MAJOR COURSE- MJ 4	Waves and Optics	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

This course aims to provide students with a comprehensive understanding of wave phenomena and optical principles. It covers harmonic oscillations, wave motion, interference, diffraction, and polarization, with a focus on both theoretical concepts and experimental applications. By the end of the course, students will develop a solid foundation in wave optics, enabling them to analyze and apply optical principles in various physical systems.

Course Outcomes:

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

1. **Understand and apply the principle of superposition** to analyze the superposition of harmonic oscillations, beat formation, and Lissajous figures with their applications.
2. **Describe the fundamental properties of wave motion**, including plane and spherical waves, longitudinal and transverse waves, wave equations, and energy transport in different media.
3. **Analyze stationary waves** and determine the velocity of transverse vibrations in stretched strings and longitudinal waves in fluids using Newton's and Laplace's formulas.
4. **Explain the principles of interference**, including temporal and spatial coherence, Young's double-slit experiment, Fresnel's biprism, and interference in thin films.
5. **Apply the concepts of interference in optical instruments**, including Newton's rings, Michelson and Fabry-Perot interferometers, and their applications in wavelength and refractive index measurement.
6. **Study diffraction phenomena**, including Fraunhofer and Fresnel diffraction, and analyze single-slit, double-slit, multiple-slit, and circular aperture diffraction patterns.
7. **Evaluate the resolving power of optical instruments**, such as telescopes and diffraction gratings, based on diffraction principles.
8. **Apply Fresnel's assumptions and zone plate theory** to explain rectilinear propagation of light and diffraction effects due to edges, slits, and wires.
9. **Understand the concept of polarization**, including linear, circular, and elliptical polarization, and study the propagation of electromagnetic waves in anisotropic media.
10. **Analyze double refraction in uniaxial and biaxial crystals** and explain the working of Nicol prisms and wave plates (quarter-wave and half-wave plates).
11. **Demonstrate an understanding of rotatory polarization**, including Biot's laws, Fresnel's theory of optical rotation, and the concept of specific rotation in optically active materials.
12. **Apply optical principles to real-world applications**, such as spectroscopy, laser optics, and optical communication systems.

This outcome-based approach ensures that students gain both conceptual and practical insights into wave and optical phenomena, preparing them for advanced studies and experimental research in optics.

Course Contents:

Superposition of Collinear and two perpendicular Harmonic oscillations (08 HRS): Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequencies and their applications.

Wave Motion (09 HRS): Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave, 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. Stationary Waves, Properties of Stationary Waves, Velocity of a Particle at any Point in a Stationary Wave, Harmonics in Stationary Waves.

Interference (05 HRS): Temporal and Spatial Coherence. Division of amplitude and wavefront. Young's double slit experiment. Fresnel's Biprism. Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Haidinger and Fizeau Fringes. Newton's Rings: Measurement of wavelength and refractive index.

Interferometer (02 HRS): Michelson Interferometer, Fabry-Perot interferometer.

Fraunhofer diffraction (06 HRS): Single Slit, Double Slit, Multiple Slits, Diffraction Grating, Circular Aperture. Resolving Power of Telescope and Grating.

Fresnel Diffraction (06 HRS): Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Waves. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral. Fresnel Diffraction Pattern of a Straight Edge, Slit, and Wire.

Polarization of Electromagnetic Waves (06 HRS): Linear, Circular, and Elliptical Polarization. Propagation of EM Waves in Anisotropic Media. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystals. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & Extraordinary Refractive Indices. Production and Detection of Plane, Circularly, and Elliptically Polarized Light. Quarter-Wave and Half-Wave Plates.

Rotatory Polarization (03 HRS): Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Specific rotation.

Reference Books

1. Waves and Acoustics, P. K. Chakraborty and Satyabrata Chowdhury.
2. Introduction to Geometrical and Physical Optics, B. K. Mathur.
3. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
4. Geometrical and Physical Optics, P. K. Chakraborty.
5. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
6. Fundamentals of Optics: Jenkins and White, McGraw Hill
7. The physics of Vibrations and Waves: H. J. Pain, Wiley
8. Optics: E. Hecht and A R. Ganesan, Pearson, India

MAJOR COURSE- MJ 4	Waves and Optics	(Practical Credit -01) (Total Marks=25)

1. Understand the applications of CRO by measuring voltage and time period of a periodic waveform using CRO. And study the superposition of two perpendicular simple harmonic oscillations using CRO (Lissajous figures).
2. Familiarization with: Schuster`s focusing; determination of angle of prism.
3. To determine refractive index of the Material of a prism using sodium source.
4. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
5. To determine wavelength of sodium light using Fresnel Biprism.
6. To determine wavelength of sodium light using Newton's Rings.
7. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
8. To determine dispersive power and resolving power of a plane diffraction grating.
9. To verify the law of Malus for plane polarized light.
10. To determine the specific rotation of sugar solution using Polarimeter.
11. To study diffraction due to straight edge.

Reference Books:

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

MAJOR COURSE- MJ 5	Electricity and Magnetism-II	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

This course aims to provide students with a deep understanding of advanced topics in electricity and magnetism, including electrostatics, electric fields in matter, magnetostatics, induction, and magnetic properties of materials. The emphasis is on mathematical formulations and physical interpretations, helping students develop problem-solving skills in classical electromagnetism.

Course Outcomes:

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

1. **Understand the fundamental principles of electrostatics**, including quantization, conservation, and invariance of electric charge.
2. **Apply Coulomb's Law and Gauss's Law** to solve problems related to electric fields from continuous charge distributions.
3. **Analyze electrostatic potential and energy**, solve Poisson's and Laplace's equations, and apply boundary conditions for electric fields.
4. **Apply the method of images** and multipole expansion to calculate electric potentials in various charge distributions.
5. **Describe the behavior of electric fields in matter**, including polarization, electric displacement, dielectric properties, and energy storage in dielectric systems.
6. **Solve boundary value problems** for dielectric interfaces and understand forces acting on dielectric materials.
7. **Understand magnetostatics and apply the Biot-Savart law and Ampere's law** to determine magnetic fields due to steady currents.
8. **Compare electrostatics and magnetostatics**, and analyze the concept of the vector potential, boundary conditions, and multipole expansion of magnetic fields.
9. **Apply Faraday's Law of induction** to analyze electromagnetic induction, RLC circuits, and the displacement current.
10. **Introduce Maxwell's Equations** and their role in unifying electricity and magnetism.
11. **Study magnetic fields in matter**, including magnetization in diamagnetic, paramagnetic, and ferromagnetic materials.
12. **Analyze torques and forces on magnetic dipoles** and understand the effect of magnetic fields on atomic orbits.
13. **Understand bound currents and their physical interpretation**, and apply Ampere's law in magnetized materials.
14. **Differentiate between linear and nonlinear magnetic media**, magnetic susceptibility, permeability, and ferromagnetic behavior.

This outcome-based structure ensures that students develop a strong foundation in electromagnetism, preparing them for advanced topics such as electrodynamics and applications in engineering and physics.

Course Contents:

ELECTROSTATICS (05 HRS): Quantization, conservation and invariance of electric charge, Electric field: Coulomb's Law, continuous charge distributions. Divergence and curl of electrostatic fields: field lines, flux, Gauss's Law, divergence of E, applications of Gauss's law, curl of E.

ELECTRIC POTENTIAL AND ENERGY (10 HRS): Poisson equation and Laplace's equation, potential of a localized charge distribution, electrostatic boundary conditions. Work and energy in electrostatics: work done to move a charge, energy of a point charge and continuous charge distribution. Conductors, induced charges, surface charge and force on a conductor, capacitors. Method of Images. Multipole expansion of scalar potential.

ELECTRIC FIELDS IN MATTER (10 HRS): Microscopic and Macroscopic fields, Polarization: dielectrics, induced dipoles, polarization. Field of a polarized object, electric displacement, Gauss's law in the presence of dielectrics, linear dielectrics, susceptibility, permittivity, dielectric constant, boundary value problems, boundary conditions at interface of dielectrics, energy in dielectric systems and forces on dielectrics.

MAGNETOSTATICS AND INDUCTION (10 HRS): Lorentz force law, Biot-Savart law: magnetic field of a steady current. Divergence and curl of B, applications of Ampere's law, comparison of magnetostatics and electrostatics. Magnetic vector potential boundary conditions, multipole expansion of the vector potential. Absence of magnetic monopoles. Faraday's Law of induction; RLC circuits, displacement current and introduction to Maxwell's equations.

MAGNETIC FIELDS IN MATTER (10 HRS): Magnetization: diamagnets, paramagnets, ferromagnets, torques and forces on magnetic dipoles, effect of magnetic field on atomic orbits, magnetization. Field of a magnetized object: bound currents, physical interpretation, magnetic field inside matter, auxiliary field H, Ampere's law in Magnetized materials, linear and nonlinear media: magnetic susceptibility and permeability, ferromagnetism.

Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, TMH 10
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
5. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press
6. Electricity and Magnetism, J. H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
7. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
8. Electricity and Magnetism K K Tewary S. Chand and Company.
9. Fundamental of Magnetism and Electricity, by D. N. Vasudiva.

MAJOR COURSE- MJ 5	Electricity and Magnetism-II	(Practical Credit -01) (Total Marks=25)

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Measurement of field strength B & its variation in a Solenoid (Determine dB/dx).
3. Magnetic field in the centre of a current carrying wire.
4. Determination of Self-Induction Coefficient (L) of a Coil.
5. To study B-H curves for different ferromagnetic materials using C.R.O.
6. To determine the frequency of A.C. main using Sonometer.
7. To determine the resistance of an electrolyte for AC current and study its concentration dependence.
8. To study the magnetic field produced by a current carrying solenoid using a pick-up coil and to find the value of permeability of air.
9. To determine the dielectric constant of a liquid.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint & H. T. Worsnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.