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# WAVE PHENOMENA AND LIGHT

## HUYGENS' PRINCIPLE

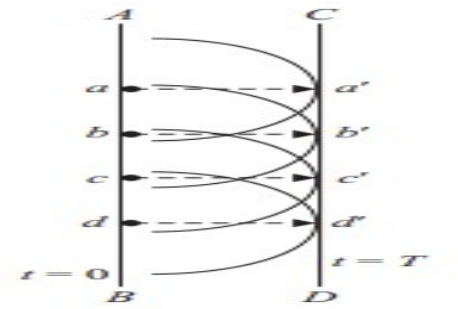
Huygens' postulated that light is a wave, which travels through a hypothetical Medium called ether.

The Huygens'principle states that

Each point on a wavefront becomes a source of secondary disturbance which spreads out in the medium.

- The position of wavefront at any later instant may be obtained by drawing a forward common envelop to all these secondary wavelets at that instant.
- In an isotropic medium, the energy carried by waves is transmitted equally in all directions.
- If the initial shape, position, the direction of motion and the speed of the wavefront is known, its position at a later instant can be ascertained bygeometrical construction.

**Propagation of Waves**

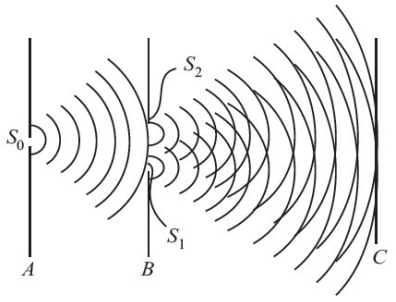



## Interference of Light

Interference of light refers to redistribution of energy due to superposition of light waves from two coherent sources.

**Young's Double Slit Experiment**

- Sunlight was allowed to pass through a pin hole S and then, at some distance away, through two pin holes S1 and S2 equidistant from S and close to each other.
- spherical wavefronts would spread Instruments out from the pin hole S which get divided into two wavefronts by $S_1$ and $S_2$ .
- If S is illuminated by a monocromatic source of light, such as sodium, these act as coherent sources and in-phase waves of equal amplitude from these sources superpose as they move beyond $S_1S_2$




**Constructive Interference**

the superposition principle that some points on the screen C will have maximum displacement (or amplitude) because the crests due to one set of waves coincide with the crests due to another set of waves.

- points will appear bright because the intensity of light wave is proportional to the square of the amplitude.
- Superposition of waves at these points leads to what is known as constructive interference

**Destructive Interference:**

- The points where the crests due to one set of waves coincide with the troughs due to the other set and vice-versa, the totalamplitude is zero.
- It is so because the waves reach these points completely out of phase. Such points appear dark on the screen.
- These points correspond to ***destructive interference.***

**Intensity of fringes:**

To analyse the interference pattern, we calculate the intensity of the bright and dark fringes in the interference pattern for harmonic waves.

$$I \propto A^2$$
$$\propto 4a^2 \cos^2(\delta/2)$$

**Phase Difference and Path Difference**

The phase difference can be expressed in terms of the path difference between the waves during their journey from the sources to a point on the observation screen.

$$\frac{d}{D}(x_n)_{\text{bright}} = n\lambda$$

$$(x_n)_{\text{bright}} = \frac{n\lambda D}{d} \; ; n = 0, 1, 2, \ldots$$

$$\frac{d}{D}(x_n)_{\text{dark}} = (n + \frac{1}{2})\lambda$$

$$(x_n)_{\text{dark}} = (n + \frac{1}{2})\frac{\lambda D}{d} \; ; n = 0, 1, 2, \ldots$$

**Fringe width**

the fringe width of an interference pattern remains the same for any two consecutive value of n

$$(x_3)_{\text{bright}} = 3\frac{\lambda D}{d}$$

and $$(x_2)_{\text{bright}} = 2\frac{\lambda D}{d}$$

Therefore, fringe width, β is given by

$$\beta = (x_3)_{\text{bright}} - (x_2)_{\text{bright}} = \frac{\lambda D}{d}$$

# DIFFRACTION OF LIGHT

**Bending of light around the edges of an obstacle is known as diffraction.**

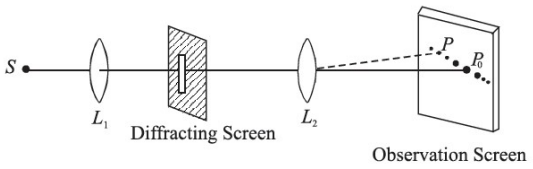
To observe diffraction, either of the following conditions must be satisfied:

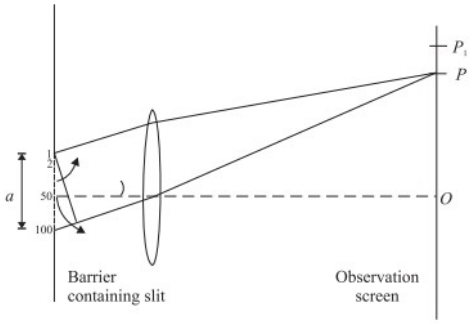
*a) The size of the obstacle or the aperture should be of the order of the wavelength of the incident wave.*

The separation between the obstacle or aperture and the screen should be considerably larger (a few thousand times) than the size of the obstacle or aperture

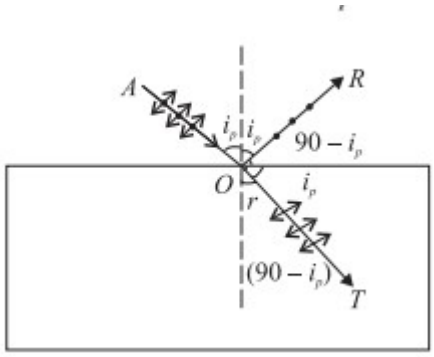
**Diffraction at a Single Slit**

when the path difference between the extreme waves diffracted by the extreme points in a particular direction is an integral multiple of ⌊, the resultant diffracted intensity in that direction will be zero.




## POLARISATION OF LIGHT




The phenomenon in which vibrations of light get confined in a particular plane containing the direction of propagation is called polarisation of light.

## Check Yourself

1. Interference of two light waves can be observed with the help of a
   A. Spectrometer
   B. Photometer
   C. Prism
   D. Michelson experiment
2. The interference of two light wave is constructive if
   A. Two waves are in same phase
   B. Two waves are in opposite phase
   C. Two waves are perpendicular to each other
   D. Two waves are obtained from two different sources
3. Fringe width in the interference pattern will be more, when coherent source are
   A. Close together
   B. Too much apart
   C. Inclined at a certain angle
   D. Inclined at π/4
4. Colours of thin films result from
   A. Dispersion of light
   B. Interference of light
   C. Absorption of light
   D. Scattering of light
5. When white light is used in Newton rings experiment, then
   A. All fringes are black

B. All fringes are white
C. All fringes are coloured
D. No fringes are observed

## Hint to Check Yourself

**1D 2 A 3 A 4 B 5 C**

## Stretch Yourself

1. What is a wavefront? What is the direction of a beam of light with respect to the associated wavefront? State the Huygens' principle and explain the propagation of light waves.
2. Describe Young's double slit experiment to produce interference. Deduce an expression for the width of the interference fringes.
3. For a material of refractive index 1.42, calculate the polarising angle for a beam of unpolarised light incident on it.
4. In Young's experimental set-up, the slit separation is 2 mm and the distance between the slits and the observation screen is 100 cm. Calculate the path difference between the waves arriving at a point 5 cm away from the point where the line dividing the slits touches the screen.
5. Distinguish between the polarized and unpolarized lights.