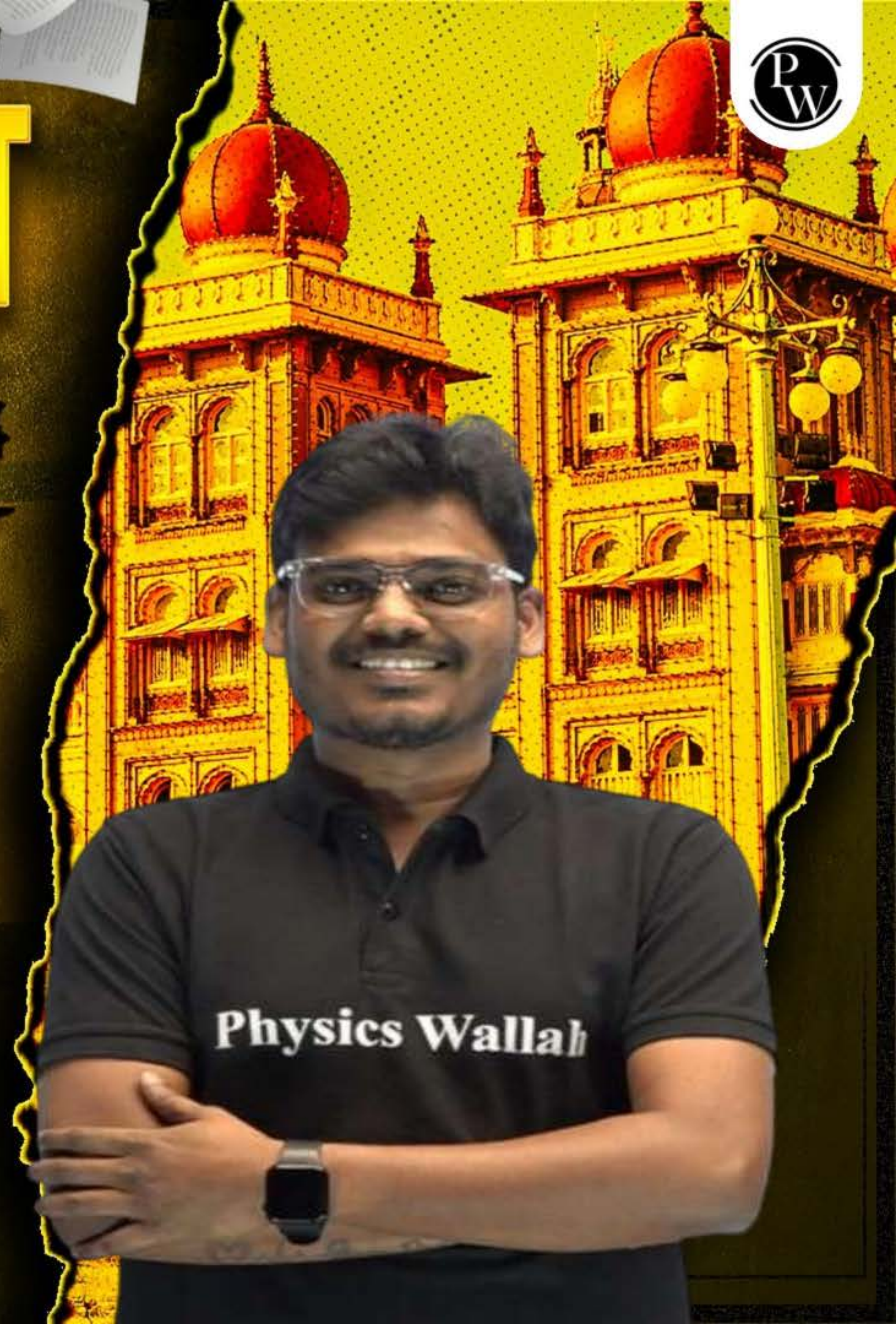
ULTIMATE KCET

CRASH COURSE 2026

PHYSICS | Lecture - 02

MOVING CHARGES AND MAGNETSIM

By – AK SIR

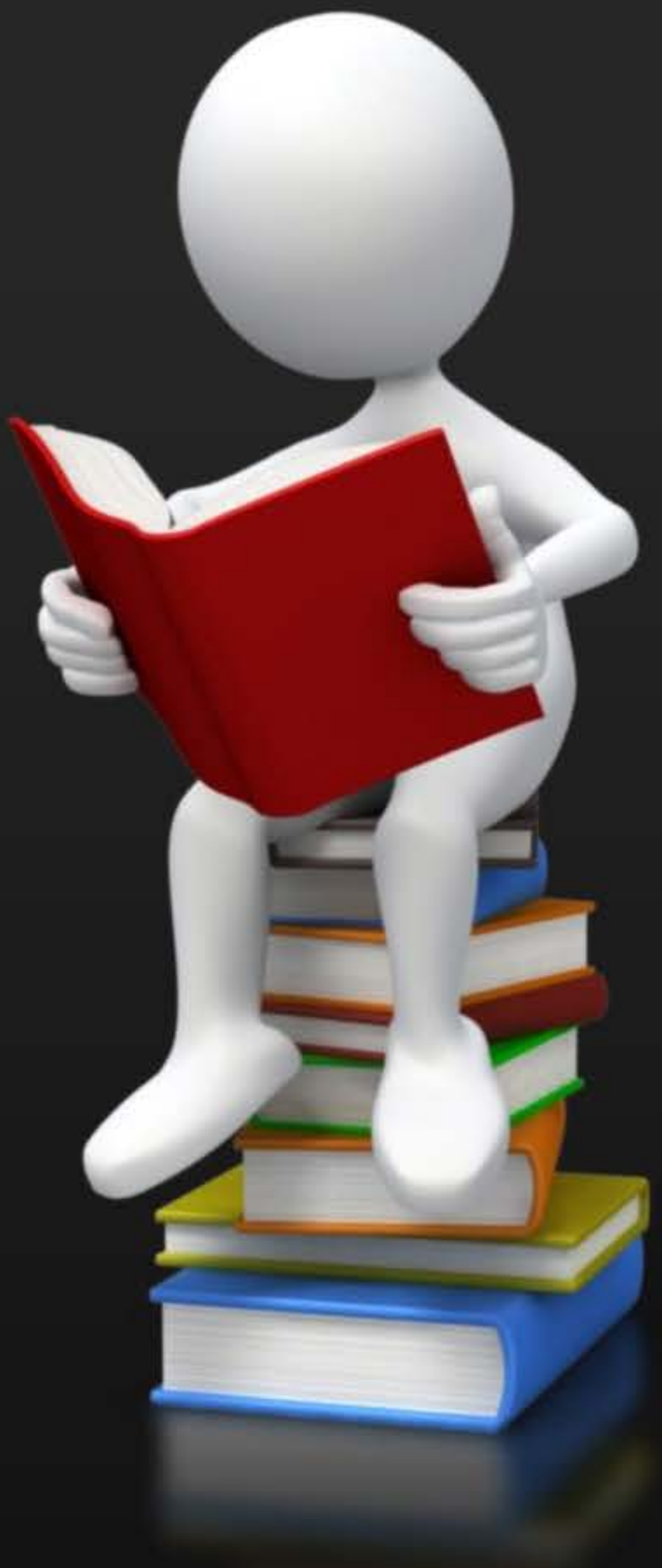


Recap *of previous lecture*

1. WHEAT STONE BRIDGE
2. MAGNETIC FIELD AND ITS SOURCE
3. BIOT-SAVARTS LAW AND ITS APPLICATIONS
4. QUESTIONS

Topics *to be covered*

1. MOTION OF A CHARGE IN UNIFORM MAGNETIC FIELD
2. MAGNETIC FORCE ON A CURRENT CARRYING CONDUCTOR
3. TORQUE ON A CURRENT CARRYING COIL IN A MAGNETIC FIELD
4. CONVERSION OF A GALVANOMETER INTO AMMETER AND VOLTMETER



Force on a Moving Charge in a Uniform Magnetic Field

Magnetic Force on a moving charge in uniform magnetic field

By experiment

$F \propto q$

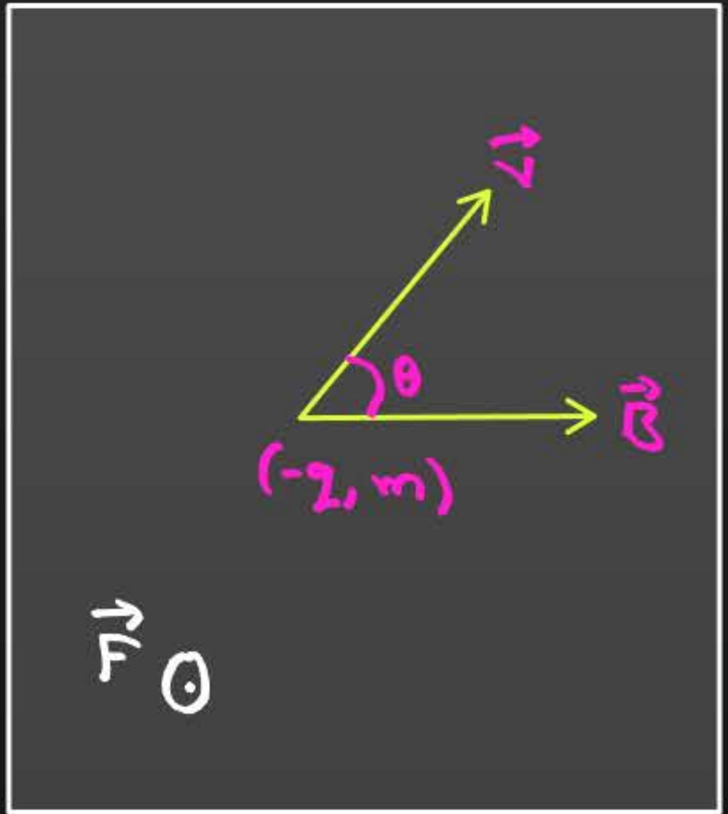
$F \propto v$

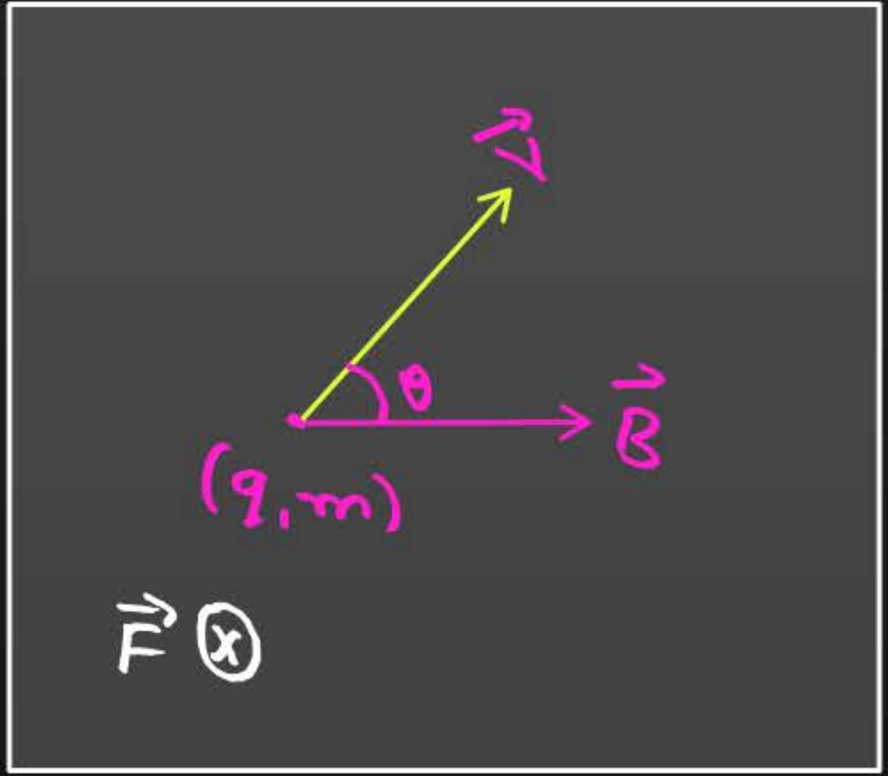
$F \propto B$

$F \propto \sin\theta$

$$F = qvB\sin\theta$$

$$\vec{F} = q(\vec{v} \times \vec{B})$$





Force on a Moving Charge in a Uniform Magnetic Field

Other units of Magnetic field :

$1T = 1N/A\text{-}m = 1Wb/m^2$

$F = qvB\sin\theta$

$B = \frac{F}{qv} = \frac{[M^1L^1T^{-2}]}{[A^1T^1][L^1T^{-1}]}$

$B = [M^1L^0T^{-2}A^{-1}]$

Dimensions of 'B' :

$\frac{1N}{1A\text{-}m} = \frac{[M^1L^1T^{-2}]}{[A^1L^1]}$

$\boxed{[\vec{B}] = [M^1L^0T^{-2}A^{-1}]}$

Force on a Moving Charge in a Uniform Magnetic Field

When magnetic force on a charge is zero ?

$F = qVB\sin\theta$

1. Chargeless particle , Neutron, photon, Helium (Atom), Deuteron (Atom) → Electrically Neutral, $q=0$, $F=0$

2. Charge at rest : $v=0$, $F=0$

3. Magnetic field is zero ; $B=0$. $F=0$

4. If charge is moving parallel or antiparallel to the magnetic field : $F=0$

   $\theta = 0^\circ$ $\theta = 180^\circ$

Question

$v=0$ $F=0$

A strong magnetic field is applied on a $\boxed{\text{stationary electron}}$. Then the electron

(A) Moves in the direction of the field. ✗

(B) $\boxed{\text{Remains stationary.}}$ ✓

(C) Moves perpendicular to the direction of the field ✗

(D) Moves opposite to the direction of the field. ✗

Question

$\vec{B} = B\hat{i} + B\hat{j} + B_0\hat{k}$

$\vec{B} = -6\hat{i} - 6\hat{j} - 8\hat{k}$

$\vec{B} = -6\hat{i} - 6\hat{j} - 8\hat{k} \Rightarrow$ D

In the product $\vec{F} = q(\vec{v} \times \vec{B}) = q[\vec{v} \times (B\hat{i} + B\hat{j} + B_0\hat{k})]$ For $q = 1$ C and $\vec{v} = 2\hat{i} + 4\hat{j} + 6\hat{k}$ and $\vec{F} = 4\hat{i} - 20\hat{j} + 12\hat{k}$ .What will be the complete expression for $\vec{B}$?

(A) $8\hat{i} + 8\hat{j} - 6\hat{k}$

(B) $6\hat{i} + 6\hat{j} - 8\hat{k}$

(C) $-8\hat{i} - 8\hat{j} - 6\hat{k}$

(D) $\boxed{-6\hat{i} - 6\hat{j} - 8\hat{k}}$

$\vec{F} = q(\vec{v} \times \vec{B})$

$$\vec{v} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 4 & 6 \\ B & B & B_0 \end{vmatrix}$$

$= \hat{i}(4B_0 - 6B) - \hat{j}(2B_0 - 6B) + \hat{k}(2B - 4B)$

$$\boxed{\vec{v} \times \vec{B} = \hat{i}(4B_0 - 6B) - \hat{j}(2B_0 - 6B) + \hat{k}(-2B)}$$

$\Rightarrow 4\hat{i} - 20\hat{j} + 12\hat{k} = 1[\hat{i}(4B_0 - 6B) - \hat{j}(2B_0 - 6B) + \hat{k}(-2B)]$

$\hat{k} \Rightarrow 12 = -2B$

$\boxed{B = -6}$

$\hat{j} \Rightarrow 20 = 2B_0 - 6B$

$20 = 2B_0 + 36$

$2B_0 = -16$ $\boxed{B_0 = -8}$

$\hat{i} \Rightarrow 4 = 4B_0 - 6B$

$4 = 4B_0 - 6 \times (-6)$

$4 = 4B_0 + 36$

$4B_0 = -32$

$\boxed{B_0 = -8}$

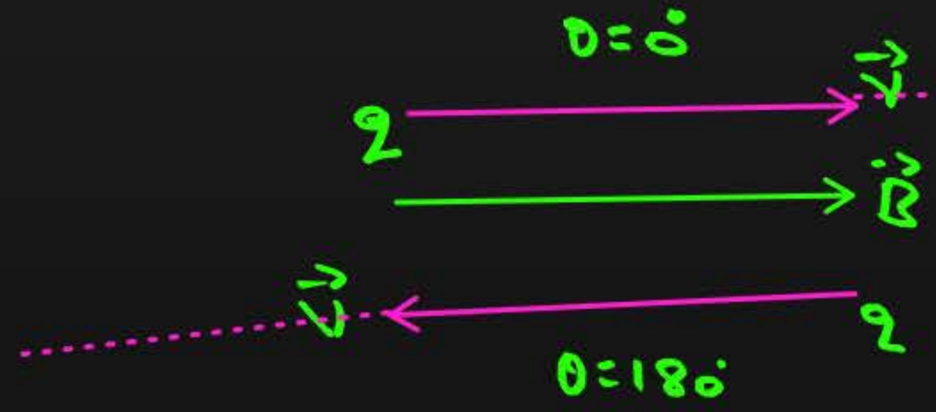
Motion of Charged particles in a Uniform Magnetic Field

Motion of a charged particles in Uniform Magnetic Field

Case (i) : When charge is at rest

$v = 0$, $F = 0$, Rest ⇒ path – undefined

Case (ii) : When charge is in motion parallel or anti-parallel to Magnetic Field



$\boxed{F = 0}$ ⇒ straight line path.

Question

$\theta = 0$ $F = 0$

A strong magnetic field is applied along the direction of the velocity of an electron. The electron would move along:

(A) a parabolic path

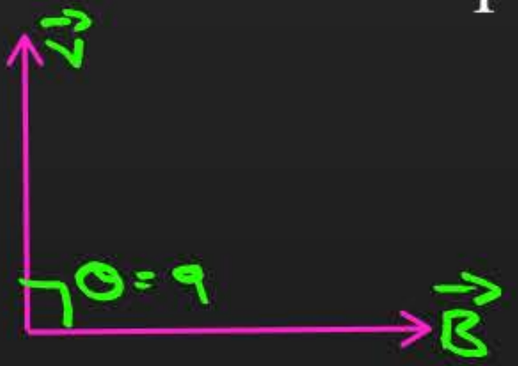
(B) the original path

(C) a helical path

(D) a circular path

Motion of Charged particles in a Uniform Magnetic Field

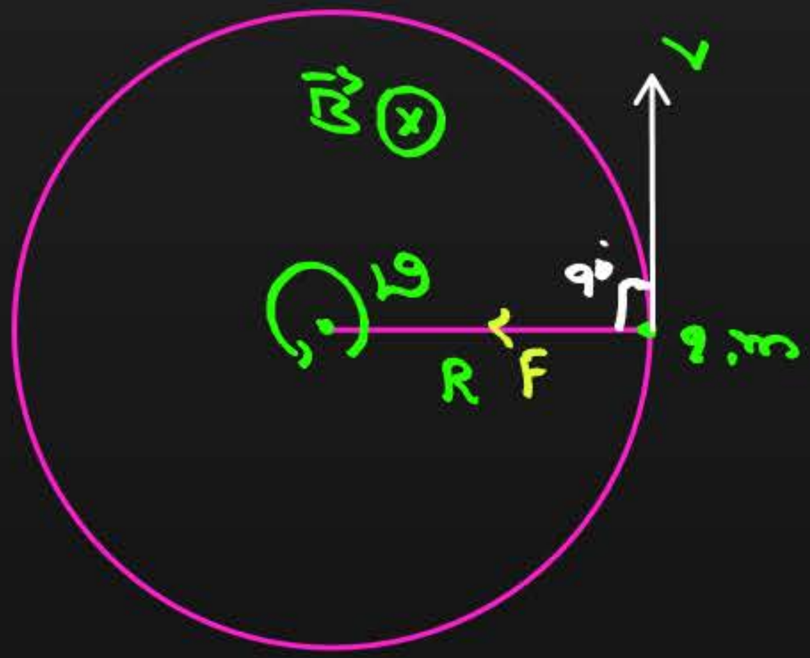
Case (iii) : When charge is in motion perpendicular to Magnetic Field



$F = qvB\sin\theta$

$\boxed{F = qvB}$, $\sin 90^\circ = 1$

↳ circular path.



Radius of circular path :

$F_c = F_m$

$\frac{mv^{\cancel{2}}}{R^2} = q\cancel{v}B \Rightarrow \boxed{R = \frac{mv}{qB}}$

Motion of Charged particles in a Uniform Magnetic Field

Angular Velocity (ω) :

$v = \omega R$

$\cancel{v} = \omega \times \frac{m\cancel{v}}{qB}$

$\boxed{\omega = \frac{qB}{m}}$ ⇒ Independent of R, V

Frequency (f) :

$\omega = 2\pi f$

$\frac{qB}{m} = 2\pi f$

$\boxed{f = \frac{qB}{2\pi m}}$ ⇒ Independent of R & V

Motion of Charged particles in a Uniform Magnetic Field

Time period (T) :

$$T = \frac{1}{f}$$

$$\boxed{T = \frac{2\pi m}{qB}}$$ Independent of R & v

Momentum (P) : $P = mv$, $R = \frac{mv}{qB}$

$$\boxed{R = \frac{P}{qB}}$$

Motion of Charged particles in a Uniform Magnetic Field

$W = \Delta K = K_f - K_i$

Kinetic energy of charge (K) :

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

$F S \cos\theta = K_f - K_i$

$\underbrace{F S \cos 90^\circ}_{0} = K_f - K_i$

$K = \frac{p^2}{2m}$

$\boxed{R = \frac{p}{qB} = \frac{\sqrt{2mK}}{qB}}$ ⇒ Independent of 'T'

$\boxed{K_i = K_f = \text{constant}}$

$p = \sqrt{2mK}$

Potential difference (ΔV): $\Delta V = \frac{W}{q}$

$\boxed{R = \frac{\sqrt{2mq\Delta V}}{qB}}$

$W = q\Delta V$

$K = q\Delta V$

*

$$\boxed{R = \frac{mv}{qB} = \frac{P}{qB} = \frac{\sqrt{2mK}}{qB} = \frac{\sqrt{2mq\Delta V}}{qB}}$$

Question

X_Z^A H_1^1 He_2^4 P $\theta = 90^\circ$

Ionized hydrogen atoms and α-particles with the same momenta enter perpendicular to a constant magnetic field, B. The ratio of their path radii $\boxed{r_H : r_\alpha}$ will be:

X_Z^A

(A) 1 : 4

(B) $\boxed{2 : 1}$

(C) 1 : 2

(D) 4 : 1

$$R = \frac{mv}{qB} = \frac{P}{qB}$$

$$R \propto \frac{1}{q}$$

$$\boxed{\frac{r_H}{r_\alpha} = \frac{q_\alpha}{q_H} = \frac{2q}{q} = \frac{2}{1}}$$

$He_2^4 \rightarrow \alpha$- particle $z = 2q$

$H_1^1 \rightarrow$ Hydrogen $z = 1q$

Question

A proton and an alpha-particle moving with the same velocity enter a uniform magnetic field with their velocities perpendicular to the magnetic field. The ratio of radii of their circular paths is

[H.W]

(A) 2 : 1

(B) 1 : 4

(C) 4 : 1

(D) 1 : 2

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

$\frac{R_p}{R_\alpha} = \frac{m_p}{q_p} \times \frac{q_\alpha}{m_\alpha}$

$R \propto \frac{m}{q}$

Proton, $m_p = m$

$q_p = q$

α-particle $m_\alpha = 4m$

$q_\alpha = 2q$ He_2^4

Question

$\theta = 90^\circ$

An electron is moving in a circular path under the influence of a $\boxed{\text{transverse}}$ magnetic field of 3.57×10^{-2}T. If the value of e/m is 1.76×10^{11}c/kg, the frequency of revolution of the electron is

(A) $\boxed{\text{1 GHz}}$

(B) 100 MHz

(C) 62.8 MHz

(D) 6.28 MHz

$$f = \frac{qB}{2\pi m}$$

$$f = \frac{e}{m}\frac{B}{2\pi}$$

$$f = 1.76\times10^{11} \times \frac{3.57\times10^{-2}}{2\times3.14}$$

$$f = 1.00\times10^{9}\ Hz$$

$$\boxed{f = 1GHz}$$

$1GHz = 10^9\ Hz$

$1MHz = 10^6\ Hz$

Question

$f = \frac{n}{t} = \frac{n}{1} = n$

An electron moving in a circular orbit of radius r makes $\boxed{n \text{ rotations per second.}}$ The magnetic field produced at the centre has magnitude:

A. $\dfrac{\mu_0 n e}{2\pi r}$

B. Zero

C. $\dfrac{n^2 e}{r}$

D. $\boxed{\dfrac{\mu_0 n e}{2r}}$

$B = \frac{\mu_0 I}{2r} = \frac{\mu_0}{2r}\frac{q}{t} = \frac{\mu_0 q f}{2r}$

$$\boxed{B = \frac{\mu_0 q n}{2r} = \frac{\mu_0 n e}{2r}}$$

Question

Charge q is uniformly spread on a thin ring of radius R. The ring rotates about its axis with a uniform frequency f Hz. The magnitude of magnetic induction at the center of the ring is :

$T = \frac{1}{f}$

$\frac{1}{T} = f$

$$\boxed{B = \frac{\mu_0 I}{2R} = \frac{\mu_0}{2R}\frac{q}{T} = \frac{\mu_0 q f}{2R}}$$

(A) $\boxed{\frac{\mu_0 q f}{2R}}$

(B) $\frac{\mu_0 q}{2fR}$

(C) $\frac{\mu_0 q}{2\pi f R}$

(D) $\frac{\mu_0 q f}{2\pi R}$

Question

A proton and an alpha particle both enter a region of uniform magnetic field B, moving at right angles to the field B. If the radius of circular orbits for both the particles is equal and the kinetic energy acquired by proton is 1 MeV, the energy acquired by the alpha particle will be:

(A) 4 MeV

(B) 0.5 MeV

(C) 1.5 MeV

(D) 1 MeV

$$\frac{K_\alpha}{K_p} = \frac{q_\alpha^2}{m_\alpha} \times \frac{m_p}{q_p^2}$$

$$= \frac{(2q)^2}{4\cancel{m}} \times \frac{\cancel{m}}{q^2}$$

$$= \frac{4\cancel{q^2}}{4} \times \frac{1}{\cancel{q^2}}$$

$$= 1$$

$$\boxed{\begin{array}{l} K_\alpha = K_p \\ K_p = K_\alpha = 1 \text{MeV} \end{array}}$$

$$R = \frac{mv}{qB} = \frac{P}{qB} = \frac{\sqrt{2mK}}{qB}$$

$$q \propto \sqrt{mK}$$

$$q^2 \propto mK$$

$$\boxed{K \propto \frac{q^2}{m}}$$

Question

Under the influence of a uniform magnetic field, a charged particle moves with constant speed v in a circle of radius R. The time period of rotation of the particle.

(A) depends on v and not on R

(B) depends on R and not on v

(C) $\boxed{\text{is independent of both } v \text{ and } R}$

(D) depends on both v and R

$$\boxed{T = \frac{2\pi m}{qB}}$$

Question

The magnetic force acting on a charged particle of charge $-2\mu C$ in a magnetic field of $2T$ acting in y-direction, when the particle velocity is $(2\hat{i}+3\hat{j})\times 10^{6}\ \mathrm{ms}^{-1}$ is

(A) 8 N in z-direction

(B) 4 N in z-direction

(C) 8 N in y-direction

(D) 4 N in y-direction

$\vec{F} = q(\vec{v}\times\vec{B})$

$\vec{F} = -2\times\cancel{10^{-6}}\left[(2\hat{i}+3\hat{j})\cancel{10^{6}}\times 2\hat{j}\right]$

$\vec{F} = -2\left[4(\hat{i}\times\hat{j}) + 6\underbrace{(\hat{j}\times\hat{j})}_{0}\right]$

$\vec{F} = -8(\hat{k})$

$\vec{F} = 8(-\hat{k})\ \mathrm{N}$

$\boxed{F = 8\ \mathrm{N} \rightarrow -z\text{ axis}}$

Question

A particle mass m, charge Q, and $\boxed{\text{kinetic energy } T}$ enter a transverse uniform magnetic field of induction $\vec{B}$. After 3sec the $\boxed{\text{kinetic energy}}$ of the particle will be :

$\boxed{K_i = K_f = \text{Const}}$

(A) $3T$

(B) $2T$

(C) $\boxed{T}$

(D) $4T$

Question

When a charged particle with velocity $\vec{v}$ is subjected to an induction magnetic field $\vec{B}$, the force on it is non-zero. What does this imply?

$F \neq 0$

(A) Angle between $\vec{v}$ and $\vec{B}$ is necessarily $90°$. ✗

(B) Angle between $\vec{v}$ and $\vec{B}$ can have any value other than $90°$. ✗

(C) $\boxed{\text{Angle between } \vec{v} \text{ and } \vec{B} \text{ can have any value other than zero and } 180°.}$ ✓

(D) Angle between $\vec{v}$ and $\vec{B}$ is either zero or $180°$. ✗

Question

Identify the $\boxed{\text{correct statement:}}$

Max'well's RHTR or Screw Rule

(A) The direction of magnetic field due to a current element is given by Fleming's Left Hand Rule. ✗

↳ F on current carrying conductor.

(B) The magnetic field inside a solenoid is non-uniform. ✗

(C) A current carrying conductor produces an electric field around it. ✗

(D) ✓ $\boxed{\text{A straight current carrying conductor has circular magnetic field lines around it.}}$

Question

$v=0$ $F=0$

A strong magnetic field is applied on a $\boxed{\text{stationary electron}}$. Then, the electron

A. moves in the direction of the field

B. moves in an opposite direction of the filed

C. $\boxed{\text{remains stationary}}$

D. starts spinning

Question

An electron is moving in a circle of radius r in a uniform magnetic field B. Suddenly, the field is reduced to $B/2$. The radius of the circular path now becomes.

A) $r/2$

B) $\boxed{2r}$

C) $r/4$

D) $4r$

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

$$R' = \frac{mv}{q\frac{B}{2}} = 2\left(\frac{mv}{qB}\right)$$

$$\boxed{R' = 2R = 2r.}$$

Question

A charge q is accelerated through a potential difference V. It is then passed normally through a uniform magnetic field, where it moves in a circle of radius r. The potential difference required to move it in a circle of radius $2r$ is

(A) $2V$

(B) $\boxed{4V}$

(C) $1V$

(D) $3V$

$$\boxed{V' = 4V}$$

$$R = \frac{mv}{qB} = \frac{P}{qB} = \frac{\sqrt{2mK}}{qB} = \frac{\sqrt{2mq\Delta V}}{qB}$$

$$R \propto \sqrt{\Delta V}$$

$$r \propto \sqrt{V}$$

$$\frac{r'}{r} = \sqrt{\frac{V'}{V}}$$

$$\frac{2r}{r} = \sqrt{\frac{V'}{V}}$$

$$2^2 = \frac{V'}{V}$$

$$4V = V'$$

Question

A proton, a deuteron and an α-particle are projected perpendicular to the direction of a uniform magnetic field with $\boxed{\text{same kinetic energy.}}$ The ratio of the radii of the circular paths described by them

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

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

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

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

$R = \frac{mv}{qB} = \frac{p}{qB} = \frac{\sqrt{2mK}}{qB} \propto \frac{\sqrt{m}}{q}$

proton: $q_p = q$

$m_p = m$

Deuteron, $q_D = q$

H_1^2 $\quad m_D = 2m$

α-particle, $q_\alpha = 2q$

He_2^4 $\quad m_\alpha = 4m$

$R_p : R_D : R_\alpha = \frac{\sqrt{m}}{q} : \frac{\sqrt{2m}}{q} : \frac{\sqrt{4m}}{2q}$

$= \frac{\cancel{\sqrt{m}}}{\cancel{q}} : \sqrt{2}\frac{\cancel{\sqrt{m}}}{\cancel{q}} : \frac{\cancel{2}\cancel{\sqrt{m}}}{\cancel{2}\cancel{q}}$

$= \boxed{1 : \sqrt{2} : 1}$

Question

$F = qvB\underbrace{\sin\theta}_{0}$ $F = 0$

A proton is projected with a uniform velocity v along the axis of a current-carrying solenoid, then

$\theta = 0^\circ$, $F = 0$ ✓

(A) the proton will be accelerated along the axis ✗

(B) the proton path will be circular about the axis ✗

(C) the proton move along helical path ✗

(D) $\boxed{\text{the proton will continue to move with velocity } v \text{ along the axis}}$

Question

A proton beam enters a magnetic field of 10^{-4} Wb m^{-2} normally. IF the specific charge of the proton is 10^{11} C kg^{-1} and its velocity is 10^{9} ms^{-1}, then the radius of the circle described will be

(A) $\boxed{100 \text{ m}}$

(B) 0.1 m

(C) 1 m

(D) 10 m

$$R = \frac{mv}{qB} = \frac{v}{\left(\frac{q}{m}\right)B}$$

$$R = \frac{10^{9}}{10^{11} \times 10^{-4}} = 10^{9+4-11}$$

$$\boxed{R = 10^{2} = 100\,m}$$

Question

$\Gamma \rightarrow F \neq 0$

A charged particle experiences magnetic force in the presence of magnetic field. Which of the following statement is correct?

(A) $\boxed{\text{The particle is moving and magnetic field is perpendicular to the velocity}}$.

$\theta = 0, F = 0$

(B) The particle is moving and magnetic field is parallel to the velocity ✗

$V = 0 \quad F = 0$

(C) The particle is stationary and magnetic field is perpendicular

(D) The particle is stationary and magnetic field is parallel

Question

A proton and helium nucleus are shot into a magnetic field at right angles to the field with same kinetic energy. Then the ratio of their radii is

H.W

A) $1:1$

B) $1:2$

C) $2:1$

D) $1:4$

Question

An α-particle and a proton moving with the same kinetic energy enter a region of uniform magnetic field at right angles to the field. The ratio of the radii of the paths of a-particle to that of the proton is [H.W]

A $1 : 8$

B $1 : 1$

C $1 : 2$

D $1 : 4$

Question

Pick out the wrong statement.

H.W

A. An electron at rest experiences no force in the magnetic field

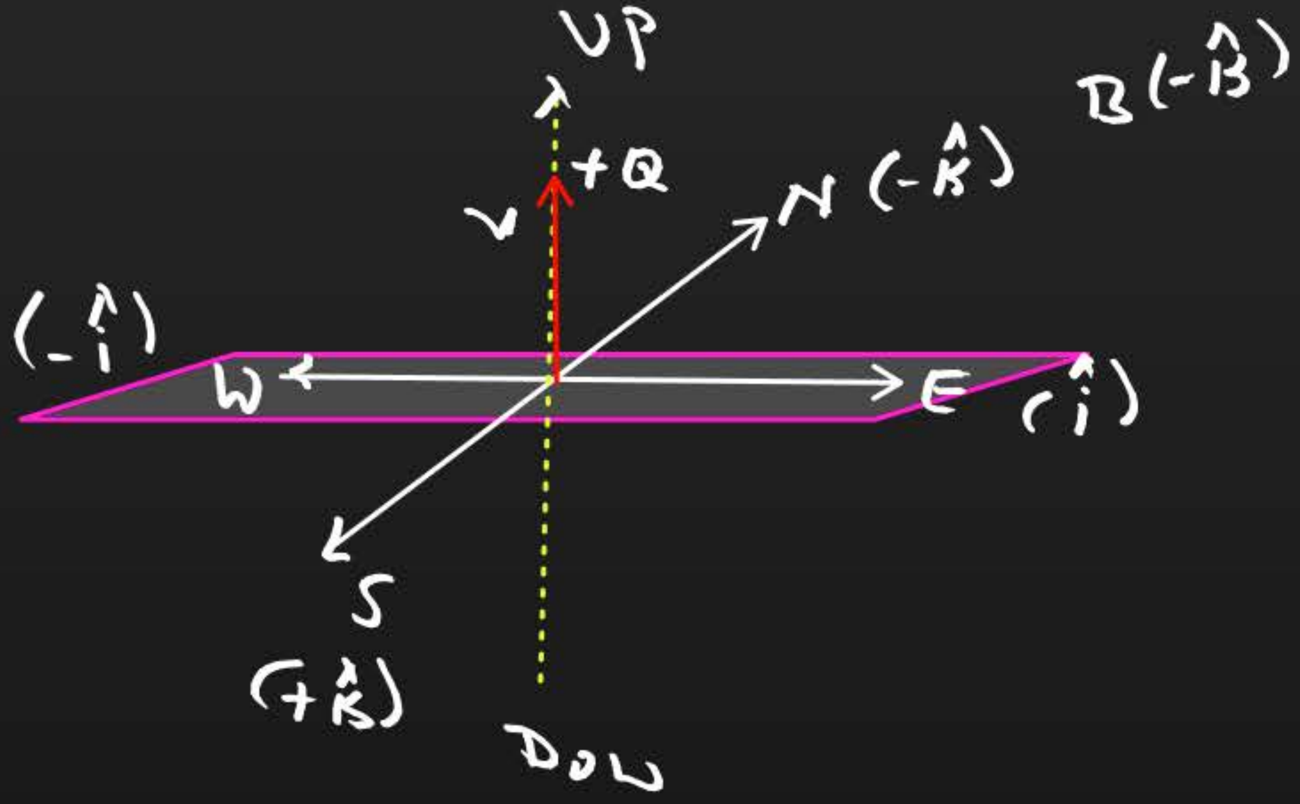
B. The gain in the KE of the electron moving at right angles to the magnetic field is zero

C. When an electron is shot at right angles to the electric field, it traces a parabolic path

D. An electron moving in the direction of the electric field gains KE

Question

A charge $+Q$ is moving upwards vertically. It enters a magnetic field directed to north. The force on the charge will be towards



(A) north

(B) south

(C) east

(D) west

Question

A charged particle is moving in a magnetic field of strength B perpendicular to the direction of the field. If q and m denote the charge and mass of the particle respectively, then the frequency of rotation of the particle is

(A) $\boxed{f = \dfrac{qB}{2\pi m}}$

(B) $f = \dfrac{qB}{2\pi m^2}$

(C) $f = \dfrac{2\pi^2 m}{qB}$

(D) $f = \dfrac{2\pi m}{qB}$

Question

→ Atoms – Electrically Neutral, $q = 0$, $F = 0$

When deuterium and helium are subjected to an accelerating field simultaneously then

(A) both acquire same energy

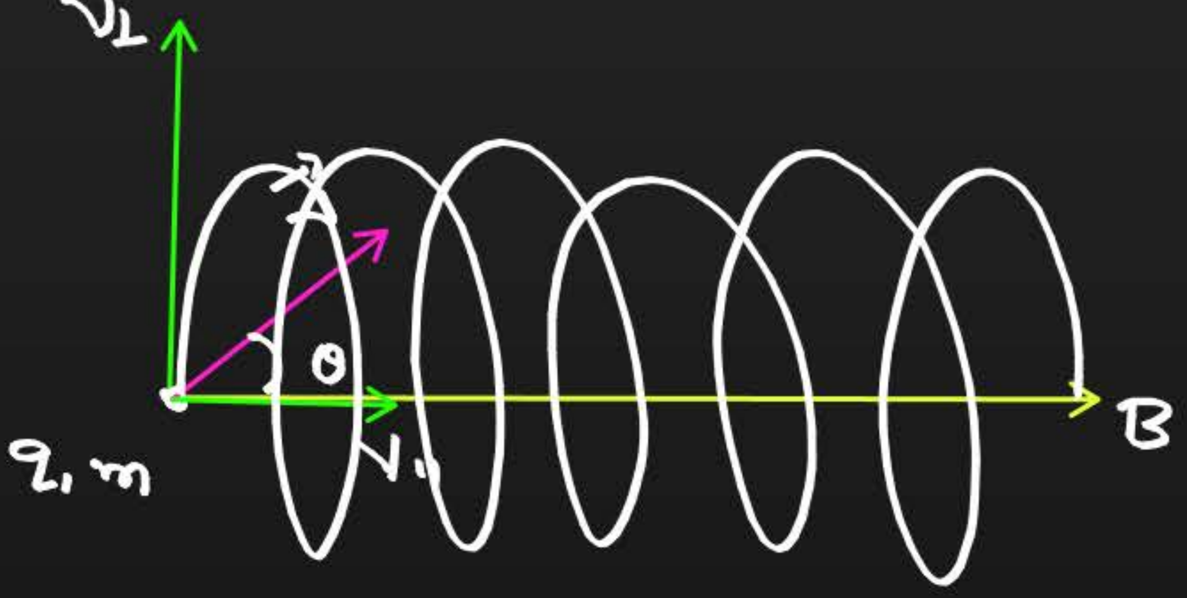
(B) deuterium accelerates faster

(C) helium accelerates faster

(D) neither of them is accelerated

Motion of Charged particles in a Uniform Magnetic Field

Case (v) : When the angle between velocity and magnetic field is neither 0^0 nor 90^0 & 180^0



$$\left.\begin{array}{c}\text{Translation motion}\\ +\\ \text{Circular motion}\end{array}\right\}\text{Helical path}$$

$v_{\parallel} = v\cos\theta$

$v_{\perp} = v\sin\theta$

Motion of Charged particles in a Uniform Magnetic Field

For vertical motion : The centripetal force is required to move the charge in a circular path is provided by the magnetic force.

Radius of circular path (R) :

$$\boxed{R = \frac{mv_\perp}{qB} = \frac{mv\sin\theta}{qB}}$$

Time period (T) :

$$\boxed{T = \frac{2\pi m}{qB}}$$

Motion of Charged particles in a Uniform Magnetic Field

For horizontal motion :

Pitch of helix (P) : The linear distance travelled by the charge particle in one revolution or in one time period along external magnetic field is called Pitch of helix

$$v = \frac{l}{t}$$

$$l = v \times t$$

$$P = v_{\parallel} \times T$$

$$\boxed{P = v\cos\theta \times \frac{2\pi m}{qB}}$$

Question

$v_{\perp}$ $v_{\parallel}$

If a velocity has both perpendicular and parallel components while moving through a magnetic field, what is the path followed by a charged particle?

A. Circular

B. Elliptical

C. Linear

D. $\boxed{\text{Helical}}$

Question

$v = \sqrt{9+16} = 5$

A charge (q, m) projected with velocity $\boxed{\vec{V} = 3\hat{\imath} + 4\hat{\jmath}}$ in external magnetic field $\vec{B} = 6\hat{\imath}\,T$. Find

$v_x + v_y$

(i) Radius of circular path : $R = \frac{mv_\perp}{qB} = \frac{mv_y}{qB} = \frac{m \times 4}{q \times 6} = \boxed{\frac{2m}{3q}}$

(ii) Pitch : $P = v_\parallel \times T = 3 \times \frac{2\pi m}{qB} = \frac{3 \times 2\pi m}{q \times 6} = \boxed{\frac{\pi m}{q}}$

(iii) Time period : $T = \frac{2\pi m}{qB} = \frac{2\pi m}{q \times 6}$

$$\boxed{T = \frac{\pi m}{3q}}$$

Motion of a charged particle in combined Electric and Magnetic fields : Lorentz force

The motion of a charged particle in a combined Electric and Magnetic fields

If a particle carrying a charge q is moving in space where both an electric field and magnetic field are present, then the force on the particle will be given by

$$\vec{F} = \vec{F}_E + \vec{F}_B$$

$$\vec{F} = q\vec{E} + q(\vec{v} \times \vec{B})$$

$$\boxed{\vec{F} = q[\vec{E} + (\vec{v} \times \vec{B})]}$$

Question

A particle having charge +5C moves with $\vec{V} = 3\hat{j}$ m/s in an electromagnetic field. If $\vec{B} = 3\hat{i} + 2\hat{j}$ T and $\vec{E} = 2\hat{k}$, then find net electromagnetic force on the particle.

$$\vec{F}_E = q\vec{E} = 5 \times 2\hat{k} = 10\hat{k}$$

$$\vec{F}_B = q(\vec{v} \times \vec{B}) = 5[3\hat{j} \times (3\hat{i} + 2\hat{j})]$$

$$= 5[9(\hat{j} \times \hat{i}) + 6\underbrace{(\hat{j} \times \hat{j})}_{0}]$$

$$\vec{F}_B = 45(-\hat{k})$$

$$\vec{F} = \vec{F}_E + \vec{F}_B = 10\hat{k} - 45\hat{k}$$

$$\boxed{\begin{array}{l} \vec{F} = -35\hat{k} = 35(-\hat{k}) \\ |\vec{F}| = F = 35\text{ N} \end{array}}$$

Question

$F = 0 \quad F_B = F_E$

A particle having a mass of $10^{-2}\ kg$ carries a charge of $5 \times 10^{-8} C$. The particle is given an initial horizontal velocity of $10^5\ ms^{-1}$ in the presence of electric field $\vec{E}$ and magnetic field $\vec{B}$. To keep the particle moving in a horizontal direction, it is necessary that

(1) $\vec{B}$ should be perpendicular to the direction of velocity and $\vec{E}$ should be along the direction of velocity.

(2) Both $\vec{B}$ and $\vec{E}$ should be along the direction of velocity.

(3) Both $\vec{B}$ and $\vec{E}$ are mutually perpendicular and perpendicular to the direction of velocity.

(4) $\vec{B}$ should be along the direction of velocity and $\vec{E}$ should be perpendicular to the direction of velocity.

Which one of the following pairs of statements are possible?

Question

A (1) and (3)

B (3) and (4)

C $\boxed{\text{(2) and (3)}}$

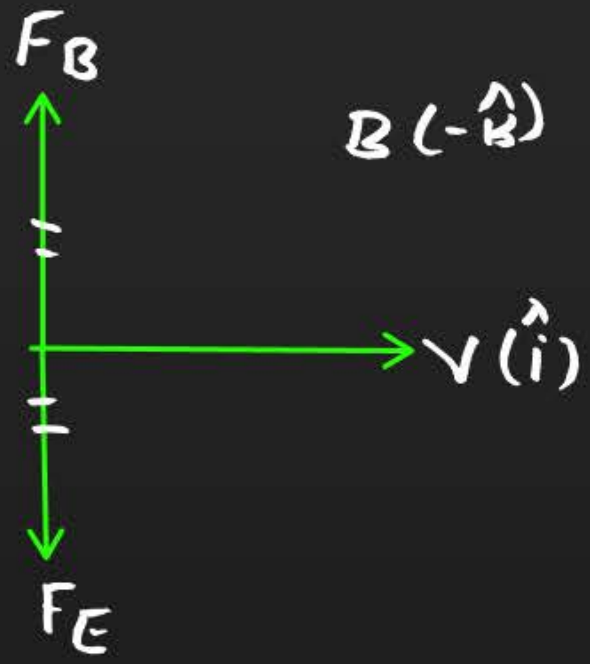
D (2) and (4)

(B) $q \rightarrow$

$\longrightarrow B \Rightarrow F_B = 0$

$\longrightarrow E \Rightarrow F_E = qE$

(C)



$$\vec{F} = \vec{F}_E + \vec{F}_B$$

$$0 = \vec{F}_E + \vec{F}_B$$

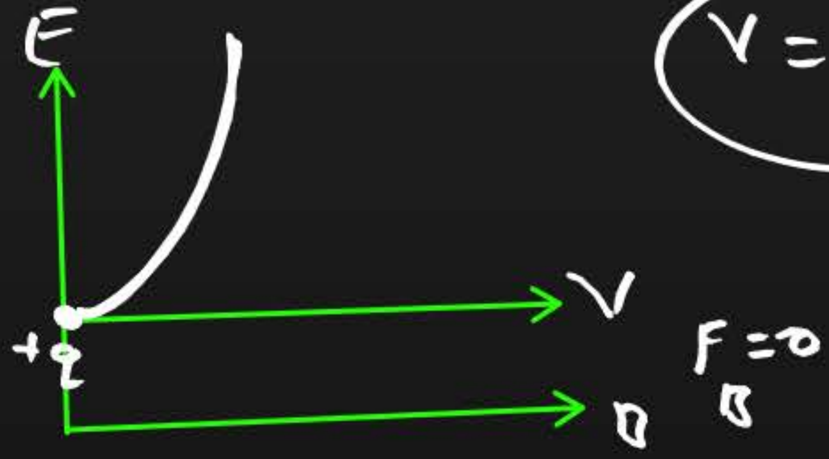
$$F_E = F_B$$

$$\cancel{q}E = \cancel{q}vB\sin\theta$$

$\sin 90^\circ = 1$

$$v = \frac{E}{B}$$

(D)



Question

A beam of electrons passes un-deflected through mutually perpendicular electric and magnetic fields. Where do the electrons move if the electric field is switched off and the same magnetic field is maintained?

(A) in an elliptical orbit.

(B) in a circular orbit.

(C) along a parabolic path.

(D) along a straight line.

Question

A proton moves with a velocity of $5 \times 10^6 \hat{j} ms^{-1}$ through the uniform electric field, $E = 4 \times 10^6 (2\hat{i} + 0.2\hat{j} + 0.1\hat{k}) Vm^{-1}$ and the uniform magnetic field $B = 0.2(\hat{i} + 0.2\hat{j} + \hat{k})$ T. The approximate net force acting on the proton is

(A) 25×10^{-13} N

(B) $\boxed{14.7 \times 10^{-13} \text{N}}$

(C) 20×10^{-13} N

(D) 5×10^{-13} N

$\vec{F} = \vec{F}_E + \vec{F}_B$

$\boxed{F = F_E + F_B}$ - (1)

$F_E = qE$

$\vec{E} = 4\times10^6(2\hat{i} + 0.2\hat{j} + 0.1\hat{k})$

$|\vec{E}| = E = 4\times10^6 \times \sqrt{2^2 + 0.2^2 + 0.1^2}$

$E = 4\times10^6 \times \sqrt{4.05}$

$E = 4\times10^6 \times 2.01 = 8.04\times10^6$ V/m

$F_E = qE = 1.6\times10^{-19} \times 8.04\times10^6 = \underbrace{12.87\times10^{-13}}$ N

$\vec{v}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & 5 & 0 \\ 0.2 & 0.04 & 0.2 \end{vmatrix} = \hat{i}(1-0) - \hat{j}(0) + \hat{k}(-1) \times 10^6$

$= (\hat{i} - \hat{k})$

$|\vec{v}\times\vec{B}| = \sqrt{1^2 + (-1)^2} = \sqrt{2} = 1.414\times10^6$

$\vec{F}_B = q(\vec{v}\times\vec{B}) = 1.6\times10^{-19} \times 1.414\times10^6 = \underbrace{2.26\times10^{-13}}$ N

$F = F_E + F_B = (12.87 + 2.26)\times10^{-13}$

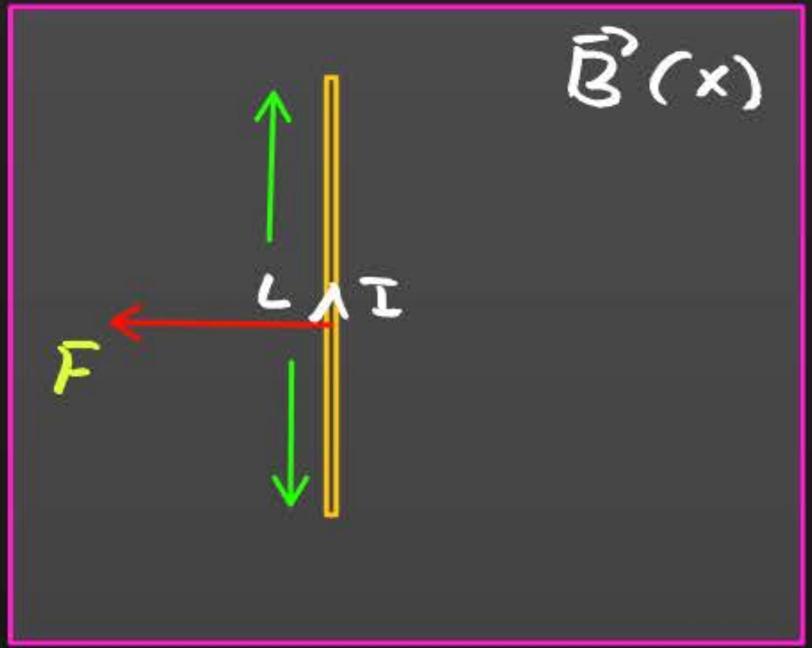
$= \boxed{15\times10^{-13} \text{N}}$

Force on a current carrying conductor in a uniform magnetic field

Rate of flow of charge (electrons) is called Electric current.

By Fleming's Rt palm Rule

$$\boxed{\begin{array}{l} F = BIL\sin\theta \\ \vec{F} = I(\vec{L}\times\vec{B}) \end{array}}$$



Question

A wire PQR is bent as shown in figure and is placed in a region of uniform magnetic field B. The length of $PQ = QR = l$. A current I ampere flows through the wire as shown. The magnitude of the force on PQ and QR will be

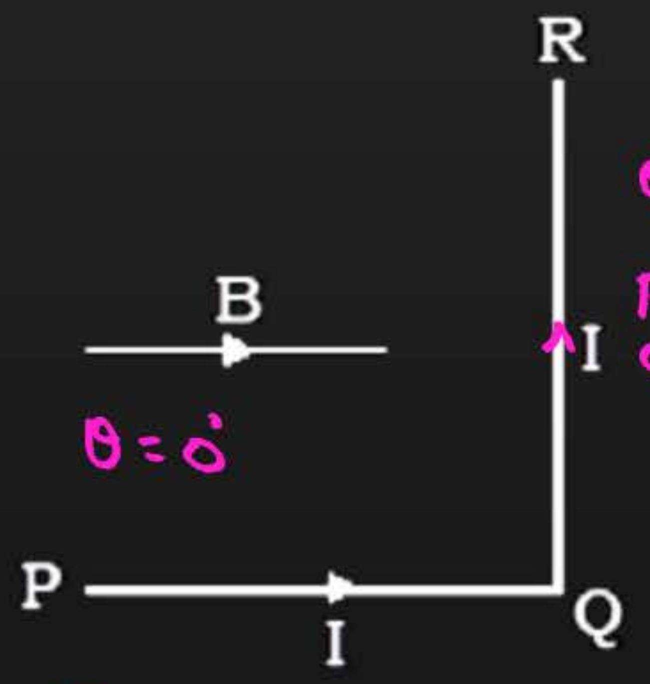
$F = BIl\sin\theta$

A) $Bll, 0$

B) $2BIl, 0$

C) $\boxed{0, BIl}$

D) $0, 0$



$\theta = 90^\circ$

$F_{QR} = BIL$

$\theta = 0^\circ$

$F_{PQ} = 0$

Question

A wire carrying a current I along the positive x-axis has length L. It is kept in a magnetic field $\vec{B} = (2\hat{i} + 3\hat{j} - 4\hat{k})$ T. The magnitude of the magnetic force acting on the wire is:

(A) $\sqrt{3}IL$

(B) $3IL$

(C) $\sqrt{5}IL$

(D) $\boxed{5IL}$

$\vec{F} = I(\vec{L} \times \vec{B})$

$F = I|\vec{L} \times \vec{B}|$

$F = I \times 5L$

$\boxed{F = 5IL}$

$$\vec{L} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ L & 0 & 0 \\ 2 & 3 & -4 \end{vmatrix} = \hat{i}(0-0) - \hat{j}(-4L-0) + \hat{k}(3L-0)$$

$$= 4L\hat{j} + 3L\hat{k}$$

$\vec{L} \times \vec{B} = 4L\hat{j} + 3L\hat{k}$

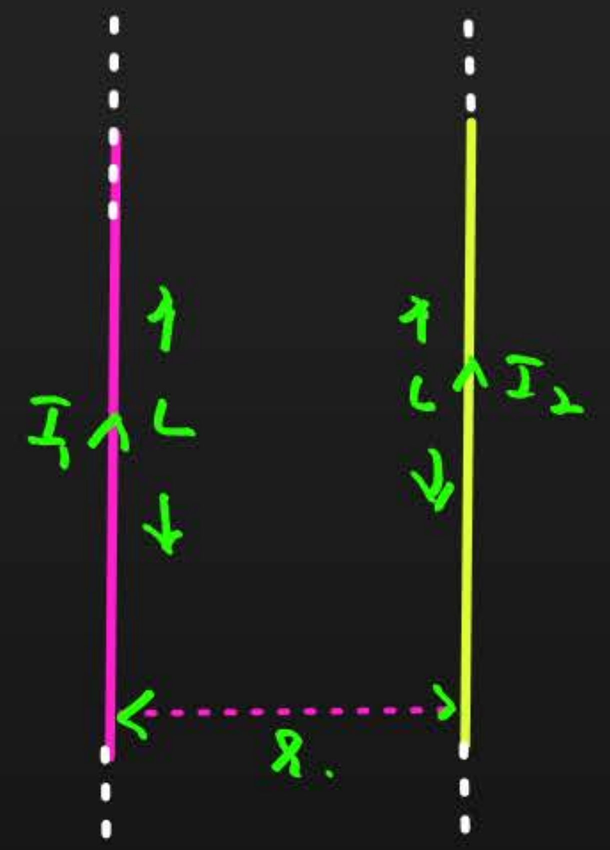
$|\vec{L} \times \vec{B}| = \sqrt{(4L)^2 + (3L)^2}$

$= \underline{\underline{5L}}$

Force between two parallel current carrying conductors/wires

When we've two infinite wires carrying current I_1 and I_2 having separation 'r'

$$\boxed{\begin{gathered}\frac{F}{L} = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r} \\ \frac{F}{L} = \frac{\mu_0}{2\pi}\frac{I_1I_2}{r}\end{gathered}}$$



Force between two parallel current carrying conductors/wires

NOTE:

1. If currents in the wires are in the same direction, then wires attracts each other.
2. If currents in the wires are in the opposite direction, then wires repels each other.
3. I ampere (1 A) is that current flowing through each of the two infinitely long parallel conductors placed in vacuum at one metre apart produces a force of 2×10^{-7} N per metre length.

Question

Two thin long parallel wires separated by a distance r from each other in vacuum carry a current of 'I' ampere in opposite directions. Then, they will

$\frac{F}{L} = \frac{\mu_0}{2\pi r} I^2$

(A) Repel each other with a force per unit length of $\mu_0 I^2/2\pi r$

(B) Attract each other with a force per unit length of $\mu_0 I^2/2\pi r$

(C) Attract each other with a force per unit length of $\mu_0 I^2/\pi r$

(D) Repel each other with a force per unit length of $\mu_0 I^2/\pi r$

Question

Two parallel wires in free space are 10 cm apart and each carries a current of 10A in the same direction. The force exerted by one wire on the other [per unit length] is

(A) $\boxed{2 \times 10^{-4}\ Nm^{-1}\ \text{[attractive]}}$

(B) $2 \times 10^{-7}\ Nm^{-1}$ [attractive]

(C) $2 \times 10^{-4}\ Nm^{-1}$ [repulsive]

(D) $2 \times 10^{-7}\ Nm^{-1}$ [repulsive]

$$\frac{F}{L} = \frac{\mu_0}{4\pi} \times \frac{2 I_1 I_2}{r}$$

$$= 10^{-7} \times \frac{2 \times \cancel{10} \times 10^{1}}{\cancel{10} \times 10^{-2}}$$

$$= \boxed{2 \times 10^{-4}\ N/m}$$

Question

Two parallel wires 1 m apart carry currents of 1 A and 3 A respectively in opposite directions. The force per unit length acting between two wires is [H.W]

(A) 6×10^{-5} Nm^{-1} repulsive

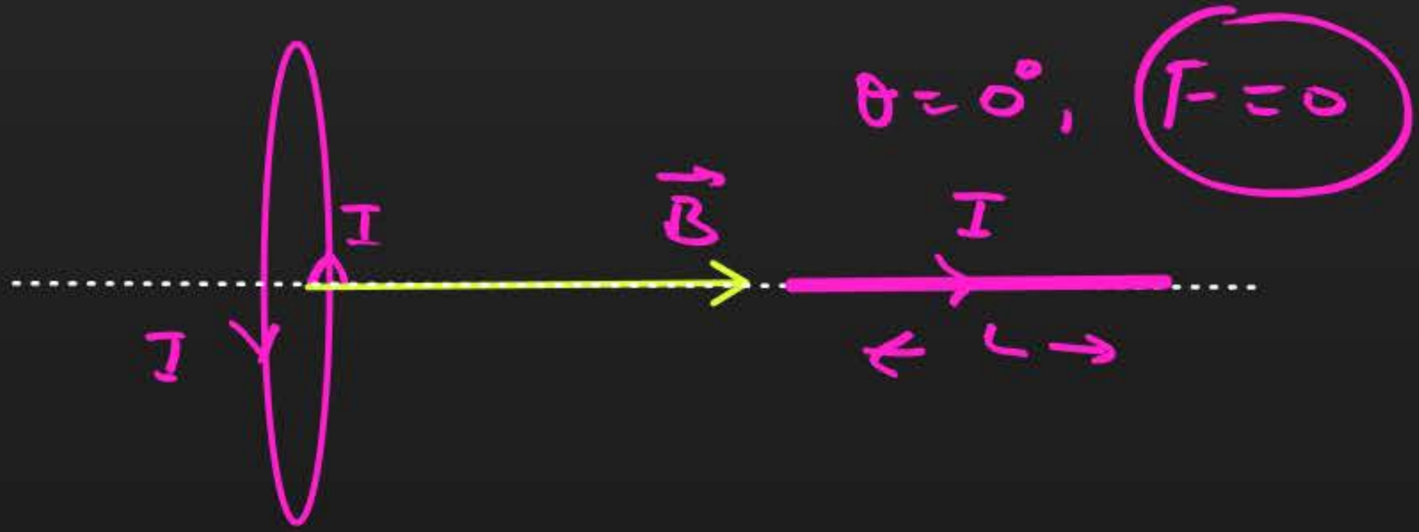
(B) 6×10^{-7} Nm^{-1} repulsive

(C) 6×10^{-5} Nm^{-1} repulsive

(D) 6×10^{-7} Nm^{-1} repulsive

Question

A straight current carrying conductor is kept along the axis of circular loop carrying current. The force exerted by the straight conductor on the loop is



(A) $\boxed{\text{zero}}$

(B) perpendicular to the plane of the loop

(C) in the plane of the loop, away from the centre

(D) in the plane of the loop, towards the centre

Question

The resultant force on the current loop *PQRS* due to a long current carrying conductor will be

$$\frac{F}{L} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r} = \left(\frac{\mu_0}{4\pi}\right)\frac{2 I_1 I_2}{r}$$

$$\Rightarrow F_{PQ} = \frac{10^{-7} \times \cancel{2} \times 20 \times 20}{\cancel{2} \times \cancel{10^{-2}}} \times 15 \times \cancel{10^{-2}}$$

$$F_{PQ} = 6000 \times 10^{-7} = 6 \times 10^{-4}\,N$$

$$F_{RS} = \frac{10^{-7} \times 2 \times 20 \times 20}{12 \times \cancel{10^{-2}}} \times 15 \times \cancel{10^{-2}}$$

$$F_{RS} = 1000 \times 10^{-7} = 1 \times 10^{-4}\,N$$

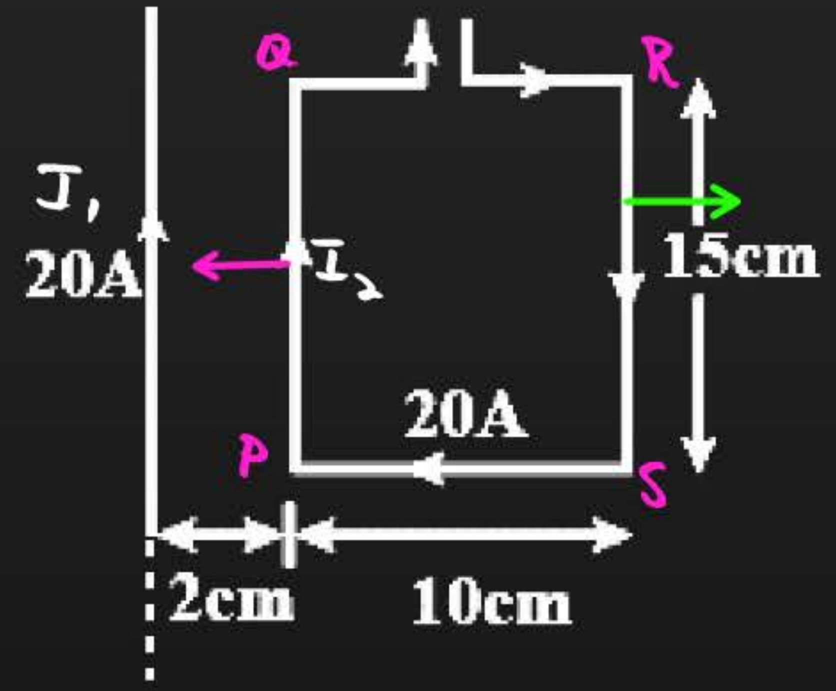
$$F = F_{PQ} - F_{RS} = (6-1) \times 10^{-4} = \boxed{5 \times 10^{-4}\,N}$$

(A) 10^{-4} N

(B) 3.6×10^{-4} N

(C) 1.8×10^{-4} N

(D) $\boxed{5 \times 10^{-4}\text{ N}}$



Question

A straight wire of length 50 cm carrying a current of 2.5A is suspended in mid-air by a uniform magnetic field of 0.5T (as shown in figure). The mass of the wire is ($g = 10\ ms^{-2}$)

(A) 250 gm

(B) 125 gm

(C) $\boxed{62.5 \text{ gm}}$

(D) 100 gm

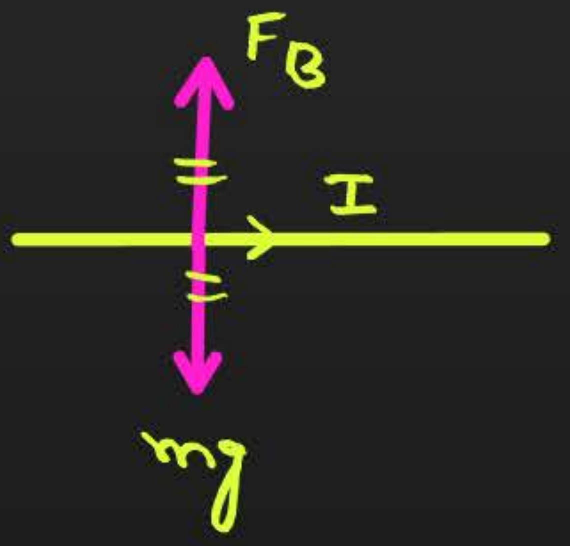
$F_B = F_W$

$BIL = mg$

$m = \frac{BIL}{g}$

$m = \frac{0.5 \times 2.5 \times 50 \times 10^{-2}}{10}$

$\boxed{m = 62.5 \text{ gm}}$



suspended ≐ Rest

Question

A straight wire of mass 200 g and length 1.5 m carries a current of 2A. It is $\boxed{\text{suspended}}$ in mid-air by a uniform horizontal magnetic field B. The magnitude of B (in tesla) is (assume $g = 9.8\ \mathrm{ms^{-2}}$)

(A) 2

(B) 1.5

(C) 0.55

(D) $\boxed{0.65}$

$F_B = F_w$

$BIL = mg$

$B = \frac{mg}{IL} = \frac{200 \times 10^{-3} \times 10}{2 \times 1.5}$

$\boxed{B = 0.66\,T}$

Question

A long straight wire of length 2 m and mass 250 g is $\boxed{\text{suspended}}$ horizontally in a uniform horizontal magnetic field of 0.7 T. The amount of current flowing through the wire will be: ($g = 9.8\ ms^{-2}$) :

(A) 2.45 A

(B) 2.25 A

(C) 2.75 A

(D) $\boxed{1.75\ A}$

$$F_B = F_w$$

$$BIL = mg$$

$$I = \frac{mg}{BL} = \frac{250 \times 10^{-3} \times 9.8}{0.7 \times 2}$$

$$\boxed{I = 1.75\ A}$$

Magnetic moment

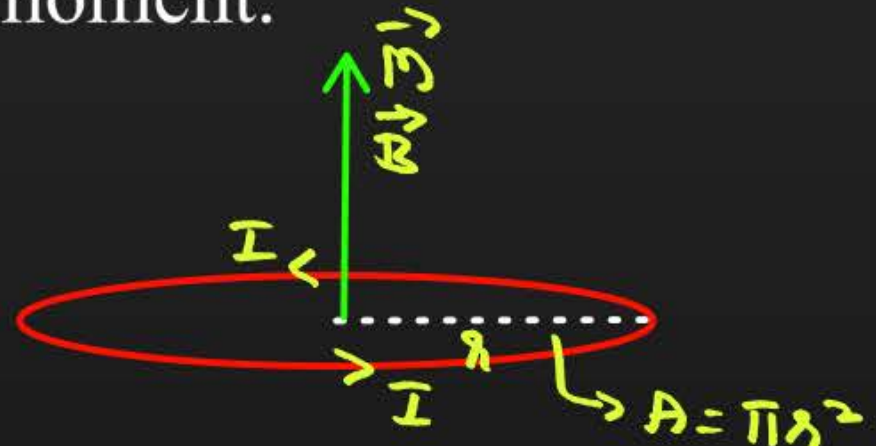
$A = (\text{side})^2 = a^2$

$A = \frac{1}{2} b \times h$

$A = l \times b$

$A = \frac{\sqrt{3}\,a^2}{4}$

When a current carrying loop has a area A and current I, then the product of area and current is called Magnetic moment.



$\vec{M} = I\vec{A} \Rightarrow A \cdot m^2$

$M = IA \Rightarrow N = 1$

$\boxed{M = NIA} \Rightarrow N > 1$

$A = \pi r^2$

Note : For direction of magnetic moment, use Right hand thumb rule

Question

A 2 amp current is flowing through two different small circular copper coils having radii ratio 1: 2. The ratio of their respective magnetic moments will be

$M = IA = i \times \pi r^2$

$M \propto r^2$

$$\boxed{\frac{M_1}{M_2} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4}}$$

(A) 1: 4

(B) 1: 2

(C) 2: 1

(D) 4: 1

Question

The magnetic dipole moment of a current loop is $\boxed{\text{independent}}$ of

$m = NIA$.

A. $\boxed{\text{magnetic field in which it is lying}}$ ✗

B. number of turns N ✓

C. area of the loop A ✓

D. current in the loop I ✓

Question

A uniform conducting wire of length $\boxed{12a}$ and resistance 'R' is wound up as a current-carrying coil in the shape of;

(i) an equilateral triangle of side 'a'

(ii) a square of side 'a'

The magnetic dipole moments of the coil in each case respectively are:

$\xleftarrow{\;12a\;} \xrightarrow{}$

↳ R

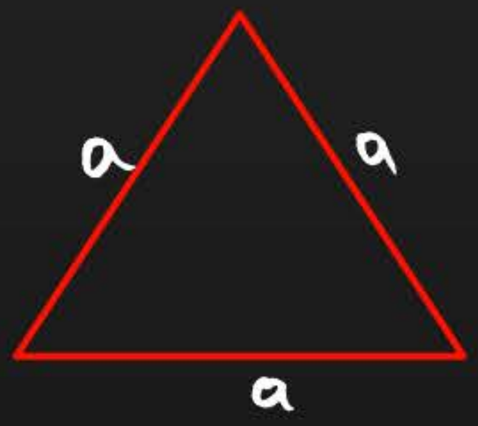
(A) $3Ia^2$ and $4Ia^2$

(B) $4Ia^2$ and $3Ia^2$

(C) $\boxed{\sqrt{3}Ia^2 \text{ and } 3Ia^2}$

(D) $3Ia^2$ and Ia^2

(i)



$N = \frac{12a}{3a}$

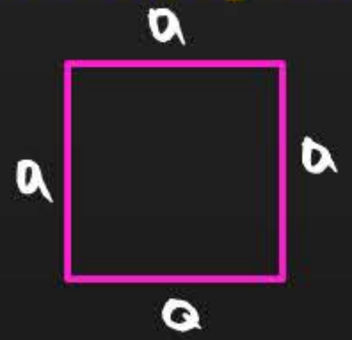
$\boxed{N = 4}$

$m = NIA$

$m = 4I \times \frac{\sqrt{3}a^2}{4}$

$\boxed{m = \sqrt{3}a^2 I}$

(ii)



$N = \frac{12a}{4a}$

$\boxed{N = 3}$

$A = l \times b$

$\boxed{A = a^2}$

$M = NIA$

$\boxed{M = 3Ia^2}$

Question

A wire of length L meters carrying a current of I ampere is bent in the form of a circle. What is its magnetic moment?

(A) $\frac{IL^2}{4}\ A-m^2$

(B) $\frac{I\times\pi L^2}{4}\ A-m^2$

(C) $\frac{2IL^2}{\pi}A - m^2$

(D) $\boxed{\frac{IL^2}{4\pi}\ A-m^2}$

$M = NIA$

$M = (1)I\pi R^2$

$M = I\pi R^2$

$M = I\cancel{\pi}\times\frac{L^2}{4\pi^{\cancel{2}}}$

$\boxed{M = \frac{IL^2}{4\pi}}$

$L = 2\pi R$

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

Question

H.W

If a charged particle (charge q) is moving in a circle of radius R at a uniform speed v, then the value of its associated magnetic moment μ will be:

A. $\frac{qvR}{2}$

B. qvR^2

C. $\frac{qvR^2}{2}$

D. qvR

Thank

You