Subject: Physics
Semester: I
Course Name: Mechanics (Theory)
Course Level: PHY-C-01
Credit: 03

Course Objective

This course introduces mathematical physics and mechanics. The basic objectives of the course are

- to introduce essential primary concepts in mathematical physics such as calculus of vectors, curvilinear coordinates and Dirac delta function which are required for developing insight of the theories of physics,
- to introduce the concepts of dynamics of particles, energy, oscillation and basic properties of matter which will equip students with the tools required for applying the concepts of physics in practical problems and

Learning outcome

On successful completion of the course, students will be able to understand the calculus of vectors and concept of curved spaces which play central roles in developing insight of the theories of physics. They will learn the powerful method of computation through Dirac delta function which often appears in complex problems of physics. Students will be able to understand and apply the concepts of dynamics of particles, energy, oscillation and basic properties of matter in various problems of physics, technology and engineering.

Part A: Mathematical Physics

Unit I- Vector Calculus

Scalar and vector fields. Derivatives of vector functions (physical examples-velocity, centripetal acceleration of a point in circular motion). Directional derivative. Gradient of a scalar field (example of Newton's gravitational force as gradient of a scalar potential). Gradient as normal vector to a surface. Divergence and curl of a vector field- solenoidal and irrotational vector fields. Laplacian operator (physical problems –Laplacian of gravitational potential, divergence of central force). Vector identities.

Unit– II: Curvilinear coordinates

Introduction to curvilinear coordinates. Orthogonal curvilinear coordinates. Examples of spherical, cylindrical and plane polar coordinates.

Part B – Mechanics

Unit 1- Reference frames

Inertial frames. Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications.

Unit –II: Gravitation and central force motion

Motion under central force. Two-body problem and its reduction to one body problem. Kepler's laws, Gravitational potential and fields due to spherical body. Gauss's law and Poisson's equation for gravitational field.

Unit –III: Conservation laws

Dynamics of a system of particles. Centre of mass. Principle of conservation of momentum. Torque. Impulse. Elastic and inelastic collisions between particles. Centre of mass and laboratory frames.

Unit–IV: Dynamics of rigid bodies

Rigid body motion. Rotational motion. Moment of inertia of rectangular lamina, disc, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Unit–V: Work and energy

Work and kinetic energy theorem. Conservative and non-conservative forces. Potential energy. Force as gradient of potential energy. Work and potential energy. Work done by non-conservative forces.

Unit –VI: Oscillations

Oscillation - differential equation of simple harmonic motion and its solution. Total energy of oscillation.

Unit –VII: Properties of matter

Relation between elastic constants. Twisting torque on a cylinder or wire. Cantilever. Kinematics of moving fluids: Poiseuille's equation for flow of a liquid through a capillary tube.

Reading list

1. Essential Mathematical Methods for the Physical Sciences; K.F. Riley and M.P. Hobson, Cambridge University Press.
2. Advanced Engineering Mathematics; E. Kreyszic, John Wiley & Sons (New York).
3. Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.
4. Mathematical Physics-I, K. K Pathak and S. Parasher, Vishal Publication, Jalandhar (Delhi).
5. Theoretical Mechanics, M. R. Spiegel, Tata McGraw Hill.
6. Mechanics; D. S. Mathur, S. Chand & Company Limited.

7. An Introduction to Mechanics, D. Kleppner and R. J. Kolenkow, Tata McGraw-Hill.
8. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al., Tata McGraw-Hill.
9. Physics, R. Resnick, D. Halliday and J. Walker, John Wiley & Sons.

Subject: Physics
Semester: I
Course Name: Mechanics (Practical)
Course Level: PHY-C-01
Credit: **0**1

Course Objective:

This course introduces mathematical physics and mechanics. The basic objectives of the course are

- ➢ To train the students with concept visualisation of dynamics of particles, energy, oscillation and basic properties of matter through some laboratory practices.

Learning outcome:

On successful completion of the course, students will be able to understand and apply the concepts of dynamics of particles, energy, oscillation and basic properties of matter in various problems of physics, technology and engineering. They will be trained in concept realisation through the laboratory practices.

Contents:

<u>At least four from the following:</u>

1. To study the motion of spring and calculate (a) spring constant and (b) rigidity modulus.2.
2. To determine the moment of inertia of a cylinder about two different axes of symmetry by torsional oscillation method.
3. To determine coefficient of viscosity of water by capillary flow method (Poiseuille's method).
4. To determine the Young's modulus of the material of a wire by Searle's apparatus.
5. To determine the modulus of rigidity of a wire (static method).
6. To determine the value of g using bar pendulum.
7. To determine the value of g using Kater's pendulum.

Reading list

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2. Advanced Engineering Mathematics; E. Kreyszic, John Wiley & Sons (New York).
3. Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.
4. Mathematical Physics-I, K. K Pathak and S. Parasher, Vishal Publication, Jalandhar (Delhi).
5. Theoretical Mechanics, M. R. Spiegel, Tata McGraw Hill.
6. Mechanics; D. S. Mathur, S. Chand & Company Limited.
7. An Introduction to Mechanics, D. Kleppner and R. J. Kolenkow, Tata McGraw-Hill.
8. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al., Tata McGraw-Hill.
9. Physics, R. Resnick, D. Halliday and J. Walker, John Wiley & Sons.

Subject: Physics
Semester: I
Course Name: Mechanics (Theory)
Course Level: PHY-M-01
Credit: 03

Course Objective

This course introduces mathematical physics and mechanics. The basic objectives of the course are

- to introduce essential primary concepts in mathematical physics such as calculus of vectors, curvilinear coordinates and Dirac delta function which are required for developing insight of the theories of physics,
- to introduce the concepts of dynamics of particles, energy, oscillation and basic properties of matter which will equip students with the tools required for applying the concepts of physics in practical problems and

Learning outcome

On successful completion of the course, students will be able to understand the calculus of vectors and concept of curved spaces which play central roles in developing insight of the theories of physics. They will learn the powerful method of computation through Dirac delta function which often appears in complex problems of physics. Students will be able to understand and apply the concepts of dynamics of particles, energy, oscillation and basic properties of matter in various problems of physics, technology and engineering.

Part A: Mathematical Physics

Unit I- Vector Calculus

Scalar and vector fields. Derivatives of vector functions (physical examples-velocity, centripetal acceleration of a point in circular motion). Directional derivative. Gradient of a scalar field (example of Newton's gravitational force as gradient of a scalar potential). Gradient as normal vector to a surface. Divergence and curl of a vector field- solenoidal and irrotational vector fields. Laplacian operator (physical problems –Laplacian of gravitational potential, divergence of central force). Vector identities.

Unit– II: Curvilinear coordinates

Introduction to curvilinear coordinates. Orthogonal curvilinear coordinates. Examples of spherical, cylindrical and plane polar coordinates.

Part B – Mechanics

Unit 1- Reference frames

Inertial frames. Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications.

Unit –II: Gravitation and central force motion

Motion under central force. Two-body problem and its reduction to one body problem. Kepler's laws, Gravitational potential and fields due to spherical body. Gauss's law and Poisson's equation for gravitational field.

Unit –III: Conservation laws

Dynamics of a system of particles. Centre of mass. Principle of conservation of momentum. Torque. Impulse. Elastic and inelastic collisions between particles. Centre of mass and laboratory frames.

Unit–IV: Dynamics of rigid bodies

Rigid body motion. Rotational motion. Moment of inertia of rectangular lamina, disc, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Unit–V: Work and energy

Work and kinetic energy theorem. Conservative and non-conservative forces. Potential energy. Force as gradient of potential energy. Work and potential energy. Work done by non-conservative forces.

Unit –VI: Oscillations

Oscillation - differential equation of simple harmonic motion and its solution. Total energy of oscillation.

Unit –VII: Properties of matter

Relation between elastic constants. Twisting torque on a cylinder or wire. Cantilever. Kinematics of moving fluids: Poiseuille's equation for flow of a liquid through a capillary tube.

Reading list

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4. Mathematical Physics-I, K. K Pathak and S. Parasher, Vishal Publication, Jalandhar (Delhi).
5. Theoretical Mechanics, M. R. Spiegel, Tata McGraw Hill.
6. Mechanics; D. S. Mathur, S. Chand & Company Limited.

7. An Introduction to Mechanics, D. Kleppner and R. J. Kolenkow, Tata McGraw-Hill.
8. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al., Tata McGraw-Hill.
9. Physics, R. Resnick, D. Halliday and J. Walker, John Wiley & Sons.

Subject: Physics
Semester: I
Course Name: Mechanics (Practical)
Course Level: PHY-M-01
Credit: 1

Course Objective

This course introduces mathematical physics and mechanics. The basic objectives of the course are

- ➢ to train the students with concept visualisation of dynamics of particles, energy, oscillation and basic properties of matter through some laboratory practices.

Learning outcome:

On successful completion of the course, students will be able to understand and apply the concepts of dynamics of particles, energy, oscillation and basic properties of matter in various problems of physics, technology and engineering. They will be trained in concept realisation through the laboratory practices.

Contents:

At least four from the following:

1. To study the motion of spring and calculate (a) spring constant and (b) rigidity modulus.
2. To determine the moment of inertia of a cylinder about two different axes of symmetry by torsional oscillation method.
3. To determine coefficient of viscosity of water by capillary flow method (Poiseuille's method).
4. To determine the Young's modulus of the material of a wire by Searle's apparatus.
5. To determine the modulus of rigidity of a wire (static method).
6. To determine the value of g using bar pendulum.
7. To determine the value of g using Kater's pendulum.

Reading list

1. Essential Mathematical Methods for the Physical Sciences; K.F. Riley and M.P. Hobson, Cambridge University Press.
2. Advanced Engineering Mathematics; E. Kreyszic, John Wiley & Sons (New York).
3. Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.
4. Mathematical Physics-I, K. K Pathak and S. Parasher, Vishal Publication, Jalandhar (Delhi).
5. Theoretical Mechanics, M. R. Spiegel, Tata McGraw Hill.
6. Mechanics; D. S. Mathur, S. Chand & Company Limited.
7. An Introduction to Mechanics, D. Kleppner and R. J. Kolenkow, Tata McGraw-Hill.
8. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al., Tata McGraw-Hill.

Physics, R. Resnick, D. Halliday and John

Subject: Physics

Semester: II

Course Name: Electricity and Magnetism (Theory)

Course Level: PHY-C-02

Credit: 03

Course Objective

- ➢ To introduce the methods of solving differential equations.
- ➢ To introduce various concepts of matrix algebra.
- ➢ Electric field from vector calculus point of view and use of potential formulation to solve electrostatic problems.
- ➢ Magnetic fields of current carrying conductors, torus, solenoids etc. Study magnetic properties of matter.
- ➢ Study and analysis of AC circuits like LCR, and use of network theorems in electrical circuits.

Learning outcome

After the successful completion of the course, students will be able to understand methods of solving various differential equations appearing in physics. It will give an idea of how to study evolution of a physical system. Through matrix algebra students will be able to compute various matrix operations which are required for solving physical problems. They will be able to understand electric field and magnetic fields in matter, dielectric properties of matter, magnetic properties of matter, application of Kirchhoff's law in different circuits, and application of network theorem in different circuits. The students will also get accustomed to using multimeters and potentiometers, and they will be able to determine some of the important physical quantities related to electricity and magnetism for a better understanding of the topic.

Part A: Mathematical Physics (Theory)

Unit 1:

Differential equations: First and second order ordinary differential equations (ODE). Homogeneous and inhomogeneous differential equations. Solutions of first order ODE – integrating factors (physical examples – radioactive decay, Newton's law of cooling, particle falling under gravity through a resistive medium). Concept of initial/boundary conditions. Solutions of second order ODE with constant coefficients - complementary function and particular integral (physical examples- simple harmonic oscillation, forced vibration). Wronskian- definition and its use to check linear independence of 2nd order homogeneous linear differential equation.

Unit– II:

Matrices: Properties of matrices. Determinant and rank. Transpose and complex conjugate of matrices. Hermitian and anti-Hermitian matrices. Unitary and orthogonal matrices. Representation of linear homogeneous and inhomogeneous equations through matrix equation. Inverse of a matrix. Eigen values and eigen-vectors. Cayley- Hamilton Theorem (statement only), Diagonalization of simple matrices.

Part B – Electricity and Magnetism (Theory)

Unit I:

Electric field and electric potential: Electrostatic field, electric flux. Gauss's law. Application of Gauss's law to charge distributions with planar, spherical and cylindrical symmetries. Conservative nature of electrostatic field. Electrostatic potential. Electrostatic energy of a system of charges. Electrostatic boundary conditions. Laplace's and Poisson's equations. Uniqueness theorem. Application of Laplace's equation involving planar, spherical and cylindrical symmetries. Potential and electric field of a dipole. Force and torque on a dipole. Capacitance of a system of charged conductors. Parallel plate capacitor. Capacitance on an isolated conductor.

Unit –II:

Dielectric properties of matter: Electric field in matter. Polarisation, polarisation charges. Electrical susceptibility and dielectric constant. Capacitor (parallel plate, spherical and cylindrical) filled with dielectric. Displacement vector, $\vec{D}$. Relation between $\vec{E}$, $\vec{P}$ and $\vec{D}$. Gauss's law in dielectrics.

Unit –III:

Magnetic field : Magnetic force on a point charge, definition and properties of magnetic field $\vec{B}$. Curl and divergence. Vector potential, $\vec{A}$. Magnetic scaler potential. Magnetic force on (i) a current carrying wire and (ii) between two elements. Torque on a current loop in a uniform magnetic field. Biot- Savart's law and its simple application: straight wire and circular loop. Current loop as a magnetic dipole and its dipole moment (analogy with electric dipole). Ampere's circuital law and its application to (i) solenoid and (ii) torus.

Unit–IV:

Magnetic properties of matter: Magnetization vector, $\vec{M}$. Magnetic intensity, $\vec{H}$. Magnetic susceptibility and permeability. Relation between $\vec{B}$, $\vec{H}$ and $\vec{M}$. Ferromagnetism. B-H curve and hysteresis.

Unit–V:

Electrical circuits: AC circuits: Kirchhoff's laws for AC circuits. Complex reactance and inductance. Series LCR circuits and parallel LCR circuits: (i) phasor diagram, (ii) resonance, (iii) power dissipation, (iv) quality factor, and (v) band width. Ideal constant-voltage and constant-current sources. Thevenin theorem and Norton theorem (only statements and solving of related problems).

Reading list

1. Essential Mathematical Methods for the Physical Sciences; K. F. Riley and M. P. Hobson, Cambridge University Press.
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5. Mathematical Physics-I; Krishna K. Pathak and Sangeeta Prasher, Vishal Publishing Co, Jalalandhar (Delhi).
6. Introduction to Electrodynamics, D. J. Griffiths.
7. Electricity and Magnetism [With electromagnetic theory and special theory of relativity], D. Chattopadhyay and P. C. Rakshit, 2013, New Central Book Agency (P) Limited.
8. Electricity, Magnetism and Electromagnetic Theory, S. Mahajan and S. R. Choudhury, 2012, Tata Mcgraw.
9. Schaum's outline of Theory and Problems of Electromagnetics, J. A. Edminister.
10. Electromagnetics, B. B. Laud, New Age International Publishers.

Subject: Physics

Semester: II

Course Name: Electricity and Magnetism (Practical)

Course Level: PHY-C-02

Credit: 01

Course Objective

➢ Electric field from vector calculus point of view and use of potential formulation to solve electrostatic problems.

➢ Magnetic fields of current carrying conductors, torus, solenoids etc. Study magnetic properties of matter.

➢ Study and analysis of AC circuits like LCR in electrical circuits.

Learning outcome

After the successful completion of the course, the students will get accustomed to using multimeters and potentiometers, and they will be able to determine some of the important physical quantities related to electricity and magnetism for a better understanding of the topic.

Content:

At least four from the following:

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De' Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB).dx
7. To verify the Thevenin and Norton Theorems.
8. To verify the superposition and maximum power transfer theorems.
9. To determine the self-inductance of a coil by Anderson's bridge.

<u>Reading list:</u>

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Hobson, Cambridge University Press.
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4. Mathematical Physics, H. K. Dass and Dr. Rama Verma, S. Chand Publication.
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9. Schaum's outline of Theory and Problems of Electromagnetics, J. A. Edminister.
10. Electromagnetics, B. B. Laud, New Age International Publishers.

Subject: Physics

Semester: II

Course Name: Electricity and Magnetism (Theory)

Course Level: PHY-M-02

Credit: 03

Course Objective

- ➢ To introduce the methods of solving differential equations.
- ➢ To introduce various concepts of matrix algebra.
- ➢ Electric field from vector calculus point of view and use of potential formulation to solve electrostatic problems.
- ➢ Magnetic fields of current carrying conductors, torus, solenoids etc. Study magnetic properties of matter.
- ➢ Study and analysis of AC circuits like LCR, and use of network theorems in electrical circuits.

Learning outcome

After the successful completion of the course, students will be able to understand methods of solving various differential equations appearing in physics. It will give an idea of how to study evolution of a physical system. Through matrix algebra students will be able to compute various matrix operations which are required for solving physical problems. They will be able to understand electric field and magnetic fields in matter, dielectric properties of matter, magnetic properties of matter, application of Kirchhoff's law in different circuits, and application of network theorem in different circuits. The students will also get accustomed to using multimeters and potentiometers, and they will be able to determine some of the important physical quantities related to electricity and magnetism for a better understanding of the topic.

Part A: Mathematical Physics (Theory)

Unit 1:

Differential equations: First and second order ordinary differential equations (ODE). Homogeneous and inhomogeneous differential equations. Solutions of first order ODE – integrating factors (physical examples – radioactive decay, Newton's law of cooling, particle falling under gravity through a resistive medium). Concept of initial/boundary conditions. Solutions of second order ODE with constant coefficients - complementary function and particular integral (physical examples- simple harmonic oscillation, forced vibration). Wronskian- definition and its use to check linear independence of 2nd order homogeneous linear differential equation.

Unit– II:

Matrices: Properties of matrices. Determinant and rank. Transpose and complex conjugate of matrices. Hermitian and anti-Hermitian matrices. Unitary and orthogonal matrices. Representation of linear homogeneous and inhomogeneous equations through matrix equation. Inverse of a matrix. Eigen values and eigen-vectors. Cayley- Hamilton Theorem (statement only), Diagonalization of simple matrices.

Part B – Electricity and Magnetism (Theory)

Unit I:

Electric field and electric potential: Electrostatic field, electric flux. Gauss's law. Application of Gauss's law to charge distributions with planar, spherical and cylindrical symmetries. Conservative nature of electrostatic field. Electrostatic potential. Electrostatic energy of a system of charges. Electrostatic boundary conditions. Laplace's and Poisson's equations. Uniqueness theorem. Application of Laplace's equation involving planar, spherical and cylindrical symmetries. Potential and electric field of a dipole. Force and torque on a dipole. Capacitance of a system of charged conductors. Parallel plate capacitor. Capacitance on an isolated conductor.

Unit –II:

Dielectric properties of matter: Electric field in matter. Polarisation, polarisation charges. Electrical susceptibility and dielectric constant. Capacitor (parallel plate, spherical and cylindrical) filled with dielectric. Displacement vector, $\vec{D}$. Relation between $\vec{E}$, $\vec{P}$ and $\vec{D}$. Gauss's law in dielectrics.

Unit –III:

Magnetic field : Magnetic force on a point charge, definition and properties of magnetic field $\vec{B}$. Curl and divergence. Vector potential, $\vec{A}$. Magnetic scaler potential. Magnetic force on (i) a current carrying wire and (ii) between two elements. Torque on a current loop in a uniform magnetic field. Biot- Savart's law and its simple application: straight wire and circular loop. Current loop as a magnetic dipole and its dipole moment (analogy with electric dipole). Ampere's circuital law and its application to (i) solenoid and (ii) torus.

Unit–IV:

Magnetic properties of matter: Magnetization vector, $\vec{M}$. Magnetic intensity, $\vec{H}$. Magnetic susceptibility and permeability. Relation between $\vec{B}$, $\vec{H}$ and $\vec{M}$. Ferromagnetism. B-H curve and hysteresis.

Unit–V:

Electrical circuits: AC circuits: Kirchhoff's laws for AC circuits. Complex reactance and inductance. Series LCR circuits and parallel LCR circuits: (i) phasor diagram, (ii) resonance, (iii) power dissipation, (iv) quality factor, and (v) band width. Ideal constant-voltage and constant-current sources. Thevenin theorem and Norton theorem (only statements and solving of related problems).

Reading list

1. Essential Mathematical Methods for the Physical Sciences; K. F. Riley and M. P. Hobson, Cambridge University Press.
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8. Electricity, Magnetism and Electromagnetic Theory, S. Mahajan and S. R. Choudhury, 2012, Tata Mcgraw.
9. Schaum's outline of Theory and Problems of Electromagnetics, J. A. Edminister.
10. Electromagnetics, B. B. Laud, New Age International Publishers.

Subject: Physics

Semester: II

Course Name: Electricity and Magnetism (Practical))

Course Level: PHY-M-02

Credit: 01

Course Objective

➢ Electric field from vector calculus point of view and use of potential formulation to solve electrostatic problems.

➢ Magnetic fields of current carrying conductors, torus, solenoids etc. Study magnetic properties of matter.

➢ Study and analysis of AC circuits like LCR in electrical circuits.

Learning outcome

After the successful completion of the course, the students will get accustomed to using multimeters and potentiometers, and they will be able to determine some of the important physical quantities related to electricity and magnetism for a better understanding of the topic.

Content:

At least four from the following:

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De' Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB).dx
7. To verify the Thevenin and Norton Theorems.
8. To verify the superposition and maximum power transfer theorems.
9. To determine the self-inductance of a coil by Anderson's bridge.

Reading list:

1. Essential Mathematical Methods for the Physical Sciences; K. F. Riley and M. P. Hobson, Cambridge University Press.
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3. Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier
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5. Mathematical Physics-I; Krishna K. Pathak and Sangeeta Prasher, Vishal Publishing Co, Jalalandhar (Delhi).
6. Introduction to Electrodynamics, D. J. Griffiths.
7. Electricity and Magnetism [With electromagnetic theory and special theory of relativity], D. Chattopadhyay and P. C. Rakshit, 2013, New Central Book Agency (P) Limited.
8. Electricity, Magnetism and Electromagnetic Theory, S. Mahajan and S. R. Choudhury, 2012, Tata Mcgraw.
9. Schaum's outline of Theory and Problems of Electromagnetics, J. A. Edminister.
10. Electromagnetics, B. B. Laud, New Age International Publishers.

Subject: Physics

Semester: III

Course Name: Waves and Optics (Theory)

Course Level: PHY-C-03

Credit: 03

Course Objective

➢ To learn the superposition of harmonic waves and oscillations, different types of wave motions, formation of standing waves and velocity of waves in media.
➢ To learn optical phenomena such as interference, diffraction and polarization in terms of the wave model
➢ To learn the principles and applications of optical instruments like biprism, interferometer and diffraction grating etc.

Learning outcome:

On successful completion of the course students will:

1. understand Simple Harmonic Oscillation and superposition principle.
2. understand the classical wave equation in transvers and longitudinal waves and solutions of few physical systems on its basis.
3. understand the concept of normal modes in transvers and longitudinal waves
4. understand the interference as superposition of waves from coherent sources and also understand the basic principle of Young's double slit experiment, Fresnel’s Biprism, Newton’s Rings, Michelson interferometer etc.
5. understand the basic concept of diffraction, Fresnel and Fraunhofer diffraction from a slit.
6. understand the concept of polarisation of light, the production and detection of polarized light.
7. understand working principle of prism, biprism, spectrometer, Newton’s ring apparatus, grating, CRO, sodium and mercury light sources etc.

Wave and Optics (Theory)

Unit I:

Superposition of harmonic oscillations: Superposition of waves: Linearity and Superposition principle, Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats), Lissajous figures and their use.

Unit– II:

Wave motion: Waves: Progressive (Travelling) Waves, wave equation, plane wave and spherical wave, Longitudinal and Transverse Waves, dispersion, group velocity, phase velocity, Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave.

Unit –III:

Velocity of waves: Velocity of Transverse Vibrations of Stretched Strings, Velocity of Longitudinal Waves in a Fluid in a Pipe, Newton's Formula for Velocity of Sound, Laplace's Correction.

Unit–IV:

Superposition of Two Harmonic Waves: Superposition of 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.

Unit–V:

Wave optics: Electromagnetic nature of light, definition and properties of wave front, Huygens principle, Temporal and Spatial coherence.

Unit–VI:

Interference: Division of wave front and amplitude, intensity distribution in an interference pattern, Young's double slit experiment, Fresnel's Biprism. Phase change on reflection: Stokes' treatment, Interference in Thin Films: parallel and wedge- shaped films, Newton's Rings: Measurement of wavelength and refractive index, Michelson interferometer.

Unit–VII:

Diffraction: Fresnel and Fraunhofer diffraction, Fresnel's Half-Period Zones for Plane Wave, Fresnel diffraction pattern of a straight edge and at a circular aperture, Fraunhofer diffraction: Single slit, Double slit, Diffraction grating, Resolving power of grating.

Unit–VIII:

Polarization: Polarized light and its mathematical representation, Production of polarized light by reflection, refraction and scattering, Polarization by double refraction and Huygen's theory, Nicol prism, Production and analysis of circularly and elliptically polarized light.

Reading list

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGrawHill.
2. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
3. Vibrations and Waves in Physics, 2nd edition, I. G. Main, 1984, Cambridge University Press.
4. A Textbook of Sound, 3rd Edition, A. B. Wood, 1955, Bell & Sons.
5. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
6. Fundamentals of Optics, F. A. Jenkins and H.E. White, 1981, McGraw-Hill
7. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
8. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

Subject: Physics

Semester: III

Course Name: Waves and Optics (Practical)

Course Level: PHY-C-03

Credit: 01

Course Objective

➢ To learn the principles and applications of optical instruments like biprism, interferometer and diffraction grating etc.

➢ To learn hand on experiments with prism, biprism, spectrometer, Newton's ring apparatus, grating, CRO, sodium and mercury light sources etc.

Learning outcome

On successful completion of the course students will:

1. understand the concept of polarisation of light, the production and detection of polarized light with the help of different apparatus.

2. understand working principle of prism, biprism, spectrometer, Newton's ring apparatus, grating, CRO, sodium and mercury light sources etc with the help of different apparatus.

<u>Content:</u>

At least four from the following:

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ2-T law.

2. Study of Lissajous Figure of two different waves using CRO and find out the unknown frequency of an electrical signal.

3. Familiarization with: Schuster's focusing, determination of angle of prism.

4. To determine refractive index of the Material of a prism using sodium source.

5. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.

6. To determine wavelength of sodium light using Fresnel Biprism.

7. To determine wavelength of sodium light using Newton's Rings.

8. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.

9. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.

10. To determine dispersive power and resolving power of a plane diffraction grating

Reading list

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
3. Vibrations and Waves in Physics, 2nd edition, I. G. Main, 1984, Cambridge University Press.
4. A Textbook of Sound, 3rd Edition, A. B. Wood, 1955, Bell & Sons.
5. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
6. Fundamentals of Optics, F. A. Jenkins and H.E. White, 1981, McGraw-Hill
7. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
8. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

Subject: Physics

Semester: III

Course Name: Mathematical Physics – I (Theory)

Course Level: PHY-C-04

Credit: 03

Course Objective:

The objective of the course is to acquaint the learner with different mathematical tools that are necessary for doing any R&D job.

It also intended to introduce a few of the numerical recipes like solution of linear and transcendental equations and solving integration by numerical methods which is indispensable component solving problems by computer.

Emphasis will be put on explaining the concept with real-life problems.

Learning outcome:

After successful completion of the course, the learner will learn about generalised coordinate system and its transformation to other coordinate system like Cartesian, polar, cylindrical, and spherical polar coordinate system; Matrix algebra, determination of eigen values and eigen vectors, etc.; Randomness of event and theory of probability; The method of error calculation and its minimisation.

The learner can apply the knowledge of coordinate system and its transformation in different field of science and engineering. The application of matrix is wide not only in Physics but also in different branches of science and technology. The knowledge of matrix will help in understanding and solving problems.

Unit I:

Orthogonal Curvilinear Coordinate: Curvilinear coordinates - Unit vectors and scale factors in orthogonal curvilinear coordinates, plane polar coordinates, right circular cylindrical coordinates, and spherical polar coordinates. Arc length, area, and volume elements in each of these systems. Gradient, Divergence, Curl, and Laplacian in plane polar coordinates, right circular cylindrical coordinates, and spherical polar coordinates.

Unit II:

Matrix algebra: Introduction to different types of matrices, Properties of matrices, Transpose of a matrix, complex conjugate matrix, Hermitian matrix, special square matrix, unit matrix, diagonal matrix, co-factor matrix, adjoint of a matrix, self-adjoint matrix, symmetric matrix, antisymmetric matrix, unitary matrix, orthogonal matrix, trace of a matrix, inverse matrix. Eigenvalue problems, Cayley-Hamilton Theorem, Diagonalization of matrices.

Unit III:

Definition of Dirac Delta Function, Representation as the limit of a Gaussian function and rectangular function, Properties of Dirac delta function.

Unit IV:

Some Special Integrals: Beta and Gamma Functions and Relation between them, Expression of Integrals in terms of Gamma Functions.

Unit V:

Theory of Probability and Errors: Independent random variables, Probability distribution functions of Binomial, Gaussian, and Poisson, with examples, Mean and variance.

Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error.

Reading List:

1. Schaum's Outline of Theory and Problems of Vector Analysis, Murray R. Spiegel, Schaum, 1959.
2. Theory and Problems of Matrix Operations, Richard Bronson, The McGraw-Hill Companies, 1989.
3. Higher Engineering Mathematics, H.K. Dass, S. Chand Publishing, 2011.
4. An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements (Vol. 2), John Robert Taylor and William Thompson, Springer, 1982.
5. Introductory Methods of Numerical Analysis, Shankar S. Sastry, PHI Learning Pvt. Ltd., 2012.
6. Numerical Methods (As Per Anna University), S.R.K. Iyengar and R.K. Jain, New Age International (P) Limited, 2009.
7. An Introduction to Computational Physics, T. Pang, Cambridge University Press, 2006.

Subject: Physics
Semester: III

Course Name: Mathematical Physics – I (Practical)

Course Level: PHY-C-04

Credit: 01

Course Objective:

The objective of the course is to acquaint the learner with different mathematical tools that are necessary for doing any R&D job.

It also intended to introduce a few of the numerical recipes like solution of linear and transcendental equations and solving integration by numerical methods which is indispensable component solving problems by computer.

Emphasis will be put on explaining the concept with real-life problems.

Learning outcome:

After successful completion of the course, the learner will learn about generalised coordinate system and its transformation to other coordinate system like Cartesian, polar, cylindrical, and spherical polar coordinate system; Matrix algebra, determination of eigen values and eigen vectors, etc.; Randomness of event and theory of probability; The method of error calculation and its minimisation.

The learner can apply the knowledge of coordinate system and its transformation in different field of science and engineering. The application of matrix is wide not only in Physics but also in different branches of science and technology. The knowledge of matrix will help in understanding and solving problems.

Content:

Basics of Coding

- Basics of Scientific Computing: Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow- emphasize the importance of making equations in terms of dimensionless variables, numerical errors of elementary floating point operations.
- Introduction to Algorithms and Flow charts. Branching with examples of conditional statements, for and while loops.
- Basic Elements of Python: Variables and assignments, variable types, output and input statements, arithmetic operations, comment statement.
- Control Statements: Logical statements- IF, IF-ELSE block, Looping Statements- WHILE, FOR loop, indentation, break and continue, List comprehension.
- Functions: Inbuilt functions, user-defined functions, local and global variables, passing functions, modules, importing modules, math module, making new modules.
- Basics of NumPy: Importing NumPy, Difference between List and NumPy array, Adding, removing and sorting elements, creating arrays using ones(), zeros(), random(),

arange(), linspace(). Basic array operations (sum, max, min, mean, variance), 2-d and 3-d arrays, matrix operations, reshaping and transposing arrays, random number generation using rand().

- Basics of Mat plotlib: Introduction to graphical analysis, the importance of visualization of computational data, mat plotlib. pyplot functions, simple plots.

List of Programs

1. To find a set of prime numbers between two given numbers.
2. To find the Fibonacci series up to 10 terms.
3. Generate random numbers (integers and floats) in a given range and calculate area and volume of regular shapes with random dimensions.
4. To transform a point from cartesian coordinate system to polar coordinate system and vice- versa.
5. Generate data for coordinates of a projectile and plot the trajectory. Determine the range, maximum height and time of flight for a projectile motion.

Matrix Algebra

Write a suitable code

1. To create a matrix with or without using numpy array/matrix.
2. To add, multiply two matrices.
3. To find determinant and inverse of a matrix.

Reading List:

1. Schaum's Outline of Theory and Problems of Vector Analysis, Murray R. Spiegel, Schaum, 1959.
2. Theory and Problems of Matrix Operations, Richard Bronson, The McGraw-Hill Companies, 1989.
3. Higher Engineering Mathematics, H.K. Dass, S. Chand Publishing, 2011.
4. An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements (Vol. 2), John Robert Taylor and William Thompson, Springer, 1982.
5. Introductory Methods of Numerical Analysis, Shankar S. Sastry, PHI Learning Pvt. Ltd., 2012.
6. Numerical Methods (As Per Anna University), S.R.K. Iyengar and R.K. Jain, New Age International (P) Limited, 2009.
7. An Introduction to Computational Physics, T. Pang, Cambridge University Press, 2006.

Subject: Physics
Semester: IV
Course Name: Mathematical Physics-II (Theory)
Course Level: PHY-C-05
Credit: 03

Course Objective

- To solve partial differential equations using separation of variables, including Laplace's equation and the wave equation.
- To apply Fourier series expansion to represent periodic functions using sine and cosine functions.
- To understand complex analysis principles, including analytic functions, integration and residue theorem.
- To develop proficiency in tensor algebra, covering transformations, contravariant and covariant tensors and tensor algebra.
- To gain a preliminary knowledge to probability theory, focusing on independent random variables, probability distributions, and mean and variance calculations.

Learning outcome

On successful completion of the course, the students will be equipped with the techniques related to solving partial differential equations using separation of variables method, application of Fourier series analysis, solving complex integrations, dealing with tensors and probability distributions which are relevant while dealing with wave mechanics, electrodynamics, quantum mechanics, theory of relativity and experimental physics.

Unit I: Partial Differential Equations
Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes.
Unit II: Fourier Series
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. Application to square and triangular waves.
Unit III: Complex Analysis
Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity. Integration of functions with complex variable. Cauchy's Integral theorem and Cauchy's Integral formula. Simply and multiply connected regions. Laurent and Taylor's series expansions. Residue Theorem with application.
Unit IV: Tensor Algebra
Introduction to tensor, Transformation of co-ordinates, Einstein's summation convention. Contravariant, covariant and mixed tensors. Symmetric and antisymmetric tensors, Kronecker delta, Levi Ci vita tensor. Quotient law of tensors. Rules of combination of tensors: addition, subtraction, outer multiplication, contraction and inner multiplication.

Unit V: Introduction to Probability

Independent random variables: Probability distribution functions; binomial, Gaussian and Poisson, with examples. Mean and variance.

Reading list

1) Mathematical Physics; H K Dass and R Verma, S Chand and Company limited.
2) Mathematical methods for Physics and Engineering; K. F Riley, M. P Hobson, S.J Bence, Cambridge University Press.
3) Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.
4) Ordinary and Partial Differential equations; M. D Raisinghania, S. Chand and Company Ltd.
5) Complex Variables; M R Spiegel,S Lipschutz, J J Schiller and D Spellman, Schaum's Outline Series, McGraw Hill Education.
6) Complex variables Demystified (A self-teaching guide); D McMahan, McGraw Hill Education.
7) A Student's Guide to vectors and Tensors; D A Fleisch, Cambridge University Press.
8) Vector analysis and an introduction to Tensor analysis; S Lipschutz, D Spellman, M R Spiegel, Schaum's Outline Series, McGraw Hill Education.
9) Tensors and applications with Scilab Programs; N D Soni, I.K International Publishing House Pvt. Limited.
10) Probability and Statistics; M R Spiegel, J J Schiller and R A Srinivasan, Schaum's Outline Series, McGraw Hill Education.

Subject: Physics
Semester: IV
Course Name: Mathematical Physics-II (Practical)
Course Level: PHY-C-05
Credit: 01

Course Objective

➢ To solve partial differential equations using separation of variables, including Laplace's equation and the wave equation.
➢ To apply Fourier series expansion to represent periodic functions using sine and cosine functions.
➢ To understand complex analysis principles, including analytic functions, integration and residue theorem.
➢ To develop proficiency in tensor algebra, covering transformations, contravariant and covariant tensors and tensor algebra.
➢ To gain a preliminary knowledge to probability theory, focusing on independent random variables, probability distributions, and mean and variance calculations.

Learning outcome

On successful completion of the course, the students will be equipped with the techniques related to solving partial differential equations using separation of variables method, application of Fourier series analysis, solving complex integrations, dealing with tensors and probability distributions which are relevant while dealing with wave mechanics, electrodynamics, quantum mechanics, theory of relativity and experimental physics.

Content:

<u>At least four from the following:</u>

1. Solve the differential equations

$\frac{dy}{dx} = e^x$ with $y = 0$ for $x = 0$

$\frac{dy}{dx} + e^{-x}y = x^2$

$\frac{d^2y}{dx^2} + 2\frac{dy}{dx} = -y$

$\frac{d^2y}{dx^2} + e^{-x}\frac{dy}{dx} = -y$

2. Perform the multiplication of two 3 × 3 matrices.
3. Compute the eigenvalues and eigenvectors of the following matrices.

4 3 7 1 $-i$ $3+4i$
[1 2 7], [i 2 4], 2 0 4 $3-4i$ 4 3
2 $-i$ $2i$
[i 4 3]
$-2i$ 3 5

4. Using random number compute the areas of circle, square, volume of sphere and value of pi (π).
5. Evaluate trigonometric functions e.g. sinθ; cosθ; tanθ etc. using Interpolation by Newton Gregory Forward and Backward difference formula.
6. Find the solution of Partial Differential Equations: (a) Wave equation (b) Heat equation.
7. Evaluate the integral I,where,

$$I = \frac{1}{\sqrt{2\pi\sigma^2}} \int exp\left[\frac{(x-2)^2}{2\sigma^2}\right](x+3)\,dx \text{ for}$$

$\sigma = 1.0, 0.1, 0.01$ and show that $I \to 5$

8. Compute the nth roots of unity for n = 2, 3, and 4. Find the two square roots of 5 + 12i.

Reading list

1. Mathematical Physics; H K Dass and R Verma, S Chand and Company limited.
2. Mathematical methods for Physics and Engineering; K. F Riley, M. P Hobson, S.J Bence, Cambridge University Press.
3. Graduate Mathematical Physics (With Mathematica Supplement); J J Kelly, Willey-VCH VerlagGmbH and Co. KGaA.
4. Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.
5. Ordinary and Partial Differential equations; M. D Raisinghania, S. Chand and Company Ltd.
6. Complex Variables; M R Spiegel,S Lipschutz, J J Schiller and D Spellman, Schaum's Outline Series, McGraw Hill Education.
7. Complex variables Demystified (A self-teaching guide); D McMahan, McGraw Hill Education.
8. A Student's Guide to vectors and Tensors; D A Fleisch, Cambridge University Press.
9. Vector analysis and an introduction to Tensor analysis; S Lipschutz, D Spellman, M R Spiegel, Schaum's Outline Series, McGraw Hill Education.
10. Tensors and applications with Scilab Programs; N D Soni, I.K International Publishing House Pvt. Limited.
11. Probability and Statistics; M R Spiegel, J J Schiller and R A Srinivasan, Schaum's Outline Series, McGraw Hill Education.

Subject: Physics
Semester: IV
Course Name: Quantum Mechanics I (Theory)
Course Level: PHY-C-06
Credit: 03

Course Objective

- To learn about the inadequacies of classical mechanics, the origin and need of quantum mechanics, historical developments in quantum mechanics.
- Dual nature of radiation & matter, description of matter wave through wave packet.
- Probabilistic nature and wave function, Schrödinger equation, the uncertainty principle, stationary and non-stationary states.
- Applications of Schrödinger equation in different cases like infinite and finite potential well, tunneling effect, linear harmonic oscillator and H-atom.
- Formulation of quantum mechanics in terms of operators.

Learning outcome

On successful completion of the course students will be able to learn physical and mathematical fundamentals of Quantum physics, and various topics in it. These concepts are used in various branches of physics, like condensed matter physics, lasers, quantum statistics, atomic and molecular physics, particle physics, astrophysics and optics etc.

Unit I: Origin of Quantum Theory
Failure of classical theories, Explanation of Black body radiation, Photoelectric effect, Compton effect, different evidences in support of quantum theory, particle nature of radiation, Bohr's correspondence principle.
Unit– II: Dynamical Variables as Operators and Uncertainty Principle
Dynamical variables as operators, definition of an operator, different types of operators and their properties, position, energy and momentum operator; commutation relations; introduction to Hilbert space, Dirac notation, eigenvalue and eigenfunctions; expectation value of an operator e.g. position, momentum operator etc, orthonormality condition, Ehrenfest's theorem, Simultaneous measurement and uncertainty principle; general statement of Heisenberg's uncertainty principle(for any two non-commutating operators), different uncertainty relations involving canonical pair of variables; particle trajectory and fuzziness, applications of the position momentum, uncertainty principle, application of energy-time uncertainty principle to virtual particles and range of an interaction.
Unit –III: Matter Wave and Wave- Particle Duality
Wave particle duality and de Broglie wavelength, particle as a wave or matter wave, wave description of particles by wave packets; phase and group velocity, wave function, wave amplitude, probability; Experimental verification of matter wave, Davisson and Germer experiment; linearity and superposition principle, two slit experiments with electrons and photons; Uncertainty principle from wave packet description, Gaussian wave packet and its wave function.
Unit–IV: Schrödinger Equation and it's applications

Time dependent Schrödinger Equation, Time independent Schrödinger Equation; Physical interpretation and properties of wave function, continuity of a wave function, boundary conditions and emergence of discrete and continuous energy levels; probabilities and normalisation in three and one dimension; equation of continuity, current density in both three and one dimension. Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wave function as a linear combination of energy eigenfunctions; General solution of the time dependent Schrödinger equation in terms of linear combinations of stationary states, discrete and continuous spectrum, wave function of a free particle, spread of Gaussian wave function in one dimension, Fourier transforms and momentum space wave function. Applications of Time independent Schrödinger Equation in different problems like : (i) particle in a one dimensional infinite potential well (quantum dot as an example) (ii) particle in a one dimensional finite square potential well (iii) barrier penetration problems – potential step and rectangular potential barrier (tunnel effect) (iv) linear harmonic oscillator (v) spherically symmetric potential for hydrogen atom- radial solution, spherical harmonics, angular momentum operator and different quantum numbers, radial distribution function and shapes of the probability densities for ground & first excited states; degeneracy of states : s, p, d states.

Reading list:

1. N. Zettili, Quantum Mechanics, John Wiley & Sons (2001).
2. J. J. Sakurai and J. Napolitano, Modern Quantum Mechanics, Cambridge Univ. Press, 2020.
3. Y. R.Waghmare, Fundamentals of Quantum Mechanics, Wheeler publishing (2014).
4. P. A. M. Dirac, Principles of Quantum Mechanics, Oxford University Press (1981).
5. B. H. Bransden and C. J. Joachain, Quantum Mechanics, Pearson Education 2nd Ed. (2004).
6. K. Gottfried and T-M Yan, Quantum Mechanics: Fundamentals,2nd Ed., Springer (2003).
7. R. Shankar, Principles of Quantum Mechanics, Springer (India) (2008).
8. D. J. Griffiths, Introduction to Quantum Mechanics, Pearson Education (2005).
9. L. Schiff, Quantum Mechanics, Mcgraw-Hill (1968).
10. A. K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, Springer (2002).
11. A. Bieser, Concepts of Modern Physics, McGraw Hill (2002). 11. Arno Bohm, Quantum Mechanics: Foundations and Applications, 3rd Edition, Springer (1993).
12. H. C. Verma, Quantum Mechanics, TBS publications (2019).
13. P M Mathews and K. Venkatesan, A Text book of Quantum Mechanics, 2nd Edition, McGraw Hill (2010

Subject: Physics
Semester: IV
Course Name: Quantum Mechanics I (Practical)
Course Level: PHY-C-06
Credit: 01

Course Objective

- To learn about the inadequacies of classical mechanics, the origin and need of quantum mechanics, historical developments in quantum mechanics.
- Dual nature of radiation & matter, description of matter wave through wave packet.
- Probabilistic nature and wave function, Schrödinger equation, the uncertainty principle, stationary and non-stationary states.
- Applications of Schrödinger equation in different cases like infinite and finite potential well, tunneling effect, linear harmonic oscillator and H-atom.
- Formulation of quantum mechanics in terms of operators.

Learning outcome
On successful completion of the course students will be able to learn physical and mathematical fundamentals of Quantum physics, and various topics in it. These concepts are used in various branches of physics, like condensed matter physics, lasers, quantum statistics, atomic and molecular physics, particle physics, astrophysics and optics etc.

Content:
At least four from the following:
1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: Photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of Hα emission line of hydrogen atom.
6. To determine the ionisation potential of mercury.
7. To determine the absorption lines in the rotational spectrum of iodine vapour.
8. To determine the value of e/m by (a) magnetic focusing or (b) bar magnet.
9. To setup the Millikan's oil drop apparatus and determine the charge of an electron.
10. To show the tunnelling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction from single slit.
12. To determine the wavelength of laser source using diffraction from double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.

Reading list

1. N. Zettili, Quantum Mechanics, John Wiley & Sons (2001).

2. J. J. Sakurai and J. Napolitano, Modern Quantum Mechanics, Cambridge Univ. Press, 2020.
3. Y. R.Waghmare, Fundamentals of Quantum Mechanics, Wheeler publishing (2014).
4. P. A. M. Dirac, Principles of Quantum Mechanics, Oxford University Press (1981).
5. B. H. Bransden and C. J. Joachain, Quantum Mechanics, Pearson Education 2nd Ed. (2004).
6. K. Gottfried and T-M Yan, Quantum Mechanics: Fundamentals,2nd Ed., Springer (2003).
7. R. Shankar, Principles of Quantum Mechanics, Springer (India) (2008).
8. D. J. Griffiths, Introduction to Quantum Mechanics, Pearson Education (2005).
9. L. Schiff, Quantum Mechanics, Mcgraw-Hill (1968).
10. A. K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, Springer (2002).
11. A. Bieser, Concepts of Modern Physics, McGraw Hill (2002). 12. Arno Bohm, Quantum Mechanics: Foundations and Applications, 3rd Edition, Springer (1993).
13. H. C. Verma, Quantum Mechanics, TBS publications (2019).
14. P M Mathews and K. Venkatesan, A Text book of Quantum Mechanics, 2nd Edition, McGraw Hill (2010)

Subject: Physics
Semester: IV
Course Name: Heat and Thermodynamics (Theory)
Course Level: PHY-C-07
Credit: 03

Course Objective:

- To understand principles of thermodynamics
- To provide concepts of thermodynamic functions
- To address the basic framework of kinetic theory of gases

Learning outcome:

Upon completion of this course, Students will be able to learn thermal properties of gas molecules and their collisions, with this course, students will acquire knowledge of thermodynamics with Practical insights into thermal physics, which will help them to understand real world situations.

Unit I: Distribution of Velocities and Molecular Collisions

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 (No proof required). Mean Free Path. Collision Probability. Transport Phenomenon in Ideal Gases: (1) Viscosity, and (2) Thermal Conductivity. Brownian Motion (qualitative idea only).

Unit II: Real Gases

Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2, Gas, Critical Constants, Continuity of Liquid and Gaseous State. Vapor and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. Joule- Thomson Porous Plug Experiment. Joule- Thomson Effect, Joule-Kelvin coefficient for Ideal and Van der Waal Gases. Temperature of Inversion.

Unit III: Principles of Thermodynamics

Thermodynamic preliminaries: Extensive and intensive properties, Thermodynamic Variables, Thermodynamic Equilibrium, P-V indicator diagram. Work done in terms of P and V, Zeroth Law of Thermodynamics & Concept of Temperature, Internal energy and First Law of Thermodynamics, Applications of First Law: General Relation between Cp and Cv. Reversible and Irreversible process with examples. Heat & work, state function, Conversion of heat into work and vice-versa, Work Done during Isothermal and Adiabatic processes, Heat Engines, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their equivalence, Carnot's Cycle, Carnot engine & efficiency, Refrigerator & coefficient of performance, Carnot's Theorem, Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Unit IV: Entropy

Concept of Entropy, Clausius Theorem, Clausius Inequality, Second Law of thermodynamics in terms of Entropy. Entropy of a perfect gas. Entropy Changes in Reversible and Irreversible processes with examples. Principle of Increase of Entropy, Temperature-Entropy diagram for Carnot's Cycle. Third Law of Thermodynamics.

Unit V: Thermodynamic Potentials and Thermodynamic

Relations Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Surface films and Variation of Surface Tension with Temperature. Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of $C_p - C_v$ (3) TdS Equations, (4) Energy equations, (5) Change of Temperature during Adiabatic Process.

Reading list

1) Heat and Thermodynamics, M. Zemansky, R. Dittman, McGraw-Hill Education, 2017.
2) A Treatise on Heat, Meghnad Saha and B. N. Srivastava, Indian Press, 1973.
3) Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics, S. C. Garg, R. M. Bansal and C. K. Ghosh, Tata McGraw Hill Education Pvt Ltd,2013.
4) Thermodynamics, Kinetic Theory and Statistical Thermodynamics, F. W. Sears & G.L. Salinger, Narosa Publishing House, 1998.
5) Thermal and Statistical Physics, R. B. Singh, New Academic Science, 2011.
6) Theory and Experiment on Thermal physics, P K. Chakrabarti, New Central Book Agency (P) Ltd, 2011.

Subject: Physics
Semester: IV
Course Name: Heat and Thermodynamics (Practical)
Course Level: PHY-C-04
Credit: 01

Course Objective:

- To understand principles of thermodynamics
- To provide concepts of thermodynamic functions
- To address the basic framework of kinetic theory of gases

Learning outcome:

Upon completion of this course, Students will be able to learn thermal properties of gas molecules and their collisions, with this course, students will acquire knowledge of thermodynamics with Practical insights into thermal physics, which will help them to understand real world situations.

Content:

At least four from the following:

1. To determine mechanical equivalent of heat J, by Callender and Barne's constant flow method
2. To determine the mechanical equivalent of heat, J, using calorimeter
3. To determine Specific heat of a liquid using calorimeter
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the coefficient of thermal Conductivity of an insulator by Lee and Charlton's disc method.
6. To determine the temperature coefficient of resistance by Platinum Resistance Thermometer (PRT).
7. To study the variation of thermo-emf of a thermocouple with difference of temperature of its two junctions.
8. To determine the change of entropy of universe for an AC circuit consists of a thermally insulated resistor.
9. To calibrate a thermocouple to measure temperature in a specified range using (1) Null method, (2) Direct measurement using OPAMP and to determine neutral temperature.

Reading list

1. Heat and Thermodynamics, M. Zemansky, R. Dittman, McGraw-Hill Education, 2017.
2. A Treatise on Heat, Meghnad Saha and B. N. Srivastava, Indian Press, 1973.

3. Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics, S. C.
Garg, R. M. Bansal and C. K. Ghosh, Tata McGraw Hill Education Pvt Ltd,2013.
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, F. W. Sears & G.L. Salinger, Narosa Publishing House, 1998.
5. Thermal and Statistical Physics, R. B. Singh, New Academic Science, 2011.
6. Theory and Experiment on Thermal physics, P K. Chakrabarti, New Central Book Agency (P) Ltd, 2011.

Subject: Physics
Semester: IV
Course Name: Heat and Thermodynamics (Theory)
Course Level: PHY-M-04
Credit: 03

Course Objective:

- To understand principles of thermodynamics
- To provide concepts of thermodynamic functions
- To address the basic framework of kinetic theory of gases

Learning outcome:

Upon completion of this course, Students will be able to learn thermal properties of gas molecules and their collisions, with this course, students will acquire knowledge of thermodynamics with Practical insights into thermal physics, which will help them to understand real world situations.

Unit I: Distribution of Velocities and Molecular Collisions

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 (No proof required). Mean Free Path. Collision Probability. Transport Phenomenon in Ideal Gases: (1) Viscosity, and (2) Thermal Conductivity. Brownian Motion (qualitative idea only).

Unit II: Real Gases

Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2, Gas, Critical Constants, Continuity of Liquid and Gaseous State. Vapor and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. Joule- Thomson Porous Plug Experiment. Joule- Thomson Effect, Joule-Kelvin coefficient for Ideal and Van der Waal Gases. Temperature of Inversion.

Unit III: Principles of Thermodynamics

Thermodynamic preliminaries: Extensive and intensive properties, Thermodynamic Variables, Thermodynamic Equilibrium, P-V indicator diagram. Work done in terms of P and V, Zeroth Law of Thermodynamics & Concept of Temperature, Internal energy and First Law of Thermodynamics, Applications of First Law: General Relation between Cp and Cv. Reversible and Irreversible process with examples. Heat & work, state function, Conversion of heat into work and vice-versa, Work Done during Isothermal and Adiabatic processes, Heat Engines, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their equivalence, Carnot's Cycle, Carnot engine & efficiency, Refrigerator & coefficient of performance, Carnot's Theorem, Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Unit IV: Entropy

Concept of Entropy, Clausius Theorem, Clausius Inequality, Second Law of thermodynamics in terms of Entropy. Entropy of a perfect gas. Entropy Changes in Reversible and Irreversible processes with examples. Principle of Increase of Entropy, Temperature-Entropy diagram for Carnot's Cycle. Third Law of Thermodynamics.

Unit V: Thermodynamic Potentials and Thermodynamic

Relations Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Surface films and Variation of Surface Tension with Temperature. Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of Cp−Cv (3) TdS Equations, (4) Energy equations, (5) Change of Temperature during Adiabatic Process.

Reading list

1) Heat and Thermodynamics, M. Zemansky, R. Dittman, McGraw-Hill Education, 2017.
2) A Treatise on Heat, Meghnad Saha and B. N. Srivastava, Indian Press, 1973.
3) Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics, S. C. Garg, R. M. Bansal and C. K. Ghosh, Tata McGraw Hill Education Pvt Ltd,2013.
4) Thermodynamics, Kinetic Theory and Statistical Thermodynamics, F. W. Sears & G.L. Salinger, Narosa Publishing House, 1998.
5) Thermal and Statistical Physics, R. B. Singh, New Academic Science, 2011.
6) Theory and Experiment on Thermal physics, P K. Chakrabarti, New Central Book Agency (P) Ltd, 2011.

Subject: Physics
Semester: IV
Course Name: Heat and Thermodynamics (Practical)
Course Level: PHY-M-04
Credit: 01

Course Objective:

- To understand principles of thermodynamics
- To provide concepts of thermodynamic functions
- To address the basic framework of kinetic theory of gases

Learning outcome:
Upon completion of this course, Students will be able to learn thermal properties of gas molecules and their collisions, with this course, students will acquire knowledge of thermodynamics with Practical insights into thermal physics, which will help them to understand real world situations.

Content:
<u>At least four from the following:</u>

1. To determine mechanical equivalent of heat J, by Callender and Barne's constant flow method
2. To determine the mechanical equivalent of heat, J, using calorimeter
3. To determine Specific heat of a liquid using calorimeter
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the coefficient of thermal Conductivity of an insulator by Lee and Charlton's disc method.
6. To determine the temperature coefficient of resistance by Platinum Resistance Thermometer (PRT).
7. To study the variation of thermo-emf of a thermocouple with difference of temperature of its two junctions.
8. To determine the change of entropy of universe for an AC circuit consists of a thermally insulated resistor.
9. To calibrate a thermocouple to measure temperature in a specified range using (1) Null method, (2) Direct measurement using OPAMP and to determine neutral temperature.

Reading list
1. Heat and Thermodynamics, M. Zemansky, R. Dittman, McGraw-Hill Education, 2017.
2. A Treatise on Heat, Meghnad Saha and B. N. Srivastava, Indian Press, 1973.

3. Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics, S. C. Garg, R. M. Bansal and C. K. Ghosh, Tata McGraw Hill Education Pvt Ltd,2013.
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, F. W. Sears & G.L. Salinger, Narosa Publishing House, 1998.
5. Thermal and Statistical Physics, R. B. Singh, New Academic Science, 2011.
6. Theory and Experiment on Thermal physics, P K. Chakrabarti, New Central Book Agency (P) Ltd, 2011.

Subject: Physics
Semester: V
Course Name: Classical Mechanics (Theory)
Course Level: PHY-C-09
Credit: 04

Course Objective:

The basic objectives of the course are

- To introduce the laws of classical dynamics.
- To train students in solving problems of motion of particles, systems of particles and fluids.
- To introduce relativity and hence the idea of how space and time play role in dynamics of matter.

Learning Outcome:

On successful completion of the course students will be able to apply the laws of classical dynamics to physical problems of motion of particles, systems of particles and fluids in various fields of physics and natural science as a whole. They will also get the exposure of the idea of how space and time play role in dynamics of matter.

Unit I: Mechanics of point particles – the Lagrangian approach
Review of Newtonian mechanics; system of particles, constrained motion – types of constraints, concept of degrees of freedom, generalised coordinates and velocities, principle of virtual work and D'Alembert's principle and associated problems,
Lagrange's (Euler-Lagrange, EL) equations, physical problems (construction of EL equations only) – simple and compound pendulums, two vibrating particles of equal mass attached to springs, Lagrange's equations for a particle in spherical and cylindrical coordinate systems, falling body in uniform gravitational field.
Unit II: Mechanics of point particles – the Hamiltonian approach
Generalised momenta, Legendre transformation, Hamilton's canonical equations, Hamiltonian from the Lagrangian, conservation of energy and momentum; physical problems – Hamiltonian for simple pendulum, particle moving in central force field (gravitational potential).
Unit III: Small Oscillation
Minimum of potential energy and concept of stable equilibrium; expansion of potential energy around a minimum; kinetic and potential energy matrices; equation of motion of small oscillation. Inadequacy of Galilean transformation; postulates of special relativity; Lorentz transformation; simultaneity and order of events; length contraction and time dilation; relativistic addition of velocities, variation of mass with velocity and mass-energy equivalence. Lorentz transformation as a rotation in spacetime; relation between proper time and coordinate time, relativistic kinematics: energy-momentum relation.
Unit V: Fluid dynamics

Definition of a fluid; idea fluids; density and pressure of a fluid, velocity of a fluid element and its time derivative; mass conservation and equation of continuity; incompressible fluid; Euler's equation of fluid dynamics; Navier-Stokes equation (introduction only).

Reading list:

1. Classical Mechanics, H. Goldstein, C.P. Poole and J.L. Safko (Pearson Education)

2. Theoretical Mechanics, M. R. Spiegel (McGraw Hill Book Company)
3. Classical Mechanics, P.S. Joag and N.C. Rana (McGraw Hill Book Company)
4. Mathematical Physics, B. S. Rajput (Pragati Prakashan)
5. Classical Mechanics, T.W.B. Kibble and F.H. Berkshire (Imperial College Press)
6. Mechanics (Course in Theoretical Physics (Vol. I), L.D. Landau and E.M. Lifshitz (Butterworth-Heinemann) (3rd Edn.)
7. Classical Mechanics: With introduction to non-linear oscillations and chaos, V.B. Bhatia (Narosa Publishing House)

Subject: Physics
Semester: V
Course Name: Statistical Mechanics (Theory)
Course Level: PHY-C-10
Credit: 04

Course Objective:

- To provide basic concepts of statistical mechanics.
- Describing various thermodynamical phenomena using probability theory.
- To learn classical and quantum statistics.

Learning Outcome:
Upon completion of the course, students will get accustomed to the microscopic origin of thermodynamic processes. After successful completion of the course, students will be able to perceive classical and quantum pictures of physical and chemical events.

Unit I: Classical Statistics
Microstate and macrostate, distributions of particles in compartments, principle of equal a priori probability. Phase space, volume of phase space. Elementary concept of ensembles. Types of ensembles. Ergodic hypothesis. Entropy and thermodynamic probability. Stirling's approximation. Maxwell-Boltzmann distribution function, Partition functions. Gibbs Paradox. Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to specific heat and its limitations. Thermodynamic parameters (internal energy, entropy, free energy, enthalpy) using partition functions.
Unit II: Classical and Quantum Theory of Radiation
Properties of thermal radiation. Blackbody radiation. Spectral distribution of Blackbody radiation, Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation pressure (for Normal and diffused case). Wien's Displacement law. Wien's Distribution Law. Saha's ionization formula. Rayleigh-Jean's Law (with proof). Ultraviolet catastrophe. Need of quantum statistics. Planck's quantum postulates. Planck's law of blackbody radiation: Experimental verification, Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jean's Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's black body radiation formula.
Unit III: Bose Einstein Statistics
Bose-Einstein (BE) distribution, Pressure of a Bose gas. BoseEinstein Condensation (qualitative description only). Properties of liquid Helium (qualitative discussion only). Radiation as a photon gas and Bose's derivation of Planck's blackbody radiation formula. Thermodynamic functions of photon gas (energy, entropy, and free energy).
Unit IV: Fermi-Dirac Statistics
Fermi-Dirac (FD) distribution. FD function and Fermi energy. Degenerate Fermi gas, strongly degenerate case (qualitative discussion only). Thermodynamic functions – energy and pressure of a completely degenerate Fermi gas. Heat capacity at low temperature. Free electron gas in metals and electronic specific heat. Relativistic Fermi gas, thermodynamics of white dwarf star (qualitative discussion only).

Reading list:
1.Statistical Mechanics, R K Pathria and P D Beale, Elsevier Science, 2021.
2.Statistical Physics, F. Reif, McGraw-Hill Education India, 2008.
3.Statistical and Thermal Physics, S. Lokanathan and R. S. Gambhir, PHI Learning, 1991.

4.Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, Springer, 2009.
5.An Introduction to Statistical Mechanics & Thermodynamics, R. H. Swendsen, Oxford University Press, 2012.
6.A Primer of Statistical Mechanics, R. B. Singh, New Age International Publishers, 2006.

Subject: Physics
Semester: V
Course Name: Astronomy and Astrophysics (Theory)
Course Level: PHY-C-11
Credit:04

Course Objective:

- To introduce the students with fundamental concepts and observational techniques in astronomy including virtual observatory tools.
- To introduce the students with physical processes occurring inside the celestial objects and to introduce the physical concepts required for the study of recent frontiers in astrophysics.

Learning outcome:

On successful completion of this course students will be able to understand the fundamental concepts in astronomy. They will be able to apply physics of celestial objects in understanding the universe. They will be equipped with the skills required for (i) observational astronomy (ii) virtual observatory tools and (iii) physical concepts of recent frontiers in astrophysics.

Unit-I: Fundamentals of astronomy

Basic components of the universe – stars, planets and galaxies; celestial sphere and celestial coordinates system – altitude-azimuth and hour angle-right ascensiondeclination (RA-DEC) – introduction to constellations through sky observation and identification; concept of time – universal time, solar and mean solar time, sidereal time, local sidereal time, Julian day; flux and luminosity of celestial objects; stellar magnitude scale – apparent and absolute magnitude; measurement of stellar distances – trigonometric parallax, introduction to HIPPARCOS and GAIA.

Unit-II: Astronomical techniques

Telescopes – size and light gathering power, resolving power; different types of optical telescopes (reflecting and refracting); space telescopes; concept of virtual observatory; virtual observatory tools (e.g. Aladin, SDSS, AAVSO, Sky-View); introduction to photometry, CCD; an introduction, spectroscopy and polarimetry.

Unit-III: Stellar astrophysics

Star formation from interstellar medium (introduction only); properties of stars – mass, luminosity, radius and effective surface temperature; mass luminosity, mass-radius and luminosity-radius-temperature relation; variable stars – cepheids; star clusters – open and globular (their ages – introduction only). Gravity and thermodynamics – hydrostatic equilibrium of stars; virial theorem; internal temperature and pressure of stars; spectral classification – HR diagram; stellar evolution- idea of nucleosynthesis to main sequence phase- pp and CNO cycle; evolution of Sun-like stars off the main sequence; red giants and white dwarfs – Chandrasekhar mass limit (introduction only); evolution of massive stars – neutron stars and black holes (introduction only).

Unit-IV: The solar system

The basic properties of photosphere, chromosphere and corona; formation of the solar system – Kant-Laplace nebular hypothesis; asteroid belt and meteorites; Distances and atmosphere of all planets, Pluto and dwarf planets; comets – Kuiper belt and Oort cloud; extra-solar planets – transit method of detection (introduction only).

Unit-V: Galaxies and cosmology

The Milky Way-shape, size and its components; classification of galaxies – Hubble's tuning fork diagram; types – spirals, elliptical and lenticular; difference between spirals and ellipticals. Large scale structure of the universe – galaxies, clusters, superclusters, filaments, sheets and voids; Cosmological Principle; Hubble's law; Newtonian cosmology and derivation of Friedman equation; closed and oscillating universe, flat and open universe; The Hot Big Bang Model; Cosmic Microwave Background (CMB) ; steady state universe (introduction only); flat rotation curve of galaxies and evidence for dark matter; dark energy (introduction only).

Reading list:

1.Astrophysics for physicists, A. Rai Choudhuri, Cambridge University Press.
2.An introduction to the theory of stellar structure and evolution, D. Prialnik, Cambridge University Press.
3.Astrophysics: Stars and galaxies, K. D. Abhyankar, Tata McGraw Hill Pub.
4.Textbook of astronomy and astrophysics with elements of cosmology, V. B. Bhatia, Narosa Pub.
5.Astronomy Methods - A Physical Approach to Astronomical Observations, Hale Bradl, Cambridge University Press.
6.Introduction to astrophysics, H.L. Duorah and K. Duorah, Mani Manik Prakash (Guwahati) Digital Principles and Applications, A. P. Malvino, D. P. Leach and Saha, 7th Ed., 2013, Tata McGraw
7.The physical universe – An introduction to astronomy, F. H. Shu, University of Science Books.
8.The structure of the universe, J.V. Narlikar, Oxford University Press.
9.Introduction to cosmology, B. Ryden, Cambridge University Press

Subject: Physics
Semester: V
Course Name: Analog Electronics (Theory)
Course Level: PHY-C-12
Credit: 03
Course Objective:

- To introduce students to analog electronics.
- To make the students understand the physics of semiconductor p-n junction and application in devices like diodes, rectifiers, etc.
- To understand the working of bipolar junction transistors, biasing, stabilization circuits, and various applications like amplifiers, oscillators, etc. together with feedback.
- To know the basics of Operational Amplifiers and applications.

Learning outcome:

On successful completion of the course, students will be able to understand the physics of semiconductor p-n junction and devices such as rectifier diodes, Zener diode, photodiode, etc.; they will understand the basics of bipolar junction transistors, transistor biasing, and stabilization circuits; the concept of feedback in amplifiers and the oscillator circuits. Students will also have an understanding of operational amplifiers and their applications.

Unit I: Semiconductor Diodes
P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width, and Current for Step Junction.
Unit II: Two- terminal Devices and their Applications
Rectifier Diode: Half- wave Rectifiers. Centre-tapped and Bridge type Full-wave Rectifiers. Calculation of Ripple Factor and Rectification Efficiency. C-filter. Zener Diode and Voltage Regulation. Power supply without filter circuit and with C-filter circuit. Principle LEDs, Photodiode, and Solar Cell (Basic concept).
Unit III: Bipolar Junction Transistors
n-p-n and p-n-p Transistors. Characteristics of CB, CE, and CC Configurations. Current gains α and β. Relations between α and β. Load line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cut-off, and Saturation Regions.
Unit IV: Amplifiers
Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as a 2-port Network. h-parameter. Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage, and Power Gains. Classification of Class A, B & C Amplifiers. Differential amplifiers.
Unit V: Coupled Amplifier
Two-stage RC-coupled amplifier and its frequency response.
Unit VI: Feedback in Amplifiers
Effects of Positive and Negative Feedback on Input Impedance. Output Impedance. Gain. Stability. Distortion and Noise.

Unit VII: Sinusoidal Oscillators
Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator. Determination of Frequency. Colpitt's oscillator.
Unit VIII: Operational Amplifiers (Black Box approach)
Characteristics of an Ideal and Practical Op-Amp (IC 741). Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and Concept of Virtual Ground.
Unit IX: Applications of Op-Amps
Inverting and non-inverting amplifiers. Adder. Subtractor. Differentiator. Integrator. Log and Anti Log amplifier. Zero crossing detector. Wein bridge oscillator. Comparator.
Unit X: Introduction to CRO
Block Diagram of CRO. Electron Gun, Deflection System, and Time Base. Deflection Sensitivity. Applications of CRO: Study of Waveform, Measurement of Voltage, Current, Frequency, and Phase Difference.

Reading List:

1. Principles of Electronics, V.K. Mehta and Rohit Mehta, S. Chand Publication
2. Basic Electronics, solid state. B.L. The Raja, S. Chand Pub.
3. Electronic Principles, Albert Malvino, David J. Bates, Patrick E. Hoppe; Mc. Graw Hill
4. Electronics Devices and circuit Theory; Robert L. Boylestad, Louis Nashelsky; Pearson public.
5. Electronics Fundamentals and Applications; D, Chatto padhay and P. C. Rakshit; New Age International publishers.

Subject: Physics
Semester: V
Course Name: Analog Electronics (Practical)
Course Level: PHY-C-12
Credit: 01
Course Objective:

- To introduce students to analog electronics with hands-on practice on implementing some of these in hardware.
- To make the students understand the physics of semiconductor p-n junction and application in devices like diodes, rectifiers, etc.
- To understand the working of bipolar junction transistors, biasing, stabilization circuits, and various applications like amplifiers, oscillators, etc. together with feedback.
- To know the basics of Operational Amplifiers and applications.
- To understand the basics of the use of CRO in measurements with hands-on experience with some applications

Learning outcome:

On successful completion of the course, students will be able to understand the physics of semiconductor p-n junction and devices such as rectifier diodes, Zener diode, photodiode, etc.; they will understand the basics of bipolar junction transistors, transistor biasing, and stabilization circuits; the concept of feedback in amplifiers and the oscillator circuits. Students will also have an understanding of operational amplifiers and their applications.

Content:

<u>At least four from the following:</u>

1. To study V-I characteristics of PN junction diode, and light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as a voltage regulator.
3. Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal Class A operation.
7. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
8. To study the frequency response of voltage gain of an RC-coupled transistor amplifier.
9. Using an Op-amp, design a Wien bridge oscillator for a given frequency.
10. To design a phase shift oscillator of given specifications using BJT.
11. To design and study Colpitt's oscillator.
12. To design an inverting amplifier using Op-amp for the DC voltage of a given gain.
13. To design inverting amplifier using Op- amp and study its frequency response.
14. To design a non-inverting amplifier using Op-amp and study its frequency response.
15. To study the zero-crossing detector and comparator.
16. To add two DC voltages using Op-amp in inverting and non-inverting modes.
17. To design a precision Differential amplifier of given I/O specification using Opamp.
18. To investigate the use of an Op-amp as an Integrator.

19. To investigate the use of an Op-amp as a Differentiator.
20. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO. Construct a series LR circuit. Display the two waveforms on the CRO and measure the phase differences between the voltages across R and L.
21. To test a Diode and Transistor using a Multimeter. Draw the forward bias characteristic of the diode. Using only the base-emitter junction of the transistor draw a characteristic curve and show that it behaves as a forward-biased diode

Note: All students will have to do an electronic project on the circuits, for example, the power supply, the AM detector, etc. to get acquainted

Reading List:

1. Principles of Electronics, V.K. Mehta and Rohit Mehta, S. Chand Publication
2. Basic Electronics, solid state. B.L. The Raja, S. Chand Pub.
3. Electronic Principles, Albert Malvino, David J. Bates, Patrick E. Hoppe; Mo. Gras Hill 4. Electronics Devices and circuit Theory; Robert L. Boylestad, Louis Nashelsky; Pearson public.

5. Electronics Fundamentals and Applications; D, Chatto padhay and P. C. Rakshit; New Age International publishers.

Subject: Physics
Semester: V
Course Name: Classical Mechanics (Theory)
Course Level: PHY-M-05
Credit: 04

Course Objective:

The basic objectives of the course are

- To introduce the laws of classical dynamics.
- To train students in solving problems of motion of particles, systems of particles and fluids.
- To introduce relativity and hence the idea of how space and time play role in dynamics of matter.

Learning Outcome:

On successful completion of the course students will be able to apply the laws of classical dynamics to physical problems of motion of particles, systems of particles and fluids in various fields of physics and natural science as a whole. They will also get the exposure of the idea of how space and time play role in dynamics of matter.

Unit I: Mechanics of point particles – the Lagrangian approach

Review of Newtonian mechanics; system of particles, constrained motion – types of constraints, concept of degrees of freedom, generalised coordinates and velocities, principle of virtual work and D'Alembert's principle and associated problems,
Lagrange's (Euler-Lagrange, EL) equations, physical problems (construction of EL equations only) – simple and compound pendulums, two vibrating particles of equal mass attached to springs, Lagrange's equations for a particle in spherical and cylindrical coordinate systems, falling body in uniform gravitational field.

Unit II: Mechanics of point particles – the Hamiltonian approach

Generalised momenta, Legendre transformation, Hamilton's canonical equations, Hamiltonian from the Lagrangian, conservation of energy and momentum; physical problems – Hamiltonian for simple pendulum, particle moving in central force field (gravitational potential).

Unit III: Small Oscillation

Minimum of potential energy and concept of stable equilibrium; expansion of potential energy around a minimum; kinetic and potential energy matrices; equation of motion of small oscillation. Inadequacy of Galilean transformation; postulates of special relativity; Lorentz transformation; simultaneity and order of events; length contraction and time dilation; relativistic addition of velocities, variation of mass with velocity and mass-energy equivalence. Lorentz transformation as a rotation in spacetime; relation between proper time and coordinate time, relativistic kinematics: energy-momentum relation.

Unit V: Fluid dynamics

Definition of a fluid; idea fluids; density and pressure of a fluid, velocity of a fluid element and its time derivative; mass conservation and equation of continuity; incompressible fluid; Euler's equation of fluid dynamics; Navier-Stokes equation (introduction only).

Reading list:

1. Classical Mechanics, H. Goldstein, C.P. Poole and J.L. Safko (Pearson Education)

2. Theoretical Mechanics, M. R. Spiegel (McGraw Hill Book Company)
3. Classical Mechanics, P.S. Joag and N.C. Rana (McGraw Hill Book Company)
4. Mathematical Physics, B. S. Rajput (Pragati Prakashan)
5. Classical Mechanics, T.W.B. Kibble and F.H. Berkshire (Imperial College Press)
6. Mechanics (Course in Theoretical Physics (Vol. I), L.D. Landau and E.M. Lifshitz (Butterworth-Heinemann) (3rd Edn.)
7. Classical Mechanics: With introduction to non-linear oscillations and chaos, V.B. Bhatia (Narosa Publishing House)

3rd Semester
MDC
Name: Light and optics
Code: MDC-03
Credit: 03 (2+1)

Objective:

The objective of the Light and Optics paper is to study the nature, properties, and behavior of light, and to understand how light interacts with different media through phenomena such as reflection, refraction, diffraction and interference. It also aims to explore the principles and applications of optical instruments in science and technology.

Learning Outcomes:

After completing this course, students will be able to:

1. Explain the fundamental nature and properties of light.

2. Apply the laws of reflection, refraction etc to solve optical problems.

3. Basic principles of wave phenomena such as interference and diffraction.

4. Understand the basic principles of optical instruments (e.g., microscope, mirrors, lenses).

Content:

1) Reflection, Refraction, refractive index Total internal reflection, interference, diffraction.

2) Mirror, lens Basic definitions, types, to Mirror formula / Lens formula

3) Optical instruments - eye: myopia, hypermetropia, simple microscope,

Compound microscope, periscope (Basic -principle and uses)

Reference:

1) 'A Text Book of Optics' by Brij Lal, M.N. Avadhanulu and N. Subrahmanyam
2) 'B. Sc. Optics' by TU Delft
3) 'A Text Book of Light' by B. Ghosh and K.G. Mazumdar
4) 'Principles of Optics, 7th Edition' by Max Born and Email Wolf
5) 'Basic Optics- Principles and Concepts' by Avijit Lahiri

Subject: Physics
Semester: VI
Course Name: Nuclear & Particle Physics (Theory)
Course Level: PHY-C-13
Credit:04

Course Objective:

- Basic ideas and concepts about the nucleus and other subatomic particles and their properties.
- Basic knowledge about the radioactive disintegration and of the nucleus and laws of radioactive decays.
- Knowledge on basic nuclear instrumentation and experimental techniques of nuclear physics.
- Basic knowledge of particle physics.

Learning outcome:

On successful completion of the course, the students shall be able to understand the structure and properties of a nucleus. They will also have adequate knowledge of the strong nuclear force that keeps the nuclei bound. They will learn about the radioactive decays and their properties and radioactive disintegration. Students will have adequate knowledge on the construction and working of particle accelerators and detectors. Moreover, students will be introduced to the world of elementary particles. Students can apply their knowledge in the areas of nuclear medicine, medical physics, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for the above fields.

Unit I: Basic Properties of Nuclei
Constituents of a nucleus: proton electron hypothesis, Thompson atom models, discovery of neutrons, Rutherford gold foil experiment (qualitative) and atom model, mass defect and binding energy of nuclei and their units. Binding energy binding energy per nucleon, stability of a nucleus-neutron to proton ratio, stability lines, stability limits against beta decays.

Unit II: Radioactivity and Radioactive Laws
Types of Radioactivity - alpha, beta, and gamma decay. Laws of radioactive decay, mean life, activity of a radioactive source, units of radioactivity. Alpha decay: range, ionization, and relation. GeigerNuttall law. Fine structure of alpha energy spectrum. Beta decay: types of beta decays, beta ray spectra, end point energy, Pauli's neutrino hypothesis. Gamma decay: origin of gamma rays, attenuation of gamma radiation in matter.

Unit III: Nuclear Instrumentation Detectors
Interaction of Radiation with matter: Energy loss by a charged particle due to ionization, electrons: Cerenkov radiation. Interaction of photon with matter - Photoelectric effect, Compton effect, and pair production. Gas filled detectors: Ionization chamber, proportional counter, and GM counter - construction and working principle. Charged particle accelerators, Need of charged particle accelerators, linear accelerator (LINAC)-Construction and working principle.

Unit IV: Fission and Fusion

Energy consideration in a Nuclear reaction. Mass defect and Q-value of a nuclear reaction. Einstein's massenergy relation. Nuclear Fission - discovery of nuclear energy, Theory of nuclear fission - spontaneous and induced fission, definition and examples, Fission chain reactions and nuclear reactor: peaceful applications of nuclear reactors. Fusion and thermonuclear reactions: Energy production in stars (brief qualitative discussions).

Unit V: Elementary Particles

Classification of elementary particles and their properties. Conservation laws - Allowed and forbidden reactions, Types of interactions strong, electro-magnetic and weak interactions.

Reading list:

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2.Nuclear Physics by S N Ghoshal, First edition, S Chand Publication, 2010.
3.Introduction to Nuclear Physics by K S Krane, 2nd Edition, Wiley-India Publication, 2008.
4.Radiation detection and measurement, G F Knoll, John Wiley Publication, 2010.
5.Schaum's Outline of Modern Physics, McGraw Hill, Tata McGraw Hill, 1999.
6.Concept of Modern Physics by Arthur Beiser Gupta, 2nd edition, Tata McGraw Hill Education, 2009.
7.Nuclear Radiation Detector by S S Kapoor and V S Ramamurthy, 1st edition, New Age international publisher.

Subject: Physics
Semester: VI
Course Name: Digital Electronics (Theory)
Course Level: PHY-C-14
Credit:03

Course Objective:

- To introduce the students to the basics of digital electronics and applications with hands-on experience in implementing some hardware.
- To enable students to develop and implement digital logic and apply it to solve reallife problems.
- To analyze, design and implement various combinational and sequential logic circuits.
- To classify different semiconductor memories.

Learning outcome:
After successful completion of the course student will be able to develop, implement and test combinational and sequential logic circuits and apply them to solve real-life problems and classify different semiconductor memories.

Unit I: Integrated Circuits (Qualitative treatment only)
Active & Passive Components, Discrete components, Wafer, Chip, Advantages and drawbacks of ICs, The scale of integration - SSI, MSI, LSI, and VLSI (basic idea and definitions only) and classification of ICs, Examples of Linear and Digital ICs

Unit II: Digital Circuits
Difference between Analog and Digital circuits, Number Systems - 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 (Universal Gates), XOR and XNOR Gates.

Unit III: Boolean Algebra
De Morgan's Theorems, Boolean Laws, Simplification of Logic Expression using Boolean Theorems, Fundamental Products. The idea of Minterms and Maxterms, Conversion of Truth table into Equivalent Logic Circuit by (1) Sum of Products methods and (2) Karnaugh Map.

Unit IV: Arithmetic Circuits
Binary Addition, Binary Subtraction using 2's Complement, Half Adder and Full Adder, Half Subtractor and Full Subtractor, 4bit Binary Adder/Subtractor.

Unit V: Timers
IC 555 Timers: IC 555 block diagram and applications: Astable Multivibrator and Monostable Multivibrator

Unit VI: Sequential Circuits
SR, D, and JK Flip-flops, Clocked (Level and Edge Triggered) Flipflops, Preset and Clear operations, Race- around conditions in JK Flipflop, M/S JK Flip-flop.

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

Unit VIII: Computer Organization
Input/output Devices, Data storage (the idea of RAM and ROM), Computer memory, Memory organization & addressing.

Reading list:

1. Digital Principles and Applications, A P Malvino, D P Leach and Saha, 7th Ed., 2011, Tata McGraw Hill.
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics G K Kharate 2010, Oxford University Press.
5. Digital Systems: Principles & Applications, R J Tocci, N S Widmer, 2001, PHI Learning.
6. Logic circuit design, Shimon P Vingron, 2012, Springer.
7. Digital Electronics, Subrata Ghoshal, 2010, 1st Cengage Learning.
8. Digital Electronics, S K Mandal, 2010, 1st Cengage Learning.
9. Electronics Fundamentals and Applications, D Chattopadhyay and P C Rakshit, 17th Edn, New Age International Publisher.

Subject: Physics
Semester: VI
Course Name: Digital Electronics (Practical)
Course Level: PHY-C-14
Credit:01

Course Objective:

- To introduce the students to the basics of digital electronics and applications with hands-on experience in implementing some hardware.
- To enable students to develop and implement digital logic and apply it to solve reallife problems.
- To analyze, design and implement various combinational and sequential logic circuits.
- To classify different semiconductor memories.

Learning outcome:
After successful completion of the course student will be able to develop, implement and test combinational and sequential logic circuits and apply them to solve real-life problems and classify different semiconductor memories

Content:
<u>At least four from the following:</u>
1.To design a switch (NOT gate) using (i) a PNP transistor and (ii) an NPN transistor.
2.To verify and design AND, OR, NOT, and XOR gates using NAND gates.
3.To design a combinational logic system for a specified Truth Table,
4.To convert a Boolean expression into a logic circuit and design it using logic gate ICs.
5.To design a Half Adder and Full Adder.
6. To design a 4-bit Adder.
7.To design a Half Subtractor and Full Subtractor.
8.To design Adder-Subtractor using Full Adder IC.
9.To design an astable multivibrator of given specifications using 555 Timer.
10.To design a monostable multivibrator of given specifications using 555 Timer.
11.To build a D flip-flop circuit using NAND gates.
12.To build a JK flip-flop circuit using NAND gates.
13.To build JK Master-slave flip-flop using flip-flop ICs.
14.To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-flop ICs.
15.To build SR flip-flop circuit using NAND gates.

Reading list:

1. Digital Principles and Applications, A P Malvino, D P Leach and Saha, 7th Ed., 2011, Tata McGraw Hill.
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics G K Kharate 2010, Oxford University Press.
5. Digital Systems: Principles & Applications, R J Tocci, N S Widmer, 2001, PHI Learning.
6. Logic circuit design, Shimon P Vingron, 2012, Springer.
7. Digital Electronics, Subrata Ghoshal, 2010, 1st Cengage Learning.

8. Digital Electronics, S K Mandal, 2010, 1st Cengage Learning.
9. Electronics Fundamentals and Applications, D Chattopadhyay and P C Rakshit, 17th Edn, New Age International Publisher.

Subject: Physics
Semester: VI
Course Name: Condensed Matter Physics (Theory)
Course Level: PHY-C-15
Credit: 03

Course Objective:

- To provide the elementary idea about crystal structure, bonding and lattice dynamics in solids.
- To make the students understand the concepts of transport properties, dielectric properties, ferroelectric properties and magnetic properties of materials.
- To familiarize students with nanomaterials, thin film, soft matter and superconductivity.

Learning outcome:

On successful completion of the course, students will be able to acquire the basic knowledge about crystal structure, bonding in solids and elementary idea lattice dynamics of solids, the physics of materials, dielectric, ferroelectric and magnetic properties of solids, the physics of electrons in solids, basic idea about nanomaterials, thin film and soft matter and understand the basic concept in superconductivity.

Unit I: Crystal Structure and Bonding in Solids
Amorphous, crystalline and polycrystalline materials, lattice translation vectors, unit cell, types of lattices, inter planar spacing, Miller Indices, inter planar spacing for cubic lattices, Miller Indices, ionic, covalent, metallic, van-derWaal and Hydrogen bonding, cohesive energy of ionic crystal, Madelung constant.

Unit II: Elementary Lattice Dynamics
Basic idea of lattice vibration and phonons, Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids, T3 Law.

Unit III: Dielectric and Ferroelectric Properties of Materials
Polarization, local electric field at an atom, depolarization field, electric susceptibility, polarizability, Clausius Mossotti equation, practical limitations of Clausius Mossotti equation, normal and anomalous dispersion, Cauchy and Selmeier relations. LangevinDebye equation. Piezoelectric effect, pyroelectric and ferroelectric effects, dielectric electrostrictive effect, Curie-Weiss Law.

Unit IV: Transport properties of materials
Free electron theory of metals, electrical and thermal conductivity, Wiedemann-Franz law, drawback of classical theory and modification with quantum theory, preliminary idea of band theory, band gap, conductor, semiconductor (p and n type) and insulator, conductivity of semiconductors, mobility, 2-probe and 4-probe resistivity measurement method, Hall effect (Qualitative idea)

Unit V: Nanophysics and soft matter

Basic idea about nanomaterials, thin film physics and soft matter.

Unit VI: Magnetic Properties of Matter

Dia-, para-, ferri-, ferro- and antiferro-magnetic properties, classical Langevin Theory of dia- and para-magnetism, Curie's law, Weiss' theory of Ferromagnetic, BH curve, Hysteresis and energy Loss.

Unit VII: Superconductivity

Basic idea of superconductivity, critical temperature, critical magnetic field, Meissner effect, Type I and Type II superconductors, Isotope effect.

Reading list

1. Introduction to Solid State Physics, C Kittel 2.
Lattice Dynamics, A K Ghatak and L S Kothari
3. Solid State Physics, A J Dekker.
4. Introductory Solid State Physics, H P Myers.
5. Solid State Physics, N W Ashcroft and N D Mermin
6. Magnetism in solids, D H Martin
7. Physics of Magnetism, S Chikazumi.
8. Solid State Physics, S O Pillai.
9. Introduction to Nanotechnology, C P Poole, J F J Owens

Subject: Physics
Semester: VI
Course Name: Condensed Matter Physics (Practical)
Course Level: PHY-C-15
Credit: 01

Course Objective:

- To provide the elementary idea about crystal structure, bonding and lattice dynamics in solids.
- To make the students understand the concepts of transport properties, dielectric properties, ferroelectric properties and magnetic properties of materials.
- To familiarize students with nanomaterials, thin film, soft matter and superconductivity.

Learning outcome:
On successful completion of the course, students will be able to acquire the basic knowledge about crystal structure, bonding in solids and elementary idea lattice dynamics of solids, the physics of materials, dielectric, ferroelectric and magnetic properties of solids, the physics of electrons in solids, basic idea about nanomaterials, thin film and soft matter and understand the basic concept in superconductivity.

Content:
At least four from the following:
1. Indexing of powder X-Ray diffraction data of cubic crystalline materials and determination of lattice parameters including inter planner spacing (X-Ray diffraction data needs to be arranged by department).
2. Measurement of susceptibility of (Quinck's Tube Method).
3. To measure the magnetic susceptibility of solids.
4. To determine the Coupling Coefficient of a piezoelectric crystal.
5. To measure the Dielectric constant of a dielectric materials with frequency.
6. To study the P−E Hysteresis loop of a Ferroelectric Crystal.
7. To draw the B−H curve of Fe using Solenoid & determine energy loss from Hysteresis.
8. To measure the variation of resistivity of a semiconductor with temperature by four-term method and to determine band gap.
9. To determine the Hall coefficient of a semiconductor sample.

Reading list
1. Introduction to Solid State Physics, C Kittel 2.
Lattice Dynamics, A K Ghatak and L S Kothari
3. Solid State Physics, A J Dekker.
4. Introductory Solid State Physics, H P Myers.
5. Solid State Physics, N W Ashcroft and N D Mermin
6. Magnetism in solids, D H Martin
7. Physics of Magnetism, S Chikazumi.
8. Solid State Physics, S O Pillai.
9. Introduction to Nanotechnology, C P Poole, J F J Owens

Subject: Physics
Semester: VI
Course Name: Electromagnetic Theory (Theory)
Course Level: PHY-C-16
Credit: 03

Course Objective:

- To lay the foundation of electromagnetism through Maxwell's equations.
- Behaviour of electromagnetic waves as it propagates through vacuum and other media.
- Various effects that occur as electromagnetic waves propagate from one medium to another medium.
- Basic concepts of waveguides and fibre optics.
- Various aspects of electromagnetic wave polarisation.

Learning outcome:

After the successful completion of the course, students will acquire the concepts of Maxwell's equations, propagation of electromagnetic (EM) waves in different homogeneous isotropic as well as anisotropic unbounded and bounded media, production and detection of different types of polarized EM waves, general information of waveguides and fibre optics.

Unit I: Maxwell's equations
Maxwell's equations, Displacement Current, Vector and Scalar Potentials, Gauge Transformations: Coulomb and Lorentz Gauge, Boundary Conditions at Interface between Different Media, Poynting Theorem and Poynting Vector.

Unit II: EM Wave Propagation in Unbounded Media
Plane EM Waves through Vacuum and Isotropic Dielectric Medium, Transverse Nature of Plane EM Waves, Refractive Index and Dielectric Constant, Propagation through Conducting Media, Relaxation Time, Skin Depth, Wave Propagation through Dilute Plasma (Basic Concepts).

Unit III: EM wave in Bounded Media
Reflection and Refraction of Plane EM Waves at Plane Interface between two Dielectric Media - Laws of Reflection and Refraction, Fresnel's Formula for Perpendicular Polarization Case, Brewster's Law, Reflection and Transmission Coefficients, Waveguides, Basic Concepts and Propagation of EM Waves in a Rectangular Waveguide.

Unit IV: Polarization of Electromagnetic Waves
Description of Linear, Circular and Elliptical Polarization, Propagation of EM Waves in Anisotropic Media, Symmetric Nature of Dielectric Tensor, Fresnel's Formula, Uniaxial and Biaxial Crystals, Light Propagation in Uniaxial Crystal, Double Refraction, Polarization by Double Refraction, Nicol Prism, 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.

Unit V: Rotary Polarization

Optical Rotation, Biot's Laws for Rotary Polarization, Fresnel's Theory of Optical Rotation, Calculation of Angle of Rotation, Experimental Verification of Fresnel's Theory, Specific rotation, Laurent's Half-Shade Polarimeter.

Unit VI: Optical Fibres

Numerical Aperture, Step and Graded Indices (Definitions Only), Single and Multiple Mode Fibres (Concept and Definition Only)

Reading list:

1. Introduction to electrodynamics, D. J. Griffiths.
2. Electromagnetics, B. B. Laud, New Age International Publishers.
3. Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
4. Introduction to Electromagnetic Theory, T. L. Chow, 2006, Jones & Bartlett Learning.
5. Feynman Lectures Vol. 2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
6. Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill.
7. Electromagnetic Field Theory, R. S. Kshetriymayun, 2012, McGraw Hill.
8. Engineering Electromagnetic, William H. Hayt, 2012, McGraw Hill.
9. Electricity and Magnetism [With electromagnetic theory and special theory of relativity], D. Chattopadhyay and P. C. Rakshit, 2013, New Central Book Agency (P) LimitedSubject: Physics

Subject: Physics
Semester: VI
Course Name: Electromagnetic Theory (Practical)
Course Level: PHY-C-16
Credit: 01

Course Objective:

- To lay the foundation of electromagnetism through Maxwell's equations.
- Behaviour of electromagnetic waves as it propagates through vacuum and other media.
- Various effects that occur as electromagnetic waves propagate from one medium to another medium.
- Basic concepts of waveguides and fibre optics.
- Various aspects of electromagnetic wave polarisation.

Learning outcome:

After the successful completion of the course, students will acquire the concepts of Maxwell's equations, propagation of electromagnetic (EM) waves in different homogeneousisotropic as well as anisotropic unbounded and bounded media, production and detection of different types of polarized EM waves, general information of waveguides and fibre optics.

Content:
<u>At least four from the following:</u>
1.To verify the law of Malus for plane polarized light.
2.To determine the specific rotation of sugar solution using Polarimeter.
3.To analyze elliptically polarised light by using Babinet's compensator.
4.To study dependence of radiation on angle for a single Dipole antenna.
5.To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene etc.) by studying the diffraction through ultrasonic grating.
6.To study the reflection and refraction of microwaves.
7.To study polarization and double slit interference in microwaves.
8.To determine the refractive index of liquid by total internal reflection using Wollaston's airfilm.
9.To determine the refractive index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10.To study the polarization of light by reflection and determine the polarizing angle for airglass interface.
11To verify the Stefan's law of radiation and to determine Stefan's constant.
12.To determine the Boltzmann constant using V-I characteristic of pn junction diode.

Reading list:
1. Introduction to electrodynamics, D. J. Griffiths.
2.Electromagnetics, B. B. Laud, New Age International Publishers.
3. Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.

4. Introduction to Electromagnetic Theory, T. L. Chow, 2006, Jones & Bartlett Learning. 5. Feynman Lectures Vol. 2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
6. Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill.
7. Electromagnetic Field Theory, R. S. Kshetriymayun, 2012, McGraw Hill.
8. Engineering Electromagnetic, William H. Hayt, 2012, McGraw Hill.
9. Electricity and Magnetism [With electromagnetic theory and special theory of relativity], D. Chattopadhyay and P. C. Rakshit, 2013, New Central Book Agency (P) LimitedSubject: Physics.

Subject: Physics
Semester: VI
Course Name: Nuclear & Particle Physics (Theory)
Course Level: PHY-M-06
Credit:04

Course Objective:

- Basic ideas and concepts about the nucleus and other subatomic particles and their properties.
- Basic knowledge about the radioactive disintegration and of the nucleus and laws of radioactive decays.
- Knowledge on basic nuclear instrumentation and experimental techniques of nuclear physics.
- Basic knowledge of particle physics.

Learning outcome:

On successful completion of the course, the students shall be able to understand the structure and properties of a nucleus. They will also have adequate knowledge of the strong nuclear force that keeps the nuclei bound. They will learn about the radioactive decays and their properties and radioactive disintegration. Students will have adequate knowledge on the construction and working of particle accelerators and detectors. Moreover, students will be introduced to the world of elementary particles. Students can apply their knowledge in the areas of nuclear medicine, medical physics, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for the above fields.

Unit I: Basic Properties of Nuclei
Constituents of a nucleus: proton electron hypothesis, Thompson atom models, discovery of neutrons, Rutherford gold foil experiment (qualitative) and atom model, mass defect and binding energy of nuclei and their units. Binding energy binding energy per nucleon, stability of a nucleus-neutron to proton ratio, stability lines, stability limits against beta decays.

Unit II: Radioactivity and Radioactive Laws
Types of Radioactivity - alpha, beta, and gamma decay. Laws of radioactive decay, mean life, activity of a radioactive source, units of radioactivity. Alpha decay: range, ionization, and relation. GeigerNuttall law. Fine structure of alpha energy spectrum. Beta decay: types of beta decays, beta ray spectra, end point energy, Pauli's neutrino hypothesis. Gamma decay: origin of gamma rays, attenuation of gamma radiation in matter.

Unit III: Nuclear Instrumentation Detectors
Interaction of Radiation with matter: Energy loss by a charged particle due to ionization, electrons: Cerenkov radiation. Interaction of photon with matter - Photoelectric effect, Compton effect, and pair production. Gas filled detectors: Ionization chamber, proportional counter, and GM counter - construction and working principle. Charged particle accelerators, Need of charged particle accelerators, linear accelerator (LINAC)-Construction and working principle.

Unit IV: Fission and Fusion

Energy consideration in a Nuclear reaction. Mass defect and Q-value of a nuclear reaction. Einstein's massenergy relation. Nuclear Fission - discovery of nuclear energy, Theory of nuclear fission - spontaneous and induced fission, definition and examples, Fission chain reactions and nuclear reactor: peaceful applications of nuclear reactors. Fusion and thermonuclear reactions: Energy production in stars (brief qualitative discussions).

Unit V: Elementary Particles

Classification of elementary particles and their properties. Conservation laws - Allowed and forbidden reactions, Types of interactions strong, electro-magnetic and weak interactions.

Reading list:

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2.Nuclear Physics by S N Ghoshal, First edition, S Chand Publication, 2010.
3.Introduction to Nuclear Physics by K S Krane, 2nd Edition, Wiley-India Publication, 2008.
4.Radiation detection and measurement, G F Knoll, John Wiley Publication, 2010.
5.Schaum's Outline of Modern Physics, McGraw Hill, Tata McGraw Hill, 1999.
6.Concept of Modern Physics by Arthur Beiser Gupta, 2nd edition, Tata McGraw Hill Education, 2009.
7.Nuclear Radiation Detector by S S Kapoor and V S Ramamurthy, 1st edition, New Age international publisher.

Subject: Physics
Semester: VIII

Course Name: Modern Spectroscopic Techniques in Physical Sciences
Course Level: PHY**-C-21**
Credit: **04**

Course Objective

The primary objective of this course is to bridge the gap between fundamental quantum mechanics and the practical application of spectroscopic techniques in modern research. It aims to:

- Establish a rigorous understanding of atomic and molecular structures through the lens of symmetry and group theory.
- Analyze the interaction of electromagnetic radiation with matter, transitioning from simple rigid models to complex anharmonic and non-linear systems.
- Introduce high-end characterization tools such as XPS, SEM-EDX, and Synchrotron radiation to prepare students for experimental research environments.
- Develop analytical skills for interpreting complex spectral data (IR, Raman, NMR, and Mass Spectrometry) to determine molecular geometry and elemental composition.

Learning outcome

Upon successful completion of this course, students will be able to systematically identify molecular point groups and apply symmetry arguments to predict the activity of vibrational and rotational modes. They will demonstrate a comprehensive grasp of the mathematical frameworks underlying Fourier Transform techniques and magnetic resonance, enabling them to interpret multi-dimensional spectral data with precision. Beyond theoretical proficiency, students will gain the ability to select appropriate spectroscopic or surface-imaging techniques—such as SEM or XPS—for specific materials-science problems, effectively bridging the divide between physical principles and laboratory characterization. Ultimately, the learner will be equipped to evaluate transition probabilities, electronic life-times, and structural dynamics, providing a solid foundation for doctoral research or industrial R&D in the physical sciences.

Unit I: Atomic Structure and Symmetry Foundations

- Vector Atom Model: Review of L-S and j-j coupling; fine structure of hydrogen and alkali atoms; Landé g-factor and the Zeeman Effect (Normal/Anomalous), Molecular Symmetry: Introduction to symmetry elements and operations (i, C_n, σ, S_n); Identifying point groups for simple molecules (H_2O, NH_3, CO_2), Symmetry Selection Rules: Qualitative application of Group Theory to determine IR and Raman activity, Nuclear Effects: Hyperfine structure and the effect of nuclear spin on spectral intensity.

Unit II: Rotational and Vibrational Spectroscopy

- Microwave Spectroscopy: Energy levels of rigid and non-rigid rotators; selection rules and population of levels (Boltzmann distribution); Determination of bond lengths, Infrared (IR) Spectroscopy: Harmonic and anharmonic oscillators; Morse potential; Vibration-rotation spectra and selection rules (P, Q, R branches), FTIR Principles: The Michelson Interferometer; Advantages of Fourier Transform techniques (Fellgett's and Jacquinot's advantages), Raman Effect: Quantum and Classical theories; Rotational and Vibrational Raman spectra; Mutual Exclusion Principle for centrosymmetric molecules.

Unit III: Electronic, Resonance, and Photoelectron Spectroscopy

- Electronic Transitions: Vibrational coarse structure and the Franck-Condon Principle; Dissociation energy determination, Magnetic Resonance: Basic principles of NMR; Chemical shift and spin-spin coupling; Introduction to ESR (EPR) and the hyperfine splitting in the Hydrogen atom, X-ray Photoelectron Spectroscopy (XPS): Photoelectric effect in inner-shell electrons; Binding energy and chemical shift analysis for surface characterization, Luminescence: Jablonski diagram; internal conversion, intersystem crossing, fluorescence, and phosphorescence.

Unit IV: Advanced Analytical and Research Techniques

- Mass Spectrometry: Principles of ion production (EI and FAB); Mass-to-charge (m/z) ratio and basic fragmentation patterns, Structural Mapping: Principles of Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray (EDX) analysis, Laser Spectroscopy: Population inversion and stimulated Raman scattering; Introduction to Laser-Induced Breakdown Spectroscopy (LIBS), Synchrotron Applications: Brief overview of X-ray Absorption Fine Structure (EXAFS) for local atomic coordination.

Reading list:

1. Fundamentals of Molecular Spectroscopy, C.N. Banwell & E.M. McCash, McGraw-Hill, 1994
2. Molecular Structure and Spectroscopy, Second Edition, G. Aruldhas, PHI Learning Private Ltd.
3. Modern Spectroscopy, J. Michael Hollas (Wiley)
4. Laser Spectroscopy: Basic Concepts and Instrumentation – Wolfgang Demtröder (Springer)
5. Principles of Instrumental Analysis – Douglas A. Skoog, F. James Holler, and Stanley R. Crouch (Cengage)

Subject: Physics
Semester: VIII

Course Name: Advanced Digital Electronics (Theory)
Course Level: PHY**-C-22**
Credit: **03**

Course Objective

- To develop advanced understanding of digital systems and design.
- To study modern digital components like PLDs, FPGA, and microprocessors.
- To introduce real-world applications in computing and embedded systems.
- To build problem-solving and circuit design skills.

Learning Outcomes

After completion, students will be able to:

- Design and analyze complex digital circuits.
- Understand modern programmable logic devices.
- Work with microprocessors and embedded systems.
- Apply digital electronics in real-world applications.

Unit I: Advanced Combinational Logic Design: Review of basic logic gates and Boolean algebra, Minimization techniques: Karnaugh Maps (K-map) and Quine–McCluskey method, Design of complex combinational circuits: Multiplexers and Demultiplexers, Encoders and Decoders, Magnitude Comparators
Arithmetic circuits: Parallel adders and subtractors, Carry Look-Ahead Adder (CLA)

Unit II: Sequential Logic Circuits: Flip-Flops: SR, JK, D, T (detailed timing analysis)
Race conditions and hazards, Counters: Asynchronous and synchronous counters,
Up/Down counters, Ring and Johnson counters
Shift Registers: SISO, SIPO, PISO, PIPO: State machine design: Mealy and Moore machines

Unit III: Memory Devices and Logic Families: Semiconductor memories: RAM, ROM, PROM, EPROM, EEPROM: Memory organization and addressing,
Logic families: TTL, CMOS, ECL (comparison), Power dissipation and speed considerations

Unit IV: Programmable Logic Devices (PLDs): Introduction to PLDs
Types: PLA (Programmable Logic Array), PAL (Programmable Array Logic), CPLD (Complex PLD), Introduction to FPGA (Field Programmable Gate Array) , Basic architecture and applications

Unit V: Microprocessors and Microcontrollers:
Basic architecture of microprocessors, Study of a typical processor (8085 or equivalent)
Instruction sets and addressing modes, Introduction to microcontrollers (8051),
Applications in control systems
Unit VI: Digital System Design & Applications: Digital to Analog and Analog to Digital Converters: DAC (Binary weighted, R-2R ladder), ADC (Successive approximation, Flash ADC), Introduction to digital communication basics, Interfacing and real-world applications, Embedded systems overview

Reading list:

1. Digital Design – M. Morris Mano
2. Digital Electronics – R.P. Jain
3. Modern Digital Electronics – R.P. Jain
4. Fundamentals of Digital Circuits – A. Anand Kumar

Subject: Physics
Semester: VIII

Course Name: Advanced Digital Electronics (Practical)
Course Level: PHY**-C-22**
Credit: **01**

Course Objectives

- To provide hands-on experience with digital electronic circuits.
- To verify theoretical concepts through experiments.
- To develop skills in circuit design, simulation, and testing.

Learning Outcomes

Students will be able to:

- Construct and test digital circuits.
- Analyze behavior of sequential systems.
- Use simulation tools for circuit design.
- Apply digital electronics concepts in real-life systems.

List of Experiments

1. Verification of basic logic gates using ICs.
2. Implementation of Boolean expressions using logic gates.
3. Design and verification of Half Adder and Full Adder.
4. Study of Multiplexer (4:1 / 8:1) and Demultiplexer.
5. Study of Encoder and Decoder circuits.

Group B: Sequential Circuits

1. Verification of Flip-Flops (SR, JK, D, T).
2. Design and study of Asynchronous Counter (Ripple Counter).
3. Design of Synchronous Counter (Up/Down).
4. Study of Shift Registers (SISO, SIPO).

Group C: Advanced Digital Circuits

1. Design of Ring Counter / Johnson Counter.
2. Study of Digital to Analog Converter (R-2R Ladder DAC).
3. Study of Analog to Digital Converter (ADC – Simulation/Trainer Kit).

Group D: Simulation-Based Experiments

1. Simulation of combinational circuits using Multisim or Proteus or any available simulation software
2. Design of a simple digital system (e.g., traffic light controller / digital counter) using simulation tools.

Mini Project (Compulsory – Any One)

Digital Clock Design, Traffic Light Controller, Simple Calculator using Logic Gates
Binary Counter with Display, Or any project based on the syllabus

Reading list:

1. Digital Design – M. Morris Mano
2. Digital Electronics – R.P. Jain
3. Modern Digital Electronics – R.P. Jain
4. Fundamentals of Digital Circuits – A. Anand Kumar

Subject: Physics
Semester: VIII

Course Name: Analog and Digital Electronics (Theory)
Course Level: PHY-**M-8**
Credit: **03**

Course Objective

- To develop fundamental understanding of analog electronic devices and circuits.
- To introduce digital electronics and logic design principles.
- To bridge theoretical knowledge with practical applications in modern electronics.
- To build analytical and problem-solving skills relevant to interdisciplinary fields.

Learning outcomes:

After completion, students will be able to:

- Understand working and applications of semiconductor devices.
- Analyze basic analog circuits like amplifiers and oscillators.
- Apply Boolean algebra and design digital logic circuits.
- Understand memory elements and digital systems.
- Relate electronics concepts to real-world devices.

UNIT I: Semiconductor Devices & Analog Fundamentals: (L-9 Hours)

Review of semiconductor physics: intrinsic and extrinsic semiconductors, p-n junction diode: characteristics and applications, Zener diode and voltage regulation, Bipolar Junction, Transistor (BJT): configuration (CE, CB, CC), characteristics, Basic amplifier concept and gain

UNIT II: Analog Circuits: (L-9 Hours)

Transistor biasing and stabilization, Single-stage CE amplifier: working and frequency response, Feedback in amplifiers: concept and types, Oscillators: Barkhausen criterion, RC phase shift oscillator and LC oscillator (basic idea)

UNIT III: Digital Electronics Fundamentals (L-9 Hours)

Number systems: Binary, Octal, Hexadecimal, Boolean algebra and logic gates (AND, OR, NOT, NAND, NOR, XOR), De Morgan's theorems, Simplification of Boolean expressions (K-map up to 4 variables), Combinational circuits: Half adder, Full adder, Multiplexer, Demultiplexer

UNIT IV: Sequential Circuits & Applications (L-9 Hours)

Flip-flops: SR, JK, D, T (concept and truth tables), Registers and Counters (basic concepts), Digital memory: RAM, ROM (introductory idea), Analog-to-Digital (ADC) and Digital-to-Analog (DAC) conversion (basic principle), Applications in communication and computing systems.

Reading list:

1) Principles of Electronics, V.K. Mehta and Rohit Mehta, S. Chand Publication
2) Basic Electronics, solid state. B.L. The Raja, S. Chand Pub.
3) Electronic Principles, Albert Malvino, David J. Bates, Patrick E. Hoppe; Mc. Graw Hill
4) Sedra & Smith – Microelectronic Circuits
5) Morris Mano – Digital Logic and Computer Design

6) Floyd – Digital Fundamentals

Subject: Physics
Semester: VIII

Course Name: Analog and Digital Electronics (Practical)
Course Level: PHY**-M-8**
Credit: **01**

Course Objective

- To provide hands-on experience with basic electronic components and circuits.
- To verify theoretical concepts of analog and digital electronics through experiments.
- To develop skills in circuit design, measurement, and troubleshooting.
- To introduce simulation tools for circuit analysis.

Learning Outcomes:

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

- Identify and use basic electronic components and instruments.
- Construct and analyze simple analog circuits.
- Design and verify digital logic circuits.
- Perform measurements using standard laboratory equipment.
- Simulate circuits using basic electronic software tools.

List of Experiments

Section A: Analog Electronics Experiments (Any 4 experiments**)**

1) Study of V-I characteristics of a p-n junction diode and determination of cut-in voltage.
2) Study of Zener diode characteristics and its use as a voltage regulator.
3) Input and output characteristics of a BJT in Common Emitter (CE) configuration.
4) Study of single-stage CE amplifier and determination of voltage gain.
5) Study of frequency response of an RC-coupled amplifier.
6) Construction and study of RC phase shift oscillator (demonstration/simulation acceptable).

Section B: Digital Electronics Experiments (Any 4 experiments)

1) Verification of basic logic gates (AND, OR, NOT, NAND, NOR, XOR) using ICs.
2) Verification of De Morgan's Theorems using logic gates.
3) Design and verification of Half Adder and Full Adder circuits.
4) Study of Multiplexer (MUX) and Demultiplexer (DEMUX).
5) Study of SR and JK flip-flops.
6) Design of simple binary counter (using ICs or simulation).
7) Section C: Skill / Simulation-Based Experiments (Compulsory – Any 2)
8) Simulation of analog circuits using software (e.g., Multisim / Proteus / LTspice).
9) Simulation of digital logic circuits and truth table verification.
10) Breadboard assembly and troubleshooting techniques

THE END

Subject: Physics
Semester: VII
Course Name: Atomic and Molecular Physics (Theory)
Course Level: PHY**-C-17**
Credit: **03**

Course Objective

- To learn the development of atom models.
- To learn the origin of atomic spectra and their modifications under different physical conditions.
- To learn the basics of molecular spectra for diatomic molecule and a few applications.

Learning outcome

Students will be ability to describe the atomic spectra of one and two valance electron atoms and will also understand the change in behavior of atoms and corresponding modification of their spectra in external applied electric and magnetic field. They will understand the basic principle of pure rotational, vibrational, Rotation-Vibration and Raman spectra of molecules and their few applications.

Unit I: Atom Model
The Bohr -model of the hydrogen-like atom,
Sommerfeld Relativistic Atom Model: Elliptical orbits, explanation of fine structure of H alpha line in Balmer series of hydrogen atom. Limitation of Sommerfeld atom model. Orbital magnetic dipole moment: Bohr Magneton, Gyromagnetic Ratio, Larmor precession, Space Quantization, Electron Spin, quantum numbers associated with vector -atom model, spin-orbit interaction, Coupling Schemes: L-S Coupling and j-j Coupling, Spectroscopic term and their notation, Stern-Gerlach experiment and its conclusion. Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).
Unit II: X- rays
Ionizing Power, X-ray Diffraction, Bragg's
Law, X-ray Spectra: Continuous and characteristic X- rays Mosley's law, Compton effect.
Unit III: Multi electron atoms
Hund's rule, Periodic table: Pauli's exclusion principle, explanation of the periodic classification of the elements, Building up or Aufbau Principle, Broad features of Alkali atom (Na etc.) spectra and its explanation.
Unit IV: Molecular Spectra
Rotational Energy levels, Selection Rules and Pure Rotational Spectra of a diatomic Molecule. Vibrational Energy Levels, Selection Rules and Vibration Spectra of a diatomic Molecule. Rotation-Vibration Energy Levels, Selection Rules and Rotation-Vibration Spectra. Determination of Internuclear Distance.
Unit V: Raman Effect
Quantum Theory of Raman Effect. characteristics of Raman Lines. Stoke's and Anti-Stoke's Lines Complimentary Character of Raman and infrared Spectra.

Reading list
1. Introduction to Atomic spectra, H. E. White, Tata McGraw Hill (1934)

2. Atomic and Molecular Spectra, Raj Kumar
3. Concepts of Modern Physics, Arthur Beiser (McGraw-Hill Book Company, 1987)
4. Atomic physics, J. B. Rajam & foreword by Louis De Broglie (S. Chand & Co., 2007)
5. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachein.
6. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash

Subject: Physics
Semester: VII
Course Name: Atomic and Molecular Physics (Practical)
Course Level: PHY**-C-17**
Credit: **01**

Course Objective

- To provide experimental understanding of atomic and molecular phenomena.
- To develop skills in spectroscopy and quantum-based measurements.
- To correlate theoretical concepts (atomic spectra, molecular structure) with experimental observations

Learning outcome

After completion, students will be able to:

- Analyze atomic spectra and determine fundamental constants.
- Understand molecular vibrational and rotational behavior.
- Use spectrometers and optical instruments with precision.
- Interpret experimental data using quantum concepts.

List of Experiments:

Group A: Atomic Physics Experiments

1) Hydrogen Spectrum Study: Determination of Rydberg constant using spectral lines.
2) Spectrometer Handling: Calibration of spectrometer using known spectral lines (e.g., mercury lamp).
3) Determination of Wavelength: Measurement of unknown spectral lines using diffraction grating.
4) Photoelectric Effect (Simulation/Experimental): Determination of Planck's constant (h) or threshold frequency.

Group B: Molecular Physics Experiments

1) Vibrational Spectrum Analysis: Study of molecular vibrational modes (using IR spectra or simulation).
2) Rotational Spectrum Study (Demonstration/Simulation): Determination of bond length or rotational constants.
3) Raman Effect (Demonstration/Virtual Lab): Identification of Stokes and Anti-Stokes lines.

Group C: General / Skill-Based Experiments

1) Determination of Refractive Index: Using prism or liquid cell (linked to molecular properties).
2) Polarization of Light: Verification of Malus' Law.
3) Absorption Spectrum Analysis: Study of absorption bands of solutions (basic spectrophotometry).

Use of Computational / Virtual Labs:

1) Simulation of atomic spectra.
2) Virtual experiments on photoelectric effect and Raman spectroscopy.
3) Data analysis using spreadsheet/simulation tools

Reading List:

1) B.H. Bransden & C.J. Joachain – Physics of Atoms and Molecules

2) H.E. White – Introduction to Atomic Spectra
3) C.N. Banwell – Fundamentals of Molecular Spectroscopy
4) K. Thyagarajan & A.K. Ghatak – Lasers: Theory and Applications

Subject: Physics
Semester: VII
Course Name: Quantum Mechanics-II
Course Level: PHY**-C-18**
Credit: **04**

Course Objective

- Introduce the learners with the formalism of Quantum Mechanics.
- Acquaint the learners with Dirac notation.
- Enable the learners to solve simple quantum mechanical problems.
- Introduce the learners with symmetry and conservation laws.
- Introduce the learners with angular momentum algebra.
- Acquaint the learners with approximation methods in quantum mechanics.

Learning outcome

Students will be able to learn the key concepts in quantum mechanics and their importance in physics. Explain the formalism, the role of symmetry and approximation methods in quantum mechanics. Recognize the approximation method suitable for a quantum mechanical problem. Apply the above quantum mechanical concepts. Solve quantum mechanical problems based on the key concepts learnt. Use approximation methods to solve real world physics problems like fine structure of hydrogen atom, Stark effect, Zeeman effect etc.

Unit I: Formalism

Overview of wave mechanics, Schrödinger equation, application to some important physical problems: particle in a box, simple harmonic oscillator, delta function potential, hydrogen atom, t Kets, Bras and Operators, Base Kets and Matrix Representations, Measurements, Observables and Uncertainty Relations, Change of basis, Generalized Uncertainty Principle. Time evolution and the Schrödinger equation, the Schrödinger versus the Heisenberg picture, time evolution of the simple harmonic oscillator.

Unit II: Symmetry in Quantum Mechanics

Symmetries, Conservation laws and Degeneracy, Space and Time displacements, Rotation, Angular Momentum and Unitary groups, commutation relations, Eigenvalues and Eigenstates of Angular Momentum, Addition of Angular momentum, Stern Gerlach Experiment, Spin, Clebcsh Gordon Coefficients.

Unit III: Time Independent Approximation Methods

Time independent perturbation theory and its application: Non degenerate case, Degenerate case, Stark effect, Fine structure and Zeeman Effect, Hyperfine splitting, Variational method and its application, Ground state of helium, Hydrogen molecule ion, WKB Approximation and its application.

Unit IV: Time Dependent Approximation Methods

Time dependent potentials: the Interaction picture, Time dependent perturbation theory, two level systems, Emission and absorption of radiation, Spontaneous emission, Applications to Interactions with Classical Radiation field, Adiabatic approximation, Sudden approximation.

Reading list

1. Modern Quantum Mechanics, J. J. Sakurai, Addison Wesley.
2. Quantum Mechanics, L. I. Schiff, McGraw Hill.
3. Quantum Mechanics, Bransden and Joachain, Pearson Education.
4. Quantum Mechanics, Powell and Craseman, Narosa Publishing House.
5. Quantum Mechanics, R. Shankar, Kluwer Academic.
6. Quantum Mechanics, D. J. Griffiths, Pearson Education.

Subject: Physics
Semester: VII
Course Name: Mathematical Physics-III
Course Level: PHY**-C-19**
Credit: **04**

Course Objective

The aim of this course is to

- Develop a basic understanding of these mathematical tools and methods.
- Acquaint a learner with application of these mathematical tools and methods in physics.
- Develop an adequate amount of mathematical skill among the learners to navigate through quantum mechanics, statistical mechanics, quantum field theory, general relativity, condensed matter physics, electrodynamics and a number of other areas in physics.

Learning outcome

At the completion of this course, a learner will be able to understand a few mathematical concepts and their importance in physics. Course define key terms and operations in integral transforms, linear vector spaces, complex analysis, group theory and tensor analysis. Explain the rules governing integral transforms, linear vector spaces, complex analysis, group theory and tensor analysis. Describe a problem in physics in terms of integral transforms, linear vector spaces, complex analysis, group theory and tensor analysis. Apply the above mathematical concepts to solve problems. Solve advanced level mathematical problems based on the key concepts in integral transforms, linear vector spaces, complex analysis, group theory and tensor analysis. Use the concepts in integral transforms, linear vector spaces, complex analysis, group theory and tensor analysis to solve problems in quantum mechanics, general relativity and electrodynamics. Analyze a problem in physics by relating it with the above mathematical concepts. Relate the learnt mathematical concepts with problems in physics.

Unit I: Linear Vector Spaces

Linear vector spaces- definition and examples, linear independence, basis and dimension, inner product, norm of a vector, orthonormal basis, Gram-Schmidt orthogonalization method, Schwarz's and Bessel's inequalities; linear operators, matrix representation of linear operators; special types of matrices- symmetric and antisymmetric, orthogonal, Hermitian and anti-Hermitian, unitary, normal; eigenvalues and eigenvectors; change of basis, similarity transformation, orthogonal and unitary transformations, diagonalization of matrices; infinite dimensional vector spaces, Hilbert space.

Unit II: Complex Analysis

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: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy’s Integral formula. Simply and multiply connected regions. Laurent and Taylor’s expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

Unit III: Group Theory

Groups- definition and examples, groups of symmetry transformation- cyclic group, dihedral group, permutation group; subgroups, Lagrange’s theorem, cosets, conjugacy classes; group representation; Continuous or Lie groups, generators of continuous group, special orthogonal groups- SO(2), SO(3); unitary groups- U(1), SU(2).

Unit IV: Tensor Analysis

Basics of tensor algebra, contravariant and covariant tensors, line element and metric tensor, associated tensors, Christoffel’s symbols, geodesics, covariant derivatives, Riemannian Christoffel’s tensor or curvature tensor, Bianchi identities.

Reading list

1. Complex Variables, A. S. Fokas, M. J. Ablowitz, Cambridge University Press.
2. Complex Variables, A. K. Kapoor, Cambridge University Press.
3. Mathematical Methods for Physicists, G. B. Arfken, H. J. Weber, Elsevier Academic Press.
4. Mathematical Method for Physics and Engineering, K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press.
5. Mathematical Methods in the Physical Sciences, M. L. Boas, John Wiley & Sons.
6. Elements of Group Theory for Physicists, A.W. Joshi, New Age International.
7. Group Theory in Physics, J. F. Cornwell, Academic Press.
8. Group Theory in a Nutshell for Physicists, A. Zee, Princeton University Press.
9. Tensor Calculus, B. Spain, Radha Publishing House (Kolkata).

Subject: Physics
Semester: VII
Course Name: Research Methodology
Course Level: PHY**-C-20**
Credit: **04**

Course Objective

- To develop understanding of research methods in physical sciences.
- To train students in experimental, theoretical, and computational research.
- To build skills in scientific writing, presentation, and ethics.
- To prepare students for PG studies, research, and innovation sectors.

Learning outcomes:

After completion, students will:

- Understand the principles and methodology of scientific research.
- Perform literature review and identify research problems.
- Apply statistical and computational tools in physics research. Write research reports and present findings effectively.
- Follow ethical practices and IPR guidelines

UNIT I: Introduction to Research Methodology (8 Lectures)
Meaning and objectives of research, Types of research: Basic, Applied, Experimental, Theoretical, Scientific method and research cycle, Features of good research, Interdisciplinary approach in physics, Role of research under National Education Policy 2020

UNIT II: Literature Survey and Problem Formulation (10 Lectures)
Sources of scientific literature, Use of: Google Scholar, arXiv, INFLIBNET etc., Review techniques and citation tracking, Identification of research gaps, Formulation of research problem and hypothesis

UNIT III: Research Design and Data Analysis (10 Lectures)
Research design: Experimental & theoretical, Sampling techniques, Data collection and documentation, Error analysis and uncertainty, Statistical tools: Mean, standard deviation, regression, Software tools: Python, MATLAB or any other updated software.

UNIT IV: Experimental Techniques in Physics (7 Lectures)
Measurement techniques and instrumentation, Calibration and precision, Data acquisition systems, Safety and laboratory practices, Handling modern instruments

UNIT V: Scientific Writing and Communication (6 Lectures)
Structure of research paper: Writing abstract, report, and thesis, Referencing styles (APA/IEEE); Use of: LaTeX, Mendeley, Oral and poster presentations.
UNIT VI: Research Ethics and IPR (4 Lectures)
Ethics in research: plagiarism, falsification, Plagiarism detection tools, Intellectual Property, Rights (IPR) in India, Patents and copyrights

*****NOTE: PRACTICAL / PROJECT**
Project Guidelines, must include:
- ✓ Literature review
- ✓ Methodology
- ✓ Data analysis
- ✓ Conclusion

Seminar/Presentation:
Project Guidelines- Individual or group (max 2 students)
Topic approved by departmental committee

Reading list:

1) C.R. Kothari – Research Methodology
2) John R. Taylor – Error Analysis
3) H.F. Ebel – Scientific Writing
4) S.L. Gupta & V. Kumar – Practical Physics

Subject: Physics
Semester: VII
Course Name: Atomic and Molecular Physics (Theory)
Course Level: PHY-**M-7**
Credit: **03**

Course Objective

- To learn the development of atom models.
- To learn the origin of atomic spectra and their modifications under different physical conditions.
- To learn the basics of molecular spectra for diatomic molecule and a few applications.

Learning outcome

Students will be ability to describe the atomic spectra of one and two valance electron atoms and will also understand the change in behavior of atoms and corresponding modification of their spectra in external applied electric and magnetic field. They will understand the basic principle of pure rotational, vibrational, Rotation-Vibration and Raman spectra of molecules and their few applications.

Unit I: Atom Model
The Bohr -model of the hydrogen-like atom,
Sommerfeld Relativistic Atom Model: Elliptical orbits, explanation of fine structure of H alpha line in Balmer series of hydrogen atom. Limitation of Sommerfeld atom model. Orbital magnetic dipole moment: Bohr Magneton, Gyromagnetic Ratio, Larmor precession, Space Quantization, Electron Spin, quantum numbers associated with vector -atom model, spin-orbit interaction, Coupling Schemes: L-S Coupling and j-j Coupling, Spectroscopic term and their notation, Stern-Gerlach experiment and its conclusion. Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).
Unit II: X- rays
Ionizing Power, X-ray Diffraction, Bragg's
Law, X-ray Spectra: Continuous and characteristic X- rays Mosley's law, Compton effect.
Unit III: Multi electron atoms
Hund's rule, Periodic table: Pauli's exclusion principle, explanation of the periodic classification of the elements, Building up or Aufbau Principle, Broad features of Alkali atom (Na etc.) spectra and its explanation.
Unit IV: Molecular Spectra
Rotational Energy levels, Selection Rules and Pure Rotational Spectra of a diatomic Molecule. Vibrational Energy Levels, Selection Rules and Vibration Spectra of a diatomic Molecule. Rotation-Vibration Energy Levels, Selection Rules and Rotation-Vibration Spectra. Determination of Internuclear Distance.
Unit V: Raman Effect
Quantum Theory of Raman Effect. characteristics of Raman Lines. Stoke's and Anti-Stoke's Lines Complimentary Character of Raman and infrared Spectra.

<u>Reading list</u>

1. Introduction to Atomic spectra, H. E. White, Tata McGraw Hill (1934)
2. Atomic and Molecular Spectra, Raj Kumar

3. Concepts of Modern Physics, Arthur Beiser (McGraw-Hill Book Company, 1987)
4. Atomic physics, J. B. Rajam & foreword by Louis De Broglie (S. Chand & Co., 2007)
5. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachein.
6. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash

Subject: Physics
Semester: VII
Course Name: Atomic and Molecular Physics (Practical)
Course Level: PHY**-M-07**
Credit: **01**

Course Objective

- To provide experimental understanding of atomic and molecular phenomena.
- To develop skills in spectroscopy and quantum-based measurements.
- To correlate theoretical concepts (atomic spectra, molecular structure) with experimental observations

Learning outcome

After completion, students will be able to:

- Analyze atomic spectra and determine fundamental constants.
- Understand molecular vibrational and rotational behavior.
- Use spectrometers and optical instruments with precision.
- Interpret experimental data using quantum concepts.

List of Experiments:

Group A: Atomic Physics Experiments

5) Hydrogen Spectrum Study: Determination of Rydberg constant using spectral lines.
6) Spectrometer Handling: Calibration of spectrometer using known spectral lines (e.g., mercury lamp).
7) Determination of Wavelength: Measurement of unknown spectral lines using diffraction grating.
8) Photoelectric Effect (Simulation/Experimental): Determination of Planck's constant (h) or threshold frequency.

Group B: Molecular Physics Experiments

4) Vibrational Spectrum Analysis: Study of molecular vibrational modes (using IR spectra or simulation).
5) Rotational Spectrum Study (Demonstration/Simulation): Determination of bond length or rotational constants.
6) Raman Effect (Demonstration/Virtual Lab): Identification of Stokes and Anti-Stokes lines.

Group C: General / Skill-Based Experiments

4) Determination of Refractive Index: Using prism or liquid cell (linked to molecular properties).
5) Polarization of Light: Verification of Malus' Law.
6) Absorption Spectrum Analysis: Study of absorption bands of solutions (basic spectrophotometry).

Use of Computational / Virtual Labs:

4) Simulation of atomic spectra.
5) Virtual experiments on photoelectric effect and Raman spectroscopy.
6) Data analysis using spreadsheet/simulation tools

Reading List:

5) B.H. Bransden & C.J. Joachain – Physics of Atoms and Molecules

6) H.E. White – Introduction to Atomic Spectra
7) C.N. Banwell – Fundamentals of Molecular Spectroscopy
8) K. Thyagarajan & A.K. Ghatak – Lasers: Theory and Applications