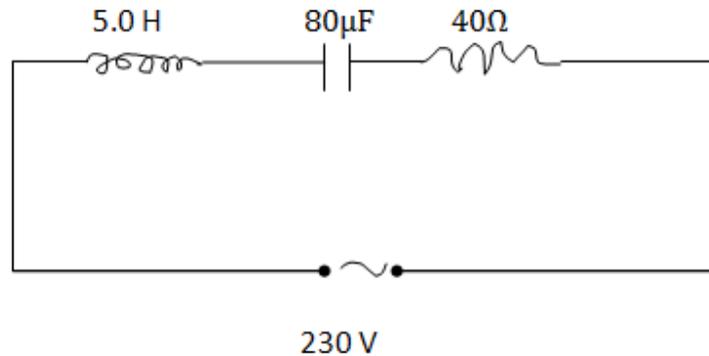




**Q28.** The given circuit diagram shows a series LCR circuit connected to a variable frequency 230 V source:



- Determine the source frequency which drives the circuit in resonance.
- Obtain the impedance of the circuit and the amplitude of current at the resonating frequency.
- Determine the rms potential drops across the three elements of the circuit.
- How do you explain the observation that the algebraic sum of the voltages across the three elements obtained in (c) is greater than the supplied voltage?

Answer:

(a) We know that resonance frequency is given by  $\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{50 \times 80 \times 10^{-6}}} = 50 \text{ rad s}^{-1}$

b) At resonance,  $Z = R = 40 \Omega$

Current amplitude,

$$I_p = \frac{E_p}{Z} = \frac{E_p}{R} = \frac{\sqrt{2}E_{rms}}{R} = \frac{1.414 \times 230}{40} = 8.1 \text{ A}$$

c) Current through the circuit  $I_{rms} = \frac{E_{rms}}{R} = \frac{230}{40} = \frac{23}{4} \text{ A}$

Potential drop across the inductance:

$$V_{Lrms} = I_{rms} \times \omega_r L = \frac{23}{4} \times 50 \times 5 = 1437.5 \text{ V}$$

Potential drop across the capacitor:

$$V_{Crms} = I_{rms} \times \frac{1}{\omega_r C} = \frac{23}{4} \times \frac{1}{50 \times 80 \times 10^{-6}} = 1437.5 \text{ V}$$

Potential drop across the resistance:

$$V_{Rrms} = I_{rms} R = \frac{23}{4} \times 40 = 230 \text{ V.}$$

- (d) Thus we find that the algebraic sum of the three voltages is more than the source voltage of 230V. These voltages are not in the same phase for example current leads potential difference in capacitor where as current lags potential in inductance therefore potential cannot be added like ordinary numbers. The voltages across L and C are out of phase hence results to zero. So  $V_{Rrms} = \text{Applied rms voltage.}$



Or,

The primary coil of an ideal step-up transformer has 100 turns and the transformation ratio is also 100. The input voltage and the power are 220V and 1100W respectively. Calculate

- (I) Number of turns in the secondary
- (II) The current in the primary
- (III) Voltage across the secondary
- (IV) Power in the secondary
- (V) The current in the secondary

Answer: Given Number of turns in Primary =  $N_p = 100$ , Transformation ratio = 100,

Voltage across Primary =  $V_p = 220$  V

Power across Primary =  $P_p = 1100$  W

Also Transformation Ratio = No of turns in secondary / No of turns in primary.

This ratio then directly corresponds to the ratio of secondary voltage (output) to primary voltage (input).

- (I)  $N_s = \text{Transformation ratio} \times N_p = 100 \times 100 = 10000$ .
- (II)  $I_p = \frac{P_p}{V_p} = \frac{1100}{220} = 5$  A
- (III)  $V_s = \text{Transformation ratio} \times V_p = 100 \times 220 = 22000$  V
- (IV)  $P_s = P_p = 1100$  W
- (V) We know  $P = I \times V$  therefore  $I_s = \frac{P_s}{V_s} = \frac{1100}{22000} = .05$  A

**Q29.** What is the interference of light? Write two essential conditions for sustained interference pattern to be produced on the screen.

Draw a graph showing the variation of intensity versus the position on the screen in Young's experiment when (a) both the slits are opened and (b) one of the slit is closed.

What is the effect on the interference pattern in Young's double slit experiment when:

- (I) Screen is moved closer to the plane of slits?
- (II) Separation between two slits is increased.

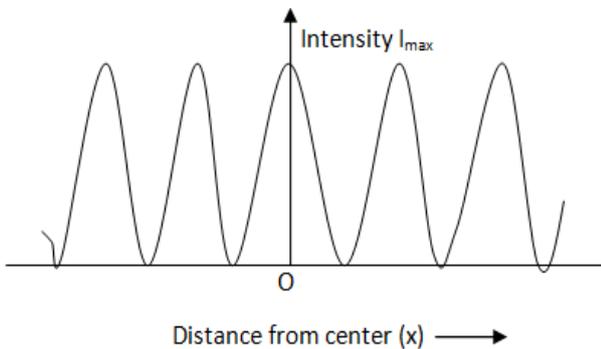
Explain your answer in each case.

Answer: The modification in the intensity distribution due to the superposition of two or more coherent wave is known as **Interference**. On the screen we get alternative bright and dark region known as interference of fringes.

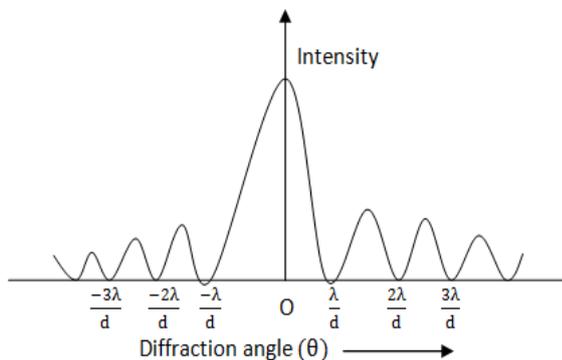


Conditions for sustained interference:

- (I) The two sources of light must be coherent.
- (II) The two sources must be narrow



Position is taken along X-axis and Intensity is along Y-axis when both the slits are open, following interference pattern observed on the screen.



When one of the slits is closed, diffraction pattern is obtained on the screen. The following intensity curve is obtained.

Fringe width,  $\beta = \frac{D\lambda}{d}$  from this formula it is evident that fringe width proportional to  $D$  and inversely proportional to  $d$ .

- (I) When screen is moved closer to the plane of the slits, the distance  $D$  decreases, the fringe width  $\beta$  also decreases.
- (II) When separation  $d$  between two slits is increased, fringe width  $\beta$  decreases.



Or,

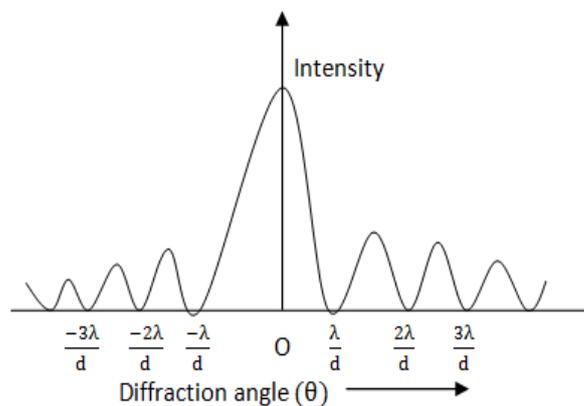
What is diffraction of light? Draw a graph showing the variation of intensity with angle in a single slit diffraction experiment. Write one feature which distinguishes the observed pattern from the double slit interference pattern.

How would the diffraction pattern of a single slit be affected when:

- (I) The width of the slit is decreased.
- (II) The monochromatic source of light is replaced by a source of white light.

Answer: The bending of light round a sharp edge or a narrow opening or a very small obstacle is known as **diffraction**. By sharp narrow or small we mean that these sizes should be comparable to the wave length of light.

The intensity distribution wave for diffraction:



In interference, all bright fringes are of same intensity however in diffraction, the intensity of bright fringes decreases with the increase in distance from the central bright fringe.

- (I) When the width of the slit is decreased, the diffraction pattern becomes narrower.
- (II) When monochromatic source is replaced by white light source, we get a colored diffraction pattern with central white band also fringe widths are different for example red fringe is wider than the violet fringe.

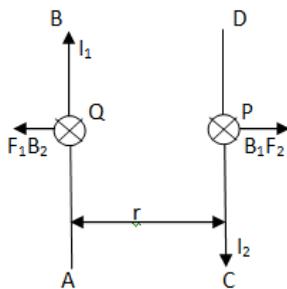


**Q30.** Derive a mathematical expression for the force per unit length experienced by each of the two long current carrying conductors placed parallel to each other in air. Hence define one ampere of current. Explain why two parallel straight conductors carrying current in the opposite direction kept near each other in air repel?

Answer: Considering two infinitely long thin conductors carrying currents in opposite directions.

$B_1$  = Magnetic field produced at P on the conductor CD due to  $I_1$  current at conductor AB

$$B_1 = \frac{\mu_0 I_1}{2\pi r}$$



The magnetic field  $B_1$  is perpendicular to plane of paper and directed inward.

$F_2$  = Force per length on CD due to  $B_1$

$$F_2 = B_1 I_2 = \frac{\mu_0 I_1 I_2}{2\pi r} \quad [\because F = BIl, \text{ Since unit length } l = 1]$$

By *Fleming's left hand rule* direction of  $F_2$  is away from the conductor AB.

Similarly the current  $I_2$  will create a field  $B_2$  at Q directed inward which in turn will create force/length  $F_1$

$$\therefore F_1 = B_2 I_1 = \frac{\mu_0 I_1 I_2}{2\pi r}$$

By *Fleming's left hand rule*, the direction of  $F_1$  is away from the conductor AB.

Thus the direction  $F_1$  and  $F_2$  on the conductors opposite hence repel each other.

Definition of Ampere: From the above expression  $F = \frac{\mu_0 I_1 I_2}{2\pi r}$

$$\text{If } I_1 = I_2 = 1 \text{ A, and } r = 1 \text{ m, then } F = \frac{\mu_0}{2\pi} = \frac{4\pi \times 10^{-7}}{2\pi} = 2 \times 10^{-7} \text{ Nm}^{-1}$$

Thus **one ampere** is that current which on flowing through each of the two parallel uniform linear conductors placed in free space at a distance of one meter from each other produces between them a force of  $2 \times 10^{-7} \text{ N}$  per meter of their lengths.