

# Engineering Physics Module–2 Notes Wave Optics

## MODULE–2 TOPICS

- Huygens' Principle
- Superposition of Waves
- Interference of Light
- Wavefront Splitting
- Amplitude Splitting
- Young's Double Slit Experiment (YDSE)
- Newton's Rings
- Michelson Interferometer
- Mach-Zehnder Interferometer
- Fraunhofer Diffraction
- Diffraction from Single Slit
- Diffraction from Circular Aperture
- Rayleigh Criterion
- Diffraction Grating
- Resolving Power of Grating

### 1. HUYGENS' PRINCIPLE

According to Huygens' principle, every point on a wavefront acts as a source of secondary wavelets and the forward envelope of these wavelets forms a new wavefront.

#### Applications:

- Reflection of light
- Refraction of light
- Diffraction of light

### 2. SUPERPOSITION OF WAVES

When two or more waves overlap, the resultant displacement is equal to the vector sum of individual displacements.

#### Principle of Superposition:

$$y = y_1 + y_2$$

#### Applications:

- Interference
- Diffraction
- Beats

### 3. INTERFERENCE OF LIGHT

Interference is the redistribution of light energy due to superposition of coherent light waves.

#### Conditions for Interference:

- Sources should be coherent.
- Same frequency and wavelength.

#### Types of Interference:

1. Constructive Interference

Occurs when path difference =  $n\lambda$

2. Destructive Interference

Occurs when path difference =  $(2n+1)\lambda/2$

### 4. WAVEFRONT SPLITTING

In wavefront splitting, a single wavefront is divided into two coherent wavefronts.

**Examples:**

- Young's double slit experiment
- Fresnel biprism

## 5. AMPLITUDE SPLITTING

In amplitude splitting, amplitude of a wave is divided into parts to produce interference.

**Examples:**

- Newton's rings
- Michelson interferometer

## 6. YOUNG'S DOUBLE SLIT EXPERIMENT (YDSE)

Young demonstrated interference of light using two coherent slits.

**Fringe Width:**

$$\beta = \lambda D / d$$

Where:

$\beta$  = fringe width

$\lambda$  = wavelength

D = distance of screen

d = slit separation

**Applications:**

- Measurement of wavelength
- Demonstration of wave nature of light

## 7. NEWTON'S RINGS

Newton's rings are concentric circular interference fringes formed due to interference between light reflected from upper and lower surfaces of thin air film.

**Diameter of nth Dark Ring:**

$$D_n^2 = 4n\lambda R$$

Where:

R = radius of curvature

**Applications:**

- Measurement of wavelength
- Determination of refractive index

## 8. MICHELSON INTERFEROMETER

Michelson interferometer works on amplitude splitting principle.

**Applications:**

- Measurement of wavelength
- Determination of small distances
- Measurement of refractive index

## 9. MACH-ZEHNDER INTERFEROMETER

It is an optical instrument used for interference measurements using beam splitting.

**Applications:**

- Optical communication
- Fluid flow measurement
- Refractive index measurement

**10. FRAUNHOFER DIFFRACTION**

Fraunhofer diffraction occurs when source and screen are effectively at infinite distance.

**(a) SINGLE SLIT DIFFRACTION**

Condition for minima:

$$a \sin\theta = n\lambda$$

Where:

a = slit width

**Features:**

- Central maximum is brightest and widest.
- Intensity decreases for higher order maxima.

**(b) CIRCULAR APERTURE DIFFRACTION**

Diffraction pattern consists of bright central disc called Airy disc.

**11. RAYLEIGH CRITERION**

Rayleigh criterion gives limit of resolution of optical instruments.

**Expression:**

$$\theta = 1.22 \lambda / D$$

Where:

D = aperture diameter

**Applications:**

- Telescope
- Microscope
- Human eye resolution

**12. DIFFRACTION GRATING**

Diffraction grating contains large number of parallel slits.

**Grating Equation:**

$$d \sin\theta = n\lambda$$

**Resolving Power of Grating:**

$$R = nN$$

Where:

n = order of spectrum

N = total number of lines

**Applications:**

- Spectroscopy
- Wavelength measurement

## **MOST IMPORTANT 14 MARK QUESTIONS**

1. Explain Young's double slit experiment with derivation.
2. Explain Newton's rings with derivation.
3. Explain Michelson interferometer with applications.
4. Explain Mach-Zehnder interferometer.
5. Explain Fraunhofer diffraction due to single slit.
6. Explain diffraction grating and resolving power.
7. Explain Rayleigh criterion and resolving power.
8. Explain interference by wavefront splitting and amplitude splitting.

## **IMPORTANT 7 MARK QUESTIONS**

1. State Huygens' principle.
2. Explain superposition principle.
3. Define interference of light.
4. Explain constructive and destructive interference.
5. Explain diffraction from circular aperture.
6. Explain Airy disc.
7. Explain resolving power.

## **IMPORTANT NUMERICALS**

1. Fringe width calculation in YDSE.
2. Newton's rings wavelength calculation.
3. Diffraction grating numerical.
4. Resolving power numerical.
5. Rayleigh criterion numerical.

## **EXAM TIPS**

- Draw neat diagrams of YDSE and interferometers.
- Learn all derivations properly.
- Practice numerical problems daily.
- Remember important formulas carefully.
- Focus on diffraction grating and Newton's rings derivations.