SEMESTER-III

I. PHY-MJ-4: WAVES AND OPTICS

(Credit: Theory-04) 60 Lectures

Course Objective:

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

Learning Outcomes:

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

Course Content:

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

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

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

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

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

Reference Books:

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

II. PHY-MJ-5: PRACTICAL-II

(Credits: Practical-04) 120 Lectures

Course Objective:

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

Learning Outcomes:

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

List of Practical:

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

Reference Books:

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