DEPARTMENT OF PHYSICS

SIDO KANHU MURMU UNIVERSITY DUMKA

SEMESTER I-VIII SYLLABUS FOR THE FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUGP)

As per Provisions of NEP-2020
to be implemented from Academic Session 2023-24

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   Assistant Professor, Department of Physics, S P College, Dumka
6) Mr. Rajesh Kumar
   Assistant Professor, Department of Physics, Model College, Dumka

Table-1: Semester wise Course Code and Credit Points for Major Courses:

Semester	Courses			Marks Distribution			
	Code	Papers	Credits	Semester Internal Theory (F.M.)	End Semester Theory (F.M.)	Semester Internal Practical/ Viva (F.M.)	End Semester Practical/ Viva (F.M.)
I	PHY-MJ-1	MECHANICS AND PROPERTIES OF MATTER	4	25	75	---	---
II	PHY-MJ-2	ELECTRICITY AND MAGNETISM	4	25	75	---	---
	PHY-MJ-3	PRACTICAL-I	4	---	---	25	75
III	PHY-MJ-4	WAVES AND OPTICS	4	25	75	---	---
	PHY-MJ-5	PRACTICAL-II	4	---	---	25	75
IV	PHY-MJ-6	ELEMENTS OF MODERN PHYSICS	4	25	75	---	---
	PHY-MJ-7	ELECTRONICS	4	25	75	---	---
	PHY-MJ-8	PRACTICAL-III	4	---	---	25	75
V	PHY-MJ-9	THERMAL PHYSICS	4	25	75	---	---
	PHY-MJ-10	MATHEMATICAL PHYSICS	4	25	75	---	---
	PHY-MJ-11	PRACTICAL-IV	4	---	---	25	75
VI	PHY-MJ-12	QUANTUM MECHANICS	4	25	75	---	---
	PHY-MJ-13	SOLID STATE PHYSICS	4	25	75	---	---
	PHY-MJ-14	STATISTICAL MECHANICS	4	25	75	---	---
	PHY-MJ-15	PRACTICAL-V	4	---	---	25	75
VII	PHY-MJ-16	CLASSICAL DYNAMICS	4	25	75	---	---
	PHY-MJ-17	ELECTROMAGNETIC THEORY	4	25	75	---	---
	PHY-MJ-18	NUCLEAR & PARTICLE PHYSICS	4	25	75	---	---
	PHY-MJ-19	PRACTICAL-VI	4	---	---	25	75
VIII (AMJ or RC)	PHY-MJ-20	SEMINAR AND PRESENTATION	4	25	75	---	---
	Advanced Major (AMJ)						
	PHY-AMJ-1	ADVANCED QUANTUM MECHANICS	4	25	75	---	---
	PHY-AMJ-2	ADVANCED ELECTRONICS	4	25	75	---	---
	PHY-AMJ-3	ADVANCED PRACTICAL	4	---	---	25	75
		Research Course (RC)					
	PHY-RC-1	RESEARCH METHODOLOGY	4	25	75	---	---
	PHY-RC-2	RESEARCH PROJECT OR DISSERTATION	8	---	---	---	200

Table-2: Semester wise Course Code and Credit Points for Minor Courses:

Semester	Minor Courses			Marks Distribution			
	Code	Papers	Credits	Semester Internal Theory (F.M.)	End Semester Theory (F.M.)	Semester Internal Practical/ Viva (F.M.)	End Semester Practical / Viva (F.M.)
I	MN-1A	MECHANICS	4	15	60	---	25
III	MN-1B	ELECTRICITY AND MAGNETISM	4	15	60	---	25
V	MN-1C	THERMODYNAMICS AND STATISTICAL PHYSICS	4	15	60	---	25
VII	MN-1D	WAVES AND OPTICS	4	15	60	---	25

Table-3: Semester wise Course Code and Credit Points for Multidisciplinary course:

Semester	Multidisciplinary Course			Marks Distribution			
	Code	Papers	Credits	Semester Internal Theory (F.M.)	End Semester Theory (F.M.)	Semester Internal Practical/ Viva (F.M.)	End Semester Practical/ Viva (F.M.)
I	MDC-I	BASIC PHYSICS	3	---	75	---	---
II	MDC-II						
III	MDC-III						

Guidelines for question setter:

Major Courses
Credit: 4 (100 marks)

	Time	Full Marks	Pass Marks	
Semester Internal Examination (SIE)	1 Hr	25	10	40
End Semester Examination (ESM)	3 Hrs	75	30	

Semester Internal Examination: 20+5=25 marks

The semester internal examination may include 20 marks questions from Writtenexamination/ Assignment/ Project/ Tutorial wherever applicable whereas 5 marks will be awarded on the attendance/ overall class performance in the semester.

Written examination (20 marks): There will be two groups of questions.

> **Group A** is compulsory which will contain two questions. **Question No.1** will be very short answer type consisting of five questions of 1 mark each. **Question No.2** will be short answer type of 5 marks.
>
> **Group B** will contain descriptive type two questions of 10 mark each, out of which any one to answer.

Attendance (5 marks): Conversion of Attendance into score may be as follows:

Attendance Upto 45%	1 mark
45< Attendance <55	2 marks
55< Attendance <65	3 marks
65< Attendance <75	4 marks
75< Attendance	5 marks

End Semester Examination: 75 marks

F.M.=75	Subject/Code Time= 3 Hrs.	Exam Year

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A [5x1=5]

1.
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....

2. .... [5]
3. .... [5]

Group B

4. .... [15]
5. .... [15]
6. .... [15]
7. .... [15]
8. .... [15]
9. .... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

Minor Courses
Credit: 4 (100 marks)

<table>
<tr><th></th><th>Time</th><th>Full Marks</th><th colspan="2">Pass Marks</th></tr>
<tr><td>Semester Internal Examination (SIE)</td><td>1 Hr</td><td>15</td><td>6</td><td rowspan="2">30</td></tr>
<tr><td>End Semester Examination (ESM)</td><td>3 Hrs</td><td>60</td><td>24</td></tr>
<tr><td>Practical</td><td>3 Hrs</td><td>25</td><td colspan="2">10</td></tr>
</table>

<u>Semester Internal Examination: 10+5=15 marks</u>

The semester internal examination may include 10 marks questions from Writtenexamination/ Assignment/ Project/ Tutorial wherever applicable whereas 5 marks will be awarded on the attendance/ overall class performance in the semester.

Written examination (10 marks): There will be two groups of questions.

> **Group A** is compulsory which will contain one question. **Question No.1** will be very short answer type consisting of five questions of 1 mark each.
>
> **Group B** will contain descriptive type two questions of 5 mark each, out of which any one to answer.

Attendance (5 marks): Conversion of Attendance into score may be as follows:

Attendance Upto 45%	1 mark
45< Attendance <55	2 marks
55< Attendance <65	3 marks
65< Attendance <75	4 marks
75< Attendance	5 marks

End Semester Examination: 60 marks

F.M.=60	Subject/Code Time= 3 Hrs.	Exam Year

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A [5x1=5]

1.
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....
2. .... [5]
3. .... [5]

Group B

4. .... [15]
5. .... [15]
6. .... [15]
7. .... [15]
8. .... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

Multidisciplinary Course
Credit: 3 (75 marks)

	Time	Full Marks	Pass Marks
End Semester Examination (ESM)	3 Hrs	75	30

F.M.=75	Subject/Code Time= 3 Hrs.	Exam Year

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A [5x1=5]

1.
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....

2. .... [5]
3. .... [5]

Group B

4. .... [15]
5. .... [15]
6. .... [15]
7. .... [15]
8. .... [15]
9. .... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

Practical
Credit: 4 (100 marks)

Semester Internal Examination (ESE): 25 marks
There will be one Practical Examination of 3Hrs duration.
Evaluation of Practical Examination may be as per the following guidelines:

Experiment	10 marks
Practical record notebook	5 marks
Viva-voce	10 marks

End Semester Examination (ESE):75 marks
There will be one Practical Examination of 3Hrs duration.
Evaluation of Practical Examination may be as per the following guidelines:

Experiment	50 marks
Practical record notebook	10 marks
Viva-voce	15 marks

SEMESTER-I

I. PHY-MJ-1: MECHANICS AND PROPERTIES OF MATTER

(Credit: Theory-04) 60 Lectures

Course Objectives:

This course aims to enable the students to acquire the key concepts of the general properties of matter, the motion of a particle under central force field, oscillations and special theory of relativity.

Learning Outcomes:

- Learn about the behaviour of physical bodies around us in daily life.
- Understand the dynamics of planetary motion.
- Build a foundation of various applied field in science and technology.
- Develop the analytical thinking on Mechanics in order to understand the response of the classical systems to external forces.

Course Content:

General Properties of Matter (20 Lectures): Hooke‟s law. Stress-strain diagram. Elastic moduli. Poisson‟s Ratio-expression for Poisson‟s ratio in terms of elastic constants. Relation between Elastic constants. Work done in stretching and work done in twisting a wire-Twisting couple on a cylinder. Bending moment. Cantilevers, beam supported at the end and loaded at middle and its application to determine Young‟s modulus. Searle‟s experiments. Kinematics of Moving Fluids: Viscous fluid, Poiseuille‟s Equation for Flow of a Liquid through a Capillary Tube with correction, Flow of compressible fluid through a capillarytube, Rankine‟s methods for measurement of viscosity of gas. Effect of temperature and pressure onviscosity. Surface tension and surface energy. Angle of contact. Expression for excess pressure. Principal of virtual work. Ripples and Gravity waves. Effect of temperature and pressure on surface tension.

Central Force Motion (10 Lectures): Motion of a particle under a central force field. Two bodies problem. Conservation of angular momentum. Kepler‟s Laws of planetary motion and their derivations. Satellite in circular orbit and applications. Weightlessness.

Oscillations (15 Lectures): Simple Harmonic Oscillations (SHM). Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Examples of Physical Systems Executing SHM: Simple Pendulum, Compound Pendulum, Torsional Pendulum, LC-Circuit. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance, power dissipation and Quality Factor.

Special Theory of Relativity (15 Lectures): Inertial and Non-inertial frames. Centrifugal force and Coriolis force and its applications. Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Lorentz contraction. Time dilation. Simultaneity and order of events. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, D. S. Mathur.

3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Feynman Lectures, Vol. I, R.P. Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
5. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
6. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

II. PHY-MN-1A: MECHANICS

(Credits: Theory-03) 45 Lectures

Course Objectives:

This course aims to enable the students to acquire the mathematical knowledge about the vector algebra and ordinary differential equation with their role in applied physics. Key concepts of the general properties of matter, the motion of a particle under central force field, oscillations and non-inertial systems.

Learning Outcomes:

- Understanding about vector algebra and ODEs will be developed.
- Learn about the behaviour of physical bodies around us in daily life.
- Understand the dynamics of planetary motion.
- Build a foundation of various applied field in science and technology.
- Develop the analytical thinking on Mechanics in order to understand the response of the classical systems to external forces.

Course Content:

Vectors (4 Lectures): Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.

Ordinary Differential Equations (4 Lectures): 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.

General Properties of Matter (12 Lectures): Hooke"s law. Stress-strain diagram. Elastic moduli. Poisson"s Ratio-expression for Poisson"s ratio in terms of elastic constants. Relation between Elastic constants. Work done in stretching and work done in twisting a wire-Twisting couple on a cylinder. Kinematics of Moving Fluids: Viscous fluid, Poiseuille"s Equation for Flow of a Liquid through a Capillary Tube with correction, Flow of compressible fluid through a capillary tube. Effect of temperature and pressure on viscosity. Surface tension and surface energy. Angle of contact. Expression for excess pressure. Effect of temperature and pressure on surface tension.

Work and Energy (5 Lectures): Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium.Elastic potential energy. Force as gradient of potential energy. Work and Potential energy. Work done by nonconservative forces. Law of conservation of Energy.

Central Force Motion (8 Lectures): Motion of a particle under a central force field. Two bodies problem. Conservation of angular momentum. Kepler"s Laws of planetary motion and their derivation. Satellite in circular orbit and applications. Weightlessness.

Oscillations (7 Lectures): Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations.

Non-Inertial Systems (5 Lectures): Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, D. S. Mathur.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Feynman Lectures, Vol. I, R.P. Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education.
5. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
6. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

III. PHY-MDC-I/II/III: BASIC PHYSICS

(Credits: Theory-03) 45 Lectures

Course Objectives:

This course aims to introduce students to the basic concepts of Mechanics, Waves, Thermodynamics and Electromagnetism and extend these ideas to other branches of physics.

Learning Outcomes:

- Learn about the behaviour of physical bodies around us in daily life.
- Understand the dynamics of planetary motion.
- Apply the laws of thermodynamics, including the zeroth and first laws, to analyze thermodynamic processes.
- Also learn about the nature of waves, electrical, magnetic, and dual properties ofmatter.

Course Content:

Introduction to Physics (8 Lectures): Overview of Physics and its branches, units & measurements, laws of motion. Conservation of linear momentum, rocket motion. Work, energy, and power. Work-energy theorem and Laws of conservation of energy.

Gravity (6 Lectures): Universal law of gravitation, mass, weight and gravitational force, Gravitational potential energy. Kepler‟s laws of planetary motion. Variation of acceleration due to gravity. Escape velocity and orbits (Qualitative ideas).

Heat and Thermodynamics (6 Lectures): Temperature and heat. Calorimetry- Specific heat and heat transfer. Different temperature scales. Laws of thermodynamics.

Waves, Sound & Light (10 Lectures): Vibrations and simple harmonic motion. Wave properties: amplitude, frequency, wavelength. Properties of sound waves. Speed of sound and Doppler effect. Laws of reflection and refraction of light, Total internal Reflection. • Electromagnetic waves and the electromagnetic spectrum. Some natural phenomena associated with light like-Rainbow, Mirage, color of sky, etc.

Electricity, Magnetism & Modern Physics (15 Lectures): Electrostatics: Electric charge and Coulomb‟s law. Electric fields and electric potential. Electric current, resistance, and Ohm‟s law. Electric power and its commercial unit. Magnetism: Basic properties, Earth‟s magnetism, Electromagnet, Dia-, Para- & Ferro-magnetism. Atomic nucleus, mass defect, nuclear fission-fusion and radioactivity, Devastating effect of atom bomb. Introduction to quantum mechanics: Wave-particle duality and Heisenberg‟s uncertainty principle.

Reference Books:

1. NCERT Physics.
2. Mechanics, D. S. Mathur.
3. Fundamental Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Feynman Lectures, R.P. Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education.
5. Optics, Ajoy Ghatak.
6. Waves and Oscillations, Brijlal and Subrahmanyam.

Practical: 30 Lectures

List of Practical:

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study errors: Truncation and round off errors, Absolute and relative errors.
3. To determine the elastic Constants of a wire by Searle‟s method.
4. To determine the value of g using Bar Pendulum.
5. To determine the value of g using Kater‟s Pendulum.
6. To determine the Modulus of Rigidity of a Wire by Maxwell‟s needle.

Reference Books:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
2. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal.
5. Numerical Methods, E Balagurusamy, McGraw Hill Education.

SEMESTER-II

I. PHY-MJ-2: ELECTRICITY AND MAGNETISM

(Credit: Theory-04) 60 Lectures

Course Objectives:

- Better understanding of electrical and magnetic phenomena in daily life.
- Comprehend various electrical circuits and their use in equipment for powerful applications.
- Extend the idea of electric and magnetic properties in science and technology.

Learning Outcomes:

- Evaluate electric field and potential for different types of charge distributions.
- Grasp the different aspects of Electromagnetic induction and its applications.
- To troubleshoot simple problems related to electrical devices.

Course Content:

Electric Field and Electric Potential (10 Lectures): Electric flux. Gauss‟ law in integral and differential form and its applications. Conservative nature of Electrostatic Field. Laplace‟s and Poisson equations. The Uniqueness Theorem. Electric field and Potential dueto electric dipole and quadrupole. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

Dielectric Properties of Matter (10 Lectures): Electric Field in matter. Polarization and Polarizability. Electrical susceptibility and Dielectric constant. Displacement vector D. Relations between E, P and D. Clausius Mossotti equation, Gauss‟ Law in dielectrics.

Magnetic field (5 Lectures): Biot-Savart‟s Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment. Torque on a current loop in a uniform Magnetic Field.

Magnetic Properties of Matter (10 Lectures): Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. B-H curve and hysteresis. Properties of magnetic materials- Dia, Para and Ferromagnetism, Langevin‟s theory, Measurement of susceptibility by Quincke‟s Method.

Electromagnetic Induction (6 Lectures): Faraday‟s Law. Lenz‟s Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Charge Conservation and Displacement current.

Electrical Circuits (15 Lectures): AC Circuits: Kirchhoff‟s laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. Anderson‟s bridge, De-Sauty bridge and Cary Foster bridge. Equivalent circuit and vector diagram. Transformer, Losses in transformer.

Ballistic Galvanometer (4 Lectures): Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping.

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw.
2. Introduction to Electrodynamics, D.J. Griffiths, Cambridge University Press.
3. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
4. Electricity and Magnetism by R. K. Tewary, S Chand.

II. PHY-MJ-3: PRACTICAL-I

(Credits: Practical-04) 120 Lectures

Course Objectives:

This practical course aims to get familiar with various measuring tools and learn the importance of accuracy of measurements along with the limitations of measuring device and check the suitability of the equipment, tools regarding their functioning.

Learning Outcomes:

- Develop the proficiency in the handling of laboratory instruments.
- Estimate uncertainty in the measured value.
- Analyze and interpret the recorded observations, calculation and graphs to draw conclusion.
- Identify the factors that influences the observations in order to perform precise measurement.

List of Practical:

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study errors: Truncation and round off errors, Absolute and relative errors.
3. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
4. To determine the elastic Constants of a wire by Searle"s method.
5. To determine the value of g using Bar Pendulum.
6. To determine the value of g using Kater"s Pendulum.
7. To determine the Modulus of Rigidity of a Wire by Maxwell"s needle.
8. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
9. To study the characteristics of a series RC Circuit.
10. To determine an unknown Low Resistance using Potentiometer.
11. To determine an unknown Low Resistance using Carey Foster"s Bridge.
12. To compare capacitances using De"Sauty"s bridge.
13. To determine self inductance of a coil by Anderson"s bridge.
14. Measurement of field strength B and its variation in a solenoid (determine dB/dx).
15. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
16. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.

References:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
2. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal.

5. Numerical Methods, E Balagurusamy, McGraw Hill Education.

SEMESTER-III

I. PHY-MJ-4: WAVES AND OPTICS

(Credit: Theory-04) 60 Lectures

Course Objective:

This course aims to provide students with a comprehensive understanding of wave phenomena in physics, including wave basics, wave optics, interference, diffraction, and polarization.

Learning Outcomes:

- Understand the properties and behaviors of plane and spherical waves, longitudinal and transverse waves, and their mathematical representations.
- Apply the wave equation and principles of energy transport to analyze wave propagation and intensity.
- Analyze and interpret phenomena such as interference fringes, diffraction patterns, and polarization effects using theoretical models and experimental techniques.
- Demonstrate proficiency in solving problems related to standing waves, interference, and diffraction in various mediums.
- Explain the electromagnetic nature of light, including the laws of reflection and refraction, and apply them to optical systems such as lenses, mirrors, and interferometers.

Course Content:

Wave Basics (14 Lectures): Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Travelling) Waves, Wave Equation, Particle and Wave Velocities, Differential Equation, Pressure of a Longitudinal Wave, Energy Transport, Intensity of Wave, Water Waves: Ripple and Gravity Waves. Linearity and Superposition Principle, Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats), Graphical and Analytical Methods, Lissajous Figures and their uses, : Standing (Stationary) Waves in a String: Fixed and Free Ends, Analytical Treatment, Phase and Group Velocities, Changes with respect to Position and Time, Energy of Vibrating String, Transfer of Energy, Normal Modes of Stretched Strings. Plucked and Struck Strings, Melde's Experiment, Longitudinal Standing Waves and Normal Modes, Open and Closed Pipes.

Wave Optics (6 Lectures): Electromagnetic nature of light, Definition and properties of wave front, Huygens Principle, Temporal and Spatial Coherence, Fermat‟s Principle, Lens and Mirror formula, Laws of reflection and refraction, Cardinal points.

Interference (16 Lectures): Division of amplitude and wavefront, Interference in Thin Films, Fringes of equal inclination (Haidinger Fringes), Fringes of equal thickness (Fizeau Fringes), Newton‟s Rings: Measurement of wavelength, Measurement of refractive index. Michelson Interferometer, Michelson-Morley experiment and its failure, Determination of Wavelength, Wavelength Difference, Refractive Index, Visibility of Fringes, Fabry-Perot Interferometer.

Diffraction (16 Lectures): Fresnel‟s Assumptions, Fresnel‟s Half-Period Zones for Plane Wave, Explanation of Rectilinear Propagation of Light, Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral and its applications, Fresnel diffraction pattern of a straight edge, a slit and a wire. Fraunhofer Diffraction**:** Single slit diffraction, Double slit diffraction, Circular aperture, Multiple slits Resolving Power of a telescope, Resolving powerof grating, Use of grating to produce monochromatic light.

Polarization (8 Lectures): Polarization by reflection, Brewster‟s law, Double refraction, Nicol prism, Ordinary& extraordinary refractive indices, Retardation plate: $\lambda/2$ and $\lambda/4$ plates, Babinet compensator, Description of Linear, Circular and Elliptical Polarization, Production and detection of plane, circular, and elliptically polarized light. Optical activity

Reference Books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Optics by B. K. Mathur.

II. PHY-MJ-5: PRACTICAL-II

(Credits: Practical-04) 120 Lectures

Course Objective:

The practical component of this course aims to provide hands-on experience in experimental techniques and measurements related to wave optics, interference, and diffraction phenomena, reinforcing theoretical concepts learned in lectures.

Learning Outcomes:

- Perform experiments to determine the refractive index, dispersive power, and Cauchy constants of optical materials using various sources such as sodium and mercury.
- Use interferometers like Michelson's and Fresnel biprism to measure the wavelength of light sources accurately.
- Apply Newton's rings method to determine the wavelength and radius of curvature of optical elements.
- Analyze interference fringes produced by thin films to determine their thickness.
- Utilize diffraction gratings and double slits to study diffraction patterns and measure unknown wavelengths of light sources.
- Determine the dispersive and resolving powers of diffraction gratings through experimental setups and measurements.

List of Practical:

1. Determine refractive index of the material of a prism using sodium source.
2. Determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
3. Determine the wavelength of sodium source using Michelson‟s interferometer.
4. Determine the wavelength of sodium light using Fresnel Biprism.
5. Determine the wavelength of sodium light using Newton‟s Rings.
6. Determine the radius of curvature of a plano-convex lens by using Newton's rings.
7. Determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
8. Determine the wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
9. Measure certain wavelengths of spectral lines of mercury vapour using diffraction grating.
10. Study diffraction of light by using double slits and determination of unknown wavelengths.
11. Determine dispersive power and resolving power of a plane diffraction grating.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

III. PHY-MN-1B: ELECTRICITY AND MAGNETISM

(Credits: Theory-03, Practicals-01)

Course Objective:

This course aims to provide students with a comprehensive understanding of electric and magnetic fields, their interactions, and their applications in electrical circuits, preparing them for advanced studies in electromagnetism and electrical engineering.

Learning Outcomes:

- Understand the concepts of electric flux, Gauss's law, and its applications in determining electric fields.
- Analyze the conservative nature of electrostatic fields and solve Laplace's and Poisson's equations for various configurations.
- Evaluate electric fields and potentials due to electric dipoles and conductors, and calculate capacitance of charged systems.
- Describe dielectric properties of matter, including polarization, dielectric constant, and susceptibility, and analyze Gauss's law in dielectrics.
- Apply Biot-Savart's law to calculate magnetic fields produced by current-carrying wires and loops, and determine torque on current loops in magnetic fields.
- Explain magnetic properties of matter, including magnetization, magnetic intensity, and susceptibility, and interpret B-H curves and hysteresis.
- Analyze electromagnetic induction phenomena, including Faraday's law, self-inductance, mutual inductance, and energy storage in magnetic fields.
- Apply Kirchhoff's laws to analyze AC circuits, calculate complex reactance and impedance, and study resonance, power dissipation, and quality factor in LCR circuits.

Course Content:

Theory: 45 Lectures

Electric Field and Electric Potential (**10 Lectures**): Electric flux. Gauss‟ law in integral and differential form and its applications. Conservative nature of Electrostatic Field. Laplace‟s and Poisson equations. The Uniqueness Theorem. Electric field and Potential dueto electric dipole and quadrupole. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors.

Dielectric Properties of Matter (**5 Lectures**): Electric Field in matter. Polarization and Polarizability. Electrical susceptibility and Dielectric constant. Displacement vector **D**. Relations between **E**, **P** and **D**. Clausius Mossotti equation, Gauss‟ Law in dielectrics.

Magnetic field (5 Lectures): Biot-Savart‟s Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment. Torque on a current loop in a uniform Magnetic Field.

Magnetic Properties of Matter (**7 Lectures**): Magnetization vector (**M**). Magnetic Intensity (**H**). Magnetic Susceptibility and permeability. Relation between **B**, **H**, **M**. B-H curve and hysteresis. Properties of magnetic materials- Dia, Para and Ferromagnetism.

Electromagnetic Induction (**5 Lectures**)**:** Faraday‟s Law, Lenz‟s Law, Self Inductance and Mutual Inductance, Reciprocity Theorem, Energy stored in a Magnetic Field, Charge Conservation and Displacement current.

Electrical Circuits (**8 Lectures**): AC Circuits: Kirchhoff‟s laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. Transformer, Losses in transformer.

Ballistic Galvanometer (5 Lectures):: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping.

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw.
2. Introduction to Electrodynamics, D.J. Griffiths, Cambridge University Press.
3. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
4. Electricity and Magnetism by R. K. Tewary, S Chand.

Practical: 30 Lectures

List of Practical:

1. Use a Multimeter for measuring: (a) Resistances (b) AC and DC Voltages (c) DC Current (d) Capacitances (e) Checking electrical fuses.
2. Determine an unknown Low Resistance using: (a) Potentiometer (b) Carey Foster‟s Bridge.
3. Compare capacitances using De‟Sauty‟s bridge.
4. Verify the Thevenin and Norton theorems.
5. Verify the Superposition and Maximum power transfer theorems.
6. Determine self-inductance of a coil by Anderson‟s bridge.
7. Study the response curve of a Series LCR circuit and determine: (a) Resonant frequency (b) Impedance at resonance (c) Quality factor Q (d) Bandwidth.
8. Study the response curve of a parallel LCR circuit and determine: (a) Anti-resonant frequency (b) Quality factor Q.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

SEMESTER-IV

I. PHY-MJ-6: ELEMENTS OF MODERN PHYSICS

(Credits: Theory-04) 60 Lectures

Course Objective:

This course aims to introduce students to the fundamental concepts of quantum theory, wave mechanics, nuclear models, and laser physics, providing a strong theoretical foundation and practical understanding of these principles.

Learning Outcomes:

- Understand the basics of quantum theory, including Planck's quantum hypothesis, the photoelectric effect, and wave-particle duality.
- Analyze experimental evidence supporting quantum theory, such as the Compton scattering and Davisson-Germer experiments.
- Apply wave mechanics principles, including the Schrödinger equation, wave functions, and probability densities, to solve quantum mechanical problems for non-relativistic particles.
- Describe nuclear models, including the liquid drop model, semi-empirical mass formula, and nuclear shell structure, and interpret experimental evidence supporting these models.
- Explain the principles of laser physics, including the operation of lasers, population inversion, and the formation of holographic images, and analyze the characteristics of different types of lasers such as Ruby and He-Ne lasers.

Course Content:

Quantum Theory (20 Lectures): Planck‟s quantum, Planck‟s constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions. Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Energy-time uncertainty principle- application to virtual particles and range of an interaction, Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Bohr Atom, Atomic spectra: Frank Hertz experiment.

Wave Mechanics (18): 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, Scattering and bound states for a general potential. One dimensional problems: particle in a box,Quantum dot, Scattering and tunneling - Steps and barriers

Nuclear Models (15 Lectures): Liquid drop model approach, Semi-empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for Nuclear Shell structure, Nuclear magic numbers, Basic assumption of Shell model, concept of mean field, residual interaction, concept of nuclear force, L-S coupling, j-j coupling, Transformation between L-S and j-j coupling schemes.

Laser and Holography (7 Lectures): Einstein‟s A and B coefficients. Laser rate equations. Metastable states. Spontaneous and stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser.

Reference Books:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.
4. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
5. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
6. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).

II. PHY-MJ-7: ELECTRONICS

(Credits: Theory-04) 60 Lectures

Course Objetive:

This course aims to provide students with a comprehensive understanding of semiconductor fundamentals, including the behavior of crystalline solids, semiconductor materials, p-n junction diodes, bipolar junction transistors, and digital circuits, preparing them for applications in electronics and device engineering.

Learning Outcomes:

- Understand the properties and behavior of crystalline solids and semiconductor materials, including electron and hole dynamics, doping, and energy band diagrams.
- Analyze the operation and characteristics of p-n junction diodes, including forward and reverse biasing, rectification, and voltage regulation.
- Describe the principles and applications of bipolar junction transistors, including transistor configurations, biasing techniques, and transistor amplifiers.
- Design and analyze digital circuits, including binary arithmetic, logic gates, Boolean algebra, and circuit simplification techniques using Karnaugh maps.
- Apply knowledge of semiconductor devices and digital circuits to solve practical problems in electronics, such as amplifier design and logic circuit implementation.

Course Content:

Semiconductor Fundamentals (8 Lectures): Crystalline solids, semiconductors, electron and hole, intrinsic semiconductor, doping and n- and p- type semiconductors, direct and indirect band gap semiconductors, effective mass, Fermi level, energy band, distinction of metal, insulator and semiconductors, energy band diagrams, drift and diffusion of carriers, Einstein Relation, continuity equation, Hall Effect, resistivity and four-probe technique.

p-n Junction Diodes and Applications (8 Lectures): Fabrication of p-n junction, barrier formation in p-n junction, barrier potential, forward and reverse biased diode, energy band diagrams, current flow mechanism in forward and reverse biased diodes, static and dynamic resistance, junction capacitances. Diode rectifier, load line and Q-point, half- wave rectifier, centre-tapped and bridge full-wave rectifiers, calculation of average and rms current and voltage, voltage regulation, ripple factor and rectification efficiency, filters. Zener Diode, Zener and avalanche breakdown, Zener diode as voltage regulator, Principle and structure of light-emitting diode (LED), photodiode and solar cell and metal-semiconductor contacts.

Bipolar Junction Transistors (12 Lectures): n-p-n and p-n-p Transistors, Characteristics of CB, CE, and CC Configurations, Current Gains and Relations between Them, Load Line Analysis of Transistors, DC Load Line and Q-point, Physical Mechanism of Current Flow, Active, Cutoff, and Saturation Regions

Transistor Amplifiers (12 Lectures): Load line and Q-point, transistor biasing and stabilization circuits, fixed bias, emitter-feedback bias, collector-feedback bias and voltage divider bias. Two-port model and hybrid (h) parameters, significance of h parameters, Thevenin and Norton equivalents of a transistor, transistor as two-port network, analysis of a single-stage CE amplifier using hybrid model, current and voltage gains, input and output impedance. Need for power amplification, conditions for transistor power amplifier, distortions due to nonlinearity, classification of amplifiers: class A, B, AB and C amplifiers.

Digital Circuits (10 Lectures): Difference between Analog and Digital Circuits, Binary numbers, Decimal to Binary and Binary to Decimal conversion. BCD, Octal and Hexadecimal numbers, AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

Boolean algebra (10 Lectures): De Morgan's Theorems, Boolean Laws, Simplification of Logic Circuit using Boolean Algebra, Fundamental Products, Idea of Minterms and Maxterms, Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn., 2009, PHI Learning.
1. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.
4. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
5. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer.
6. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India.
7. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.
8. Hand book of electronics by Gupta and Kumar.
9. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
10. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
11. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
12. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
13. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

III. PHY-MJ-8: PRACTICAL-III

(Credits: Practical-04) 120 Lectures

Course Objective:

The practical component of this course aims to provide students with hands-on experience in experimenting with semiconductor devices and digital circuits, reinforcing theoretical concepts learned in lectures and enhancing practical skills in electronics.

Learning Outcomes:

- Utilize a CRO to measure voltage and time period of periodic waveforms accurately.
- Test diodes and transistors using a multimeter to verify their functionality.
- Design a transistor-based switch (NOT gate) and verify its operation.
- Construct AND, OR, NOT, and XOR gates using only NAND gates and verify their truth tables.
- Analyze the V-I characteristics of PN junction diodes and Zener diodes to understand their behavior and applications.
- Investigate the characteristics of a Bipolar Junction Transistor (BJT) in CE configuration to understand its amplification properties.
- Study the frequency response of voltage gain of an RC-coupled transistor amplifier to analyze its performance.
- Verify Thevenin and Norton theorems experimentally to understand their applications in circuit analysis.
- Demonstrate the principles of superposition and maximum power transfer theorems through experimental setups and measurements.

List of Practical:

1. Measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. Test a Diode and Transistor using a Multimeter.
3. Design a switch (NOT gate) using a transistor.
4. verify and design AND, OR, NOT and XOR gates using NAND gates.
5. Study V-I characteristics of PN junction diode, and verification of diode equation.
6. Study the V-I characteristics of a Zener diode and its use as voltage regulator.
7. Study the characteristics of a Bipolar Junction Transistor in CE configuration.
8. Study the frequency response of voltage gain of a RC-coupled transistor amplifier.
9. Verify the Thevenin and Norton theorems.
10. Verify the Superposition and Maximum power transfer theorems.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, Vani Pub.
5. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

SEMESTER-V

I. PHY-MJ-9: THERMAL PHYSICS

(Credits: Theory-04) 60 Lectures

Course Objective:

This course aims to provide students with a comprehensive understanding of the fundamentals of gases and thermodynamic variables, including the kinetic theory of gases, laws of thermodynamics, thermodynamic potentials, phase transitions, Maxwell's thermodynamic relations, and transport phenomena.

Learning Outcomes:

- Understand the behavior of gases, including the Maxwell-Boltzmann distribution of velocities, degrees of freedom, and specific heats, and analyze real gas behavior using equations of state such as the virial equation and Vander-Waal's equation.
- Apply the laws of thermodynamics, including the zeroth and first laws, to analyze thermodynamic processes, equilibrium conditions, and the conversion of heat and work.
- Analyze reversible and irreversible processes, heat engines, refrigerators, and the efficiency of Carnot cycles using concepts such as entropy, heat engines, and the Kelvin-Planck and Clausius statements.
- Describe thermodynamic potentials such as internal energy, enthalpy, Helmholtz free energy, and Gibbs free energy, and analyze phase transitions using the Clausius-Clapeyron equation and Maxwell's thermodynamic relations.
- Explain transport phenomena in gases, including viscosity, thermal conductivity, and diffusion, and apply concepts such as mean free path and collision probability to analyze thermal conductivity and diffusion processes.

Course Content:

Fundamentals of Gases and Thermodynamic Variables (10 Lectures): Kinetic Theory of Gases: Maxwell-Boltzmann Law of Distribution of Velocities, Degrees of Freedom, Law of Equipartition of Energy, Specific Heats of Gases. Real Gases and Thermodynamic Properties: Behavior of Real Gases, Virial Equation, Critical Constants and Boyle Temperature, Vander-Waal"s Equation of State.

Laws of Thermodynamics and Applications (25 Lectures): Zeroth and First Law of Thermodynamics, Extensive and Intensive Thermodynamic Variables, Thermodynamic Equilibrium, Concept of Work and Heat, State Functions, Internal Energy, General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient. Reversible and Irreversible Processes, Conversion of Work into Heat and Heat into Work, Heat Engines, Carnot"s Cycle and Efficiency, Refrigerators and Coefficient of Performance, Kelvin-Planck and Clausius Statements, Carnot"s Theorem, Clausius Inequality, Applications of Second Law, Entropy and Clausius Theorem, Entropy of a perfect gas. Principle of increase of Entropy, Entropy Changes in Reversible and Irreversible processes with examples, Mixing of entropy of two ideal gases, Entropy of the Universe, Temperature-Entropy Diagrams for Carnot"s Cycle, Third Law of Thermodynamics, Unattainability of Absolute Zero.

Thermodynamic Potentials and Phase Transitions (7 Lectures): Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. First and Second Order Phase Transitions: Clausius-Clapeyron Equation and Ehrenfest Equations.

Maxwell's Thermodynamic Relations (8 Lectures) : Derivations and Applications of Maxwell‟s Relations. Maxwell‟s Relations: Clausius-Clapeyron Equation, Values of C_p-C_v, T-ds Equations, Joule-Kelvin Coefficient for Ideal and Van der Waal Gases.

Transport Phenomena and Thermal Conductivity (10 Lectures): Molecular Collisions and Transport Phenomena: Mean Free Path, Collision Probability, Viscosity, Thermal Conductivity, and Diffusion in Ideal Gases, Brownian Motion and its Significance. Thermal Conductivity: Rectilinear Flow of Heat in Metal Rod, Conductivity by Periodic Flow Method.

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger.1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press.

II. PHY-MJ-10: MATHEMATICAL PHYSICS

(Credits: Theory-04) 60 Lectures

Course Objective:

This course aims to equip students with a solid foundation in differential equations, vector calculus, complex analysis, Fourier series, Fourier transforms, and Laplace transforms, providing them with essential mathematical tools for solving problems in various scientific and engineering fields.

Learning Outcomes:

- Understand and solve first-order differential equations using integrating factors, homogeneous equations with constant coefficients, and the method of particular integrals.
- Apply vector calculus concepts such as directional derivatives, gradient, divergence, and curl to analyze vector fields and solve problems involving line, surface, and volume integrals.
- Apply complex analysis techniques, including Euler's formula, De Moivre's theorem, Cauchy-Riemann conditions, and Cauchy's integral formula, to analyze and integrate functions of complex variables.
- Analyze periodic functions and represent them using Fourier series, understanding orthogonality conditions, Dirichlet conditions, and complex representations of Fourier series.
- Apply Fourier transforms to analyze and represent functions in the frequency domain, understanding properties such as convolution theorem and inverse Fourier transform.
- Understand Laplace transforms, including their application to elementary functions, properties such as change of scale theorem and shifting theorem, and their use in solving differential equations and convolution problems.

Course Content:

Differential equations (6 Lectures): First Order Differential Equations and IntegratingFactor, Homogeneous Equations with constant coefficients, Wronskian and general solution, Particular Integral. Partial differential equation (Basic idea).

Vector Differentiation (6 Lectures): Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation, Divergence and curl of a vector field, Del and Laplacian operators, Vector identities.

Vector Integration (6 Lectures): Line, surface and volume integrals of Vector fields, Flux of a vector field, Gauss' divergence theorem, Green's and Stokes Theorems and their applications.

Complex Analysis (14 Lectures): Brief Revision of Complex Numbers and their Graphical Representation, Euler's formula, De Moivre's theorem, Roots of Complex Numbers, Functions of Complex Variables, Analyticity and Cauchy-Riemann Conditions, Examples of analytic functions, Singular functions, Integration of a function of a complex variable, Cauchy's Inequality, Cauchy‟s Integral formula, Taylor‟s theorem.

Fourier Series (8 Lectures): Periodic functions, Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only), Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients, Complex representation of Fourier series, Analysis of saw tooth, triangular and square wave form.

Fourier Transforms (10 Lectures): Fourier transform of trigonometric, Gaussian, finite wave train & other functions, Representation of Dirac delta function as a Fourier Integral, Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem.

Laplace Transforms (10 Lectures): Laplace Transform (LT) of Elementary functions, Properties of LTs: Change of Scale Theorem, Shifting Theorem, Dirac Delta function, Periodic Functions, Convolution Theorem. LT of derivatives and integral, Inverse LT and applications of LT.

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. Mathematical Physics, H. K. Dass and Rama Verma, S. Chand & Company Pvt. Ltd.
3. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press.
4. Mathematical Methods for Physicis & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence, 3rd Ed., 2006, Cambridge University Press.
5. Mathematical physics by B.S. Rajput.

III. PHY-MJ-11: PRACTICAL-IV

(Credits: Practical-04) 120 Lectures

Course Objective:

The practical component of this course aims to provide students with hands-on experience in conducting experiments related to thermal physics and properties of materials, reinforcing theoretical concepts learned in lectures and enhancing practical skills in experimental physics.

Learning Outcomes:

- Measure the coefficient of thermal conductivity of copper using Searle's apparatus and understand its significance in heat transfer.
- Determine the coefficient of thermal conductivity of a bad conductor using Lee and Charlton's disc method, illustrating the importance of material properties in heat conduction.
- Use a platinum resistance thermometer (PRT) to measure the temperature coefficient of resistance, demonstrating the relationship between temperature and electrical resistance.
- Investigate the thermo-electric behavior of a thermocouple and study its thermo-emf variation with temperature differences at its junctions.
- Determine the specific heat of a liquid using the method of cooling, understanding heat transfer mechanisms.
- Measure the specific heat of a solid with radiation correction to account for energy losses, enhancing accuracy in heat capacity determination.
- Determine the latent heat of fusion of ice with radiation correction, illustrating phase change phenomena.
- Calibrate a thermocouple and use it to measure unknown temperatures, demonstrating practical temperature measurement techniques.
- Determine the ratio of specific heats of a gas using Clement and Desorme's apparatus, exploring gas thermodynamics.
- Measure the temperature coefficient of resistance of a wire material, illustrating its electrical properties with temperature changes.

List of Practical:

1. Determine the Coefficient of Thermal Conductivity of Cu by Searle‟s Apparatus.
2. Determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton‟s disc method.
3. Determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
4. Study the variation of Thermo-Emf of a Thermocouple with the Difference of Temperature of its Two Junctions.
5. Determine the specific heat of a liquid by the method of cooling.
6. Determine of Specific Heat of Solid with radiation correction.
7. Determine of Latent heat of fusion of ice with radiation correction.
8. Calibrate a thermocouple and determination of unknown temperature.
9. Determine of the Ratio of the Specific Heats of a Gas by Clement and Desorme‟s apparatus.
10. Determine of temperature co-efficient of the resistance of the material of a wire.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,
4. reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, Vani Pub.

IV. PHY-MN-1C: THERMODYNAMICS AND STATISTICAL MECHANICS

(Credits: Theory-03, Practicals-01)

Theory (45 Lectures)

Course Objective:

This course aims to provide students with a thorough understanding of the laws of thermodynamics, kinetic theory of gases, quantum theory of radiation, and statistical mechanics, enabling them to analyze and solve complex thermodynamic problems and phenomena.

Learning Outcomes:

- Understand the fundamental principles of thermodynamics, including the zeroth, first, second, and third laws, and apply them to analyze heat and work interactions, thermodynamic processes, and entropy changes.
- Describe the kinetic theory of gases, including Maxwell-Boltzmann distribution, mean speeds, degrees of freedom, and the law of equipartition of energy, and apply it to calculate specific heats of gases.
- Explain the quantum theory of radiation, including Planck's law of blackbody radiation and its implications for spectral distribution, energy density, and various radiation laws.
- Analyze statistical mechanics concepts such as macrostates, microstates, entropy, and thermodynamic probability, and apply distribution laws like Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac to describe the behavior of gases at different temperature regimes.
- Apply theoretical principles from thermodynamics, kinetic theory, quantum theory, and statistical mechanics to solve problems related to heat, work, radiation, and gas behavior in various physical systems.

Course Content:

Laws of Thermodynamics (15 lectures): Zeroth Law of thermodynamics and concept of temperature. First law of thermodynamics and internal energy. Conversion of heat into work. Various Thermodynamical Processes. Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes. Compressibility and Expansion Coefficient. Reversible and irreversible processes with examples. Second law of thermodynamics and concept of Entropy. Carnot‟s cycle & Carnot theorem. Entropy-temperature diagrams for Carnot‟s cycle. Entropy changes in reversible & irreversible processes. Third law of thermodynamics and Unattainability of absolute zero.

Kinetic Theory of Gases (10 Lectures Lectures): Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy & its applications to specific heat of gases; monoatomic and diatomic gases.

Quantum Theory of Radiation (10 Lectures): Spectral Distribution of Black Body Radiation. Concept of Energy Density. Planck‟s Quantum Postulates. Planck‟s Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien‟s Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien‟s Displacement law from Planck‟s law.

Statistical Mechanics (10 Lectures): Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability. Maxwell-Boltzmann Distribution Law. B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation. Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy.

Reference Books:

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L. Salinger. 1988, Narosa
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.

Practical: 30 Lectures

List of Practical:

1. Measurement of Planck‟s constant using black body radiation and photo-detector.
2. Determine the Planck‟s constant using LEDs of at least 4 different colours.
3. Verify the Stefan`s law of radiation and to determine Stefan‟s constant.
4. Determine the coefficient of thermal conductivity of Cu by Searle‟s Apparatus.
5. Determine the temperature co-efficient of resistance by Platinum resistance thermometer.
6. Study the variation of thermo emf across two junctions of a thermocouple with temperature.
7. Record and analyze the cooling temperature of a hot object as a function of time using a thermocouple.

Reference Books:

1. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New
3. Delhi.
4. A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal, 1985, Vani Publication.

SEMESTER-VI

I. PHY-MJ-12: QUANTUM MECHANICS

(Credits: Theory-04) 60 Lectures

Course Objective:

This course aims to introduce students to the principles and concepts of quantum mechanics, highlighting its departure from classical mechanics and its applications in understanding the behavior of microscopic particles and systems.

Learning Outcomes:

- Understand the inadequacy of classical mechanics in explaining certain phenomena and recognize the need for quantum mechanics.
- Explain key concepts such as Planck's theory of blackbody radiation, the photoelectric effect, Compton scattering, and the De Broglie wavelength.
- Analyze experimental evidence supporting wave-particle duality, including theDavisson-Germer experiment, and understand the implications of the Heisenberg uncertainty principle.
- Describe the postulates of quantum mechanics and properties of wave functions, including normalization, linearity, superposition, and probability interpretation.
- Solve the Schrödinger equation, both time-dependent and time-independent, for various systems including bound states in arbitrary potentials, and apply the solutions to analyze wave packet dynamics and energy eigenvalues.

Course Content:

Introduction to Quantum Mechanics (30 Lectures): Inadequacy of classical mechanics. Planck‟s theory of blackbody radiation. Photo-electric effect and Compton scattering. De-Broglie wavelength and matter waves. Davisson-Germer experiment. Group and Phase velocities and relation between them. Wave-particle duality, Heisenberg uncertaintyprinciple. Consequences of the Uncertainty Principle- The path of an object, Zero Point Energy, The size of an atom, Existence of the electron inside the Nucleus. Postulates of Quantum Mechanics. Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Wave Function of a Free Particle. Normalization. Linearity and Superposition Principles. Eigenfunctions and Eigenvalues. Hermitian Operators. Commuting and Non-Commuting Operators. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum.

Schrodinger equation (15 Lectures): Time dependent Schrodinger equation and dynamical evolution of a quantum state. Time independent Schrodinger equation**.** Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction.

General discussion of bound states in an arbitrary potential (15 Lectures)- Continuity of wavefunction, boundary condition and emergence of discrete energy levels; application to one-dimensional problem- Free particle in a box with rigid wall, Finite potential step, One dimensional square well, Linear harmonic oscillator, Rigid rotator and Hydrogen atom (s-state) ground state.

Reference Books:

1. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
2. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
3. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
4. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
5. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
6. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.

II. PHY-MJ-13: SOLID STATE PHYSICS
(Credits: Theory-04) 60 Lectures

Course Objective:

This course aims to provide students with a comprehensive understanding of the crystal structure of materials, including lattice translation vectors, unit cells, lattice dynamics, magnetic properties, dielectric properties, ferroelectric properties, elementary band theory, and superconductivity, enabling them to analyze the physical properties and behavior of various materials.

Learning Outcomes:

- Understand the difference between amorphous and crystalline materials and describe the crystal lattice structure using lattice translation vectors, unit cells, and Miller indices.
- Explain the principles of diffraction of X-rays by crystals, including Bragg's law, and analyze atomic and geometrical factors influencing diffraction patterns.
- Describe lattice vibrations and phonons in solids, including linear monoatomic and diatomic chains, and analyze Dulong and Petit's law, Einstein and Debye theories of specific heat.
- Explain the magnetic properties of matter, including dia-, para-, ferri-, and ferromagnetic materials, and analyze Langevin's theory, Curie's law, and Weiss's theory of ferromagnetism.
- Describe dielectric properties of materials, including polarization, electric susceptibility, and polarizability, and analyze classical and quantum mechanical theories of electric polarizability.
- Explain ferroelectric properties of materials, including structural phase transitions, piezoelectric effect, pyroelectric effect, and ferroelectric domains.
- Understand elementary band theory, including Kronig Penny model, band gap, conductor, semiconductor, and insulator properties, and analyze conductivity, mobility, and Hall effect in semiconductors.
- Describe superconductivity phenomena, including experimental results, critical temperature, critical magnetic field, and type I and type II superconductors, and analyze London's equation and the Meissner effect.

Course Content:

Crystal Structure (12 Lectures): Solids: Amorphous and Crystalline Materials, Lattice Translation Vectors, Lattice with a Basis – Central and Non-Central Elements, Unit Cell, Miller Indices, Reciprocal Lattice, Types of Lattices, Brillouin Zones, Diffraction of X-rays by Crystals, Bragg‟s Law, Atomic and Geometrical Factor.

Elementary Lattice Dynamics (10 Lectures): Lattice Vibrations and Phonons: Linear Mono-atomic and Diatomic Chains, Acoustic and Optical Phonons, Qualitative description ofthe Phonon Spectrum in Solids, Dulong and Petit‟s Law, Einstein and Debye theories of specific heat of solids, T3 law.

Magnetic Properties of Matter (8 Lectures): Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin Theory of dia– and Paramagnetic Domains, Quantum Mechanical Treatment of Paramagnetism, Curie‟s law, Weiss‟s Theory of Ferromagnetism and Ferromagnetic Domains, Discussion of B-H Curve, Hysteresis and Energy Loss.

Dielectric Properties of Materials (8 Lectures): Polarization, Local Electric Field at an Atom, Depolarization Field, Electric Susceptibility, Polarizability, Clausius Mosotti Equation, Classical Theory of Electric Polarizability, Normal and Anomalous Dispersion, Cauchy and Sellmeir relations, Langevin-Debye equation, Complex Dielectric Constant, Optical Phenomena, Application: Plasma Oscillations, Plasma Frequency, Plasmons, TOmodes.

Ferroelectric Properties of Materials (6 lectures): Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

Elementary Band theory (10 Lectures): Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient.

Superconductivity (6 Lectures): Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London‟s Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Solid State Physics, S. O. Pillai
3. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
5. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India

III. PHY-MJ-14: STATISTICAL MECHANICS

(Credits: Theory-04) 60 Lectures

Course Objective:

This course aims to provide students with a thorough understanding of classical and quantum statistics, including the concepts of macrostate and microstate, ensembles, entropy, distribution laws (Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac), and their applications in describing the behavior of particles in various physical systems.

Learning Outcomes:

- Understand the concepts of macrostate and microstate, ensembles (micro-canonical, canonical, grand canonical), and phase space in classical statistics, and apply them to analyze thermodynamic systems.
- Describe classical statistics distributions such as Maxwell-Boltzmann distribution law, partition function, and Sackur-Tetrode equation, and apply them to analyze the behavior of an ideal gas and specific heat.
- Explain the quantum theory of radiation, including Planck's postulates and laws of blackbody radiation, and analyze spectral distribution laws (Wien's, Rayleigh-Jeans, Stefan-Boltzmann) derived from Planck's law.
- Understand Bose-Einstein statistics, including the Bose-Einstein distribution law, Bose-Einstein condensation, and properties of a strongly degenerate Bose gas, and analyze thermodynamic functions of photon gas.
- Describe Fermi-Dirac statistics, including the Fermi-Dirac distribution law, Fermi energy, and thermodynamic functions of a strongly degenerate Fermi gas, and analyze specific heat of metals, thermionic emission, and Pauli spin paramagnetism.

Course Content:

Classical Statistics (18 Lectures): Macrostate & Microstate, Elementary Concept of Ensemble: micro-canonical, canonical, grand canonical, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox & resolution, Sackur-Tetrode equation, Law of Equipartition of Energy (with proof), Applications to Specific Heat and its Limitations, Saha‟s Ionisation Formula.

Quantum Theory of Radiation (12 Lectures): Spectral Distribution of Black Body Radiation, Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement Law from Planck's law, Applications.

Bose-Einstein Statistics (15 Lectures): B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas, Bose derivation of Planck's law.

Fermi-Dirac Statistics (15 Lectures): Fermi-Dirac Distribution Law, Thermodynamic functions of a strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal,Specific Heat of Metals, Thermionic emission, Photoelectric Emission, Richardson equation, Pauli spin paramagnetism.

Reference Books:

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill.
3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir, 1991, Prentice Hall.
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press.
7. An Introduction to Thermal Physics, Daniel V. Schroeder, Addison-Wesley, Reading, Massachusetts, 2000.

IV. PHY-MJ-15: PRACTICAL-V

(Credits: Practical-04) 120 Lectures

Course Objective:

This practical course aims to provide students with hands-on experience in conducting experiments related to solid-state physics, semiconductor physics, magnetism, dielectric properties, and statistical mechanics. Through these experiments, students will reinforce theoretical concepts learned in lectures and develop practical skills in experimental techniques and data analysis.

Learning Outcomes:

- Estimate the energy gap of a semiconductor using a PN junction and understand the semiconductor properties.
- Determine the magnetic susceptibility of solids and understand their magnetic behavior.
- Determine the coupling coefficient of a piezoelectric crystal and analyze its piezoelectric properties.
- Measure the dielectric constant of dielectric materials with frequency and understand their electrical properties.
- Draw the BH curve of iron using a solenoid and determine energy loss from hysteresis, gaining insights into magnetic hysteresis.
- Study the tunneling effect in a tunnel diode using I-V characteristics and analyze its behavior.
- Perform numerical studies of Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein distribution functions and understand statistical mechanics.
- Estimate metallic specific heat numerically and analyze its dependence on temperature.
- Perform numerical studies of the partition function and its properties, gaining insights into thermodynamic systems.
- Simulate spin systems and understand their behavior in magnetic materials.
- Verify the Stirling approximation for large numbers and understand its applicability in statistical mechanics.

List of Practical:

1. Estimate the energy gap of a semiconductor using a PN junction.
2. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method).
3. Measure the Magnetic susceptibility of Solids.
4. Determine the Coupling Coefficient of a Piezoelectric crystal.
5. Measure the Dielectric Constant of a dielectric Materials with frequency.
6. Draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
7. Determine the Hall coefficient of a semiconductor sample.
8. Study the tunneling effect in tunnel diode using I-V characteristics.
9. Numerical study of Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein distribution functions.
10. Numerical estimates of metallic specific heat.
11. Numerical studies of the Partition function and its properties.
12. Simulating Spin systems.
13. Numerical analysis of Bose gas confined in a harmonic trap.
14. Verification of Stirling approximation for large numbers.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia PublishingHouse.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

Semester-VII

I. PHY-MJ-16: CLASSICAL DYNAMICS

(Credits: Theory-04) 60 Lectures

Course Objective:

This course aims to provide students with a comprehensive understanding of classical mechanics, including Newtonian mechanics, Lagrangian dynamics, Hamiltonian dynamics, variational principles, canonical transformations, and special theory of relativity. Through theoretical lectures, students will develop a strong foundation in classical mechanics principles and their applications to various physical systems.

Learning Outcomes:

- Understand the principles of classical mechanics, including Newton's laws of motion, and their application to the motion of point particles in external electric and magnetic fields.
- Apply Lagrangian dynamics principles, including generalized coordinates, D‟ Alembert‟s Principle, and Lagrange‟s equations, to analyze the motion of simple mechanical systems and particles in electromagnetic fields.
- Apply Hamiltonian dynamics principles, including generalized momentum, conservation theorems, and Hamilton's equations, to analyze the motion of particles in central force fields and electromagnetic fields.
- Understand variational principles, including the calculus of variations, Euler-Lagrange equations, and Hamiltonian principle, and apply them to analyze mechanical systems and determine the path of least action.
- Apply canonical transformations principles, including Legendre transformations and Poisson brackets, to analyze the transformation of coordinates and momenta in phase space.
- Understand the postulates of the special theory of relativity, Lorentz transformations, and their consequences such as length contraction, time dilation, and addition of velocities and its realization in relativistic phenomena.

Course Content:

Classical Mechanics of Point Particles (6 Lectures): Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields.

Lagrangian Dynamics (8 Lectures): Coordinate Systems, Degrees of freedom, Generalized coordinates and velocities, Principle of Virtual work, D‟ Alembert‟s Principle, Hamilton‟s principle and Lagrange‟s equations, Euler- Lagrange equations, Examples of the Euler-Lagrange equations: one- dimensional Simple Harmonic Oscillation and falling body in uniform gravity, Applications to simple systems such as coupled oscillators, Charges particle moving in an Electromagnetic field.

Hamiltonian Dynamics (10 Lectures): Generalized momentum and cyclic coordinates, Conservation Theorems, Hamiltonian‟s equations in Different Coordinate Systems. Examples in Hamiltonian Dynamics: 1-D and 2-D Harmonic Oscillator, Motion of a particle in a central force field, Charged particle moving in an electromagnetic field, Compound Pendulum.

Variational Principles (8 Lectures): The Calculus of Variations and Euler-Lagrange‟s Equations, Hamiltonian Principle from D‟Alembert‟s Principle, Modified Hamiltonian Principle, Lagrange‟s Method of Undetermined Multipliers: Simple Pendulum, Rolling hoop on an inclined Plane. Principle of Least Action.

Canonical Transformations (8 Lectures): Canonical transformations and Legendre Transformations, Generating Functions, Condition for Canonical Transformations, Poisson‟s Brackets, Lagrange Brackets, Invariance of Poisson Bracket.

Special Theory of Relativity (20 Lectures): Postulates of Special Theory of Relativity, Lorentz Transformations, Consequences of Lorentz Transformations: length contraction, Simultaneity, Time dilation, Addition of velocities, Minkowski space, The invariant interval, light cone and world lines, Space- time diagrams, Four-vectors: space-like, time-like and light-like, Examples of Four-vectors: Position Four-vectors, Velocity Four-vectors, Momentum Four-vectors, Acceleration Four-vectors, and Four-force Minkowski force, Doppler Effect from a four-vector perspective, Conservation of Four-momentum, Geometrical Interpretation of Lorentz Transformations, Simultaneity, Length Contraction andTime Dilation.

Reference Books:

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
2. Classical Mechanics, J. C. Uppadhyaya, Himalaya Publising House Pvt. Ltd.
3. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
4. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
5. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
6. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.

II. PHY-MJ-17: ELECTROMAGNETIC THEORY

(Credits: Theory-04) 60 Lectures

Course Objective:

This course aims to equip students with a deep understanding of electromagnetic theory, focusing on Maxwell's equations and their applications in various media. Through theoretical lectures, students will gain proficiency in analyzing electromagnetic wave propagation, polarization phenomena, and the behavior of electromagnetic waves in different materials and structures.

Learning Outcomes:

- Understand the derivation of Maxwell's equations and the significance of displacement current in electromagnetism.
- Analyze the concepts of vector and scalar potentials and apply boundary conditions at interfaces between different media.
- Describe the characteristics of plane electromagnetic waves in unbounded and bounded media.
- Analyze polarization phenomena, including linear, circular, and elliptical polarization, and their applications in optical devices.
- Describe the propagation of electromagnetic waves in waveguides, including planar optical waveguides, and calculate phase and group velocities of guided waves.
- Explain the principles of optical fibers, including numerical aperture, step and graded indices, and differentiate between single and multiple mode fibers.

Course Content:

Maxwell Equations (10 Lectures): Derivation of Maxwell‟s equations, Displacement Current, Vector and Scalar Potentials, Boundary Conditions at Interface between Different Media, Wave Equations, Plane Waves in Dielectric Media, Poynting Theorem and Poynting Vector, Electromagnetic (EM) Energy Density.

EM Wave Propagation in Unbounded Media (10 Lectures): Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth.

EM Wave in Bounded Media (10 Lectures): Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law, Reflection & Transmission coefficients. Total internal reflection, evanescent waves, Metallic reflection (basic idea), surface plasmon resonance and its applications.

Polarization of Electromagnetic Waves (10 Lectures): Description of Linear, Circular, and Elliptical Polarization, Uniaxial and Biaxial Crystals, Light Propagation in Uniaxial Crystal, Double Refraction. Polarization by Double Refraction. Nicol Prism (construction and working), Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly, and Elliptically Polarized Light, Phase Retardation Plates: Quarter-Wave and Half-Wave Plates, Babinet Compensator and its Uses, Analysis of Polarized Light.

Rotatory Polarization (10 Lectures): Optical Rotation, Biot‟s Laws for RotatoryPolarization, Fresnel‟s Theory of optical rotation, Calculation of angle of rotation, Experimental verification of Fresnel‟s theory, Specific rotation.

Wave Guides (6 Lectures): Planar optical wave guides, Planar dielectric wave guide, Condition of continuity at interface, Phase shift on total reflection, Eigenvalue equations, Phase and group velocity of guided waves, Field energy and Power transmission.

Optical Fibres (4 Lectures): Numerical Aperture, Step and Graded Indices, Single and Multiple Mode Fibres (Concept and Definition Only).

Reference Books:

1. Introduction to Electrodynamics, D. J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
3. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
4. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
5. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
6. Optical Electronics, Ajoy Ghatak and K. Tyagrajan, Cambridge University Press.

III. PHY-MJ-18: NUCLEAR & PARTICLE PHYSICS

(Credits: Theory-04) 60 Lectures

Course Objective:

The course on Nuclear Physics aims to provide students with a comprehensive understanding of nuclear forces, reactions, properties of nuclei, radioactivity decay, accelerators and detectors, as well as an introduction to particle physics. Students will gain knowledge about the fundamental principles governing nuclear interactions and the behavior of subatomic particles.

Learning Outcomes:

- Describe different types of nuclear reactions, conservation laws, and the kinematics of reactions, including Q-value and reaction rates.
- Explain the general properties of nuclei, including their constituents, mass, radii, binding energy, and angular momentum.
- Analyze radioactivity decay processes, including alpha, beta, and gamma decay, and apply relevant theories and laws to explain decay phenomena.
- Describe the interaction of particles and radiation with matter and the principles behind various detectors and particle accelerators.
- Explain the fundamental interactions in particle physics, including the quark model of hadrons, conservation laws, and the Standard Model.
- Familiarize with key experiments and theoretical techniques used in particle physics to evaluate cross-sections and decay rates.
- Gain insight into physics beyond the Standard Model and current research areas in particle physics.

Course Content:

Nuclear Forces (5 Lectures): Ground state of Deuteron, Neutron-Proton Scattering at low energies, Proton-Proton Scattering at low energies, Analysis of n-p and p-p scattering, Interpretation of p-p and n-n scattering.

Nuclear Reactions (10 Lectures): Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, Reaction rate, Reaction cross section, Concept of Compound and Direct Reaction, Resonance reaction, Statistical theory of Nuclear reactions, Optical model of nuclear reaction at low energies, Coulomb scattering (Rutherford scattering). Nuclear Fission.Nuclear reactors, Nuclear Fusion, Nuclear Fusion in stars, Fusion reactors.

General Properties of Nuclei (10 Lectures): Scattering of alpha particles, Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

Radioactivity decay (10 Lectures): Nuclear stability and Radioactivity, Activities and half life, Types of radioactivity- (a) Alpha decay: basics of -decay processes, theory of - emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis, (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.

Accelerators and Detectors (10 Lectures): Interaction of particles and radiation with matter. Bethe- Block formula, Cerenkov detector, Ionization chamber and GM counter,Scintillation detectors, Semiconductor detectors, Basic principle of calorimetry for detection of highly energetic particles, Basic acceleration mechanisms and introduction to particle accelerators: cyclotron, linear accelerator, storage rings.

Particle Physics (15 Lectures): Four fundamental interactions. Quantum numbers -- spin, isospin, strangeness, parity, hypercharge, Conservation laws, Particle classification -- hadron and lepton, Quark model of hadron -- baryon and meson, Gell-Mann plot, Elementary discussion of key experiments that led to the current understanding of unified electro-weak interaction and strong interaction, Standard Model, Elementary exposition of diagrammatic techniques (without actual calculation) used to evaluate cross-sections of production processes and decay rates, Introduction to physics beyond the Standard Model.

References:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.
4. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
5. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
6. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).

IV. PHY-MJ-19: PRACTICAL-VI

(Credits: Theory-04) 120 Lectures

Course Objective:

The objective of this course is to provide students with practical experience in conducting experiments to reinforce fundamental principles of physics. Through hands-on activities, students will develop critical thinking skills, problem-solving abilities, and an understanding of experimental techniques commonly used in physics research and industry.

Learning Outcomes:

- Develop proficiency in conducting physics experiments, including equipment operation and data collection.
- Apply theoretical knowledge to practical contexts, enhancing understanding of fundamental principles.
- Analyze experimental data, identifying patterns, trends, and sources of error.
- Enhance critical thinking skills through troubleshooting and interpretation of results.
- Communicate effectively through written reports and oral presentations, conveying experimental procedures, findings, and conclusions.

List of Practical:

1. Measurement of gravitational acceleration using a simple pendulum.
2. Verification of Newton's second law using a dynamics cart and track system.
3. Determination of the coefficient of friction between two surfaces using an inclined plane.
4. Measurement of the magnetic field produced by a current-carrying wire using a Hall probe.
5. Study of electromagnetic induction through Faraday's law using a coil and magnet setup.
6. Investigation of simple harmonic motion using a mass-spring system.
7. Verification of Ampère's law using a solenoid and current-carrying wire.
8. Measurement of the capacitance of a parallel plate capacitor and verification of the relationship between charge, voltage, and capacitance.
9. Measurement of the moment of inertia of irregular objects using a torsion pendulum.
10. Investigation of radioactive decay and determination of decay constants using a Geiger counter and various radioactive sources.
11. Study of projectile motion and its dependence on initial velocity and angle of projection.
12. Measurement of the half-life of a radioactive isotope using a decay curve analysis.
13. Verification of the inverse square law for gamma radiation using a radiation detector at varying distances from a gamma source.
14. Study of particle interactions in a cloud chamber and identification of different types of particles.
15. Determination of the binding energy per nucleon for various nuclei using nuclear reactions and mass spectrometry.

References

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House

2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,
4. reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, Vani Pub.

V. PHY-MN-1D: WAVES AND OPTICS

(Credits: Theory-03) 45 Lectures

Course Objective:

This course aims to provide students with a comprehensive understanding of wave motion and optics, covering topics such as wave types, wave equations, wave optics principles, interference phenomena, and polarization of light. Through theoretical lectures, students will develop a strong foundation in wave mechanics and optical principles essential for further studies in physics and related fields.

Learning Outcomes:

- Understand the characteristics and behavior of plane and spherical waves, including longitudinal and transverse waves, and their propagation properties.
- Apply the wave equation and differential equations to describe wave motion, including the determination of particle and wave velocities and the pressure of longitudinalwaves.
- Understand the electromagnetic nature of light and the principles of wave optics, including wavefront properties, Huygens Principle, and laws of reflection and refraction.
- Analyze interference phenomena, including thin film interference, Newton's rings, and measurement techniques for determining wavelength and refractive index.
- Understand Fresnel and Fraunhofer diffraction principles, including their assumptions, explanations of light propagation, and applications in resolving power and grating analysis.
- Explain polarization phenomena, including Brewster's law, double refraction, and the production and detection of polarized light using various optical elements such as Nicol prisms and retardation plates.

Course Content:

Wave Motion (5 Lectures): Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Travelling) Waves, Wave Equation, Particle and Wave Velocities, Differential Equation, Pressure of a Longitudinal Wave, Energy Transport.

Wave Optics (8 Lectures): Electromagnetic nature of light, Definition and properties of wave front, Huygens Principle, Temporal and Spatial Coherence, Fermat‟s Principle, Lens and Mirror formula, Laws of reflection and refraction, Cardinal points.

Interference (10 Lectures): Division of amplitude and wavefront, Interference in Thin Films, Fringes of equal inclination (Haidinger Fringes), Fringes of equal thickness (Fizeau Fringes), Newton‟s Rings: Measurement of wavelength, Measurement of refractive index.

Fresnel Diffraction (8 Lectures): Fresnel‟s Assumptions, Fresnel‟s Half-Period Zones for Plane Wave, Explanation of Rectilinear Propagation of Light, Theory of a Zone Plate:Multiple Foci of a Zone Plate.

Fraunhofer Diffraction (8 Lectures): Single slit diffraction, Double slit diffraction, Circular aperture and disc diffraction, Resolving Power of a telescope, Rayleigh criterian, Plane transmission grating, Concave grating, Resolving power of grating.

Polarization (6 Lectures): Polarization by reflection, Brewster‟s law, Double refraction, Nicol prism, Retardation plate: λ/2 and λ/4 plates. Production and detection of plane, circular, and elliptically polarized light.

Reference Books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Optics by B. K. Mathur.

Practical (Credit-01) 30 Lectures

1. Determine the value of Cauchy Constants.
2. Determine the Resolving Power of a Prism.
3. Determine wavelength of sodium light using Fresnel Biprism.
4. Determine wavelength of sodium light using Newton‟s Rings.
5. Determine the wavelength of Laser light using Diffraction of Single Slit.
6. Determine wavelength of (1) Sodium source and (2) Spectral lines of the Mercury light using plane diffraction Grating.
7. Determine dispersive power and resolving power of a plane diffraction grating.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

Semester-VIII

I. PHY-MJ-20: SEMINAR AND DISCUSSION
(Credits: Theory-04) 60 Lectures

Course Objectives:

- To enhance students' communication skills through active participation in seminars and group discussions.
- To prepare students for professional and academic settings where effective communication and collaboration are essential.

Course Outcomes:

- Students will be prepared to apply the communication and collaboration skills developed in this course to professional and academic contexts, enhancing their overall employability and academic success.

Course Contents:

The Head of the Department and faculty members will assign topic to the students from the course content of semester VII and VIII. Students will have to work under the supervision of a teacher of the department. Each and every student has to submit electronically typed hardbound dissertation along with the raw data on a week before the examination.

Evaluation Process: Presentation and the report submitted by the students will be evaluated by one external member and one internal member. The External Member may be a Permanent faculty members working in the postgraduate department of the university or othercolleges or Retired Professor/Associate Professor/Assistant Professor of the university.

Distribution of marks:

Dissertation Report	25 marks
Presentation	50 marks
Subject Knowledge	25 marks

II. PHY-AMJ-1: ADVANCED QUANTUM MECHANICS
(Credits: Theory-04) 60 Lectures

Course Objective:

This course aims to develop the advanced understanding about mathematical foundation useful to explain the various quantum phenomena such as scattering, perturbation theory and approximation methods.

Learning Outcomes:

- Understand the advanced mathematical tools applicable to study the quantum phenomena.
- Able to explain the scattering theory and the approximation methods.
- Apply the concept of K-G and Dirac equation for the case of relativistic system.

Course Content:

Mathematical Foundation of Quantum Mechanics (12 Lectures): Vectors and Linear vector space, Closure property, Linear independence of vectors, Bases and dimensions. Some examples of linear vector spaces, Dirac"s notations, Bra and Ket vectors, Combining bras with kets, Inner product and inner product space, Orthonormality of vectors, Completeness condition, Outer product, Hilbert space and the Coordinate Representation, Operator on a linear vector space, Algebra of linear operators.

Angular Momentum (8 Lectures): Commutation relations for angular momentumoperators, Eigenvalues and eigenvectors, Pauli spin matrices and spin eigenvectors, Motion ina centrally symmetric field, Clebsch-Gordon Coefficients. Space-time symmetries and conservation Laws for linear momentum, Angular momentum, Energy and Parity. Electron Spin, Exclusion principle, Symmetric and Antisymmetric Wave Functions, Spin-Orbit Coupling, Total Angular Momentum.

Scattering (10 Lectures): Differential Scattering Cross Section and Total Scattering Cross Section, Formulation of quantum scattering theory, Scattering amplitude, Scattering of a Wave Packet, Green"s function in Scattering theory, Partial wave analysis, Scattering in a Coulomb Field, Optical theorem, Born Approximation, Phase Shifts, Scattering length and effective range for short range potential.

Perturbation Theory (12 Lectures): Time Independent Perturbation Theory (First andSecond order), Degenerate and non-degenerate cases, Stark Effect, Time dependent perturbation theory, Transition Probability, Fermi"s Golden Rule, Constant and Harmonic perturbation.

Other Approximation methods (8 Lectures): Variation methods and its application to Ground State of Hydrogen Atom and First excited state of Harmonic oscillator, WKB approximation.

Relativistic Quantum Mechanics (10 Lectures): Klein-Gordon (K-G) equation, Limitations of K-G equations, Dirac equation and matices, Plain wave solution of Dirac equation, Probability density and current density, Concept of negative energy state of electron.

Reference Books:

1. A Text Book of Quantum Mechanics, Mathews, P.M., &Venkatesan, K., TMH.
2. Quantum Mechanics, Merzbacker, E., John Wiley
3. Quantum Mechanics Messiah, A., North-Holland Publishing Co.
4. Quantum Mechanics Schiff, L.I., Tata McGraw-Hill, 3rd Edition 2010

5. Quantum Mechanics Ghatak, A., Narosa Publishing House, New Delhi.
6. Quantum Mechanics, Agarwal, B. K., PHI
7. Modern Quantum Mechanics, J.J. Sakurai
8. Quantum Mechanics, Landau, L.D. & Lifshitz, E.M., Pergman Press

III. PHY-AMJ-2: ADVANCED ELECTRONICS

(Credits: Theory-04) 60 Lectures

Course Objetive:

This course aims to equip students to use the understanding of semiconductor fundamentals to various analog and digital electronic devices.

Learning Outcomes:

- Understand the properties and behavior of amplifiers and oscillators.
- Able to learn the construction and application of CRO.
- Learn the basic digital circuits and their applications in counters and memory devices.

Course Content:

Coupled Amplifier (8 Lectures): Transformer coupling, push-pull amplifiers, two stage RC-coupled amplifier and its frequency response. Frequency response of amplifier, cutoff frequency.

Feedback in Amplifiers (3 Lectures) Concept of feedback, effects of positive and negative feedback on input impedance, output impedance, gain, stability, distortion and noise.

Oscillators and Network Theorems (10 Lectures): Barkhausen criterion for self-sustained oscillations, Hartley oscillator, Colpitts oscillator, RC phase shift oscillator, multivibrators, crystal oscillator. Network Theorems - Thevenin Theorem, Norton Theorem, MaximumPower Transfer Theorem.

Operational Amplifier (Op-Amp) (10 Lectures) Characteristics of an ideal and a practical op-amp, IC 741, open loop and closed-loop gain, frequency response, differential amplifier, common-mode rejection ratio (CMRR), offset current and voltage, slew rate. Inverting and non-inverting amplifiers, concept of virtual ground and virtual short, adder, differentiator, integrator, active filters, logarithmic amplifier, comparator, zero-crossing detector and Schmitt trigger, Wein bridge oscillator. Multivibrator, Timing IC555

Introduction to Cathode Ray Oscilloscope (CRO) (4 Lectures): Block diagram of CRO, electron gun, deflection and focusing systems, time base, deflection sensitivity, applications of CRO: study of waveforms, measurement of voltage, current, frequency, and phase difference

Integrated Circuit (IC) (4 Lectures): Active passive components, discrete components, wafer, chip, advantages and limitations of ICs, scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only), classification of ICs, examples of linear and digital IC's.

Arithmetic Circuits (4 Lectures): Binary Addition, Binary Subtraction using 2's Complement, Half and Full Adders, Half & Full Subtractors, 4-bit binary Adder/Subtractor.

Sequential Circuits (7 Lectures): SR, D, T, and JK Flip-Flops, Clocked (Level and Edge Triggered) Flip- Flops, Preset and Clear operations, Race-around conditions in JK Flip-Flop. Master-Slave JK Flip-Flop.

Shift registers (4 Lectures): Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel- in-Parallel-out Shift Registers (only up to 4 bits).

Counters (4 Lectures): Ring Counter, Asynchronous counters, Decade Counter, Synchronous Counter (only up to 4 bits).

Memory Devices (2 Lectures): ROM, RAM, CMOS, NMOS

Reference Books:

1. Boylestad R. L. and Nashelsky L., Electronic Devices and Circuit Theory, Pearson.
2. Raychaudhuri Barun, Electronics: Analog and Digital, Cambridge University Press.
3. Cathey J. J., Schaum‟s Outline of Theory and Problems of Electronic Devices and Circuits, McGraw-Hill.
4. Helfrick A. D. and Cooper W. D., Modern Electronic Instrumentation and Measurement Techniques, PHI.
5. Malvino A. P. and Bates D. J., Electronic Principles, McGraw-Hill Education.
6. Millman J. and Halkias C. C., Integrated Electronics: Analog and Digital Circuits and Systems, McGraw-Hill, Inc.
7. Streetman B. G. and Banerjee S.K., Solid State Electronic Devices, PHI.
8. Gayakwad R. A., Op-Amps and Linear Integrated Circuits, Pearson.

IV. PHY-AMJ-3: PRACTICAL-VII
(Credits: Theory-04) 120 Lectures

Course Objective:

This practical course aims to provide students with hands-on experience in experimenting with electronic and optical devices.

Learning Outcomes:

- Able to construct (Gates) and verify different electronic devices (Gates and Flip-flops).
- To get expertise in use of different function generators and to study digital signal processing, Surface Plasmon resonance, Electron spin resonance, and measurement of dielectric constant.

List of Practical:

1. Construction of half and full adder using XOR and NAND gates and verification of its operation.
2. Verify the truth table of RS, JK, T and D flip-flops using NAND and NOR gates.
3. Analyze Function generator using operational amplifier (sine, triangular and square wave).
4. Study voltage regulator using operational amplifier to produce output of 12V with maximum load current of 50mA.
5. Study general digital signal processing (DSP) functions, Transform functions, Filter functions, Compression methods and to design DSP.
6. Find the numerical aperture of a given optical fibre and hence to find its acceptance angle.
7. Calculate the beam divergence and spot size of the given laser beam.
8. Determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR).
9. Determine the refractive index of a dielectric layer using Surface Plasmon resonance (SPR).
10. Study of Electron spin resonance (ESR)- determine magnetic field as a function of the resonance frequency.
11. Study of Zeeman effect: with external magnetic field; Hyperfine splitting.
12. Measure the Dielectric Constant of a dielectric Materials with frequency.
13. Study Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
14. Determine Energy Band Gap of Semiconductor.
15. Study the effect of X-ray tube voltage and current on the spectra.
16. Estimation of Precise Lattice Parameter of Cubic Crystals.

References

1. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
2. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson.
3. B. D. Cullity, Elements of X-Ray Diffraction, Addison-Wesley, 1978.
4. Concepts of Modern physics by Sir Arthur Beiser.
5. Optical Electronics, Ajoy Ghatak and Tyagrajan.
6. Analog Methods, Karplus, W. J., and Soroka, W. W., McGraw-Hill, New York, 1959.

7. O. Pluchery, R. Vayron and K.-M. Van. “Laboratory experiments for exploring the surface plasmon resonance”(2011).
8. Andrew E.R. "Nuclear Magnetic Resonance", Cambridge University Press, (1955).
9. A. C. Melissions, „Experiments in Modern Physics‟, Academic Press, N.Y. (1996).

V. PHY-RC-1: RESEARCH METHODOLOGY
(Credits: Theory-04) 60 Lectures

Course Objective:

This course aims to inculcate research aptitude among the learners and equip them with knowledge and skills required to successfully undertake various steps in the research process.

Learning Outcomes:

- Able to analyze research concepts, its types and steps in the research process.
- Identify the appropriate research problems and approach to solve them.
- Recognize various techniques of data analysis and interpretation, and learn different mathematical modeling.
- Develop the sense of ethics in research process.
- Able to prepare a complete research report in appropriate format and searching of reputed journals for publishing their articles/reports.

Course Content:

What Scientists Actually Do (10 Lectures): Forming scientific questions, Proposing and testing hypotheses, Proposing postulates, Measuring the value of a parameter or a constant, Establishing a functional relationship, Developing a mathematical model, Seeking something new by observation or experiment, Putting it together, Forming a Hypothesis, the requirements for a hypothesis to be scientific, Null and alternative hypothesis, Testing of hypothesis.

Statistical Data Analysis (15 Lectures): Sampling, Analysis of the sampled data, Distribution of the data, Measurement and Confidence Intervals, Measurement of a value, Experimental error analysis, Measurement of a proportion, Propagation of errors.

Mathematical Modeling of Physical Systems (7 Lectures): Models built from first principles, Dimensional consistency, Modeling using dimensional analysis,Phenomenological models, Examples.

Ethical Conduct in Science (8 Lectures): Elements of scientific ethics, Research misconduct, Maintenance of research data, Dissemination of research results, Ethical issues related to authorship, Openness in research, Copyright issues, Unethical publishing practices, Ethics in reviewing, Citation and impact of a paper, Environmental safety and experiments with living organisms, Cases of scientific misconduct.

Scientific Database and Scientific Publications (4 Lectures): UGC Care, Scopus, Google Scholar, Web of Science, Science Citation Index (SCI), Orchid, Archives. Types of Publications: Articles, Books, Journals, Archives, Conference Papers, Theses, Patents, Journal Impact: Journal citation reports, SCImago Journal Rank (SJR), Citescore, Source Normalized Impact per Paper (SNIP), h-index.

The Art of Scientific Communication (8 Lectures): Before you start writing, Title, Abstract, The body of the paper, Methodology (Experiments, Theoretical and Simulation) Figures, Conclusion, Acknowledgement, References, Citing references, Revising the manuscript, Writing a thesis, Text stylistics.

Presentation in Seminars and Conferences (8 Lectures): The art of preparing visual presentation material, The art of delivering a talk at a conference, Poster presentation, Preparing the poster, Presenting a poster.

Reference Books:

1. Soumitro Banerjee, Research Methodology for Natural Sciences, IISc Press, 2022.
2. Research Methodology- C. R. Kothari

VI. PHY-RC-2: RESEARCH PROJECT OR DISSERTATION
Credits: 8

Note: Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year.

Course Objectives:

The objectives of the course is to facilitate students to carry out extensive research and develop as self-guided learning and analytical skills through problem and gap identification, development of research methodology, interpretation of findings and presentation of results.

Learning Outcomes: After completion of the course, the learners will be able to:

- Gain in-dept knowledge in the major field of study.
- Design and justify research methodology.
- Utilize appropriate research methodology for data collection
- Analyze the collected data and draws conclusions accordingly.

Course Contents:

The HOD of the department has to allot supervisor to the students from among the faculty members who have PhD degree. After that the students have to select a research problem with the help of the supervisor and they have to submit a summary or research proposal to the department. Thereafter, the HOD of the department will organize a meeting of the Departmental Committee and after the presentation of the student the committee will approve or reject his/her synopsis/research proposal. Students will start their research work after getting approval from the departmental committee.

At the end of the semester the student has to submit the project dissertation to the department and that will be evaluated by the following members:

(i) HOD of the Department–Chairmen

(ii) HOD, University Department/ Nominated Faculty - External member

(ii) Faculty members of the department – Internal member

External members may be any of the following:

1. Permanent professors working in the postgraduate department of the university or other colleges who have the qualification to become PhD supervisors.

OR

2. Retired Professor/Associate Professor/Assistant Professor of the university who has been supervise PhD scholar.

OR

3. Professor/Associate Professor/Assistant Professor of the outside university who has been supervise PhD scholar.

Note- The project dissertation will be evaluated under the following heads:

- Motivation for the choice of topic
- Project dissertation design
- Methodology and Content depth

- Results and Discussion
- Future Scope & References
- Participation in Internship programme with reputed organization
- Application of Research technique in Data collection
- Report Presentation
- Presentation style Broad

Guidelines for distribution of marks may be as follows or as appropriate:

Assessment of project synopsis	75 marks
Assessment of project Thesis	100 marks
Viva-voce	25 marks