

**Four Year Undergraduate Course in Physics**

**Semester III**

**Paper Name: Wave and Optics**

**Paper Code: PHY030104**

**Total Number of Lectures = 45, Total Credits = 4**

**(Total Marks 100: Internal-25+External-75)**

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

**Course learning outcomes:**

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)**

**Total Credits = 3**

### **Unit I: Superposition of harmonic oscillations (Lectures 04)**

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 (Lectures 04)**

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 (Lectures 04)**

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 (Lectures 09)**

Superposition of Two Harmonic Waves: 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 (Lectures 04)**

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

### **Unit VI: Interference (Lectures 08)**

Division of wavefront 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 (Lectures 07)**

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 VII: Polarization: (Lectures 05)**

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.

### **Wave and Optics (Practical)**

**Total Credits = 1**

A minimum of four experiments to be done.

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify  $\lambda^2$ -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.

### **Reference Books**

- [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, 2<sup>nd</sup> edition, I. G. Main, 1984, Cambridge University Press.

- [4] A Textbook of Sound, 3<sup>rd</sup> 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
- [9] Principles of Optics, B. K. Mathur and T. P. Pandya, 1981, Tata McGraw-Hill International.
- [10] Fundamental of Optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand Publications.