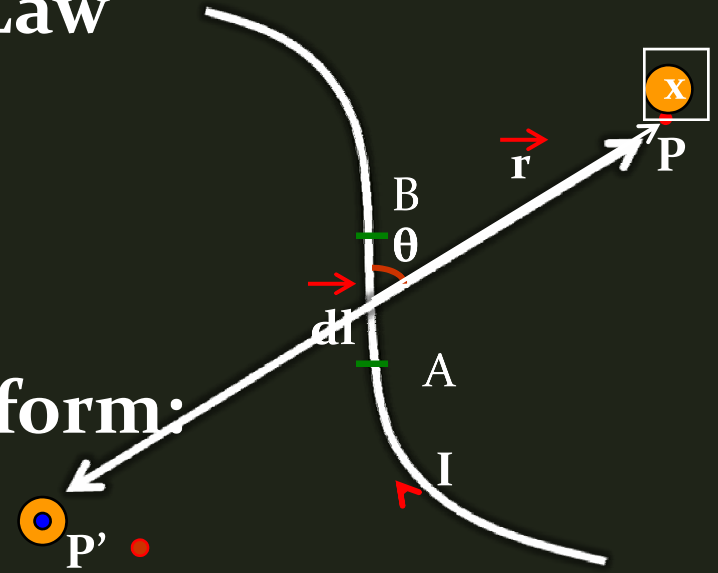
CET – Physics

Magnetic Effect
and
Mechanical Effect
of
electric current

The magnitude of magnetic field at a point due to a current element is

Laplace's (Biot – Savart's) Law

$$dB = \frac{\mu_0 I\, dl \sin\theta}{4\pi\, r^2}$$



Biot – Savart's Law in vector form:

$$\vec{dB} = \frac{\mu_0\, I\, \vec{dl} \times \vec{r}}{4\pi\, r^3}$$

Value of $\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$ or $Wb\ m^{-1}\ A^{-1}$

Magnetic Field due to a Straight Wire carrying current:

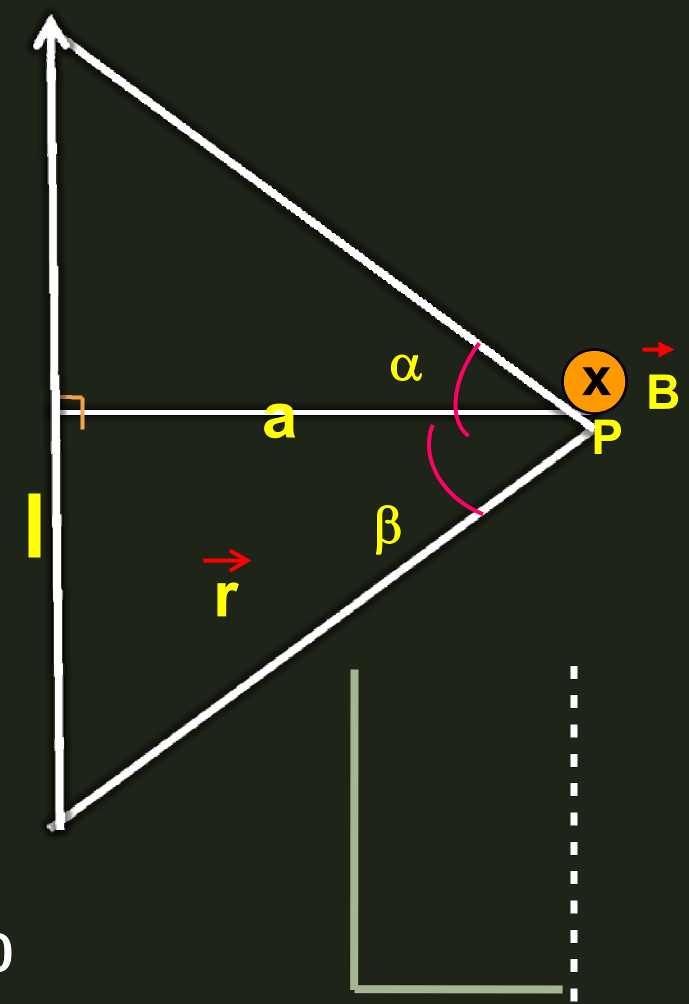
$$B = \frac{\mu_0 I (\sin\alpha + \sin\beta)}{4\pi a}$$

If the conductor is infinitely long, then $\alpha=\beta=90^o$

$$B = \frac{\mu_0 I}{4\pi a}(1+1) = \frac{\mu_0 I}{2\pi a}$$

The field near one end of a long straight conductor is

$$B = \frac{\mu_o}{4\pi}\left(\frac{I}{a}\right)$$ Since $\alpha = \pi/2$ & $\beta=0$



Magnetic Field due to a solenoid

$$B=\frac{\mu_0 N I}{2}(\cos\Phi_1-\cos\Phi_2)$$

At the mid point of an ideal solenoid

$\Phi_1=0^o$, $\Phi_2=180^o$

$$\therefore B=\frac{\mu_0 N}{l}$$

At one end of the solenoid,

$\Phi_1=0^o$, $\Phi_2=90^o$.

$$\therefore B=\frac{\mu_0 N}{2l}$$

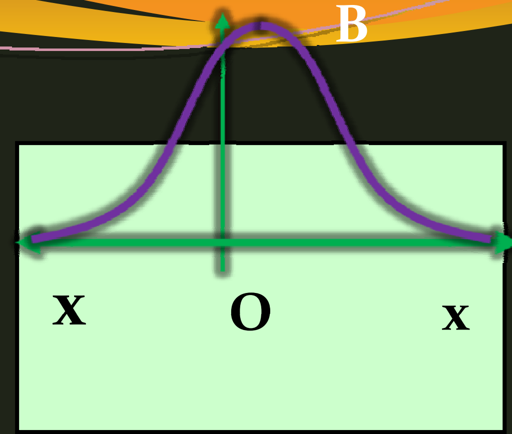
Magnetic Field due to a Circular Loop carrying current:

$$B = \frac{\mu_0}{4\pi} \times \frac{2\pi a I^2 r}{\left(r^2 + x^2\right)^{3/2}}$$

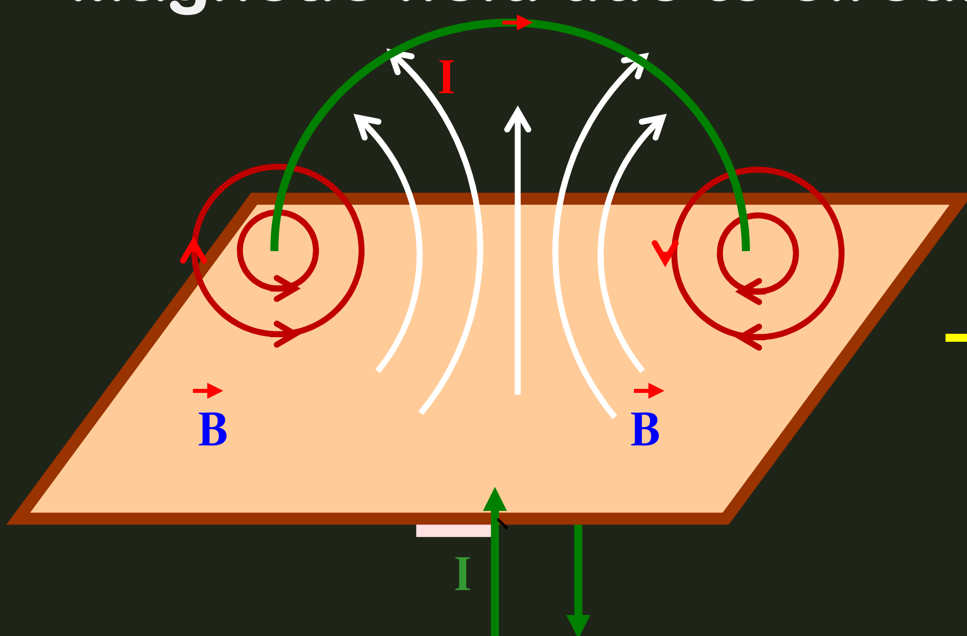
Magnetic moment of a current carrying circular loop = M=IA

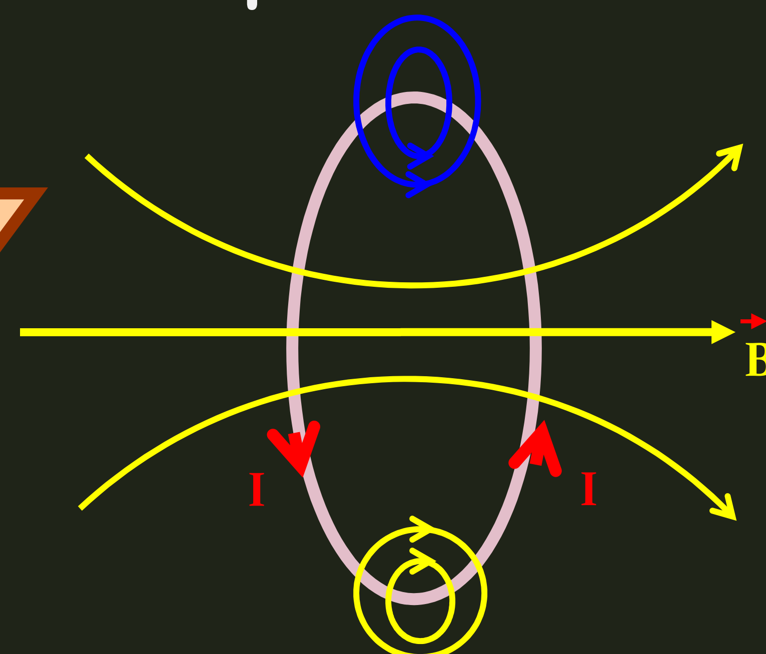
Magnetic field at the centre of the circular coil carrying current.

$$B = \frac{\mu_0}{4\pi} \times \frac{2\pi i}{r}$$



Different views of direction of current and Magnetic field due to circular loop of a coil:





Tangent law in magnetism

$$B = B_H \tan\theta$$

Reduction factor of TG and its units

$$K = \left(\frac{4\pi}{\mu_0}\right)\frac{r\,B_H}{2\pi n}$$

is called the 'reduction factor' of TG.

$$I = K \tan\theta$$

SI unit of K is ampere(A)

Mechanical effect of Electric current:

1. A charged particle moving in a magnetic field will experience a force of $F=Bqv \sin \theta$, if $\theta = 0$ $F=0$ and if $\theta = 90^0$ then it will experience a maximum force of $F=Bqv$.

2. If the charged particle is moving at an angle θ not equal to 0^0 and 90^0 then it describes an helix.

2. A charged particle moving normal to the magnetic field direction then it will describes a circular path of radius

$$r = \frac{mv}{Bq} \quad interms\ of\ kinetic\ energy$$

$$r = \frac{\sqrt{2mE_k}}{Bq}$$

3. When a current carrying conductor placed in a magnetic field will experience a force of F=BIl sin θ.

5. The time period of the charged particle describing circular path is

$$T = \frac{2\pi m}{Bq}$$

6. Two straight parallel conductors carrying current will experience a force of

$$F = \frac{\mu_0 I_1 I_2}{2\pi a}$$

If current direction is same in both then they will attract each other and if current direction is opposite to each other then they will repel each other.

7. The torque acting on a current loop placed in a magnetic field is $\tau = MB\cos\theta$ where, θ is the angle between plane of the coil and magnetic field.
   a) If $\theta = 0^0$ torque is maximum $\tau = MB = niAB$
   b) If $\theta = 90^0$ torque is minimum $\tau = 0$
8. A galvanometer can be converted into an ammeter by connecting a low resistance of $s = \frac{I_g G}{I - I_g}$ and its range can be increased by using a low resistance in parallel.

9. A galvanometer can be converted into a voltmeter by

connecting a high resistance of $R = \frac{V}{I_g} - G$ and its range can be increased by using a high resistance R in series .

10. The resistance of ideal ammeter is zero where as the resistance of ideal voltmeter is infinity.

11. The moment of deflecting couple acting on a moving coil galvanometer is

$$C_D = nBIA$$

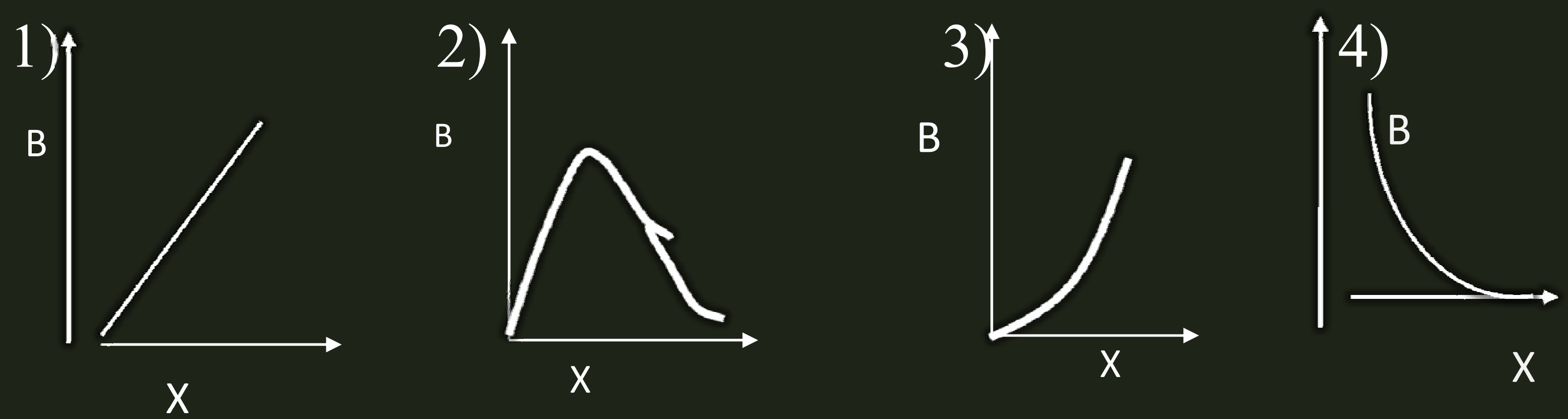
12. The Magnetic potential energy of a current loop in a magnetic field is

$$U = -\vec{M}.\vec{B}$$

$$U = -MB\cos\theta$$

Where θ is the angle between magnetic moment and magnetic field direction, if θ decreases from 180^0 to 0^0 then potential energy decreases.

1. Which curve represents the correct variation of the magnetic field B due to long straight current carrying conductor versus distance x from the conductor



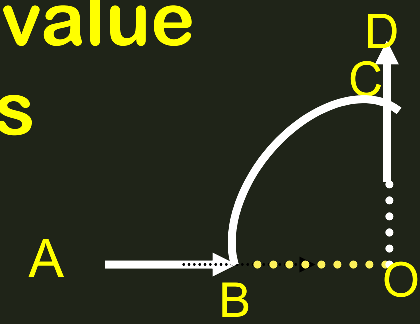
Answer:

Since $B = \frac{\mu_o I}{2\pi d}$ $\quad B \propto \frac{1}{d}$

The magnetic field at a point varies inversely with the distance of the point from the conductor, hence

Answer is 4

2. A wire ABCD is bent as shown in figure. Section BC is a quarter circle of radius R. If the wire carries a current I, the value of the magnetic field at center O is



1) Zero

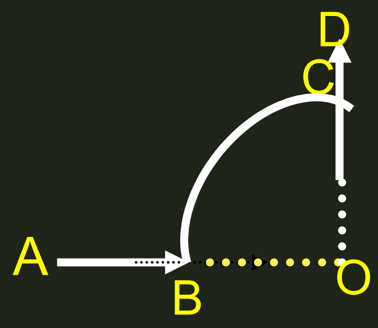
2) $\frac{\mu_0 i}{4r}$ directed along the bisector of angle OBC

3) $\frac{\mu_0 I}{8r}$ directed perpendicular to plane of the paper and into the paper

4) $\frac{\mu_0 i}{4\pi r}$ directed along the bisector of angle OBC

Answer:

The magnetic field at a point due to an arc is



$$B = \frac{\mu_0 i}{2r}\,\frac{\theta}{2\pi}$$

$$B = \frac{\mu_0 i}{2r}\,\frac{\frac{\pi}{2}}{2\pi} \qquad B = \frac{\mu_0 i}{8r}$$

this field is directed in to the paper hence

Answer 3

3. The strength of the magnetic field at a point distance r near a long straight current carrying wire is B. The field at a distance r/2 will be

1) B/2   2) B/4

3) 4B   4) 2B

Answer:

Since magnetic field at a point due to a long conductor is

$$B = \frac{\mu_0 I}{2\pi r} \qquad B \propto \frac{1}{r} \qquad B^1 \propto \frac{1}{\frac{r}{2}}$$

$B^1 = 2B$, hence answer is (4)

4. A current is flowing in a circular coil of radius R and the magnetic field at the center is B_0. At what distance on the axis of the coil from center the magnetic field will be $\frac{B_o}{8}$

1) $\sqrt{7}R$ 2) $\sqrt{3}R$

3) 2R 4) 8R

Answer:

$$B = \frac{B_0}{8} \quad , \quad \frac{\mu_0 n I R^2}{2(R^2 + x^2)^{3/2}} = \frac{\mu_0 n I}{2R}\frac{1}{8}$$

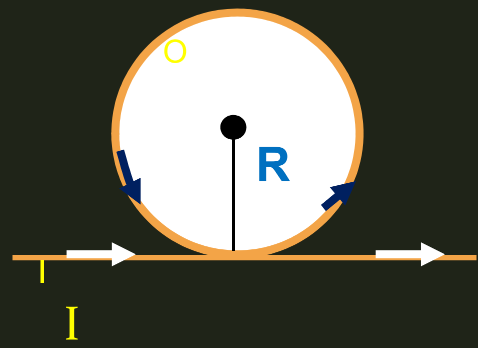
$$8R^3 = (R^2 + x^2)^{3/2}$$

Take the power 2/3 on either side then,

$$4R^2 = R^2 + x^2$$

on solving $x = \sqrt{3}R$ hence Answer 2

5. An infinite straight current carrying conductor is bent into a circle as shown in the figure. If the radius of the circle is R, the magnetic field at the centre of the coil is



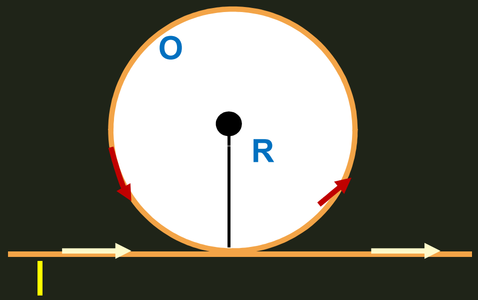
1) ∞ 2) Zero

3) $\frac{\mu_0 I}{2R}$ 4) $\frac{\mu_0 I}{2\pi R}(\pi+1)$

Answer:

magnetic field at the center of the circle is

$$B_{cent} = B_o + B$$



$$B_{cent} = \frac{\mu_0 I}{2R} + \frac{\mu_0 I}{2\pi R}$$

$$= \frac{\mu_0 I}{2\pi R}(\pi + 1)$$

answer (4)

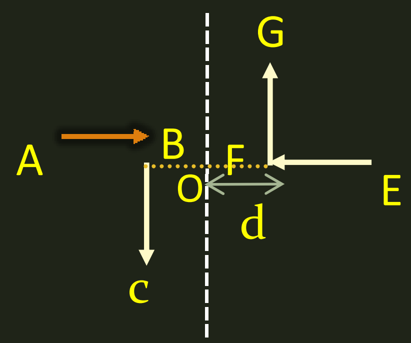
6. Two long thin wires ABC and EFG are shown in figure. They carry currents 'I' as shown. The magnitude of the magnetic field at 'O' is

1) Zero

2) $\frac{\mu_0 I}{4\pi d}$

3) $\frac{\mu_0 I}{2\pi d}$

4) $\frac{\mu_0 I}{2\sqrt{2}\pi d}$



Answer: magnetic field at a point due to a straight conductor is

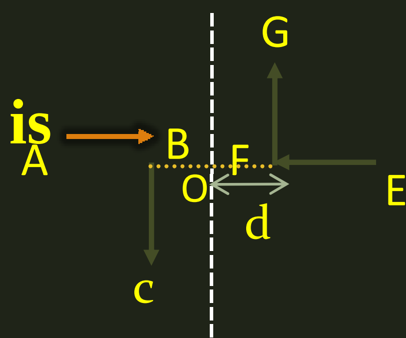
$$B = \frac{\mu_o I}{4\pi d}(\sin\alpha + \sin\beta)$$

angle subtended by AB at o is $\alpha = 0$ and BC is $\beta = 90^0$

$$B_1 = \frac{\mu_o I}{4\pi d}$$ towards the observer

similarly magnetic field at o due to EFG is also

$$B_2 = \frac{\mu_o I}{4\pi d}$$ towards the observer



hence the net field at o is $B = B_1 + B_2$

$$B = \frac{\mu_o I}{4\pi d} + \frac{\mu_o I}{4\pi d}$$

on solving

Hence answer is (3) $B = \frac{\mu_o I}{2\pi d}$

7. Two circular current carrying coils of radii 3 cm and 6 cm are each equivalent to a magnetic dipole having equal Magnetic moments. The currents through the coils are in the ratio of

1) $\sqrt{2}: 1$

2) 2:1

3) $2\sqrt{2}:1$

4) 4:1

Answer:

magnetic moment $M = nIA$

$$M_1 = M_2$$

$$nI_1\pi r_1^2 = nI_2\pi r_2^2$$

$$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2} = \left(\frac{6}{3}\right) = \frac{4}{1} \quad \boxed{\frac{I_1}{I_2} = \frac{4}{1}}$$

Hence answer is (4)

8. The magnetic field at the centre of the circular coil of radius r carrying current I is B_1. The field at the centre of another coil of radius 2r carrying same current I is B_2. The ratio B_1/B_2 is

1) 1:2

2) $\sqrt{2}$:1

3) 1:$\sqrt{2}$

4) 2:1

Answer: magnetic field at the Center of the circular coil is

$$B = \frac{\mu_0 nI}{2r}$$

$$B \propto \frac{1}{r}, \quad B_1 \propto \frac{1}{r}, \quad B_2 \propto \frac{1}{2r}$$

$$\frac{B_1}{B_2} = \frac{2}{1}$$

Answer 4

9. An electron is accelerated from rest through a potential difference V. This electron experiences a force F while moving normal to uniform magnetic field. On increasing the potential difference to V^1 , the force experienced by the electron in the same magnetic field becomes 2F. then, the ratio (V^1/V) is equal to

1) $\frac{4}{1}$

2) $\frac{2}{1}$

3) $\frac{1}{2}$

4) $\frac{1}{4}$

Answer:

$$kE = \frac{1}{2}mv^2 = eV$$ or $$v = \sqrt{\frac{2eV}{m}}$$

Also, $$F = evB = e\left[\sqrt{\frac{2eV}{m}}\right] \times B$$

Therefore, $$\frac{F}{2F} = \sqrt{\frac{V_1}{V_2}} = \sqrt{\frac{V}{V^1}}$$ $$\therefore \frac{V^1}{V} = \frac{4}{1}$$

Answer : 1

10. Two circular coils P and Q are made from similar wires but the radius of Q is twice that of P. what should be the value of potential difference across them so that the magnetic induction at their centers may be the same?

1) $V_q = 2V_p$ 2) $V_q = 3V_p$

3) $V_q = 4V_p$ 4) $V_q = \frac{1}{4V_p}$

Answer:

$$B_1 = \frac{\mu_o}{4\pi}\left(\frac{2\pi I_1}{r_1}\right) \qquad B_2 = \frac{\mu_o}{4\pi}\left(\frac{2\pi I_2}{r_2}\right)$$

$$r_2 = 2r_1\,,\quad B_1 = B_2 \quad and \quad I_2 = 2I_1$$

$$\frac{V_q}{V_p} = \frac{I_2 \times r_2}{I_1 \times r_1} = \frac{2I_1}{I_1} \times \frac{2r_1}{r_1} = \frac{4}{1}$$

$$\Rightarrow \quad V_q = 4V_p$$

Answer (3)

11. A circular loop of radius R, carrying a current I, lies in x-y plane with its centre at origin. The total magnetic flux through x-y plane is

1) directly proportional to I

2) directly proportional to R

3) inversely proportional to R

4) zero

Answer :

on passing current through the coil the number of magnetic fields entering the coil are equal to number field lines leaving the coil hence the total flux through the coil is zero.

Answer (4)

12. A particle of charge **q** and mass **m** moves in a circular orbit of radius r with angular speed ω. The ratio of the magnitude of its magnetic moment to that of its angular momentum depends on

1) ω and q

2) ω, q and m

3) q and m

4) ω and m

Answer: The angular momentum L of the particle is given by

$$L = mr^2\omega \qquad \text{Where } \omega = 2\pi n$$

$$\therefore \quad n = \frac{\omega}{2\pi}$$

Further $i = q\,x\,n = \dfrac{\omega q}{2\pi}$

Magnetic moment, $M = iA = \dfrac{\omega q}{2\pi} \times \pi r^2;$

$$\therefore \frac{\omega q r^2}{2} \Rightarrow \frac{M}{L} = \frac{\omega q r^2}{2mr^2\omega} = \frac{q}{2m}$$

Answer (3)

13. A proton moving with a constant velocity passes through a region of space without any change in its velocity. If E and B represent the electric and magnetic fields respectively, this region of space may have

1) $E = 0, B = 0$ 2) $E = 0, B \neq 0$

3) $E \neq 0, B \neq 0$ 4) all the above

Answer:

There is no change in velocity. It can be possible when electric magnetic fields are absent, i.e., E=0, B=0. Or when electric and magnetic fields are present but force due to electric field is equal and opposite to the force due to magnetic field, (i.e., $E \neq 0$, $B \neq 0$). Or when E=0 but $B \neq 0$.

$$F = qvB\sin\theta$$

i.e., $\sin\theta = 0$, i.e., $\theta = 0 \Rightarrow$ v and B, are in the same direction.

Answer(4)

14. A wire extending from x = 0 to x = a, carries a current i. If point P is located at x = 2a. The magnetic field due to the wire at P is

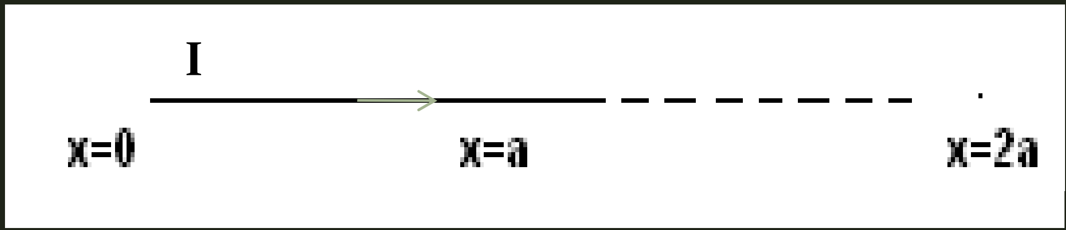
1) $\frac{\mu_0 I}{2\pi r}$

2) $\frac{\mu_0 I}{\pi a}$

3) $\text{Log}_e \frac{\mu_0 I}{2\pi a}$

4) Zero

Answer:



Angle made by the wire at the point p is θ=0, by Biot Savart's law

$$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$$

since θ=0

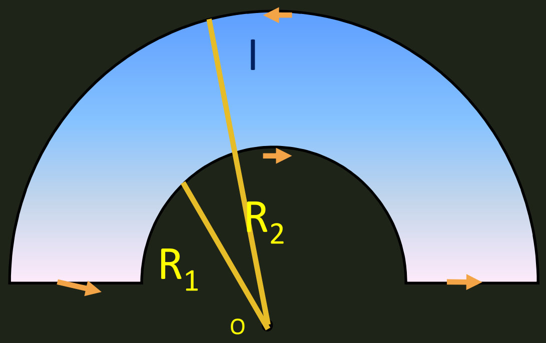
sin θ=0

dB=0

Answer (4)

15. The wire loop formed by joining two semi circular sections of radii R_1 and R_2 and centre O, carries a current I as shown. The magnetic field at O has a magnitude

1) $\frac{\mu_0 I}{4}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ 2) $\frac{\mu_0 I}{2}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$



3) $\frac{\mu_0 I}{4}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$ 4) $\frac{\mu_0 I}{2}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

Answer: angle subtended by the arcs of radius R_1 and R_2 at the point o is $\theta = \pi$

But the magnetic field at a point due to an arc is $B = \frac{\mu_0 I}{2R}\frac{\theta}{2\pi}$

Hence, magnetic field due to R_1 is $B_1 = \frac{\mu_0 I}{2R_1}\frac{\pi}{2\pi} = \frac{\mu_0 I}{4R_1}$

away from the observer due to R_2 is

$B_2 = \frac{\mu_0 I}{2R_2}\frac{\pi}{2\pi} = \frac{\mu_0 I}{4R_2}$ towards the observer

net field at O is $B = B_1 - B_2$ $B = \frac{\mu_0 I}{4R_1} - \frac{\mu_0 I}{4R_2} = \frac{\mu_0 I}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Answer (1)

16. Two concentric coils carry the same current in opposite directions. The diameter of the inner coil is half that of the outer coil. If the magnetic field produced by the outer coil at the common centre is 1 tesla, the net field at the centre is

1) 1 T **2) 2 T**

3) 3 T **4) 4 T**

Answer:

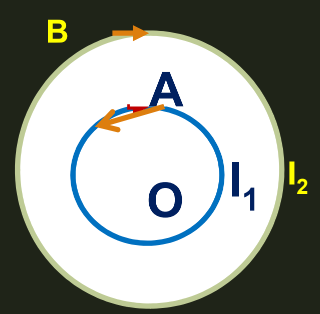
Magnetic field at the center of a circular coil is $B = \frac{\mu_0 n i}{2r}$ $B \propto \frac{I}{r}$

Magnetic field due to inner coil $B_1 \propto \frac{I}{\frac{r}{2}} = 2B = 2T$

Magnetic field due to outer coil $B_2 \propto \frac{I}{r} = B = 1T$

since $B_1 > B_2$ also, directions of currents are opposite

Net magnetic field at the center, $B = B_1 - B_2$

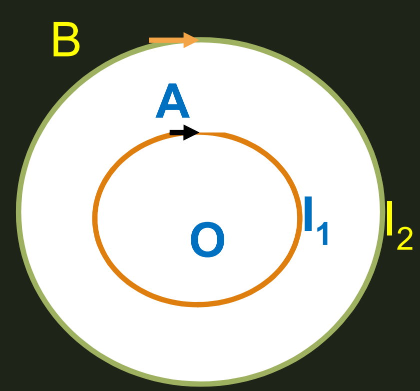


$B = 2 - 1 = 1T$ **answer (1)**

17). A and B are two concentric circular conductors of centre O and carrying currents I_1 and I_2 as shown in figure. The ratio of their radii is 1 : 2 and ratio of the flux densities at O due to A and B is 1 : 4. The value of I_1/I_2 is

1) $\frac{1}{8}$ 2) $\frac{1}{3}$

3) $\frac{1}{6}$ 4) $\frac{1}{4}$



Answer: **Magnetic field produced at the center of the circular coil is**

$$B = \frac{\mu_0 nI}{2r}, \quad B \propto \frac{I}{r}, \quad B_1 \propto \frac{I_1}{r_1}, \quad B_2 \propto \frac{I_2}{r_2}$$

$$\frac{B_1}{B_2} = \frac{I_1 r_2}{I_2 r_1}$$

$$\frac{1}{4} = \frac{I_1}{I_2}\frac{2}{1}$$

$$\frac{r_1}{r_2} = \frac{1}{8}$$

Hence answer (1)

18. A TG of reduction factor 1 A is placed with the plane of its coil perpendicular to the magnetic meridian. When a current of 1 A is passed through it, the deflection produced is

1) 30^0 2) 60^0

3) 45^0 4) Zero

Answer:

on keeping the plane of the coil normal to the magnetic meridian, if the current passing through the coil is in clockwise direction then the magnetic needle is in the direction of magnetic meridian, hence the angle made by the needle is $\mathbf{0^0}$, if the current is in anticlockwise the field produced is opposite to magnetic meridian hence the needle makes 180^0, therefore

Answer (4)

19. A current of 2A produces a deflection of 30^0 in a TG. A deflection of 60^0 will be produced in it by a current of

1) 1 A

2) 3 A

3) 4 A

4) 6 A

Answer:

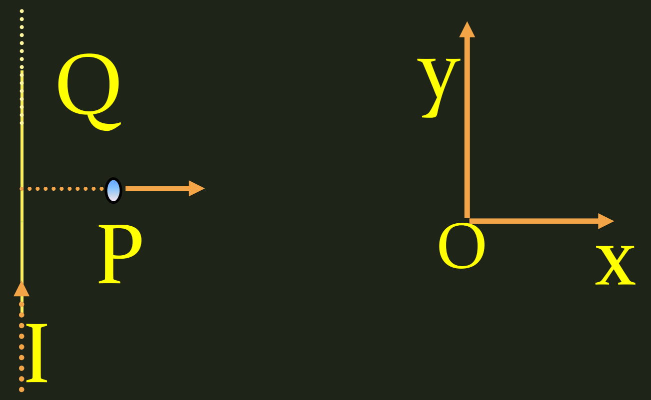
$I_1 = k \tan \emptyset_1$ also $I_1 = k \tan \emptyset_2$

$$\frac{I_2}{I_1} = \frac{\tan\emptyset_2}{\tan\emptyset_1}, \quad \frac{I_2}{2} = \frac{\tan 60°}{\tan 30°} \qquad \frac{I_2}{2} = \frac{\frac{\sqrt{3}}{1}}{\frac{1}{\sqrt{3}}}$$

on solving $I_2 = 6A$ hence

answer (4)

20. A very long straight wire carries a current I. At the instant when a charge +Q at point P has velocity, as shown, the force on the charge is :



1) Opposite to ox

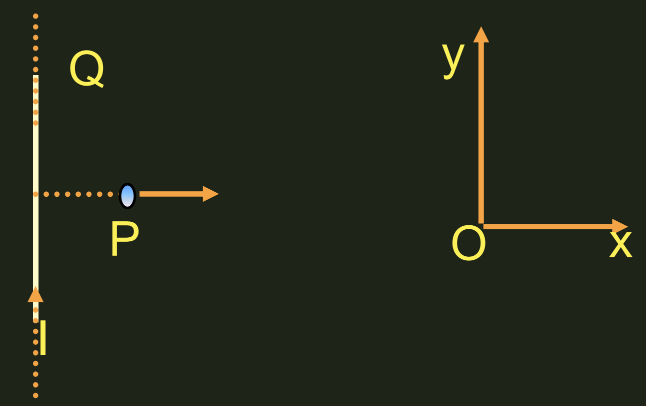
2) Along ox

3) Opposite to oy

4) Along oy

Answer : By right hand clasp rule magnetic field at a point is into the board. Hence by fleming's left hand rule. The direction of force acting on the charge is along oy

4) Along oy



21. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per milliampere and voltage sensitivity is 2 divisions per millivolt. In order that each division reads 1 volt, the resistance in ohm needed to be connected in series with the coil will be (in Ω)

1) 99995

2) 9995

3) 10^3

4) 10^5

Answer : I_g = 150/10 = 15 mA also potential difference required for 2 division deflection = 1 mV $\therefore$ the maximum potential difference required for 150 divisions is 75 mV. Galvanometer resistance = G = $\frac{V_{max}}{I_g} = \frac{75}{15} = 5\Omega$

$$R = \frac{V}{I_g} - G = \frac{150}{15} \times 10^3 - 5$$

R =10000 – 5 = 9995 Ω in series

2) 9995

22. A proton, a deuteron and an α - particle having the same kinetic energy are moving in circular trajectories in a constant magnetic field. If r_p, r_d and r_α denote respectively the radii of the trajectories of these particles, then :

1) $r_\alpha = r_p < r_d$

2) $r_\alpha > r_d > r_p$

3) $r_\alpha = r_d > r_p$

4) $r_p = r_d = r_\alpha$

Answer :

Radius of circular path described by charged particle is r = $\frac{mv}{Bq} = \frac{\sqrt{2mE_K}}{Bq}$

If E_K and m are constant

$$r \propto \frac{\sqrt{m}}{q}$$

$$r_p : r_d : r_\alpha = \frac{\sqrt{m_p}}{q_p} : \frac{\sqrt{m_d}}{q_d} : \frac{\sqrt{m_\alpha}}{q_\alpha}$$

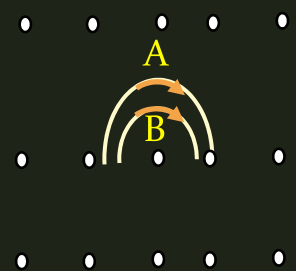
$$r_p : r_d : r_\alpha = \frac{\sqrt{1}}{1} : \frac{\sqrt{2}}{1} : \frac{\sqrt{4}}{2} = 1 : \sqrt{2} : 1$$

${}_1H^1, {}_1H^2, {}_1H^3$

Hence, $r_\alpha = r_p < r_d$

1) $r_\alpha = r_p < r_d$

23. Two particles A and B masses m_A and m_B respectively and having the same charge are moving in a plane. A uniform magnetic field exists perpendicular to this plane. The speeds of the particles are v_A and v_B respectively and the trajectories are as shown in the figure. Then :



1) $m_A v_A < m_B v_B$ 2) $m_A v_A > m_B v_B$

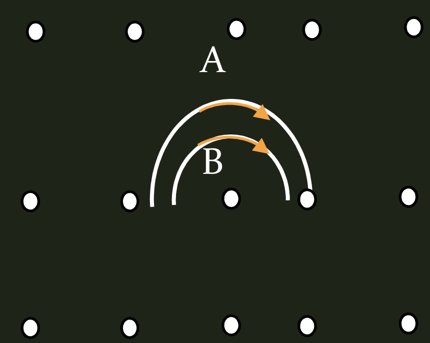
3) $m_A < m_B$ and $v_A < v_B$,

4) $m_A = m_B$ and $v_A = v_B$

Answer : Radius of path described by the charged particle $r = \frac{mv}{Bq}$ if B, q constant then

$$r \propto mv$$

As $r_A > r_B$ hence $v_A > v_B$



$$\therefore m_A v_A > m_B v_B$$

2) $m_A v_A > m_B v_B$

24. Two long conductors separated by a distance d have currents I_1 and I_2 in same direction. They exert a fore F on each other. If current in one is increased to two times and distance is made 3d. The new value of force between them is :

1) $\frac{F}{3}$

2) – 2F

3) $\frac{F}{2}$

4) $\frac{2F}{3}$

Answer:

$$F = \frac{\mu_0 I_1 I_2}{2\pi a} \qquad F \propto \frac{I_1 I_2}{a}$$

$$F' \propto \frac{2I_1 I_2}{3a} \qquad F' \propto \frac{2}{3}F$$

4) $\frac{2F}{3}$

25. A milli ammeter of range 10mA has a coil of resistance 1Ω. To use it as a voltmeter of range 10V, the resistance that must be connected in series with it is

1) 9 Ω

2) 99 Ω

3) 999 Ω

4) 1000 Ω

Answer :

$$R = \frac{V}{Ig} - G$$

$$= \frac{10}{1\times 10^{3}}$$

$$= 1000 - 1 = 999\ \Omega$$

3) 999 Ω

26. A particle of mass m carrying charge q is accelerated by a p.d. V. It enters perpendicularly in a region of uniform magnetic field B and executes circular arc of radius R. The specific charge (q/m) is

1) $\frac{2V}{B^2R^2}$

2) $\frac{V}{2BR}$

3) $\frac{VB}{2R}$

4) $\frac{mV}{BR}$

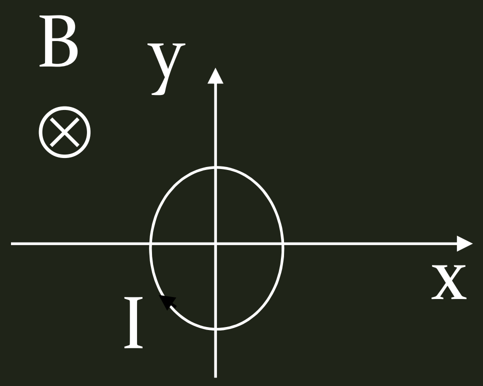
Answer : $R = \dfrac{mv}{Bq}$ $\quad v = \dfrac{Bq}{m}$

work done $\quad W = E_k \quad Vq = \frac{1}{2} mv^2 \quad \dfrac{q}{m} = \dfrac{v^2}{2V}$

specific charge $\quad \dfrac{q}{m} = \dfrac{B^2q^2R^2 / m^2}{2V} \quad \dfrac{q}{m} = \dfrac{2V}{B^2R^2}$

$1) \ \dfrac{2V}{B^2R^2}$

27. A conducting loop carrying a current I is placed in a uniform magnetic field pointing into the plane of the paper as shown. The loop will have a tendency to :



1) Contract

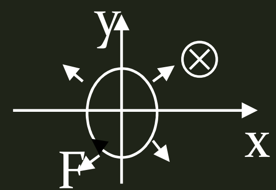
2) Expand

3) Move towards +ve x-axis

4) Move towards –ve x-axis

Answer : Since net force on a current carrying loop in uniform magnetic field is zero, hence loop cannot translate hence (3) and (4) are wrong. From Fleming's left hand rule we can see that magnetic field is perpendicular to the board and inwards and current in the loop is clockwise hence the magnetic force on each element of the loop is radially outwards hence, the loop will have tendency to expand.

2) Expand



28. A conducting circular loop of radius r carries a constant current i. It is placed in a uniform magnetic field $\overrightarrow{B_0}$ such that $\overrightarrow{B_0}$ is perpendicular to the plane of the loop. The net magnetic force acting on the loop is :

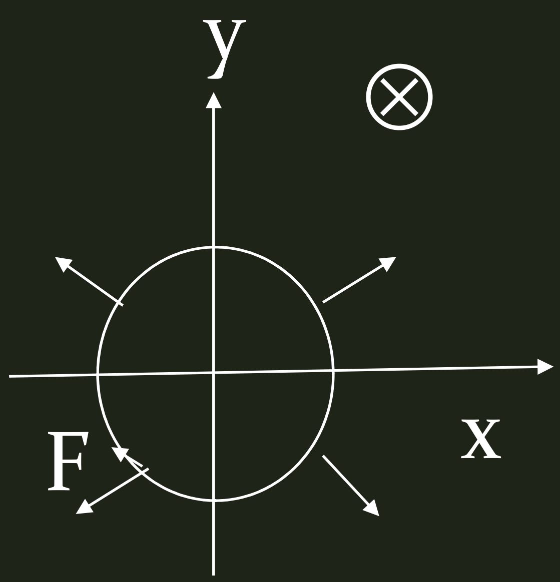
1) ir $\overrightarrow{B_0}$

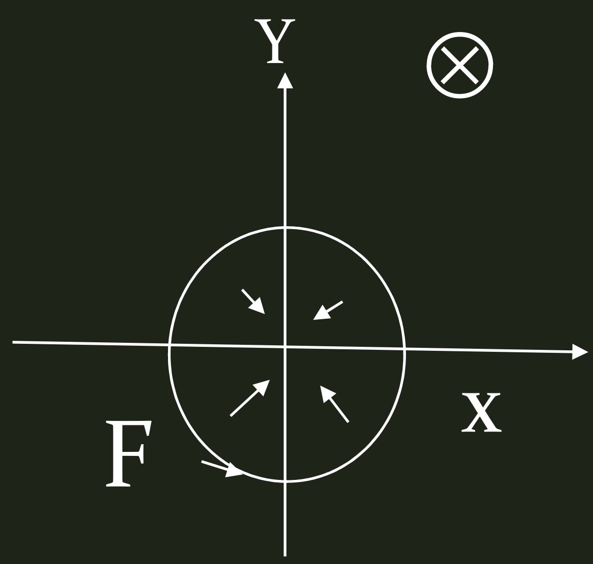
2) 2πir $\overrightarrow{B_0}$

3) Zero

4) πir $\overrightarrow{B_0}$

Answer :





net force acting is zero
but loop expands

net force acting is zero
but loop contracts

3) Zero

29. 2 MeV proton is moving perpendicular to a uniform magnetic field of 2.5 T, the force on the proton is : (mass of the proton = 1.6×10^{-27}kg)

1) 10×10^{-12} N

2) 8×10^{-11} N

3) 2.5×10^{-10} N

4) 8×10^{-12} N

Answer :

$E_k = \frac{1}{2} mv2 \quad 2MeV = 2 \times 1.6 \times 10^{-13}$

$= \frac{1}{2} mv^2 = 3.2 \times 10^{-13}$ J

$$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2 \times 3.2 \times 10^{-13}}{1.6 \times 10^{-27}}} = 2 \times 10^7 \text{ m/s}$$

$F = Bqv \text{ Sin } 90^0$

$F = 2.5 \times 1.6 \times 10^{-19} \times 2 \times 10^7 = 8 \times 10^{-12}$ N

4) 8×10^{-12} N

30. A charged particle enters a magnetic field at an angle of 45^0 with the magnetic field. The path of the particle will be

1) A helix **2) An Ellipse**

3) A Circle **4) A Straight line**

Answer :

charged particle moving with θ not equal to 0^0 and 90^0 the trajectory of the particle is a helix this is because the component of v perpendicular to B ie v sin θ makes the particle moves in circle and the component v cos θ which is parallel to B makes the particle move along the straight line. The resultant of these two motion is an helix.

31. Two particles X and Y having equal charges, after being accelerated through the same potential difference, enter a region of uniform magnetic field and describe circular paths of radii R_1 and R_2 respectively. The ratio of the mass of X to that of Y is

1) $\left(\frac{R_1}{R_2}\right)^{1/2}$

2) $\frac{R_2}{R_1}$

3) $\left(\frac{R_1}{R_2}\right)^2$

4) $\frac{R_1}{R_2}$

Answer :

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

$$R = \frac{\sqrt{2mV}}{Bq}, \quad R \propto \sqrt{m}$$

$$\frac{R_1}{R_2} = \sqrt{\frac{m_x}{m_y}} \qquad \frac{m_x}{m_y} = \left(\frac{R_1}{R_2}\right)^2$$

$$3) \left(\frac{R_1}{R_2}\right)^2$$

$E_k = W$

$\frac{1}{2} mv^2 = Vq$

$$\frac{m^2v^2}{2} = mV$$

$$mv = \sqrt{2\ldots}$$ [illegible]

32. A charged particle is moving in a uniform magnetic field in a circular path of radius r. When the energy of the particle is four times, then the new radius will be :

1) $\frac{r}{\sqrt{2}}$

2) 2r

3) $\frac{r}{2}$

4) $r\sqrt{2}$

Answer :

Radius of the path of charged particle is

$$r = \frac{mv}{Bq} \qquad r = \frac{\sqrt{2mE_K}}{Bq}$$

$$r \propto \sqrt{E_K} \qquad r' \propto \sqrt{E'_K}$$

$$\frac{r'}{r} = \sqrt{\frac{E'_k}{E_k}} = \sqrt{\frac{4E_k}{E_k}} \qquad \frac{r'}{r} = 2, \quad r' = 2r$$

2) 2r

33. An electron accelerated through a potential difference enters into a uniform transverse magnetic field and experience a force F. If the accelerating potential is increased to 2V, the electron in the same magnetic field will experience a force :

1) F

2) $\frac{F}{2}$

3) $\sqrt{2}F$

4) 2F

Answer : $E_k = W$ $\frac{1}{2}mv^2 = eV$ $v = \left(\frac{2eV}{m}\right)^{\frac{1}{2}}$

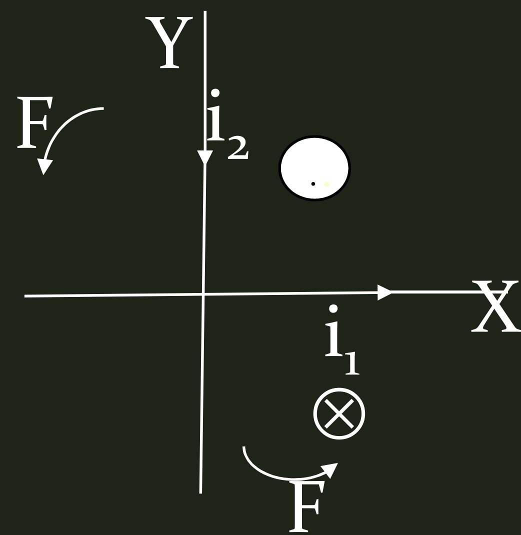
$F = evB$ $\theta = 90^o$

$$F = \left(\frac{2eV}{m}\right)^{\frac{1}{2}} E$$

$F \propto \sqrt{V}$ $$\frac{F_2}{F_1} = \sqrt{\frac{V_2}{V_1}} = \sqrt{\frac{2V}{V}}$$

Hence, $F_2 = \sqrt{2}F_1 = \sqrt{2}F$ 3) $\sqrt{2}F$

34. Two wires A and B carry currents as shown in figure. The magnetic interactions :



1) push i_2 away from i_1

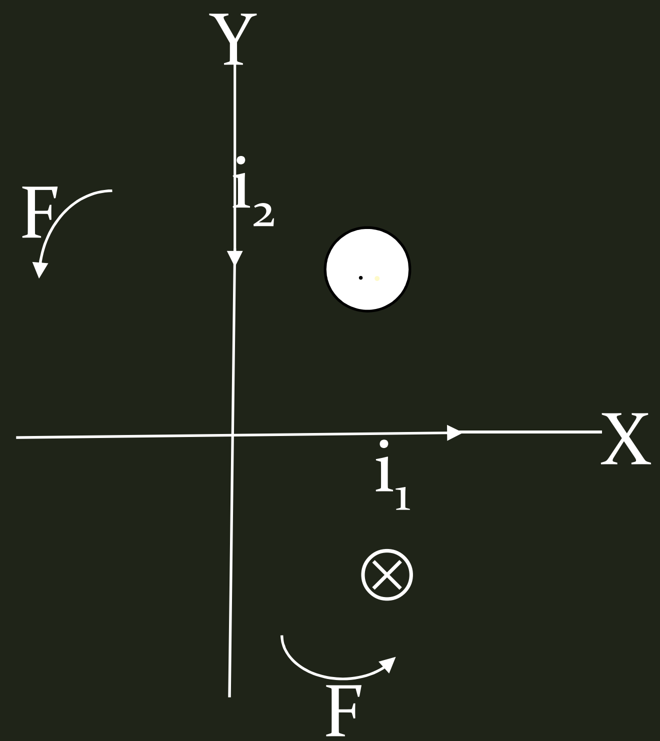
2) push i_2 close to i_1

3) turn i_2 clockwise

4) turn i_2 anticlockwise

Answer :

Magnetic field produced due to i_1 in x is into the board on one side and towards the observer on another side, hence by Fleming's left hand rule force on i_2 is anticlockwise



4) turn i_2 anticlockwise

35. When two TGs of the same radii are connected in series, a flow of current in them produces deflections of 60^0 and 45^0. The ratio of the number of turns is

1) $\frac{4}{3}$

2) $\frac{\sqrt{3}}{1}$

3) $\frac{(\sqrt{3}+1)}{1}$

4) $\frac{\sqrt{3}+1}{\sqrt{3}\quad 1}$

Answer: In series current through both the coils are equal

$$I_1 = I_2$$

$$\frac{2rB_H tan\theta_1}{\mu_0 n_1} = \frac{2rB_H tan\theta_2}{\mu_0 n_2}$$

$$\frac{n_1}{n_2} = \frac{\tan\theta_1}{\tan\theta_2}$$

$$\frac{n_1}{n_2} = \frac{\tan 60^\circ}{\tan 45^\circ} \quad \frac{n_1}{n_2} = \frac{\sqrt{3}}{1}$$

(2) $\frac{\sqrt{3}}{1}$

36. A solenoid 1.5m long and 0.4 cm in diameter possesses 10 turns per cm length. A current of 5A flows through it. The magnetic field at the middle on the axis inside the solenoid is

1) $4\pi \times 10^{-2}$ T

2) $4\pi \times 10^{-3}$ T

3) $2\pi \times 10^{-3}$ T

4) $2\pi \times 10^{-5}$ T

Answer: magnetic field at the middle along the axis of the solenoid is

$$B = \mu_0 n I \qquad n = \frac{N}{l} = \frac{10}{10^{-2}} = 10^3$$

$$B = 4\pi x 10^{-7} x 10^3 x 5$$

$$B = 2\pi x 10^{-3} T$$

(3) $2\pi \times 10^{-3}$ T

37. The magnetic field at the centre of a circular current carrying conductor of radius r is B_c. The magnetic field on its axis at a distance r from the centre is B_a. The value of $B_c : B_a$ will be

1) $2\sqrt{2}:1$

2) $\sqrt{2}:1$

3) $1:\sqrt{2}$

4) $1:2\sqrt{2}$

Answer:

$$\frac{B_c}{Ba} = \frac{\dfrac{\mu_0 nI}{2r}}{\dfrac{\mu_0 nIr^2}{2(r^2+x^2)^{3/2}}}$$

x = r

on solving $\frac{B_c}{Ba} = \frac{2\sqrt{2}}{1}$

(1) $2\sqrt{2}:1$

38. At a certain place, the angle of dip is 30^0 and horizontal component of earth's magnetic field is 0.5 oersted. The earth's total magnetic field (in oersted) is

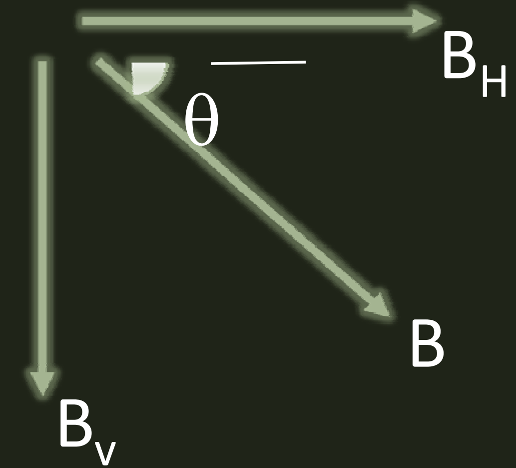
1) $\sqrt{3}$ 2) 1

3) $\frac{1}{\sqrt{3}}$ 4) 0.5

Answer:

$$B_H = B\cos\theta$$

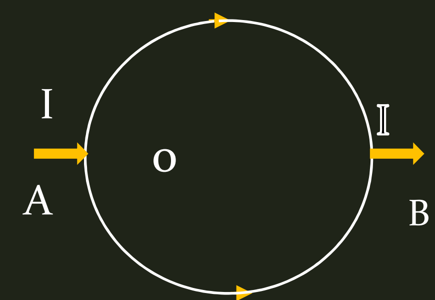
$$\frac{1}{2} = B\cos 30^0 \quad , \quad \frac{1}{2} = B.\frac{\sqrt{3}}{2}$$



$$B = \frac{1}{\sqrt{3}}$$

(3) $B = \frac{1}{\sqrt{3}}$

39. A and B are diametrically opposite points of a uniform circular conductor of radius r. A current of I amp enters the conductor at A. Then the magnetic field at O, the centre of the circle is (in T)



1) $10^{-7} \times \frac{2\pi r I}{r^2}$

2) $10^{-7} \times \frac{\pi I}{r}$

3) $10^{-7} \times \frac{\pi r}{I}$

4) Zero

Answer:

The magnetic fields at the center due to the two portions of the conductor are equal and opposite. Therefore the resultant field at the center is zero.

(4) zero.

40.Two circular coils have number of turns in the ratio 1:3 and radii in the ratio 3:1. If the same current flows through them, the magnetic fields at their centers will be in the ratio

1) 1:1

2) 1:3

3) 3:1

4) 1:9

Answer: The field due to the first coil is

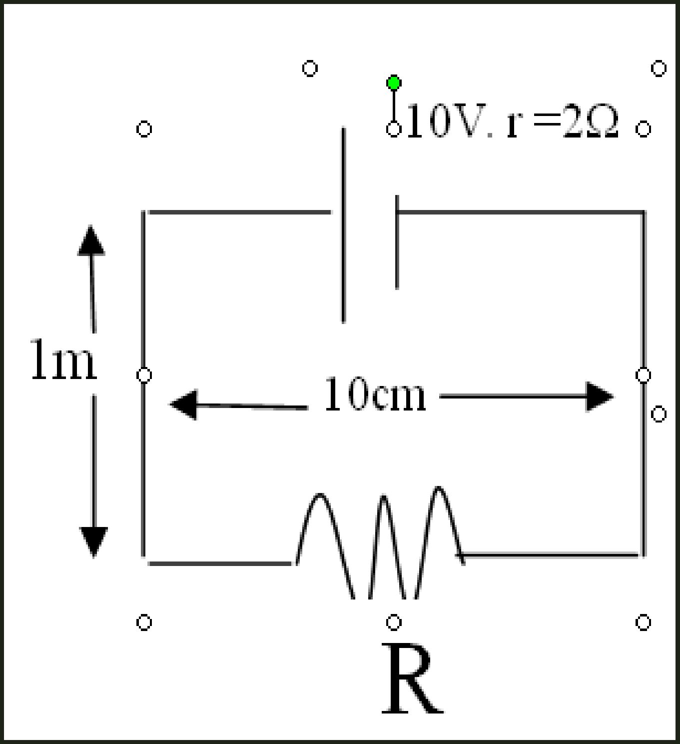
$$B_1 = \frac{\mu_0 n_1 I}{2r_1} \qquad B_2 = \frac{\mu_0 n_2 I}{2r_2}$$

$$\therefore \frac{B_1}{B_2} = \frac{n_1}{n_2} \cdot \frac{r_2}{r_1} \quad , \qquad B \propto \frac{n}{r}$$

$$\frac{B_1}{B_2} = \frac{1}{3} \cdot \frac{1}{3} = \frac{1}{9}$$

(4) 1:9

41. In the figure shown, the force per unit length of the long parallel wires is $2 \times 10^{-6}\,Nm^{-1}$ then the resistance R is



1) 1 Ω

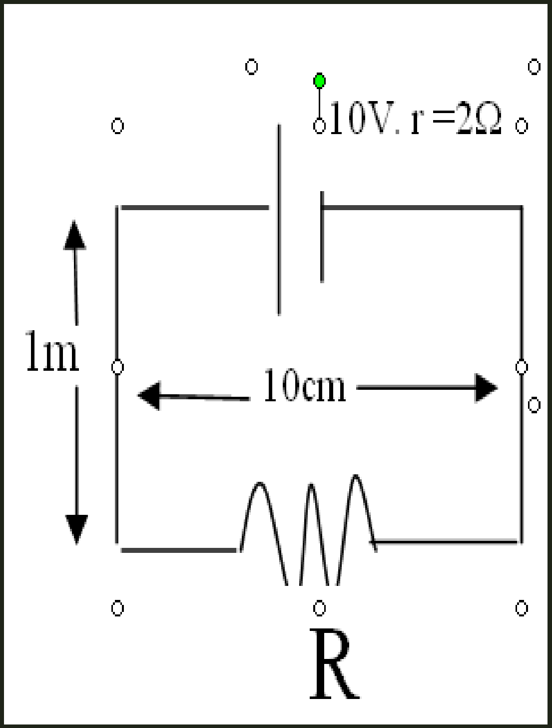
2) 2 Ω

3) 4Ω

4) 8Ω

Answer: $f = \dfrac{\mu_0 I^2}{2\pi a}$

$$I^2 = \frac{2\pi a f}{\mu_0} = \frac{2\pi \times 0.1 x 2 x 10^{-6}}{4\pi \times 10^{-7}} = 1A$$



Also, $I = \dfrac{E}{R+r}$, $\quad R + r = \dfrac{E}{I}$

$$R+2=10 \qquad R=8\Omega$$

4) 8Ω

42. The deflecting couple of the coil of a suspended coil galvanometer, if the number of turns 2000, area is $6x10^{-4}$ m^2, field is 1T When the coil carries a current of 1A is

1) $6x10^{-6}$ Nm
2) $6x10^{-7}$ Nm
3) $2x10^{-7}$ Nm
4) $3x10^{-6}$ Nm

Answer:

$$C_D = nB$$

[illegible]

$$= 2\times10^{-7}$$

3) 2x10^{-7} Nm

43. If an α - particle describes a circular path of radius r in a magnetic field B, then the radius of the circular path described by a proton of same energy in the same magnetic field is :

1) 2r

2) $\frac{r}{2}$

3) $\frac{r}{\sqrt{2}}$

4) r

Answer:

$$r = \frac{mv}{Bq} = \frac{\sqrt{2mE_k}}{Bq}$$

For same E_k and m $r \alpha \frac{\sqrt{m}}{q}$

$$\frac{r_p}{r_\alpha} = \sqrt{\frac{m_p}{m_\alpha} \frac{q_\alpha}{q_p}} = \sqrt{\frac{m_p}{4m_p} \times \frac{2e}{e}} = 1$$

hence $r_p = r_\alpha = r$ 4) r

44. Two concentric circular coils of 5 turns each are situated in the same plane. Their radii are 0.1 m and 0.2 m and they carry currents of 0.1 A and 0.3 A respectively in the opposite directions. The magnetic field at the common centre in T is

1) $\frac{5}{4}\mu_0$ 2) $\frac{4}{5}\mu_0$

3) zero 4) μ_0

Answer:

The field due to the first coil is $B_1 = \frac{\mu_0}{4\pi} \times \frac{2\pi \times 5 \times 0.1}{0.1} = \frac{5}{2}\mu_0 T$

The field due to the second coil is

$$B_2 = \frac{\mu_0}{4\pi} \times \frac{2\pi \times 5 \times 0.3}{0.1} = \frac{15}{2}\mu_0 T$$

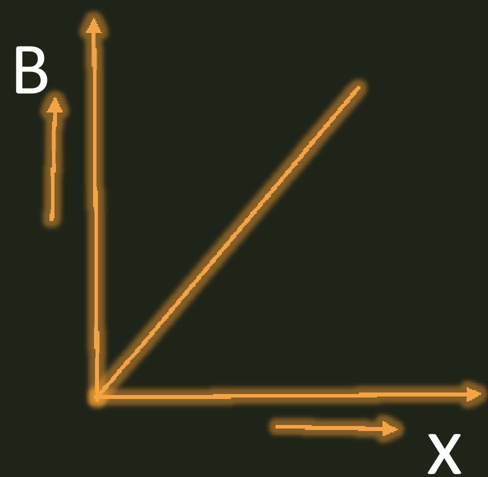
These two fields are in opposite directions. ∴ Their resultant is ,

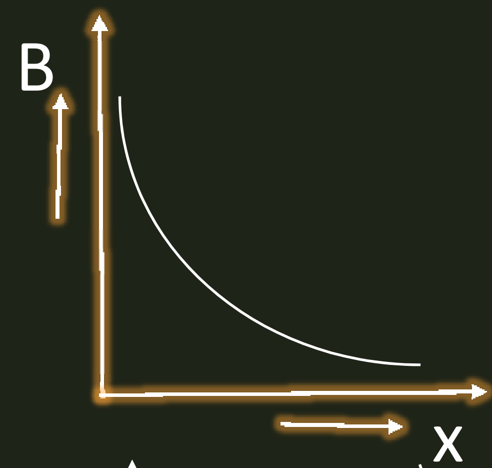
$$B_R = \frac{15}{4}\mu_0 - \frac{5}{2}\mu_0$$

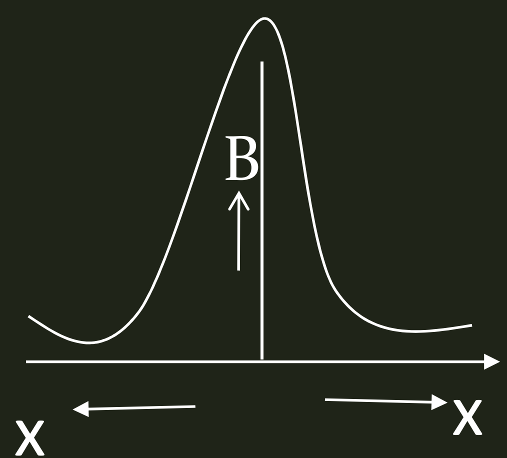
$$B_R = \frac{(15 - 10)}{4}\mu_0 = \frac{5}{4}\mu_0 T$$

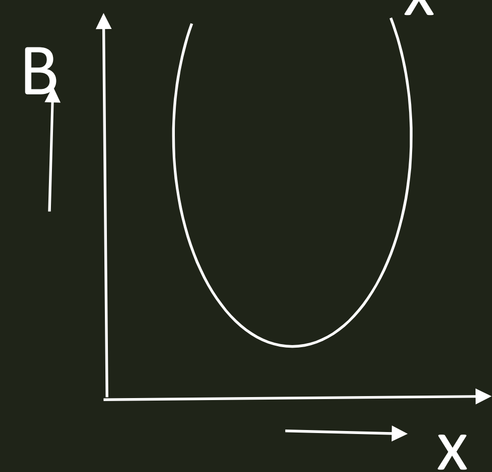
Answer (1)

45. The variation of magnetic field *B* due to a circular coil carrying current with distance *x* form the centre of the coil is given by

1. 

2. 

3. 

4. 

Answer: The expression for the field is,

$$B = \frac{\mu_0}{4\pi} \times \frac{2\pi a^2 n I}{\left(r^2 + x^2\right)^{3/2}}$$

at the centre of the coil i.e., x=0, the field is maximum. As x increases, the field decreases on either side of the coil as shown in the fig. (3). hence answer is (3)

46) The number of turns in the coils of two TG's are n_1 and n_2 and the radii of their coils are r_1 and r_2 respectively. The TG's are connected in series and a current is passed through them. The deflection produced in them will be equal only in

1. $r_1 n_2 = r_2 n_1$
2. $r_1 r_2 = n_1 n_2$
3. $r_1 n_1 = r_2 n_2$
4. $r_1 r_2 n_1 = n_2$

Answer : **Since the TG’s are in series currents through them are equal.**

$$I_1 = I_2$$

[illegible]

[illegible]

Hence answer is (1)

47. Two resistances of 2Ω and 5 Ω are connected in series with a TG of resistance 3Ω and a cell of emf 10V and negligible internal resistance. The deflection produced in the TG if its reduction factor is $1/\sqrt{3}$ A is

1) 30^0

2) 45^0

3) 50^0

4) 60^0

Answer: The current in the circuit is

$$I = \frac{E}{R_1 + R_2 + R_G + r} = \frac{10}{2+5+3} = \frac{10}{10} = 1A$$

$$I = K tan\theta, \qquad \therefore tan\theta = \frac{1}{K}$$

$$= \frac{1 \times \sqrt{3}}{1}, \qquad \therefore \theta = 60^0$$

Hence answer is (4)

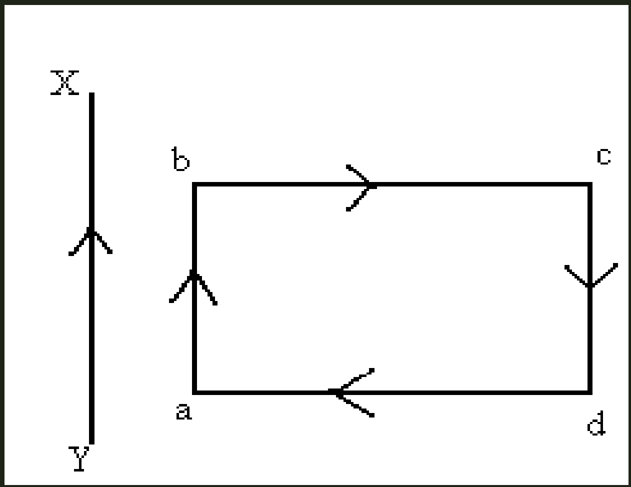
48. A rectangular loop carrying a current i is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and it is in the plane of the loop. If steady current I is established in the wire as shown in the figure, the loop will :

1) Rotate about an axis parallel to the wire

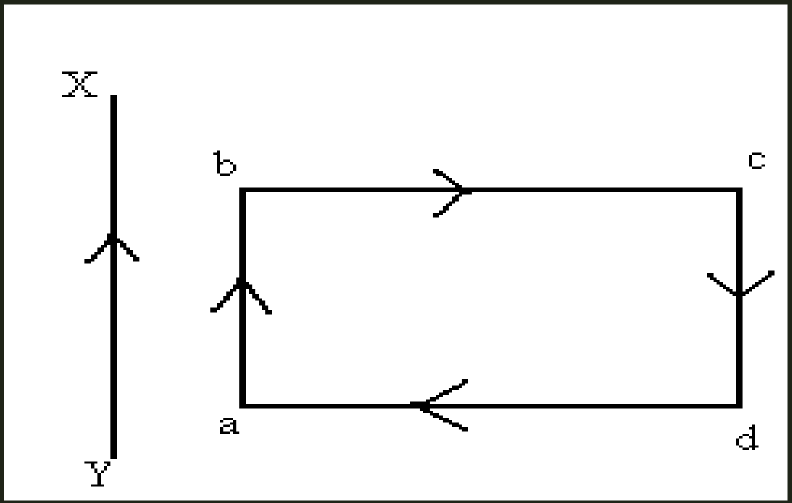
2) Move away from the wire

3) Move towards the wire

4) Remain stationary



Answer : A straight wire carrying current produce non uniform field towards right of it. Force bc and ad get cancelled. Force on ab is attractive where as an cd it is repulsive as F α1/d. Therefore Force of attraction is more hence, loop move towards the wire.



3) Move towards the wire

49. A moving coil galvanometer of resistance 100 Ω is converted to ammeter by a resistance of 0.1 Ω in the circuit. Galvanometer gives full scale deflection at 100 μA. The minimum current in the circuit for maximum deflection is

1) 100.1mA

2) 1000.1mA

3) 10.01mA

4) 1.001mA

Answer:

$$s = \frac{I_g G}{I - I_g}$$

$$I_g G = [I - I_g] s$$

$$I = \frac{I_g [G + S]}{S}$$

$$I = \frac{100 \times 10^{-6} [100 + 0.1]}{0.1}$$

$$I = 100.1 mA$$

1) 100.1mA

50. With a resistance R connected in series with a galvanometer of resistance 100 Ω it acts as a voltmeter of range 0 – V. To thrice the range, a resistance of 1000 Ω is to be connected in series with R. Then the value of R is (in Ω) :

1) 1100

2) 800

3) 900

4) 400

Answer : G = 100 Ω, V = V, V' = 3V, R = ?

$$R = \frac{V}{Ig} - G \qquad \frac{V}{Ig} = R + G$$

To increase the range to thrice the initial

$$R + 1000 = 3\frac{V}{Ig} - G = 3\,(R + G) - G$$

R + 1000 = 3R + 2G = 3R + 200

800 = 2R because G = 100

Hence R = 400 Ω **Answer (4)**

51. A voltmeter has a range 0 – V with a series resistance R. With a series resistance 2R, the range is 0 – V'. The correct relation between V and V' is

1) V’ > 2V

2) V’ = 2V

3) V’ >> 2V

4) V’ < 2V

Answer:

$$R = \frac{V}{I_g} - G,$$

$$\frac{V}{I_g} = R + G \quad for\ constant\ I_g$$

$$V \propto (R + G)$$

$$\frac{V'}{V} = \frac{2R + G}{R + G} \qquad \frac{V'}{2V} = \frac{2R + G}{2R + 2G} < 1$$

$$V' < 2V$$

Answer:(4)

52. To increase the range of voltmeter :

1) A shunt must be used

2) The resistance of the voltmeter must be decreased

3) The series resistance must be increased

4) The resistance must be removed

Answer:

$$R = \frac{V}{I_g} - G,$$

$$\frac{V}{I_g} = R + G \quad for\ constant\ I_g$$

$$V \propto (R + G)$$

Hence range of voltmeter increases with series resistance R.

Answer: 3

53. To send 10% of the main current through a moving coil galvanometer of resistance 99 ohm, the shunt required is (in ohm)

1) 10

2) 9.9

3) 9

4) 11

Answer:

$$I_g = \frac{IS}{G+S}$$

$$\frac{10}{100}I = \frac{IS}{G+S}$$

$$10S = G + S$$

$$10S = 99 + S$$

$$9S = 99$$

$$S = 11\Omega$$

3) $S = 11\Omega$

54. A galvanometer has a resistance G and a current Ia flowing in it produces full scale deflection. S_1 is the value of the shunt, which converts it into an ammeter of range 0 – I and S_2 is the shunt for the range 0 – 2I. The ratio S_1/S_2 is

1) $\frac{S_1}{S_2} = \left[\frac{I - I_a}{2I - I_a}\right]$

2) $\frac{S_1}{S_2} = \frac{2I - I_g}{I - I_g}$

3) 1

4) 2

Answer:

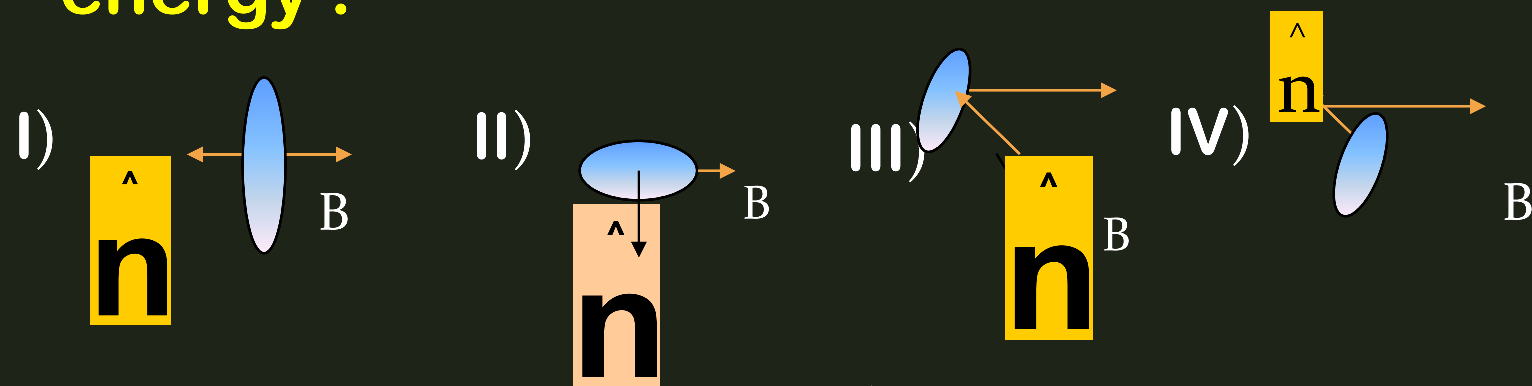
$$S = \frac{I_g G}{I - I_g} \qquad S \propto \frac{I_g}{I - I_g}$$

$$S_1 \propto \frac{I_g}{I - I_g} \qquad S_2 \propto \frac{I_g}{2I - I_g}$$

$$there\ fore\ \frac{S_1}{S_2} = \frac{2I - I_g}{I - I_g}$$

Answer: 2

55. A current carrying loop is placed in a uniform magnetic field in four different orientations, I, II, III and IV, arrange them in the decreasing order of potential energy :



1) I > III > II > I

2) I > II > III > IV

3) I > IV > II > III

4) III > IV > I > II

Answer :

Magnetic Potential Energy $U = \vec{M} \cdot \vec{B}$ = - MB cos θ

θ = angle between $\vec{B}$ And $\vec{M}$

$\vec{M}$= magnetic moment,

U_{max} when θ = 180°, U_{min} when θ = 0°

So as θ decreases from 180° to 0° its potential energy also decreases.

hence I > IV > II > III

Because, $U = 1\ for\ \theta = 180^0$

$$U = \frac{1}{\sqrt{2}}\ for\ \theta = 135^0$$

$$U = 0\ for\ \theta = 270^0$$

$$U = -\frac{1}{\sqrt{2}} for\ \theta = 315^0$$

3) I > IV > II > III

56. Two parallel wires carrying currents in the same direction attract each other because of :

1) Potential difference between them

2) Mutual inductance between them

3) Electric force between them

4) Magnetic force between them

Answer:

On passing the electric current in a conductor a magnetic field will be produced. Since the two parallel conductors are carrying current that results in a magnetic field. That means both conductors are in the magnetic field of the other. Hence they experience an attractive magnetic force according to Fleming's left hand rule.

Answer: (4)

57. An ammeter and a voltmeter are joined in series to a cell. Their readings are A and V respectively. If a resistance is now joined in parallel with the voltmeter, then S

1) A will increase, V will decrease

2) A will decrease, V will increase.

3) Both A and V will decrease.

4) Both A and V will increase.

Answer:

When resistance is joined in parallel with the voltmeter the equivalent resistance is less than both the resistance, as a result of this current in A will increase and voltmeter reads the potential difference of the resistance. But the potential difference of the cell is more than the potential difference of resistance therefore V decreases.

Answer: 1

58. A voltmeter of range 3V and resistance 200 Ω can't be converted to an ammeters of range

1) 10 mA

2) 100mA

3) 1A

4) 10A

Answer:

$$new\ current\ required\ I_g = \frac{V}{G}$$

$$I_g = \frac{3}{200} = 0.015 = 15mA$$

$$so\ new\ range\ cannot\ be\ less\ than\ 15mA$$

Hence it can't be converted into an ammeter of range 10mA

Answer: 1

59. A uniform electric and magnetic fields are acting along same direction in a certain region. An electron projected in the direction of fields with some velocity

1) It will turn towards right of direction of motion
2) It will turn towards left of direction of motion
3) Its velocity will decrease
4) Its velocity will increase

Answer:

Since the charge particle is moving along the magnetic field direction hence the magnetic force acting $F=Bqv \sin \theta$ is zero because θ is zero but the electron will experience an electric force $F=Eq$ opposite to field. Hence its velocity will be increased.

Answer: 4

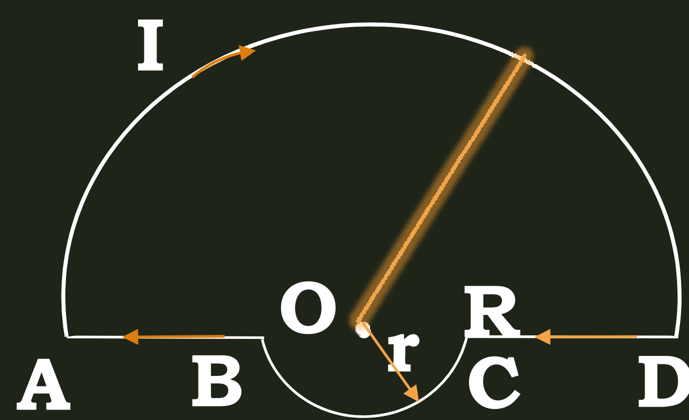
60. Two semi-circular loops of radii *R* and r are connected to two straight conductors *AB* and *CD* as shown in the figure. A current of *I* A is passed through the loops as shown. The resultant field at their common centre is.

1) $\frac{\mu_0 I}{2}(R+r)$

2) $\frac{\mu_0 I}{4}\left[\frac{1}{r}-\frac{1}{R}\right]$

3) $\frac{\mu_0 I}{4}\left[\frac{1}{r}+\frac{1}{R}\right]$

4) $\frac{\mu_0 I}{4}(R\ r)$



Answer: The field at O due to the straight conductors *AB* and *CD* is zero. The field at O due to the semicircular loop of radius R is

$$B_1 = \frac{\mu_0}{4\pi} \times \frac{I\pi R}{R^2} = \frac{\mu_0 I}{4R} \quad \because dl = \pi R \ \& \ \sin\theta = 1$$

The field at O due to the semicircular loop of radius r is

$$B_2 = \frac{\mu_0}{4\pi} \times \frac{I\pi r}{r^2} = \frac{\mu_0 I}{4r} \quad \because dl = \pi r \ \& \ \sin\theta = 1$$

These two fields are in the same direction.

$\therefore$ their resultant is

$$B_R = B_2 + B_1 = \frac{\mu_0 I}{4r} + \frac{\mu_0 I}{4R} = \frac{\mu_0 I}{4}\left(\frac{1}{r} + \frac{1}{R}\right)$$

Answer (2)

Thank you