2016

Set: I

Set: I

Question: 1

Answer all questions briefly and to the point.

How does the (i) pole strength and (ii) magnetic moment of each part of a bar magnet change if it is cut into two equal pieces transverse to its length? [1]

Answer:
Pole strength of each part is same as the original magnet but magnetic moment is halved.

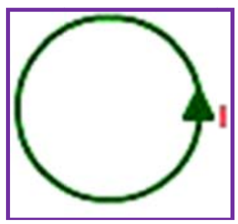
Question: 2

Define electrical conductivity of a conductor and give its S.I. unit. [1]

Answer:

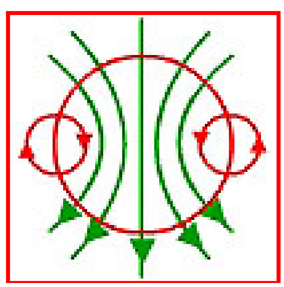
The reciprocal of resistivity of the material of a conductor is called its conductivity. i.e., $\sigma = \frac{1}{\rho}$

Question: 3



In the diagram above is shown a circular loop carrying current I. Show the direction of the magnetic field with the help of lines of force. [1]

Answer:
The magnetic lines of force of a circular loop carrying current I am shown below.



Question: 4

An electric dipole of dipole moment 20×10^{-6} Cm is enclosed by a closed surface. What is the net flux coming out of the surface? [1]

Answer:
Net flux coming out of the closed surface is zero, because the net charge on electric dipole is zero.

Question: 5

Write the relationship between angle of incidence 'i', angle of prism 'A' and angle of minimum deviation for a triangular prism. [1]

Answer:
The relation between the angle of incidence **I**, angle of prism A and the angle of minimum deviation Δm for a triangular prism is given as in given by $i = \frac{A + \Delta_m}{2}$

Question: 6

Electrons are emitted from a photosensitive surface when it is illuminated by green light but electron emission does not take place by yellow light. Will the electrons be emitted when the surface is illuminated by red light, and blue light? [1]

Answer:
- Electrons are not emitted with red light.
- Electrons are emitted with blue light.

Question: 7

With that purpose was famous Davisson-Germer experiment with electrons performed? [1]

Answer:
Davisson-Germer experiment confirmed the wave nature of electrons.

Question: 8

Define the term 'dielectric constant' of a medium in terms of capacitance of a capacitor. [1]

Answer:
Dielectric constant of a medium is defined as the ratio of the capacitance of the capacitor with the dielectric as the medium to its capacitance with vacuum between its plates.

Question: 9
What is the angle of dip at a place where the horizontal and vertical components of earth's magnetic field are equal? [2]

Answer:

$$\tan \delta = \frac{B_V}{B_H} = 1$$

$$\therefore \delta = 45^0$$

Question: 10

Using Gauss's law, show that no electric field intensity exists inside a hot-low charged conductor. [2]

Answer:
Consider a charged conductor with a cavity inside it. Take a Gaussian surface inside the conductor near the cavity E = 0, everywhere inside the conductor. By Gauss's law, charge

enclosed by the Gaussian surface is zero. Hence electric field must be zero at all point inside the cavity.

Question: 11

A convex lens of focal length 25 cm placed coaxially in contact with a concave lens of focal length 20 cm. Determine the power of the combination. Will the system be converging or diverging in nature? [2]

Answer:
We have focal Length of Convex Lens,
f_1 = +25 cm = +0.25 m and focal length of concave lens, f_2 = -20cm = -0.20 m.

Equivalent focal length, $F = \frac{1}{f_1} + \frac{1}{f_2}$

$= \frac{1}{25} + \frac{1}{-20}$

$= \frac{-1}{100}$

$\therefore$ F = -100 cm

Power of Convex Lens, $P_1 = \frac{1}{f_1} = \frac{1}{0.25}$

Power of Concave Lens, $P_2 = \frac{1}{f_2} = \frac{1}{-0.20}$

Power of the combination,

$P = P_1 + P_2 = \frac{1}{0.25} + \frac{1}{-0.20}$

$= \frac{100}{25} - \frac{100}{20}$

$= \frac{400-500}{100}$

$= \frac{-100}{100}$

= -ID.

As the focal length is in negative, the system will be diverging in nature.

Question: 12

The thermo-emf of a thermocouple is given by the expression, E = αθ - βθ2, where ‘θ’ is the temperature of the hot junction. If α = 42 μ V^0C-1, β = 0.035 μ V^0C-2, calculate the (i) neutral temperature and (ii) temperature of the inversion of the thermocouple, if the cold junction is at 20^0C. [2]

Answer:
E = αθ - βθ2

$\therefore \frac{dE}{d\theta} = \alpha - 2\beta\theta$

$\frac{dE}{d\theta} = 0$

or $\alpha - 2\beta\theta = 0$

$$\theta_n = \frac{\alpha}{2\beta}$$

$$= \frac{42}{2 \text{ x } 0.035}$$

$$= 600^0 C$$

$$\theta_i = \frac{\alpha}{\beta} - 20$$

$$= 1200 - 20$$

$$= 1180^0 C$$

Question: 13

Calculate the current drawn by the primary of a transformer, which steps down 200 V to 20 V to operate a device of resistance 20Ω. Assume the efficiency of the transformer to be 80%. [2]

Answer:

Current in secondary: $I_2 = \frac{V_2}{R} = \frac{20}{20} = 1 \text{ A}$

$$\text{Efficiency} = \frac{\text{Power output}}{\text{Power input}}$$

$$= \frac{V_2 . I_2}{V_1 . I_1}$$

$$= \frac{80}{100}$$

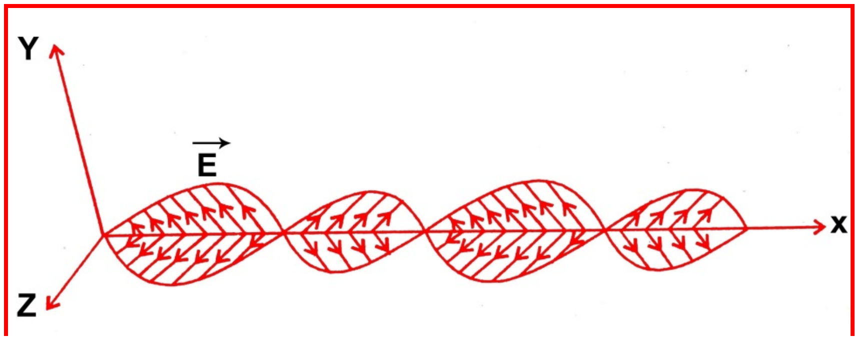
$$= \frac{20 \text{ x } 1}{200 \text{ x } I_1}$$

$$I_1 = \frac{20 \text{ x } 100}{200 \text{ x } 80}$$

Question: 14

a. An em wave is travelling in a medium with a velocity $\vec{v} = v\hat{i}$. Draw a sketch showing the propagation of the em wave, indicating the direction of the oscillating electric and magnetic fields.

Answer:



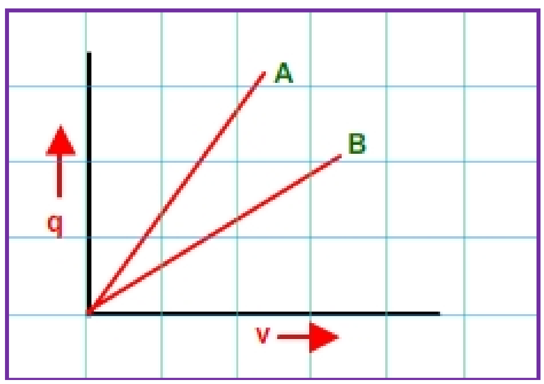
Given that velocity, V = $v\hat{i}$ and electric filed, E along X-axis and magnetic field, B along Z-axis.

b. How are the magnitudes of the electric and magnetic fields related to the velocity of the em wave? [2]

Answer:

Speed of EM wave can be given as the ratio of magnitude of electric field (ε_0) to the magnitude of magnetic field (B_0). $C = \frac{\varepsilon_0}{B_0}$

Question: 15



The given graph shows the variation of charge q versus potential difference V for two capacitors The two capacitors C_1 and C_2 have same plate separation but the plate area of C_2 is double than that of C_1 . Which of the lines in the graph correspond to C_1 and C_2 and why? [2]

Answer:

As, $q = \frac{C}{V}$ and graph A has a larger slope than B, so the graph A represents a capacitor of larger capacitance.

Also, $C = \frac{\varepsilon_0 A}{d}$ i.e., $C \propto A$

As the plate area of C_2 is double of that of C_1 so C_2 has a larger capacitance. Hence the line A of the graph corresponds of C_2.

Question: 16

Define the terms threshold frequency and stopping potential in relation to the phenomenon of photoelectric effect. How is the photoelectric current affected on increasing the frequency and intensity of the incident radiations and why? [2]

Answer:

Threshold frequency

The minimum frequency of incident radiation which can eject electrons from a metal is called threshold frequency. Below threshold frequency, there is no photo-electric emission.

Stopping potential

The minimum negative potential given to the anode of a photo-cell for which the photoelectric current becomes zero is called stopping potential.

- The increase of frequency of incident radiation has no effect on the photoelectric current.
- The photoelectric current increases proportionally with the increase in intensity of incident radiation.

Question: 17

Define refractive index of a transparent medium. A ray of light passes through a triangular prism. Plot a graph showing the variation of the angle of deviation with the angle of incidence. [2]

Answer:

Refractive index

The ratio of the velocity of light in vacuum to the velocity of light in medium is called absolute refractive index of the medium.

Graph

The plot of angle of deviation (δ) versus angle of incidence (i) for a triangular prism is shown below.

Question: 18

Answer the following questions: [2]

a. Optical and radio telescopes are built on the ground while X-ray astronomy is possible only from satellites orbiting the Earth? Why?

Answer:

Since the transmission of signals using ground waves restricted up to a frequency of 1500 Hz to save the loss of energy.

b. The small ozone layer on top of the stratosphere is crucial for human survival. Why?

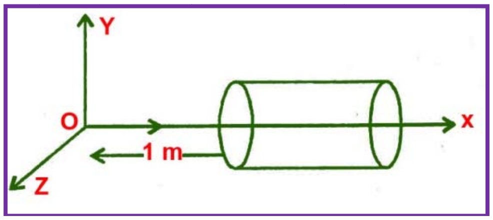
Answer:

The ultraviolet radiations from the sun is harmful to the living cells and plants. The ozone layer absorbs ultraviolet radiation and prevents it from reaching the earth. It also keeps the earth warm by trapping infra-red radiations.

OR

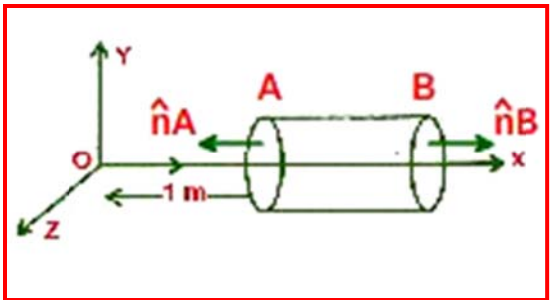
A hollow cylindrical box of length 1 m and the area of cross – section $25cm^2$ is placed in a three dimensional coordinate system as shown in the figure . The electric field in the region is given by $\vec{E} = 50x\hat{i}$, where E is in NC^{-1} and x is in meters. Find [2]

i. Net flux through the cylinder.



Answer:

i. Given, $\vec{E} = 50\ \chi\hat{i}$ and $\Delta s = 25cm^2 = 25 \times 10^{-4}$ m2



As the electric field I sonly along the x-axis, so flux will pass only through the cross-section of cylinder.
Magnitude of electric field at cross-section A,
$E_A = 50 \times 1 = 50NC^{-1}$
Magnitude of electric field at cross section B,
$E_B = 50\ X\ 2 = 100\ NC^{-1}$
The corresponding electric fluxes are :

$\phi_A = \vec{E}.\vec{\Delta s} = 50\ X\ 25\ X\ 10^{-4}\ X \cos 180^0$

$\phi_A = \vec{E}.\vec{\Delta s} = -0.125Nm^2 / C$

$\phi_B = \vec{E}.\vec{\Delta s} = 100\ X\ 25\ X\ 10^{-4}\ X\ \cos 0^0$

$\phi_B = \vec{E}.\vec{\Delta s} = 0.25Nm^2 / C$

So , The net flux through the cylinder ,

$\phi = \phi_A + \phi_B$
= -0.125 + 0.25
= 0.125 Nm^2/C

ii. Charge enclosed by the cylinder.

Answer:

ii. Using Gauss's Law :

$$\oint \vec{E}.\vec{ds} = \frac{q}{\varepsilon_0} \Rightarrow 0.125$$

$$= \frac{q}{8.85 \text{ X } 10^{-12}}$$

$q = 8.85 \text{ X } 0.125 \text{ X } 10^{-12}$

$= 1.1 \text{ X } 10^{-12}$ C

Question: 19

a. In a typical unclear reaction, e.g $^2_1H + ^2_1H \rightarrow ^3_2He + n + 3.27\,MeV$, although number of nucleons is conserved, yet energy is released. How? Explain.

Answer:

In a nuclear reaction, the sum of the masses of the target nucleus $\left(^2_1H\right)$, and the bombarding particle $\left(^2_1H\right)$ may be greater or less than the sum of the masses of the product nucleus $\left(^3_1He\right)$ and the outgoing particle $\left(^1_0n\right)$. So from the Law of conservation of mass energy (3.27 MeV) is evolved or involved in a nuclear reaction. This energy is called Q-value of the nuclear reaction.

b. Show that nuclear density in a given nucleus is independent of mass number A. [3]

Answer:

Density of the nucleus

$= \frac{\text{mass of nucleus}}{\text{volume of nucleus}}$

Mass of the nucleus

= A amu

$= A \text{ x } 1.66 \text{ x } 10^{-27}$ kg

Volume of the nucleus

$= \frac{4}{3}\pi R^3$

$= \frac{4}{3}\pi (R_0 A^{\frac{1}{3}})^3$

$= \frac{4}{3}\pi R_0^3 A$

Thus, density

$$\frac{A \text{ x } 1.66 \text{ x } 10^{-27}}{\left(\frac{4}{3}\pi R_0^3\right)A}$$

$$\frac{1.66 \text{ x } 10^{-27}}{\left(\frac{4}{3}\pi R_0^3\right)}$$

Question: 20

a. In Young's double slit experiment, monochromatic light of wavelength 630 nm illuminates the pari of slits and produces an interference pattern in which two consecutive bright fringes are separated by 8.1 mm. another source of monochromatic light produces the interference pattern in from the second source.

What is the effect on the interference fringes if the monochromatic source is replaced by a source of white light? [3]

Answer:
Here,
λ_1 = 630nm = 630 x 10^{-9} m,
β_1 = 8.1 mm = 8.1 x 10^{-3} m
λ_2 = ?
β_2 = 7.2 mm = 7.2 x 10^{-3} m

Let, d be the slit width and D be the distance between slit and screen then

$$\beta_1 = \frac{\lambda_1 D}{d}, \text{and, } \beta_2 = \frac{\lambda_2 D}{d}$$

$$\therefore \frac{\beta_1}{\beta_2} = \frac{\lambda_1 D}{d} \times \frac{\lambda_2 D}{d} = \frac{\lambda_1}{\lambda_2}$$

$$\text{or, } \frac{8.1 \text{x} 10^{-3}}{7.2 \text{ x } 10^{-3}} = \frac{630 \text{ x } 10^{-9}}{\lambda_2}$$

$$\text{or, } \frac{8.1}{7.2} = \frac{630 \text{ x } 10^{-9}}{\lambda_2}$$

$$\therefore \lambda_2 = \frac{7.2 \text{ x } 630 \text{ x } 10^{-9}}{8.1}$$

Question: 21

Write the basic features of photon picture of electromagnetic radiation on which Einstein's photoelectric equation is based. [3]

Answer:
Photon picture of electromagnetic radiation on which Einstein's photoelectric equation is based on particle nature of light. Its basic features are:

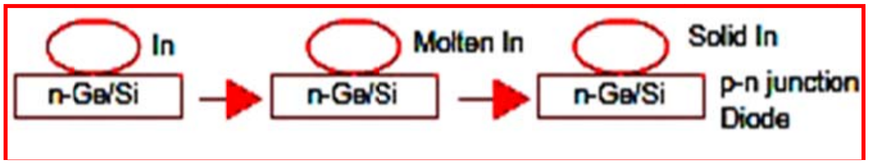
i. In interaction with matter, radiation behaves as if it is made up of particles called photons.
ii. Each photon has energy E = hv and momentum $p = \frac{hv}{c}$ and speed C, the speed of light.
iii. All photons of light of a particular frequency v, or wavelength λ have the same energy $E = hv = \frac{hv}{\lambda}$ and momentum $p = \frac{hv}{c} = \frac{hv}{\lambda}$ whatever the intensity of radiation may be.
iv. By increasing the intensity of light of given wavelength, there is only an increase in the number of photons per second crossing a given area, with each photon per second crossing a given area, with each photon having the same energy. Thus, photon energy is independent of intensity of radiation.
v. Photons are electrically neutral and are not deflected by electric and magnetic fields.

Question: 22

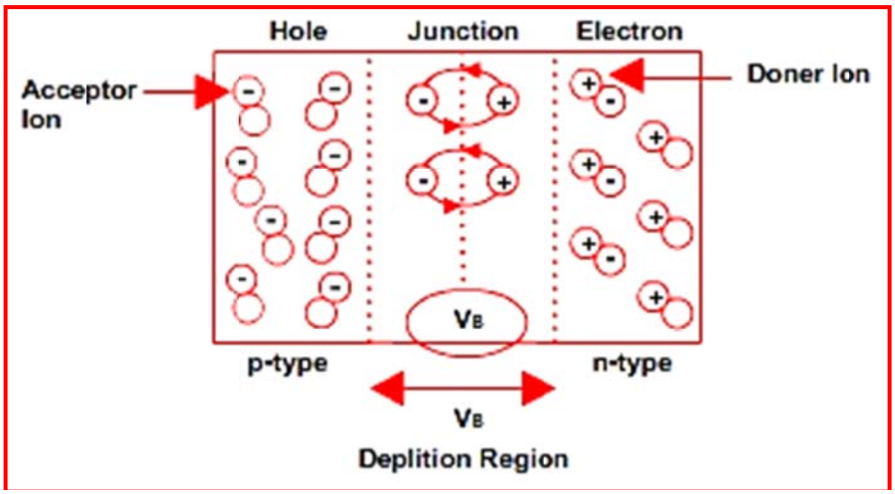
With the help of a suitable diagram explain the formation of depletion region in a p-n junction. How does its width change when the junction is (i) forward biased and (ii) reverse biased? [3]

Answer:

p-n junction: When a small piece of III group metal like In(Indium) is placed over n-Ge or n-Si and melted. The lower portion of molten indium forms alloy with the n-semiconductor and converts its top layer into p-layer to form p-n junction.



Formation of potential barrier and depletion to form p-n junction.



In a p-n junction diode, due higher concentration of holes on p-side and electrons on n-side, the diffusion of holes towards n-side and electrons towards p-side takes place. Hence a region of un-neutralized negative ion on p-side and positive ions on n-side is formed near the junction which is depleted of mobile charges. This region is called depletion region.

In the depletion region, a potential difference VB is created is called potential barrier as it creates an electric field which opposes the further diffusion of electrons and holes.

- In forward biased, the width of depletion region is increased.
- In reverse biased, the width of depletion region is decreased.

Question: 23

Deduce the expression for the electrostatic energy stored in a capacitor of capacitance 'C' and having charge 'Q'. How will the (i) energy stored and (ii) the electric field inside the capacitor be affected when it is completely filled with a dielectric material of dielectric constant 'K'? [3]

Answer:

The work required to charge a capacitor is stored in the form of electric potential energy U in the electric field between the plates. Let at a given instant a charge q' has been transferred from one plate to the other.

The potential difference V' between the plates at that instant will be q'/c. If an extra increment of charge dq' is transferred then,

$dW = V'dq'$

$= \frac{q'}{c}.dq'$

The work required to bring the total capacitor charge up to a final value q is,

$W = \int dw = \frac{1}{C}\int_0^q q'dq' = \frac{q^2}{2C}$

Potential Energy

$U = \frac{q^2}{2C} = \frac{CV^2}{2} = \frac{QV}{2}$

When dielectric is filled

i. Energy stored:

$U' = \frac{Q^2}{2C'} = \frac{Q^2}{2KC} = \frac{U}{K}$

The energy becomes 1/K times.

ii. The dielectric makes the new electric field 1/K times the electric field of nondielectric capacitor.

Question: 24 [3]

a. In what way is diffraction from each slit related to the interference pattern in a double slit experiment?

Answer:
If the width of each slit is comparable to the wavelength of light used, the interference pattern thus obtained in the double-slit experiment is modified by diffraction from each of two slits.

b. Two wavelengths of sodium light 590nm and 596nm are used, in turn, to study the detraction taking place at a single slit of aperture 2 x 10^{-4} m. The distance between the slit and the screen is 1.5m. Calculate the separation between the positions of the first maxima of the diffraction pattern obtained in the two cases.

Answer:
Given that: Wavelength of the light beam,
λ_1 = 590nm = 5.9 x 10-7 m
Wavelength of another light beam,
λ_1 = 596nm = 5.96 x 10^{-7} m
Distance of the slits from the screen = D = 1.5 m
Distance between the two slits = a = 2 x 10-4 m
For the first secondary maxima,

$\sin\theta = \frac{3\lambda_1}{2a} = \frac{x_1}{D}$

Question: 25

c. In what way is diffraction from each slit related to the interference pattern in a double slit experiment?

Answer:
If the width of each slit is comparable to the wavelength of light used, the interference pattern thus obtained in the double-slit experiment is modified by diffraction from each of two slits.

d. Two wavelengths of sodium light 590nm and 596nm are used, in turn, to study the detraction taking place at a single slit of aperture 2×10^{-4} m. The distance between the slit and the screen is 1.5m. Calculate the separation between the positions of the first maxima of the diffraction pattern obtained in the two cases.

Answer:
Given that: Wavelength of the light beam,

λ_1 = 590nm = 5.9 x 10-7 m

Wavelength of another light beam,

λ_1 = 596nm = 5.96×10^{-7} m

Distance of the slits from the screen = D = 1.5 m

Distance between the two slits = a = 2 x 10-4 m

For the first secondary maxima,

$\sin\theta = \frac{3\lambda_1}{2a} = \frac{x_1}{D}$

Question: 26

While travelling back to his residence in the car, Dr. Pathak was caught up in the thunderstorm to stop. Suddenly he noticed a child walking alone on the road. He asked the boy to come inside the car inside the car till the boy to come inside the car till the thunder stopped. Dr. Pathak dropped the boy at his residence. The boy insisted that Dr. Pathak should meet his parents. The parents expressed their gratitude to Dr. Pathak for his concern for safety of the child.
Answer the following questions based on the above information:

a. Why is it safer to sit inside a car during a thunderstorm?

Answer:
It is safer to be inside a car during thunder-storm because the car acts like a Faraday cage. The metal in the car will shield you from any external electric field and thus prevent the lighting from travelling within the car.

b. Which two values are displayed by Dr. Pathak in his actions?

Answer:
Awareness and Humanity

c. Which values are reflected in parents' response to Dr. Pathak?

Answer:
Gratitude and obliged

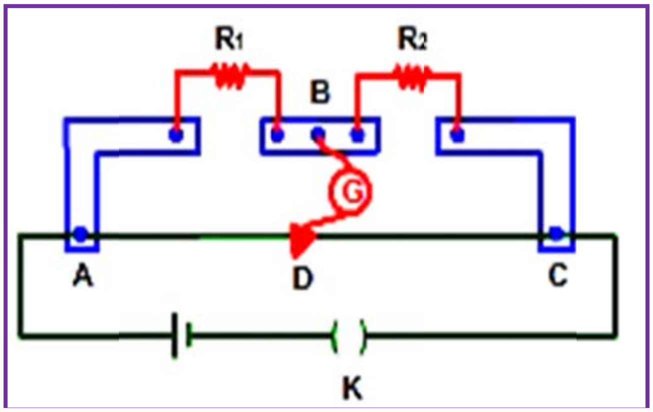
d. Give an example of a similar action on your part in the past from everyday life. [3]

Answer:

I once came across to a situation where a puppy was struck in the middle of a buzy road during rain and was not able to cross due to heavy flow, so I quickly rushed and helped him.

Question: 27

a. In the meter bridge experiment set up, shown in the figure, the null point 'D' is obtained at a distance of 40cm from end A of the meter bridge wire. If a resistance of 10Ω is connected in series with R_1, null point is obtained at AD = 60cm. calculate the values of R_1 and R_2.



Answer:
Considering both the situations and writing them in the form of equations.
Let R be the resistance per unit of length of the potential meter wire.

$$\frac{R_1}{R_2} = \frac{R' x 40}{R'(100-40)}$$

$$= \frac{40}{60} = \frac{2}{3}$$

$$\frac{R_1 + 10}{R_2} = \frac{R' x 60}{R'(100-60)}$$

$$= \frac{60}{40} = \frac{3}{2}$$

$$\frac{R_1}{R_2} = \frac{2}{3} \qquad .....(i)$$

$$\frac{R_1 + 10}{R_2} = \frac{3}{2} \qquad .....(ii)$$

Putting the value of R_1, from equation (i) subtracting in equation (ii)

$$\frac{2}{3} + \frac{10}{R_2} = \frac{3}{2}$$

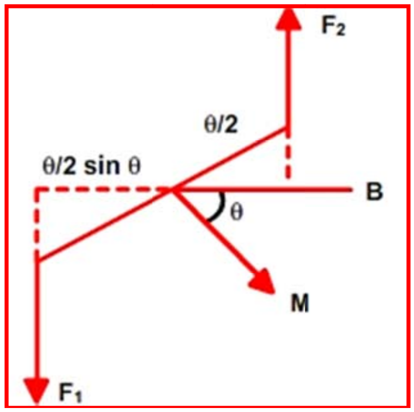
R2 = 12Ω
Recalling equation (i) again

$$\frac{R_1}{I^2} = \frac{2}{3}$$

R_1 = 8Ω

b. A proton and a deuteron having equal momenta enter in a region of uniform magnetic field at right angle to the direction of the field. Depict their trajectories in the field.

Answer:



We know, Lorentz force

F = Bqv sinθ

Where θ = angle b/w velocity of particle and magnetic field

$\theta = 90^0$

So, Lorentz force F = Bqv.

Thus, the particles will move in circular path.

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

$$r = \frac{mv}{Bq}$$

Let m_p = Mass of proton

M_d = Mass of dentron

V_p = Velocity of proton

V_d = Velocity of dentron

The charge of proton and dentron are equal.

Given that MpVp = MdVd

$$r_p = \frac{m_p V_p}{Bq} \quad \ldots.(i)$$

$$r_d = \frac{m_d v_d}{Bq} \quad \ldots(ii)$$

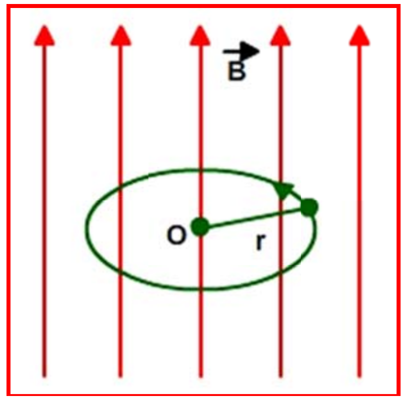
As (i) and (ii) are equal, So $r_p = r_d = r$.

Thus, the trajectory of both the particles will be same.

OR

a. A small compass needle of magnetic moment 'm' is free to turn about an axis perpendicular to the direction of uniform magnetic field 'B'. the moment of inertia of the needle about the axis is 'I'. the needle is then released. Prove that it executes simple harmonic motion. Hence deduce the expression for its time period.

Answer:



The torque on the needle is τ = m x B
In magnitude
τ = mB sinθ
Here τ is restoring torque and θ is the angle between m and B.

Therefore, in equilibrium $I\frac{d^2\theta}{dt^2} = -mB\sin\theta$

Negative sing with mB sin θ implies that restoring torque is in opposition to deflecting torque.

For small values of θ in radians, we approximate sin θ = θ and get $I\frac{d^2\theta}{dt^2} = -mB\sin\theta$

Or $\frac{d^2\theta}{dt^2} = \frac{-mB}{I}\theta$

This represents a simple harmonic motion.

The square of the angular frequency is $\omega^2 = \frac{mB}{\tau}$ and the time period is $T = 2\pi\sqrt{\frac{I}{mB}}$

b. A compass needle, free to turn in a vertical plane orients itself with its axis vertical at a certain place on the earth. Find out the values of (i) horizontal component of earth's magnetic field and (ii) angle of dip at the place.

Answer:

i. As Horizontal component of earth's magnetic field, BH = B cos δ
Putting δ = 90^0
∴ BH = O
ii. for a compass needle align vertical at a certain place, angle of dip
δ = 90^0

Question: 28 [5]

What is 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 slits 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:
Interference of light is the phenomenon of redistribution of light intensity in a medium due to the superposition of light waves from two coherent sources. Essential conditions for sustained interference are as follows:

i. The two sources of light must be coherent.
ii. The two sources must be narrow.

When both the slits are open, we get interference pattern on the screen. Then the following intensity distribution curve is obtained.

When one f the slits are closed, diffraction pattern is obtained on the screen.

Fringe width: $\beta = \frac{D\lambda}{d}$

See topics on 'Figure 21: Young's experiment'

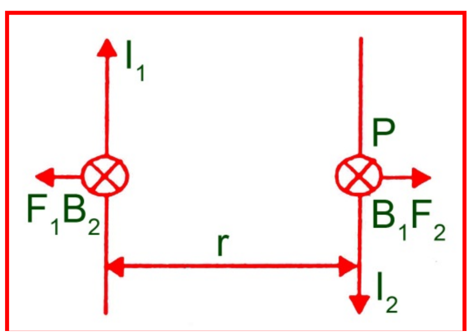
Question: 29 [5]

a. 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:
Consider two infinitely long thin conductors carrying currents in opposite directions. Magnetic filed B_1 due to I_1 at P on 2nd conductor is given by,

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



The magnetic field B_1 is perpendicular to plane of paper and directed inward. This field will produce a force / length F_2 on 2nd conductor given by

$$F_2 = B_1 I_1 = \frac{\mu_o I_1 I_2}{2\pi r}$$

By Fleming's left hand rule direction of F_2 is away from 1st conductor. Similarly the current I_2 will create a field B_2 at Q directed inward which in turn will create force/length F_1

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

By Fleming's left hand rule, the direction of F1 is away from the second conductor. Hence the two conductors repel each other.

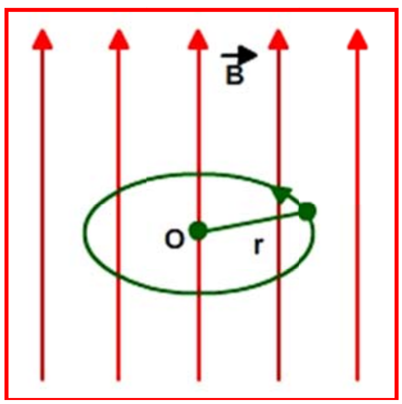
Ampere. If $I_1 = I_2 = 1$ A, and r = 1 m then

$$F = \frac{\mu_o}{2\pi}$$
$$= \frac{4\pi \times 10^{-7}}{2\pi}$$
$$= 2 \times 10^{-7}\ \text{Nm}^{-1}$$

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 one produces between them a force of 2×10^{-7} N per meter of their lengths.

b. A small compass needle of magnetic moment 'm' is free to turn about an axis perpendicular to the direction of uniform magnetic field 'B'. the moment of inertia of the needle about the axis is 'I'. the needle is then released. Prove that it executes simple harmonic motion. Hence deduce the expression for its time period.

Answer:



The torque on the needle is τ = m x B
In magnitude
$\tau = mB \sin\theta$
Here τ is restoring torque and θ is the angle between m and B.

Therefore, in equilibrium $I\frac{d^2\theta}{dt^2} = -mB\sin\theta$

Negative sing with mB sin θ implies that restoring torque is in opposition to deflecting torque.

For small values of θ in radians, we approximate sin $\theta = \theta$ and get $I\frac{d^2\theta}{dt^2} = -mB\sin\theta$

Or $\frac{d^2\theta}{dt^2} = \frac{-mB}{I}\theta$

This represents a simple harmonic motion.

The square of the angular frequency is $\omega^2 = \frac{mB}{\tau}$ and the time period is $T = 2\pi\sqrt{\frac{I}{mB}}$

c. A compass needle, free to turn in a vertical plane orients itself with its axis vertical at a certain place on the earth. Find out the values of (i) horizontal component of earth's magnetic field and (ii) angle of dip at the place.

Answer:

i. As Horizontal component of earth's magnetic field, $B_H = B \cos \delta$

Putting $\delta = 90^0$

$\therefore B_H = O$

ii. for a compass needle align vertical at a certain place, angle of dip

$\delta = 90^0$