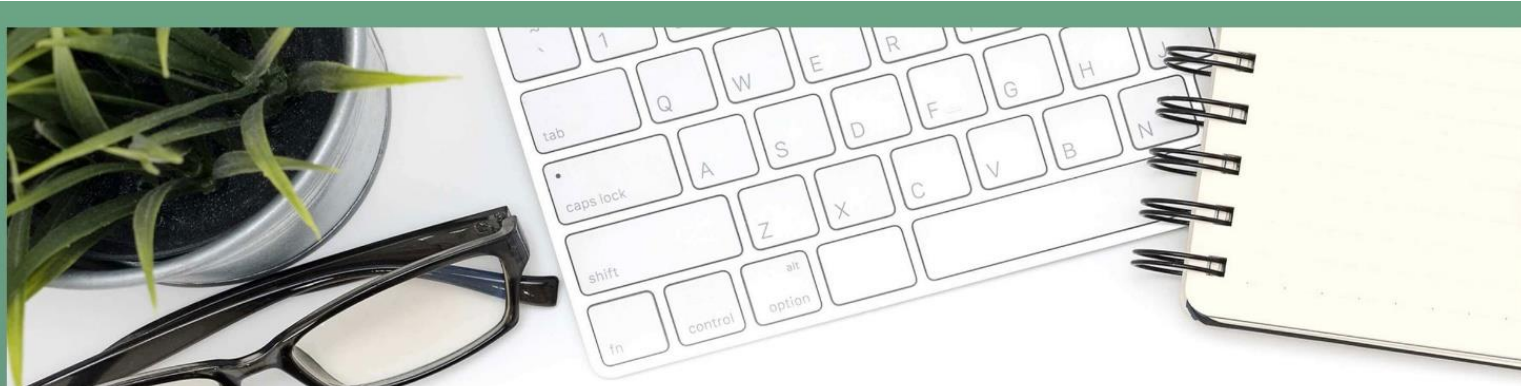

JEE Main Physics

Short Notes

Wave Optics

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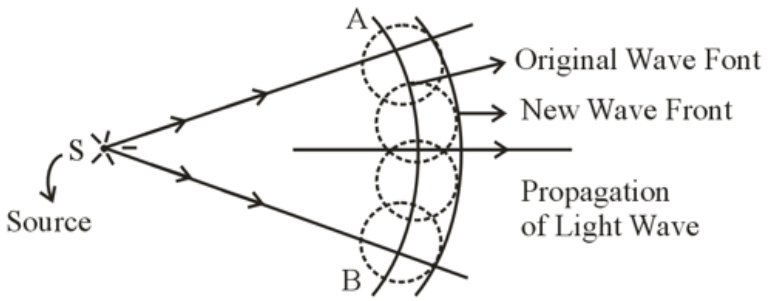
Wave Optics is an important topic from JEE Main / JEE Advanced Exam Point of view. Every year there are 1-2 questions asked from this topic. This short notes on Wave Optics will help you in revising the topic before the JEE Main & IIT JEE Advanced Exam.

Wave Optics

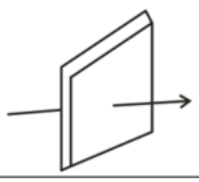
In 1678, Huygens's gave the wave theory of light, but it was not primarily accepted because of Newton's corpuscles theory of light. In 1801, British Physicist Thomas Young showed experimentally by interference experiment that light also has wave nature and thus wave optics came into existence.

Wavefront and Huygens principle

According to Huygens principle light emits in the form of waves and source of lights is a center of disturbance from which waves spread in all direction.



Wavefront: the locus of all the particles of the medium vibrating in the same phase at a given instant is known as a wavefront. The shape of wavefront depends on the source producing the waves and is usually spherical, cylindrical, or plane as

Wave front	Shape of light source	Diagram of shape of wave front	Variation of amplitude with distance	Variation of intensity with distance
Spherical	Point source		$A \propto \frac{1}{d}$	$I \propto \frac{1}{r^2}$
Cylindrical	Linear or slit		$A \propto \frac{1}{\sqrt{d}}$	$I \propto \frac{1}{r}$
Plane	Extended large source situated at very large distance		A = constant	I = cons.

Each point on a wavefront is a source of new disturbance, called secondary wavelets.

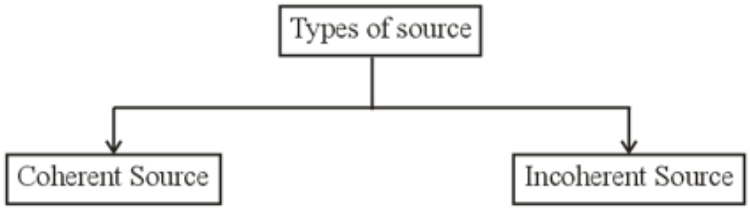
Interference

When two light waves of the same frequency with zero initial phase difference or constant phase difference superimpose over each other, then the resultant amplitude in the region of superimposition is different from the amplitude of individual waves. This modification in intensity in the region of superposition is known as interference.

Condition for Interference

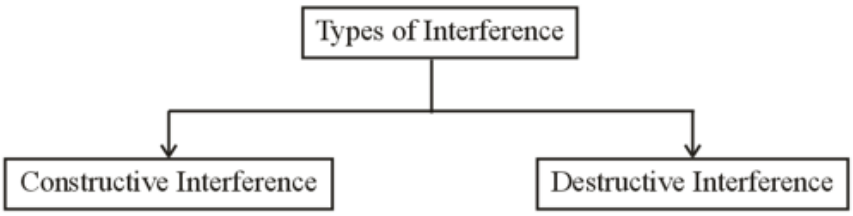
(1) The source must be coherent

(2) The source should be monochromatic (single wavelength)



Coherent source- Two sources are said to be coherent if they emit light waves of the same wavelength and start with the same phase or have a constant phase difference.

Incoherent source- Two sources are said to be incoherent if they emit light waves of the same wavelength but waves are not in phase.

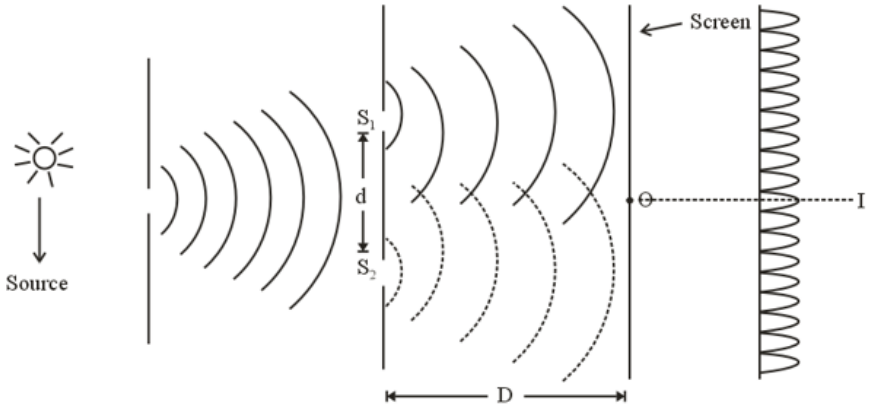


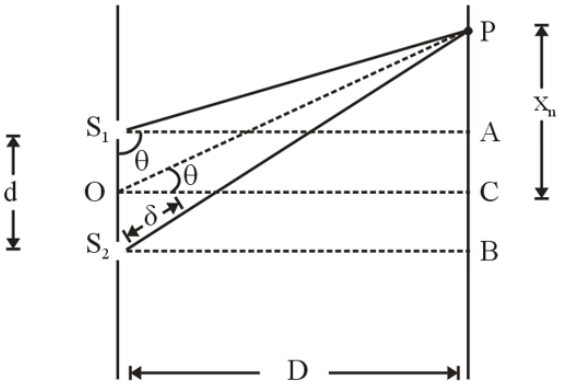
Constructive interference- when resultant intensity is greater than the sum of two individual wave intensities $[I > (I_1 + I_2)]$ then the interference is said to be constructive.

Destructive Interference- when the resultant intensity is less than the sum of two individual wave intensities $[I < (I_1 + I_2)]$ then the interference is said to be destructive.

Young's Double Slit experiment

Young's double slit experiment proves the wave nature of light. In this experiment, a narrow slit S is illuminated by a monochromatic source of light and light wavefront sends in all direction. Then slit S_1 and S_2 become the source of secondary wavelets which are in phase and of the same frequency. These waves superimpose to each other and produce an interference pattern on the screen. On the screen, bright and dark fringes are appeared due to constructive and destructive interference.





For Bright and Dark Fringes

Bright Fringe

For constructive interference path difference $S = PS_2 - PS_1 = S_2L = 2n\left(\frac{\lambda}{2}\right)$

The distance of n^{th} bright fringe from the central bright fringe, $x_n = \frac{nD\lambda}{d}$

Dark fringe

For destructive interference path difference S = (2m-1) $\left(\frac{\lambda}{2}\right)$

The distance of m^{th} dart fringe from the central bright fringe, x_m = $\frac{(2m-1)D\lambda}{2d}$

Fringe width, $\beta = \frac{D\lambda}{d}$

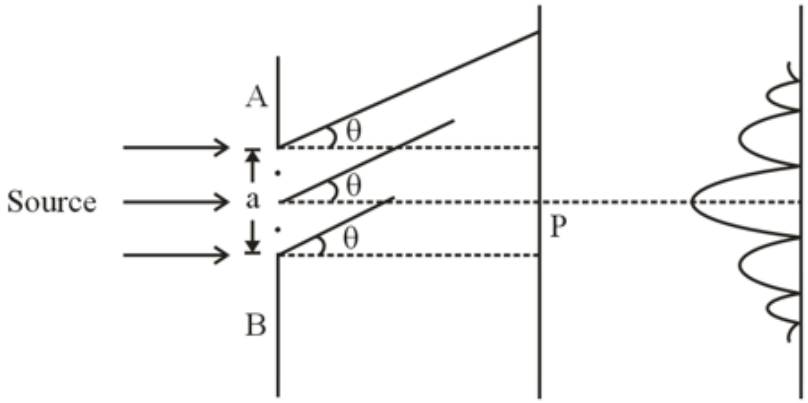
Angular fringe width, $x = \frac{\beta}{D} = \frac{\lambda}{d}$

Diffraction

Diffraction is the phenomenon in which light rays is bend from sharp edges of an opaque obstacle or aperture.

Single Slit Diffraction

Let a plane wavefront is incident on a slit of width secondary wavelets coming from every part of AB and reach axial point P in the same phase forming central maxima. The intensity of the central maxima is maximum in this diffraction.



For n^{th} minima, $a\sin\theta_n = n\lambda$

If θ_n is small $\sin\theta_n \approx \theta_n = \theta_n = \frac{n\lambda}{a}$

Linear width of central maxima, $\omega_x = \frac{2D\lambda}{a}$

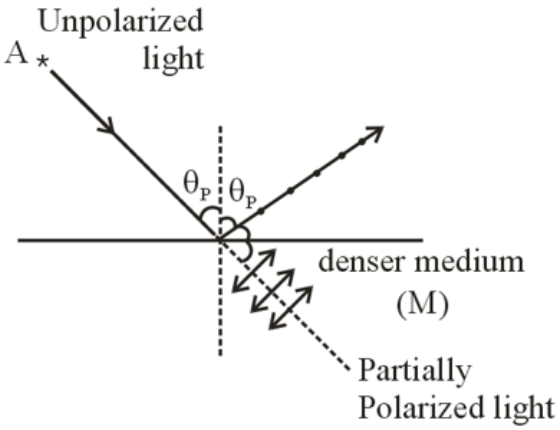
Angular width of central maxima, $\omega_\theta = 2\theta = \frac{2\lambda}{a}$

For maxima $a\sin\theta_n = (2n+1)\left(\frac{\lambda}{2}\right)$

Polarization

Polarization is the phenomenon in which the vibration of light (electric vector) restricted in a particular direction In a polarized light, the vibration of the electric vector occur in a plane perpendicular to the direction of propagation of light.

Brewster' law - When unpolarized light is incident at a particular angle θ_p, so that the reflected ray is completely polarized. The angle θ_p is known as the Brewster angle. $\mu = \tan\theta_p$



Law of Malus - When a completely plane polarized light beam is incident on an analyzer, then the intensity of emergent light varies as the square of the cosine of the angle between the planes of transmission of the analyzer and the polarizer.

$I \propto \cos^2\theta$

$I = I_o\cos^2\theta$

Resolving power of optical instrument

Resolving power of an optical instrument is the ability to separate points is an object that are located at a small angular distance.

Resolving power of the telescope $= \frac{1}{\Delta\theta} = \frac{d}{1.22\lambda}$

Where d is the diameter of the telescope.

Resolving power of microscope = $\frac{2n \sin\theta}{\lambda}$

Where n is the refractive index of medium separating object and aperture.

All the best!

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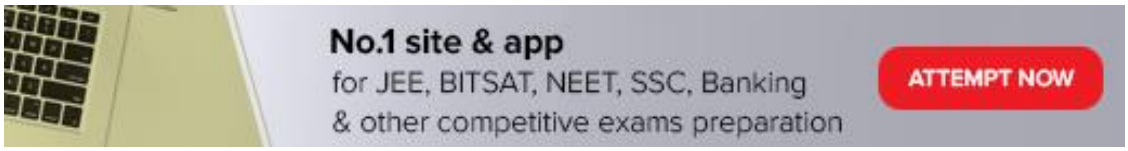

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