34. Magnetic Field

Short Answer

Answer.1

Formula used:

The magnetic force is given by

$F = qvBsin\theta$

Where F is magnetic force

q is electric charge $=1.6 \times 10^{-19} C$

v is velocity

Angle between magnetic force and velocity component

A Charge particle is moving near a conducting wire. And also a frame is moving in the same direction which the charge is moving. Seeing from the frame it is known that the charge is at rest. So velocity of the charge particles will be zero. Thus magnetic force will be zero.

When the charge is at rest the current will be zero. We don't know either it is a positive or negative charge. Let us consider it is a negative charge. Seeing from the frame negative charge is at rest. But there is a positive charge flow. Due to this magnetic field will exists. So the magnetic field should not be zero.

Answer.2

Formula used:

$F = ma$

Where F is magnetic force

m is mass

a is acceleration

Here the force (magnetic force) which is acting on the charged particle will try to accelerate it. If the charged particle is in the direction perpendicular to the magnetic field, then the particle will move in a circular path. In that circular path the direction of the charged particle will change.

Formula used: Magnetic force is given by

$$F = qvBsin\Theta$$

Where F is magnetic force

q is electric charge =$1.6 \times 10^{-19}C$

v is velocity

Angle between magnetic force and velocity component

Force is always act perpendicular to the direction of velocity of a charged particle. So it can’t change the magnitude of the velocity of the charged particle. Velocity, magnetic field and force are perpendicular to each other. So it can change the direction of the velocity of a charged particle. So our answer is Yes, a charged particle can be accelerated by a magnetic filed but its speed can’t be increase.

Answer.3

Effect of the magnetic force on a current loop is totally based on the uniformity of the magnetic field. If the field is non uniform, then current loop will not experience a force. So magnetic force on the loop will be zero. If the field is uniform, then the force experienced on the current loop either zero or non zero.

Answer.4

Formula used: The magnetic force is given by

$$F = ILBsin\theta$$

Where F is magnetic force

I is current

L is length of the wire

B is magnetic field

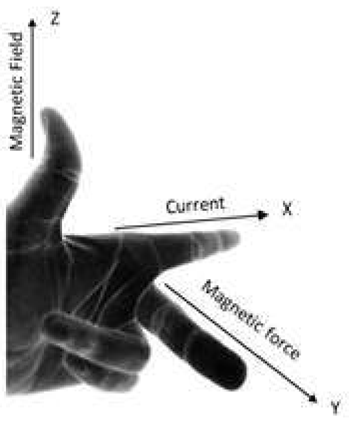
If the electron is in motion definitely there will be a magnetic force on it. Electrons are present in conducting wire. But current flowing in the wire is zero. When this wire is placed in a magnetic field the electrons will come to motion but the motion will be random. So we can neglect the effect of force on each electron. So total magnetic force acting on the wire will be zero.

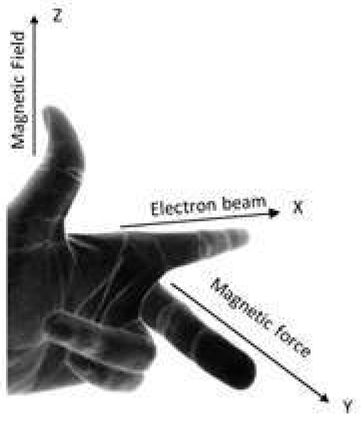
Answer.5

Magnetic field is uniform(assumption). If the charged particle is perpendicular to the magnetic field the particle will exhibits a circular trajectory. Let us consider that the charged particle is coming into the field from outside along the positive y-axis. And Let us take the field is in x-axis. X-axis is perpendicular to the y-axis. So magnetic field will be perpendicular to the changed particle. Then the particle will make a circular path.

Answer.6

If the force is acting in the y-axis then the electron beam will be deflected from positive x-axis along y-axis. The electrons motion is in positive x-axis and then current will be along negative x-axis. And the force is acting along the y-axis. According to Fleming's left hand rule the magnetic filed will be in z-axis. So we can conclude that the field is parallel to the z-axis.





Answer.7

Yes

Formula used: The net torque of a loop is given by

$\tau = iABsin\Theta$

Where τ is torque

i is current

A is area vector

B is magnetic field

θ is the angle between the area vector and magnetic field

When θ=0, $\tau = iABsin(0)\ \sin(0) = 0$

$\tau = 0$

When θ=180,

$\tau = iABsin(180)\ \sin(180) = 0$

$\tau = 0$

If θ is zero or 180° (integral multiple of π) then torque will be zero. So coil will stop its rotation. θ=nπ represents that the magnetic field is in parallel with area vector. So the loop can stay in a uniform magnetic field without rotation.

Answer.8

Mostly positive charge on the wire is because of protons which are containing nucleus. When the protons are not in motion the force acting on them will be zero. So charge will be zero. But there is a negative charge too. Negative charge is due to electrons.

Formula used: $F = qvBsin\Theta$

Where F is magnetic force

q is electric charge =$1.6 \times 10^{-19}C$

v is velocity

B is magnetic field

Θ is angle between magnetic field and a charge

So when the electrons are in motion the wire will carry current. Magnetic force will act on the wire. That's why magnetic field exerts a force on the wire.

Answer.9

Formula used: Potential energy is given by

$U = -mBcos\theta$

Where m is magnetic moment

B is magnetic field

Let is take B=0.1T, m = 7.85×10^{-11} A m �

If θ is zero, then

$U = -7.85 \times 10^{-11} \times 0.1 \times \cos(0)$

$= -7.85 \times 10^{-11} \times 0.1 \times 1$

$U = -7.85 \times 10^{-12} J$

If θ=180 then

$U = -7.85 \times 10^{-11} \times 0.1 \times \cos(180)$

$= -7.85 \times 10^{-11} \times 0.1 \times (-1)$

$U = +7.85 \times 10^{-12} J$

If energy is minimum, then system will be more stable. If energy is increase, then the system will loose it's stability. For θ=0 the energy is minimum and the equilibrium will stable. For θ=180 the energy is maximum and equilibrium will unstable.

Answer.10

Formula used: Magnetic force is by

$F = qvB$

Where F is magnetic force

q is electric charge =$1.6 \times 10^{-19}C$

v is velocity

B is magnetic field

$$B = \frac{F}{qv}$$

One of the unit that magnetic force measured is Weber/m �.

N m² is newton meter²

C is Coulomb

m/s is meter per second

V/m is volt per meter

$$\frac{weber}{m^2} = \frac{N\,m^2}{C\frac{m}{s}}$$

$$weber = \frac{N}{C} m\,s$$

$$= \frac{V}{m} m\,s$$

(We know that $\frac{N}{C} = \frac{V}{m}$)

$$weber = V\,s$$

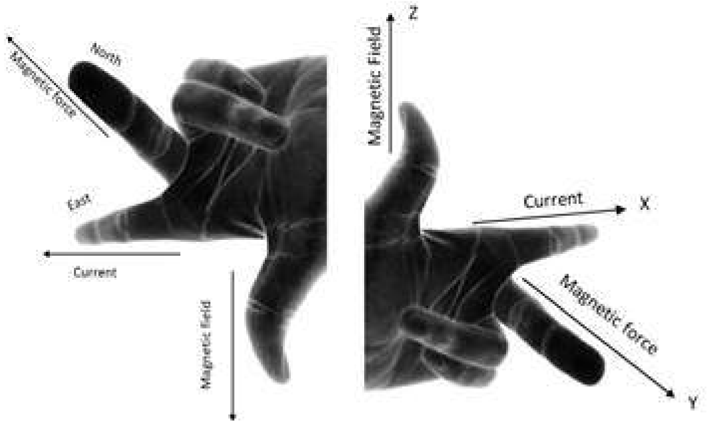
$$1\,weber = 1 volt\,second$$

Thus weber and the volt second are same.

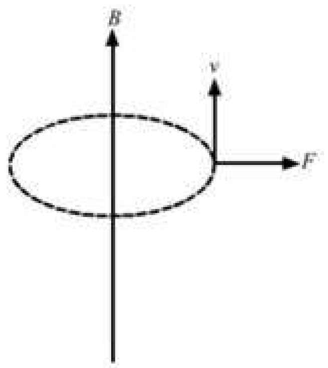
Objective I

Answer.1

The positive charge is moving towards east. So the current is in the direction of east. It is deflected towards north. So the magnetic force is acting in the north direction. Motion is in east and force is acting in north. Magnetic field is always perpendicular to the both force and velocity of a particle. According to left hand Fleming's rule the magnetic force will be in downward direction.



Answer.2



Force is depending upon the direction of the whirl and also charge of a particle. Which type of charge particle it is not given. And We don’t know which direction the whirl is rotating. Based on these things we can say that force(tension) may increase or decrease. The magnetic field is in vertical direction and also we don’t know it is upward or downward. According to Flemings left hand rule the force will act either inward or outward. So option D is correct.

Answer.3

Here the particle is experiencing a maximum magnetic filed and projected with a same velocity. There are no variations in the both. So both magnetic field and velocity are constant over here.

Formula used: The magnetic force is given by

$F = qvBsin\Theta$

Where F is magnetic force

q is electric charge $=1.6 \times 10^{-19}C$

v is velocity

Θ is angle between magnetic field and a charge

In the above equation magnetic field and velocity are constant. So force will depend on the charge. In the option given Li^{++} has the highest charge. After Li^{++}, He^{+} has highest charge. So Li^{++} will experience a maximum magnetic field.

Answer.4

In the options given election has a lowest charge.

Electron < Proton < He^{+} <Li^{++}

Formula used: The magnetic force is given by

$F = qvB$

Where F is magnetic force

q is electric charge $=1.6 \times 10^{-19}C$

v is velocity

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

m is mass of the charge particle

v is velocity

r is radius of the projectile motion

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

$$mv^2 = rqvB$$

$$mv = rqB$$

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

Here v and B are constants and q is same for all the charge particles. r is proportional to m. If radius is small radius will become small. Electron exhibits light weight among the all other charge particles. Because of light weight it will creates a circle with a small radius when it is projected. So option A is correct.

Answer.5

Formula used: Time period of revolution of a particle is given by

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

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

In the above options Electron is light weight particle and Li^+ has highest weight compared to other particles in the options given. Frequency f is inversely proportional to mass m. So Li^+ will have minimum frequency of revolution. So option D is correct.

Answer.6

Given a circular loop area =1cm �

Current =10A

Magnetic field strength =0.1 T

Given loop is circular. On each and every point of this circular loop there exists two forces. It will happen in case of circular loop only. The forces are equal but their magnitudes are opposite. Because of the opposite magnitudes they cancel each other. Then net force will be equal to zero. If we place any loop in magnetic field it definitely conducts current. In case of circular loop, the torque due to magnetic field on loop will be zero.

Answer.7

Formula used: Magnetic force is given by

$F = qvB$

Where F is magnetic force

q is electric charge =$1.6 \times 10^{-19} C$

v is velocity

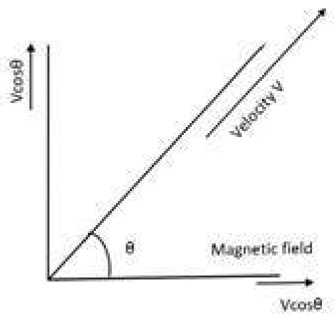
Force on the electron is $F = -qvB$

Force on a the proton is $F = +qvB$

The magnitudes of force on proton and electron are different but magnetic force acting on the both are same. The force acting on the proton is in positive in direction and the force acting on the electron is in negative direction. Even same force is acting on them but because of different directions they got deviated by different angles and then they will separate. So option C is correct.

Answer.8

Given that velocity of a particle is making an acute angle with the magnetic field. Velocity of a particle is resolves into two components. Magnetic field always change the direction of the velocity. One component is perpendicular to the magnetic field that is Vsinθ and another component is parallel to the magnetic field that is Vcosθ. Vertical component of a velocity is perpendicular to the magnetic field. Then force will act on the charged particle. Because of the vertical force(Vsinθ), the particle will make a circular path. Because of the two components of the velocity the particle will move in a helical path. This path will maintain the uniformity. So option C is correct.



Answer.9

The region has a uniform magnetic field and an electric field.

Formula used: Lorentz's force is given by

$$F = qE + qvB$$

Where F is Lorentz's force

q is electric charge $= 1.6 \times 10^{-19} C$

E is electric field strength

B is magnetic field strength

V is velocity

The electric field will accelerate the particle to move in the direction of the magnetic field. Magnetic field will always change the direction of velocity of a particle. Because of these the particle will move in a helix path with non-uniformity. So option D is correct.

Answer.10

Current is entering into the circular wire. According to right hand thumb rule the magnetic field will be in axis of the circular wire. It is given that the charge particle is moving along the axis of the wire.

Formula used: Magnetic force is given by the formula

$$F = qvBsin\Theta$$

Where F is magnetic force

q is electric charge =$1.6 \times 10^{-19}C$

v is velocity

B is magnetic filed

Θ is angle between magnetic field and a charge

θ will be zero because the angle between the magnetic field and charge particle is 0° or 180°.

$F = qvBsin(0°)$

$F = 0$ [$\sin(0°) = 0$]

When the particle is moving along the axis of a wire the magnetic force acting on it will be zero. So option D is correct.

Objective II

Answer.1

Formula used: The magnetic force is given by

$F = qvBsin\Theta$

Where F is magnetic force

q is electric charge =$1.6 \times 10^{-19}C$

v is velocity

B is magnetic filed

Θ is angle between magnetic field and charge

Here the particle is rest so velocity is zero. Then magnetic force is zero. But we don't know whether the magnetic field is zero or not as the force exerted on a particle under the influence of magnetic field depends on the orientation of the particle with respect to the magnetic field. And the electromagnetic force on particle is also not present. Magnetic field may not be zero. So electric field must be zero. So option A and D are correct.

Answer.2

The electromagnetic force is acting on the charge particle.

Formula used: 1. Electric force is given by

$F = qE$

Where F is electric force

q is electric charge $= 1.6 \times 10^{-19} C$

E is electric field

From the above formula we can say that electric field should not be zero. Because electric force is acting on the particle. And the particle is rest, so velocity of the charged particle is zero.

2. The magnetic force is given by

$F = qvBsin\Theta$

Where F is magnetic force

q is electric charge $=1.6 \times 10^{-19} C$

v is velocity

B is magnetic filed

Θ is angle between magnetic field and charge

From the above equation we can say that magnetic fore will become zero. But we don't know whether the magnetic filed is zero or not. We cannot make the statement about magnetic field. So magnetic field may or may not be zero. Option A and D are correct.

Answer.3

The particle is projected in gravity-free room. If no force is acting on the charge particle means magnetic and electric force is not acting on the particle, then the particle will not deflect. If any one the force is acting on the charged particle, then it gets deflects. And also if both the force is acting on it then also the particle will deflect. So both electric and magnetic field cannot be zero. And also they can be non zero. So options C an D are correct.

Answer.4

The particle is in a gravity free space. If no force is acting on the particle, the velocity will be constant. If both the force electric and magnetic forces acting on the particle is same then both forces get canceled and force acting on the particle will be zero. And if electric force is zero and magnetic force is non zero, in this case if the magnetic field is in the direction of velocity of a particle then the magnetic force acting on it will become zero. Option A, B and D are correct.

Answer.5

charged particle is moving in a circle. If Electric force is acting on the particle, the speed of the particle will increase. Because of this the particle cannot be move in a circle. In case of magnetic field, it will only change the direction of the velocity of a particle. It can’t change speed of the charged particle. So magnetic field cannot be zero. So option b is correct.

Answer.6

Let us consider the electric field is parallel to the magnetic field. In this case the charges particle will accelerate and also it will move in same direction. Then it cannot deflect. If electric field is not parallel to magnetic field means that may be in perpendicular to each other. In this case magnetic field, electric field and velocity of a particle will be in perpendicular to each other. If both forces are equal, then force acting on the particle will be zero. Then particle will not deflect. So option A and B are correct. Option C and D are not valid conditions.

Answer.7

The charged particle must not accelerate in the region. If both the field are counter balance, then the particle won't accelerate. If Electric force is acting along the direction of magnetic force and both are same then the particle will not effect by these fields. So particle won't accelerate. And if the electric field is parallel to the velocity of a particle then it will definitely accelerate. So electric field must be perpendicular to the direction of the velocity. So options A and B are correct.

Answer.8

Formula used: Radius of the orbit of a particle is given by

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

Where r is radius of the orbit

m is mass

v is velocity

q is electric charge

B is electric field

Radius r is inversely proportional to the charge. So singly ionized charge will have a double radius than doubly ionized charge. And both the charges are projected from the same place. So they will touch each other at the beginning. So options B and D are correct.

Answer.9

Electron is moving along the positive x-axis now. If the particle is moving in the direction of magnetic field, then the field does not change the direction of velocity of the electron. If we apply the magnetic field in the y-axis it can reverse the direction of velocity of the electron. And also field in z-axis also can reverse the direction of the electron. So option A and B are correct.

Answer.10

Formula used:

Electric force is given by $F = qE$

Where F is electric force

q is electric charge $= 1.6 \times 10^{-19} C$

E is electric field

Magnetic force is given by $F = qv$

Where F is magnetic force

q is electric charge $= 1.6 \times 10^{-19} C$

v is velocity

B is magnetic force

From the above formulas $E = vB$ and $B = \frac{E}{v}$

From the dimensional analysis we can write equations as

i. $B_y' = B_y + \frac{vE_z}{c^2}$

ii. $E'_y = E_y + vB_z$

So only options A and D are correct.

Exercises

Answer.1

Given -

Speed of the alpha particle in upward direction,

$v = 3 \times 10^4$ km/s

since 1Km = 1000m

$\Rightarrow v = 3 \times 10^7$ m/s

Magnetic field, $B = 1.0$ T

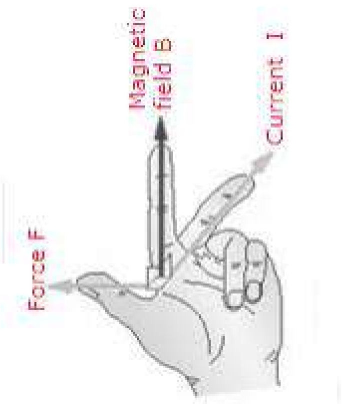
Charge on the alpha particle is given as ,

$q = 2 \times e$

where e is the charge of an electron.

$\Rightarrow q = 2 \times 1.6 \times 10^{-19}$ C,

We need to calculate the magnetic force that acts on the α-particl



The direction of magnetic force can be found using Fleming's left-hand rule.

The direction of the magnetic field is from south to north.

We know, Lorentz force F is given by -

$F = q \times v \times B\ sin\theta,$

where,

q = charge

v = velocity of the charge

B=magnetic field

and

θ= angle between V and B

Now, magnetic force acting on the α -particle,

$F = qvB\, sin\theta,$

Substituting the values

$F = qvB\, sin 90°$

$= 2 \times 1.6 \times 10^{-19} \times 3 \times 10^{7} \times 1$

$= 9.6 \times 10^{-12}$ N

Answer.2

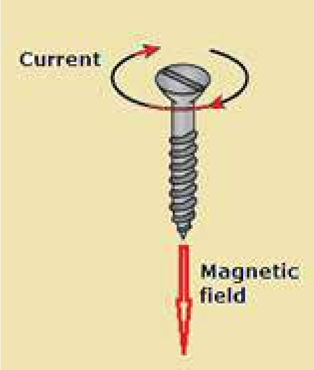
Given-The kinetic energy of the electron when projected towards horizontal direction,

$K.E$ = 10 keV = 1.6×10^{-15} J

Magnetic field, $B = 1 \times 10^{-7}$ T

Charge on an electron =1.60×10^{-19}

mass of an electron = 9.1×10^{-31} kilograms



(a) The direction electron deflection can be found by the right-hand screw rule.

Given the direction of magnetic field is vertically upward.

So, the electron will be deflected towards left.

(b) Kinetic energy-

$K.E. = \frac{1}{2}mv^2$

Where

m is the mass of the electron

v is the velocity of the electron

Solving for v, we get

$\Rightarrow \ \mathbf{v} \ = \sqrt{\frac{K.E. \times 2}{m}} \ (1)$

We know, Lorentz force F is given by -

$F \ = \ qvB \ sin\theta \ (2)$

where,

q = charge

v = velocity of the charge

B=magnetic field

and

θ= angle between V and B

And Newton's second law of motion

$F \ = \ m \times a \ (3)$

where m = mass

a= acceleration

we know

$$velocity = \frac{distance}{time}$$

⇒

$$time = \frac{distance}{velocity}$$

From (1) and (2) -

$$a = \frac{q \times v \times B}{m} \ (4)$$

Applying 2nd equation of motion

$$s = ut + \frac{1}{2}at^2 \ (5)$$

where,

a= acceleration

u = initial velocity

t= Time taken to cross the magnetic field

Since, the initial velocity is zero,

from (1),(2) and (3)

$$s = \frac{1}{2}at^2$$

$$s = \frac{1}{2} \times \frac{q \times v \times B}{m} \times \left(\frac{distance}{velocity}\right)^2$$

substituting the values -

$$\Rightarrow s = \frac{1}{2} \times \frac{q \times v \times B}{m} \times t^2$$

$$= \frac{1}{2} \times \frac{q \times v \times B}{m} \times \frac{x^{\ 2}}{v^2}$$

$$= \frac{1}{2} \times \frac{q \times B}{m} \times \frac{x^2}{v}$$

From (1)

$$\Rightarrow s = \frac{1}{2} \times \frac{q \times B}{m} \times \frac{x^2}{\sqrt{\frac{K.E. \times 2}{m}}}$$

substituting the values-

$$\Rightarrow s = \frac{1}{2} \times \frac{1.6 \times 10^{-19} \times 1 \times 10^{-7}}{9.1 \times 10^{-31}} \times \frac{1^2}{\sqrt{\frac{1.6 \times 10^{-15} . \times 2}{9.1 \times 10^{-31}}}}$$

$$\Rightarrow s = 1.5 \times 10^{-2}\ cm$$

Answer.3

Given -

$$Force, F = (4.0\,\hat{\imath} + 3.0\,\hat{\jmath}) \times 10 - 10N$$

Magnetic field, $B = 4.0 \times 10^{-3}\ \hat{k}$ T

Electric charge on the particle, $q = 1 \times 10^{-9}$ C

Also given that the charge is going in the X-Y plane,

Therefore, the x-component of force, $F_x = 4 \times 10^{-10}$ N

and the y-component of force, $F_y = 3 \times 10^{-10}$ N

We know, Lorentz force F is given by -

$$F = qvB\ sin\theta$$

where,

q = charge

v = velocity of the charge

B=magnetic field

and

θ= angle between V and B

$$\Rightarrow v = \frac{F}{q \times B\ sin\theta}\ (1)$$

On putting the respective values, we get

Let's take motion along x-axis-

From (1)

$$v_x = \frac{4 \times 10^{-10}}{1 \times 10^{-9} \times 4.0 \times 10^{-3}}$$

$$= 100\ m/s$$

Similarly, motion along y-axis

from (1)

$$v_y = \frac{3 \times 10^{-10}}{1 \times 10^{-9} \times 4.0 \times 10^{-3}}$$

$$= 75\ m/s$$

Hence. velocity of the particle, $= -75i + 100j$ m/s

Answer.4

Given-

Magnetic field, $B = (7.0\hat{\imath} - 3.0\hat{\jmath}) \times 10^{-3}\ T$

Acceleration of the particle, $a = (\alpha\hat{\imath} + 7\hat{\jmath}) \times 10^{-6}\ m/s^2$

Let denoted the unidentified number as α

Since, magnetic force always acts perpendicular to the motion of the particle, so, B and a are perpendicular to each other.

So, the dot product of the two quantities should be zero.

That is,

$$B.a = 0$$

$$\Rightarrow (\alpha\hat{\imath} + 7\hat{\jmath}) \times 10^{-6} . (7.0\hat{\imath} - 3.0\hat{\jmath}) \times 10^{-3} = 0$$

$$\Rightarrow 7\alpha \times 10^{-3} \times 10^{-6} - 3 \times 10^{-3} \times 7 \times 10^{-6} = 0$$

$\Rightarrow\ 7\alpha - 21 = 0$

$$\alpha = \frac{21}{7} = 3$$

Hence acceleration of the particle is $(3\hat{i} + 7\hat{j}) \times 10^{-6}$ m/s^2.

Answer.5

Given-

Mass of the bullet, *m* = 10g = 10^{-3} Kg

Charge of the bullet, *q* = 4.00 μC =10^{-6} C

Speed of the bullet in horizontal direction, *v* = 270 m/s

Vertical magnetic field, *B* = 500 μT = 500× 10^{-6} T

Distance travelled by the bullet, *d* = 100 m

Magnetic force,

We know, Lorentz force F is given by -

$$F = qvB\ sin\theta\ (1)$$

where,

q = charge

v = velocity of the charge

B=magnetic field

and

θ= angle between V and B

Also,

And Newton's second law of motion

$$F = m \times a\ (3)$$

where m = mass

a= acceleration

Using equation (1) –

$$m \times a = qvB\ sin\theta$$

$$\Rightarrow a = \frac{qvB}{m}$$

$$= \frac{4.00 \times 10^{-6} \times 270 \times 500 \times 10^{-6} 10}{10^{-3}}$$

we know

$$velocity = \frac{distance}{time}$$

$$\Rightarrow$$

$$time = \frac{distance}{velocity}$$

Substituting the values, time taken by the bullet to travel 100 m horizontally,

$$t = \frac{d}{v} = \frac{100}{270}\ s$$

Applying 2nd equation of motion

$$s = ut + \frac{1}{2}at^2 \ (5)$$

where,

a= acceleration

u = initial velocity

t= Time taken to cross the magnetic field

Since, the initial velocity is zero,

from (1),(2) and (3)

$$s = \frac{1}{2}at^2$$

Now, the deflection caused by the magnetic field in this time

interval,

$$s = \frac{1}{2}at^2$$

$$= \frac{1}{2} \times 4.00 \times 10^{-6} \times 270 \times 500 \times 10^{-6} 10 \times 10 - 3 \times (\frac{100}{270})^{2}$$

$$= 3.7 \times 10^{-6}\, m.$$

Answer.6

Given-

Proton is released from rest in a room, it starts with an initial acceleration a_0 towards west

Now, we know coulomb's force F given by –

$$F = qE$$

where

q = charge

E= electric field

Also,

And Newton's second law of motion

$$F = m \times a \ (1)$$

Where

m = mass

a= acceleration

$$\Rightarrow F = ma_0 \ (2)$$

From (1) and (2)

$$qE = ma_0$$

Electric field,

$$\Rightarrow E = \frac{ma_0}{q}$$

which acts towards west.

We know, Lorentz force F is given by -

$$F = qvB\, sin\theta \ (1)$$

where,

q = charge

v = velocity of the charge

B=magnetic field

and

and θ = the angle between B and l

Now, given that when the proton is projected towards north with a speed v_0, it moves with an initial acceleration $3a_0$ towards west.

$$F = q \times v_0 \times B\, sin\theta$$

$$\Rightarrow B = \frac{F}{q \times v_0}$$

An electric force will act on the proton in the west direction, which produces an acceleration a_0 on the proton.

Initially the proton was moving with velocity v, so a magnetic force was also acting on the proton.

So, magnetic force acting will be the only cause behind the change in acceleration of the proton

Change in acceleration towards west due to the magnetic force acting on it is -

$\Delta a = 3a_0 - a_0 = 2a_0$

So from (2), the force will become -

$$F = m \times 2 \times a_0$$

Hence, required magnetic field

$$B = 2m \times a_0 \times q \times v_0$$

Answer.7

Given-Length of wire, l = 10 cm

Electric current passing through the wire, I = 10 A

Magnetic field, B = 0.1 T

Angle between the wire and magnetic field, θ = 53°

Magnetic Force on a Current carrying wire is given by

$$\boldsymbol{F = BIL \sin\theta}$$

where,

B= magnetic field

I = current

L = length of the wire

and θ = the angle between B and l

hence, magnetic force,

$$\boldsymbol{F = BIL\, sin\, \theta}$$

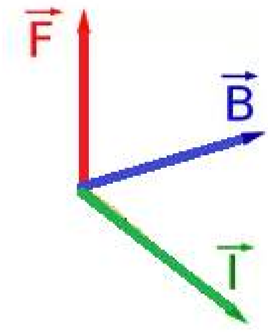
$$\boldsymbol{F = BIL\, sin 53°}$$

$$\boldsymbol{\Rightarrow F = 10 \times 10 \times 10^{-2} \times 0.1 \times 0.798}$$

$$\boldsymbol{\Rightarrow F = 0.0798 \approx 0.08\, N}$$

The direction of force can be found using Fleming's left-hand rule –

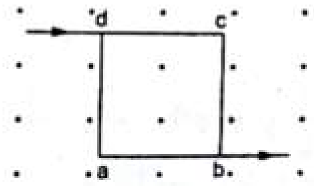
which states that –



whenever a current carrying conductor is placed inside a magnetic field, a force acts on the conductor, in a direction perpendicular to both the directions of the current and the magnetic field

Therefore, the direction of magnetic force is perpendicular to the wire as well as the magnetic field.

A current of 2A enters at the corner d of a square frame abcd of side 20 cm and leaves at the opposite corner b. A magnetic field B = 0.1 T exists in the space in a direction perpendicular to the plane of the frame as shown in figure. Find the magnitude and direction of the magnetic force on the four sides of the frame.



Answer.8

Given-

square of side, l = 20 cm

Electric current passing through the wire, I = 2 A

Magnetic field, B = 0.1 T

The direction of magnetic field is perpendicular to the plane of the frame, coming out of the plane.

Given in the question, that current enters at the corner *d* of the square frame and leaves at the opposite corner *b.*

Hence, angle between the frame and magnetic field, θ = 90°

Now, we know-

Magnetic Force on a Current carrying wire is given by

$$F = BIL\sin\theta$$

where,

B= magnetic field

I = current

L = length of the wire

and θ = the angle between B and l

Hence, magnetic force,

$$F = BIL\sin\theta$$

For wire along the sides da and cb,

$$F = BIL\sin\theta$$

$$F = B \times I \times L\ sin\ 90°$$

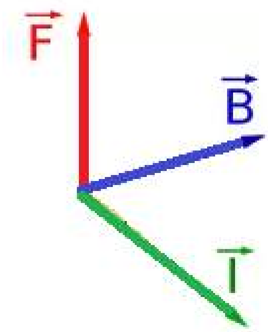
$= 22 \times 20 \times 10^{-2} \times 0.1$

$= 0.02\, N$

The direction of force can be found using Fleming's left-hand

rule.

which states that –



whenever a current carrying conductor is placed inside a magnetic field, a force acts on the conductor, in a direction perpendicular to both the directions of the current and the magnetic field

Thus, the direction of magnetic force will be towards the left.

now, for wires along sides, *dc* and *ab*,

$F = \hat{B} I \hat{l} \sin\theta$

$F = B \times I \times L\ sin\ 90°$

$= 22 \times 20 \times 10^{-2} \times 0.1$

$= 0.02\, N$

Again, here the direction of force can be found using Fleming's left-hand rule.

Thus, the direction of magnetic force will be downwards.

Answer.9

Given-

Magnetic field, (B) = 1 T

Radius of the cylindrical region, r = 4.0 cm

Electric current through the wire, I = 2 A

The wire is placed perpendicular the direction of magnetic field

So, angle between wire and magnetic field, θ = 90

Magnetic Force on a Current carrying wire is given by

$$Force, F = BIL \sin \theta$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between B and l

Magnetic force,

$$Force, F = BIL \sin \theta$$

$$F = B \times I \times L \; sin 90^{\circ}$$

Here, length l which is under the base of the cylinder is of radius 2r

$$l = 2r = 8 \times 10^{-2} m$$

$$F = B \times 2r \times I \times \; sin 90^{c}$$

$$= 2.0 \, A \times 8 \times 10^{-2} m \times 1.0T \times 1$$

$$= 0.16N$$

Answer.10

Given-

length of wire *l* cm

Electric current through the wire = $\boldsymbol{I\ \hat{\imath}}$ A

Magnetic field in vector form is given as –

$$\boldsymbol{B = B_0(\hat{\imath} + \hat{\jmath} + \hat{k})T}.$$

Given in the question, that the current is passing along the *X*-axis.

Magnetic Force on a Current carrying wire is given by

$$\boldsymbol{F\ =\ BIL\sin\theta}$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between *B* and *l*

Magnetic force-

$$\boldsymbol{F\ =\ \hat{B}I\hat{l}\sin\theta}$$

Substituting the values –

$$\boldsymbol{F = B_0\big((\hat{\imath} + \hat{\jmath} + \hat{k})\big) \times I\hat{\imath} \times l\ sin\ \theta}$$

since current I is along x- axis, from vector laws, cross product of same vectors is zero –

$$\boldsymbol{ie\ ,\hat{\imath} \times \hat{\imath} = 0}$$

$$\boldsymbol{\Rightarrow F = B_0(\hat{\imath} + \hat{\jmath} + \hat{k}) \times I\hat{\imath}\ \times l}$$

$$\boldsymbol{\Rightarrow F = B_0(\hat{\imath} + \hat{\jmath} + \hat{k}) \times I\hat{\imath}\ \times l}$$

$$\boldsymbol{= B_0Il\hat{k} -\ B_0Il\hat{\jmath}}$$

The magnitude of the magnetic force,

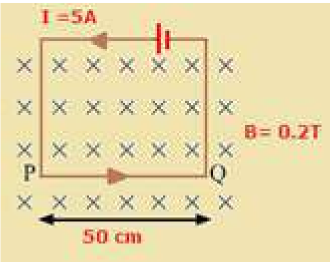
$$\boldsymbol{|\ \vec{F}\ |\ =\ \sqrt{(B_0Il)^2 +\ (B_0Il)^2}}$$

$$\boldsymbol{F =\ \sqrt{2}\ B_0Il}$$

Answer.11

Given-Length of the wire PQ inside the magnetic field, l = 50 cmElectric current , I = 5 AMagnetic field, B = 0.2 T

From fig since magnetic field is displayed as “cross”, we can say that the direction of magnetic field is perpendicular to the plane and it is going into the plane.



Angle between the plane of the wire and the magnetic field,

$\theta = 90^0$

$$F = BIL\sin\theta$$

where,

B= magnetic field

I = current

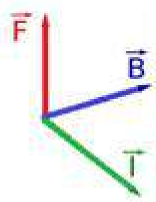
L = length of the wire

and θ = the angle between B and L

$$F = B \times I \times L \sin 90^0$$

$$= 5 \times 50 \times 10^{-2} \times 0.2 \times 1$$

$$= 0.50\ N$$



The direction of force can be found using Fleming’s left-hand rule.

whenever a current carrying conductor is placed inside a magnetic field, a force acts on the conductor, in a direction perpendicular to both the directions of the current and the magnetic field

Thus, the direction of magnetic force is upwards in the plane of the paper.

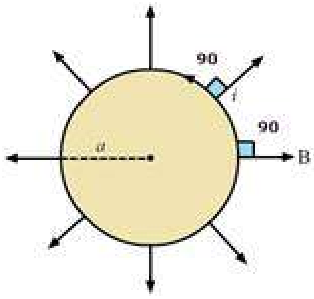
Answer.12

Given –

circular loop of radius = a

So, the length of the loop is its circumference ,

$$l = 2 \times \pi \times a \ (1)$$



Electric current through the loop = i

Given that the loop is placed in a two-dimensional magnetic field.

Also the centre of the loop coincides with the centre of the field.

The strength of the magnetic field at the periphery of the loop is B

Hence, the direction of the magnetic is radially outwards.

Here, the angle between the length of the loop and the magnetic field, $\theta = 90^0$

$$F = BIL\sin\theta$$

where,

B= magnetic field

I = current

l = length of the wire

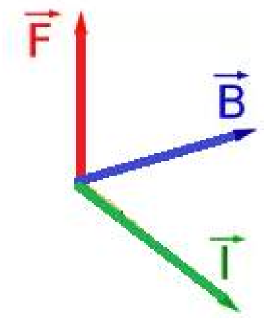
and θ = the angle between B and l

$$F = BIL\sin\theta$$

$$F = B \times I \times (2 \times \pi \times a)\ sin\ 90^0$$

$$F = B \times I \times (2 \times \pi \times a)$$

The direction of force can be found using Fleming's left-hand rule -



whenever a current carrying conductor is placed inside a magnetic field, a force acts on the conductor, in a direction perpendicular to both the directions of the current and the magnetic field

Thus, the direction of magnetic force lies perpendicular to the plane pointing inwards.

Answer.13

Given-hypothetical magnetic field exists in a region,

$$\hat{B} = B_0 \hat{e}_r$$

Where

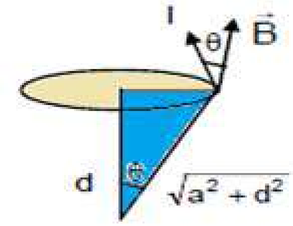
$\hat{e}_r$, is a unit vector along the radial direction a.

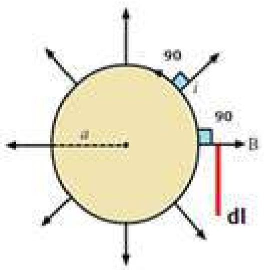
It is a circular loop of radius a

So, the length of the loop, $l = 2\pi a$

Electric current through loop = i

Also, the loop is placed with its plane parallel to the X–Y plane and its centre lies at (0,0, d).





The angle between the length of the loop l and the magnetic field B is θ

Magnetic force is given by

$$\boldsymbol{F = BIL\sin\theta}$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between B and l

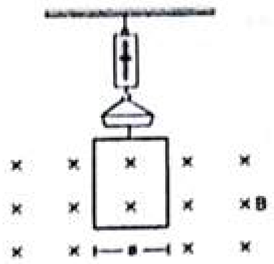
Substituting the values -

$$\boldsymbol{F = B \times I \times 2\pi a \sin\theta}$$

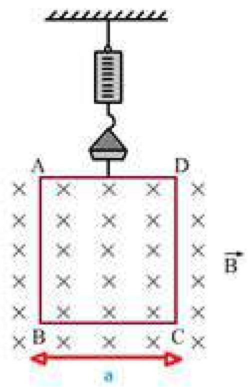
Looking into the fig, $\boldsymbol{B\sin\theta = B_0 \frac{a}{\sqrt{a^2+d^2}}}$

$$\Rightarrow \boldsymbol{F = I \times 2\pi a \times B_0 \frac{a}{\sqrt{a^2+d^2}}}$$

$$\Rightarrow \boldsymbol{F = I \times 2\pi \times B_0 \frac{a^2}{\sqrt{a^2+d^2}}}$$



Answer.14



Given-

width of wire loop = a

Electric current through the loop = i

Direction of the current is anti-clockwise.

Strength of the magnetic field in the lower region = BFrom fig, we can say that direction of the magnetic field is into the plane of the loop.

Here, angle between the length of the loop and magnetic field, $\theta = 90^0$

Magnetic force is given by

$$\boldsymbol{F = BIL\sin\theta}$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between B and l

The magnetic force will act only on side AD and BC.

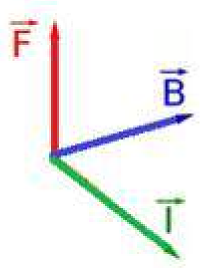
As side AD is outside the magnetic field, so $F = 0$Magnetic force on side BC is

$$\boldsymbol{F = \hat{B}Ia\sin\theta}$$

$$\boldsymbol{\hat{B}Ia\sin 90^0}$$

$= \hat{B}Ia$

Direction of force can be found using Fleming's left-hand rule.



whenever a current carrying conductor is placed inside a magnetic field, a force acts on the conductor, in a direction perpendicular to both the directions of the current and the magnetic field

Thus, the direction of the magnetic force will be upward.

Similarly altering the direction of current to clockwise, the force

along BC-

$$F = \hat{B}I\hat{l}\sin\theta$$

$$= -\hat{B} \times I \times a$$

Thus, the change in force is equal to the change in tension

$$F_{net} = \hat{B} \times I \times a - \left(-\hat{B} \times I \times a\right)$$

$$= 2\hat{B} \times I \times a$$

Answer.15

Let's

assume a square magnetic loop

Let,Uniform magnetic field existing in the region of the arbitrary loop = *B*current flowing through the loop be *i*.

Length of each side of the loop be *l*.

Assuming the direction of the current clockwise.

Direction of the magnetic field is going towards the plane of the loop.

Magnetic force is given by

$\boldsymbol{F = B \times I \times l \sin\theta}$

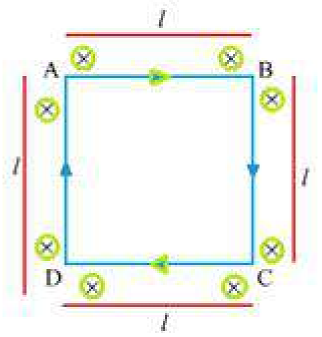
where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between B and l



$\boldsymbol{F = B \times I \times L \sin\theta}$

Here, θ = 90^0

Direction of force can be found using Fleming's left-hand rule.

Force F_1 acting on side AB is

= $\boldsymbol{B \times I \times L}$ directed upwards

Force F_2 acting on side DC = $\boldsymbol{B \times I \times L}$

directed downwards

Since, F_1 and F_2 are equal and in opposite direction, they will cancel each other.

Similarly,

Force F_3 acting on AD = $\boldsymbol{B \times I \times L}$

directed outwards pointing

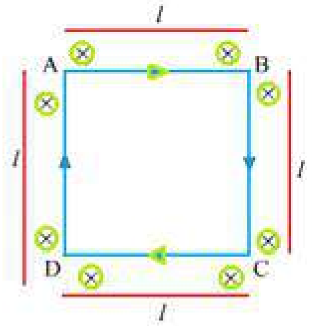
And

Force F_4 acting on BC = $\boldsymbol{B \times I \times L}$ directed outwards

Since, F_3 and F_4 are equal and in opposite direction, they will cancel each other

Hence, the net force acting on the arbitrary loop is 0.

Answer.16



Magnetic force acting on a current carrying wire in an uniform magnetic field is given by

$F = BIL \sin\theta$

where,

B= magnetic field

I = current

l = length of the wire

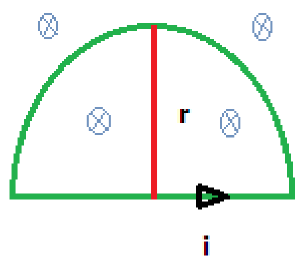
and θ = the angle between *B* and *l*

Since

$F = BIl \sin\theta$ is vector

Also, the length of the wire is fixed from A to B, so force is independent of the shape of the wire.

Answer.17



Given-

Radius of semicircular wire, $r = 5.0$ cm

Thus, the length of the wire = $2r = 10\ cm$

Electric current flowing through wire = 5.0 A

Magnetic field, $B = 0.50$ T

Direction of magnetic field is perpendicular to the plane of the.

Hence angle between length of the wire and magnetic field, $\theta = 90^0$

As we know the magnetic force is given by

$$\hat{F} = I\hat{B} \times \hat{l}$$

$$\hat{F} = I\hat{B}\hat{l}\sin 90^0$$

$$= 5 \times 2 \times 0.05 \times 0.5$$

$$= 0.25\ N$$

Answer.18

Given-

Current passing through the wire = I A

The wire is kept in the x–y plane along the curve,

$$y = A\sin\{\frac{2\pi}{\lambda}x\}$$

Also given that the magnetic field exists in the z direction.

To find the magnetic force on the portion of the wire between $x = 0$ and $x = \lambda$.

We know ,magnetic force acting on a current carrying wire in an uniform magnetic field is given by

$$F = B \times I \times L$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between *B* and *l*

For a differential length *dl*,

$$F = IB \times dI \sin\theta$$

The effective force on the whole wire due to force acting on the wire of length λ placed along the x axis.

So,

$$F = iB\int_0^{\lambda} dl$$

$$\Rightarrow F = i\lambda B$$

Answer.19

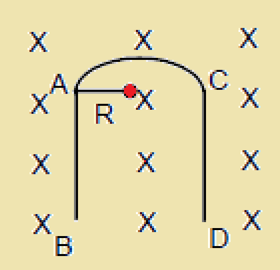
Given-

Radius of the semi-circular portion = *R*

Perpendicular Magnetic field = *B*

Electric current flowing through the wire = *I* A

Given in the question, the wire is partially immersed in a perpendicular magnetic field.



As AB and CD are straight wires of length *l* each and strength of the magnetic field is also same on both the wires, the force acting on these wires will be equal in magnitude

Direction of force can be found out using Fleming's left hand rule.

So, their directions will be opposite to each other.

So, the magnetic force on the wire AB and the force on the wire CD are equal and opposite to each other. Both the forces cancel out each other.

Therefore, only the semicircular loop RC will experience a net magnetic force.

Here, angle between the length of the wire and magnetic field, θ = 90^0

We know ,magnetic force acting on a current carrying wire in an uniform magnetic field is given by

$$\hat{F} = \hat{B} \times I \times \hat{l}$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between B and l

Here, length l = 2R

$$\hat{F} = \hat{B} \times I \times 2R$$

$$\hat{F} = I\hat{B} \times 2R\ sin90^0$$

$$= 2\ iRB$$

Answer.20

Given-

Mass of the wire, M = 10 mg = 10^{-5} Kg

Length of the wire, l = 1.0 m

Electric current flowing through wire, I = 2.0 A

It is said in the question, the weight of the wire should be balanced by the magnetic force acting on the wire.

Also angle between the length of the wire and magnetic field is

90°.

We k now weight of an object is given by

$$w = m \times g$$

where,

m = mass

g = acceleration due to gravity =9.8 m/s^2

We know,magnetic force acting on a current carrying wire in an uniform magnetic field is given by

$$F = B \times I \times L$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between *B* and *l*

Thus,

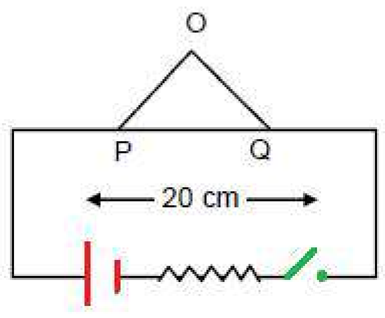
$$Mg = IBl\, sin90^0$$

$$\Rightarrow B = \frac{Mg}{Il}$$

$$= 10^{-5} \times 9.82 \times 1$$

$$= 4.9 \times 10^{-5}\, T$$

Answer.21



Given-

Length of the rod PQ = 20.0 cm

Mass of the rod, M = 200 g

Length of the two threads, l = 20.0 cm

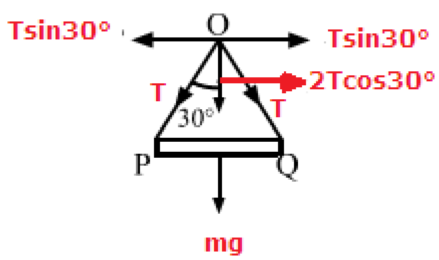
Magnetic field applied, B = 0.500 T

(a) When the switch is open-

The weight of the rod is balanced by the tension in the rod.

So,

$$2Tcos30^\circ = Mg$$



$$T = Mg2cos30^\circ$$

$$= 0.2 \times 9.8232$$

$$= 1.13\ N$$

(b)When switch is closed and current flowing through the circuit = 2 A

Then, there exists a magnetic force due to presence of current given by –

$$F = B \times I \times L$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between *B* and *l*

Hence, $\Rightarrow 2T\cos 30° = Mg + ilB$

substituting the values

$\Rightarrow 2T\cos 30° = (0.200 \times 9.8) + (2 \times 0.2 \times 0.5)$

$= 1.95 + 0.2$

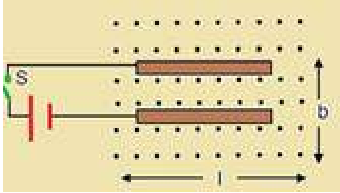
$= 2.16$

$\Rightarrow 2T = 2.16 \times 23$

$\Rightarrow T = 1.245$

$= 1.25\, N$

Answer.22



Given-

Length of the two metallic strips = *l*

Distance between the strips = *b*

Mass of the wire = *m*

Strength magnetic field = B

Coefficient of friction between the wire and the floor = μ

Let the wire moved by a distance *x.*

The magnetic field present,will act on the wire towards the right.

As coefficient of friction is zero as the space between the wire and strip is smooth .

Due to the influence of magnetic force, the wire firstly will travel a distance equal to the length of the strips.

After this, it travels a distance x and then ,a frictional force will act opposite to its direction of motion on the wire.

So work done by the magnetic force and the frictional

force will be equal.

$$F_f = \mu W$$

where

μ is the coefficient of friction for the two surfaces

W is the weight of the object

= mass × acceleration due to gravity

= mg

Magnetic force due to presence of current given by –

$$F = B \times I \times L$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between *B* and *l*

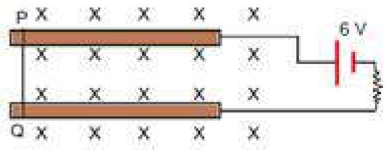
Thus,

$$F \times l = \mu mg \times x,$$

$$\Rightarrow ibBl = \mu mgx$$

$$\Rightarrow x = \frac{iblB}{\mu mg}$$

Answer.23



Given-

Mass of the metal wire, M = 10 g

Distance between the two metallic strips, l = 4.90 cm

Magnetic field acting vertically-downward, B = 0.800 T

Given in the question that when the resistance of the circuit is slowly decreased below 20.0Ω the wire end PQ starts sliding on the metallic rails.

At that time, current I from ohm's law becomes

$$\boldsymbol{i} = \frac{\boldsymbol{v}}{\boldsymbol{R}}$$

where,

v= applied voltage and

R = resistance of the circuit

$$\boldsymbol{i = 620A}$$

From Fleming's left-hand rule, we can confer that the magnetic force will act towards the right.

This magnetic force will make the wire glide on the rails.

The frictional force present at the surface of the metallic rails will try to oppose this motion of the wire.

When the wire starts sliding on the rails, the frictional force acting on the wire present between the wire and the metallic rail will just balance the magnetic force acting on the wire due to current flowing through it.

Thus,

$\mu \boldsymbol{R} = \boldsymbol{F},$

where

μ is the coefficient of friction

R is the normal reaction force and

F is the magnetic force

frictional force will be equal.

$$\boldsymbol{F_f} = \boldsymbol{\mu W}$$

where

μ is the coefficient of friction for the two surfaces

W is the weight of the object

= mass × acceleration due to gravity

= mg

Also,

Magnetic force due to presence of current given by –

$$\widehat{\boldsymbol{F}} = \widehat{\boldsymbol{B}} \times \boldsymbol{I} \times \hat{\boldsymbol{l}}$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between *B* and *l*

Hence,

$$\Rightarrow \mu \times \boldsymbol{M} \times \boldsymbol{g} = \boldsymbol{ilB}$$

substituting values

$$\mu \times 10 \times 10^{-3} \times 9.8 = 620 \times 4.9 \times 10^{-2} \times 0.8$$

$$\mu = \frac{620 \times 4.9 \times 10^{-2} \times 0.8}{10 \times 10^{-3} \times 9.8}$$

$$\Rightarrow \mu = 0.12$$

Answer.24

Given-Length of the wire = *l*

Distance between the plastic rails = *d*

The coefficient of friction between the wire and the rails = μ

Electric current flowing through the wire = *i*

The magnetic force will make the wire glide on the rails.

The frictional force present at the surface of the metallic rails will try to oppose the motion of the wire.

The minimum magnetic field required in the space, in order to slide the wire on the rails, will be such that this magnetic force acting on the wire should be able to balance the frictional force on the wire.

Thus,

$$\mu \boldsymbol{R} = \boldsymbol{F_f},$$

where

μ is the coefficient of friction

R is the normal reaction force and

F is the magnetic force

Frictional force will be equal.

$$\boldsymbol{F_f} = \boldsymbol{\mu W}$$

where

μ is the coefficient of friction for the two surfaces

W is the weight of the object

= mass × acceleration due to gravity

= mg

Also,

Magnetic force due to presence of current given by –

$$\hat{\boldsymbol{F}} = \hat{\boldsymbol{B}} \times \boldsymbol{I} \times \hat{\boldsymbol{l}}$$

where,

B= magnetic field

I = current

l = length of the wire

and θ = the angle between *B* and *l*

Hence,

$$\Rightarrow \mu \times M \times g = ilB$$

$$\Rightarrow B = \frac{\mu \times M \times g}{il}$$

Answer.25

Given-

Radius of the circular wire = *a*

Electric current passing through the loop = *i*

Magnetic field Perpendicular to the plane = *B*

(a) Magnetic force due to presence of current on a small differential length dl given by –

$$\widehat{F} = \widehat{B} \times I \times \widehat{dl}$$

where,

B= magnetic field

I = current

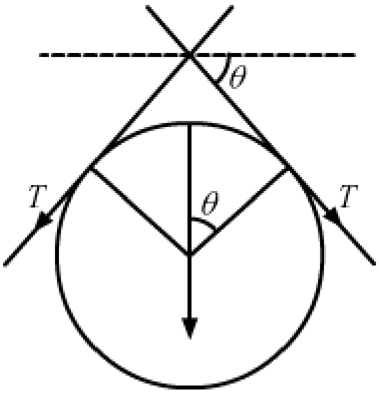
dl =differential length of the wire

and θ = the angle between *B* and *dl*

The direction of magnetic force,using Fleming's left-hand rule is towards the centre for any differential length *dl* of the wire.

Also, d*l* and B are perpendicular to each other

(b) Suppose a part of loop subtends a small angle 2θ at the centre of a circular loop as shown in fig.



Then, looking into the fig. we can say

$$2T\sin\theta = \hat{B} \times I \times \widehat{dl}$$

We know length *l* of an arc –

$$l = r\theta$$

where ,

r is radius of the circle and θ the angle subtended by the arc at the center

here, the arc is subtending an angle 2θ

$$\Rightarrow 2T\sin\theta = \hat{B} \times I \times 2\theta$$

Since is small, sinθ will become negligible

$$\Rightarrow \sin\theta = \theta$$

$$\Rightarrow 2T \times \theta = \hat{B} \times I \times 2\theta$$

$$2T\theta = I.2\theta.B$$

$$\Rightarrow T = i.B$$

Answer.26

Given-

Radius of cross section of the wire used in the previous

problem = *r*

Young's modulus of the metallic wire = *Y*.

It said in the question that, when the applied magnetic field is switched off, the tension in the wire increased and so iyd length is increased.

We know Young's modulus,

$$\gamma = \frac{Stress}{Strain}$$

we know, stress is, s is –

$$s = \frac{Force\ or\ Tension}{unit\ Area} = \frac{T}{A}$$

and strain

$$\delta = \frac{length\ of\ strech}{original\ stretch} = \frac{\Delta l}{l}$$

Young's modulus,

$$\gamma = \frac{\frac{T}{A}}{\frac{\Delta l}{l}} = \frac{T}{A} \times \frac{l}{\Delta l}$$

$$\Delta l = \frac{T}{A} \times \frac{l}{\gamma}\ (1)$$

Area of circle

$$A = \pi r^2$$

Let, a be the radius of loop

$$l = 2\,\pi\,\Delta a$$

from (1)

$$\Delta l = \frac{T}{\pi r^2} \times \frac{2\,\pi\,\Delta r}{\gamma}$$

Now the tensile force will be the magnetic force acting on a conductor of length *l* given by –

$$\hat{F} = \hat{B} \times I \times a$$

where,

B= magnetic field

I = current

a =differential length of the wire

and θ = the angle between B and a

$$\Rightarrow \Delta l = \frac{\hat{B} \times I \times a}{\pi r^2} \times \frac{2\,\pi\,\Delta a}{\gamma}$$

$$\Rightarrow \Delta l = \frac{B \times I a^2}{\pi r^2\,\gamma}$$

Answer.27

Given-

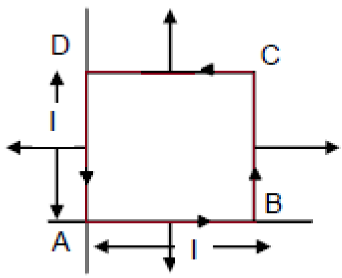
A square loop with-

Magnetic field, $\hat{B} = B_0(1 + \frac{x}{l})\vec{k}$

Length of the edge of a square loop = l

Electric current flowing through it = i

Given in the question that the loop is lies with its edges parallel to the $X\text{–}Y$ axes.



In the fig, arrow shows the direction of force on different sides of the square.

Magnetic force acting due to presence of current on a small length l given by –

$$\vec{F} = \vec{B} \times I \times l$$

where,

$\vec{F}$ = magnetic field

I = current

$\vec{l}$ = length of the wire

Now,

Force on side AB -

Consider a differential element of length dx at a distance x from the origin along line AB

Force on this small element,

$$\overrightarrow{dF} = i\,B_0\left(1+\frac{x}{l}\right)dx$$

Force on the full length of AB,

$$F_{AB} = i\,B_0\int_0^l\left(1dx+\frac{x}{l}\,dx\right)$$

$$= i\,B_0\,(l+\frac{l}{2})$$

Force on AB will be acting downwards.

Similarly, force on CD,

$$F_{CD} = i\,B_0\,(l+\frac{l}{2})$$

The net force acting vertically will be -

$$= F_{AB} - F_{CD}$$

$$= 0$$

Force on AD,

$$F_{AD} = i\,B_0\,(l+\frac{0}{2})$$

$$= iB_0 l$$

Force on BC

$$F_{BC} = i\,B_0\,(l+\frac{1}{2})$$

Then, the net horizontal force

$$\mathrm{F_{net}} = F_{AD} - F_{BC}$$

$= iB_0l$

Answer.28

Given-

Length of the conducting wire = *l*

Inward magnetic field = *B*

Velocity of the conducting wire = *v*

As the wire is moving with velocity *v,* we can take this as the motion of free electrons present inside the wire with velocity *v.*

(a) The average magnetic force on a free electron of the wire

We know, Lorentz force F is given by -

$$F = e(v \times B)$$

where,

e = charge on an electron

v = velocity of the electron

B=magnetic field

(b)The redistribution of electrons stops when the electric force is just balanced by the magnetic force.

Electric force coulomb's law,

$$F = eE$$

where

e = charge

E=electric field of the charge

and also magnetic force, we know, Lorentz force F is given by -

$$\boldsymbol{F} = \boldsymbol{e}(\boldsymbol{v} \times \boldsymbol{B})$$

where,

e = charge on an electron

v = velocity of the electron

B=magnetic field

On equating these two forces, we get-

$$\boldsymbol{e}(\boldsymbol{v} \times \boldsymbol{B}) = \boldsymbol{eE}$$

$$\Rightarrow \boldsymbol{E} = \boldsymbol{vB}\ (\mathbf{1})$$

(c) The potential difference developed between the ends of the wire , V is -

$$\boldsymbol{V} = \boldsymbol{lE}$$

where l is length of wire and E is applied electric field

From (1)

$$\boldsymbol{V} = \boldsymbol{lvB}$$

Answer.29

Given-Width of the silver strip = *d*

Area of cross-section = *A*

Electric current flowing through the strip = *i*

The number of free electrons per unit volume = *n*

(a) We know the relation between the drift velocity of electrons and current through any wire,

$$i = v_d nAe$$

where

e is the charge of an electron

v_d is the drift velocity.

A is the area of the conductor

On solving for the drift velocity, we get

$$\Rightarrow v_d = \frac{i}{nAe}$$

(b)The magnetic field existing in the region is *B*

.Magnetic force acting due to presence of current on a small length l given by –

$$\vec{F} = \vec{B} \times I \times \vec{l}$$

where,

$\vec{F}$ = magnetic field

I = current

$\vec{l}$ = length of the wire

So, the force on a free electron

$$F = \frac{ilB}{nAl}$$

$$= \frac{iB}{nA} \ (1)$$

which acts towards upward direction

(c) Let us consider, electric field as *E*.

Now, the accumulation of electrons will stop when magnetic force just balances the electric force.

Electric force, coulomb's law,

$$F = eE\ (2)$$

where

e = charge

E=electric field of the charge

From (1) and (2)

$$eE = \frac{iB}{nA}$$

$$\Rightarrow E = \frac{iB \times e}{nA}$$

(d)The potential difference , V developed across the width d of

the conductor due to the electron-accumulation is given by-

$$V = Ed$$

where

d is length of wire

and E is applied electric field

$$\Rightarrow V = Ed = \frac{iB \times e}{nA}$$

Answer.30

Given-

Charge on the particle, $q = 2.0 \times 10^{-8}$ C

Mass of the particle, $m = 2.0 \times 10^{-10}$ g velocity of the particle when projected, v = 2.0 × 10^3 m s^{-1}

Magnetic field, B = 0.10 T.

Given in the question that, the velocity is perpendicular to the field.

So, for the particle to move in a circle, the centrifugal force comes into acts which is provided by the magnetic force acting on it.

Also magnetic force, we know, Lorentz force F is given by -

$$F = e(v \times B)$$

where,

e = charge on an electron

v = velocity of the electron

B=magnetic field

Using the formula for centrifugal force

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

where,

v= velocity of the particle

r= radius of circle form

m =mass of the electron

Equating the two forces, we will get-

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

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

$$= \frac{2 \times 10^{-13} \times 2 \times 10}{32 \times 10^{-8} \times 0.10}$$

$$= 20\ cm$$

Now,

Time period,

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

$$= \frac{2 \times 3.14 \times 2 \times 10^{-13}}{2 \times 10^{-8} \times 0.10}$$

$$= 6.28 \times 10^{-4}\ s$$

Answer.31

Given-Radius of the circle, r = 1 cm

Magnetic field , B= 0.10 T

We know that the charge on a proton is e and that of an alpha

particle is 2e.

Also, the mass of a proton is m

Mass of an alpha particle is 4m.

let assume that both the particles are moving with speed v.

So, for the particle to move in a circle, the centrifugal force comes into acts which is provided by the magnetic force acting on it.

Also magnetic force, we know, Lorentz force F is given by -

$$F = e(v \times B)$$

where,

e = charge on an electron

v = velocity of the electron

B=magnetic field

Using the formula for centrifugal force

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

where,

v= velocity of the particle

r= radius of circle form

Equating the two forces, we will get-

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

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

Then, we can confer from question that-

$$r_p = \frac{mv}{eB},$$

Where

r_p is the radius of the circle described by the proton which is 0.01

$$\Rightarrow 0.01 = \frac{mv}{e \times 0.1} \ (1)$$

For alpha particle, radius is given by –

$$r_\alpha = \frac{4mv}{2eB}$$

$$= \frac{4mv}{2e \times 0.1} \ (2)$$

On dividing equation (1) by (2), we get:

$$\frac{r_\alpha}{0.01} = \frac{4mv \times e \times 0.1}{2e \times 0.1 \times mv}$$

$$\Rightarrow r_\alpha = 0.02\ m$$

$$= 2\ cm$$

Answer.32

Given-Kinetic energy of an electron = 100 eV

Radius of the circle = 10 cm

We now kinetic energy is given by

$$KE = \frac{1}{2}\mathrm{mv}^2$$

Where

From question , we can confer that

$$\frac{1}{2}mv^2 = 100\ eV$$

Here,m is the mass of an electron

v is the velocity of an electron.

We know that 1 eV = 1.6 × 10^{-19} J

Thus,

$$\frac{1}{2} \times 9.1 \times 10^{-31} \times v^2 = 1.6 \times 10^{17}$$

$$\Rightarrow v^2 = 0.35 \times 10^{14}$$

$v = 0.591 \times 10^7\ m/s$Now, radius r -

$$r = \frac{mv}{eB}\ (1)$$

$$\Rightarrow B = \frac{mv}{er}$$

$$= \frac{9.1 \times 10^{-31} \times 0.591 \times 10^7}{1.6 \times 10 - 19 \times 0.1}$$

$$= 3.3613 \times 10^{-4}\ T$$

Therefore, magnetic field applied is 3.4 × 10^{-4} T

Number of revolutions per second of the electron is nothing but the frequency given by ,

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

$$T = \frac{2\pi r}{v}$$

From (1)

$$v = \frac{reB}{m}$$

$$\Rightarrow T = \frac{2\pi m}{eB}$$

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

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

$$\Rightarrow f = \frac{3.4 \times 10^{-4} \times 1.6 \times 10^{-19}}{2 \times 3.14 \times 9.1 \times 10^{-31}}$$

$$= 0.094 \times 10^{8} = 9.4 \times 10^{6}$$

$$f = 9.4 \times 10^{6}\ Hz$$

Answer.33

Given-Kinetic energy of proton = *K*

Distance between the target and the accelerator = *l*

Therefore, radius of the circular orbit ≤ *l*

From question it is given that, the beam is bent by a

perpendicular magnetic field, let it be B.

We know-

Now, radius r -

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

e= charge on the particle

For a proton, the above equation can be written as-

$$l = \frac{m_p v}{eB} \ (1)$$

where r = *l*

Kinetic energy, K $K = \frac{1}{2}\text{mv}^2$

$$\Rightarrow v = \sqrt{\frac{2K}{m_p}}$$

Substituting the values of v in the equation (1)

$$l = \frac{2K\, m_p}{eB}$$

$$\Rightarrow B = \frac{2K\, m_p}{el}\ T$$

Answer.34

Given-

Applied potential difference to the charged particle , $V = 12\text{ kV} = 12 \times 10^3\text{ V}$

Speed acquire by the charged particle, $v = 1.0 \times 10^6\text{ m s}^{-1}$

Perpendicular Magnetic field $B = 0.2\text{ T}$

We know

The kinetic energy acquired by the particle is produced due to

applied potential difference, hence

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

$$\Rightarrow \frac{m}{q} = \frac{2V}{v^2}$$

$$= \frac{2 \times 12 \times 10^3}{(1 \times 10^6)^2}$$

$$\Rightarrow \frac{m}{q} = 24 \times 10^{-9}$$

and

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle

$$\Rightarrow r = \frac{24 \times 10^{-9} \times 10^{6}}{0.2}$$

$$\Rightarrow r = 12 \times 10^{-2}\, m$$

$$= 12\, cm$$

Answer.35

Given-

Speed of the helium ions, v = 10 km s^{-1} = 10^4 m/s

Uniform magnetic field, B = 1.0 T

Charge on the helium ions = 2e

Mass of a helium ion, m = $4 \times 1.6 \times 10^{-27}$ Kg

(a) The force acting on an ion –

Magnetic force, we know, Lorentz force F is given by -

$$F = qvBsin\theta$$

where,

e = charge on an electron

v = velocity of the electron

B=magnetic field

θ= angle between B and v

$$F = qvBsin\theta$$

$= 2 \times 1.6 \times 10^{-19} \times 10^{4} \times 1.0$

$= 3.2 \times 10^{-15}\ N$

(b) The radius of the circle is given by,

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle

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

$$= \frac{4 \times 1.6 \times 10^{-27} \times 10^{4}}{2 \times 1.6 \times 10^{-19} \times 1}$$

$2 \times 10^{-4}\ m$

(c) The time taken by an ion to complete the circle,

we know

$$speed = \frac{distance}{time}$$

$$\Rightarrow time = \frac{distance}{speed}$$

Since the total time taken for a complete cycle will be its circumference $2\pi r$ and the velocity is V -

$$\Rightarrow T = \frac{2\pi r}{v}$$

$$= \frac{6.28 \times 2.1 \times 10^{-4}}{10^{4}}$$

$= 1.31 \times 10^{-7}\ s$

Answer.36

Given-

Velocity of the proton, $v = 3 \times 10^6$ m s^{-1}

Uniform magnetic field, B = 0.6 T

As per the question, the proton is projected perpendicular to a

uniform magnetic field.

We know, Newton's second law, Force F is given by –

$$F = ma$$

where

m is mass of the object

a=acceleration

For proton

$$\Rightarrow F = m_p a \ (1)$$

Magnetic force, we know, Lorentz force F is given by -

$$F = evB\sin\theta \ (2)$$

where,

e = charge on an electron

v = velocity of the electron

B=magnetic field

θ= angle between B and v

Equating (1) and (2),

$$m_p a = evB\sin\theta$$

As $\theta = 90^0$

$$\Rightarrow a = \frac{evB}{m}$$

$$= \frac{1.6 \times 10^{-19} \times 3 \times 10^6 \times 0.6}{1.67 \times 10^{-27}}$$

$$= 1.72 \times 10^{14}\ m/s^2$$

Answer.37

Given-

(a) For electron

Radius of the circle = 1 m

Magnetic field strength = 0.50 T

Now,

The radius of the circle is given by,

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

where,

m is the mass of a electron

v= velocity of the particle

B = magnetic force

q= charge on the particle =$1.6 \times 10-^{19}$ C

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

$$\Rightarrow v = \frac{reB}{m}$$

$$= \frac{1 \times 0.50 \times 1.6 \times 10-^{19}}{9.1 \times 10^{-31}}$$

$$\approx 8.8 \times 10^{10}\ m/s^2$$

Speed of light is $3x10^8$ m/s^2

Here, the speed of the electron moving along the circle is greater than the speed of light, so it is not reasonable.

(b) For a proton,

The radius of the circle is given by,

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle =$1.6 \times 10{-}^{19}$ C

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

$$\Rightarrow v = \frac{reB}{m}$$

$$= \frac{1 \times 0.50 \times 1.6 \times 10^{-19}}{1.6 \times 10^{-27}}$$

$$= 5 \times 10^{7}\ m/s$$

Answer.38

Given-Mass of the particle = *m*Positive charge on the particle = *q*velocity of the particle = *v*Magnetic field = *B*

(a)The radius of the circular arc described by the particle in the magnetic field-

We know,

The radius of the circle is given by,

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

where,

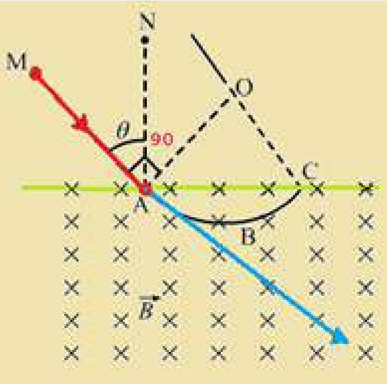
m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle =$1.6 \times 10-^{19}$ C

(b) The angle subtended by the arc at the centre



Line MAB is the tangent to arc ABC,

When the particle enters into the magnetic field, it follows a path in the form of arc as shown in fig.

Now, the angle described by the charged particle is nothing but the angle ∠ MAO is ,

∠MAO = 90°

Also from fig , ∠NAC = 90°

∠OAC = ∠ OCA = θThen, by angle-sum property of a triangle, sum of all angles of a triangle is 180^0

∠AOC =180°– (θ + θ)

= $\pi - 2\theta$ (1)

(c)The time for which the particle stay inside the magnetic field is given by-

Distance covered by the particle inside the magnetic field,is the length of arc subtended by angle θ and the radius

l = *r*θ

from (1)

l= *r* $(\pi - 2\theta)$

time taken for a complete cycle will be its circumference $2\pi r$ and

the velocity is V -

$$\Rightarrow T = \frac{2\pi r}{v}$$

Also The radius of the circle is given by,

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

where,

m is the mass of a proton

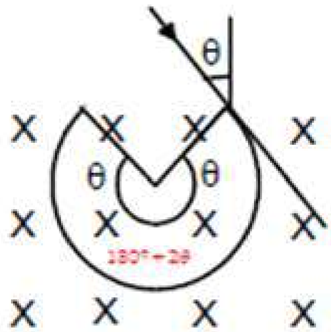
v= velocity of the particle

B = magnetic force

q= charge on the particle =$1.6 \times 10-^{19}$ C

$$\Rightarrow T = \frac{m}{qB}(\pi - 2\theta)$$

(d) If the charge *q* on the particle is negative, then



(i) Radius of circular arc is given by

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

(ii) The centre of the arc lies within the magnetic field

Therefore, the angle subtended by the arc = $\pi + 2\theta$

(iii) The time taken by the particle to cover the path inside the magnetic field

$$\Rightarrow T = \frac{m}{qB}(\pi + 2\theta)$$

Answer.39

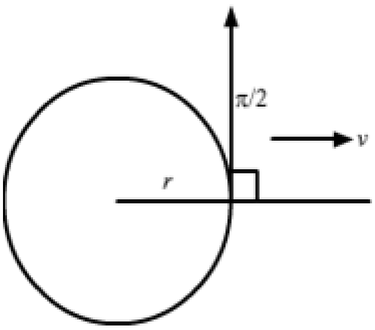
Given-

Mass of the particle = m

Charge of the particle = q

Perpendicular magnetic field = B

To find the angle of deviation figure of the particle as it comes out of the magnetic field when -



(a) When the width,

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

d is equal to the radius

θ is the angle between the radius and tangent drawn to the circle , which is equal to $\frac{\pi}{2}$.

(b) When the width,

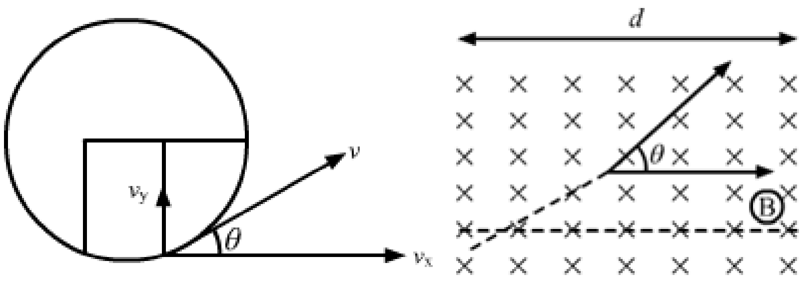
$$d = \frac{mv}{2qB}$$

Now, in this case, the width of the region in where magnetic field is applied is half of the radius of the circular path.

As the magnetic force is acting only along the y –axis,the velocity of the particle will remain constant along the x-axis.

So, if *d* distance is travelled along the x axis,

then,



$$d = v_x \times t$$

$$t = \frac{d}{t} \, (1)$$

where,

v=velocity

t=time

for constant velocity the acceleration along the x direction is zero.

Hence the force will act only along the y direction.

Using the 3rd equation of motion along the y axis-

$$V_y = u_y + a_y t$$

where

u = initial velocity

a = acceleration

t= time taken

since, initial velocity is 0

Also, as $\theta = 90^0$

$$\Rightarrow a = \frac{evB}{m}$$

$$\Rightarrow V_y = 0 + \frac{qu_x Bt}{m}$$

$$= \frac{qu_x Bt}{m}$$

From (1)

$$V_y == \frac{qu_x Bt\, d}{mv_x}$$

We know

$$tan\theta = \frac{v_y}{v_x}$$

From above fig.

$$\frac{qBd}{mv_x} = \frac{qBmv_x}{2qBmv_x}$$

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

$$\Rightarrow \theta = \tan^{-1}\frac{1}{2}$$

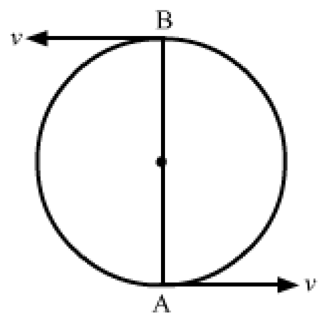
$$= 26.4$$

$$= 30°$$

$$= \frac{\pi}{6}$$

(c) When the width, *d* =

$$d = \frac{2mv}{qB}$$



From above fig., it can be concluded that the angle between the initial direction and final direction of velocity is π.

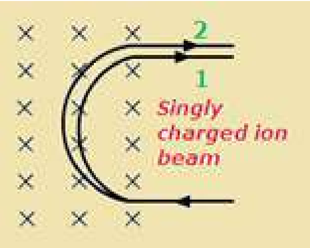
Answer.40

Given-

Velocity of a narrow beam of singly-charged carbon ions,

$v = 6.0 \times 10^4$ m s^{-1}

Strength of magnetic field $B = 0.5$ T



Separation between the two beams from the incident beam are 3.0 cm and 3.5 cm.

Mass of an ion = $A(1.6 \times 10^{-27})$ kg

The radius of the curved path taken by the beam 1 -

$$r_1 = \frac{3}{2} = 1.5\ cm\ (1)$$

The radius of the curved path taken by the beam 2-

$$r_2 = 3.52\ cm\ (2)$$

The radius of the circle is given by,

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle $= 1.6 \times 10 -^{19}$ C

For the first beam

$$r_1 = \frac{m_1 v}{qB}$$

where

m_1 = mass of the first isotope

q = s the charge.

For the second beam

$$r_2 = \frac{m_2 v}{qB}$$

where

m_2 = mass of the second isotope

q = the charge.

$$\frac{r_1}{r_2} = \frac{m_1}{m_2}$$

from (1) and (2),

$$\frac{\frac{3}{2}}{3.52} = \frac{A_1 \times 1.6 \times 10^{-27}}{A_2 \times 1.6 \times 10^{-27}}$$

$$\frac{6}{7} = \frac{A_1}{A_2} \ (3)$$

Now, we know,

$$r_1 = \frac{m_1 v}{qB}$$

$$\Rightarrow m_1 = \frac{qBr_1}{v}$$

$$= \frac{1.6 \times 10^{-19} \times 0.5 \times 0.015}{6 \times 10^4}$$

$$= 20 \times 10^{-27}\ kg$$

$$= \frac{20 \times 10^{-27}}{1.6 \times 10^{-27}}\ u$$

$$= 12.5\ u$$

Also, from (3)

$$A_2 = \frac{7}{6} A1$$

$= \frac{7}{6} \times 12.5$

$= 14.58\, u$

Looking at the mass of the material obtained, we can infer that these are the two isotopes of carbon used are $^{12}C_6$ and $^{14}C_6$.

Answer.41

Given-Potential difference through which the Fe^+, V = 500 V

Strength of the homogeneous magnetic field

B = 20.0 mT= 20 × 10^{-3} T

Mass numbers of the two isotopes ,

m_1 =57 and m_2 =58.

Mass of an ion = A (1.6 × 10^{-27}) kg

The radius of the circular path described by a particle in a magnetic field,

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle =$1.6 \times 10{-}^{19}$ C

For calculating the radius of isotope 1-

$$r_1 = \frac{m_1 v_1}{qB}$$

For isotope 2,

$$r_2 = \frac{m_2 v_2}{qB}$$

$$\frac{r_1}{r_2} = \frac{m_1 v_1}{m_2 v_2}$$

Since isotopes are accelerated from the same potential V, the Kinetic energy gained by the two particles will be same for both the particles.

We, know the force developed by potential difference –

$$F = qV$$

where

v = applied potential

q=charge

$$\Rightarrow qV = \frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_2 v_2^2 \ (1)$$

$$= \frac{v_1^2}{v_2^2}$$

$$\Rightarrow \frac{r_1}{r_2} = \left(\frac{m_1}{m_2}\right)^{\frac{3}{2}} \ (2)$$

Also,we have

$$r_1 = \frac{m_1 v_1}{qB}$$

From (1)

$$r_1 = \frac{m_1 \sqrt{2qVm_1}}{qB}$$

$$= \frac{1}{B} \frac{\sqrt{2Vm_1}}{q}$$

$$= \frac{\sqrt{1000 \times 57 \times 1.6 \times 10^{-27}}}{\sqrt{1.6 \times 10^{-19} \times 20 \times 10^{-3}}}$$

$$= 1.19 \times 10^{-2} \ m$$

$$= 119 \ cm$$

For calculating the radius of 2 isotope-

From (2)

$$\frac{r_1}{\left(\frac{m_1}{m_2}\right)^{\frac{3}{2}}} = r_2$$

$$= \left(\frac{58}{57}\right)^{\frac{3}{2}} \times 119\ cm$$

$$= 120\ cm$$

Answer.42

Given -

Kinetic energy of singly-charged potassium ions = 32 keV

Width of the magnetic region = 1.00 cm

Magnetic field's strength, *B* = 0.500 T

Distance between the screen and the region = 95.5 cm

Atomic weights of the two isotopes are $m_1 = 39$ and $m_2 = 41$

.Mass of a potassium ion = *A* (1.6×10^{-27}) kg

For a singly-charged potassium ion K-39, separation between the points can be calculated as follows –

Mass of K-39 = $39 \times 1.6 \times 10^{-27}$ kg

Charge, $q = 1.6 \times 10^{-19}$ C

Given in the question that the narrow beam of singly-charged potassium ions is injected into a region of magnetic field.

As, given that kinetic energy K.E is

K.E = 32 keV

$$\frac{1}{2} mv^2 = 32 \times 10^3 \times 1.6 \times 10^{-19}$$

$$12 \times 39 \times (1.6 \times 10^{-27}) \times v^2 = 32 \times 10^3 \times 1.6 \times 10^{-19}$$

$$v = 4.05 \times 10^5 \ m/s$$

We know that throughout the motion, the horizontal velocity remains constant.

So, the time taken to cross the magnetic field,

$$t = dv$$

$$= 0.014.05 \times 105$$

$$= 24.7 \times 10^{-9} \ s$$

Now, the acceleration in the magnetic field region-

$$F = qvB = ma$$

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

$$= \frac{1.6 \times 10^{-19} \times 4.05 \times 10^5}{39 \times 1.6 \times 10^{-27}}$$

$$= 5192 \times 10^8 \ m/s2$$

Now, velocity in the vertical direction can be found from Newton's 2nd law as

$$v_y = U_Y + at$$

Since, initial velocity is 0,

$$v_y = +at$$

Substituting the values-

$$v_y = 5193.53 \times 10^8 \times 24.7 \times 10^{-9}$$

$$= 12824.24 \ m/s$$

Time taken by the ion to reach the screen-

$$time = \frac{distance}{velocity}$$

$$= \frac{0.955}{4.05 \times 10^5}$$

$$\Rightarrow t = 0.000002358\ s.$$

Now, distance moved by the ion vertically in this given time -

$$d = v_y \times t$$

$$= 12824.24 \times 2358 \times 10^{-9}$$

$$= 3023.95 \times 10^{-5}\ m$$

Vertical distance travelled by the particle inside magnetic field

can be calculated by using 3rd equations of motion –

$$v^2 - u^2 = 2aS$$

where,

v= final velocity

u=initial velocity

a= acceleration acting on the ion

S=distance travelled

Since initial velocity is zero,

$$\Rightarrow v^2 = 2aS$$

$$\Rightarrow (12824.24)2 = 2 \times 5192 \times 108 \times S \Rightarrow 15.83 \times 10^{-5} = S$$

Now, time taken t,

$$t = 15.83 \times 10^{-5} + 3023.95 \times 10^{-5}$$

$$= 3039.787 \times 10^{-5}\ m.$$

Now,for the potassium ion K-41

$$\Rightarrow \frac{1}{2}mv^2 = 32 \times 10^3 \times 1.6 \times 10^{-9}$$

$$\Rightarrow \frac{1}{2} \times 41 \times 1.6 \times 10^{-27} v^2 = 32 \times 10^3 \times 1.6 \times 10^{-9}$$

$$\Rightarrow v = 3.94 \times 10^5\ m/s$$

And, acceleration a is given by-

$$a = 4805 \times 10^8\ m/s2$$

t = time taken by the ion to exit the magnetic field is given by -

$$= 25.4 \times 10^{-9}\ sec$$

From newton's law velocity in vertical direction-

$$v_{y1} = a\,t$$

$$= 4805 \times 10^{8} \times 25.4 \times 10^{-9}$$

$$= 12204.7 \times 10^{-9}\ m/s$$

Time to reach the screen, t -

$$t = 2423 \times 10 - 9\ s.$$

Now distance moved in vertical direction is-

$$= \frac{12204.7 \times 10^{-9}}{2423 \times 10^{-9}}$$

$$= 2957.1 \times 10^{-5}\ m\ (1)$$

Now,Vertical distance travelled by the particle inside magnetic field can be found out by using 3rd equation of motion given by

$$v^2 - u^2 = 2aS$$

where,

v= final velocity

u=initial velocity

a= acceleration acting on the ion

S=distance travelled

Since initial velocity is zero,

$$v^2 = 2aS$$

$$(12204.7)^2 = 2 \times 4805 \times 10^{8}\ S$$

$$\Rightarrow S = 15.49 \times 10^{-5}\ m$$

Net distance travelled by K-41 potassium ion

$$= 15.49 \times 10^{-5} + 2957.1 \times 10^{-5} = 2972.68 \times 10^{-5}\ m\ (2)$$

Net gap between K-39 and K-41 potassium ions is given by-

From (1) and (2)

$$= 3039.787 \times 10^{-5} - 2972.68 \times 10^{-5}$$

$$= 67\ mm.$$

Answer.43

Given-Focal length of the convex lens = 12 cm

Uniform magnetic field, B = 1.2 T

Charge of the particle, q = 2.0×10^{-3} C

an mass, m = 2.0×10^{-5} kg

Speed of the particle, v = 4.8 m s^{-1}

Distance between the particle and the lens = 18 cm

Given in the question that the object is projected perpendicularly on the plane of the paper.

The radius of the circular path described by a particle in a magnetic field r,

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle =$1.6 \times 10-^{19}$ C

$$r = \frac{2 \times 10^{-5} \times 4.8}{2 \times 10^{-3} \times 1.2}$$

$r = 0.04\,m$

$= 4\,cm$

Given that, the object distance, u = -18 cm

Using the lens formula –

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

where,

v=distance of image formed from lens

u=distance of the object from lens

f =focal length of the lens

substituting the values-

$$\frac{1}{v} - \frac{1}{8} = \frac{1}{12}$$

$$\Rightarrow v = 36\,cm$$

Let the radius of the circular path of image be r'.

Hence magnification -

$$\frac{v}{u} = \frac{r'}{r}$$

$$\Rightarrow r' = \frac{v}{u} \times r$$

$$= 8\,cm$$

Therefore, the radius of the circular path in which the image of the object formed from the lens moves is 8 cm.

Answer.44

Given-Electrons are accelerated by applying a potential difference = V

Let the mass of an electron = m

charge of an electron= e

Electric field,

$$E = \frac{V}{r}$$

Force experienced by the electron by coulomb's law is given by,

$$F = eE$$

Acceleration a, of the electron is given by,

$$a = \frac{eV}{rm} \; (1)$$

where,

e= electronic charge

V= applied potential difference

r= radius of the curve

m= mass of the object

Using the 3rd equation of motion

$$v^2 - u^2 = 2aS$$

where,

v= final velocity

u=initial velocity

a= acceleration acting on the ion

S=distance travelled

Since initial velocity is zero,

$$v^2 = 2 \times a \times s$$

Here, $s = r$ which is the radius of the curve

From (1)

$$\mathbf{v} = \sqrt{\frac{2eV}{rm}r}$$

$$= \sqrt{\frac{2eV}{m}}$$

We know that time taken by electron to cover the curved path is given as,

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

As the acceleration of the electron is along the y axis only, it travels along the $x$axis with uniform velocity.

Velocity of the electron moving along the field remains v.

Therefore, the distance at which the beam is

$d = velocity \times Time$

$$d = \sqrt{\frac{2eV}{m}} \times \frac{2\pi m}{eB}$$

$$= \sqrt{\frac{8\pi^2 mV}{eB^2}}$$

Answer.45

Given-Mass of two particles = mDistance between the particles = dAlso magnitude of charges of both the particles are equal but opposite polarity equal = q.From the question we can confer that, both the particles are projected towards each other with equal speed v.

Assuming that Coulomb force between the charges is switched off.

(a) The maximum value v_m of the projection speed so that the two particles do not collide-

The particles will not collide with each other if

$d = r_1 + r_2$

where, $r_1 = r_2$ = radius of circular orbit followed by the charged particles

The radius of the circular path described by a particle in a magnetic field r,

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle =$1.6 \times 10{-}^{19}$ C

$$\Rightarrow d = \frac{mv}{qB} + \frac{mv}{qB}$$

$$= 2\frac{mv}{qB}$$

So,

$$\Rightarrow v_m = \frac{qB}{d2m} \ (1)$$

(b) The minimum and maximum separation between the particles if $v = v_m/2$-

Let the radius of the curved path taken by the particles in the condition when $v_m/2$, be r

So, minimum separation between the particles will be

$$= (d - 2r)$$

$$\Rightarrow (d - 2r) = \frac{2m_v v}{qB} - \frac{2mv}{qB}$$

$$\Rightarrow (d - 2r) = \frac{m_v v}{qB}$$

$$\Rightarrow (d - 2r) = \frac{d}{2}$$

Now, the maximum distance of separation between the particles will be = $(d + 2r)$

$$\Rightarrow d + 2r = d + \frac{d}{2}$$

$$= \frac{3d}{2}$$

(c) The instant at which the collision occurs between the particles if $v=2v_m$ –

The particles along the horizontal direction will collide at a distance , $d/2$

Let they collide after time *t*.

Velocity of the particles before and after collision along the horizontal direction will remain the same.

Therefore,

$$t = \frac{\frac{d}{2}}{2v_m}$$

From (1)

$$\Rightarrow t = \frac{d}{4} \times \frac{2mq}{Bd}$$

$$\Rightarrow t = \frac{m}{2qB} \ (1)$$

(d) The motion of the two particles after collision when the collision is completely inelastic and $v = 2vm$ –

Let the P be t he point of particles collision.

And at point P, both the particles will have motion in upwards

As the collision is inelastic these particles will stick together.

Distance between centers = *d*

Velocity of the particles before and after collision along the horizontal direction will remain the same.

At point P, velocities along the horizontal direction are equal in magnitude and opposite in direction.

So, they will cancel out each other.

So, the velocity along the vertical upward direction will add up.

Magnetic force acting along the vertical direction,

Magnetic force, we know, Lorentz force F is given by -

$$F = qvBsin\theta$$

where,

q = charge on an electron

v = velocity of the electron

B=magnetic field

θ= angle between B and v

$$\Rightarrow F = q2v_mB$$

Now, from Newton's second law, the acceleration along the vertical direction,

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

$$= \frac{2qv_mB}{m}$$

So, from 1^{st} equation of motions-

$$v = u + at$$

where

v= final velocity

u=initial velocity

a= acceleration due to gravity

t=time taken

since inititial velocity u =0,

Velocity of the combined mass at point P is along the vertical

direction v'.

$v' = a \times t$

$$v' = \frac{2qv_mB}{m} \times \frac{m}{2qB}$$

$\Rightarrow v' = v_m$

Hence, the particles will behave as a combined mass and move with same velocity v_m.

Answer.46

Given-

Magnetic field, B = 0.20 T

Mass of the particle, m = 0.010 g = 1 × 10^{-5} kg

Charge of the particle, q = 1.0 × 10^{-5} C

Given in the question that, if the particle has to move with

uniform velocity in the region of the applied field,

the gravitational force experienced by the particle must be

equal to the magnetic force experienced by the particle.

Gravitational force,

$\mathbf{F} = mg$

where

m is the massof theobject

g=acceleration due to gravity

And

Magnetic force, we know, Lorentz force F is given by -

$F = qvB$

where,

q = charge on an electron

v = velocity of the electron

B=magnetic field

θ= angle between B and v

So,

$$qvB = mg$$

$$\Rightarrow 1 \times 10^{-5} \times v \times 2 \times 10^{-1} = 1 \times 10^{-5} \times 9.8$$

$$\Rightarrow v = 4.9 \times 10$$

$$= 49\, m/s$$

Answer.47

Given-Diameter of the circle = 1.0 cm

Thus, radius of circle, r = = 0.5×10^{-2} m

Magnetic field, B = 0.40 T

Electric field, E = 200 V m^{-1}

From the question we can confer that, the particle is moving in a circle under the action of a magnetic field.

But when an electric field is applied on the particle, it moves in a straight line.

So, we can say that the electric field is balanced by the magnetic field ie,

$$F_e = F_m$$

Magnetic force, we know, Lorentz force F is given by -

$$F_m = qvB$$

where,

q = charge on an electron

v = velocity of the electron

B=magnetic field

θ= angle between B and v

$qE = qvB$

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

$$= \frac{200}{0.4}$$

$$= 500\ m/s$$

The radius of the circular path described by a particle in a magnetic field r,

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle =$1.6 \times 10{-}^{19}$ C

$$\frac{q}{m} = \frac{v}{rB}$$

$$r = \frac{500}{0.5 \times 10^{-2} \times 0.4}$$

$$= 2.5 \times 10^{5}\ C/kg$$

Answer.48

Given-Mass of the proton, $m = 1.6 \times 10^{-27}$ kg

Speed of the proton inside the crossed electric and magnetic field, $v = 2.0 \times 10^{5}$ ms^{-1}

Given from question we can confer that , the proton is not deflected under the combined action of the electric and magnetic fields.

Thus, the forces applied by both the fields are equal and opposite to each other

Magnetic force, we know, Lorentz force F is given by -

$$F_m = qvB$$

where,

q = charge on an electron

v = velocity of the electron

B=magnetic field

θ= angle between B and v

Also,

We, know the Columb's force–

$$F = eE$$

where

E = applied electric field

e=charge

Now,

$$qE = qvB$$

$$\Rightarrow E = vB \ (1)$$

But when the electric field is switched off, the proton moves follows circular path due to the presence of force of the magnetic field.

The radius of the circular path described by a particle in a magnetic field r,

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle =$1.6 \times 10-^{19}$ C

$$\Rightarrow B = \frac{mv}{qr}$$

$$= \frac{1.6 \times 10^{-27} \times 2 \times 10^{5}}{1.6 \times 10^{-19} \times 4 \times 10^{-2}}$$

$= 0.05\,T$

Substituting the value of B in equation (1), we get

$E = 2 \times 10^5 \times 0.05$

$= 1 \times 10^4\ N/c$

Hence magnitudes of the electric and the magnetic fields are

$= 0.05\,T\ and\ 1 \times 10^4\ N/c$ respectively

Answer.49

Given-Charge on the particle, $q = 5\ \mu C = 5 \times 10^{-6}$ C

Magnetic field, $B = 5 \times 10^{-3}$ T

Mass of the particle, $m = 5 \times 10^{-12}$ kg

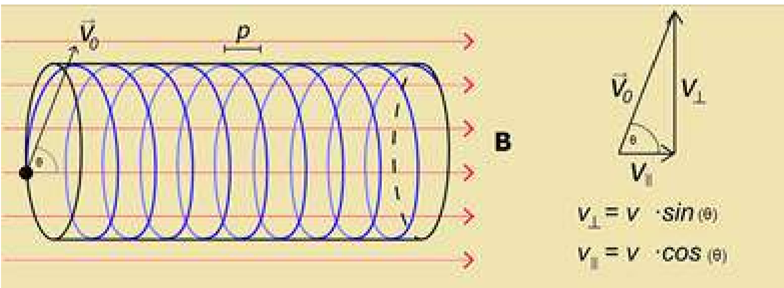
Velocity of projection, $v = 1$ Km/s = 10^3 m/s

Angle between the magnetic field and velocity,

$\theta = \sin^{-1}(0.9)$

Since there are no forces in the horizontal direction ie there is no force in the direction of magnetic field, so, the particle moves with uniform velocity in horizontal direction.

Thus, it moves in a helical form.In helical motion we have two components of velocity.



Component of velocity which is perpendicular to the magnetic field is given by -

$v_\perp = v sin\theta$

Similarly component of velocity in the direction of magnetic field will be the parallel component given by -

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

The velocity has a vertical component along which it accelerates with an acceleration *a* and moves in a circular cross-section.

We know motion in helical direction which is centripetal force and is given by –

$$F_c = \frac{mv_{\perp}^2}{r}$$

Now, this force is balanced by Lorentz force acting due to presence of magnetic field ,

$$\frac{mv_{\perp}^2}{r} = qv_{\perp}B$$

$$\Rightarrow r = \frac{mv\sin\theta}{qB}$$

$$= \frac{5 \times 10^{-12} \times 10^{3} \times 0.90}{5 \times 10^{-6} \times 5 \times 10^{-3}}$$

$$= 0.18\ m$$

Hence, diameter of the helix can be calculated as ,

$$2r = 0.36\ m = 36\ cm$$

And the Pitch of the helix is ,

$$P = \frac{2\pi r}{v\sin\theta} \times v\cos\theta$$

$$= \frac{2 \times 3.14 \times 0.18}{0.90} \times \sqrt{1 - 0.81}$$

$$= 0.55\ m$$

$$= 55\ cm$$

Answer.50

Given

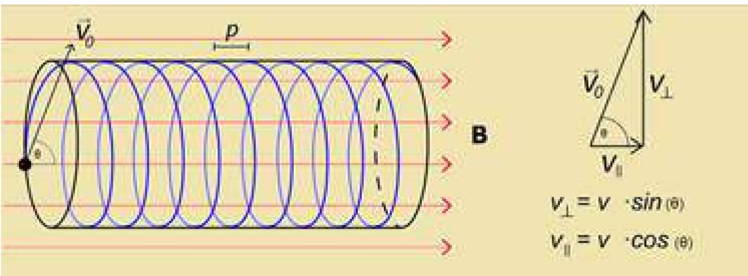
Mass of the proton, m_p = 1.6 × 10^{-27} kg

Magnetic field intensity, B = 0.02 T

Radius of the helical path, r = 5 cm = 5 × 10^{-2} m

Pitch of the helical path, p = 20cm = 2 × 10^{-1} m

In helical motion we have two components of velocity.



Component of velocity which is perpendicular to the magnetic field is given by -

$$v_\perp = vsin\theta$$

Similarly component of velocity in the direction of magnetic field will be the parallel component given by -

$$v_\parallel = vcos\theta$$

Now,

Now, this force is balanced by Lorentz force acting due to presence of magnetic field ,

$$\frac{mv_\perp^2}{r} = qv_\perp B$$

$$\Rightarrow r = \frac{mvsin\theta}{qB}$$

$$\Rightarrow 5 \times 10^{-2} = \frac{1.6 \times 10^{-27} \times v_\perp}{1.6 \times 10^{-19} \times 0.02}$$

$$\Rightarrow v_\perp = 1 \times 10^5\ m/s$$

Now, pitch of the helix is calculated as –

$$Pitch = \frac{v_\parallel 2\pi r}{v_\perp}$$

$$v_\parallel = \frac{v_\perp P}{2\pi r}$$

$$= \frac{10^5 \times 0.2}{2 \times 3.14 \times 5 \times 10^{-2}}$$

$$= 0.6369 \times 10^5$$

$$= 6.4 \times 10^4 \ m/s$$

Answer.51

Given-

Mass of the particle = *m*

Charge of the particle = *q*

Electric field and magnetic field are given by

$$\vec{B} = -B_0\vec{J}$$

$$\vec{E} = E_0\vec{k}$$

Velocity,

$$v = v_x\hat{\imath} + v_y\hat{\jmath} + v_z\hat{k}$$

Magnetic force, we know, Lorentz force F is given by -

$$F_m = qvB$$

where,

q = charge on an electron

v = velocity of the electron

B=magnetic field

θ= angle between B and v

Also, coulomb's force experienced by the electron is given by,

$$F = eE$$

where e= charge on the electron and

E= electric field applied

So, total force on the particle,

$F = q\,(E + v \times B)$

=q$(E_0\vec{k} + v_x\hat{\imath} + v_y\hat{\jmath} + v_z\hat{k} \times - B_0\vec{J}\,)$

= q$(E_0\vec{k} + B_0v_x\hat{\imath} + B_0v_z\hat{k})$

Now, since

$vx = 0,$

$\Rightarrow F_z = qE_0$

So, acceleration is given by

$$a_z = \frac{qE_0}{m}$$

From 3rd equation for motion

$$v^2 = u^2 + 2as$$

where

u = initial velocity

v= final velocity

s=distance travelled

and a = acceleration of the particle

$$v^2 = \frac{2qE_0z}{m}$$

So,

$$v = \sqrt{\frac{2qE_0z}{m}}$$

Here, *z* is the distance along the *z*-direction.

Answer.52

Given-Potential difference applied across the plates of the capacitor = *V*Separation between the plates = *d*Magnetic field intensity = *B*

The electric field applied across the plates of a capacitor

,

$$E = \frac{V}{d}$$

Also, coulomb's force experienced by the electron is given by,

$$F = eE$$

where e= charge on the electron and

E= electric field applied

Hence, the force experienced by the electron due to this electric field,

$$F = e\frac{V}{d}$$

Now, acceleration a is given by-

$$acceleration = force \times mass$$

$$\Rightarrow a = \frac{F}{m} = \frac{eV}{m_e \times d},$$

where

e = charge of the electron

m_e = mass of the electron

From 3rd equation for motion

$$v^2 = u^2 + 2as$$

where

u = initial velocity

v= final velocity

s=distance travelled

and a = acceleration of the particle

substituting the value of *a*-

$$v^2 = 2 \times \frac{eV}{m_e \times d} \times d$$

$$\Rightarrow v = \sqrt{\frac{2\,e\,V}{m_e}}$$

The electron will move in a circular path due to the presence of the magnetic field.

The radius of the circular path described by a particle in a magnetic field r,

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

where,

m is the mass of a proton

v= velocity of the particle

B = magnetic force

q= charge on the particle =$1.6 \times 10{-}^{19}$ C

Radius of the circular path followed by the electron is ,

$$r = \frac{m_e v}{eB}$$

And the electron will fail to strike the upper plate of the

capacitor if and only if the radius of the circular path will be less

than *d*,

i.e. d>r

$$\Rightarrow d > \frac{m_e}{eB} \times \frac{m_e v}{eB}$$

$$\Rightarrow d > \sqrt{\frac{2m_e v}{eB^2}}$$

Thus, the electron will fail to strike the upper plate if

$$d > \sqrt{\frac{2m_e v}{eB^2}}$$

Answer.53

Given-No. of turns in the coil, n = 100

Area of the coil, $A = 5 \times 4\ \text{cm}^2 = 20 \times 10^{-4}\ \text{m}^2$

Magnitude of current = 2 A

Torque acting on the coil, $\tau = 0.2\ \text{N m}^{-1}$

We know that torque acting on a rectangular coil having n turns is given by

$$Torque, \tau = niA \times B$$

Where

B= applied magnetic field

A= area of rectangular loop

I = current flowing through coil

n = number of turns

$$\tau = niA \times B$$

$$\Rightarrow \tau = niBA \sin 90°$$

$$\Rightarrow 0.2 = 100 \times 2 \times 20 \times 10 - 4 \times B$$

$$\Rightarrow B = 0.5\,T$$

Answer.54

Given-No. of turns of the coil, n = 50

Magnetic field intensity, $B = 0.20\ \text{T} = 2 \times 10^{-1}\ \text{T}$

Radius of the coil, $r = 0.02\ \text{m} = 2 \times 10^{-2}\ \text{m}$

Magnitude of current =5 A

We know that torque acting on a rectangular coil having n turns is given by

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

Where

B= applied magnetic field

A= area of rectangular loop

I = current flowing through coil

θ = angle between the area vector and magnetic field

Torque is maximum if

$\theta = 90°$.

$\tau_{max} = niAB\sin 90°$

$= 50 \times 5 \times 3.14 \times 4 \times 10^{-4} \times 2 \times 10^{-1}$

$= 6.28 \times 10^{-2}\ N - m$

Given that ,

$\tau = \frac{1}{2}\tau_{max}$

$\Rightarrow \sin\theta = \frac{1}{2}$

$\Rightarrow \theta = 30°$

So, the angle between the magnetic field and the plane of coil is given by -

$90° - 30° = 60°$

Answer.55

Given-No. of turns of the coil, n = 50

Magnetic field, B = 0.20 T = 2×10^{-1} T

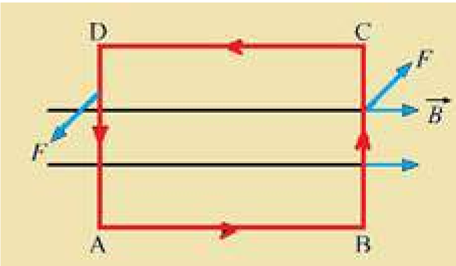
Magnitude of current, I = 5 A

Length of the loop, l = 20 cm = 20×10^{-2} m,

Breadth of the loop, w = 10 cm = 10×10^{-2} m,

So, area of the loop, A = length ×width = 0.02 m^2,

Let ABCD be the rectangular loop.



(a)There is no force acts along the the sides *ab* and *cd*, as they are parallel to the magnetic field.

$$\Rightarrow \tau = niBA \sin 0°$$

$$= 0$$

But the force acting on the sides *ad* and *bc* are equal in magnitude but opposite

So, they cancel out each other

.Hence, the net force on the loop is zero.

(b) Torque acting on the coil,

$$\Rightarrow \tau = niBA \sin \theta$$

Where

B= applied magnetic field

A= area of rectangular loop

I = current flowing through coil

θ = angle between the area vector and magnetic field

$$\Rightarrow \tau = niBA \sin 90^0$$

$$= 1 \times 5 \times 0.02 \times 0.2$$

$= 0.02\ Nm$

So, the torque acting on the loop is 0.02 Nm and is parallel to the shorter side

Answer.56

Given-

No. of turns of the coil, n = 500

Magnetic field intensity, B = 0.40 T = 4×10^{-1} T

Radius of the coil, r = 2 cm = 2×10^{-2} m

Magnitude of current, i = 1 A

Angle between the area vector and magnetic field, θ = 30°

Torque acting on the coil,

$\Rightarrow \tau = niBA \sin\theta$

Where

B= applied magnetic field

A= area of rectangular loop

I = current flowing through coil

θ = angle between the area vector and magnetic field

$\tau = 500 \times 1 \times 3.14 \times 4 \times 10^{-4} \times 4 \times 10^{-1} \times 12$

$= 12.56 \times 10^{-2}$

$= 0.1256$

$= 0.13\ Nm$

Answer.57

Given-Magnetic field intensity = *B*

Magnitude of current = *i*

Circumference, $L = 2\pi r$,

where

r is the radius of the coil

So, area of the coil,

$$A = \frac{L^2}{4\pi}$$

Torque acting on the coil,

$$\Rightarrow \tau = niBA \sin\theta$$

Where

B= applied magnetic field

A= area of rectangular loop

I = current flowing through coil

θ = angle between the area vector and magnetic field

$$\Rightarrow \tau = niBA$$

$$= \frac{iL^2B}{4\pi}$$

(b) Let *s* be the length of the square loop.

Then given in the question that

$$4s = L$$

$$\Rightarrow s = \frac{L}{4}$$

$$A = \left(\frac{L}{4}\right)^2$$

$$= \frac{L^2}{16}$$

$$\Rightarrow \tau = niBA = \frac{iL^2B}{16}$$

So, the torque in case of the circular loop is larger.

Answer.58

Given-Number of turns in the coil = *n*

Edge of the square loop = *l*

Magnetic field intensity = *B*

Magnitude of current = *i*

Angle between area vector and magnetic field, θ

= 90°Torque acting on the coil,

$$\Rightarrow \tau = niBA \sin\theta$$

Where

B= applied magnetic field

A= area of rectangular loop

I = current flowing through coil

θ = angle between the area vector and magnetic field

$$\tau = nil2Bsin90^\circ$$

$$= nil^2B \ (1)$$

Torque produced due to weight is

given by,

$$T_{weight} = \frac{mgl}{2} \ (2)$$

where m is the mass

g is the acceleration due to gravity

For the coil to start tipping towards downwards,

$$T \geq T_{weight}$$

For minimum value of *B*,

$$T = T_{weight}$$

From (1) and(2)

$$\Rightarrow nil^2B = \frac{mgl}{2}$$

$$\Rightarrow B = \frac{mg}{2nil}$$

Answer.59

Given-Radius of the ring = *r*

Mass of the ring = *m*

Total charge enclosed on the ring =

q

(a) Angular speed-

We know that angular speed is given by-
$\omega = 2\pi f$
now frequency f

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

$$\omega = \frac{2\pi}{T}$$

$$\Rightarrow T = \frac{2\pi}{\omega}$$

Current in the ring,

$i \ = charge \times time$

$= \ qT$

$= \ q\frac{\omega}{2\pi} \ (1)$

(b)For a ring of area *A* with current *i* flowing through it, magnetic moment,

$\mu \ = \ niA$

where,

A= area of cross section

i=current flowing through it

n = number of turns

for number of turns *n* = 1

$\mu \ = \ ia$

From (1)

$\mu = q\frac{\omega}{2\pi}\times\pi r^2 =$

$\mu = \frac{q\omega r^2}{2} \ (2)$

(d) Angular momentum *l*,

$l \ = I\omega$

where

I is moment of inertia of the ring about its axis of rotation.

ω is angular velocity

$I \ = \ mr^2$

Where

m is the mass

r is the radius of gyration.

$I \ = \ mr^2\omega$

So,

$\Rightarrow \omega r^2 \ = \ \frac{l}{m}$

Putting this value in equation (2), we get-

$$\mu = \frac{q\omega r^2}{2} = \frac{ql}{2m}$$

Answer.60

Given-Radius of the ring =

rMass of the ring = m

Total charge of the ring =

qAngular speed$\omega = 2\pi f$

Where

F is the frequency

Now frequency f

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

Where,

T is the time period

$$\Rightarrow \omega = \frac{2\pi}{T}$$

$$\Rightarrow T = \frac{2\pi}{\omega}$$

Magnetic moment,

where,

A= area of cross section

i=current flowing through it

n = number of turns$\mu = niA$

for number of turns n = 1

$\mu = ia$

Current in the ring,

$$current = charge \times time$$

$$i = qT$$

$$= q\frac{2\pi}{\omega}$$

For the ring of area *A* with current *i*, magnetic moment,m is given by

$$m = iA$$

Where A is the area of the loop

$$\Rightarrow m = q\frac{2\pi}{\omega} \times \pi r^2 = \frac{q\omega r^2}{2} \ (1)$$

Angular momentum,

$$l = I\omega \ (2)$$

where

I is the moment of inertia of the ring about its axis of rotation.

ω is the angular moment

Moment of inertia, *I* is given by-

$$I = mr^2$$

where,

m is the mass of the object

r is the radius of the circular object

So, substituting in (2)

$$l = mr^2\omega$$

$$\Rightarrow \omega r^2 = \frac{l}{m}$$

Putting this value ωr^2 in equation (1),

$$\mu = \frac{q\omega r^2}{2} = \frac{ql}{2m}$$

Answer.61

Given

radius of solid sphere = r

mass of sphere = m

charge on the sphere =q

angular speed of the sphere = ω

magnetic moment and the angular momentum ℓ of the sphere are related –

$$\mu = \frac{q}{2m} l$$

Lets consider a differential strip of width *dx* at a distance *x* from the centre of the sphere.

Area of the strip is given as,

$$da = 4\pi \times dx$$

now, current i is given by-

$$i = \frac{dq}{dt}$$

Angular speed,

$$\omega = 2\pi f$$

Now frequency f

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

$$\Rightarrow \omega = \frac{2\pi}{T}$$

$$\Rightarrow T = \frac{2\pi}{\omega}$$

current i becomes

$$i = q\frac{\omega}{2\pi}$$

Magnetic moment is given by-$\mu = \boldsymbol{niA}$

where,

A= area of cross section

i=current flowing through it

n = number of turns

for number of turns n = 1

$$\boldsymbol{\mu = ia}$$

Integrating over the sphere-

$$\boldsymbol{\mu = \frac{q\omega}{2\pi} 4\pi \int_0^r x\, dx}$$

$$\boldsymbol{= q.\omega r^2}$$

$$\boldsymbol{= \frac{q}{m} l}$$