XII PHYSICS (FOREIGN 2015) SET-2

Time allowed : 3 hours ***Maximum Marks : 70***

General Instructions :

(i) *There are 26 questions in all. All questions are compulsory.*

(ii) *This question paper has five sections : Section A, Section B, Section C, Section D and Section E.*

(iii) *Section A contains five questions of one mark each, Section B contains five questions of two marks each, Section C contains twelve questions of three marks each, Section D contains one value based question of four marks and Section E contains three questions of five marks each.*

(iv) *There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all the three questions of five marks weightage. You have to attempt only one of the choices in such questions.*

(v) *You may use the following values of physical constants wherever necessary :*

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

$m_e = 9.1 \times 10^{-31}$ kg

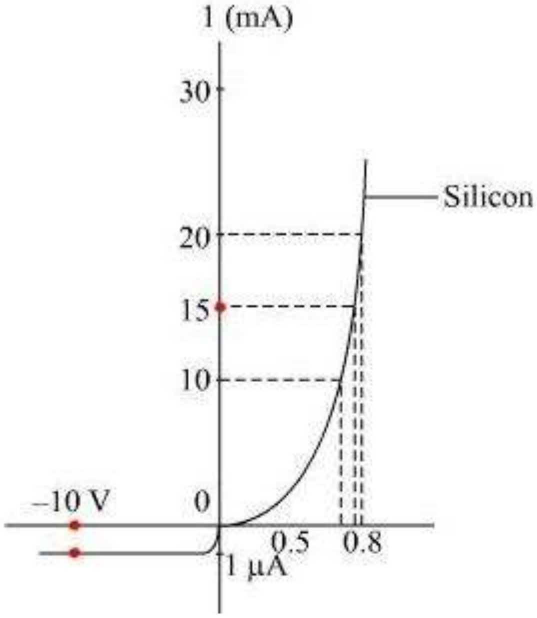
1) Why does the Sun look reddish at sunset or sunrise ?
2) The power factor of an a.c. circuit is 0.5. What is the phase difference between voltage and current in this circuit ?
3) Is it necessary for a transmitting antenna to be at the same height as that of receiving antenna for LOS communication ?
4) Plot a graph showing the variation of resistivity of a conductor with temperature.
5) Write the expression for the torque $\vec{\tau}$ acting on a dipole of dipole moment $\vec{p}$ placed in an electric field $\vec{E}$.

6) (a)Write the β-decay of tritium in symbolic form.

(b)Why is it experimentally found difficult to detect neutrinos in this process ?

7) Given the resistances of 1Ω, 2 Ω and 3 Ω, how will you combine them to get an equivalent resistance of (i) $\frac{11}{3}\Omega$ and (ii) $\frac{11}{5}\Omega$.

8) The *V- I* characteristic of a silicon diode is as shown in the figure. Calculate the resistance of the diode at (i) I = 15 mA and (ii) *V*= –10 V.



9) How does the refractive index of a transparent medium depend on the wavelength of incident light used ?

Velocity of light in glass is 2×10^8 m/s and in air is 3×10^8 m/s. If the ray of light passes from glass to air, calculate the value of critical angle.

OR

An equiconvex lens of focal length *if is cut* into two identical plane convex lenses. How will the power of each part be related to the focal length of the original lens ?

A double convex lens of + 5 D is made of glass of refractive index 1.55 with both faces of equal radii of curvature. Find the value of its radius of curvature.

10) The kinetic energy of the electron orbiting in the first excited state of hydrogen atom is 3.4 eV. Determine the de Broglie wavelength associated with it.

11) Write briefly the important processes that occur during the formation of *p-n* junction. With the help of necessary diagrams, explain the term 'barrier potential'.

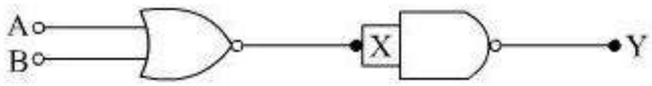
12) A beam of monochromatic radiation is incident on a photosensitive surface. Answer the following questions giving reasons :

(a) Do the emitted photoelectrons have the same kinetic energy?

(b) Does the kinetic energy of the emitted electrons depend on the intensity of incident radiation?

(c) On what factors does the number of emitted photoelectrons depend?

13) (a) What is an 'integrated circuit (I . C.) ? Distinguish between (i) linear I.C. and (ii) digital I.C.
(b) Identify the equivalent gate for the following circuit and write its truth table.

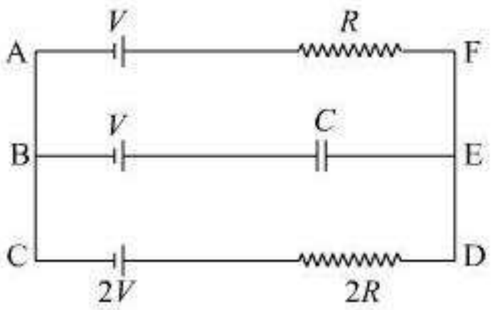


14) Why does a galvanometer when connected in series with a capacitor show a momentary deflection, when it is being charged or discharged?

How does this observation lead to modifying the Ampere's circuital law?

Hence write the generalised expression of Ampere's law.

15) In the given circuit in the steady state, obtain the expressions for (a) the potential drop (b) the charge and (c) the energy stored in the capacitor, C.



16) A circular coil of radius 10 cm. 500 turns and resistance 200 is placed with its plane perpendicular to the horizontal component of the Earth's magnetic field. It is rotated about its vertical diameter through 180° in 0.25 s. Estimate the magnitude of the emf and current induced in the coil. (Horizontal component of the Earth's magnetic field at the place is 3.0×10^{-5} T)

17) Using Rydberg formula, calculate the longest wavelength belonging to Lyman and Balmer series. In which region of hydrogen spectrum do these transitions lie? [Given $R = 1.1 \times 10^7\ m^{-1}$]

18) Why cannot two independent monochromatic sources produce sustained interference pattern? Deduce, with the help of Young's arrangement to produce interference pattern, an expression for the fringe width.

19) Answer the following questions :

(a) Define 'bandwidth' and describe briefly its importance in communicating signals.

(b) Distinguish between digital and analogue signals.

(c) Write the functions of transducer and repeater.

20) Four charges $+q$, $-q$. $+q$ and $-q$ are to be arranged respectively at the four corners of a square ABCD of side 'a'.

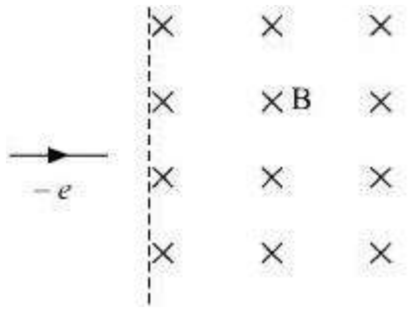
(a) Find the work required to put together this arrangement.

(b) A charge qo is brought to the centre of the square, the four charges being held fixed. How much extra work is needed to do this ?

OR

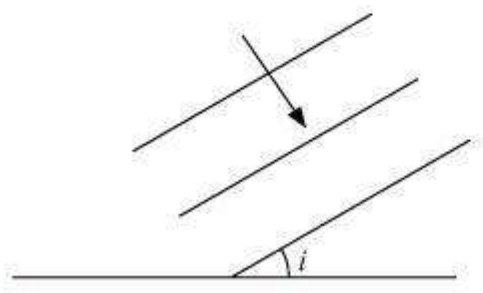
Three point charges $+q$ each are kept at the vertices of an equilateral triangle of side 'l'. Determine the magnitude and sign of the charge to be kept at its centroid so that the charges at the vertices remain in equilibrium.

21) (a) An electron moving horizontally with a velocity of 4×10^4 m/s enters a region of uniform magnetic field of 10^{-5} T acting vertically upward as shown in the figure. Draw its trajectory and find out the time it takes to come out of the region of magnetic field



(b) A straight wire of mass 200 g and length 1.5 m carries a current of 2 A. It is suspended in mid air by a uniform magnetic field *B*. What is the magnitude of the magnetic field?

22) A plane wavefront propagating in a medium of refractive index 'μ_1' is incident on a plane surface making the angle of incidence as shown in the figure. 'i' enters into a medium of refractive index μ_2 ($\mu_2 > \mu_1$). Use Huygens' construction of secondary wavelets to trace the propagation of the refracted wavefront. Hence verify Snell's law of refraction.



23) Sushi is in the habit of charging his mobile and then leaving the charger connected through the mains with the switch on. When his sister Asha pointed it out to him, he replied there was no

harm as the mobile had been disconnected. Asha then explained to him and convinced him, how the energy was still being wasted as the charger was continuously consuming energy.

Answer the following questions :

(a) What values did Asha display in convincing her brother?

(b) What measures, in your view, should be adopted to minimise the wastage of electric energy in your households?

(c) Imagine an electric appliance of 2 W, left connected to the mains for 20 hours. Estimate the amount of electrical energy wasted.

24) (a) A small conducting sphere of radius carrying a charge $+q$ is surrounded by a large concentric conducting shell of radius R on which a charge +Q is placed. Using Gauss's law, derive the expressions for the electric field at a point Y

(i) between the sphere and the shell $(r < x < R)$,

(ii) outside the spherical shell.

(b) Show that if we connect the smaller and the outer sphere by a wire, the charge q on the former will always flow to the latter, independent of how large the charge Q is.

OR

(a) Consider a system of n charges $q_1, q_2, ...q_n$ with position vectors $\vec{r}_1, \vec{r}_2, ...\vec{r}_n$ [relative to some origin 'O'. Deduce the expression for the net electric field $\vec{E}$ at a point P with position vector $\vec{r}$ due to this system of charges.

(b) Find the resultant electric field due to an electric dipole of dipole moment, 2aq, (2a being the separation between the charges : q) at a point distant 'x' on its equator.

25) Draw a ray diagram showing the image formation of a distant object by a refracting telescope.

Define its magnifying power and write the two important factors considered to increase the magnifying power.

Describe briefly the two main limitations and explain how far these can be minimized in a reflecting telescope.

OR

(a) Draw a ray diagram showing image formation in a compound microscope. Define the term 'limit of resolution' and name the factors on which it depends. How is it related to resolving power of a microscope ?

(b) Suggest two ways by which the resolving power of a microscope can be increased.

(c) "A telescope resolves whereas a microscope magnifies." Justify this statement.

26) Write any two important points of similarities and differences each between Coulomb's law for the electrostatic field and Biot-Savart's law of the magnetic field.

Use Biot-Savart's law to find the expression for the magnetic field due to a circular loop of radius *'r'* carrying current *'I'*, at its centre.

OR

What are eddy currents? How are they produced? Describe briefly three main useful application of eddy currents.

SOLUTIONS

1) **Why does the Sun look reddish at sunset or sunrise ?**

SOL: Due to scattering of light.

Alternatively, Red light gets scattered the least)

2) **The power factor of an a.c. circuit is 0.5. What is the phase difference between voltage and current in this circuit ?**

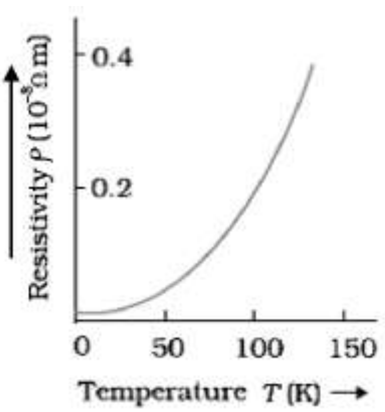
SOL: $\frac{\pi}{3}$ [Note: Award $^1/2$ mark if the student just writes $\cos\theta = 0.5$]

3) **Is it necessary for a transmitting antenna to be at the same height as that of receiving antenna for LOS communication ?**

SOL: No

4) **Plot a graph showing the variation of resistivity of a conductor with temperature.**

SOL:



5) **Write the expression for the torque $\vec{\tau}$ acting on a dipole of dipole moment $\vec{p}$ placed in an electric field $\vec{E}$.**

SOL:

$$\vec{\tau} = \vec{p} \times \vec{E}$$

6) **(a)Write the β-decay of tritium in symbolic form.**
(b)Why is it experimentally found difficult to detect neutrinos in this process ?

SOL:

a) $^{3}_{1}H \rightarrow ^{3}_{2}He + \ ^{0}_{-1}e + \bar{\vartheta} + Q$

Also accept: $^{A}_{Z}X \rightarrow ^{A}_{ZH}Y + \ ^{0}_{-1}e + \bar{\vartheta} + Q$

b) Due to their very weak interaction with matter.

7) **Given the resistances of 1Ω, 2 Ω and 3 Ω, how will you combine them to get an equivalent resistance of (i) $\frac{11}{3}\Omega$ and (ii) $\frac{11}{5}\Omega$.**

SOL:

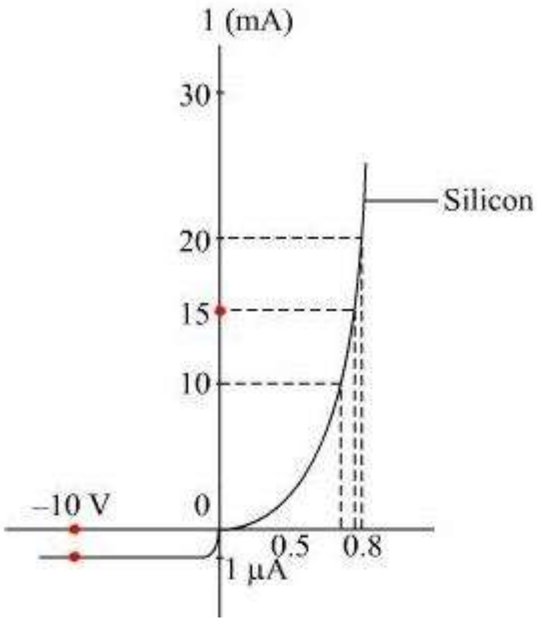
(i) Combining the resistors of 1Ω and 2Ω in parallel
Net resistance = $\frac{2}{3}$ Ω
Now connecting $\frac{2}{3}$ Ω and 3Ω in series

$$R = (\frac{2}{3} + 3)\Omega = \frac{11}{3}\Omega$$

(ii) 2Ω and 3Ω are to be connected in parallel
Net Resistance = $\frac{6}{5}$ Ω
Now connecting $\frac{6}{5}$ Ω and 1Ω in series

$$R = \frac{6}{5} + 1 = \frac{11}{5}\Omega$$

8) **The *V*- *I* characteristic of a silicon diode is as shown in the figure. Calculate the resistance of the diode at (i) I = 15 mA and (ii) *V*= –10 V.**



SOL:

(i) $R = \frac{\Delta V}{\Delta I} = \frac{(0.8-0.7)V}{(20-10)mA}$

$= \frac{0.1}{10} \times 10^3$

$= 10\Omega$

(Also accept if a student calculates different value of the resistance like 30Ω using this method)

(ii) $R = \frac{10\,V}{1\mu A}$

$= 10^7\Omega$

9) How does the refractive index of a transparent medium depend on the wavelength of incident light used ?

Velocity of light in glass is 2×10^8 m/s and in air is 3×10^8 m/s. If the ray of light passes from glass to air, calculate the value of critical angle.

SOL:

Refractive index of the transparent medium decreases with increase in wavelength of the incident light.

Also accept: $\mu = A + \frac{B}{\lambda^2}$

$$\mu_{ga} = \frac{speed\ of\ light\ in\ air}{speed\ of\ light\ in\ glass}$$

$$= \frac{3\times10^8}{2\times10^8} = 1.5$$

Also $\mu_{ga} = \frac{1}{Sin\ I_c} \Rightarrow i_c = sin^{-1}\left(\frac{1}{\mu}\right)$

$$= sin^{-1}\left(\frac{2}{3}\right)$$

OR

An equiconvex lens of focal length *if is cut* into two identical plane convex lenses. How will the power of each part be related to the focal length of the original lens ?

A double convex lens of + 5 D is made of glass of refractive index 1.55 with both faces of equal radii of curvature. Find the value of its radius of curvature.

SOL:

Power of a lens = $\frac{1}{focal\ Length}$

After cutting the lens into two identical parts, the power of each part will be half of the power of original lens. i.e. focal length of each part will be

$\therefore P = \frac{1}{2f}$

$P = \frac{1}{f} \Longrightarrow f = \frac{1}{5}m = 0.2m = 20\ cm$

$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

(Since $R_1 = +R, R_2 = -R$

$$\Rightarrow \frac{1}{20} = (1.5 - 1)\left(\frac{2}{R}\right)$$

$$R = 20\ cm$$

10) The kinetic energy of the electron orbiting in the first excited state of hydrogen atom is 3.4 eV. Determine the de Broglie wavelength associated with it.

SOL:

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$$

$$= \frac{6.63\ X\ 10^{-34}}{\sqrt{2\ X\ 9.1\ X\ 10^{-31}\ X\ 3.4\ X\ 1.6\ X\ 10^{-19}}}m$$

$$= 6.63 \times 10^{-10} m$$

Alternatively,

For first excited state $n = 2$

$$\therefore\ r_2 \cong 4 \times\ 0.53 A^0$$

$$= 2.12\ A^0$$

As $2\pi\ r_n = n\lambda$

$$\lambda\ = \frac{2 \times 3.14 \times 2.12 \times 10^{-10}}{2} m$$

$$\lambda\ \cong 6.6\ \times\ 10^{-10}\ m$$

11) Write briefly the important processes that occur during the formation of *p-n* junction. With the help of necessary diagrams, explain the term 'barrier potential'.

SOL:

Two important processes involved during the formation of p-n jumction are

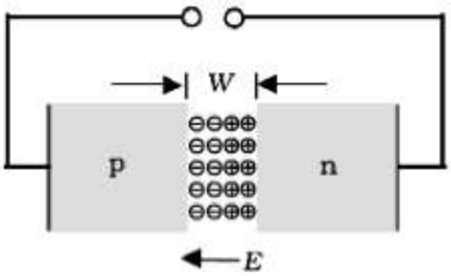
(i) Diffusion
(ii) Drift

Due to the different concentration gradient of the charge carriers on two sides of the junction, electrons from n-side start moving towards p-side and holes start moving from p-side to n-side . This process is called Diffusion.

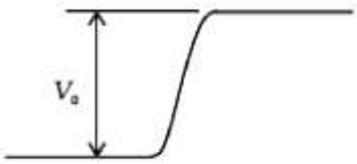
Due to diffusion, positive space change region is created on the n-side of the junction and negative space change region is created on the p-side of the junction. Hence, an electric field called Junction field is set up from n-side to p-side which forces the holes of n-side to move towards p-side and electrons of p-side to move towards n-side . This process is called Drift.

[Also accept :

Diffusion : Movement of majority charge carriers across the junction. Drift : Movement of minority charge carriers across the junction]



Alternatively :



The loss of electron from n region and gain of electron by p region causes a difference of potential across the junction called barrier potential whose polarity is such that it opposes further flow of charges.

12) A beam of monochromatic radiation is incident on a photosensitive surface. Answer the following questions giving reasons :

(d) Do the emitted photoelectrons have the same kinetic energy?

(e) Does the kinetic energy of the emitted electrons depend on the intensity of incident radiation?

(f) **On what factors does the number of emitted photoelectrons depend?**

SOL:

a) No Electrons at different depths, need different energies to come out.

b) No, The K.E. depends on the energy of each photon and not on the number of photons (intensity of light).

c) Number of photoelectrons emitted depends on the intensity of incident light .

13) (a) What is an 'integrated circuit (I . C.) ? Distinguish between (i) linear I.C. and (ii) digital I.C. (b) Identify the equivalent gate for the following circuit and write its truth table.

SOL: Equivalent gate is OR gate

[Note: If a student identifies (i) NOR gate (ii) NAND gate separately, award this one mark]

Truth Table

A	B	X	Y
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1

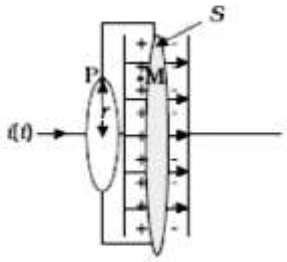
14) Why does a galvanometer when connected in series with a capacitor show a momentary deflection, when it is being charged or discharged?

How does this observation lead to modifying the Ampere's circuital law?

Hence write the generalised expression of Ampere's law.

SOL: During charging / discharging of the capacitor, displacement current between the plates is set up. Hence, circuit becomes complete and galvanometer show momentary deflection.

(Alternatively , There is a momentary flow of current during charging / discharging.)



According to Ampere's circuital Law

$$\oint \vec{B}.\overrightarrow{dl} = \mu_o I$$

Applying it to surface P, $\oint \vec{B}.\overrightarrow{dl} = \mu_o I_c$
Applying it to surface S, $\oint \vec{B}.\overrightarrow{dl} = 0$

$$\therefore \oint_p \vec{B}.\overrightarrow{dl} \neq \oint_s \vec{B}.\overrightarrow{dl}$$

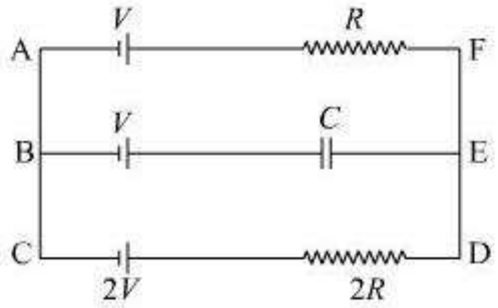
This is in contradiction to Ampere's circutial law. Hence the law needs modification.

Alternatively: this observations shows that during charging/ discharging, the circuit is (momentarily) complete and there is a 'current flow' between the capacitor plates also.

There is, therefore, a need to include this current ' flowing' across the 'gap'.] Modified form of Ampere's circuital law

$$\oint \vec{B}.\overrightarrow{dl} = \mu_o \left[i_c + \epsilon_o \frac{d}{dt}\phi_e\right]$$

15) In the given circuit in the steady state, obtain the expressions for (a) the potential drop (b) the charge and (c) the energy stored in the capacitor, C.



SOL:

a) Net e.m.f = $2V - V = V$

Net resistance = $2R + R = 3R$

So current in the circuit I = $\frac{V}{3R}$

Potential difference across $BE = 2V - I \times 2R$

$$= 2V - \frac{V}{3R} \times 2R = \frac{4}{3}V$$

So potential differnce across C= $\frac{4}{3}V - V = \frac{V}{3}$

(i) Charge $Q = C \times \frac{V}{3} = \frac{CV}{3}$

(ii) Energy stored = $\frac{1}{2}CV^2$

$$= \frac{1}{2}C\left(\frac{V}{3}\right)^2 = \frac{CV^2}{18}$$

16) **A circular coil of radius 10 cm. 500 turns and resistance 200 is placed with its plane perpendicular to the horizontal component of the Earth's magnetic field. It is rotated about its vertical diameter through 180° in 0.25 s. Estimate the magnitude of the emf and current induced in the coil. (Horizontal component of the Earth's magnetic field at the place is 3.0 × 10^{-5} T)**

SOL: Intial flux through the coil

$$(\phi_B)_{initial} = NBA\cos\theta$$

$$= 500 \times (3.0 \times 10^{-5} \times \pi \times 10^{-2} \cos 0^0) Wb$$

$$= 1.5\,\pi \times 10^{-4} Wb$$

Final flux after rotation

$$(\phi_B)_{final} = 500 \times (3.0 \times 10^{-5} \times \pi \times 10^{-2} \cos 180^0)\ Wb$$

$$= -1.5\pi \times 10^{-4}\, Wb$$

Induced emf $e = -\frac{d\varphi}{dt}$

$$= \frac{3\pi \times 10^{-4}}{0.25} V \simeq 3.8 \times 10^{-3} V$$

=3.8mV

Induced current = $\frac{e}{R}$

$$= \frac{3.8 \times 10^{-3}}{200} \text{A}$$

$$= 1.9 \times 10^{-5} A\ (=19\text{A}\mu)$$

17) Using Rydberg formula, calculate the longest wavelength belonging to Lyman and Balmer series. In which region of hydrogen spectrum do these transitions lie? [Given R = 1.1 × 10^7 m^{-1}]

SOL:

Rydberg's formula

$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

Transistions corresponding to Longest wavelength in Lyman series

$n_i = 2, n_f = 1$

$\frac{1}{\lambda} = R\left(1 - \frac{1}{4}\right) = \frac{3}{4}R$

$\lambda = \frac{4}{3R} = \frac{4}{3\times1.1\times10^7}$ m

$= 1.21 \times 10^{-7} = 121\ nm$

Transistion corresponding to Longest wavelength in Balmer Series.

$n_i = 3, n_f = 2$

$\frac{1}{\lambda} = R\left(\frac{1}{4} - \frac{1}{9}\right)$

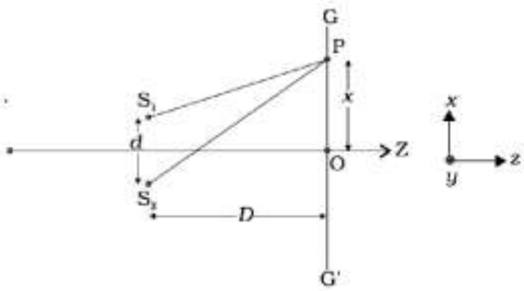
$= \frac{5}{36}R = 6.545 \times 10^{-7} m \simeq 655\ nm$

First transistion lies in ultraviolet region

Second transistion lies in Visible region

18) Why cannot two independent monochromatic sources produce sustained interference pattern? Deduce, with the help of Young's arrangement to produce interference pattern, an expression for the fringe width.

SOL: Two independent sources do not maintain constant phase difference, therefore the interference pattern will also change, with time.



Consider a point P on the screen and let there be the maximum intensity

$S_2P - S_1P = n\lambda \qquad (n = 0,1,2, \ldots\ldots\ldots..) \quad \ldots\ldots(i)$

$(S_2P)^2 - (S_1P)^2 = \left[D^2 + \left(x + \frac{d}{2}\right)^2\right] - \left[D^2 + \left(x - \frac{d}{2}\right)^2\right]$

$= 2xd$

Where, $SS_1 = d\,, OP = x,$

$\therefore \quad S_2P - S_1P = \frac{2xd}{S_2P + S_1P}$

If $x, d \ll D,\ then$

$S_2P - S_1P = \frac{2xd}{2D} = \frac{xd}{D} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(ii)$

From (i) & (ii)

$\frac{xd}{D} = n\lambda$

$\Rightarrow x = \frac{n\lambda D}{d}$ for nth maximum

Similarly for (n+1)th maximum $x' = \frac{(n+1)\lambda D}{d}$

$\therefore$Fringe width $\beta = x' - x = \frac{\lambda D}{d}$

19) Answer the following questions :

(d) **Define 'bandwidth' and describe briefly its importance in communicating signals.**

(e) **Distinguish between digital and analogue signals.**

(f) **Write the functions of transducer and repeater.**

SOL:

(a) Defined as the frequency range over which a given equipment operates .

[Alternatively: The ‘frequency spread’ of a given signal]

Importance :

To design the equipments used in communication system for distinguishing different message signals

(b) Digital signals are those which take only discrete stepwise values and analogue signals are continuous variations of voltage /current .

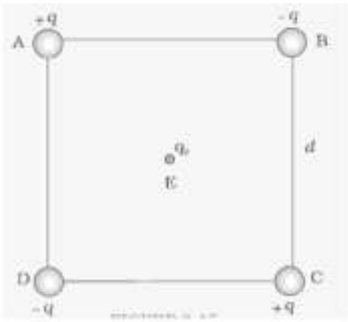
(c) Transducer : converts one form of energy into another
Repeater : Enhances the range of communication.

20) Four charges +*q*, –*q*. +*q* and –*q* are to be arranged respectively at the four corners of a square ABCD of side 'a'.

(c) Find the work required to put together this arrangement.

(d) A charge qo is brought to the centre of the square, the four charges being held fixed. How much extra work is needed to do this ?

SOL:



a) Work done

$$W = 0 + \left(\frac{-kq^2}{a}\right) + \left(-\frac{kq^2}{a} + \frac{kq^2}{a\sqrt{2}}\right) + \left(\frac{-kq^2}{a} + \frac{-kq^2}{a\sqrt{2}} + \frac{kq^2}{a\sqrt{2}}\right)$$

$$= -\frac{4kq^2}{a} + 2\frac{kq^2}{a\sqrt{2}}$$

$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{a}\left[\sqrt{2} - 4\right]$$

b) Potential at the centre of the square $V = 0$,
Hence extra work done

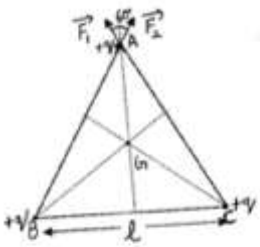
$$W = q_0 \times V$$

$$= q_0 \times 0 = 0$$

OR

Three point charges $+q$ each are kept at the vertices of an equilateral triangle of side *'l'*. Determine the magnitude and sign of the charge to be kept at its centroid so that the charges at the vertices remain in equilibrium.

SOL:



The charge, at any one vertex will remain in equilibrium, if the net electric force there, due to the other three charges, is zero.

Let Q be the required charge

$\vec{F}_1$ = Force at A due to the charge at B

$= \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{l^2}$ along $\overrightarrow{BA}$

$\vec{F}_2$ = Force at A due to the charge at C

$= \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{l^2}$ along $\overrightarrow{CA}$

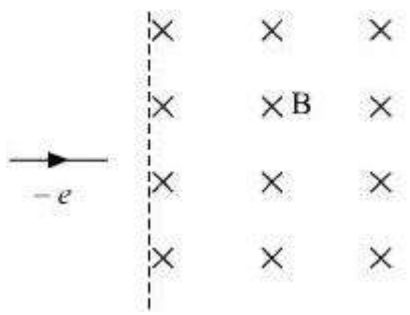
$\vec{F}_1 + \vec{F}_2 = \sqrt{3}.\frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{l^2}$ along GA

Force at A due to charge at G $= \frac{1}{4\pi\epsilon_0} \cdot \frac{Qq(3)}{l^2}$

$3Qq = -\sqrt{3}q^2$

$Q = -\frac{q}{\sqrt{3}}$

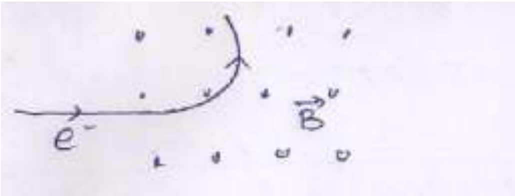
21) (a) An electron moving horizontally with a velocity of 4×10^4 m/s enters a region of uniform magnetic field of 10^{-5} T acting vertically upward as shown in the figure. Draw its trajectory and find out the time it takes to come out of the region of magnetic field



(b) A straight wire of mass 200 g and length 1.5 m carries a current of 2 A. It is suspended in mid air by a uniform magnetic field *B*. What is the magnitude of the magnetic field?

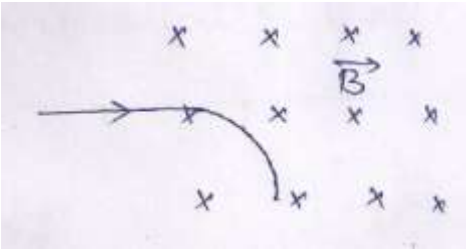
SOL:

a) When field is taken vertically upward



Alternatively,

When Magnetic field is taken vertically inward



a) When field is taken vertically upward

Alternatively,

When Magnetic field is taken vertically inward

$$\frac{mv^2}{r} = qvB$$

$$\therefore r = \frac{mv}{qB} = \frac{9.1\times10^{-31}\times4\times10^4}{1.6\times10^{-19}\times10^{-5}}\,\text{m}$$

$$= \frac{9.1\times4}{1.6}\times10^{-3}\text{m}$$

$$= 22.3\times10^{-3}m = 2.23\times10^{-2}\text{m}$$

$$= 2.23\ cm$$

$$T = \frac{\pi r}{v} = \frac{\pi\times2.25\times10^{-3}}{4\times10^4} \approx 1.8\times10^{-7}\ s$$

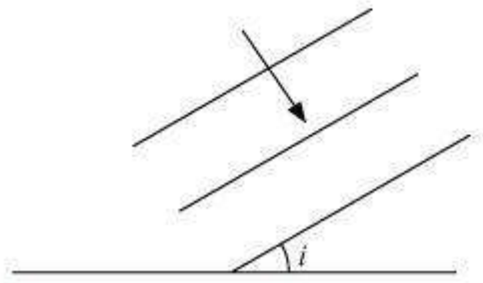
b) $ILB = mg$

$2 \times 1.5 \times B = 200 \times 10^{-3} \times 9.8$

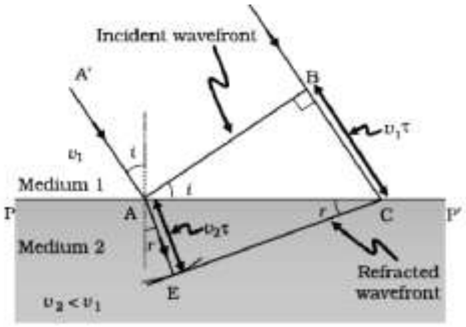
$B = \frac{200 \times 9.8 \times 10^{-3}}{3}$ T

$= 0.653$T

22) A plane wavefront propagating in a medium of refractive index 'μ_1' is incident on a plane surface making the angle of incidence as shown in the figure. 'i' enters into a medium of refractive index μ_2 ($\mu_2 > \mu_1$). Use Huygens' construction of secondary wavelets to trace the propagation of the refracted wavefront. Hence verify Snell's law of refraction.



SOL:



In ΔABC

$$Sin\ i = \frac{BC}{AC} = \frac{V_1\tau}{AC}$$

In ΔAEC

$$Sin\ r = \frac{AE}{AC} = \frac{V_2\tau}{AC}$$

$$\Rightarrow \frac{Sin\ i}{Sin\ r} = \frac{v_1}{v_2} = \mu_{21}$$

23) **Sushi is in the habit of charging his mobile and then leaving the charger connected through the mains with the switch on. When his sister Asha pointed it out to him, he replied there was no harm as the mobile had been disconnected. Asha then explained to him and convinced him, how the energy was still being wasted as the charger was continuously consuming energy.**

Answer the following questions :

(d) **What values did Asha display in convincing her brother?**

(e) **What measures, in your view, should be adopted to minimise the wastage of electric energy in your households?**

(f) **Imagine an electric appliance of 2 W, left connected to the mains for 20 hours. Estimate the amount of electrical energy wasted.**

SOL:

(a) Any two values –

Knowledgeable , concern for conservation of resources, convincing , thoughtful etc.

(b) (i) High power devices should be used only when required. (ii)All electrical devices should be switched off when not in use .

(c) Energy $= P \times t = \frac{2}{1000} \times 20\, kWh = .04\, kWh$

Or, $E = 2 \times 20 \times 3600\, J = 144000$ J

24) (a) A small conducting sphere of radius carrying a charge +*q* is surrounded by a large concentric conducting shell of radius *R* on which a charge +Q is placed. Using Gauss's law, derive the expressions for the electric field at a point Y

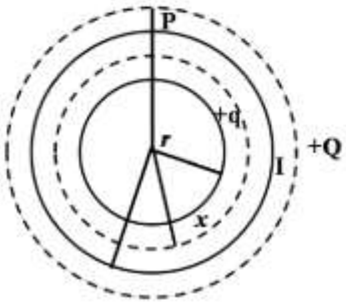
(iii) **between the sphere and the shell *(r < x < R)*,**

(iv) **outside the spherical shell.**

(b) Show that if we connect the smaller and the outer sphere by a wire, the charge *q* on the former will always flow to the latter, independent of how large the charge Q is.

SOL:

(a)



(i) According to Gauss's law $\oint \vec{E}.\overrightarrow{ds} = \frac{q}{\epsilon_0}$

Applying Gauss's law to surface I

$E.4\pi x^2 = \frac{q}{\epsilon_0}$

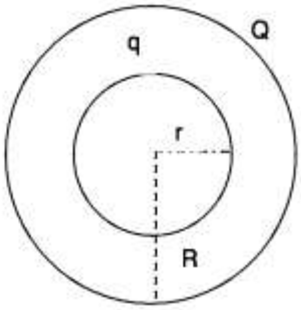
$E = \frac{q}{4\pi\epsilon_0 x^2}$

(ii) Using Gauss law for the Gaussian surface II

$E.4\pi x^2 = \frac{Q+q}{\epsilon_0}$

$E = \frac{q+Q}{4\pi\epsilon_0 x^2}$

(b)



$V_r = \frac{1}{4\pi\epsilon_o}(\frac{q}{r} + \frac{Q}{R})$

$V_R = \frac{1}{4\pi\epsilon_o}(\frac{q}{r} + \frac{Q}{R})$

$V_r > V_R$

Hence charge will always flow from the smaller sphere to the larger sphere.

OR

(c) **Consider a system of n charges** $q_1, q_2, ...q_n$ **with position vectors** $\vec{r}_1, \vec{r}_2, ...\vec{r}_n$ **[relative to some origin 'O'. Deduce the expression for the net electric field** $\vec{E}$ **at a point P with position vector** $\vec{r}$ **due to this system of charges.**

(d) **Find the resultant electric field due to an electric dipole of dipole moment, 2aq, (2a being the separation between the charges : q) at a point distant 'x' on its equator.**

SOL:

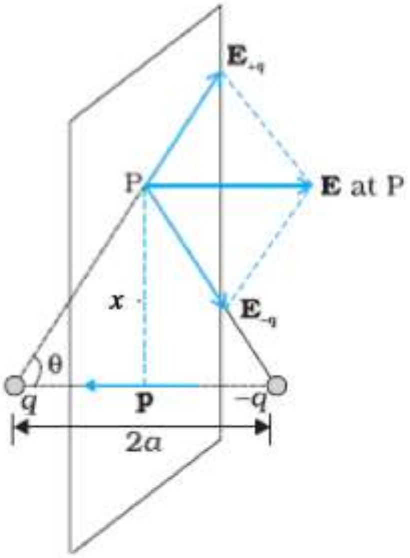
By super position principle

$$\mathbf{E}(\mathbf{r}) = \mathbf{E}_1(\mathbf{r}) + \mathbf{E}_2(\mathbf{r}) + \dots$$

$$= \frac{1}{4\pi\epsilon_o}\left[\frac{q_1}{r_{1p}^2}\hat{r}_{1P} + \frac{q_2}{r_{2p}^2}\hat{r}_{2P} + \dots\dots\right]$$

Where, $\vec{r}_{ip} = \vec{r}_p - \vec{r}_i$

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{r_{iP}^2}\hat{\mathbf{r}}_{iP}$$



The magnitudes of electric field at point P due to charges +q and -q

$$E_{+q} = \frac{q}{4\pi\varepsilon_0}\frac{1}{x^2 + a^2}$$

$$E_{-q} = \frac{q}{4\pi\varepsilon_0}\frac{1}{x^2 + a^2}$$

The direction of $\overrightarrow{E_{+q}}$ and $\overrightarrow{E_{-q}}$ are shown in the figure. Clearly, the components normal to the dipole axis cancel away and along dipole axis add up. The total Electric field is opposite to $\hat{p}$

$$\mathbf{E} = -(E_{+q} + E_{-q})\cos\theta\ \hat{\mathbf{P}}$$
$$= -\frac{2qa}{4\pi\varepsilon_o(x^2+a^2)^{3/2}}\hat{\mathbf{P}}$$

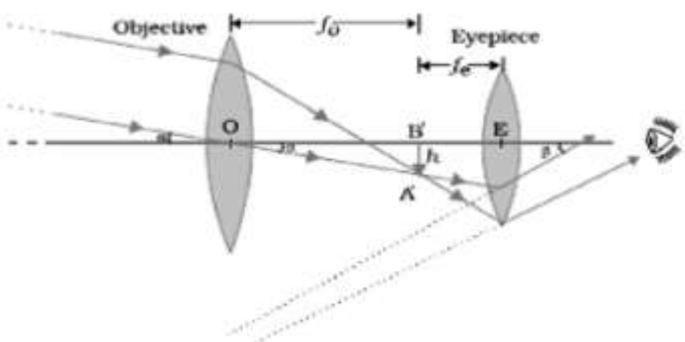
where $\vec{p} = q \times \overrightarrow{2a}$

25) **Draw a ray diagram showing the image formation of a distant object by a refracting telescope.**

Define its magnifying power and write the two important factors considered to increase the magnifying power.

Describe briefly the two main limitations and explain how far these can be minimized in a reflecting telescope.

SOL:



Magnifying power is the ratio of angle subtended at the eye by the final image to the angle which the object subtends at the eye .

$$m = \frac{f_o}{f_e}$$

Factors:

1. Increasing focal length of objective
2. Decreasing focal length of eye piece

Limitations (Any two):

1. Suffers from chromatic abberration
2. Suffers from spherical aberration
3. Small magnifying power
4. Small resolving power

Advantages of reflecting telescope (Any two):

1. No chromatic aberration, because mirror is used.
2. Spherical aberration can be removed by using a parabolic mirror .
3. Image is bright because no loss of energy due to reflection.
4. Large mirror can be provided easier mechanical support .

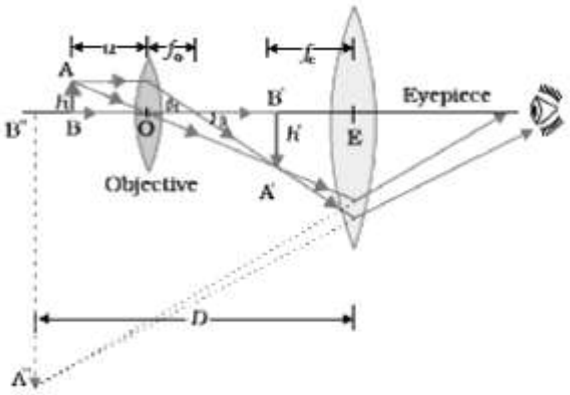
OR

(d) Draw a ray diagram showing image formation in a compound microscope. Define the term 'limit of resolution' and name the factors on which it depends. How is it related to resolving power of a microscope ?

(e) Suggest two ways by which the resolving power of a microscope can be increased.

(f) "A telescope resolves whereas a microscope magnifies." Justify this statement.

Sol:



Definition of limit of resolution

The minimum linear or angular separation between two point objects at which they can be just separately seen or resolved by an optical instrument.

It depends on

i) Wavelength of light used
ii) Medium between object and objective lens

Resolving power of microscope is the reciprocal of its limit of resolution

b) Resolving power of compound microscope can be increased by

i) Decreasing wavelength
ii) Increasing refractive index of the medium between object and objective of the microscope.

c) A telescope produces an (angularly) magnified image of the far object and therby

26) Write any two important points of similarities and differences each between Coulomb's law for the electrostatic field and Biot-Savart's law of the magnetic field.

Use Biot-Savart's law to find the expression for the magnetic field due to a circular loop of radius *'r'* carrying current *'I'*, at its centre.

SOL:

Similarities

i) Both are long range, since both depend inversely on the square of distance to the point of interest.

ii) Principle of super position is applicable in both cases.

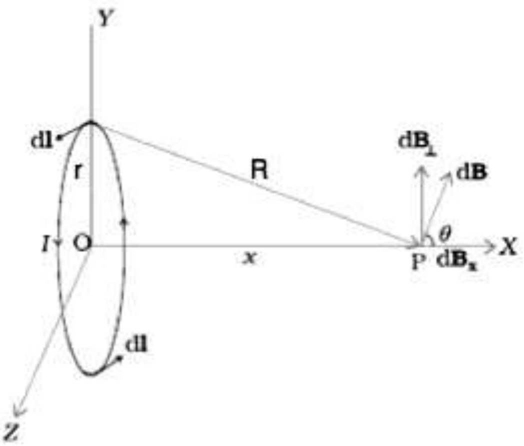
Differences

i) Electrostatic field is produced by a scalar source (electric charge).

The magnetic field is produced by a vector source Id

ii) Electrostatic field is along the displacement vector joining the source and field point. The magnetic field is perpendicular to the

plane containing the current element (Id).



By Biot-Savart's Law

$$dB = \frac{\mu_0 I dl}{4\pi r^2)} = \frac{\mu_0 I dl}{4\pi x^2 + r^2)}$$

When the perpendicular components are summed over, they cancel out and. The contribution is only from the x component which can be obtained by integrating

dBX = dBcos $\boldsymbol{\theta}$

$$= \frac{\mu_o}{4\pi} \frac{Idl}{(x^2 + r^2)} \cdot \frac{r}{(x^2 + r^2)^{1/2}}$$

$$= \frac{\mu_o Idl}{4\pi(x^2 + r^2)^{3/2}}$$

$$\boldsymbol{B} = B_x\hat{\imath} = \frac{\mu_o Ir}{4\pi(x^2+r^2)^{3/2}} .2\pi r\hat{\imath}$$

$$= \frac{\mu_0 Ir^2}{2(x^2+r^2)^{3/2}} \hat{\imath}$$

At the centre x=0, $\vec{B}_0 = \frac{\mu_0 I}{2r} \hat{\imath}$

OR

What are eddy currents? How are they produced?

Describe briefly three main useful application of eddy currents.

SOL:

The induced circulating current produced in the bulk piece of a conductor, when it is subjected to changing magnetic flux are known as 'eddy currents'/ Eddy currents are produced when a bulk conductor is present in a changing magnetic field.

Application of Eddy Current

i) Magnetic braking in trains

Strong electromagnets are situated above the rails in some electrically powered trains. When the electromagnet are activated, the eddy currents induced in the rails oppose, the motion of the train. As there are no mechanical linkage, the breaking effect is strong.

ii) Electronmagnetic damping

Certain galvanometers have fixed core made of non magnet metallic material. When the coil oscillates, the eddy current generated in the core oppose the motion and bring the coil to rest quickly.

iii) Electric power meters

The shiny metal disc in the electric power meter rotates due to eddy currents. Electric currents are induced in the disc by magnetic fields produced by sinusoidally varying current in a coil.