

**Q17.** State one feature by which the phenomenon of interference can be distinguished from that of diffraction.

A parallel beam of light of wavelength 600 nm is incident normally on a slit of width 'a'. if the distance between the slits and the screen is 0.8 m and the distance of 2nd order maximum from the center of the screen is 15 mm, calculate the width of the slit.

Answer

Diffraction is the bending of waves around an obstacle, while interference is the meeting of two waves. Interference is due to superposition of two distinct waves coming from two coherent sources and Diffraction is produced as a result of superposition of the secondary wavelets coming from different parts of the same wavefront.

***Given***

$\lambda = 600\ \text{nm} = 600\ \times\ 10^{-9}\ \text{m} = 6 \times 10^{-7}\text{m}$

$\text{D} =\ 0.8\ \text{m}, \text{x} = 15\ \text{mm} = 1.5 \times 10^{-3}\text{m}, \text{n} = 2, \text{a} = ?$

$\text{a}\ \frac{\text{x}}{\text{D}} = \text{n}\ \lambda$

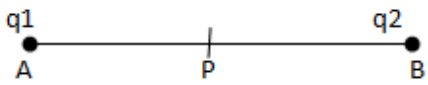
$\text{a} = \frac{\text{n}\ \lambda \text{D}}{\text{x}} = \frac{2\times6\times10^{-7}\times0.8}{1.5\times10^{-3}} = \frac{9.6\times10^{-4}}{1.5}$

$= 6.4 \times 10^{-4}\ \text{nm}$

**Q18.** Two point charges $\text{q}_1 = 10 \times 10^{-8}\ \text{C}$ and $\text{q}_2 = -2 \times 10^{-8}\ \text{C}$ are separated by a distance of 60 cm in air.

(I) Find at what distance from the first charge, $\text{q}_1$, would the electric potential be zero.
(II) Also calculate the electrostatic potential energy of the system.

Answer




Neutral point must be between the two charges, since Positive charge will repel and negative charge will attract , there direction of force exerted by two charges are equal and opposite.

i. Here $\text{q}_1 = 10 \times 10^{-8}\ \text{C}, \text{q}_2 = -2 \times 10^{-8}\ \text{C}$

and $\text{AB} = 60\ \text{cm} = 0.6\ \text{m}$

Let $\text{AP} =\ \text{x}$ then $\text{PB} =\ 0.6 - \text{x}$

Potential P due to charge $\text{q}_1 = \frac{\text{Kq}_1}{\text{AP}}$



Potential at P due to charge $q_2 = \frac{Kq_2}{PB}$

$\because$ Potential at P $= 0 \Rightarrow \frac{Kq_1}{AP} + \frac{Kq_2}{PB} = 0$

or, $\frac{Kq_1}{AP} = -\frac{Kq_2}{PB} \Rightarrow \frac{q_1}{AP} = -\frac{q_2}{PB}$

$\therefore \frac{10\times10^{-8}}{x} = \frac{-(-2\times10^{-8})}{0.6-x} \Rightarrow \frac{10}{x} = \frac{2}{0.6-x}$

$2x = 6.0 - 10x \Rightarrow 2x + 10x = 6$

$\therefore 12x = 6 \Rightarrow x = \frac{6}{12} = 0.5$ m

$\therefore$ Distance from first charge $= 0.5 = 50$ cm.

(ii) Electrostatic potential energy of the system

$U = K\frac{q_1q_2}{r}$

$U = 9\times10^9 \times \frac{10\times10^{-8}\times(-2\times10^{-8})}{0.6}$

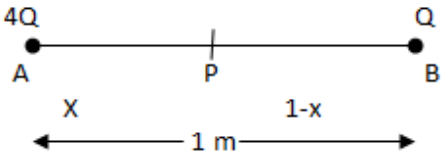
$U = \frac{-18\times10^{-6}}{0.6} \Rightarrow U = -30\times10^{-6} = -3\times10^{-5}$ J

**Or,**

Two point charges 4Q, Q are separated by 1m in air. At what point on the line joining the charges is the electric field intensity zero?

Also calculate the electrostatic potential energy of the system of charges, taking the value of charge, $Q = 2\times10^{-7}$ C ?

Answer




Let the point be at a distance x from 4Q charge. Electric field at P due to 4Q= Electric field at P due to Q

$\therefore K\times\frac{4Q}{x^2} = K\times\frac{Q}{(1-x)^2}$



$\frac{4}{x^2} = \frac{1}{(1-x)^2} \Rightarrow \frac{2}{x} = \pm \frac{1}{1-x}$

$\frac{2}{x} = \frac{1}{1-x}$ or, $\frac{2}{x} = \frac{-1}{1-x}$

$x = 2 - 2x$ or, $-x = 2 - 2x$

$x + 2x = 2$ or, $-x + 2x = 2$

$3x = 2$ or, $x = 2$

$x = \frac{2}{3}$ or, $x = 2$

$\because x = 2m$ is not possible $\therefore x = \frac{2}{3}$ m.

Electrostatic potential energy of the system is

$U = K \frac{q_1 q_2}{r}$

$\Rightarrow U = K.\frac{4Q.Q}{r} = K.\frac{4Q^2}{r}$

$U = 9 \times 10^9 \times \frac{4\times(2\times10^{-7})^2}{1}$

$[\because Q = 2 \times 10^{-7}C]$

$= 9 \times 10^9 \times \frac{4\times4\times10^{-14}}{1}$

$= 144 \times 10^{-5} = 1.44 \times 10^{-3}$J

**Q19.** Identify the following electromagnetic radiations as per the wavelengths given below. Write one application of each.

(a) $10^{-3}$ nm
(b) $10^{-3}$ m
(c) 1 nm

Ans.

(a) **Wavelength range** : $10^{-3}$ nm $= 10^{-3} \times 10^{-9} = 10^{-12}$ m

**Type of EMW:** X-rays

**Application :**

X-rays reveal structural information about the material through which it passes or falls over. X-rays are widely used in medicine to reveal the architecture of the bone and other soft tissues and to find out any abnormality in the form of fracture, growth of tumor etc. It is also used in dental imaging. X-rays in airports to examine for the presence of dangerous weapons or bombs



(**b**) **Wavelength range**: $10^{-3}$ m

**Type of EMW:** Microwave

**Application:** Microwaves are used in Radar systems for air craft navigation and for cooking.

(**c**) **Wavelength range**: 1 nm

**Type of EMW:** Infra-red

**Application:** Infra-red waves are used for taking photographs during the conditions of fog, smoke etc. Doctors use infrared lamps to treat skin diseases and relieve the pain

**Q20.** Explain why high frequency carrier waves are needed for effective transmission of signals.

A message signal of 12 kHz and peak voltage 30 V. Calculate the (i) modulation index, (ii) side-band frequencies.

Answer

For the effective transmission of signals, the high frequency carrier waves are used because these high frequency carrier waves travel through space or medium with the speed of light and they are not obstructed by earth's atmosphere.

**Numerical:** $v_m = 12$ kHz, $E_m = 20$ V, $v_c = 12$ MHz $= 12000$ kHz, $E_c = 30$ V

Modulation index, $\mu_a = \frac{A_m}{A_c} = \frac{20}{30} = 0.67$

(ii) The side bands are

USB $= v_c + v_m = 12000 + 12 = 12012$ kHz

LSB $= v_c - v_m = 12000 - 12 = 11988$ kHz