_)                                      | Student may choose any two subjects from the following list of options | C           | 100   | 80       | -- | 20 | 3                           |
| MPHL-4394(OPT-_)  |  | C           | 100   | 80       | -- | 20 | 3                           |
| MPHD-4395   | Assignment/ Project  |             | 50    | -        | 40 | 10 |                             |

- OPT-I            Photonics  
OPT-II            Radiation Physics  
OPT-III           Reactor Physics  
OPT-IV           Nano Technology  
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 the 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. The student will have the knowledge of the topics of the research conducted by researchers at the Department of Physics, and knowledge of a well-defined area of research within 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.
- PSO 4. The student will learn to carry out experiments in basic as well as certain advanced areas of physics such as nuclear physics, condensed matter physics, spectroscopy, lasers and electronics.
- PSO 5. The work course of project and assignment will give the students special expertise within one of the research areas represented at the Department of Physics which will result in some research experience within a specific field of physics, through a supervised project.
- 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, and advanced mathematical methods.
- PSO 7. 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 understands the value of lifelong learning.
  - Gather, assess, and make use of new information.

**Master of Science (Physics)**  
SEMESTER-I

(SESSION 2021-22)

**COURSE CODE: MPHL-1391**  
**ANALOG AND DIGITAL ELECTRONICS**

**COURSE OUTCOMES**

After passing this course the student will be able to:

- CO 1. Understand the concept of Electronic devices (MOSFET, UJT, SCR) and their applications.
- CO 2. Demonstrate the concept of Electronic circuits: Operational Amplifier and its applications
- CO 3. Use concept of Digital Principles for electronic conversions.
- CO 4. Demonstrate application of sequential circuits.

# Master of Science (Physics)

SEMESTER-I  
(SESSION 2021-22)

## COURSE CODE: MPHL-1391 ANALOG AND DIGITAL ELECTRONICS

Maximum Marks: 100 (External 80 + Internal 20)

Examination Time: 3 Hours

Pass Marks: 40

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 20 marks, and the final examination at the end of the semester carries 80 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 16 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.

**Lectures 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

**Lectures 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-Subtractor circuits.

**Lectures 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.

**Lectures 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 2021-22)

## **COURSE CODE: MPHL-1392 MATHEMATICAL PHYSICS**

### **COURSE OUTCOMES OF MATHEMATICAL PHYSICS**

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

- CO 1. Understand and use, advanced mathematical methods and theories on various mathematical and physical problems.
- CO 2. Identify different special mathematical functions.
- CO 3. Understand Cartesian ( $X, Y, Z$ ), Spherical polar ( $r, \theta, \phi$ ) and Cylindrical ( $\rho, \phi, z$ ) coordinate systems and their transformation equations.
- CO 4. Solve partial differential equations with appropriate initial or boundary conditions with Green function techniques
- CO 5. Have confidence in solving mathematical problems arising in physics by a variety of mathematical techniques

# Master of Science (Physics)

SEMESTER-I  
(SESSION 2021-22)

**COURSE CODE: MPHL-1392**

**MATHEMATICAL PHYSICS**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 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 16 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 transform of derivatives and integrals, Inverse Laplace transform, Application of Laplace Transform.

**20Lectures**

### **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.

**10Lectures**

### **Unit –III: Differential equations and Special Functions.**

Second order differential equations, Frobenius method, wronskian and a second solution, the Sturm 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.

**20Lectures**



**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  $SU(2)$

**10 Lectures****Text and Reference Books**

1. Mathematical Methods for Physicist by George Arfken - New York Academy, 1970.
2. Mathematical Physics by P.K. Chattopadhyay, New Age International, 1990.

# **Master of Science (Physics)**

**Semester-1**

(SESSION 2021-22)

**COURSE CODE: MPHL-1393**

## **CLASSICAL MECHANICS**

### **COURSE OUTCOMES**

- CO 1. After the students complete this course they will be familiar with aspects of Classical Mechanics such as Lagrangian and Hamiltonian formulation, particle in central potentials, rigid body motion. These will form the essential background for other courses such as Quantum Mechanics, Electrodynamics and High Energy Physics that students would learn in the subsequent semesters.
- CO 2. Students will learn the importance of Lagrangian and Hamiltonian mechanics over the Newtonian mechanics and be able to solve the complex problems on the equations of motion by applying these two techniques.
- CO 3. Having successfully completed this course, students will be able to demonstrate knowledge and understanding of orbit problems using the conservation of angular momentum and total energy.
- CO 4. Students will also be able to demonstrate understanding of rigid body motion using Euler theorem and Euler angles, which will help them to solve advanced problems pertaining to celestial mechanics.

# Master of Science (Physics)

SEMESTER-I  
(SESSION 2021-22)

**COURSE CODE: MPHL-1393**  
**CLASSICAL MECHANICS**

**Maximum Marks: 100 (External 80 + Internal 20)**

**Examination Time: 3 Hours**

**Pass Marks: 40**

**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 20 marks, and the final examination at the end of the semester carries 80 marks.

**Note for the PaperSetters:**

**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 16 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:** Hamilton's principle, some techniques of the Calculus of variations, derivation of Lagrange equations from Hamilton's principle, conservation theorems and symmetry properties.

**Lectures 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).

**Lectures 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.

**Lectures 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:** Eigen value equation, Free vibrations, Normal Coordinates, vibrations of a triatomic molecule.

**Lectures 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 2021-22)

## **COURSE CODE: MPHL-1394 COMPUTATIONAL TECHNIQUES**

### **COURSE OUTCOMES**

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

- CO 1. The very first outcome of the course is having knowledge about various programming languages, their need in research and development.
- CO 2. The introduction to MATLAB gives a basic knowledge about syntaxes and procedures used in MATLAB to solve various mathematical problems.
- CO 3. Understanding of interpolation of data from an experimental data with equal and unequal intervals.
- CO 4. The students will be able to solve integration and differentiation numerically by using various methods.
- CO 5. Understanding of various numerical methods to solve polynomial and transcendental equations gives an insight of working of these methods.

# **Master of Science (Physics)**

SEMESTER-I  
(SESSION 2021-22)

**COURSE CODE: MPHL-1394**

## **COMPUTATIONAL TECHNIQUES**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 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 16 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: Scriptfiles, function files, Compiled files, p-code, variables, loops, branches, and control flow, Input/Output, Advanced data objects, structures, cells

**Lectures18**

### **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

**Lectures12**

### **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.

### **Lectures15**

#### **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

### **Lectures15**

#### **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 2021-22)

**COURSE CODE: MPHP-1395**  
**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 2021-22)

**COURSE CODE: MPHP-1395**  
**ELECTRONICS LAB**

**Maximum Marks: 100 (External 80 + Internal 20)**

**Examination Time: 3 Hours**

**Pass Marks: 40**

**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 20 marks, and the final examination at the end of the semester carries 80 marks.

## **Note for the Practical Examiners:**

Question paper is to be set on the spot jointly by the external and internal examiners. Two copies of the same to be submitted for the record to COE office, KanyaMahaVidyalaya, Jalandhar

## **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 2021-22)

**COURSE CODE: MPHP-1396**  
**COMPUTER LAB**

**After completion of this lab Student will be**

CO1: familiar with various MATLAB syntaxes and techniques to carryout 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 2021-22)

**COURSE CODE: MPHP-1396**  
**COMPUTER LAB**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 marks.

## **Note for the Practical Examiners:**

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## **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 Schrodinger Equation
- c) Time period calculation for a potential
- d) Luminous intensity of a perfectly blackbody vs. temperature

# **Master of Science (Physics)**

SEMESTER-II  
(SESSION 2021-22)

**COURSE CODE: MPHL-2391**  
**QUANTUM MECHANICS-I**

## **COURSE OUTCOMES OF QUANTUM MECHANICS**

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 complex functions and Hilbert spaces, and the theory of operator algebra and the concept that quantum states could be described in a vector space. Solutions of ordinary and partial differential equations that arise in quantum mechanics will also be studied.
- CO 2. The student will be able to build connections between mathematical development and conceptual understanding.
- 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 the utilization of simple harmonic oscillator and the role of Hilbert space in developing simple harmonic oscillator.

# Master of Science (Physics)

SEMESTER-II  
(SESSION 2021-22)

**COURSE CODE: MPHL-2391**

## QUANTUM MECHANICS-I

**Maximum Marks: 100 (External 80 + Internal 20)**

**Examination Time: 3 Hours**

**Pass Marks: 40**

**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 20 marks, and the final examination at the end of the semester carries 80 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 16 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.

**Lectures18**

**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 observable in Schrodinger and Heisenberg pictures, Heisenberg equations of motion, Ehrenfest's theorem. Simple harmonic oscillator Energy eigen values and eigen vectors of SHO, Matrix representation of creation and annihilation operators, Zero-point energy; Coherent states.

**Lectures12**

**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.

**Lectures12**

**UNIT-IV: *Spherical Symmetric Systems and Angular momentum* :**Schrodinger equation for a spherically symmetric potential. Orbital angular momentum commutation relations. Eigen value 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. Eigen vectors and eigen functions of  $J^2$  and  $J_z$ . Addition of angular momentum and C.G. coefficients.

**Lectures18**

### **Text and Reference Books**

1. Modern Quantum Mechanics by J.J.Sakurai-Pearson Education 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 (2<sup>nd</sup> Ed.) by V.K. Thankappan, New Age International Publications, New Delhi, 1996

# **Master of Science (Physics)**

SEMESTER-II  
(SESSION 2021-22)

**COURSE CODE: MPHL-2392**  
**ELECTRODYNAMICS-I**

## **COURSE OUTCOMES**

After passing this course the students will be able to:

CO1: understand the basic concepts of electrostatics and magnetism and related quantities and their calculations for different charge distribution as well as the behaviour of electric and magnetic field inside matter. The students will have the ability to solve the electrostatic problems by method of images helps.

CO2: demonstrate knowledge about the time-varying magnetic and electric fields and their effects by

CO3: understand the propagation of electromagnetic waves in conducting and insulating media.

# Master of Science (Physics)

SEMESTER-II  
(SESSION 2021-22)

**COURSE CODE: MPHL-2392**  
**ELECTRODYNAMICS-I**

**Maximum Marks: 100 (External 80 + Internal 20)**

**Examination Time: 3 Hours**

**Pass Marks: 40**

**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 20 marks, and the final examination at the end of the semester carries 80 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 16 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.

**Lectures 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.

**Lectures 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

**Lectures 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 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.

**Lectures 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)



SEMESTER-II  
(SESSION 2021-22)

**COURSE CODE: MPHL-2393**  
**Condensed Matter Physics-I**

**Course Outcome of Condensed Matter Physics-I**

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 crystal 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 Ferro Electrics and thermodynamics of ferroelectric transitions

# Master of Science (Physics)

SEMESTER II  
(SESSION 2021-22)

**COURSE CODE: MPHL-2393**

## Condensed Matter Physics-I

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 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 16 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 the 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 Ferro Electrics:

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 BaTiO<sub>3</sub>, 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. Kittel-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 2021-22)

**COURSE CODE: MPHL-2394**

## **ATOMIC AND MOLECULAR SPECTROSCOPY**

### **COURSE OUTCOMES**

Students will have achieved the ability to

- CO 1. Describe the atomic spectra of one and two valence 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 change in behaviour of atoms in external applied electric and magnetic field.
- 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.
- CO 5. state and justify the selection rules for various optical spectroscopies in terms of the symmetries of molecular vibrations

# Master of Science (Physics)

SESSION 21-22

SEMESTER-II

COURSE CODE: MPHL-2394

## ATOMIC AND MOLECULAR SPECTROSCOPY

Maximum Marks: 100 (External 80 + Internal 20)

Examination Time: 3 Hours

Pass Marks: 40

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 20 marks, and the final examination at the end of the semester carries 80 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 16 marks.

### UNIT-I: Spectra of one and two valance electron systems

Magnetic dipole moments, Larmor's theorem, Space quantization of orbital, spin and total angular momenta, Vector model for one and two valance 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.

15Lectures

### 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.

15Lectures

**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.

15Lectures

### 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)**  
**SESSION 21-22**  
**SEMESTER-II**  
**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 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 cell.

**Master of Science (Physics)**  
**SESSION 21-22**  
**SEMESTER-II**  
**COURSE CODE: MPHP-2395**  
**CONDENSED MATTER PHYSICS LAB-I**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 marks.

**Note for the Practical Examiners:**

Question paper is to be set on the spot jointly by the external and internal examiners. Two copies of the same to be submitted for the record to COE office, Kanya Maha Vidyalaya, Jalandhar

**LIST OF EXPERIMENTS**

1. To determine Hall coefficient by Hall Effect.
2. To determine the band gap of a semiconductor using p-n junction diode.
3. To determine the magnetic susceptibility of a material using Quink's method.
4. To determine the g-factor using ESR spectrometer.
5. To determine the energy gap and resistivity of the semiconductor using four probe method.
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.

**SEMESTER-II**  
**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.



SEMESTER-II  
COURSE CODE: MPHP-2396  
SPECTROSCOPY LAB

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 marks.

**Note for the Practical Examiners:**

Question paper is to be set on the spot jointly by the external and internal examiners. Two copies of the same to be submitted for the record to COE office, Kanya Maha Vidyalaya, Jalandhar

**LIST OF EXPERIMENTS**

1. To find the wavelength of monochromatic light using Fabry 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 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 2021-22)

## **COURSE CODE: MPHL-3391 QUANTUM MECHANICS-II**

### **Course outcomes**

- CO 1. Quantum mechanics-II aim at the applications of quantum mechanics. The course should give deeper knowledge about the foundations of quantum mechanics and skills in problem solving in quantum mechanics.
- CO 2. Make students familiar with various approximation methods applied to atomic, nuclear and solid-state physics, and to scattering.
- CO 3. The students will learn the applications of Time-independent and time-dependent perturbation theory in quantum mechanics and will develop a knowledge and understanding of perturbation theory, level splitting, and radiative transitions;
- CO 4. Develop a knowledge and understanding of the scattering matrix and partial wave analysis; and to solve quantum mechanics problems;

# Master of Science (Physics)

SEMESTER III  
(SESSION 2021-22)

**COURSE CODE: MPHL-3391**  
**QUANTUM MECHANICS-II**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 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 16 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

# **Master of Science (Physics)**

SEMESTER III  
(SESSION 2021-22)

**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 quadrupole. 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 2021-22)

COURSE CODE: MPHL-3392

Electrodynamics-II

Maximum Marks: 100 (External 80 + Internal 20)

Pass Marks: 40

Examination Time: 3 Hours

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 20 marks, and the final examination at the end of the semester carries 80 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 16 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:** In homogenous 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, Larmor'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 2021-22)

**COURSE CODE: MPHL-3393**  
**Condensed Matter Physics-II**

## **Course Outcome of Condensed Matter Physics-II**

- 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 2021-22)

## **COURSE CODE: MPHL-3393 CONDENSED MATTER PHYSICS-II Syllabus**

**Maximum Marks: 100 (External 80 + Internal 20)  
Pass Marks: 40**

**Examination Time: 3 Hours  
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 20 marks, and the final examination at the end of the semester carries 80 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 16 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-Wiley, New Delhi.
2. Solid State Physics by A.J. Dekkar-Macmillan India Ltd., New Delhi.
3. Material Science and Engineering by William D. Callister JR, Wiley
4. Elementary Solid State Physics by Omar, Addison Wesley.
5. Principles of Solid State Physics by R.A. Levy-New York Academy.
6. Solid State Physics by Ashcroft and Mermin-New York Holt.



# **Master of Science (Physics)**

SEMESTER III  
(SESSION 2021-22)

**COURSE CODE: MPHL-3394**

**NUCLEAR PHYSICS**

**Course Outcomes**

Upon completion of this course, the student will be able to:

- CO 1. Identify basic nuclear properties and outline their theoretical descriptions.
- CO 2. Understand the nature of nuclear forces that bind atomic nuclei together and the structure and dynamics of nuclei.
- CO 3. Apply the semi-empirical mass formula to evaluate the binding energy of a nucleus and other binding energy related properties.
- CO 4. Describe the role of spin-orbit coupling in the shell structure of atomic nuclei, and predict the properties of nuclear ground and excited states based on the shell model.
- CO 5. Understand the various decay properties of unstable nuclei such as beta decay, gamma decay, and parity violation.
- CO 6. Compare different nuclear reaction mechanisms in relation to cross-sections, excitation functions and angular distributions.

# Master of Science (Physics)

SEMESTER III  
(SESSION 2021-22)

SEMESTER III

COURSE CODE: MPHL-3394

NUCLEAR PHYSICS

Syllabus

**Maximum Marks: 100 (External 80 + Internal 20)**

**Examination Time: 3 Hours**

**Pass Marks: 40**

**Total Teaching hours: 60**

Out of 100 Marks, internal assessment (based on mid-semester test/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 80 marks.

**Note for the Paper Setters for final examination:** 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 16 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 2021-22)

## **COURSE CODE: MPHL-3395 CONDENSED MATTER LAB-II**

### Course Outcomes

Upon completion of this course, the student 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 2021-22)

## **COURSE CODE: MPHL-3395 CONDENSED MATTER LAB-II Syllabus**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**Total Teaching hours: 60**

Out of 100 Marks, internal assessment (based on mid-semester test/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 80 marks.

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 set up.

# **Master of Science (Physics)**

SEMESTER III  
(SESSION 2021-22)

**COURSE CODE: MPHL-3396**

**NUCLEAR PHYSICS LAB**

**Course Outcomes**

Upon completion of this course, the student 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 2021-22)

**COURSE CODE: MPHL-3396**

**NUCLEAR PHYSICS LAB**

**Syllabus**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**Total Teaching hours: 60**

Out of 100 Marks, internal assessment (based on mid-semester test/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 80 marks.

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)**

**SESSION 2021-22**

**SEMESTER IV**

**COURSE CODE: MPHL-4391**

**PARTICLE PHYSICS**

**Course Outcomes**

CO1: After completing this course the students will understand the fundamental principles and concepts governing particle physics. The students will learn various experimental techniques used in discovering the elementary particles and their various properties such as mass, lifetime, parity and spin.

CO2: Students will be able to understand the role of symmetries in particle physics. They will acquire basic knowledge on the fundamental forces of universe and various conservation laws followed in these forces (interactions).

CO3: Students will also learn the concept of CP violation in detail which will lead them to their knowledge about current area of research on the missing antimatter of universe.

CO4: The students will learn the Feynman rules and their application in calculating the cross sections for various particle interactions.

CO5: They will also be able to understand the theory of spontaneous breaking symmetry and its application to Higgs mechanism. Students will also have a broad overview of the standard model of particle physics and its predictions.



# Master of Science (Physics)

SESSION 2021-22

SEMESTER IV

COURSE CODE: MPHL-4391

PARTICLE PHYSICS

**Maximum Marks: 100 (External 80 + Internal 20)**

**Examination Time: 3 Hours**

**Pass Marks: 40**

**Total Teaching hours: 60**

Out of 100 Marks, internal assessment (based on mid-semester test/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 80 marks.

**Note for the Paper Setters for final examination:** 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 16 marks.**

## Unit-I

***Elementary Particles and Their Properties:*** Historical survey of elementary particles and their classification, fundamental forces of nature, determination of mass, life time, 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  $K^0 - \bar{K}^0$  doublet, time reversal invariance, CPT theorem, Gellmann's eightfold way of hadrons, quark model.

## Unit-III

***Weak Interactions:*** Classification of weak interactions,  $\tau$ - $\theta$  puzzle, parity violation in beta decay, parity violation in  $\Lambda$ -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  $\frac{1}{2}$ ), 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)**

**SESSION 2021-22**

**SEMESTER-IV**

**COURSE CODE: MPHL-4392**

**STATISTICAL MECHANICS**

## **Course**

After passing this course, students will be able to understand:

CO1: Why statistical mechanics arose, its basic contact with thermodynamics. How the diffusion problem of different and similar gases was resolved i.e. Gibbs paradox. The movement of phase points i.e. Liouville's theorem.

CO2: Students will understand the ensemble language of statistical mechanics i.e. micro canonical, canonical and grand canonical ensemble. Their description in terms of partition function and various areas where they are implied such as classical ideal gas, system of harmonic oscillators, paramagnetic behavior of gases, cluster expansion of classical gas. The need of switching from micro canonical to canonical and hence from canonical to grand canonical ensemble has also been explained.

CO3: Till now only the classical description of statistical mechanics has been explained, but now the students will understand about the quantum description also in terms of density matrix, also the quantum statistics of various ensembles. Various examples have also been explained.

CO4: Quantum description of classical gas has been fully described. Detailed quantum analysis of Bose Einstein statistics and Fermi Dirac statistics has been studied. Students will be able to understand the phenomenon of Bose Einstein condensation, gas of photons and phonons. Fermi Dirac Statistics has been explained through electron gas in metals, paramagnetic behavior of gases and about the life cycle of white dwarf stars.

# Master of Science (Physics)

SESSION 2021-22

SEMESTER-IV

COURSE CODE: MPHL-4392

STATISTICAL MECHANICS

|                         |     |
|-------------------------|-----|
| Maximum Marks: External | 80  |
| Internal                | 20  |
| Total                   | 100 |

Examination Time: 3 Hours

Total Teaching hours: 60

Pass Marks: 40

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 80 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.

## 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 Lectures**

## 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 canonical 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 Lectures**

## UNIT-III: Quantum Statistical Mechanics I

Quantum 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 Boltzmann formula in classical and quantum statistical mechanics.

**15**

## Lectures UNIT-IV: Quantum Statistical Mechanics II

An ideal gas in 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**

**Lectures**

**Text and Reference Books**

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

**Master of Science (Physics)**  
**SESSION 2021-22**  
**SEMESTER-IV**  
**COURSE CODE: MPHL-4393/94 (OPT-1)**  
**OPTICS AND PHOTONICS**

**Course Outcomes:**

After completing this course, the students will be able to :

CO1: understand basics idea about different types of wave guides.

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)**  
**SESSION 2021-22**  
**SEMESTER-IV**  
**COURSE CODE: MPHL-4393/94 (OPT-1)**  
**PHOTONICS**

Maximum Marks: External 80  
Hours

Internal 20  
Total 100

Examination Time: 3

Total Teaching hours: 60  
Pass Marks: 40

Out of 100 Marks, internal assessment (based on one mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 80 marks.

**Instructions for the Paper Setters:**

Eight questions of equal marks (Specified in the syllabus) are to be set, two in 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.

**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 (4th Edition), Addison-Wesley (2001)



**Master of Science (Physics)**  
**SESSION 2021-22**  
**COURSE CODE: MPHL-4392**  
**SEMESTER IV**  
**COURSE CODE: MPHL- 4393/94 (OPT-II)**  
**COURSE TITLE: RADIATION PHYSICS**

Course outcomes

- CO 1. Radiation Physics aim at study the knowledge of ionizing Radiation and Radiation Quantities.
- CO 2. Make students familiar with various types of dosimeters.
- CO 3. The students will have knowledge of Radiation effects and its protection.
- CO 4. Develop a knowledge and understanding of the radiation shielding.

# Master of Science (Physics)

SESSION 2021-22

SEMESTER IV

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

COURSE TITLE: RADIATION PHYSICS

Maximum Marks: 100 (External 80 + Internal 20)

Examination Time: 3 Hours

Pass Marks: 40

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 20 marks, and the final examination at the end of the semester carries 80 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 16 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-Kernal. Radiation attenuation from a line and plane source. Practical applications of some simple numerical problems.

***Books :***

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)**  
**SESSION 2021-22**

SEMESTER IV

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

**COURSE TITLE: REACTOR PHYSICS**

**Course Outcomes-**

CO1. Reactor Physics aims to give an insight on functioning of Reactors.

CO2. To learn about Reactor safety and control

CO3. Types of reactors and detailed working of Indian nuclear reactors

**Master of Science (Physics)**  
**SESSION 2021-22**  
**SEMESTER IV**  
**COURSE CODE: MPHL- 4393/94(OPT-III)**  
**COURSE TITLE: REACTOR PHYSICS**  
**Syllabus**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 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 16 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.

**Lectures 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.

**Lectures 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.

**Lectures 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.

**Lectures 15**

**Books:**

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)**  
**SESSION 2021-22**  
**SEMESTER IV**  
**COURSE CODE: MPHL- 4393/94(OPT-IV)**  
**COURSE TITLE: NANOTECHNOLOGY**

**Course Outcomes :**

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

CO1: understand basic ideas of nanotechnology and synthesis techniques of nano materials.

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)**  
**SESSION 2021-22**  
**SEMESTER IV**  
**COURSE CODE: MPHL- 4393/94(OPT-IV)**  
**COURSE TITLE: NANOTECHNOLOGY**  
**Syllabus**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 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 16 marks.**

**SECTION-A**

**Introduction and Synthesis of Nano Materials:**

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.

(Lectures  
15)

### SECTION-B

#### **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

(Lectures  
15)

### SECTION-C

#### **Carbon Nanotubes and other Carbon based materials:**

Preparation of Carbon nano tubes, 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 Fullerene and other associated carbon clusters/molecules, Graphene preparation, characterization and properties, DLC and nano diamonds.

(Lectures 15)

### SECTION-D

#### **Nanosemiconductors and Nano sensors:**

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

(Lectures  
15)

#### **Books:**

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 Microscopy: 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)**  
**SESSION 2021-22**  
**SEMESTER IV**  
**COURSE CODE: MPHL- 4393/94(OPT-V)**  
**COURSE TITLE: MATERIAL SCIENCE**

**Course Outcomes:**

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

CO1: understand basics about thin films and various methods used to prepare thin films.

CO2: understand basics of Polymers and Ceramics and their characteristics.

CO3: **understand** Spectroscopic techniques like UV-VIS, NMR & Photoluminescence  
Transmission electron microscopy (TEM), Scanning electron microscopy (SEM)

CO4: understand the characterisation techniques like XRD, Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), Secondary ion mass spectroscopy (SIMS)

**Master of Science (Physics)**  
**SESSION 2021-22**  
**SEMESTER IV**  
**COURSE CODE: MPHL- 4393/94(OPT-V)**  
**COURSE TITLE: MATERIAL SCIENCE**  
**Syllabus**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 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 16 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, glasses and refractories.

**UNIT III**

Characterization Techniques-I: Spectroscopic techniques: UV-VIS, NMR & Photoluminescence spectroscopy for characterization of materials. Transmission electron microscopy (TEM), Scanning electron microscopy (SEM)

**UNIT IV**

Characterization Techniques-II: X-ray diffraction, data manipulation of diffracted X-rays for structure determination; X-ray fluorescence spectrometry for element detection with concentration; Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), Secondary ion mass spectroscopy (SIMS)

### **Text and Reference Books:**

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 and T.A. Delchar- Cambridge University Press, 1994.

**Master of Science (Physics)**  
**SESSION 2021-22**  
**SEMESTER IV**  
**COURSE CODE: MPHL- 4393/94(OPT-VI)**  
**COURSE TITLE: SPACE SCIENCE**

**COURSE OUTCOMES:**

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

**CO1: understand** Hydrostatics , Emission mechanisms and Excitation mechanism 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)**  
**SESSION 2021-22**  
**SEMESTER IV**  
**COURSE CODE: MPHL- 4393/94(OPT-VI)**  
**COURSE TITLE: SPACE SCIENCE**  
**Syllabus**

**Maximum Marks: 100 (External 80 + Internal 20)**  
**Pass Marks: 40**

**Examination Time: 3 Hours**  
**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 20 marks, and the final examination at the end of the semester carries 80 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 16 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<sub>1</sub>), Variations in these regions.

**F<sub>2</sub> region:** Formation of F<sub>2</sub>-layer, Continuity equation, F<sub>2</sub>-region anomalies, Thermal properties of the F<sub>2</sub>-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 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).

**Text Books:**

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)**  
**SESSION 2021-22**  
**SEMESTER IV**  
**ASSIGNMENT/PROJECT**

**Course No. MPHD-4395**

**Maximum Marks: 50 (External 40 + Internal 10)**  
**Pass Marks: 20**

**Examination Time: 3 Hours**  
**Total Teaching hours: 90**

Assignment and Project should be based on following techniques in:

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, College/ Internal Examiner