Q.1: A parallel plate capacitor has a separation of 4 mm and potential difference of 200 volt between its plates. The capacitor is placed in a uniform magnetic field \( B \). An electron projected vertically upward parallel to the plates with a velocity of \( 10^6 \) m/s, passes between the plates undeflected. Find the magnitude and direction of the magnetic field \( B \) between the plates. [IIT 81]

Sol.:  

\[
E = \frac{V}{d} = \frac{200V}{4 \times 10^{-3} \text{m}} = 5 \times 10^4 \text{ V/m}
\]

and force due to this electric field on \( e^- \)

\[ F = eE \quad \ldots(i) \]

and force on the \( e^- \) due to presence of magnetic field

\[ F = evB \quad \ldots(ii) \]

so from (i) and (ii)

\[ eE = evB \]

\[ B = \frac{E}{v} = \frac{5 \times 10^4}{10^6} = 5 \times 10^{-2} \text{ wb/m}^2 \]

Q.2: An electron is moving in a magnetic field of intensity \( 10^{-2} \) wb/m\(^2\) with a velocity of \( 10^7 \) m/s in a circular path of radius 0.57 cm. Find out the specific charge of electron.
Sol.: When particle moves in circular path, necessary centripetal force \( \frac{mv^2}{r} \) is maintained with lorentz force due to magnetic field i.e. \( qvB \).

So for electron

\[
e vB = \frac{mv^2}{r} \Rightarrow \frac{e}{m} = \frac{v}{Br}
\]

\[
\therefore \quad \frac{e}{m} = \frac{10^7}{10^{-2} \times (0.57 \times 10^{-2})} = 1.76 \times 10^{11} \text{ C/kg}
\]

Q.3 : An electron after being accelerated through a P. D. of \( 10^4 \) V enters a uniform magnetic field of 0.04 T perpendicular to its direction of motion. Calculate the radius of curvature of its trajectory.

Sol.: When electron is accelerated with potential \( V \) then

\[
\frac{1}{2}mv^2 = eV \quad \text{...(i)}
\]

and in magnetic field \( B \), electron takes circular path and centripetal force

\[
\frac{mv^2}{r} = evB \quad \text{...(ii)}
\]

from (i) and (ii)

\[
r = \frac{1}{B} \sqrt{\frac{2mV}{e}}
\]

\[
= \frac{1}{0.04} \sqrt{\frac{2 \times 9.1 \times 10^{-31} \times 10^4}{1.6 \times 10^{-19}}}
\]

\[
= 84.3 \times 10^{-4} \text{ m}
\]

\[
= 8.43 \text{ mm}
\]

Q.4 : In cylindrical coordinates, \( B = \left( \frac{4}{r} \right) \hat{\phi} \text{ T.} \) Determine the magnetic flux \( \phi \) crossing the plane surface given by \( 0.5 \leq r \leq 2.5 \text{ m} \) and \( 0 \leq z \leq 2.0 \text{ m} \).

Sol.: We know that flux

\[
\phi = \oint \mathbf{B} \cdot d\mathbf{s}
\]
\[ \int_0^2 \int_0^{2.5} \left( \frac{4}{r} \right) \hat{\rho} \, dr \, dz \]

\[ = 8 \ln \left( \frac{2.5}{0.5} \right) = 12.88 \, \text{wb} \]

Q.5: What is the magnitude of force on a wire of length 0.02 m placed inside a solenoid near its centre making an angle of 30° with its axis? The wire carries a current of 6A and the magnetic field due to solenoid is 0.25 T.

Sol.: The force on any conductor of length \( l \) is given by

\[ F = I l B \sin \theta \]

\[ = 6 \times 0.02 \times 0.25 \times 0.5 \]

\[ = 0.015 \, \text{N}. \]

Q.6: A horizontal overhead power lines carries a current of 90A from East to West. Compute the magnetic field generated at a distance of 1.5 m below the line.

Sol.: The magnitude of magnetic field due to a long, straight conductor is given by

\[ B = \frac{\mu_0 I}{2\pi R} \]

here

\[ \frac{\mu_0}{2\pi} = 2 \times 10^{-7} \, \text{N/A}^2 \]

\[ = \left( 2 \times 10^{-7} \right) \times \frac{90}{1.5} \]

\[ = 1.2 \times 10^{-5} \, \text{NA}^{-1} \, \text{m}^{-1} \]

Q.7: A differential current element with 10 Amp current and length \( 2 \times 10^{-3} \, \text{m} \) is located at (2, 0, 0). Calculate the magnetic field \( \vec{B} \) due to this element at (0, 0, 2).

Sol.: Here

\[ I = 10 \, \text{amp} \]

\[ dl = 2 \times 10^{-3} \, \text{m} \]

and

\[ \vec{dl} = 2 \times 10^{-3} \hat{i} \, \text{m} \]

so

\[ I \cdot dl = 2 \times 10^{-2} \hat{i} \]

the distance between point and current element
\[ \vec{r} = (0-2)i + (0-0)j + (2-0)k \]
\[ = -2i + 2k \]
\[ |\vec{r}| = \sqrt{2^2 + 2^2} = \sqrt{8} = 2\sqrt{2} \]

and
\[ \hat{r} = \frac{-2\hat{i} + 2\hat{k}}{\sqrt{8}} = \frac{2(-\hat{i} + \hat{k})}{2\sqrt{2}} \]
\[ = \frac{-\hat{i} + \hat{k}}{\sqrt{2}} \]

from Biot Savart law

\[ \vec{B} = \frac{\mu_0}{4\pi} \frac{I}{r^2} \times \hat{r} \]
\[ = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{0.02\hat{i}}{(\sqrt{2})^2} \times \frac{2(-\hat{i} + \hat{k})}{\sqrt{2}} \]
\[ = -0.02 \times 10^{-7} \frac{\hat{j}}{\sqrt{2}} \]
\[ = -\frac{2 \times 10^{-9}}{\sqrt{2}} \hat{j} = -\sqrt{2} \times 10^{-9} \hat{j} \]
\[ = -1.414 \times 10^{-9} \hat{j} \text{ weber/m} \]

Q.8 : A helium nucleus is completing one round of a circle of radius 0.8 m in 4 seconds. Show that the magnetic field at the centre of the circle is \(0.5 \times 10^{-19} \mu_0 \text{ T.}\)

Sol.: As we know that helium nucleus has a charge of +2e hence it is considered as a circle of radius \(r\) meter equivalent to a current loop and the centre, the magnetic field

\[ \vec{B} = \frac{\mu_0 I}{2r} \text{ T} \]

if one revolution takes \(t\) sec then the current is

\[ I = \frac{2e}{t} \text{ amp} \]
so

\[ B = \frac{\mu_0 2e}{2rt} = \frac{\mu_0 e}{rt} \]

\[ = \frac{\mu_0 \times 1.6 \times 10^{-19}}{0.8 \times 4} \]

\[ = 0.5 \times 10^{-19} \mu_0 \, T . \]

**Q.9 : The magnetic flux threading a coil changes form** \(12 \times 10^{-3} \text{ wb} \) **to** \(6 \times 10^{-3} \text{ wb} \) **in** \(0.01 \text{ s} \). **Calculate the induced emf.**

**Sol.:** According to Faraday’s law, the induced emf is

\[ e = -\frac{\Delta (N \phi)}{\Delta t} \]

\[ = -\frac{(6 \times 10^{-3}) - (12 \times 10^{-3})}{0.01} \]

\[ = 0.6 \, \text{wb/s} \]

\[ = 0.6 \, \text{V} \]

**Q.10 : A coil having 100 turns and area 0.20 m² is placed normally in a magnetic field. the field changes from 0.20 wb/m² to 0.60 wb/m² uniformly over a period of 0.01 s. Calculate the emf induced in the coil.**

**Sol.:** For each coil placed perpendicular to a magnetic field \(B\) is given by

\[ \phi = BA \]

and change in flux due to change in \(B\) is

\[ \Delta \phi = (\Delta B) \, A \]

\[ = (0.60 - 0.20) \, \text{wb/m}^2 \times 0.20 \, \text{m}^2 \]

\[ = 0.08 \, \text{wb} \]

By Faraday law, the magnitude of the induced emf is

\[ |e| = N \frac{\Delta \phi}{\Delta t} \]

\[ = \frac{100 \times 0.08}{0.01} \]

\[ = 800 \, \text{V} \]

**Q.11 : When a magnetic flux lines changes from** \(5.5 \times 10^{-4} \) **to** \(5 \times 10^{-5} \) **in** \(0.1 \text{ sec} \)
through a coil of resistance 10 ohm with 1000 times. Find the electromotive force and
the charge flowing through the coil.

Sol.: Here change in flux

\[ \Delta \phi = \left( 5 \times 10^{-5} \right) - \left( 5.5 \times 10^{-4} \right) \]

\[ = -50 \times 10^{-5} \text{ wb} \]

hence induced emf

\[ e = -N \frac{\Delta \phi}{\Delta t} \]

\[ = -1000 \times \left( -50 \times 10^{-5} \right) \]

\[ = 5 \text{ V} \]

the developed current \[ I = \frac{e}{R} \]

\[ = \frac{5 \text{ V}}{10 \Omega} = 0.5 \text{ Amp} . \]

so the charge passed through the coil is

\[ q = I \times \Delta t = 0.5 \times 0.1 = 0.05 \text{ C} \]

Q.12 : A current distribution gives rise to the vector potential
\[ \vec{A} = x^2 y \hat{i} + y^2 \hat{j} - 4xyz \hat{k} \text{ wb/m. Calculate (i) } \vec{B} \text{ at } (-1, 2, 5) \text{ (ii) magnetic flux through the surfaces defined by } z = 1, \quad 0 \leq x \leq 1, \quad -1 \leq y \leq 4 . \text{ [RU 2001]} \]

Sol.: As curl of the vector potential will give the magnetic field intensity

\[ \vec{B} (-1, 2, 5) = \text{curl } \vec{A} \]

\[
\begin{vmatrix}
\hat{i} & \hat{j} & \hat{k} \\
\frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\
x^2y & y^2x & -4xyz
\end{vmatrix}
\]
\[ = [-4xz] \hat{i} - [-4yz] \hat{j} + (y^2 - x^2) \hat{k} \]

\[ = 20 \hat{i} + 40 \hat{j} + 3 \hat{k} \text{ wb/m}^2 \]

and flux \( \phi = \oint \vec{B} \cdot d\vec{s} \)

where \( \vec{B} = -4xz \hat{i} + 4yz \hat{j} + (y^2 - x^2) \hat{k} \)

and \( d\vec{s} = dx \, dy \, \hat{k} \)

so the flux \( \phi = \oint \vec{B} \cdot d\vec{s} \)

\[ = \int_{-1}^{1} \int_{0}^{1} \left[ -4xz \hat{i} + 4yz \hat{j} + (y^2 - x^2) \hat{k} \right] dx \, dy \hat{k} \]

\[ = \int_{-1}^{1} \int_{0}^{1} (y^2 - x^2) dx \, dy = \int_{-1}^{1} \left[ y^2 \left( -\frac{1}{3} \right) \right] dy \]

\[ = \left[ \frac{y^3}{3} - \frac{y}{3} \right]_{-1}^{1} = \frac{60}{3} = 20 \text{ wb} \]

**Q.13**: Copper has \( 8 \times 10^{28} \) free conduction electrons/m\(^3\). A copper wire of length 2.0 m and cross sectional area \( 8 \times 10^{-6} \) m\(^2\) carrying a current and lying perpendicular to a magnetic field of \( 5 \times 10^{-3} \) T experiences a force of \( 8 \times 10^{-2} \) N. Calculate the drift velocity of free electrons in the wire.

**Sol.**: When free electrons move with velocity \( v_d \) in the wire then the current is

\[ I = neA \, v_d \] \hspace{1cm} \text{...(i)}

and force on the conductor

\[ F = IBl \] \hspace{1cm} \text{...(ii)}

so

\[ I = \frac{8 \times 10^{-2} \text{N}}{(5 \times 10^{-3}) \times 2 \text{m}} \]

\[ = 8 \text{A} \]
and

\[ v_d = \frac{I}{\text{neA}} = \frac{8A}{8 \times 10^{-8} \times 1.6 \times 10^{-19} \times 8 \times 10^{-6}} \]

\[ = 0.78 \times 10^{-4} \text{ m/s} \]

Q.17 : A current of 20 Amp flows in downward direction in a long straight vertical wire and magnetic flux density in horizontal direction is \( 2 \times 10^{-4} \) T. what is the distance of the neutral point form the wire?

Sol.: Neutral point will be where horizontal magnetic field will become equal to the magnetic field produced by current carrying conductor.

So

\[ B_H = \frac{\mu_0 I}{2\pi r} \]

\[ 2 \times 10^{-5} = \frac{4\pi \times 10^{-7} \times 20}{2\pi \times r} \]

\[ r = 0.2 \text{ m} \]

Q.18 : A circular coil is placed in uniform magnetic field of 0.10 T normal to the plane of the coil. If the current is 5.0 A in the coil, Find (a) total torque on the coil (b) total force on the coil (c) average force on each electron due to magnitude field (The coil in made of copper wire of cross section \( 10^{-5} \) m² and free electron density in copper is \( 10^{29} \) m⁻³).

Sol.: We know that the torque on a current carrying coil of area A is

\[ \tau = NIAB \sin \theta \]

(a) here \( \theta = 0 \) i.e. \( \sin \theta = 0 \) so \( \tau = 0 \)

(b) the net forces will always zero.

(c) and magnitude of force on a free electron

\[ F = ev_d B \]

\[ = \frac{IB}{nA} \]  

(as \( I = neAv_d \))

\[ = \frac{5 \times 0.10}{10^{29} \times 10^{-5}} = 5 \times 10^{-25} \text{ N} \]

Q.19 : In the figure two current carrying wires are A and B. Find the magnitude and directions of the magnetic field at points 1, 2 and 3.

Sol.:
We know that magnetic field at R distance from straight current carrying wire

\[ B = \frac{\mu_0 I}{2\pi R} \]

\[ = \left(2 \times 10^{-7}\right) \frac{I}{R} \text{ NA}^{-1} \text{ m}^{-1} \]

Due to current in wire A at point 1 field will perpendicular upward and at 2 and 3 downwards and similarly due to current in wire B, 1 and 2 will be downward and 3 will be upward.

Hence points 1 and 3 are in opposite fields whereas point 3 will be always in same direction.

So resultant field at 1

\[ B = B_1 - B_2 \]

\[ = \left(2 \times 10^{-7}\right) \frac{20}{0.1} - \left(2 \times 10^{-7}\right) \times \frac{30}{0.3} \]

\[ = 2 \times 10^{-5} \text{ NA}^{-1} \text{ m}^{-1} \text{ perpendicular and upward to page.} \]

at 2

\[ B = B_1 + B_2 \]

\[ = \left(2 \times 10^{-7}\right) \left[ \frac{20}{0.1} + \frac{30}{0.3} \right] \]

\[ = 1 \times 10^{-4} \text{ NA}^{-1} \text{ m}^{-1} \text{ perpendicular and downward to page.} \]
\[
B = B_2 - B_1 \\
= \left(2 \times 10^{-7}\right) \left[ \frac{30}{0.1} - \frac{20}{0.3} \right] \\
= 4.7 \times 10^{-5} \text{ NAm}^{-1}\text{m}^{-1} \text{ perpendicular and upward to the page.}
\]

**Q.20**: 8.0 cm length of a conductor is placed parallel to 2m length of a conductor at a distance of 2.0 cm. The conductors carry currents of 2 and 5 Amp respectively in opposite direction. Find the total force exerted on the long conductor.

**Sol.**: We know the magnetic field near to any straight conductor

\[
B = \frac{\mu_0 I}{2\pi R}
\]

So the force experienced by the short conductor carrying a current \(I_2\)

\[
F = I_2 Bl
\]

\[
= \frac{\mu_0 I_1 I_2 l}{2\pi R}
\]

so

\[
F = \left(2 \times 10^{-7}\right) \times \frac{5 \times 2 \times 8 \times 10^{-2}}{2 \times 10^{-2}}
\]

\[
= 8 \times 10^{-6} \text{ N}
\]

according to Newton’s third law, the long conductor will also experience an equal repulsive force \(8 \times 10^{-6} \text{ N}\) due to the small conductor.

**Q.21**: An air-cored solenoid of length 50 cm and area of cross-section 28 cm\(^2\) has 200 turns and carries a current of 5A. On switching off, the current decreases to zero within a time interval of 2 ms. Find the average induced emf across the ends of the switch.

**Sol.**: As we know magnetic field

\[
B = \mu_0 n I \quad \quad \text{(n = No. of turns/length)}
\]

\[
= \left(4\pi \times 10^{-7}\right) \times \left(\frac{200}{50 \times 10^{-2}}\right) \times 5
\]
when switch off, flux reduces to zero, so change in flux.

\[ \Delta \phi = 0 - NBA \]

\[ = -200 \times (25 \times 10^{-4}) \times (28 \times 10^{-4}) \]

\[ = -14 \times 10^{-4} \text{ wb} \]

and induced emf

\[ e = -\frac{\Delta \phi}{\Delta t} = \frac{14 \times 10^{-7}}{2 \times 10^{-3}} = 0.7 \text{ V} \]

**SUMMARY**

- When any electric charge moves in a combined effect of electric and magnetic field then total force experienced by the charge

\[ \vec{F} = q \left[ \vec{E} + \vec{v} \times \vec{B} \right] \]

- If a current carrying conductor of length is placed in any magnetic field then the force experienced by that length of the conductor

\[ F = I \vec{l} \times \vec{B} \]

\[ = I l b \sin \theta \]

- Magnetic flux

\[ \phi_B = \oint \vec{B} \cdot \hat{d}s \]

- Gauss law of magnetism

\[ \oint \vec{B} \cdot \hat{d}s = 0 \]

- Divergence of magnetic field is given as

\[ \vec{\nabla} \cdot \vec{B} = 0 \]

which shows that magnetic poles exist in pairs.

- According to Biot-Savart law, the magnetic field at a point near to any current
carrying conductor is given by
\[ dB = \frac{\mu_0}{4\pi} \frac{I \, d\vec{l} \times \hat{r}}{r^2} \]

- Magnetic field at the centre of a current carrying loop of radius \( r \).
  \[ B = \frac{\mu_0 I}{2r} \]

- Magnetic field at a point due to current carrying straight conductor
  \[ B = \frac{\mu_0}{4\pi} \frac{I}{R} \left( \sin \phi_1 + \sin \phi_2 \right) \]

- Magnetic field of a solenoid
  \[ B = \frac{\mu_0 n I}{2\pi} \text{ m}^{-1} \]

- Force between two parallel current carrying conductors
  \[ F = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{R} \]

  this is attractive when currents are in same direction and repulsive when currents are in opposite direction.

- Magnetic field at the axis of current carrying circular coil
  \[ B = \frac{\mu_0 N I a^2}{2 \left( a^2 + x^2 \right)^{3/2}} \text{ m}^{-1} \]

- Magnetic field at the centre
  \[ B = \mu_0 n I \]

According to Ampere's circuital law the line integral of magnetic field due to a closed current carrying loop
\[ \oint \vec{B} \cdot d\vec{l} = \mu_0 I \quad \text{Integral form} \]

\[ \nabla \times \vec{B} = \mu_0 \vec{J} \quad \text{Differential form} \]

- Magnetic field due to a current carrying cylinder

\[ B = \frac{\mu_0 I r}{2\pi R^2} \quad \text{for} \quad r < R \]

\[ = \frac{\mu_0 I}{2\pi r} \quad \text{for} \quad r > R \]

\[ = 0 \quad \text{for a hollow cylinder and} \quad r < R. \]

- According to 1st law of electromagnetic induction, when ever there is a change in magnetic flux linked with any closed solenoid then there is emf produced known as induced emf.

- According to 2nd law of electromagnetic induction the induced emf is given by

\[ e = \frac{\Delta \phi}{\Delta t} \]

- According to 3rd law of EMI, the direction of induced emf is such as to oppose its cause of production so

\[ e = -\frac{\Delta \phi}{\Delta t}, \text{ this is known as Lenz's law.} \]

\[ \oint \vec{E} \cdot d\vec{l} = -\oint \frac{\partial \vec{B}}{\partial t} \cdot d\vec{s} \quad \text{integral form of Faraday electromagnetic law.} \]

\[ \nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \quad \text{Differential form of Faraday's electromagnetic law.} \]

- **Right hand palm rule No. 2**
If we stretch palm of right hand such that the stretched fingers points towards the magnetic field direction and thumb points to the direction of current the force on the conductor will be perpendicular to the palm.

- **Flemming’s left hand rule –**

If the thumb, middle finger and fore finger of the left hand are stretched in mutually perpendicular direction such that fore finger points in the direction of magnetic field $\vec{B}$ and middle finger towards the current direction then thumb will point in force $\vec{F}$ direction on the conductor.

- **Right hand palm rule no. 1**

If we stretch right hand palm such that thumb points in current direction and fingers towards the P point at which magnetic field $\vec{B}$ direction is to be found, then the perpendicular to the palm will show the direction of $\vec{B}$ at P.

- **Right hand thumb rule –**
It is used to find the direction of magnetic field due to a straight current carrying conductor. If we hold the straight conductor in our right hand in such away that thumb points in current direction, then the encircled fingers represents the magnetic field lines around the conductor.

- **Maxwell's right hand screw rule**

If we takes the screw driver in our right hand such that it points to current direction and if we rotates it in such a manner that screw moves in the direction of current, then the direction of rotation of screw driver will tell the direction of magnetic field lines.

- **Direction of Induced current - Fleming's right hand rule**–
If we stretch the right hand thumb, fore finger and middle finger in mutually perpendicular direction in such a manner that fore finger is towards direction of magnetic field and thumb points in the direction of motion of conductor, then the middle finger will point in the direction of induced current.

**EXERCISE**

1. Describe the magnitude and direction of force acting on a charge moving in a magnetic field. When it is minimum and when it is maximum?

2. Derive an expression for the force experienced by a current-carrying straight conductor placed in a uniform magnetic field. State the rule to find the direction of this force.

3. Write Biot-Savart law for the magnetic field due to a current element, explaining the symbols.

4. Discuss analogies and differences between coulomb's law and Biot-Savart law.

5. A current is flowing through a thin, straight metallic conductor of infinite length. Find expression for the magnetic field at a distance from it.

6. Derive the relation for the force per unit length between two infinitely-long, parallel, straight conductors carrying current. Hence define one ampere.

7. Derive an expression for the magnetic field at a point on the axis of a circular coil carrying current, and hence at the centre of the coil.

8. Derive the expression for the magnetic field at the centre of a circular current carrying coil.

9. Deduce the expression for the magnetic field produced at the centre of a semicircular wire loop of radius $R$, carrying a current $I$.

10. Describe the magnetic field within a long, current carrying solenoid. Obtain expressions for the field within and at the ends of the solenoid.

11. State and explain Ampere's circuited law. Hence derive an expression for the magnetic
field due to a solenoid.

12. Calculate, using Ampere's circuital law, the magnetic field due to infinitely-long current carrying conductor.


14. Show that lenz's law follows the principle of conservation of energy.

15. Give integral form of Faraday's laws of electromagnetic induction and convert these into differential forms.


17. Write the formula for the force on a charge q moving with velocity \( \vec{v} \) in a uniform magnetic field \( \vec{B} \). What is the magnitude of this force? When this will be zero?

18. Prove that \( \vec{\nabla} \cdot \vec{B} = 0 \) where \( \vec{B} \) is the magnetic flux density.

19. What is vector potential? How the vector field can be calculated?

20. Prove that \( \vec{\nabla} \times \vec{B} = \mu_0 \vec{J} \).

21. Deduce the differential form of Ampere's circuital law and hence prove that static magnetic field is not conservative.


23. An electron is moving vertically upward with a speed of \( 2 \times 10^8 \) m/s. What will be the magnitude and direction of the force on the electron exerted by a horizontal magnetic field of 0.50 wb/m\(^2\) directed towards west? What will be the acceleration of the electron? \( [1.6 \times 10^{-11} \text{N north}, 1.8 \times 10^{19} \text{m/s}^2] \)

24. An electron moving with velocity \( 5 \times 10^7 \) m/s enters a magnetic field of 1.0 wb/m\(^2\) at an angle of 30 to the field. Calculate the force on the electron.

\[ 4 \times 10^{-12} \text{N} \]

25. A 2-MeV proton is moving perpendicular to a uniform magnetic field of 2.5 T. Find the force on the proton. [Given mass of proton = \( 1.65 \times 10^{-27} \) kg]

\[ \text{Ans.: } 7.88 \times 10^{-12} \text{N} \]

26. A 40 cm long wire carrying a current of 2.5A is placed perpendicular to a magnetic field of \( 8 \times 10^{-3} \) wb/m\(^2\). Find the force experienced by the wire. \[ 8 \times 10^{-3} \text{N} \]

27. A current of 5.0 A is flowing upward in a long vertical wire placed in a uniform
horizontal north-ward magnetic field of 0.0207. How much forces and in what
direction will the field exert on 0.06 m length of the wire. [6 × 10⁻³ N, west]

28. A straights wire carries a current of 3A. Calculate the magnitude of the magnetic
field at a point 10 cm away from the wire. Draw a diagram to show the direction
of the magnetic field. [6 × 10⁻⁶ T]

29. A circular loop of radius 5 cm carries a current of 0.5 amp. Calculate the magnitude
of the magnetic field at its centre. [6.28 × 10⁻⁶ N/A-m]

30. Calculate the force per unit length on a long straight wire carrying a current 4 amp
due to a parallel wire carrying a current of 6 A. The distance between the wires is
3.0 cm. [1.6 × 10⁻⁴ N/m]

31. Two parallel wires, each of length 2 m and carrying a current of 0.40 A in the same
direction, are placed 0.40 m apart in air. Find the force per unit length on each wire.
[8 × 10⁻⁸ N/m attractive]

32. An Air-solenoid has 500 turn of wire in its 40 cm length. If the current in the wire
be 1.0 A, find the magnetic field at the axis inside the solenoid.
[1.57 × 10⁻³ NA⁻¹ m⁻¹]

33. The magnetic field at the centre of a 50 cm long solenoid is 4 × 10⁻² N/(A-m) when
a current of 8 amp flows through it. What is the number of turns in the solenoid.
[1990]

34. A 0.5 m long solenoid has 500 turns and has a flux density of 2.52 × 10⁻³ T at its
centre. Find the current in the solenoid. [2.0 Amp.]

35. A test charge having charge 0.4 C is moving with a velocity of \( \left( 4\hat{i} - \hat{j} + 2\hat{k} \right) \) m/s
through an electric field of intensity \( 10\hat{i} + 10\hat{k} \) and a magnetic field \( 2\hat{i} - 6\hat{j} - 6\hat{k} \).
Determine the magnitude and direction of the lorentz force acting on the test charge.
[WBUT 2007]

36. If the vector potential \( A = \left( x^2 + y^2 - z^2 \right)\hat{j} \) at \( (x, y, z) \). Find the magnetic field at
(1, 1, 1). [WBUT 2007]