Previous Year Question Paper 2018

SECTION - A

1. A proton and an electron travelling along parallel paths enter a region of uniform magnetic field, acting perpendicular to their paths. Which of them will move in a circular path with higher frequency ?

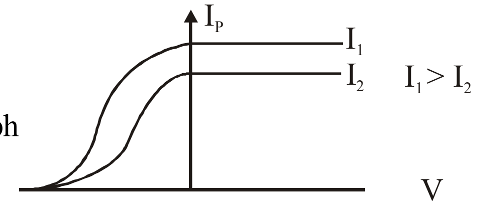
Ans. Electron as it has low mass.

2. Name the electromagnetic radiations used for **(a)** water purification, and **(b)** eye surgery.

Ans. **(a)** $U \cdot V \cdot$ **(b)** laser

3. Draw graphs showing variation of photoelectric current with applied voltage for two incident radiations of equal frequency and different intensities. Mark the graph for the radiation of higher intensity.

Ans. Graph



4. Four nuclei of an element undergo fusion to form a heavier nucleus, with release of energy. Which of the two — the parent or the daughter nucleus — would have higher binding energy per nucleon?

Ans. Daughter nuclei B.E. > Parent nuclei B.E.

(∵ stable) (unstable)

5. Which mode of propagation is used by short wave broadcast services ?

Ans. Sky waves

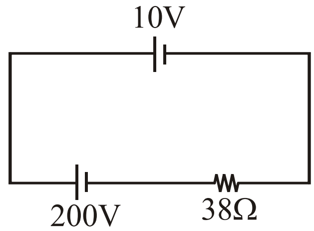
SECTION - B

6. Two electric bulbs P and Q have their resistances in the ratio of 1 : 2. They are connected in series across a battery. Find the ratio of the power dissipation in these bulbs.

Ans. $\frac{R_P}{R_Q} = \frac{1}{2}$ $\qquad \therefore$ in series $\therefore I_P = I_Q$

$$\frac{P_P}{P_Q} = \frac{I_P^2 R_P}{I_Q^2 R_Q} = \frac{1}{2}$$

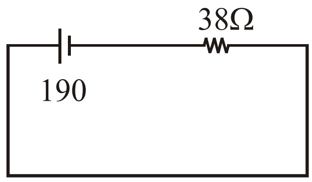
7. A 10 V cell of negligible internal resistance is connected in parallel across a battery of emf 200 V and internal resistance $38\,\Omega$ as shown in the figure. Find the value of current in the circuit.



Ans. $E = 200 - 10$

$= 190$

$$I = \frac{V}{R} = \frac{190}{30} = 20A$$



(OR)

In a potentiometer arrangement for determining the emf of a cell, the balance point of the cell in open circuit is 350 cm. When a resistance of $9\,\Omega$ is used in the external circuit of the cell, the balance point shifts to 300 cm. Determine the internal resistance of the cell.

Ans. Potentiometer at open circuit $\ell_1 = 350$

$R = 9$

$\ell_2 = 300$

$$r = 9\left(\frac{350}{300} - 1\right) \qquad = 1.5\,\Omega$$

8. **(a)** Why are infra-red waves often called heat waves ? Explain.

Ans. Infrared produce heat or emitted from hot bodies.

(b) What do you understand by the statement, "Electromagnetic waves transport momentum"?

Ans. When electromagnetic waves hit body the mass is lost by the momentum is conserved. i.e., transfered from EMW to body.

$\therefore$ EMW transports momentum.

9. If light of wavelength 412.5 nm is incident on each of the metals given below, which ones will show photoelectric emission and why ?

Metal	Work function (eV)
Na	1.92
K	2.15
Ca	3.20
Mo	4.17

Ans. $E = hv = \frac{hc}{\lambda}(J)$

$$= \frac{hc}{\lambda e}(eV)$$

$$= \frac{6.6\times10^{-34}\times3\times10^{8}}{412.5\times10^{-9}\times1.6\times10^{-19}}$$

$$E = 3\,eV$$

$Na \rightarrow$ emission $\quad E > \phi_0$

$K \rightarrow$ emission $\quad E > \phi_0$

$Ka \rightarrow$ No emission $\quad E > \phi_0$

$Mo \rightarrow$ No emission $\quad E < \phi_0$

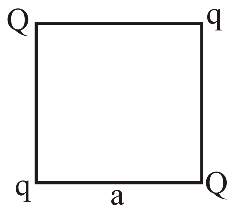
10. A carrier wave of peak voltage 15 V is used to transmit a message signal. Find the peak voltage of the modulating signal in order to have a modulation index of 60%.

Ans. $\mu = \frac{A_m}{A_c}$

$$60\% = \frac{15V}{A_C}, A_C = \frac{15}{60}\times100 = 25V$$

SECTION - C

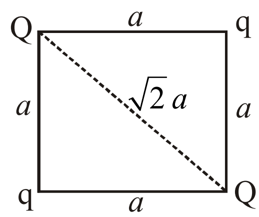
11. Four point charges Q, q, Q and q are placed at the corners of a square of side ‘a’ as shown in the figure.

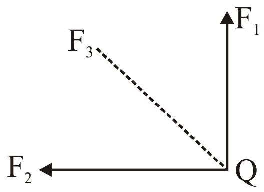


Find the

(a) resultant electric force on a charge Q, and

Ans. There will be three forces on charge Q





$$F_1 = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{a^2}$$

$$F_2 = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{a^2}$$

$$F_3 = \frac{1}{4\pi\varepsilon_0}\frac{QQ}{(\sqrt{2}a)^2} = \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{2a^2}$$

F_1 and F_2 are perpendicular to each other so their resultant will be

$$F' = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos 90^\circ}$$

$$F_1 = F_2$$

$$F' = \sqrt{2}\,\frac{1}{4\pi\varepsilon_0}\frac{qQ}{a^2}$$

F_3 and resultant of F_1 and F_2 will be in same direction

Net force

$$F = F' + F_3$$

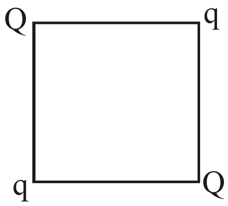
$$F = \frac{Q}{4\pi\varepsilon_0}\left[\frac{\sqrt{2}\,q}{a^2} + \frac{Q}{2a^2}\right]$$

$$= \frac{Q}{4\pi\varepsilon_0}\left[\frac{2\sqrt{2}q + Q}{2a^2}\right]$$

$$\boxed{F = \frac{Q}{4\pi\varepsilon_0}\left[\frac{2\sqrt{2}\,q + Q}{2a^2}\right]}$$

(b) potential energy of this system.

Ans.

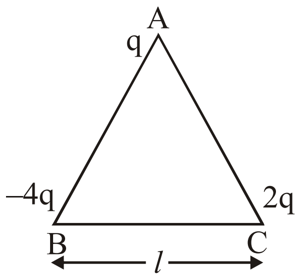


$$W = \frac{4KQq}{a} + \frac{Kq^2}{\sqrt{2}\,a} + \frac{KQ^2}{\sqrt{2}\,a}$$

$$K = \frac{1}{4\pi\varepsilon_0}$$

OR

(a) Three point charges q, – 4q and 2q are placed at the vertices of an equilateral triangle ABC of side '*l*' as shown in the figure. Obtain the expression for the magnitude of the resultant electric force acting on the charge q.



Ans.

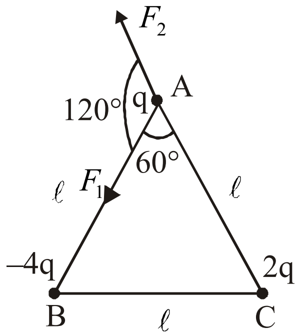
$$\left|\overrightarrow{F_1}\right| = \frac{1}{4\pi\varepsilon_0}\frac{(4q)(q)}{\ell^2}$$

$$F_1 = \frac{1}{4\pi\varepsilon_0}\frac{4q^2}{\ell^2}$$

$$F_1 = \frac{1}{\pi\varepsilon_0}\frac{q^2}{\ell^2}$$

$$\left|\overrightarrow{F_2}\right| = \frac{1}{4\pi\varepsilon_0}\frac{(q)(2q)}{\ell^2}$$

$$F_2 = \frac{1}{2\pi\varepsilon_0}\frac{q^2}{\ell^2}$$



angle between $\overrightarrow{F_1}$ and $\overrightarrow{F_2}$ is 120°

$$\vec{F} = \sqrt{F_1^1 + F_2^2 + 2F_1F_2\cos 120^\circ}$$

$$F_1 = 2F_2$$

$$F = \sqrt{(2F_2)^2 + F_2^2 + 4F_2^2 \cos 120^\circ}$$

$$F = \sqrt{4F_2^2 + F_2^2 - 2F_2^2}$$

$$F = \sqrt{3F_2^2}$$

$$F = \sqrt{3}F_2$$

$$\boxed{F = \sqrt{3}\frac{1}{2\pi\varepsilon_0}\frac{q^2}{\ell^2}}$$

(b) Find out the amount of the work done to separate the charges at infinite distance.

Ans. The amont workdone to separate the charges at infinity will be equal to potential energy.

$$U = \frac{1}{4\pi\varepsilon_0\ell}\left[q\times(-4q)+(q\times 2q)+(-4q\times 2q)\right]$$

$$U = \frac{1}{4\pi\varepsilon_0\ell}\left[-4q^2 + 2q^2 - 8q^2\right]$$

$$U = \frac{1}{4\pi\varepsilon_0\ell}\left[-10q^2\right]$$

$$U = -\frac{1}{4\pi\varepsilon_0\ell}10q^2\ unit$$

12 **(a)** Define the term 'conductivity' of a metallic wire. Write its SI unit. (b)

Ans. Conductivity

$$R = \frac{\rho\ell}{A}$$

$$\rho = \frac{RA}{\ell}$$

$$\frac{1}{\rho} = \frac{\ell}{R\cdot A}$$

$$\sigma = \frac{\ell}{RA}$$

Conductivity of a wire is defined as resiprocal of resistivity.

S.I. unit mho/m

(b) Using the concept of free electrons in a conductor, derive the expression for the conductivity of a wire in terms of number density and relaxation time. Hence obtain the relation between current density and the applied electric field E.

Ans. As we know that

$$R=\frac{\rho\ell}{A}$$

$$V=IR$$

$$V=\frac{I\,\rho\ell}{A}$$

$$\frac{I}{A}=j = \text{current density}$$

$$V=j\,\rho\,\ell$$

$$V=E\cdot\ell$$

$$E\cdot\ell=j\,\rho\,\ell$$

$$E=j\,\rho$$

$$j=\frac{E}{\rho} \qquad \frac{1}{\rho}=\sigma$$

$$\boxed{j=\sigma E}$$

$$V=u+at$$

$$a=\frac{F}{m}$$

$$a=\frac{-eE}{m}$$

$$|V_d|=\frac{eE}{m}\tau$$

$$I\cdot\Delta t=n\,e\,A(V_d)\Delta t$$

$$j=i/A$$

$$j=ne\,A\frac{eE}{m}\tau$$

$$j=\frac{ne^2E}{m}\tau$$

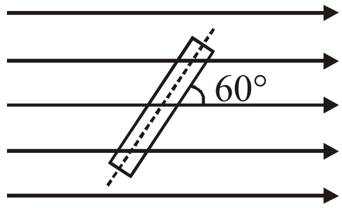
$$j=\frac{ne^2\tau}{m}E$$

13. A bar magnet of magnetic moment 6 J/T is aligned at 60° with a uniform external magnetic field of 0.44 T. Calculate **(a)** the work done in turning the magnet to align its magnetic moment **(i)** normal to the magnetic field, **(ii)** opposite to the magnetic field, and **(b)** the torque on the magnet in the final orientation in case **(ii).**

Ans. $M = 6\,J/T$

$\theta = 60°$

$B = 0.44\,T$



$\tau = m\,B\sin\theta$

$\tau = 6\times 0.44\sin 60°$

$= 6\times 0.44\times\frac{\sqrt{3}}{2}$

$= 3\sqrt{3}\times 0.44$

$= 2.836$

$$dw\int_{\theta=60°}^{90°}\tau\cdot d\theta = -mB\left[\cos 90° - \cos 60°\right]$$

$$= 6\times 0.44\times\left[-\frac{1}{2}\right]$$

$$= 3\times 0.44 = 1.32\,J$$

(ii) $$dw = \int_{\theta=60°}^{180°} mB\sin\theta\cdot d\theta$$

$$= -mB\left[\cos 180° - \cos 60°\right]$$

$$= -6\times 0.44\left[-1-\frac{1}{2}\right]$$

$$= -6\times 0.44\left[-\frac{3}{2}\right]$$

$$= 9\times 0.44$$

$$= 39.6\,J$$

(b) $\vec{\tau} = \vec{m}\times\vec{B}$

$\tau = m\,B\sin\theta$

$= 6\times 0.44\times\sin 180°$

$\tau = 0$

14. **(a)** An iron ring of relative permeability μ_r has windings of insulated copper wire of n turns per metre. When the current in the windings is I, find the expression for the magnetic field in the ring.

Ans. There will be two magnetic field one due to current and another due to magnetics.

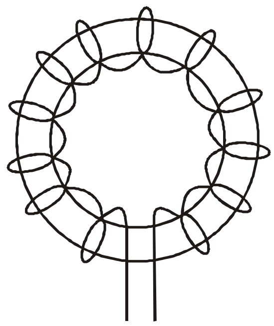
$$B = B_0 + B_m$$

$$B = \mu_0\, nI + \mu_0 M$$

$$B = \mu_0 H + \mu_0\, \chi H$$

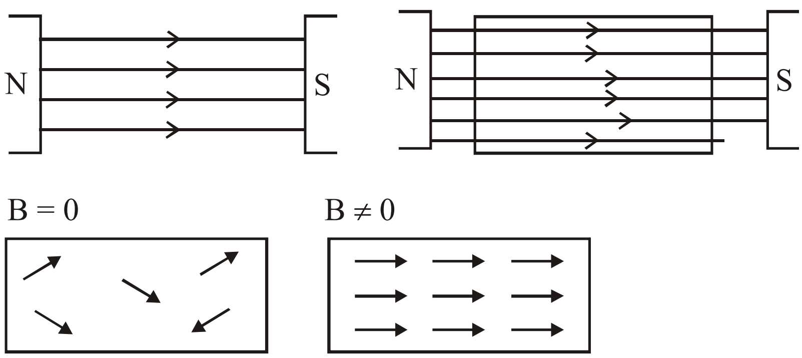
$$B = \mu_0 (1+\chi) H$$

$$\boxed{B = \mu_0\, \mu_r H}$$



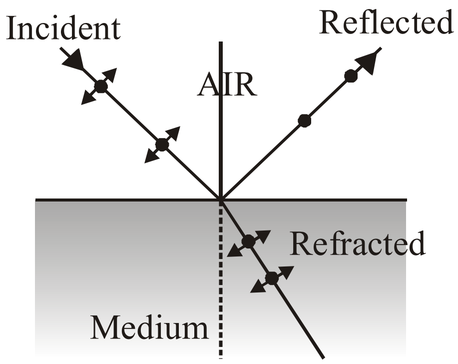
(b) The susceptibility of a magnetic material is 0.9853. Identify the type of magnetic material. Draw the modification of the field pattern on keeping a piece of this material in a uniform magnetic field.

Ans. The susceptibility of this material is between 0 and 1 so its a paramagnetic material.

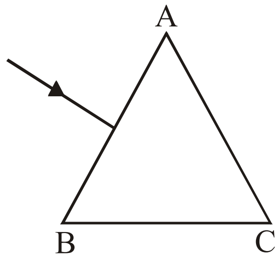


15. **(a)** Show using a proper diagram how unpolarised light can be linearly polarised by reflection from a transparent glass surface.

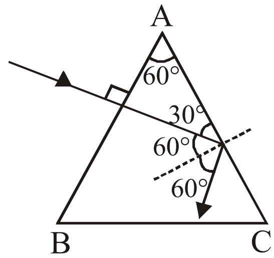
Ans.



(b) The figure shows a ray of light falling normally on the face AB of an equilateral glass prism having refractive index $\frac{3}{2}$, placed in water of refractive index $\frac{4}{3}$. Will this ray suffer total internal reflection on striking the face AC? Justify your answer.



Ans. No it will not suffer total internal reflection



$$a_{\mu w} = \frac{\mu_w}{\mu_s} = \frac{4/3}{3/2} = \frac{8}{9}$$

$$i = \sin^{-1}(\mu) = \sin^{-1}\left(\frac{8}{9}\right) = 62.73^0$$

so if i is less than 60° then TIR will not happen.

16. **(a)** If one of two identical slits producing interference in Young's experiment is convered with glass, so that the light intensity passing through it is reduced to 50%, find the ratio of the maximum and minimum intensity of the fringe in the interference pattern.

Ans. We know that intensity is directly proportional to square of amplitude.

$$I \propto a^2$$

$$\text{if } I_1 = \frac{I}{2}$$

if intensity reduced to 50%, amplitude will be $\frac{a}{\sqrt{2}}$

then $r = \sqrt{2}$

then

$$\frac{I_{\max}}{I_{\min}} = \frac{(r+1)^2}{(r-1)^2} = \frac{\left(\sqrt{2}+1\right)^2}{\left(\sqrt{2}-1\right)^2}$$

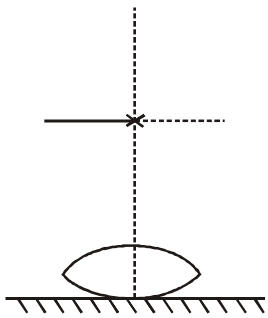
$$\frac{I_{\max}}{I_{\min}} = \left(\frac{2.414}{0.414}\right)^2 = (5.83)^2$$

$$\frac{I_{\max}}{I_{\min}} = 33.98 \simeq 34$$

(b) What kind of fringes do you except to observe if white light is used instead of monochromatic light ?

Ans. Central fringe will be white and remaining will be coloured in VIBGYOR sequence.

17. A symmetric biconvex lens of radius of curvature R and made of glass of refractive index 1.5, is placed on a layer of liquid placed on top of a plane mirror as shown in the figure. An optical needle with its tip on the principal axis of the lens is moved along the axis until its real, inverted image coincides with the needle itself. The distance of the needle from the lens is measured to be x. On removing the liquid layer and repeating the experiment, the distance is found to be y. Obtain the expression for the refractive index of the liquid in terms of x and y.



Ans. f = focal length liquid + lens

f_1 = focal length of lens only

f_2 = focal length of liquid mirror

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{f_2} = \frac{1}{f} - \frac{1}{f_1}$$

$$\frac{1}{f_2} = \frac{1}{x} - \frac{1}{y}$$

$$f_2 = \frac{xy}{y-x}$$

Now,

$$\frac{1}{f_1} = (\mu - 1)\left(\frac{2}{R}\right) \qquad \text{(Convex lens)}$$

$$\frac{1}{y} = (1.5-1)\frac{2}{R}$$

$$\frac{1}{y} = \frac{0.5 \times 2}{R}$$

$$R = y$$

Now for liquid

$$\frac{1}{f_2} = (\mu'-1)\left(\frac{1}{R}\right)$$

$$-\frac{(y-x)}{xy} = (\mu'-1)\left(\frac{1}{R}-\frac{1}{\infty}\right)$$

$$-\frac{(y-x)}{xy} = \frac{(\mu'-1)}{y}$$

$$\therefore \quad \frac{x-y}{x} = \mu'-1$$

$$1+1-\frac{y}{x} = \mu'$$

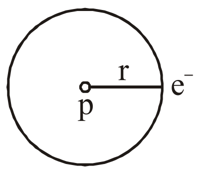
$$2-\frac{y}{x} = \mu'$$

18. **(a)** State Bohr's postulate to define stable orbits in hydrogen atom. How does de Broglie's hypothesis explain the stability of these orbits?

Ans. **Bohr's postulate**

1. All the electrons revolve in circular orbit. Necessary centripetal force is provided by electrostitic force between electron and proton.

$$\frac{mv^2}{r} = \frac{1}{4\pi r_0}\frac{e^2}{r^2}$$



2. Electron revolve only in those orbits for which angular momentum is integral multiple of $\left(\frac{h}{2\pi}\right)$.

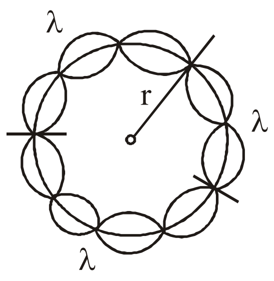
$$L = mvr = \frac{nh}{2\pi}$$

3. When electron jumps from n[th] heigher orbit to p[th] lower orbit it emits energy in form of photon.

$$E_n - E_p = hv$$

According to de'Broglie hypothesis

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$



$$n\lambda = 2\pi r$$

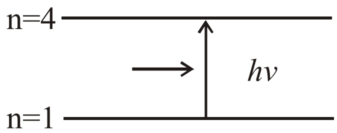
$$n\frac{h}{mv} = 2\pi r$$

$$nh = 2\pi\, mvr$$

$$L = \frac{nh}{2\pi}$$

(b) A hydrogen atom initially in the ground state absorbs a photon which excites it to the $n = 4$ level. Estimate the frequency of the photon.

Ans. $$E_4 - E_1 = \frac{hv}{e}$$



$$-\frac{13.6}{4} + 13.6 = \frac{6.63\times10^{-34}\times v}{1.6\times10^{-19}}$$

$$13.6\left[1-\frac{1}{4}\right] = \frac{6.63\times10^{-34}}{1.6\times10^{-19}}v$$

$$\frac{1.6\times10^{-19}\times13.6\times3}{6.63\times10^{-34}\times4} = v$$

$$v = 2.4615\times10^{15}\,Hz$$

19. (a) Explain the processes of nuclear fission ans nuclear fusion by using the plot of binding energy per nucleon (BE/A) versus the mass number A.

Ans. **Nuclear Fission :**

When heavy nucleus bombarded with neutrons & it splits into smaller nucleus & energy released.

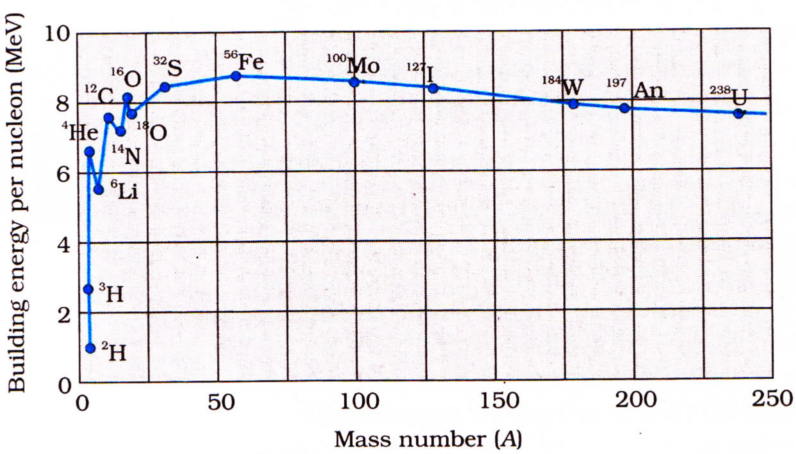
Ex: ${}_{92}U^{235} + n^1 \rightarrow {}_{56}Ba^{144} + {}_{36}Kr^{89} + 3{}_0n^1 + Energy$

Nuclear Fusion :

When 2 smaller nucleus fuse to formed heavy nucleus again energy released.

Ex : ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + approx.26\,Mev$

BE Graph :



(b) A radioactive isotope has a half-life of 10 years. How long will it rake for the activity to reduce to 3.125% ?

Ans. $A_0 = 100$

$A_t = 3.125$

$A_t = A_0 \cdot e^{-\lambda t}$

$3.125 = 100 e^{-\frac{0.693}{10} t}$

$\frac{3.125}{100} = e^{-0.0693t}$

$\frac{100}{3.125} = e^{0.0693t}$

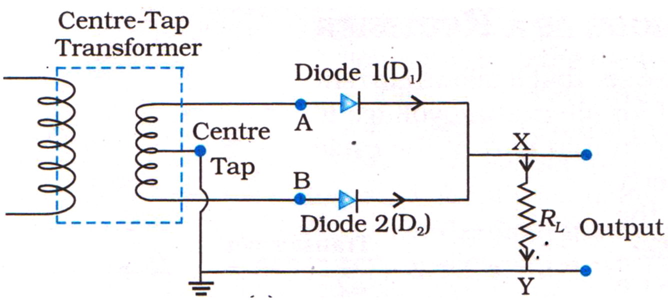
$\log_e \frac{100}{3.125} = 0.0693t$

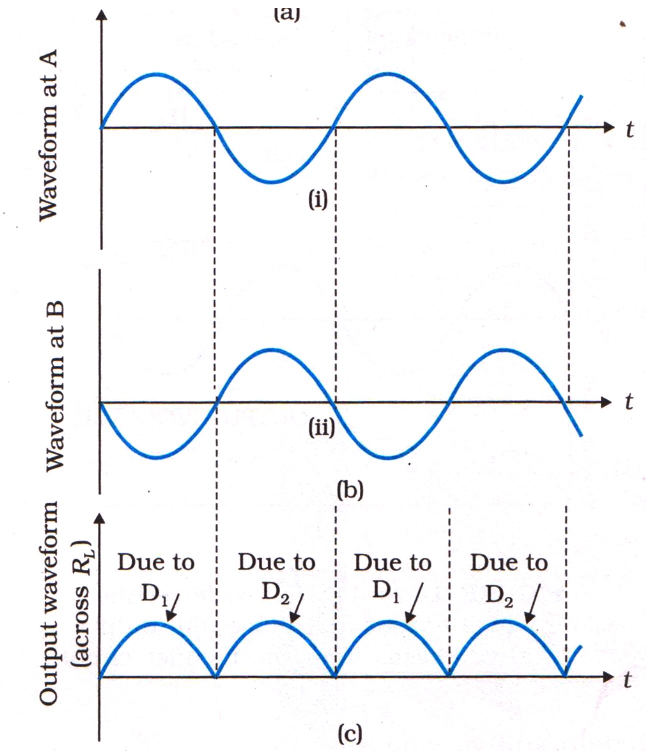
$t_2 = \frac{2.303 \log_{10}^{32}}{0.0693}$

$t = 50.1$ years.

20. **(a)** A student wants to use two p-n junction diodes to convert alternating current into direct current. Draw the labelled circuit diagram she would use and explain how it works.

Ans. **(a)** Full wave rectifier :

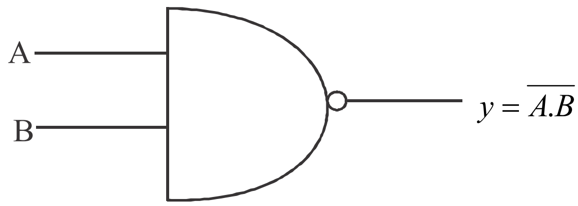




Wave : During positive half cycle diode D_1 is forward bias and during negative half cycle diode D_2 is forward bias so due to conduction of diode D positive half will upper and due to conduction of D_2 negative half cycle will appear .

(b) Give the truth table and circuit symbol for NAND gate.

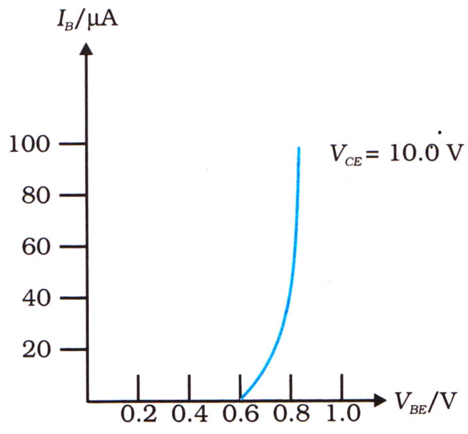
Ans. **(b)** NAND gate :



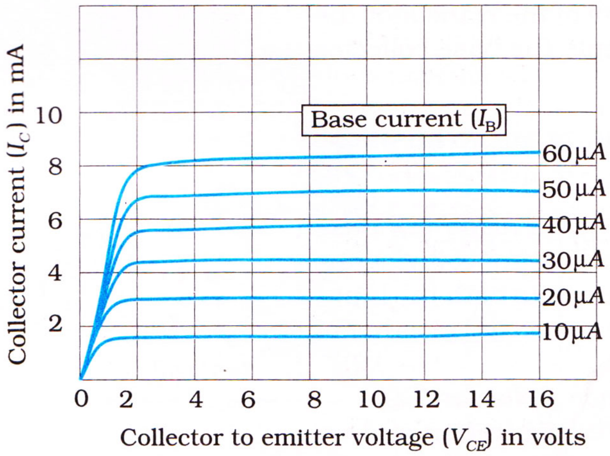
A	B	$y = \overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

21. Draw the typical input and output charateristics of an n-p-n transistor in CE configuration. Show how these characteristics can be used to determine **(a)** the input resistance (r_i), and **(b)** current amplification factor (β).

Ans.



(a)



(b)

$$r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$$

$$r_o = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$$

$$\beta_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$$

22. **(a)** Give three reasons why modulation of a message signal is necessary for long distance transmission.

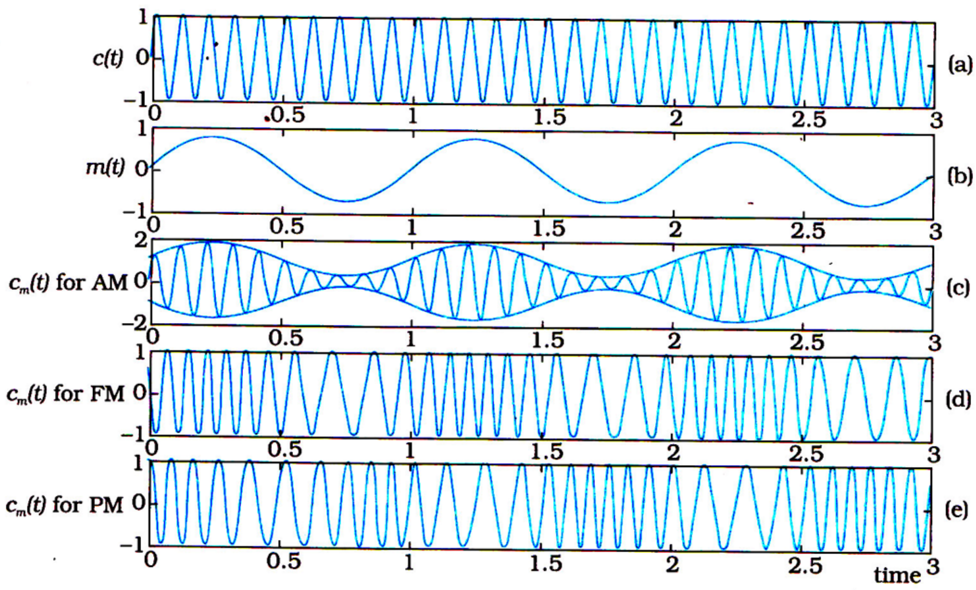
Ans. **(i)** Height of antenna

(ii) Utilization of frequency

(iii) Power of signal.

(b) Show graphucally an audio signal, a carrier wave and an amplitude modulated wave.

Ans.



SECTION - D

23. The teachers of Geeta's school took the students on a study trip to a power generating station, located nearly 200 km away from the city. The teacher explained that electrical energy is transmitted over such a long distance to their city, in the form of alternating current (ac) raised to a high voltage. At the receiving end in the city, the voltage is reduced to operate the devices. As a result, the power loss is reduced. Geeta listened to the teacher and asked questions about how the ac is converted to a higher or lower voltage.

(a) Name the device used to change the alternating voltage to a higher or lower value. State one cause for power dissipation in this device.

Ans. Step up or step down transformer, Eddy current losses.

(b) Explain with an example, how power loss is reduced if the energy is transmitted over long distances as an alternating current rather than a direct current.

Ans. With higher voltage, power losses are less, so voltage can be increased by step up transformer and transformer works on A/c only.

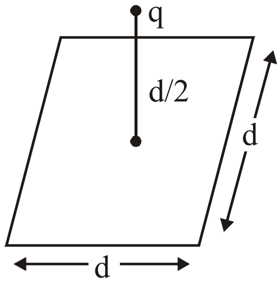
(c) Write two values each shown by the teachers and Geeta.

Ans. Both are interested towards technical knowledge and both are having sufficient ideas about power transmission.

SECTION - E

24. **(a)** Define electric flux. Is it a scalar or a vector quantity ?

A point charge q is at a distance of $\frac{d}{2}$ directly above the centre of a square of side d, as shown in the figure. Use Gauss' law to obtain the expression for the electric flux through the square.



Ans. Electric flux is defined as,

$$\phi_E = \vec{E} \cdot d\vec{s}$$

It is scalar quantity.

Electric flux through square is

$$\phi_E = \frac{q}{\epsilon_0 6}$$

(b) If the point charge is now moved to a distance 'd' from the centre of the square and the side of the square is doubled, explain how the electric flux will be affected.

Ans. Flux will not changed,

i.e., $\phi_E = \frac{q}{\epsilon_0 6}$

(OR)

(a) Use Gauss' law to derive the expression for the electric field $(\vec{E})$ due to a straight uniformly charged infinite line of charge density λ C/m.

Ans. To calculate the field, imagine a cylindrical Gaussian surface, as shown in the figure. Since the field is everywhere radial, flux through the two ends of the cylindrical Gaussian surface is zero. At the cylindrical part of the surface, E is normal to the surface at every point, and its magnitude it constant, since it depends on r. The surface area of the curved part if $2\pi rl$, where l is the length of the cylinder.

Flux through the Gaussian surface

= flux through the curved cylindrical part of the surface

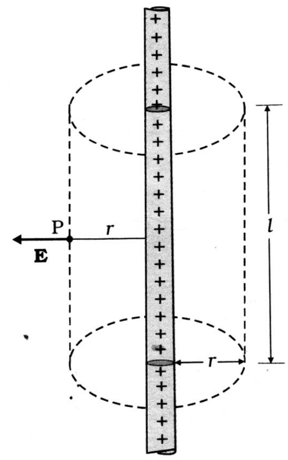
$= E \times 2\pi rl$

The surface includes charge equal to λl. Gauss's law then gives $E \times 2\pi rl = \frac{\lambda l}{\varepsilon_0}$

i.e., $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$

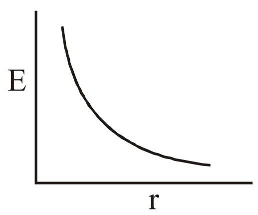
Vectorially, E at any point is given by

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{n}$$



(b) Draw a graph to show the variation of E with perpendicular distance r from the line of charge.

Ans.



(c) Find the work done in bringing a charge q from perpendicular distance r_1 to r_2 $(r_2 > r_1)$.

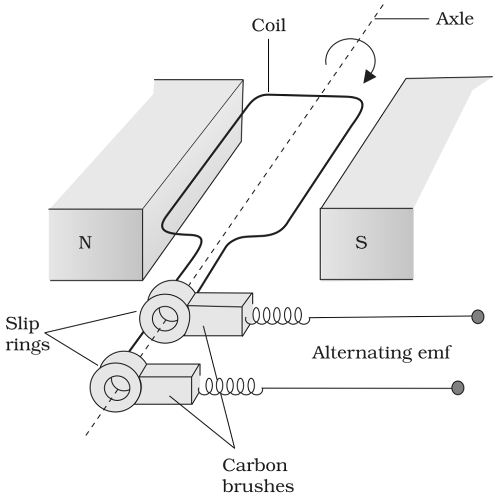
Ans. Work done $= -\int_{r_1}^{r_2} q\, E \cdot dr = \dfrac{-q\lambda}{2\pi\varepsilon_0}\log\dfrac{r_2}{r_1}$

25. **(a)** State the principle of an ac generators and explain its working with the help of a labelled diagram.

Obtain the expression for the emf induced in a coil havin N turns each of cross-sectional area, rotating with a constant angular speed 'ω' in a magnetic field $\vec{B}$, directed perpendicular to the axis of rotation.

Ans. **Principle - Electromagnetic Induction**

AC Gene: The phenomenon of electromagnetic induction has been technologically exploited in many ways. An exceptionally important application is the generation of alternating currents (ac). The modern ac generator with a typical output capacity of 100 MW is a highly evolved machine. In this section, we shall describe the basic principles behind this machine. The Yugoslav inventor Nicola Tesla is credited with the development of the machine. As was pointed out in, one method to induce an emf or current in a loop is through a change in the loop's orientation or a change in its effective area. As the coil rotates in a magnetic field B, the effective area of the loop (the face perpendicular to the field) is $A\cos\theta$, where θ is the angle between A and B. This method of producing a flux change is the principle of operation of a simple ac generator. An ac generator converts mechanical energy into electrical energy.



The basic elements of an ac generator are shown in figure. It consists of a coil mounted on a rotor shaft. The axis of rotation of the coil is perpendicular to the direction of the magnetic field. The coil (called armature) is mechanically rotated in the uniform magnetic field by some external means. The rotation of the coil causes the magnetic flux through it to change, so an emf is induced in the coil. The ends of the coil are connected to an external circuit by means of slip rings and brushes.

When the coil is rotated with a constant angular speed ω the angle θ between the magnetic field vector B and the area vector A of the coil at any instant t is $\theta = \omega t$ (assuming $\theta = 0°$ at t = 0).

As a result, the effective area of the coil exposed to the magnetic field lines changes with time, and from equation the flux at any time t is

$$\Phi_B = BA\cos\theta = BA\cos\omega t$$

From Faraday's law, the induced emf for the rotating coil of N turns isthen,

$$\varepsilon = -N\frac{d\Phi_B}{dt} = -NBA\frac{d}{dt}(\cos\omega t)$$

Thus, the instantaneous value of the emf is

$$\varepsilon = NBA\,\omega\sin\omega t \qquad \textbf{...(1)}$$

where $NBA\omega$ is the maximum value of the emf, which occurs when $\sin\omega t = \pm 1$. If we denote $NBA\omega$ as ε_0, then

$$\varepsilon = \varepsilon_0 \sin\omega t \qquad \textbf{...(2)}$$

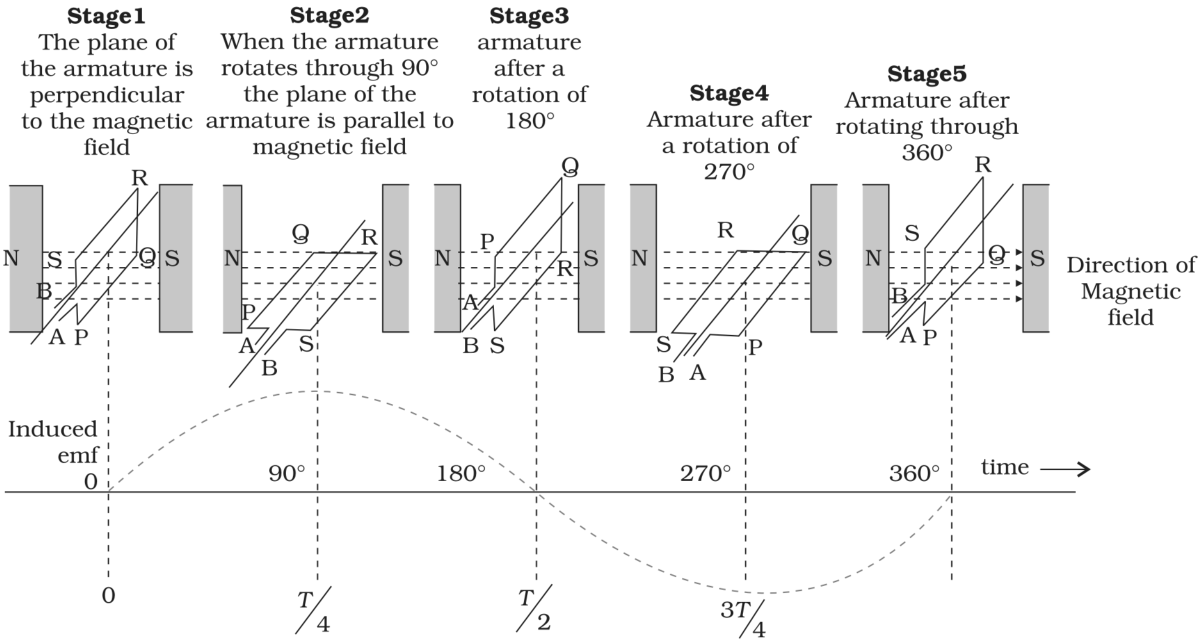
Since the value of the sine fuction varies between +1 and –1, the sign, or polarity of the emf changes with time. Note from figure that the emf has its extremum value when $\theta = 90°$ or $\theta = 270°$, as the change of flux is greatest at these points.

The direction of the current changes periodically and therefore the current is called alternating current (ac). Since $\omega = 2\pi v$, equation 2 can be written as

$\varepsilon = \varepsilon_0 \sin 2\pi \nu t$ **...(3)**

where ν is the frequency of revolution of the generator's coil.

Note that equation 2 and 3 give the instantaneous value of the emf and ε varies between $+\varepsilon_0$ and $-\varepsilon_0$ periodically. We shall learn how to determine the time-averaged value for the alternating voltage and current.



An alternating emf is generated by a loop of wire rotating in a magnetic field.

(b) An aeroplane is flying horizontally from west to east with a velocity of 900 km/hour. Calculate the potential difference developed between the ends of its wings having a span of 20 m. The horizontal component of the Earth's magnetic field is 5×10^{-4} T and the angle of dip is 30°.

Ans. $$e = B_V \cdot V \cdot l = 5\times10^{-4}\sin 30\times 900\times\frac{5}{18}\times 20 = 1.25V$$

(OR)

A device X is connected across an ac source of voltage $V = V_0 \sin \omega t$. The current through X is given as

$$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

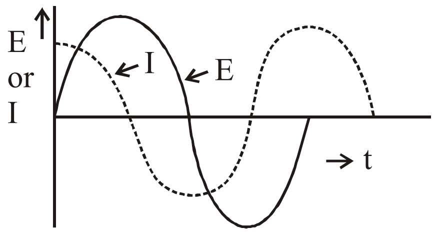
(a) Identify the device X and write the expression for its reactance.

Ans. X - Capacitor

$$X_C = \frac{1}{2\pi fC}$$

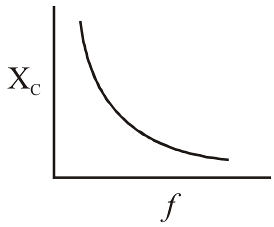
(b) Draw graphs showing variation of voltage and current with time over one cycle ac, for X.

Ans.



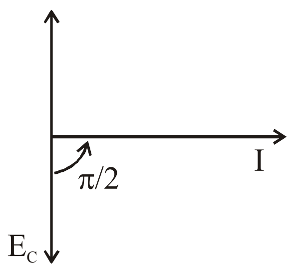
(c) How does the reactance of the device X vary with frequency of the ac ? Show this variation graphically.

Ans. $X_C \propto \frac{1}{f}$



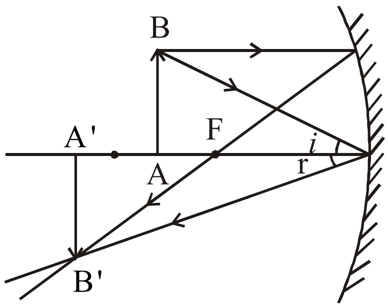
(d) Draw the phasor diagram for the device X.

Ans.



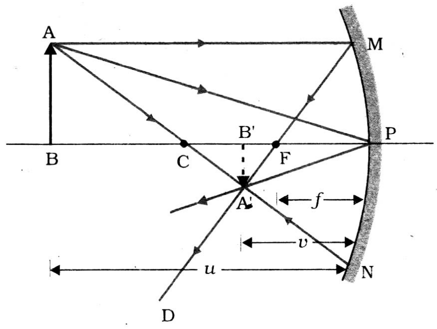
26. **(a)** Draw a ray diagram to show image formation when the concave mirror produces a real, inverted and magnified image of the object.

Ans.



(b) Obtain the mirror formula and write the expression for the linear magnification.

Ans.



Ray diagram for image formation by a concave mirror

Figure shows the ray diagram considering three rays. It shows the image $A'B'$ (in this case, real) of an object AB formed by a concave mirror. It does not mean that only three rays emanate from the point A. An infinite number of rays emanate from any source, in all directions.Thus, point A' is image point of A if every ray originating at point A and falling on the concave mirror after reflection passes through the point A.

We now derive the mirror equation or the relation between the object distance (u), image distance (v) and the focal length (f).

From Figure, the two right-angled triangles $A'B'F$ and MPF are similar. (For paraxial rays, MP can be considered to be a straight line perpendicular to CP.) Therefore,

$$\frac{B'A'}{PM} = \frac{B'F}{FP}$$

or $$\frac{B'A'}{BA} = \frac{B'F}{FP} \quad (\because PM = AB) \qquad ...(i)$$

Since $\angle APB = \angle A'PB'$, the right angles triangles $A'B'P$ and ABP are also similar. Therefore,

$$\frac{B'A'}{BA} = \frac{B'P}{BP} \qquad ...(ii)$$

Comparing equation and (i) and (ii), we get

$$\frac{B'F}{FP} = \frac{B'P - FP}{FP} = \frac{B'P}{BP} \qquad ...(iii)$$

Equation (iii) is a relation involving magnitude of distances. We now apply the sign convention. We note that light travels from the object to the mirror *MPN*. Hence this is taken as the positive direction. To reach the object *AB*, image $A'B'$ as well as the focus *F* from the pole *P*, we have to travel opposite to the direction of incident light. Hence, all the three will have negative signs. Thus,

$$B'P = -\upsilon, FP = -f, BP = -u$$

Using these in equation, we get

$$\frac{-\upsilon + f}{-f} = \frac{-\upsilon}{-u}$$

or $\frac{\upsilon - f}{f} = \frac{\upsilon}{u}$

This relation is known as the mirror equation.

The size of the image relative to the size of the object is another important quantity to consider. We define linear magnification (*m*) as the ratio of the height of the image (h') to the height of the object (h):

$$m = \frac{h'}{h}$$

h and h' will be taken positive or negative in accordance with the accepted sign convention. In triangles $A'B'P$ and $ABP,$ we have,

$$\frac{B'A'}{BA} = \frac{B'P}{BP}$$

With the sign convention, this becomes

$$\frac{-h'}{h} = \frac{-\upsilon}{-u}$$

so that,

$$m = \frac{h'}{h} = -\frac{\upsilon}{u}$$

(c) Explain two advantages of a reflecting telescope over a refracting telescope.

Ans. **1.** Spherical and chromatic abbreviation eliminated.

2. Objective lenses are large and expensive in refracting telescope, where as reflecting telescope is economical.

(OR)

(a) Define a wavefront. Using Huygens' principle, verify the laws of reflection at a plane surface.

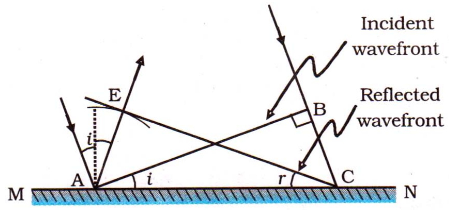
Ans. Locus obtainted by all the points vibrating in same phase called wavefront.

The next consider a plane wave AB incident at an angle *i* on a reflecting surface *MN*. If *v* is represents the speed of the wave in the medium and it τ represents the time taken by the wavefront to advance from the point B to C then the distance

$$BC = \upsilon\tau$$

In order the construct the reflected wavefront we draw a sphere of radius $\upsilon\tau$ from the point A as shown in figure. Let CE represent the tangent plane drawn from the point C to this sphere. Obviously

$$AE = BC = \upsilon\tau$$



Reflection of a plane wave AB by the reflecting surface MN,
AB and CE represent incident and reflected wavefronts

If we now consider the triangles *EAC* and *BAC* we will find that they are conguent and therefore, the angles *i* and *r* would be equal. This is the law of reflection.

(b) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band ? Explain.

Ans. Size will be halved, intensity will increased to four times.

(c) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the obstacle. Explain why.

Ans. Due to diffraction and always central maxima is bright.