



NCERT Solutions for Class 12 Physics Chapter 4 Moving Charges and Magnetism

Q 4.1) A circular coil of wire consisting of 100 turns, each of radius 8.0 cm carries a current of 0.40 A. What is the magnitude of the magnetic field B at the centre of the coil?

Answer 4.1:

Given:

The number of turns on the coil (n) is 100

The radius of each turn (r) is 8 cm or 0.08 m

The magnitude of the current flowing in the coil (I) is 0.4 A

The magnitude of the magnetic field at the centre of the coil can be obtained by the following relation:

$$|\vec{B}| = \frac{\mu_0 2\pi n I}{4\pi r}$$

where

μ_0
is the permeability of free space =
 $4\pi \times 10^{-7} \text{ T m A}^{-1}$

hen

$$|\vec{B}| = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{2\pi \times 100 \times 0.4}{0.08}$$

$$3.14 \times 10^{-4} \text{ T}$$

The magnitude of the magnetic field is

$$3.14 \times 10^{-4} \text{ T}$$

Q 4.2) A long straight wire carries a current of 35 A. What is the magnitude of the field B at a point 20 cm from the wire?

Answer 4.2:

The magnitude of the current flowing in the wire (I) is 35 A

The distance of the point from the wire (r) is 20 cm or 0.2

m



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At this point, the magnitude of the magnetic field is given by the relation:

$$|\vec{B}| = \frac{\mu_0 2I}{4\pi r}$$

where,

μ_0
= Permeability of free space
=

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

Substituting the values in the equation, we get

$$|\vec{B}| = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{2 \times 35}{0.2}$$

$$3.5 \times 10^{-5} \text{ T}$$

Hence, the magnitude of the magnetic field at a point 20 cm from the wire is

$$3.5 \times 10^{-5} \text{ T}$$

Q 4.3) A long straight wire in the horizontal plane carries a current of 50 A in the north-to-south direction. Give the magnitude and direction of B at a point 2.5 m east of the wire.

Answer 4.3:

The magnitude of the current flowing in the wire is (I) = 50 A.

Point B is 2.5 m away from the east of the wire.

Therefore, the magnitude of the distance of the point from the wire (r) is 2.5 m

The magnitude of the magnetic field at that point is given by the relation:

$$|\vec{B}| = \frac{\mu_0 2I}{4\pi r}$$

where,



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$$\mu_0$$

= Permeability of free space
=

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

$$|\vec{B}| = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{2 \times 50}{2.5}$$

=

$$4 \times 10^{-6} \text{ T}$$

The point is located normal to the wire length at a distance of 2.5 m. The direction of the current in the wire is vertically downward. Hence, according to Maxwell's right-hand thumb rule, the direction of the magnetic field at the given point is vertically upward.

Q 4.4) A horizontal overhead power line carries a current of 90 A in the east-to-west direction. What is the magnitude and direction of the magnetic field due to the current 1.5 m below the line?

Answer 4.4:

The magnitude of the current in the power line is (I) = 90

A The point is located below the electrical cable at

$$|\vec{B}| = \frac{\mu_0 2I}{4\pi r}$$

where

$$\mu_0$$

= Permeability of free space
=

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

Substituting values in the above equation, we get



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$$|\vec{B}| = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{2 \times 90}{1.5}$$

=

$$1.2 \times 10^{-5} \text{ T}$$

The current flows from east to west. The point is below the electrical cable.

Hence, according to Maxwell's right-hand thumb rule, the direction of the magnetic field is towards the south.

Q 4.5) What is the magnitude of magnetic force per unit length on a wire carrying a current of 8 A and making an angle of 30° with the direction of a uniform magnetic field of 0.15 T?

Answer 4.5:

In the problem,

The current flowing in the wire is (I) = 8 A

The magnitude of the uniform magnetic field (B) is 0.15

The angle between the wire and the magnetic field,

$$\theta = 30^\circ$$

The magnetic force per unit length on the wire is given as $F =$

$$BI \sin \theta$$

=

$$0.15 \times 8 \times 1 \times \sin 30^\circ$$

=

$$0.6 \text{ N m}^{-1}$$

Hence, the magnetic force per unit length on the wire is

$$0.6 \text{ N m}^{-1}$$



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Q 4.6) A 3.0 cm wire carrying a current of 10 A is placed inside a solenoid perpendicular to its axis. The magnetic field inside the solenoid is given to be 0.27 T. What is the magnetic force on the wire?

Answer 4.6:

In the problem,

The length of the wire (l) is 3 cm or 0.03 m

The magnitude of the current flowing in the wire (I) is 10 A

The strength of the magnetic field (B) is 0.27 T

The angle between the current and the magnetic field is

$$\theta = 90^\circ$$

The magnetic force exerted on the wire
is

$$F = BIl \sin \theta$$

Substituting the values in the above equation, we get

$$0.27 \times 10 \times 0.03 \times \sin 90^\circ$$

=

$$8.1 \times 10^{-2} \text{ N}$$

Hence, the magnetic force on the wire is

$$8.1 \times 10^{-2} \text{ N}$$

The direction of the force can be obtained from Fleming's left-hand rule.

Q 4.7) Two long and parallel straight wires, A and B, carrying currents of 8.0 A and 5.0 A in the same direction, are separated by a distance of 4.0 cm. Estimate the force on a 10 cm section of wire A.

Answer 4.7:

The magnitude of the current flowing in the wire A (



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$$I_A) \text{ is } 8 \text{ A}$$

The magnitude of the current flowing in wire B (

$$I_B) \text{ is } 5 \text{ A}$$

The distance between the two wires (r) is 4 cm or 0.04 m

The length of the section of wire A (L) = 10 cm = 0.1 m

The force exerted on the length L due to the magnetic field is calculated as follows:

$$F = \frac{\mu_0 I_A I_B L}{2\pi r}$$

where,

$$\begin{aligned} \mu_0 &= \text{Permeability of free space} = \\ &4\pi \times 10^{-7} \text{ T m A}^{-1} \end{aligned}$$

Substituting the values, we get

$$F = \frac{4\pi \times 10^{-7} \times 8 \times 5 \times 0.1}{2\pi \times 0.04} = 2 \times 10^{-5} \text{ N}$$

The magnitude of the force is

$$2 \times 10^{-5} \text{ N}$$

This is an attractive force normal to A towards B because the direction of the currents in the wires is the same.

Q 4.8) A closely wound solenoid 80 cm long has 5 layers of windings of 400 turns each. The diameter of the solenoid is 1.8 cm. If the current carried is 8.0 A, estimate the magnitude of B inside the solenoid near its centre.

Answer 4.8:

Solenoid length (l) = 80 cm = 0.8 m

Five layers of windings of 400 turns each on the solenoid.

∴

Total number of turns on the solenoid, N = 5 × 400 = 2000

Solenoid Diameter (D) = 1.8 cm = 0.018 m

The current carried by the solenoid (I) = 8.0 A



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The relation that gives the magnitude of the magnetic field inside the solenoid near its centre is given below:

$$B = \frac{\mu_0 NI}{l}$$

Where,

$$\begin{aligned} \mu_0 &= \text{Permeability of free space} = \\ &4\pi \times 10^{-7} \text{ T m A}^{-1} \\ B &= \frac{4\pi \times 10^{-7} \times 2000 \times 8}{0.8} \\ &= \\ &2.5 \times 10^{-2} \text{ T} \end{aligned}$$

Hence, the magnitude of B inside the solenoid near its centre is

$$2.5 \times 10^{-2} \text{ T}$$

Q 4.9) A square coil of side 10 cm consists of 20 turns and carries a current of 12 A. The coil is suspended vertically, and the normal to the plane of the coil makes an angle of 30° with the direction of a uniform horizontal magnetic field of magnitude 0.80 T. What is the magnitude of torque experienced by the coil?

Answer 4.9:

In the given problem,

The length of a side of the square coil (l) is 10 cm or 0.1 m

The magnitude of the current flowing in the coil (I) is 12 A

The number of turns on the coil (n) is 20

The angle made by the plane of the coil with B (Magnetic field),

$$\theta = 30^\circ$$

The strength of the magnetic field (B) is 0.8 T

The following relation gives the magnitude of the magnetic torque experienced by the coil in the magnetic field:



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$$\tau = n BIA \sin\theta$$

Where,

A = Area of the square coil

$$= 1 \times 1 = 0.1 \times 0.1 = 0.01 \text{ m}^2$$

So,

$$\tau = 20 \times 0.8 \times 12 \times 0.01 \times \sin 30^\circ$$

$$= 0.96 \text{ N m}$$

Hence, 0.96 N m is the magnitude of the

Q 4.10) Two moving coil meters, M_1 and

$$R_1 = 10 \Omega, N_1 = 30$$

,

$$A_1 = 3.6 \times 10^{-3} \text{ m}^2, B_1 = 0.25 \text{ T}$$

$$R_2 = 14 \Omega, N_2 = 42$$

,

$$A_2 = 1.8 \times 10^{-3} \text{ m}^2, B_2 = 0.5 \text{ T}$$

(The spring constants are identical for the two meters). Determine the ratio of (a) current sensitivity and (b) voltage sensitivity of M_2 and M_1 .

Answer 4.10:

Given data:

	Moving Coil Meter M_1	Moving Coil Meter M_2
Resistance	$R_1 = 10 \Omega$	$R_2 = 14 \Omega$



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Number of turns	$N_1=30$	$N_2=42$
Area	$A_1=3.6 \times 10^{-3} \text{ m}^2$	$A_2=1.8 \times 10^{-3} \text{ m}^2$
Magnetic field strength	$B_1 = 0.25 \text{ T}$	$B_2 = 0.5 \text{ T}$
Spring constant	$K_1 = K$	$K_2 = K$

(a) Current sensitivity of M_1

$$I_{s1} = \frac{N_1 B_1 A_1}{K_1}$$

And, Current sensitivity of M_2

$$I_{s2} = \frac{N_2 B_2 A_2}{K_2}$$

$$\therefore \text{Ratio } \frac{I_{s2}}{I_{s1}} = \frac{N_2 B_2 A_2}{N_1 B_1 A_1} = \frac{42 \times 0.5 \times 1.8 \times 10^{-3} \times K}{K \times 30 \times 0.25 \times 3.6 \times 10^{-3}} = 1.4$$

Hence, the ratio of the current sensitivity of

(b) Voltage sensitivity for M_2

$$V_{s2} = \frac{N_2 B_2 A_2}{K_2 R_2}$$

And voltage sensitivity for M_1

$$V_{s1} = \frac{N_1 B_1 A_1}{K_1 R_1}$$

$$\therefore \text{Ratio } \frac{I_{s2}}{I_{s1}} = \frac{N_2 B_2 A_2 K_1 R_1}{N_1 B_1 A_1 K_2 R_2} = \frac{42 \times 0.5 \times 1.8 \times 10^{-3} \times 10 \times K}{K \times 14 \times 30 \times 0.25 \times 3.6 \times 10^{-3}} = 1$$

Hence, the ratio of voltage sensitivity of M_2 to M_1 is 1.



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Q 4.11) In a chamber, a uniform magnetic field of 6.5 G ($1 \text{ G} = 10^{-4} \text{ T}$) is maintained. An electron is shot into the field with a speed of $4.8 \times 10^6 \text{ m/s}$, normal to the field. Explain why the path of the electron is a circle. Determine the radius of the circular orbit. (

$$e = 1.6 \times 10^{-19} \text{ C}, m_e = 9.1 \times 10^{-31} \text{ kg}$$

)
Answer 4.11:

Magnetic field strength (B) = 6.5 G =

$$6.5 \times 10^{-4} \text{ T}$$

Speed of the

$$4.8 \times 10^6 \text{ m/s}$$

Charge on the

$$1.6 \times 10^{-19} \text{ C}$$

Mass of the

$$9.1 \times 10^{-31} \text{ kg}$$

The angle between the shot electron

$$\theta = 90^\circ$$

The relation for Magnetic force exerted on the electron in the magnetic field is given as:

$$F = evB \sin\theta$$

This force provides centripetal force to the moving electron. Hence, the electron starts moving in a circular path of radius r .

Hence, the centripetal force exerted on the electron,

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



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In equilibrium, the centripetal force exerted on the electron is equal to the magnetic force, i.e.,

$$F_c = F$$

=>

$$\frac{mv^2}{r} = evB \sin\theta$$

=>

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

S

$$r = \frac{9.1 \times 10^{-31} \times 4.8 \times 10^6}{6.5 \times 10^{-4} \times 1.6 \times 10^{-19} \times \sin 90^\circ} = 4.2 \times 10^{-2} \text{ m} = 4.2 \text{ cm}$$

Hence, 4.2 cm is the radius of the circular

Q 4.12) In Exercise 4.11, find the frequency of revolution of the electron in its circular orbit. Does the answer depend on the speed of the electron? Explain.

Answer 4.12:

$$6.5 \times 10^{-4} \text{ T}$$

Charge on the

$$1.6 \times 10^{-19} \text{ C}$$

Mass of the electron (m_e) =

$$9.1 \times 10^{-31} \text{ kg}$$

Speed of the electron (v) =

$$4.8 \times 10^6 \text{ m/s}$$



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Radius of the orbit, $r = 4.2 \text{ cm} = 0.042 \text{ m}$

Frequency of revolution of the electron = ν

Angular frequency of the electron =

$$\omega = 2\pi\nu$$

The velocity of the electron is related to the angular frequency as:

$$v = r\omega$$

In the circular orbit, the magnetic force on the electron is balanced by the centripetal force.

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

\Rightarrow

$$eB = \frac{mv}{r} = \frac{m(r\omega)}{r} = \frac{m(r \cdot 2\pi\nu)}{r}$$

\Rightarrow

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

This expression for frequency is independent of the speed of the electron. On substituting the known values in this expression, we get the

$$\nu = \frac{6.5 \times 10^{-4} \times 1.6 \times 10^{-19}}{2 \times 3.14 \times 9.1 \times 10^{-31}} = 1.82 \times 10^6 \text{ Hz} \approx 18 \text{ MHz}$$

Hence, the frequency of the electron is around 18 MHz and is independent of the speed of the electron.

Q 4.13) (a) A circular coil having a radius of 8.0 cm, the number of turns as 30 and carrying a current of 6.0 A is suspended vertically in a uniform horizontal magnetic field of magnitude 1.0 T. The field lines make an angle of 60° with the normal of the coil. To prevent the coil from turning, determine the magnitude of the counter-torque that must be applied.

(b) Would your answer change, if the circular coil in (a) were replaced by a planar coil of some irregular shape that encloses the same area? (All other particulars are also unaltered.)



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Answer 4.13:

(a) Number of turns on the circular coil (n)

= 30 Radius of the coil (r) = 8.0 cm = 0.08 m

Area of the coil =

$$\pi r^2 = \pi(0.08)^2 = 0.0201 \text{ m}^2$$

Current flowing in the coil (I) = 6.0

A Magnetic field strength, B = 1 T

The angle between the field lines and

$$\theta = 60^\circ$$

The coil experiences a torque in the magnetic field. Hence, it turns. The counter torque applied to prevent the coil from turning is given by the

$$\tau = nIBA \sin\theta$$

=

$$30 \times 6 \times 1 \times 0.0201 \times \sin 60^\circ$$

$$= 3.133 \text{ Nm}$$

(b) It can be inferred

$$\tau = nIBA \sin\theta$$

that the magnitude of the applied torque is not dependent on the shape of the coil. It depends on the area of the coil. Hence, the answer would not change if the circular coil in the above case is replaced by a planar coil of some irregular shape that encloses the same area.