NEP and Learning Outcome-based Curriculum Framework

For

M.Sc. Physics (Integrated) Programme

Academic Session (w.e.f. 2025-2026)

DEPARTMENT OF PHYSICS

GURUGRAM UNIVERSITY, GURUGRAM

(A State Govt. University Established Under Haryana Act17 of 2017)

1. Core Courses

Scheme for M.Sc. Physics (Integrated)

Core Course(s)

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
CC-A1	Mechanics	242/PHYI/ CC101	3	0	2	3	0	1	4	25	50	5	20	100
CC-A2	Mathematical Physics-I	242/PHYI/ CC102	3	0	2	3	0	1	4	25	50	5	20	100
CC-A3	Waves and Oscillations	242/PHYI/ CC201	3	0	2	3	0	1	4	25	50	5	20	100
CC-A4	Electrodynamics-II	242/PHYI/ CC202	3	0	2	3	0	1	4	25	50	5	20	100
CC-A5	Electronics-I	242/PHYI/ CC301	3	0	2	3	0	1	4	25	50	5	20	100
CC-A6	Concepts of Modern Physics	242/PHYI/ CC302	3	0	2	3	0	1	4	25	50	5	20	100
CC-A7	Optics	242/PHYI/ CC401	3	0	2	3	0	1	4	25	50	5	20	100
CC-A8	Mathematical Physics-II	242/PHYI/ CC402	3	0	2	3	0	1	4	25	50	5	20	100
CC-A9	Heat and Thermodynamics	242/PHYI/ CC403	3	0	2	3	0	1	4	25	50	5	20	100
CC-A10	Quantum Mechanics	242/PHYI/ CC404	3	0	2	3	0	1	4	25	50	5	20	100
CC-A11	Atomic & Molecular Physics	242/PHYI/ CC501	4	0	0	0	4	0	4	30	70	0	0	100
CC-A12	Statistical Physics	242/PHYI/ CC502	4	0	0	0	4	0	4	30	70	0	0	100
CC-A13	Nuclear and Particle Physics	242/PHYI/ CC503	4	0	0	0	4	0	4	30	70	0	0	100
CC-A14	Physics Lab	242/PHYI/	0	0	8	0	0	4	4	0	0	30	70	100

		CC504											
CC-A15	Quantum Mechanics-II	242/PHYI/ CC601	4	0	0	4	0	0	4	30	70	0	0	100
CC-A16	Solid State Physics	242/PHYI/ CC602	3	0	2	3	0	1	4	25	50	5	20	100
CC-A17	Electrodynamics-II	242/PHYI/ CC603	3	0	2	3	0	1	4	25	50	5	20	100
CC-A18	Synthesis and characterization of Materials	242/PHYI/ CC604	3	0	2	3	0	1	4	25	50	5	20	100

Ranjit

DETAILED SYLLABI OF CORE COURSES FOR M.Sc. PHYSICS (INTEGRATED)

Semester-I

Core Course(s)

COURSE ID: 242/PHYI/CC101

MECHANICS

Marks (Theory): 50 **Credits: 3 (45 lectures)**
Marks (Internal Assessment): 25 **Time: 3 Hrs**

Note: The paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of five short answer type questions, each of marks. The rest of the eight questions are to be set uniformly, with two questions from each unit selected. A student is required to attempt five questions, selecting one from each unit along with compulsory question no 1. The question paper shall contain 20 % numerical problems in the relevant papers.

Course Objective: The objective of this course is to teach the students fundamentals of Newtonian Mechanics, rigid body dynamic, concept of inverse square force and the special theory of relativity.	**Course Outcome:** The student will be able to understand the concept and the applications of Newtonian mechanics. The origin and applications of special theory of relativity should be clear to students.

Unit - I

Time derivative of a vector, Motion in Plane Polar coordinates, Newton's Law and their applications, Forces and equation of motion, Dynamics of a system of particles, Principle of conservation of momentum, Impulse, Work and Kinetic Energy Theorem, Conservative Forces and Non-Conservative Forces. Potential Energy, Energy diagram, Stable, Unstable and Neutral Equilibrium, Force as gradient of the potential energy, Centre of Mass and Laboratory Frames.

Unit - II

Angular momentum of a particle and system of particles, Torque, Principle of conservation of Angular Momentum, Rotation about a fixed axis, Determination of Moment of Inertia of symmetric Rigid Bodies (rectangular, cylindrical and spherical) using Parallel and Perpendicular axes theorems, Kinetic energy of rotation, Motion involving both translation

Ranjit

and rotation, Vector Nature of Angular Velocity and Angular Momentum, Gyroscope, Non-Inertial Systems: Non-inertial frames and fictitious forces, Uniformly rotating frame, Centrifugal force, Coriolis force and its applications.

Unit - III

Central forces, Law of conservation of Angular Momentum for Central Forces, Two-Body problem and its reduction to equivalent One-Body problem and its solution, Concept of effective potential energy and stability of orbits for central potentials, Discussion on Trajectories, Solution of Kepler's Problem, Kepler's Laws for planetary motion, Orbit for Artificial Satellites.

Unit - IV

Inertial and Non-Inertial Frames, Invariance of Newton s Laws of motion under Galilean transformations, Postulates of Special Theory of Relativity, Lorentz Transformations, simultaneity, Length Contraction, Time Dilation, Proper Length and Proper Time, Life Time of a Relativistic Particle (for example Muon Decay Time and Decay Length), Relativistic Transformation of Velocity and Acceleration, Variation of Mass with Velocity, Mass-Energy Equivalence.

References:

1. An introduction to Mechanics, D. Kleppner, R.J. Kolenkow, McGraw-Hill.
2. Mechanics, Berkeley Physics, Vol.1, C. Kittel, W. Knight, et al., Tata McGraw-Hill.
3. Fundamentals of Physics, R. Resnick, D. Halliday and J. Walker, Wiley Publications.
4. Mechanics, D.S. Mathur, S. Chand and Company Limited.
5. Feynman Lecture Series, Vol. I, R. P. Feynman, R. B. Leighton, M. Sands, Pearson Education.

MECHANICS LAB

Marks (External): 20 — **Credits: 1 (30 Hrs)**
Marks (Internal Assessment): 05 — **Time: 3 Hrs**

1. Each student should perform at least five experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary and some experiments may be added during the course.

List of Experiments:

Ranjit

1. Measurements of Length (or Diameter) using Vernier Caliper, Screw Gauge and Travelling Microscope.
2. To Study the Random Error in observations.
3. To determine the Height of a Building using a Sextant.
4. To determine the vertical distance between two given points using Sextant.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique
7. To determine the Young's Modulus of a Wire by Optical Lever Method.
8. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
9. To determine the elastic Constants of a wire by Searle's method.
10. To determine the value of acceleration due to gravity (g) using bar pendulum

References:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. BSc Practical Physics, Harnam Singh, S. Chand Publications, 2020.
3. BSc Practical Physics, Geeta Sanon, R. Chand Publications, 2020.
4. Advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 1511, Kitab Mahal.

COURSE ID: 242/PHYI/CC102

MATHEMATICAL PHYSICS-I

Marks (Theory): 50 **Credits: 3 (45 lectures)**
Marks (Internal Assessment): 25 **Time: 3 Hrs**

Note: The paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. The rest of the eight questions are to be set uniformly, with two questions from each unit selected. A student is required to attempt five questions, selecting one from each unit along with compulsory question no 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: The present course introduces about the vector calculus, differential equation and Curvilinear Coordinates and their applications. It also develops an understanding of Special mathematical functions required for advanced physics problems.	**Course Outcome:** After completing this course, students would be able to deal with mathematics that appears in other papers such as Classical Mechanics, Quantum Mechanics, Nuclear Physics, Condensed Matter Physics, etc.

Rayt

UNIT-I

Vector Calculus: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

Vector Differentiation: Gradient of a scalar field and its geometrical interpretation. Divergence and curl of vector fields. Laplacian operator. Vector identities.

Vector Integration: Infinitesimal line, surface and volume elements. Line, surface and volume integrals of vector fields

Unit-II

Flux of a vector field. The Fundamental Theorem for Gradients, Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

Orthogonal Curvilinear Coordinates, Spherical and cylindrical coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical

The Dirac Delta Function: Properties and basic applications

Unit-III

Calculus: Review of basic concepts, limits, continuity, average and instantaneous quantities, differentiation, Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).

First Order and Second Order Differential equations: Integrating Factor, Homogeneous Equations with constant coefficients, Wronskian and general solution, Statement of existence and Uniqueness Theorem for Initial Value Problems, Particular Integral,

Unit-IV

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

Introduction to Partial Differential Equations, Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry

References:

1. Mathematical Methods for Physicists. B. Arfken, H. J. Weber, F.E.Harris,2013, 7th Ed., Elsevier.
2. An introduction to ordinary differential equations, E. A. Coddington, 2009, PHI learning

Ranjit

3. Mathematical Physics, Goswami, 1st edition, Cengage Learning
4. Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press
5. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.

MATHEMATICAL PHYSICS-I LAB

Marks (External): 20 **Credits: 1 (30Hrs)**
Marks (Internal Assessment): 05 **Time: 3 Hrs**

1. Each student should perform at-least five experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary and some experiments may be added during the course.

List of Experiments:

1. Basic plotting using MATLAB/Mathematica
2. Visualization of vectors and their multiplications using MATLAB/Mathematica
3. Vector differentiation using MATLAB/Mathematica
4. Line integration of vector using MATLAB/Mathematica
5. Surface integration of vector using MATLAB/Mathematica
6. Volume integration of vector MATLAB/Mathematica
7. Verification of fundamental theorems of gradient/curl/divergence using MATLAB/Mathematica
8. Solution of differential equations using MATLAB/Mathematic and plotting the solutions

References:

1. Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers, Rudra Pratap, Oxford University Press
2. MATLAB: An Introduction with Applications, Amos Gilat, Wiley
3. MATLAB and Its Applications in Engineering, Raj Kumar Bansal, Pearson Education
4. MATLAB Programming for Engineers, Stephen J. Chapman, Cengage
5. MATLAB: A Practical Introduction to Programming and Problem Solving, Stormy Attaway, Elsevier

Semester-II

Core Course(s)

COURSE ID: 242/PHYI/CC201

Rangt

WAVES AND OSCILLATIONS

Marks (Theory): 50 | **Credits :3 (45 lectures)**
Marks (Internal Assessment) : 25 | **Time : 3 Hrs**

Note: The paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of five short answer type questions, each of two marks. The rest of the eight questions are to be set uniformly, with two questions from each unit selected. A student is required to attempt five questions, selecting one from each unit along with compulsory question no 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: The objective of this course is to introduce the basics of oscillatory motion, wave motion, transmission linens, ultrasonic and their applications.	**Course Outcome:** After completion of this course, students will be familiar with the concept of wave and oscillations.

UNIT – I

Simple Harmonic Motion (SHM): Oscillatory motion, Oscillations of a Spring-Mass System; Simple harmonic oscillator: Equation of motion, solution, characteristics and energy stored; Examples of Physical Systems Executing SHM: Simple Pendulum, Compound Pendulum, LC-Circuit; Principle of Superposition; Superposition of Two Collinear Harmonic Oscillations of Same/Different Frequencies; Beats; Superposition of Two Perpendicular Simple Harmonic Oscillations of Same/Different Frequencies and Lissajous Figures.

UNIT – II

Damped Oscillations and Forced Oscillation: Equation of Motion of a Damped Oscillator and its Solutions; Heavy Damping; Critical Damping; Weak Damping and its Characteristics: Logarithmic Decrement, Relaxation Time, Quality Factor; Forced Oscillator: Differential Equation and its Solution, Resonance, Power Absorbed; Quality Factor.

UNIT – III

Coupled Oscillations: Coupled Oscillator comprising Two Oscillators and its Solution; Normal Coordinates; Degrees of Freedom and Normal Modes of Vibration, Energy relations in Coupled Oscillations, Many Coupled Oscillators.

UNIT – IV

Waves: Waves in One Dimension; Superposition of Waves; Stationary Waves; Waves on a Stretched String with Fixed Ends; Phase Velocity and Group Velocity; Transverse and Longitudinal Waves, The Doppler Effect.

Ranjit

References:

1. Vibrations and Waves by A. P. French. (CBS Pub. and Dist., 1987).
2. Wave and Oscillation by W. F. Smith (OUP USA, 2010).
3. The Physics of Waves and Oscillations by N.K. Bajaj (Tata McGraw-Hill, 1988).
4. The Physics of Vibrations and Waves by H. J. Pain (Wiley, 2006).
5. An Introduction to Mechanics by Daniel Kleppner, Robert J. Kolenkow (McGraw-Hill, 1973).

WAVES AND OSCILLATIONS LAB

Marks (External) : 20
Marks (Internal Assessment) : 05

Credits : 1 (30 Hrs)
Time : 3 Hrs

1. Each student should perform at least six experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary and experiments may be added during the course.

List of Experiments:

1. Estimate limits on angular displacement for SHM by measuring the time period at different angular displacements and compare it with the expected value of time period for SHM using Bar Pendulum.
2. To study the damped oscillations using bar pendulum.
3. To study the effect of area of the damper on damped oscillations. Also plot amplitude as a function of time and determine the damping coefficient and Q factor for different dampers.
4. To determine the value of acceleration due to gravity using Kater's pendulum for (a) $T1 \approx T2$ and (b) $T1 \neq T2$ and discuss the relative merits of both cases by estimation of error in the two cases.
5. Understand the applications of CRO by measuring voltage and time period of a periodic waveform using CRO.
6. To study the superposition of two perpendicular simple harmonic oscillations using CRO (Lissajous figures).

Ranjit

7. To calculate g, spring constant and mass of a spring using static and dynamic methods.
8. To calculate spring constant of series and parallel combination of two springs.
9. To determine the frequency of an electrically maintained tuning fork by Melde's experiment and to verify λ^2 –T Law.

References:

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
4. A Text Book of Practical Physics, Vol I and II, Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
5. An Introduction to Error Analysis: The study of uncertainties in Physical Measurements, J. R. Taylor, 1997, University Science Books List of experiments.

COURSE ID: 242/PHYI/CC202

ELECTRODYNAMICS

Marks (Theory): 50 **Credits: 3 (45 lectures)**
Marks (Internal Assessment): 25 **Time: 3 Hrs**

Note: The paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of five short answer type questions, each of marks. The rest of the eight questions are to be set uniformly, with two questions from each unit selected. A student is required to attempt five questions, selecting one from each unit along with compulsory question no 1. The question paper shall contain 20 % numerical problems in the relevant papers.

Course Objective: The course on electricity and magnetism aims to provide the basics of electrostatic system and introduce the concept of magnetism and magnetic materials. Further fundamental of electromagnetism and A.C. circuit are also involved in the study of electricity and magnetism.	**Course Outcome:** The student will be able to know the basic concepts of electric field, magnetic field, electromagnetic induction and dielectric behavior of matter. The electrical circuits and networks theorems should also be clear to students.

UNIT – I

Rajat

Electrostatics: Coulomb's Law, Electric field and field lines, Electric flux, Gauss's Law with applications, Divergence and Curl of Electrostatic Fields, Electrostatic Potential, Laplace's and Poisson equations, Electrostatic energy of system of charges and continuous charge distribution, Conductors in an electrostatic Field, Capacitors

UNIT – II

Laplace Equation: Laplace equation and its properties, Boundary Conditions and Uniqueness Theorems, Method of Image and its applications, Potential using method of separation of variables, Multipole Expansion of potential due to a charge distribution

Electric field in Matter: Polarization of atoms and molecules, The Field of a Polarized Object, Bound charges and their physical interpretation, Gauss's Law in the Presence of Dielectrics, Susceptibility, Permittivity, Dielectric Constant for linear dielectrics

UNIT – III

Magnetostatics: Lorentz force law, The Biot-Savart Law and its applications, Ampère's Law, The Divergence and Curl of B, Magnetic Vector Potential, Multipole Expansion of the Vector Potential

Magnetic Fields in Matter: Magnetization, Diamagnets, Paramagnets, Ferromagnets, Torques and Forces on Magnetic Dipoles, The Field of a Magnetized Object, Physical Interpretation of Bound Currents, Ampère's Law in Magnetized Materials, Magnetic Susceptibility and Permeability

UNIT – IV

Electromagnetic Induction: Motional emf, Faraday's Law and Induced Electric Field, Inductance (Mutual and self), Energy in Magnetic Fields, Maxwell's contribution, Maxwell's Equations in Matter, Boundary Conditions

References:

1. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
2. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
3. Feynman Lectures, Vol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
4. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
5. Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. 1, 1991, Oxford Univ. Press.
6. Network Analysis, Mac E. Van Valkenburg, PHI Publications.

ELECTRICITY AND MAGNETISM LAB

Marks (External): 20 — **Credits: 1 (30Hrs)**

Marks (Internal Assessment): 05 — **Time: 3 Hrs**

Rangt

1. Each student should perform at least six experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary and experiments may be added during the course.

List of Experiments:

1. To compare the capacitances of two capacitors by De'sauty bridge and hence to find the dielectric constant of a medium.
2. To study B-H curves for different ferromagnetic materials.
3. To study the variation of magnetic field with distance and to find the radius of coil by Stewart and Gee's apparatus
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
6. To determine self-inductance of a coil by Anderson's bridge.
7. To determine self-inductance of a coil by Rayleigh's method.
8. Magnetic field variation along the axis of a circular coil and in a Helmholtz coil ((r>a, r=a and r<a), Here 'a' is radius of coil and 'r' is distance between the coils).

References:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. BSc Practical Physics, Geeta Sanon, R. Chand Publications, 2020.
3. BSc Practical Physics, Harnam Singh, S. Chand Publications, 2020.
4. A Text Book of Practical Physics, I. Prakash &Ramakrishna, 11th Ed., 1511,Kitab Mahal
5. Advanced level Physics Practical, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
6. Engineering Practical Physics, S. Panigrahi and B. Mallick, 1515, Cengage Learning.

Ranjit

NEP and Learning Outcome-based Curriculum Framework

For

M.Sc. Physics (Integrated) Programme

Academic Session (w.e.f. 2025-2026)

DEPARTMENT OF PHYSICS

GURUGRAM UNIVERSITY, GURUGRAM

(A State Govt. University Established Under Haryana Act17 of 2017)

Ranjit

14

Scheme for M.Sc. Physics (Integrated)

Semester I

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)														
CC-A1	Mechanics	242/PHYI/ CC101	3	0	2	3	0	1	4	25	50	5	20	100
CC-A2	Mathematical Physics-I	242/PHYI/ CC102	3	0	2	3	0	1	4	25	50	5	20	100
Minor/ Vocational Course(s)														
MIC-1	One from Pool													
Multidisciplinary Course(s)														
MDC-1	One from Pool													
Ability Enhancement Course(s)														
AEC-1	One from Pool													
Skill Enhancement Course(s)														
SEC-1	One from Pool													
Value-added Course(s)														
VAC-1	One from Pool													
Total Credits									**22**					**550**

Semester II

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)														
CC-A3	Waves and Oscillations	242/PHYI/ CC201	3	0	2	3	0	1	4	25	50	5	20	100
CC-A4	Electrodynamics	242/PHYI/ CC202	3	0	2	3	0	1	4	25	50	5	20	100
Minor/ Vocational Course(s)														
MIC-2	One from Pool													
Multidisciplinary Course(s)														
MDC-2	One from Pool													
Ability Enhancement Course(s)														
AEC-2	One from Pool													
Skill Enhancement Course(s)														
SEC-2	One from Pool	242/PHYI/ SE201	0	0	6	0	0	3	3	0	0	25	50	75
Value-added Course(s)														
VAC-2	One from Pool .	242/PHYI/ VA201	2	0	0	2	0	0	2	15	35	0	0	50

Semester III

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)														
CC-A5	Electronics-I	242/PHYI/ CC301	0	0	8	0	0	4	4	30	75	0	0	100
CC-A6	Mathematical Physics-II	242/PHYI/ CC302	3	0	2	3	0	1	4	25	50	5	20	100
Minor/ Vocational Course(s)														
MIC-3	One from Pool													
Multidisciplinary Course(s)														
MDC-3	One from Pool													
Ability Enhancement Course(s)														
AEC-3	One from Pool													
Skill Enhancement Course														
SEC3	One from Pool													
Value Added Course														
VAC3	One from Pool													

Semester IV

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
					Core Course(s)									
CC-A7	Electronics-II	242/PHYI/ CC401	3	0	2	3	0	1	4	25	50	5	20	100
CC-A8	Optics	242/PHYI/ CC402	3	0	2	3	0	1	4	25	50	5	20	100
CC-A9	Heat and Thermodynamics	242/PHYI/ CC403	3	0	2	3	0	1	4	25	50	5	20	100
CC-A10	Concepts of Modern Physics	242/PHYI/ CC404	4	0	0	4	0	0	4	30	75	0	0	100
					Minor/ Vocational Course(s)									
MIC/VOC-4	One from Pool													
					Ability Enhancement Course(s)									
AEC-4	One from Pool													
					Value-added Course(s)									
VAC-4	One from Pool													

Ranjit

Semester V

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
						Core Course(s)								
CC-A11	Atomic & Molecular Physics	242/PHYI/ CC501	4	0	0	0	4	0	4	30	70	0	0	100
CC-A12	Statistical Physics	242/PHYI/ CC502	4	0	0	0	4	0	4	30	70	0	0	100
CC-A13	Nuclear and Particle Physics	242/PHYI/ CC503	4	0	0	0	4	0	4	30	70	0	0	100
CC-A14	Physics Lab	242/PHYI/ CC504	0	0	8	0	0	4	4	0	0	30	70	100
						Minor/ Vocational Course(s)								
MIC-5	One from Pool													
						Skill Enhancement Course(s)								
Internship #	Internship#								4			30	70	100

#Four credits of internship earned by a student during summer internship after 2nd semester or 4th semester will be counted in 5th semester of a student who pursue 3-year UG Programmes without taking exit option.

Ranjit

Semester VI

Course Code	Course Title	Course ID	L	T	P	L	T	P	Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)														
CC-A15	Quantum Mechanics	242/PHYI/ CC601	4	0	0	4	0	0	4	30	70	0	0	100
CC-A16	Solid State Physics	242/PHYI/ CC602	3	0	2	3	0	1	4	25	50	5	20	100
CC-A17	Electromagnetic Theory	242/PHYI/ CC603	3	0	2	3	0	1	4	25	50	5	20	100
CC-A18	Synthesis and characterization of Materials	242/PHYI/ CC604	3	0	2	3	0	1	4	25	50	5	20	100
Minor/ Vocational Course(s)														
MIC-6	One from Pool													
Skill Enhancement Course(s)														
SEC-4	One from Pool													

1. *The curriculum for semesters 7th, 8th, 9th and 10th will be provided in due course of time.*
2. *The MDC, AEC, SEC, and VAC courses could be chosen from the Departmental shortlisted Swayam-NPTEL Course list.*

Rajt

NEP and Learning Outcome-based Curriculum Framework

For

M.Sc. Physics (Integrated) Programme

Academic Session (w.e.f. 2025-2026)

DEPARTMENT OF PHYSICS

GURUGRAM UNIVERSITY, GURUGRAM

(A State Govt. University Established Under Haryana Act17 of 2017)

1. Pool Courses

Scheme for M.Sc. Physics (Integrated)

Multidisciplinary Course(s)

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
MDC-1	Modern Physics-I	242/PHYI/ MD101	3	0	0	3	0	0	3	25	50	0	0	75
MDC-2	Modern Physics-II	242/PHYI/ MD201	3	0	0	3	0	0	3	25	50	0	0	75
MDC-3	Modern Physics-III	242/PHYI/ MD301	3	0	0	3	0	0	3	25	50	0	0	75

Skill Enhancement Course(s)

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
SEC-1	Basic Instrumentation Skills	242/PHYI/ SE101	0	0	6	0	0	3	3	0	0	25	50	75
SEC-2	Programming in Physics using Python	242/PHYI/ SE201	0	0	6	0	0	3	3	0	0	25	50	75
SEC-3	Radiation Hazards and Safety	242/PHYI/ SE301	0	0	6	0	0	3	3	0	0	25	50	75
SEC-4	Scientific writing and presentation using LateX	242/PHYI/ SE601	2	0	0	2	0	0	2	15	35	0	0	50

Detailed Syllabi of Pool Courses for M.Sc. Physics (Integrated)

Semester-I

Skill Enhancement Course(s)

COURSE ID: 242/PHYI/SE101

BASIC INSTRUMENTATION SKILLS

Marks (External): 50 — **Credits : 3 (90 Hrs)**
Marks (Internal Assessment) : 25 — **Time : 6 Hrs**

1. Each student should perform at least five experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary and new experiments may be added during the course.

List of Experiments:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. To observe sine wave, square wave, triangular wave and ramp waveforms on the C.R.O. and to measure amplitude and frequency of the waveforms.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using an Oscilloscope.
7. Measurement of R, L and C using a LCR bridge/ universal bridge.
8. To study the variation in current and voltage in a series LCR circuit and hence determine the resonant frequency of the circuit
9. To study the variation in current and voltage in a parallel LCR circuit and hence determine the resonant frequency of the circuit
10. To study the effect of voltmeter resistance on voltage measurement.

Ranjit

References:

1. A text book in Electrical Technology - B L Theraja - S Chand and Co. Performance and design of AC machines - M G Say ELBS Edn.
2. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill. Logic circuit design, Shimon P. Vingron, 2012, Springer.
3. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
4. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.

Multidisciplinary Course(s)

COURSE ID: 242/PHYI/MD101

MODERN PHYSICS-I

Marks (External) : 50 | **Credits : 3 (45 lectures)**
Marks (Internal Assessment) : 25 | **Time : 2 Hrs**

Note: The paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of five short answer type questions. The rest of the eight questions are to be set uniformly, with two questions from each unit selected. A student is required to attempt five questions, selecting one from each unit along with compulsory question no 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: The course is based on imparting practical knowledge about commonly used electronic instruments including multimeter, cathode ray oscilloscope and LCR circuit to the undergraduate students of physics.	**Course Outcome:** After completion of this course, students will be able to understand the basic equipment's used in physics laboratory.

UNIT-I

Relativity: Inadequacy of Galilean Transformations, Michelson-Morley experiment, Postulates of Special relativity, Lorentz transformation, Time dilation, length contraction, twin paradox, velocity transformation and its applications

UNIT-II

Relativistic energy and momentum, Mass-energy equivalence, Four vectors, Doppler Effect for light, Gravity and light, Principal of equivalence, Spacetime: timelike and spacelike intervals, Introductory idea of general theory of relativity (no derivation).

Ranjit

UNIT-III

Particle Properties of Waves: Electromagnetic waves, Blackbody radiation, Planck's radiation formula, Quantum nature of light, Photoelectric effect. X-rays, X-rays spectra, X-ray diffraction, Compton effect, Pair production, Photon absorption, Photons and gravity, gravitational red shift.

UNIT-IV

Wave properties of particles: De Broglie Matter waves, waves of probability, characteristics of general waves, phase and group velocities, diffraction from particles-Davisson-Germer experiment, Particle in a box (No derivation), Uncertainty principle, energy and time.

References:

1. Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
2. Modern Physics, John R. Taylor, Chris D. Zafiratos, M. A. Dubson,2009, PHI Learning
3. Six Ideas that Shaped Physics: Particle Behave like Waves, T. A. Moore, 2003, McGraw Hill
4. Quantum Physics, Berkeley Physics Course, Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
5. Modern Physics, R.A. Serway, C.J. Moses, and C.A. Moyer, 2005, Cengage Learning. Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill

Rayt

Semester-II

Skill Enhancement Course(s)

COURSE ID: 242/PHYI/SE201

PROGRAMMING IN PHYSICS USING PYTHON

Marks (External): 50 | **Credits : 3 (90 Hrs)**
Marks (Internal Assessment) : 25 | **Time : 6 Hrs**

1. Each student should perform at least five experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary and new experiments may be added during the course.

List of Experiments:

1. Write a Python program to illustrate the various functions of the "Math" module.
2. Write a function that takes the lengths of three sides: side1, side2 and side3 of the triangle as the input from the user using input function and return the area of the triangle as the output. Also, assert that sum of the length of any two sides is greater than the third side.
3. Write a Python function that takes a number as an input from the user and computes its factorial.
4. Write a function that takes a number with two or more digits as an input and finds its reverse and computes the sum of its digits.
5. Write a function that takes two numbers as input parameters and returns their least common multiple and highest common factor.
6. Write a Python function to calculate the sum and product of two compatible matrices.
7. Write a function that takes a list of numbers as input from the user and produces the corresponding cumulative list where each element in the list present at index i is the sum of elements at index j <= i.
8. Write a function that takes n as an input and creates a list of n lists such that ith list contains first five multiples of i.
9. Solution of differential equations using Taylor's series method.
10. Numerical integration using (a) Simpson 1/3 and 3/8 rule
11. Gauss quadrature methods for one and two dimensional integrals.

Ranjit

References:

1. Sheetal Taneja, Naveen Kumar, Python Programming "A Modular Approach" Pearson India.
2. E. Balaguruswamy, Introduction to Computing and Problem Solving using Python, 2nd edition, McGraw Hill Education, 2018
3. R C Desai, Fortran Programming and Numerical methods, Tata McGraw Hill, New Delhi.
4. Suresh Chandra, Computer Applications in Physics, Narosa Publishing House
5. M L De Jong, Introduction to Computation Physics, Addison-Wesley publishing company.
6. R C Verma, P K Ahluwalia and K C Sharma, Computational Physics an Introduction, New Age International Publisher.
7. S S Sastry Introductory methods of numerical Analysis, Prentice Hall of India Pvt. Ltd.

Multidisciplinary Course(s)

COURSE ID: 242/PHYI/MD201

MODERN PHYSICS-II

Marks (External) : 50 | **Credits : 3 (45 lectures)**
Marks (Internal Assessment) : 25 | **Time : 2 Hrs**

Note: The paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of five short answer type questions. The rest of the eight questions are to be set uniformly, with two questions from each unit selected. A student is required to attempt five questions, selecting one from each unit along with compulsory question no 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: The course is based on imparting practical knowledge about commonly used electronic instruments including multimeter, cathode ray oscilloscope and LCR circuit to the undergraduate students of physics.	**Course Outcome:** After completion of this course, students will be able to understand the basic equipment's used in physics laboratory.

UNIT-I

Atomic Structure: Rutherford's scattering experiment, Rutherford Model, Nuclear dimensions, Failures of classical picture of atom, Atomic spectra: emission and absorption,

Ranjit

Bohr's model of atom: energy levels and spectra, correspondence principle, Nuclear motion and correction to electronic energy, Franck-Herts experiment.

UNIT-II

Basics of Laser: Introduction to Stimulated and spontaneous emission introduction to LASER, Important properties of laser light, Principle of laser- Light amplification, population inversion and pumping; Working of laser- schematic diagram for functioning of laser, three level and four level Laser systems; applications of Lasers in different fields of science and technology.

UNIT-III

Introductory Quantum Mechanics: The wave equation, Postulates of quantum mechanics, Probability amplitude, Schrodinger equation in time-dependent form, Linearity and superposition, expectation values, operators, Schrodinger equation in time-independent form, Orthogonalization and normalization, Application of Schrodinger wave equations: Particle in a box, finite potential well, and tunneling.

UNIT-IV

Solid State Physics: Crystalline and amorphous solids, types of bonding in a solid: ionic bond, covalent bond, Van der Waals bond, metallic bond, kinetic theory of electrons in a metal: collision time, drift velocity and Ohm's law, elementary idea of band formation, differentiation between metal, semiconductor and insulators using energy bands, pn-junction diode: depletion region, forward and reverse bias.

References:

1. Concept of Modern Physics by Arthur Beiser, McGraw Hill Education.
2. Modern Physics (2nd edition), by S.L. Kakani and Shubhra Kakani, Viva Books, New Delhi.
3. Semiconductor Devices - Physics and Technology by S.M .Sze ,Wiley (1985)
4. Laser and Non-linear optics by B. B. Laud. ,Wiley Eastern Limited (1985)
5. Semiconductor Electronics by A. K. Sharma, New Age International Publisher (1996)
6. Kenneth S. Krane, Introductory Nuclear Physics, Wiley, New York, 1988
7. Radiation detection and measurement: G.F. Knoll (Wiley, New York) (2000)
8. Verma and Srivastava : Crystallography for Solid State Physics
9. Rajnikant; Solid State Physics, Willey India, 2011.
10. J.C. Anderson, KD. Leaver, R.D. Rawlings and J.M. Alexander, Materials Science, 4thEdition (Chapman Hall, London, 1990).
11. V. Raghavan, Materials Science and Engineering, 3rd Ed. (Prentice-Hall India, New Delhi,1993).

Rampt

NEP and Learning Outcome-based Curriculum Framework (LOCF)

For

M.Sc. (Physics) Programme

Academic Session (w.e.f. 2024-2025)

DEPARTMENT OF PHYSICS

GURUGRAM UNIVERSITY, GURUGRAM

(A State Govt. University Established Under Haryana Act17 of 2017)

List of Pool Courses for M. Sc. (Physics)

Multidisciplinary Course(s)

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
MDC-1	Modern Physics	241/PHY/ MD101	3	0	0	3	0	0	3	25	50	0	0	75
MDC-2	Spectroscopi c Techniques	241/PHY/ MD201	3	0	0	3	0	0	3	25	50	0	0	75
MDC-3	Radiation Safety	241/PHY/D S301	3	0	0		0	0	3	25	50	0	0	75
MDC-4	Concepts of Optics	241/PHY/ MD401	3	0	0	3	0	0	3	25	50	0	0	75

Discipline Specific Course(s)

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
DSE-1	i) Electronics ii) Vacuum Science and Thin Films Technology iii) Physics of Nanomaterials	241/PHY/DS101	3	0	0	3	0	0	3	25	50	0	0	75
DSE-2	i) Solid State Physics ii) Plasma Physics	241/PHY/DS201	3	0	0	3	0	0	3	25	50	0	0	75
DSE-3	i) Condensed Matter Physics-I ii) Material Science – I	241/PHY/DS301	3	0	0	3	0	0	3	25	50	0	0	75
DSE-4	i) Condensed Matter Physics-II ii) Material Science – II	241/PHY/DS401	3	0	0	3	0	0	3	25	50	0	0	75

Ranjit

Value Added Course(s)

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
VAC-1	Indian Science History	241/PHY /VA101	2	0	0	2	0	0	2	15	35	0	0	50
VAC-2	History of Physics	241/PHY /VA301	2	0	0	2	0	0	2	15	35	0	0	50

Skill Enhancement Course(s)

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
SEC-1	Radiation Physics	241/PHY/SE201	2	0	0	2	0	0	2	15	35	0	0	50
SEC-2	Digital Electronics and Applications	241/PHY/SE301	2	0	0	2	0	0	2	15	35	0	0	50

Ability Enhancement Course(s)

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
AEC-1	Programming using Python	241/PHY/AE101	0	0	4	0	0	2	2	0	0	15	35	50
AEC-2	Electronic Devices Lab	241/PHY/AE201	0	0	4	0	0	2	0	0	0	15	35	50
AEC-3	Introduction to Astrophysics	241/PHY/AE401	2	0	0	2	0	0	2	15	35	0	0	50

Ranjit

Detailed Syllabi of Pool Courses for M. Sc. (Physics)

Semester-I

Multidisciplinary Course

COURSE ID: 241/PHY/MD101

MODERN PHYSICS

Max. Marks: 50 **Credit: 3**
Internal Assessment: 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Modern Physics, a student will be able to:

- *Understand the quantum theory of light and wave-particle duality.*
- *Describe Heisenberg uncertainty principle and linear superposition principle.*
- *Solve the Schrödinger equation for simple systems and interpret wave functions in terms of probabilities and normalization.*
- *Distinguish between different types of radioactive decays.*

Unit-I

Blackbody Radiation, Planck's proposition and quantum theory of light, Photoelectric effect, Compton scattering, Pair Production, De Broglie Waves, Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and the relation between them. Two-Slit experiment with electrons, Probability, Wave amplitude and wave functions, Rutherford Model, Bohr model of atom, Explanation of Hydrogen spectra

Unit-II

Position measurement- gamma-ray microscope thought experiment; Heisenberg uncertainty principle: its application for estimating minimum energy of a confined particle, Energy-time uncertainty principle application to virtual particles and range of interaction. Two slit interference experiment with photons; Wave-particle duality, Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

Rampt

Unit-III

Solution of Schrodinger equation for one-dimensional problems: One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier.

Unit-IV

Nuclear Decay: Stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta-decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma-ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

Lasers: Basic principle of lasers, Spontaneous and Stimulated emissions. population inversion, Einstein's A and B coefficients. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser.

References/Books:

1. Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
2. Modern Physics, John R. Taylor, Chris D. Zafiratos, M. A. Dubson,2009, PHI Learning
3. Six Ideas that Shaped Physics: Particle Behave like Waves, T. A. Moore, 2003, McGraw Hill
4. Quantum Physics, Berkeley Physics Course, Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
5. Modern Physics, R.A. Serway, C.J. Moses, and C.A. Moyer, 2005, Cengage Learning.
   Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill

Discipline-Specific Course(s)

(Choose one out of 241/PHY/DS201(i), 241/PHY/DS101(ii) & 241/PHY/DS101(iii) Options)

COURSE ID: 241/PHY/DS101(i)

ELECTRONICS

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 40% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Electronics, a student will be able to:

- *Explain the basic properties of semiconductors, the operation and characteristics of the pn-junction diode, and bipolar junction transistors (BJTs), and their behavior under different biasing conditions.*
- *Analyze amplifier circuits with feedback, understand various transistor biasing techniques, evaluate the role of negative feedback in amplifiers, and oscillators*
- *Understand the structure and operation of field effect transistors (JFET, MOSFET), including channel formation, pinch-off, and I-V characteristics, and assess the impact of interface states and MOS junction behaviors.*
- *Design and implement linear and nonlinear circuits using operational amplifiers (IC-741), and analyze the working in various configurations including as comparators, integrators, differentiators.*

Unit – I

Basics of PN-junction and BJT: PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Forward and Reverse Biased Diode. n-p-n and p-n-p Transistors. I-V characteristics of CB and CE Configurations. Active, Cutoff and Saturation Regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point.

Unit-II

Amplifiers and Oscillators: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Two stage RC-coupled amplifier and its frequency response. Positive and Negative Feedback in amplifiers. Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, Hartley & Colpitts oscillators.

Ranjit

Unit – III

Heterojunctions, Field effect transistors: Metal/Semiconductor Contact, MOS Junction (Accumulation, Depletion and Inversion), Interface States and Their Effects, Construction of JFET, MOSFET, Idea of channel formation, pinch off and saturation voltage, current voltage output characteristics.

Unit – IV

Op-Amp (IC-741): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. Applications of Op-Amps: Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier, Comparator and Zero crossing detector, Wein bridge oscillator.

References/Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
2. Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
3. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
4. Electronic Principles, A. Malvino, D.J. Bates, 7th Edition, 2018, Tata Mc-Graw Hill Education.
5. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson
6. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI

Ranjit

COURSE ID: 241/PHY/DS101(ii)

VACUUM SCIENCE AND THIN FILM TECHNOLOGY

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Vacuum Science and Thin Film Technology, a student will be able to:

- *Understand the fundamentals of vacuum techniques.*
- *Demonstrate various vacuum pumps and leak detection.*
- *Get familiar about the concept and basics of thin films.*
- *Explain various methods of thin films deposition.*

Unit–I

Vacuum Fundamentals and Its Production: Kinetic theory of gases, Mean free path, Mass flow, Pumping speed, Importance of Vacuum, Design, Principles, Construction, Operational Characteristics and the uses of Rotary pump, Roots pump, Turbomolecular pump, Diffusion pumps, Cryogenic-pump, Sputter-ion pump.

Unit-II

Vacuum Measurement and Detection: Importance of measurement of Pressure, Concept of different gauges: McLeod gauge, thermal conductivity gauges, spin rotor gauge, Ionization gauges, hot cathode, cold cathode gauges; Pirani, Penning and pressure control, Flow Meters and Residual Gas Analyzer, Leak Detection.

Unit-III

Introduction and preparation of thin film: Environment for Thin Film Deposition, Evolution of Thin Film: Absorption (Physisorption), Surface Diffusion, Chemical Bond Formation (Chemisorption), Nucleation, Microstructure Formation, Deposition Parameters and their effects on Film Growth, Epitaxy–homo, hetero and coherent epilayers, lattice misfit and imperfections.

Unit-IV

Ranjit

Thin Film Deposition Techniques: Thermal evaporation, Electron beam evaporation, DC and RF Sputtering Technique: Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Chemical Vapour Deposition (CVD), Pulsed Laser Deposition (PLD), Atomic layer deposition (ALD), Spin Coating, Spray pyrolysis, Molecular beam epitaxy.

References/Books:

1. Vacuum Science and Engineering, CM Van Atta, Tata McGraw Hill, New York.

2. Vacuum Technology, Andrew Guthrie, Wiley, New York.

3. Vacuum Technology – An introduction by LG Carpenter

4. Thin Film Phenomenon, K. L. Chopra, McGraw Hill, New York.

5. Vacuum Physics and Techniques, T. A. Delchar, Chapman & Hall.

Ranjit

COURSE ID: 241/PHY/DS101(iii)

PHYSICS OF NANO-MATERIALS

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Physics of Nano-Materials, a student will be able to:

- *Understand the quantum confinement effect and analyze its consequences through simple models.*
- *Describe different types of fabrication techniques of nanomaterials like PVD and CVD.*
- *Demonstrate the physics behind various characterization techniques.*
- *Learn widely used applications of nanomaterials: LED, solar cells, MEMS, NEMS.*

Unit-I

Nanoscale Systems: Density of states (1-D,2-D,3-D). Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at the nanoscale, Size Effects in nano-systems, Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

Unit-II

Nanostructure Materials: Metals, Metal Oxides, Carbon-based nanomaterials CNT, C60, graphene. Top-down and bottom-up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, Chemical vapor deposition (CVD). Sol-Gel. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.

Unit-III

Characterization: X-ray diffraction, UV-Vis Spectroscopy, Photoluminescence Spectroscopy, Optical microscope vs Electron Microscopes, Scanning Electron Microscopy, Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunnelling Microscopy.

Unit-IV

Applications: Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells), CNT-based transistors, Nanomaterial Devices: Quantum dots

Ranjit

heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots-magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

References/Books:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
4. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
5. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

Ranjit

Ability Enhancement Course(s)

COURSE ID: 241/PHY/AE101

PROGRAMMING USING PYTHON

Marks (Final Exam): 35 **Credits: 2**

Marks (Internal Assessment): 15 **Time: 3 Hours**

Course Outcomes:

After successful completion of the course on Programming using Python Lab, a student will be able to:

- *Apply various Python modules to perform numerical computations effectively.*
- *Utilize the **Matplotlib** library for visual representation and analysis of data.*
- *Implement the **Runge-Kutta method** for solving and evaluating definite integrals numerically.*
- *Conduct matrix creation, manipulation, and operations using the **NumPy** library.*

Pre-requisite Overview: Before proceeding to programming using python course, students are introduced to the foundational concepts of Python, including the Python interpreter, print statements, variables and assignments, strings, comments and documentation, debugging, input/output handling, data types and type conversion, list operations, and logical and comparison operations. Control flow mechanisms such as sequencing, iteration, selection structures (if, if-else, elif), loops (for, while), and control statements (break, continue), with practical examples like reversing a string, computing the sum of consecutive numbers, and calculating factorials. Python functions (built-in and user-defined), as well as essential data structures like lists, dictionaries, tuples, sets, and list comprehensions through real-world problem-solving exercises (e.g., hashtag generator, search engine, simple calculator). The NumPy module is then introduced for efficient array handling, covering topics such as the difference between Python lists and NumPy arrays, array creation using ones(), zeros(), random(), arange(), linspace(), along with key array operations (sum, mean, variance), matrix manipulation, reshaping, transposing arrays, and reading/writing data using savetxt() and loadtxt().

List of Programs:

1. Program to calculate mean, median and mode from a dataset.
2. Program to plot experimental data with error bars using Matplotlib.
3. Program to fit experimental data with a polynomial curve.
4. Program to find roots of a function using Newton-Raphson method.
5. Program for numerical integration using the Runge-Kutta method.
6. Program to create a 2D array (matrix) and perform basic operations like addition, subtraction, and multiplication.
7. Program for Random Walk Problem.

Ranjit

References/Books:

1. Python Crash Course by Eric Matthes (No Starch Press, 2nd ed., 2019).
2. Python Programming: An Introduction to Computer Science by John Zelle (Franklin, Beedle & Associates Inc., 2003).
3. Computation Physics: Problem Solving with Python, 3rd Edition by Rubin H. Landau, Manuel J Páez, Cristian C. Bordeianu (Wiley VCH, 2015).
4. Python documentation available at the Python web page (https://docs.python.org/3/).
5. Numpy documentation: https://numpy.org/doc/stable/index.html.

Value Added Course

COURSE ID: 241/PHY/VA101

INDIAN SCIENCE HISTORY

Marks (Theory): 35 **Credits: 2**

Marks (Internal Assessment): 15 **Time: 2 Hours**

Note: The examiner will set 9 questions, asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Indian Science History, a student will be able to:

- *Gain familiarity with the biographies of Indian scientists and the various challenges they faced in the evolution of Indian science.*
- *Learn the contribution of Indian scientists in the different disciplines of science.*

Unit-I

Physics: Bibliography of Indian scientists in the field of Physics, Work and life of CV Raman and Bhabha, History of Indian rocket technology, Indian Missile Man, History of Bose-Einstein Condensation, Contribution of Chandrasekhar and Saha in astrophysics, Evolution of Nuclear power in India, ISRO contributions.

Unit-II

Bibliography of Scientists in the field of Chemical Sciences, Contribution made by the Chemists of Ancient India like Nagarjuna and Kanada. Shanti Swaroop Bhatnagar - "Father of Research Laboratories" in India, contribution to industrial research and role in establishments of CSIR, Founder of India's first pharmaceutical company, research on pharmaceuticals.

Unit-III

Mathematics: Bibliography and contribution of Indian Mathematicians: Aryabhatta, Brahmagupta, Bhaskara I, Bhaskara II, Srinivasa Ramanujan, Shakuntala Devi, Manjul Bhargava, Akshay Venkatesh. Statistics.

Unit-IV

Geography: Contribution of Varahamihira, Brahmagupta, Bhaskaracharya, Aryabhata and Ancient Indian Literature to the development of scientific knowledge in geography, knowledge management in ancient India, protection of traditional knowledge, need and significance for protecting traditional knowledge.

Ranjit

References/Books:

1. Science India, Scientific Magazines by Vijnana Bharati. For details visit: https://scienceindiamag.in.
2. Everyman's Science by ISCA. For details visit: http://www.sciencecongress.nic.in.
3. Evolution of Geographical Thought, Husain, M., 2012, Rawat Publications.
4. Knowledge Traditions and Practices of India (a text book) 2012, Kapil Kapoor, Michel Danino.
5. E-resources: http://nptel.ac.in/courses/121106003.
6. Probability and Statistical Inference, Mukhopadhyay, N., 2000. Marcel Dekker, Inc. New York.

Ranjit

Detailed Syllabi of Pool Courses for M. Sc. (Physics)

Semester-II

Multi-Disciplinary Course

COURSE ID: 241/PHY/MD201

SPECTROSCOPIC TECHNIQUES

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Spectroscopic Techniques, a student will be able to:

- *Understand the fundamental aspects of spectroscopy.*
- *Understand the basics, working principles and working of Optical and Thermal Characterization Techniques*
- *Carry out experimental and theoretical studies on atoms and molecules, with a focus on the Magnetic Characterization Techniques.*
- *Apply and analyze the electron microscopic techniques for real life problems.*

Unit-I

Fundamentals of Spectroscopy: Recapitulation and role of Quantum Mechanics, Electromagnetic Spectrum, Interaction of Electromagnetic Radiations with Matter, Heisenberg's Uncertainty Principle, Basic elements of Spectroscopy and its advantages, Einstein Coefficients, Transition Dipole Moment, Selection Rule based on Symmetry

Unit-II

Optical and Thermal Characterization Techniques: UV-Visible spectroscopy, Infrared spectroscopy, Atomic absorption spectroscopy (AAS), Raman spectroscopy, Thermo gravimetric analysis (TGA), Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC).

Unit-III

Ranjit

Magnetic Characterization Techniques: Mass spectroscopy, Nuclear Magnetic Resonance (NMR) and Electron Spin Resonance (ESR) spectroscopy, Mössbauer Spectroscopy.

Surface Analysis: X-ray absorption spectroscopy (XAS), X-ray photoelectron spectroscopy (XPS).

Unit-IV

Electron Microscopy: Interaction of electrons with solids, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Scanning Probe Microscope (SPM): Atomic force microscopy (AFM), scanning tunneling microscopy (STM).

References/Books:

1. Fundamentals of molecular spectroscopy, Colin N. Banwell & Elaine M. McCash, Tata McGraw –Hill publishing company limited.
2. Molecular structure & spectroscopy, G. Aruldhas; Prentice – Hall of India, New Delhi.
3. Introduction to Molecular Spectroscopy by Gordon M Barrow, McGraw-Hill Inc. US.
4. Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series) A. K. Tyagi, Mainak Roy, S. K. Kulshreshtha and S. Banerjee, Volumes 49 – 51 (2009).

Ranjit

Discipline-Specific Course(s)

(Choose one out of 241/PHY/DS201(i), & 241/PHY/DS201(ii) Options)

COURSE ID: 241/PHY/DS201(i)

SOLID STATE PHYSICS

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Solid State Physics, a student will be able to:

- *To grasp and apply concepts like Bravais lattice, unit cells (primitive, conventional, Wigner-Seitz), and crystal structures with bases and determine crystal structures using X-ray diffraction techniques, including the reciprocal lattice, Brillouin zones, and structure factor.*
- *To calculate the dispersion relation of lattice waves and grasp the knowledge of phonons and utilizing it to determine the lattice heat capacity.*
- *To learn band theory of solids including Bloch's theorem and solution of wave equation for an electron in a periodic potential; to differentiate between metals, semiconductor and insulator.*
- *To understand the fundamental properties of superconductors, including qualitative insights into the BCS theory.*

Unit – I

Crystal Structure: Recapitulation of basic concepts: Bravais lattice and Primitive vectors; Primitive, Conventional and Wigner-Seitz unit cells; Crystal structures and lattices with bases; Symmetry operations and fundamental types of lattices; Index system for crystal planes. Determination of crystal structure by X-ray diffraction: Reciprocal lattice and Brillouin zones (examples of *sc*, *bcc* and *fcc* lattices); Bragg and Laue formulations of X-ray diffraction by a crystal and their equivalence; Ewald construction; Brillouin interpretation; Crystal and atomic structure factors (Introduction Only).

Unit – II

Lattice dynamics and thermal properties: Classical theory of lattice vibration (in harmonic approximation): Vibrations of crystals with monatomic basis-Dispersion relation, First Brillouin zone, Group velocity; Two atoms per primitive basis-dispersion of acoustical and optical modes. Quantization of lattice waves: Phonons, Phonon momentum, Inelastic scattering of neutrons by

Ranjit

phonons. Thermal properties: Lattice (phonon) heat capacity; Normal modes; Density of states in one and three dimensions; Models of Debye and Einstein, Debye T^3 law.

Unit – III

Electronic properties of solids: Sommerfeld's free electron gas model, Density of states, Fermi sphere, Fermi and ground-state energy; Difficulties with the free electron gas model; Band theory of solids: Nearly free electron model, Origin and magnitude of the energy gap; Periodic potential and Bloch's theorem; Kronig-Penney model; Wave equation of electron in a periodic potential, Central equation, Crystal momentum of electron, Solution of the central equation, momentum of electron, Approximate solution at and near a zone boundary; Number of orbitals in a band; Classification into metals, semiconductors and insulators.

Unit – IV

Superconductivity: Experimental survey: Superconductivity and its occurrence, Destruction of superconductivity by magnetic fields, Meissner effect, Type I and type II superconductors, Entropy, Free energy, Heat capacity, Energy gap, Isotope effect; Theoretical survey: Thermodynamics of the superconducting transition, London equation, London penetration depth, Coherence length; Microscopic theory: Qualitative features of the BCS theory, BCS ground state wave function; Quantitative predictions of the BCS theory, critical temperature, energy gap, critical field, specific heat; Flux quantization in a superconducting ring.

References/Books:

1. Introduction to Solid State Physics (7th edition) by Charles Kittel.

2. Solid State Physics by Neil W. Ashcroft and N. David Mermin.

3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth.

4. Principles of the Theory of Solids (2nd edition) by J. M. Ziman.

5. Applied Solid State Physics by Rajnikant.

Ranjit

COURSE ID: 241/PHY/CC201(ii)

PLASMA PHYSICS

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Plasma Physics, a student will be able to:

- *Grasp knowledge about plasma and its properties, and motion of charge particles in electromagnetic field.*
- *Explain electron and ions wave, and calculate their dispersion relations.*
- *Interpret damping of plasma waves through different interactions in the medium.*
- *Learn and understand the techniques of plasma production and its confinement.*

Unit – I

Introduction to Plasmas and Particle Dynamics: Definition and general properties of plasma, plasma oscillations, Debye shielding and criteria for plasma, Motion of charged particles in electromagnetic field and non-uniform magnetostatic field, electric field drift, gradient B drift, parallel acceleration and magnetic mirror effect, curvature drift, adiabatic invariants.

Unit – II

Waves and Transport Processes in Plasmas: Fluid description of plasmas, continuity and momentum balance equations of fluid mechanics, electron plasma waves, ion acoustic waves, electromagnetic waves in plasma, magneto-sonic and Alfven waves and their dispersion relations and properties, stability of plasmas, ambipolar diffusion, hydromagnetic equilibrium, diffusion of magnetic lines and frozen-in fields, concept of magnetic pressure, plasma confinement schemes.

Unit – III

Nonlinear Effects and Controlled Fusion: Vlasov equation, landau damping, physical mechanism of landau damping, plasma sheath, Bohm sheath criterion, Bohm velocity, presheath region, pondermotive force and applications as self-focusing, wave-wave interaction, $\omega - k$ matching conditions for the decay of an electron plasma wave, stimulated Raman scattering and stimulated Brillouin scattering, nuclear fusion.

Unit – IV

Rampt

Plasma Production: Townsend's theory of gas discharge, Paschen's law, Low-pressure cold cathode discharge, Radio-frequency discharge, Plasma diagnostic techniques: Resistivity of plasma Langmuir single probe method, Langmuir double probe method, microwave method of plasma density determination, Plasma Heating, Confinement of plasma, magnetic mirror, stellarator, Tokamak and inertial confinement.

References/Books:

1. Introduction to plasma physics and controlled fusion Chen, Francis F, Springer, 3rd edition, 2016.
2. The physics of fluids and plasmas: an introduction for astrophysicists. Choudhuri, Arnab Rai. Cambridge University Press, 2015.
3. Principles of Plasma Discharges and Materials Processing, Lieberman and Lichtenberg, Wiley-Inter-science; 2nd edition, 2008.
4. Introduction to dusty plasma physics. Shukla P. K. and Mamun A. A., CRC Press; 2001.

Ability Enhancement Course

COURSE ID: 241/PHY/AE201

ELECTRONIC DEVICES LAB

Marks (End Semester exam): 35 **Credits: 02**

Marks (Internal): 15 **Time: 4 Hours**

Course Objectives (COs):

After successful completion of the course on Electronic Devices lab, a student will be able to:

- *Designing and working of diodes, solar cell, transistor and their applications.*
- *Explore the operation and advantages of operational amplifiers.*
- *Learn to design filters and analog to digital converts.*
- *Learn and understand about oscillators circuits.*
- *Understanding and working of 8085 nicroprocessor.*

Students assigned the electronic/ general physics laboratory work will perform at least 8 experiments of the following sections:

1. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
2. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
3. To design a Wien bridge oscillator for given frequency using an op-amp.
4. To design a phase shift oscillator of given specifications using BJT.
5. To design a digital to analog converter (DAC) of given specifications.
6. To design an inverting/ non-inverting amplifier using Op-amp (741,351)
7. To investigate the use of an op-amp as an Integrator and Differentiator..
8. To design a circuit to simulate the solution of simultaneous equation and 1st/2ndorder differential equation.
9. To Design filters (Low pass, High pass, band pass and band rejection) of the given specifications.
10. To Design multistage amplifiers of the given specifications.
11. To Design a triangular wave to sine wave converter.
12. To design, analyse and demonstrate positive and negative voltage level detectors.
13. To design and analyse Pulse Width Modulation using op-amp.
14. To study the zero-crossing detector and comparator using op-amp.
15. To design RC-Oscillator using an Op-Amp.
16. To design a Square Wave Generator.
17. Programs using 8085 Microprocessor: Addition, subtraction, multiplication and division.

Ranjit

References/Books:

1. Electronic Instrumentation and Measurement Techniques, W. D. Cooper and A. D. Helfrick (2nd Ed., Phi Learning, 2008)
2. Electronic Devices and Circuits, J. Millman and C. C. Halkias and S. Jit (4th Ed., McGraw-Hill, 2015)
3. Measurement, Instrumentation and Experimental Design in Physics and Engineering, M. Sayer and A. Mansingh (Prentice Hall India, 2010)
4. Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
5. Microprocessor 8085: Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.
6. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1994, McGraw Hill.
7. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.

Rayt

Skill Enhancement Course

COURSE ID: 241/PHY/SE201

RADIATION PHYSICS

Marks (Theory): 35 **Credits: 2**

Marks (Internal Assessment): 15 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Radiation Physics, a student will be able:

- *Define and explain different interactions of ionizing radiation with matter.*
- *Understand the basic working principles of radiation detectors.*
- *Grasp the concept of radiation dose and analyze the effect of radiation on the functioning of living cells.*
- *Evaluate radiation hazards and get familiar with radiation dose limitations.*

Unit – I

Interaction of Radiation with Matter: Type of nuclear radiation, modes of interaction: ionization, excitation, elastic and inelastic scattering, Bremsstrahlung, Cerenkov radiation, concepts of specific ionization, mean free path, interaction of light charged particles with matter, interaction of heavy charged particles with matter, interaction of electromagnetic radiations with matter, interaction of neutrons with matter.

Unit – II

Radiation Detectors: Principles of radiation detection, gas-filled radiation detectors: ionization chambers, proportion counters, GM counters, scintillation counter, semiconductor detectors (Si and Ge) and their applications, Thermo- Luminescent dosimeters (TLD), SSNTD.

Unit – III

Radiation quantities and units: Exposure, Dose, Equivalent Dose, Effective Dose, KERMA, Annual Limit on Intake (ALI), and Derived Air Concentration (DAC); Biological Effects of Ionizing Radiation, Principles of Radiological Protection: Justification of Practice, Optimization of Practice, and Dose Limitations; Internal Exposure, Dose Limit for (i) Radiation Workers (ii) Public, Occupational Exposure of Women, Apprentices and Students

Ranjit

Unit – IV

Radiation Hazard Evaluation and Control: Radiation Hazard: Internal Hazards and External Hazards; Evaluation and Control of Radiation Hazard, Radiation Shield, Monitoring of External Radiation, Control of Internal Hazard: (i) Containment of Source (ii) Control of Environment (iii) Contamination (iv) Air Contamination Monitoring (v) Personal Contamination Monitoring (vi) Decontamination Procedures; Radiation Emergency and Preparedness.

References/Books:

1. Introduction to Radiological Physics and Radiation Dosimetry, by Frank H. Attix, https://www.google.co.in/search?tbo=p&tbm=bks&q=inauthor:"Frank+H.+Attix"John Wiley & Sons, 1986.
2. Radiation Detection and Measurement 4th Edition by Glenn F. Knollhttp://www.amazon.com/Glenn-F.-Knoll/e/B001H6KUME/ref=dp_byline_cont_book_1http://www.amazon.com/Glenn-F.-Knoll/e/B001H6KUME/ref=dp_byline_cont_book_1
3. Physics and Engineering of Radiation Detection by Syed Ahmed, Laurentian University, Ontario, Canada.
4. Measurement and Detection of Radiation, Fourth Edition by Nicholas Tsoulfanidis and Sheldon Landsberger.
5. Introduction to Experimental Nuclear Physics by R. M. Singru.
6. Elements of Nuclear Physics by W. E. Meyerhof.
7. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy
8. Introduction to High Energy Physics (2nd edition) by D. H. Perkins.
9. Techniques For Nuclear and Particle Physics Experiments by William R. Leo.

Ranjit

Detailed Syllabi of Pool Courses for M. Sc. (Physics)

Semester-III

Multi-Disciplinary Course

COURSE ID: 241/PHY/MD301

RADIATION SAFETY

M Marks: 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Radiation Physics, a student will be able:

- *To know the basics of radiation and to analyze the effect of radiation on the functioning of living cells.*
- To *define and explain different interactions of ionizing radiation with matter.*
- *To Understand the basic working principles of radiation detectors.*
- *To evaluate the radiation hazards and get familiar with radiation dose limitations*

Unit – I

Basics of radiation: Origin of radiation, binding energy and Q value, stable and unstable isotopes, radioactive decay (alpha, beta, gamma, neutron), mean life and half life, nuclear reactions, kinematics of nuclear reactions. Basic idea of different units of activity, Radiation quantities & units: Exposure, Dose, Equivalent Dose, Effective Dose, KERMA, Annual Limit on Intake (ALI), and Derived Air Concentration (DAC); Biological Effects of Ionizing Radiation

Unit – II

Interaction of Radiation with matter: Modes of interaction: ionization, excitation, elastic and inelastic scattering, Bremsstrahlung, Cerenkov radiation, Concepts of specific ionization, mean free path; Interaction of Light Charged Particles with matter; Interaction of Heavy Charged Particles with matter; Interaction of Electromagnetic Radiations with matter: Photoelectric effect, Compton Scattering, and Pair production; Attenuation of Gamma Radiation: Linear and mass attenuation coefficient; Interaction of Neutrons with matter

Unit – III

Ranjit

Radiation Detection: Principles of radiation detection; Gas filled radiation detectors: ionization chambers, proportion counters, GM counters, Scintillation (organic/inorganic) counter; Solid State Detector: Crystal detector, Semiconductor Detectors, Neutron Detectors, Thermo – Luminescent Dosimeters (TLD), SSNTD, Chemical detectors (Photographic Emulsions Films).

Unit – IV

Radiation Hazards, Evaluation and Protection: Radiation Hazards: Internal Hazards and External Hazards; Evaluation of external radiation hazard: Effect of distance, time and shielding, shielding calculation, personnel and area monitoring-Internal radiation hazards: radio toxicity of different radio nuclides, control of contamination-bioassay and air monitoring. Basic concepts of radiation protection standards: historical background, International Commission of Radiological Protection and its recommendations, the system of radiological protection, justification of practice, optimization of protection and individual limits, Dose Limit for Radiation Workers, Public, Occupational Exposure of Women. Radiation Emergency and Preparedness. Responsibilities of operator, regulatory bodies, and government.

References/Books:

1. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy
2. Radiation Detection and Measurement 4th Edition by Glenn F. Knoll
3. Physics and Engineering of Radiation Detection by Syed Ahmed, Laurentian University, Ontario, Canada
4. Introduction to Radiological Physics and Radiation Dosimetry, by Frank H. Attix, John Wiley & Sons, 1986.
5. Techniques For Nuclear and Particle Physics Experiments by William R. Leo.
6. Elements of Nuclear Physics by W. E. Meyerhof.
7. Measurement and Detection of Radiation, Fourth Edition by Nicholas Tsoulfanidis and Sheldon Landsberger

Ranjit

Discipline-Specific Course(s)

(Choose one out of 241/PHY/DS301(i), & 241/PHY/DS301(ii) Options)

COURSE ID: 241/PHY/DS301(i)

CONDENSED MATTER PHYSICS-I

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Condensed Matter Physics-I, a student will be able to:

- *Have an understanding of basic physical concepts (like band gap, holes, effective mass, etc.) related to semiconductors.*
- *Appreciate the concept and importance of Fermi surface of metals and its experimental determination through De Hass-van Alphen effect.*
- *Learn the description of collective excitations of the Fermi Sea (plasmons) and the electrostatic screening of electron-impurity interaction, in terms of the dielectric function of the electron gas.*
- *Understand different physical quantities (reflectivity coefficient, reflectance, real & imaginary parts of response etc.) related to the optical response of solids.*
- *Relate the dielectric polarization with the macroscopic electric field and the local electric field acting on an atom in the dielectric, along with frequency dependence of polarizability.*
- *Calculate magnetic susceptibility for atoms, insulating solids and conduction electrons, and have an understanding of the microscopic origin of ferromagnetism.*
- *Determine the low-energy excitations (spin waves/magnons) for ferromagnetic systems, understand principle underlying their experimental measurement, and learn about ferromagnetic domains.*

Unit – I

Energy bands, Semiconductor crystals, Fermi surfaces & metals: Calculation of energy bands using tight-binding method, Reduced, extended and periodic zone schemes; Semiconductor crystals: Band gap, Direct and indirect absorption processes; Equations of motion in an energy band, Concept and properties of holes, Effective mass and its physical interpretation; Intrinsic carrier concentration, Law of mass action, Intrinsic mobility, Fermi surface and its construction

Rajt

for square lattice (free electrons and nearly free electrons), Quantization of orbits in a magnetic field, De Hass-van Alphen effect.

Unit – II

Optical Properties of Solids-I: Dielectric function of free electron gas, Plasma optics, Dispersion relation for *em* waves, Transverse optical modes in a plasma, Transparency of alkalis in UV region, Longitudinal plasma oscillations, Plasmons and their measurement; Electrostatic screening, Screened Coulomb potential, Mott metal-insulator transition, Screening and phonons in metals.

Unit – III

Optical Properties of Solids-II: Optical reflectance, Kramers-Kronig relations, Electronic inter-band transitions.

Dielectrics: Polarization, Macroscopic electric field, Dielectric susceptibility, Local electric field at an atom, Dielectric constant and polarizability, Clausius-Mossotti relation, electronic polarizability, Classical theory of electronic polarizability.

Unit – IV

Magnetism: Diamagnetism and paramagnetism, Magnetization density and susceptibility, Calculation of atomic susceptibilities, Larmor diamagnetism; Quantum theory of paramagnetism-Curie law; Paramagnetic susceptibility of conduction electrons. Ferromagnetism and anti-ferromagnetism: Ferromagnetic order, Mean field theory- Curie-Weiss law; Electrostatic origins of magnetic interactions, Magnetic properties of a two-electron system, Singlet-triplet (exchange) splitting in Heitler-London approximation, Exchange interaction; Spin Hamiltonian and the Heisenberg model; Spin waves and their dispersion; Quantization of spin waves, Magnons, Origin of ferromagnetic domains.

References/Books:

1. Introduction to Solid State Physics (8th edition) by Charles Kittel.
2. Solid State Physics by Neil W. Ashcroft and N. David Mermin.
3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth.
4. Principles of the Theory of Solids (2nd edition) by J. M. Ziman.
5. Condensed Matter Physics by Michael P. Marder.

Ranjit

SJ

COURSE ID: 241/PHY/DS301(ii)

MATERIAL SCIENCE-I

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Material Science-I, a student will be able to:

- *Understand the basic concepts, properties of Materials and describe how and why defects (point, line and planar) in materials greatly affect engineering properties*
- *Understand the mechanical properties and grasp the importance of various strengthening mechanisms.*
- *Understand the synthesis procedures for the nanomaterials and thin films*
- *Perform computations of depth profiles and concentration analysis using these techniques, Choose the most appropriate technique for characterization.*

Unit – I

Imperfections in Solids: Point Defects: vacancy, substitutional, interstitial, Frenkel and Schottky defects, equilibrium concentration of Frenkel and Schottky defects; Line Defects: slip planes and slip directions, edge and screw dislocations, Burger's vector, cross-slip, glide and climb, jogs, dislocation energy, super & partial dislocations, dislocation multiplication, Frank Read sources; Planar Defects: grain boundaries and twin interfaces; Dislocation Theory – experimental observation of dislocation, dislocations in FCC, HCP and BCC lattice.

Unit – II

Mechanical Properties: Stress Strain Curve; Elastic Deformation: atomic mechanism of elastic deformation and anisotropy of Young's modulus, elastic deformation of an isotropic material; Anelastic and Viscous deformation; Plastic Deformation: Schmid's law, critically resolved shear stress; Strengthening Mechanisms: work hardening.

Unit – III

Introduction to material synthesis and fabrication: Top-down and Bottom-Up approach, Synthesis of bulk phase materials-Solid state reaction route, ball milling, introduction to precipitation & co-precipitation, sol-gel technique, hydrothermal; thin film growth by physical vapour deposition and chemical vapour deposition, lithography- UV, electron beam and ion beam lithography.

Unit – IV

Materials Processing and Characterization: Ion Implantation: introduction, ion implantation process, depth profile, radiation damage and annealing effects of trace-impurities, implantation induced alloying and structural phase transformation; Rutherford Backscattering Spectrometry (RBS): principle, kinematics of elastic collision, shape of the backscattering spectrum, depth profiles and concentration analysis, applications; Elastic Recoil Detection Analysis (ERDA): basic principle, kinematics, concentration analysis, depth profiling, depth resolution, applications.

References/Books:

1. Material Science, J.C. Anderson, K.D. Leaver, J. M. Alexander and R. D. Rawlings.
2. Mechanical Metallurgy, G.E. Dieter.
3. Electronic Processes in Materials, L. V. Azaroff and J. J. Brophy.
4. Solid State Physics – A J Dekker (McMillan, 1971).
5. Materials Science and Engineering by William D. Callister.

Skill Enhancement Course(s)

COURSE ID: 241/PHY/SE301

DIGITAL ELECTRONICS AND APPLICATIONS

Marks (Theory): 35 **Credits: 2**

Marks (Internal Assessment): 15 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 40% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Digital Electronics and Applications, a student will be able to:

- *Understand the fundamental differences between analog and digital circuits and demonstrate proficiency in number systems and logic gates, including Boolean algebra and De Morgan's theorems.*
- *Apply Boolean laws, truth tables, and simplification techniques such as the Sum of Products and Karnaugh Map to design and implement combinational logic circuits.*
- *Analyze and design data processing and arithmetic circuits including multiplexers, demultiplexers, encoders, decoders, binary adders, subtractors, and logic-based arithmetic operations using 2's complement method.*
- *Understand the operation and application of various flip-flops (SR, D, JK), including clocked and edge-triggered types, and identify race-around conditions and solutions using master-slave configurations.*
- *Design and implement sequential logic circuits using shift registers and counters (asynchronous and synchronous) and understand their use in digital system design.*

Unit – I

Digital Circuits and Boolean algebra: Difference between Analog and Digital Circuits, Binary Numbers, Decimal to Binary and Binary to Decimal Conversion, AND, OR, NOT, NAND, NOR, XOR and XNOR Gates, De Morgan's Theorems, Boolean Laws, Conversion of Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

Unit-II

Data processing and Arithmetic Circuits: Multiplexers, De-multiplexers, Decoders, Encoders, Binary Addition, Binary Subtraction using 2's Complement, Half and Full Adders, Half & Full Subtractors.

Rayt

Unit – III

Sequential Circuits: SR, D, and JK Flip-Flops, Clocked (Level and Edge Triggered), Preset and Clear operations, Race-around conditions in JK Flip-Flop, M/S JK Flip Flop.

Unit – IV

Shift registers and Counters (4 bits): Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in- Parallel-out Shift Registers, Ring Counter, Asynchronous counters, Decade Counter, Synchronous Counter.

References/Books:

1. Digital Principles and Applications, A.P.Malvino, D.P.Leach and G. Saha, 8th Ed., 2018, Tata McGraw Hill Education
2. Fundamentals of Digital Circuits, Anand Kumar, 4th Edn, 2018, PHI Learning Pvt. Ltd. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill
3. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.
4. Digital Computer Electronics, A.P. Malvino, J.A. Brown, 3rd Edition, 2018, Tata McGraw Hill Education. 53
5. Digital Design, Morris Mano, 5th Ed. Pearson.

Ranjit

Value Added Course

COURSE ID: 241/PHY/VA301

HISTORY OF PHYSICS

Marks (Theory): 35 **Credits: 2**

Marks (Internal Assessment): 15 **Time: 2 Hours**

Note: The examiner will set 9 questions, asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on History of Physics, a student will be able to:

- *Describe ancient cosmological ideas and explain the transformative impact of the Scientific Revolution, including the contributions of key figures such as Copernicus, Galileo, Kepler, Huygens, and Newton.*
- *Understand the major scientific advancements in mechanics, thermodynamics, and electrodynamics during the 18th and 19th centuries, and assess the contributions of scientists like Faraday, Maxwell, and Boltzmann.*
- *Explain the emergence of modern physics through developments in atomic and nuclear physics, and evaluate the scientific achievements and historical significance of Curie, Thomson, Rutherford, Einstein, Planck, Bohr, Hubble, Hoyle, Dirac, and Schrödinger.*
- *Discuss key ideas and technologies in contemporary physics including quantum field theory (QFT), lasers, cosmology, and particle physics, and reflect on the lives and impact of Feynman and Weinberg as well as the role of major research centers and future directions in physics.*

Unit-I

Ancient Indian, Greek, and Chinese concepts about the universe, Scientific Revolution, Contributions and the life of Copernicus, Galileo Galilei, Kepler, Huygens, and Isaac Newton.

Unit-II

18^{th} and 19^{th} century developments in Mechanics, Thermodynamics and Electrodynamics, Life and contributions of Michael Faraday, Maxwell, and Boltzmann.

Unit-III

Birth of Modern Physics, Developments in Nuclear and atomic physics, life and contribution of Marie Curie, Thomson, Rutherford, Albert Einstein, Max Planck, Neils Bohr, Huble, Hoyle, Dirac and Schrodinger.

Unit-IV

Ranjit

Contemporary Physics, Development of QFT, Laser, Developments in Cosmology, Astrophysics, Particle Physics, Quest for unification, life and contribution of Feynman and Weinberg, Major centres for Particle and Nuclear Physics, Future directions.

References/Books:

1. Science India, Scientific Magazines by Vijnana Bharati. For details visit: https://scienceindiamag.in.
2. Everyman's Science by ISCA. For details visit: http://www.sciencecongress.nic.in.
3. Evolution of Geographical Thought, Husain, M., 2012, Rawat Publications.
4. Knowledge Traditions and Practices of India (a text book) 2012, Kapil Kapoor, Michel Danino.
5. E-resources: http://nptel.ac.in/courses/121106003.
6. Probability and Statistical Inference, Mukhopadhyay, N., 2000. Marcel Dekker, Inc. New York.

Raypt

Detailed Syllabi of Pool Courses for M. Sc. (Physics)

Semester-IV

Multi-Disciplinary Course

COURSE ID: 241/PHY/MD401

CONCEPTS OF OPTICS

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Concepts of Optics, a student will be able to:

- *Understand the principle of superposition and explain various interference phenomena of light, including the working and applications of instruments like the Fresnel biprism, Newton's rings, and Michelson interferometer.*
- *Distinguish between Fresnel and Fraunhofer diffraction, and evaluate the resolving power of optical instruments such as telescopes, microscopes, and diffraction gratings.*
- *Explain the nature of polarized light, different methods of polarization, and the functioning of devices like Nicol prisms and retardation plates, along with applications of polarization in optical systems.*
- *Describe the principles and structure of optical fiber communication systems, understand different types of optical fibers and their properties, and assess their applications, advantages, and limitations in modern communication technologies.*

Unit-I

Interference of Light: Superposition of light waves and interference, young's double slit experiment, Conditions for sustained interference pattern, Coherent sources of light, Interference pattern by division of wave front, Fresnel Biprism, Displacement of fringes, Change of phase on reflection, Interference in thin films due to reflected and transmitted light, non- reflecting films, Newton's Rings. Michelson Interferometer.

Unit-II

Diffraction: Huygen's fresnel theory, half-period zones, Zone plate, Distinction between fresnel and fraunhoffer diffraction. Fraunhoffer diffraction at rectangular and circular apertures, Effect of

Ranjit

diffraction in optical imaging, Resolving power of telescope in diffraction grating, its use as a spectroscopic element and its resolving power, Resolving power of microscope.

Unit-III

Polarization: Plane Polarized light, elliptically polarized light, wire grid polarizer, Sheet polarizer, Mauls' Law, Brewester Law, Polarization by reflection, Scattering, Double reflection, Nicol prism, Retardation plates, Production Analysis of polarized light, Quarter and half wave plates.

Unit-IV

Optical Fiber communication: Introduction, Historical development, general system, advantages, disadvantages, and applications of optical fiber communication, optical fiber waveguides, Ray theory, cylindrical fiber, single mode fiber, cutoff wave length. Optical Fibers: fiber materials, photonic crystal, fiber optic cables specialty fibers.

References/Books:

1. Fundamentals of Optics: F.A. Jenkins and Harvey E White, (Megraw Hill) 4th Edition, 2001.

2. Optics: Ajoy Ghatak, (McMillan India) 2nd Edition, 7th Reprint, 1997

3. Optics: Born and Wolf, (Pergamon Press) 3rd Edition, 1965.

4. Laser Fundamentals: W.T. Silfvast (Foundation Books), New Delhi, 1996.

5. Laser and Non-Liner Optics: B.B. Laud (New Age Pub.) 2002 6. Laser: Svelto, Plenum Press) 3rd Edition, New York

6. Fiber optic communication – Joseph C Palais: 4th Edition, Pearson Education

Ranjit

Discipline-Specific Course(s)

(Choose one out of 241/PHY/DS401(i), & 241/PHY/DS401(ii) Options)

COURSE ID: 241/PHY/DS401(i)

CONDENSED MATTER PHYSICS-II

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Condensed Matter Physics-II, a student will be able to:

- *Explicate response of band electrons to an external electric field and their scattering, and calculate currents in bands.*
- *Develop a semi-classical description of electrical transport in metals using the Boltzmann approach, and explain different thermoelectric effects.*
- *Calculate the electronic structure of nano-scale 1D, 0D solids in effective mass approximation, and use it to explain the electrical transport in these solids.*
- *Treat the electron-electron interactions in Hartree and Hartree-Fock approximations using the variational principle and apply these to calculate electronic properties of simple metals.*
- *Learn the concept of screening and calculate the screened potential using the Thomas-Fermi.*
- *Learn the method of density functional theory and concept of exchange and correlation within the independent-electron approach.*

Unit – I

Electron transport phenomenon: Motion of electrons in bands and the effective mass tensor (semi-classical treatment); Currents in bands and holes; Scattering of electrons in bands (elastic, inelastic and electron-electron scatterings); The Boltzmann equation, Relaxation time *ansatz* and linearized Boltzmann equation; Electrical conductivity of metals, Temperature dependence of resistivity and Matthiesen's rule; energy and thermal current densities in linear response (excluding derivations), Thermoelectric effects, Thermopower, Seebeck effect, Peltier effect, The Wiedemann-Franz law.

Ranjit

Unit – II

Nanostructures and Electron Transport: Nanostructures; Electronic structure of 1D systems: 1D sub-bands, Van Hove singularities; 1D metals- Coulomb interactions and lattice couplings; Electrical transport in 1D: Conductance quantization and the Landauer formula, Two barriers in series- Resonant tunneling, Incoherent addition and Ohm's law, Coherence-Localization; Electronic structure of 0D systems (Quantum dots): Quantized energy levels, Semiconductor and metallic dots, Optical spectra, Discrete charge states and charging energy; Electrical transport in 0D- Coulomb blockade phenomenon.

Unit – III

Beyond independent electron approximation-I: The basic Hamiltonian in a solid: Electronic and ionic parts, The Born-Oppenheimer Approximation; The Hartree method using with variational principle; Exchange: The Hartree-Fock approximation, Hartree-Fock equation (without derivation), Koopmans' theorem; Application of Hartree and Hartree-Fock methods to homogeneous electron gas- One-electron energy, Band width, DOS, Effective mass, Ground-state energy, Exchange energy; Concept of correlation energy.

Unit – IV

Beyond independent electron approximation-II: Screening in an electron gas: Thomas-Fermi theory, Density functional theory: Hohenberg-Kohn theorems, derivation of Kohn-Sham equations, solution of self-consistent Kohn-Sham equations, Exchange-correlation functionals, Local density approximation (LDA), Generalized gradient approximation (GGA).

References/Books:

1. Introduction to Solid State Physics (7th edition) by Charles Kittel.
2. Solid State Physics by Neil W. Ashcroft and N. David Mermin.
3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth.
4. Electronic structure basic theory and practical methods by Richard M. martin.
5. Principles of the Theory of Solids (2nd edition) by J. M. Ziman.
6. Applied Solid State Physics by Rajnikant.

Ranjit

COURSE ID: 241/PHY/DS401(ii)

MATERIAL SCIENCE-II

Marks (Theory): 50 **Credits: 3**

Marks (Internal Assessment): 25 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Material Science-II, a student will be able to:

- *Understand the fundamental aspects of crystal structure and phase formations.*
- *Understand the fundamental aspects of electron microscopic techniques and apply for real life problems.*
- *Understand the basics, working principles and working of spectroscopic techniques.*
- *Understand the basics, working principles and working of Optical and Thermal Characterization Techniques.*

Unit – I

Structural Characterization Techniques: X-rays generation; crystal lattice, diffraction-Brags equation; X-ray diffractometer instrumentation; Small and Wide-angle X-ray diffraction. Applications of Powder X-Ray Diffraction (PXRD)-identification of phases, crystallite size determination, intercalation in compounds; Quantitative X-ray diffraction.(W H Analysis,)

Unit – II

Probing/microscopy techniques: Interaction of electrons with solids, Optical microscopes vs electron microscopes, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), High resolution Transmission electron microscopy (HRTEM), Scanning Probe Microscope (SPM): Atomic force microscopy (AFM), scanning tunneling microscopy (STM).

Unit – III

Spectroscopy techniques: Electron Spin Resonance (ESR) spectroscopy, , UV-Vis Spectroscopy, Secondary Ion Mass Spectroscopy (SIMS): basic principle, working, yield of secondary ions and applications, X-ray absorption spectroscopy (XAS), X-ray photoelectron spectroscopy (XPS), Photoluminiscence Spectroscopy.

Unit – IV

Ranjit

Optical and Thermal Characterization Techniques: UV-Visible spectroscopy, Fourier transform Infrared spectroscopy, Raman spectroscopy and its applications, Thermogravimetric analysis (TGA), Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC).

References/Books:

- Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series) A. K. Tyagi, Mainak Roy, S. K. Kulshreshtha and S. Banerjee, Volumes 49 – 51 (2009).
- Fundamentals of Surface and Thin Film Analysis, L.C. Feldman and J. W. Mayer
- Surface Analysis Methods in Material Science, D. J. O'Connor, B. A. Sexton and R. St. C Smart (Eds), Springer Series.

Ranjit

Ability Enhancement Course(s)

COURSE ID: 241/PHY/AE401

INTRODUCTION TO ASTROPHYSICS

Marks (Theory): 35 **Credits: 2**

Marks (Internal Assessment): 15 **Time: 2 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Radiation Physics, a student will be abie:

- *Explain the historical evolution of astronomy and interpret key astronomical scales such as distance, mass, time, brightness, and temperature; apply concepts of positional astronomy using celestial coordinate systems.*
- *Demonstrate understanding of astronomical observation techniques, including the principles and types of telescopes, telescope mountings, and modern detectors, along with the role of Earth's atmosphere in astronomical observations.*
- *Analyze the structure, dynamics, and classification of galaxies, including the Milky Way's rotation; understand fundamental cosmological concepts such as standard candles, Hubble's law, and explore the scientific basis of astrobiology.*
- *Summarize India's contributions to astronomy from ancient to modern times and describe the significance of current Indian observatories and space-based astronomy missions.*

Unit – I

Introduction and Astronomical Scales: History of astronomy, wonders of the Universe, overview of the night sky, diurnal and yearly motions of the Sun, Astronomical Distance, Mass and Time, Scales, Brightness, density, Radiant Flux and Luminosity and temperature of astronomical objects, basic concepts of positional astronomy: Celestial sphere, Astronomical coordinate systems, Horizon system and Equatorial system.

Unit – II

Astronomical techniques: Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes).

Unit – III

Ranjit

Physics of Galaxies: Basic structure and properties of different types of Galaxies, Nature of rotation of the Milky Way (Differential rotation of the Galaxy), Idea of dark matter

Cosmology and Astrobiology: Standard Candles (Cepheids and SNe Type1a), Cosmic distance ladder, Olber's paradox, Hubble's expansion, History of the Universe, Chemistry of life, Origin of life, Chances of life in the solar system

Unit – IV

Astronomy in India: Astronomy in ancient, medieval and early telescopic era of India, current Indian observatories (Hanle-Indian Astronomical observatory, Devasthal Observatory, Vainu Bappu Observatory, Mount Abu Infrared Observatory, Gauribidanur Radio Observatory, Giant Metre-wave Radio Telescope, Udaipur solar observatory, LIGO-India)(qualitative discussion)Indian astronomy missions(Astrosat, Aditya)

References/Books:

- Modern Astrophysics, B.W.Carroll & D.A.Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
- Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- K.S. Krishnasamy, Astro Physics a modern perspective, Reprint, New Age International (p) Ltd, New Delhi, 2002.
- Baidyanath Basu, An introduction to Astrophysics, Second printing, Prentice - Hall of India Private limited, New Delhi,2001.
- Explorations: Introduction to Astronomy, Thomos Arny and Stephen Schneider, 2014, 7th edition, McGraw Hill
- Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
- Astronomy in India: A Historical Perspective, Thana Padmanabhan, Springer.

Ranjit