FACULTY OF SCIENCES

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

(Under Continuous Evaluation System)

Session: 2022-23

The Heritage Institution

KANYA MAHA VIDYALAYA
JALANDHAR
(Autonomous)

Master of Science (Physics)
Semester-III
Session: 2022-23

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
Total			**600**				

Master of Science (Physics)
Semester-IV

Course Code	Course Name	Course Type	Total	L	P	CA	Examination Time (in Hours)
MPHL-4391	Particle Physics	C	100	80	--	20	3
MPHL-4392	Statistical Mechanics	C	100	80	--	20	3
MPHL-4393 (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	
Total			**450**				

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 III

(SESSION 2022-23)

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 2022-23)

COURSE CODE: MPHL-3391
QUANTUM MECHANICS-II

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: 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 2022-23)

COURSE CODE: MPHL-3392

Electrodynamics-II

Course outcomes

After passing this course the students will be able to:

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

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

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

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

Master of Science (Physics)

SEMESTER III

(SESSION 2022-23)

COURSE CODE: MPHL-3392

Electrodynamics-II

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

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

UNIT-IV

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

Text and Reference Books:

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

Master of Science (Physics)

SEMESTER III

(SESSION 2022-23)

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 2022-23)

COURSE CODE: MPHL-3393
CONDENSED MATTER PHYSICS-II
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 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-WielyEstem Ltd., New Delhi.
2. Solid State Physics by A.J. Dekkar-Maemillan India Ltd., New Delhi.
3. Material Science and Engineering by William D. Callister JR, Wiley
4. Elementary Solid State Physics by Omar, Addison Wesly.
5. Principles of Solid State Physics by R.A. Levy-New York Academy.
6. Solid State Physics by Aschroft and Mermin-New York Holt.

Master of Science (Physics)

SEMESTER III

(SESSION 2022-23)

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 2022-23)

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 2022-23)

COURSE CODE: MPHL-3395

CONDERNSED 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 2022-23)

COURSE CODE: MPHL-3395

CONDERNSED MATTER LAB-II

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.

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 2022-23)

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 2022-23)

COURSE CODE: MPHL-3396

NUCLEAR PHYSICS LAB

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.

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 2022-23)

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 2022-23)

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 $K^o - \overline{K^o}$ doublet, time reversal invariance, CPT theorem, Gellmann's eightfold way of hadrons, quark model.

Unit-III

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

Unit-IV

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

Reference books:

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

Master of Science (Physics)

(SESSION 2022-23)

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 2022-23)

SEMESTER-IV

COURSE CODE: MPHL-4392
STATISTICAL MECHANICS

Maximum Marks: External	80		Examination Time: 3 Hours
Internal	20		Total Teaching hours: 60
Total	100		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 canononical ensemble, the physical significance of the statistical quantities, examples, fluctuation of energy and density. Cluster expansion of classical gas, the virial equation of state.

15 Lectures

UNIT-III: Quantum Statistical Mechanics I

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

15

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-2022-23)

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-2022-23)

SEMESTER-IV

COURSE CODE: MPHL-4393/94 (OPT-1)

PHOTONICS

Maximum Marks: External 80 Examination Time: 3 Hours

Internal 20 Total Teaching hours: 60

Total 100 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 (4thEdition), Addison-Wesley (2001)

Master of Science (Physics)

(Session-2022-23)

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-2022-23)

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 kernal 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.

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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

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SEMESTER IV

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

COURSE TITLE: REACTOR 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 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 ration 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, breading 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.

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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.

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SEMESTER IV

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

COURSE TITLE: NANOTECHNOLOGY

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

(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 solarcells, 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 Microcopy: Ian. M. Watt-Cambridge University Press, 1997.
11. Ultrasonic Testing of Materials: J.K. Krammer and H.K. Krammer-Springer Verlag, 1996.
12. Physical Properties of Carbon Nanotube: R. Satio, G. Dresselhaus and M. S. Dresselhaus-Imperial College Press, 1998.
13. Sensors Vol. 8, Micro and Nanosensor Technology: H. Meixner and R. Jones (Editor)-John Wiley and Sons, 2000.

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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 characeristics.

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)

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SEMESTER IV

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

COURSE TITLE: MATERIAL SCIENCE

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 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.

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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.

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SEMESTER IV

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

COURSE TITLE: SPACE SCIENCE

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 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_1), Variations in these regions.
F_2 region: Formation of F_2-layer, Continuity equation, F_2-region anomalies, Thermal properties of the F_2-region.

UNIT III

Ionospheric Irregularities and disturbances: Spread-F, Travelling ionospheric disturbances, Perturbation by electromagnetic and corpuscular radiation, Ionospheric and magnetic storms.
Propagation of radio waves through 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

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SEMESTER IV

<u>ASSIGNMENT/PROJECT</u>

Course No. MPHD-4395

Maximum Marks: 50 (External 40 + Internal 10) **Examination Time: 3 Hours**
Pass Marks: 20 **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