University of Al-Mustaqbal
College of Science
Department of Medical
Physics

Optics

Lecture 10: Diffraction of Light Wave

Second stage

Dr. Duaa jaafer Al-fayadh

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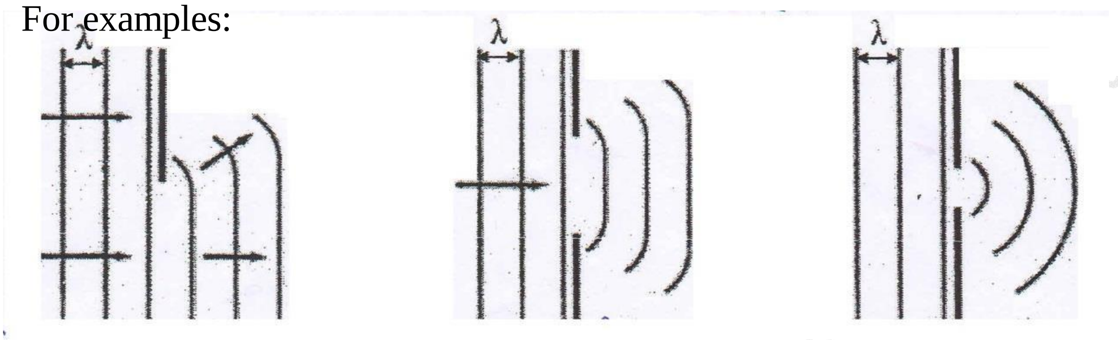
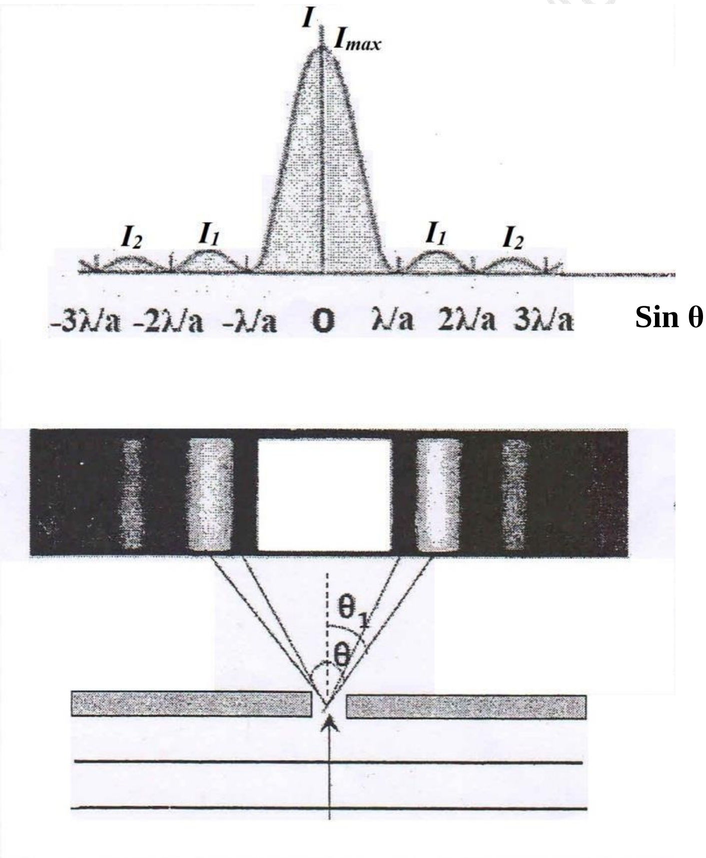
1.7 Diffraction of Light Wave

- Definition: is defined as the bending of waves as they travel around obstacles or pass through an aperture comparable to the wavelength of the waves.
- For examples:

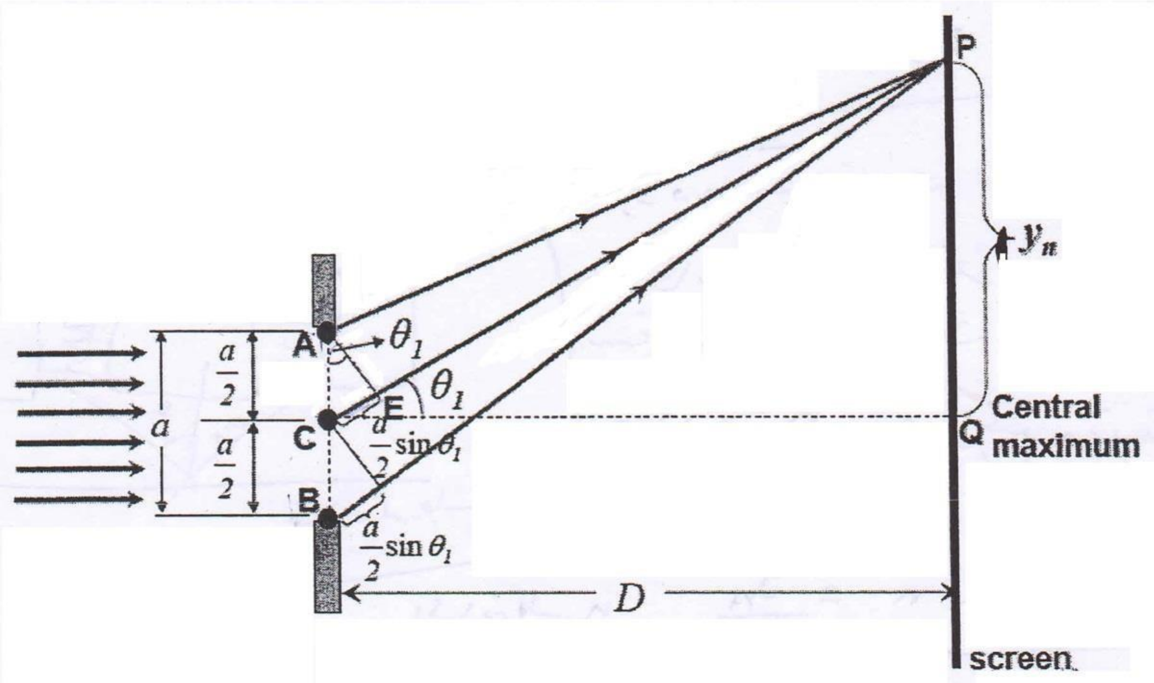


(a) Obstacle **(b) a > λ** **(c) a ≈ λ**

2.7 Diffraction by a Single Slit



- The central fringe is a bright fringe (central maximum).
- Other rays with angle θ and θ_1 will produce minimum and maximum on both sides of the central maximum.



- The slit is spilt into two equal parts, AC and CB. A, C and B are new sources of secondary wavelets according to (Huygens principle).
- When the wave fronts from A, C and B superpose, Interference will occur at P.
  - As AB is very small, thus AE is perpendicular to CP and AP = EP, and therefore the path difference at p between ray AP and CP is given

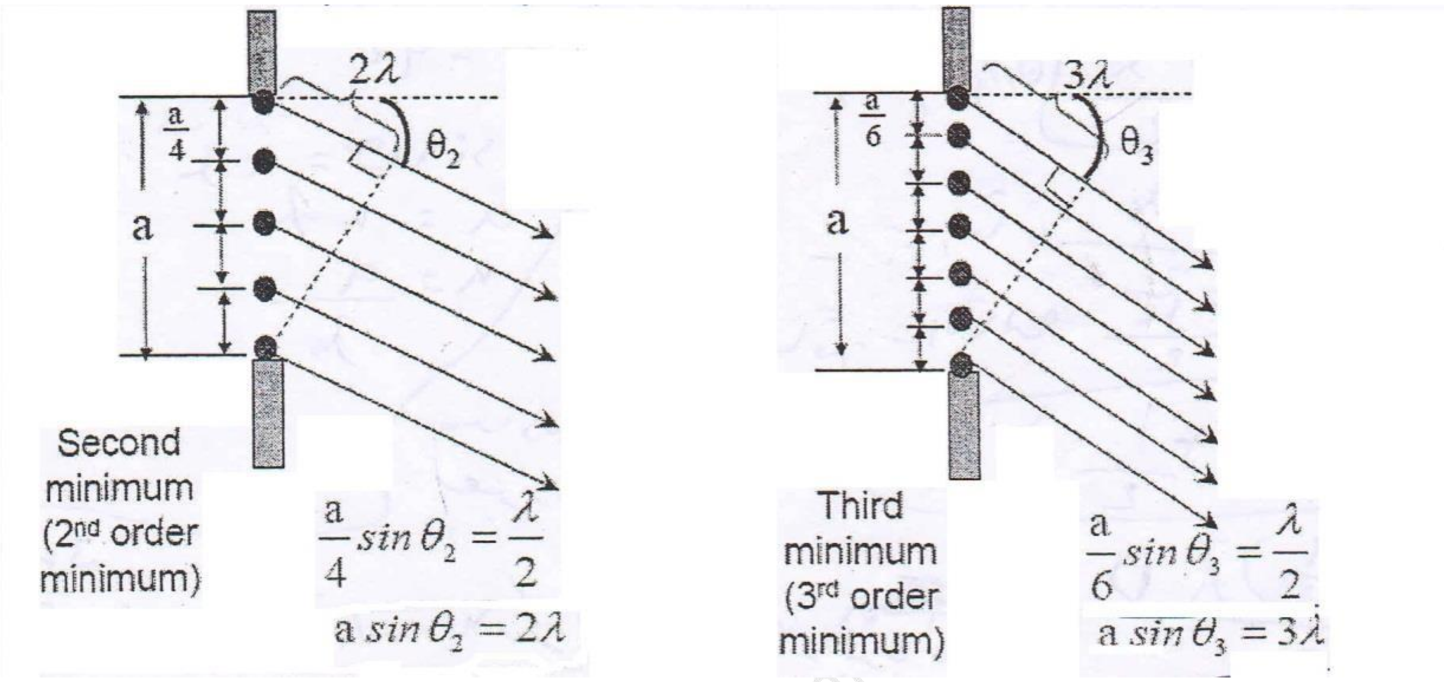
$$\text{Path difference} = CE = \frac{a}{2}\sin\theta_1$$

- If the first minimum (first order) is at P, hence:

$$\text{Path difference} = \frac{a}{2}\sin\theta_1 = \frac{\lambda}{2}$$

$$a \sin\theta_1 = \lambda$$

- If AB is split into 4 and 6 equal parts and so on, we get



Example1:

A monochromatic light of wavelength 6×10^{-7} m passes through a single slit of width 2×10^{-6} m. Find:

1. Calculate the width of central maximum:
   i. in degrees
   ii. in centimeters, on a screen 5 cm away from the slit
2. Find the number of minimum that can be observed.

Solution: $\lambda = 6\times10^{-7}$ m, $a = 2\times10^{-6}$ m

1. i $a \sin \theta_n = n \lambda; \quad n = 1$

$$\theta_1 = 17.46^\circ$$

The width of central maximum; $2\,\theta_1 = 2 \times 17.46^\circ = 34.96^\circ$

ii. Given $D = 5 \times 10^{-2}\ m$

$$y_n = \frac{n\lambda D}{a}; \qquad n = 1$$

$$y_1 = \frac{\lambda D}{a} = 0.015\ \text{m}$$

The width of central maximum; $2\,y_1 = 2 \times 0.015 = 0.030\ \text{m} = 3\ \text{cm}$

2. $a \sin \theta_n = n\,\lambda$

For maximum no. of n, $\theta = 90^\circ$

$a \sin 90 = n\,\lambda \longrightarrow n = \frac{a}{\lambda} = 3.33$

Maximum order, n = 3

Thus the number of minimum that can be observed is 6.

<u>Howe works about lecture</u>

Q1- A beam of a monochromatic light of wavelength 600 nm passes through a single slit of width 3×10^{-3} mm. A beam of light has a radius of 1.5 mm. Calculate the distance of the screen from the slit so that the radius of the central maximum is 2 times the radius of the light beam.

(a) 1 cm, **(b) 1.5 cm,** **(c) 2 cm,** **(d) 2.5 cm**

Q2- Is defined as the bending of waves as they travel around obstacles.

(a) Reflection, (b) Interference, (c) Diffraction, (d) Refraction

Q3- The condition of diffraction is

(a) $\lambda >> a$ **(b)** $a >> \lambda$ **(c)** $a = \lambda$ **(d)** none of them

Q4: In diffraction by a single slit the central fringe is a bright fringe

(a) Maximum **(b)** minimum **(c)** no value **(d)** none of them