## QUESTIONS FOR SHORT ANSWER

1. An electric current flows in a wire from north to south. What will be the direction of the magnetic field due to this wire at a point east of the wire ? West of the wire ? Vertically above the wire ? Vertically below the wire ?
2. The magnetic field due to a long straight wire has been derived in terms of $\mu_0$, $i$ and $d$. Express this in terms of $\varepsilon_0$, $c$, $i$ and $d$.
3. You are facing a circular wire carrying an electric current. The current is clockwise as seen by you. Is the field at the centre coming towards you or going away from you ?
4. In Ampere's law $\oint \vec{B}\cdot d\vec{l} = \mu_0 i$, the current outside the curve is not included on the right hand side. Does it mean that the magnetic field $B$ calculated by using Ampere's law, gives the contribution of only the currents crossing the area bounded by the curve ?
5. The magnetic field inside a tightly wound, long solenoid is $B = \mu_0 ni$. It suggests that the field does not depend on the total length of the solenoid, and hence if we add more loops at the ends of a solenoid the field should not increase. Explain qualitatively why the extra-added loops do not have a considerable effect on the field inside the solenoid.
6. A long, straight wire carries a current. Is Ampere's law valid for a loop that does not enclose the wire ? That encloses the wire but is not circular ?
7. A straight wire carrying an electric current is placed along the axis of a uniformly charged ring. Will there be a magnetic force on the wire if the ring starts rotating about the wire ? If yes, in which direction ?
8. Two wires carrying equal currents $i$ each, are placed perpendicular to each other, just avoiding a contact. If one wire is held fixed and the other is free to move under magnetic forces, what kind of motion will result ?
9. Two proton beams going in the same direction repel each other whereas two wires carrying currents in the same direction attract each other. Explain.
10. In order to have a current in a long wire, it should be connected to a battery or some such device. Can we obtain the magnetic field due to a straight, long wire by using Ampere's law without mentioning this other part of the circuit ?
11. Quite often, connecting wires carrying currents in opposite directions are twisted together in using electrical appliances. Explain how it avoids unwanted magnetic fields.
12. Two current-carrying wires may attract each other. In absence of other forces, the wires will move towards each other increasing the kinetic energy. Does it contradict the fact that the magnetic force cannot do any work and hence cannot increase the kinetic energy ?

## OBJECTIVE I

1. A vertical wire carries a current in upward direction. An electron beam sent horizontally towards the wire will be deflected
(a) towards right (b) towards left
(c) upwards (d) downwards.
2. A current-carrying, straight wire is kept along the axis of a circular loop carrying a current. The straight wire
(a) will exert an inward force on the circular loop
(b) will exert an outward force on the circular loop
(c) will not exert any force on the circular loop
(d) will exert a force on the circular loop parallel to itself.
3. A proton beam is going from north to south and an electron beam is going from south to north. Neglecting the earth's magnetic field, the electron beam will be deflected
(a) towards the proton beam
(b) away from the proton beam
(c) upwards (d) downwards.
4. A circular loop is kept in that vertical plane which contains the north-south direction. It carries a current that is towards north at the topmost point. Let $A$ be a point on the axis of the circle to the east of it and $B$ a point on this axis to the west of it. The magnetic field due to the loop
(a) is towards east at $A$ and towards west at $B$
(b) is towards west at $A$ and towards east at $B$
(c) is towards east at both $A$ and $B$
(d) is towards west at both $A$ and $B$.
5. Consider the situation shown in figure (35-Q1). The straight wire is fixed but the loop can move under magnetic force. The loop will
(a) remain stationary
(b) move towards the wire
(c) move away from the wire
(d) rotate about the wire.

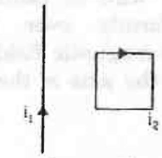



Figure 35-Q1

6. A charged particle is moved along a magnetic field line. The magnetic force on the particle is
(a) along its velocity (b) opposite to its velocity
(c) perpendicular to its velocity (d) zero.
7. A moving charge produces
(a) electric field only (b) magnetic field only
(c) both of them (d) none of them.

8. A particle is projected in a plane perpendicular to a uniform magnetic field. The area bounded by the path described by the particle is proportional to
(a) the velocity (b) the momentum
(c) the kinetic energy (d) none of these.

9. Two particles $X$ and $Y$ having equal charge, after being accelerated through the same potential difference enter a region of uniform magnetic field and describe circular paths of radii $R_1$ and $R_2$ respectively. The ratio of the mass of $X$ to that of $Y$ is
(a) $(R_1/R_2)^{1/2}$ (b) $R_1/R_2$ (c) $(R_1/R_2)^2$ (d) $R_1R_2$.

10. Two parallel wires carry currents of 20 A and 40 A in opposite directions. Another wire carrying a current antiparallel to 20 A is placed midway between the two wires. The magnetic force on it will be
(a) towards 20 A (b) towards 40 A (c) zero
(d) perpendicular to the plane of the currents.

11. Two parallel, long wires carry currents $i_1$ and $i_2$ with $i_1 > i_2$. When the currents are in the same direction, the magnetic field at a point midway between the wires is 10 μT. If the direction of $i_2$ is reversed, the field becomes 30 μT. The ratio $i_1/i_2$ is
(a) 4 (b) 3 (c) 2 (d) 1.

12. Consider a long, straight wire of cross-sectional area $A$ carrying a current $i$. Let there be $n$ free electrons per unit volume. An observer places himself on a trolley moving in the direction opposite to the current with a speed $v = \frac{i}{nAe}$ and separated from the wire by a distance $r$. The magnetic field seen by the observer is very nearly
(a) $\frac{\mu_0 i}{2\pi r}$ (b) zero (c) $\frac{\mu_0 i}{\pi r}$ (d) $\frac{2\mu_0 i}{\pi r}$.

## OBJECTIVE II

1. The magnetic field at the origin due to a current element $i\,\vec{dl}$ placed at a position $\vec{r}$ is
(a) $\frac{\mu_0 i}{4\pi}\frac{\vec{dl}\times\vec{r}}{r^3}$ (b) $-\frac{\mu_0 i}{4\pi}\frac{\vec{r}\times\vec{dl}}{r^3}$
(c) $\frac{\mu_0 i}{4\pi}\frac{\vec{r}\times\vec{dl}}{r^3}$ (d) $-\frac{\mu_0 i}{4\pi}\frac{\vec{dl}\times\vec{r}}{r^3}$.

2. Consider three quantities $x = E/B$, $y = \sqrt{1/\mu_0\varepsilon_0}$ and $z = \frac{l}{CR}$. Here, $l$ is the length of a wire, $C$ is a capacitance and $R$ is a resistance. All other symbols have standard meanings.
(a) $x$, $y$ have the same dimensions.
(b) $y$, $z$ have the same dimensions.
(c) $z$, $x$ have the same dimensions.
(d) None of the three pairs have the same dimensions.

3. A long, straight wire carries a current along the $Z$-axis. One can find two points in the $X$–$Y$ plane such that
(a) the magnetic fields are equal
(b) the directions of the magnetic fields are the same
(c) the magnitudes of the magnetic fields are equal
(d) the field at one point is opposite to that at the other point.

4. A long, straight wire of radius $R$ carries a current distributed uniformly over its cross-section. The magnitude of the magnetic field is
(a) maximum at the axis of the wire
(b) minimum at the axis of the wire
(c) maximum at the surface of the wire
(d) minimum at the surface of the wire.

5. A hollow tube is carrying an electric current along its length distributed uniformly over its surface. The magnetic field
(a) increases linearly from the axis to the surface
(b) is constant inside the tube
(c) is zero at the axis
(d) is zero just outside the tube.

6. In a coaxial, straight cable, the central conductor and the outer conductor carry equal currents in opposite directions. The magnetic field is zero
(a) outside the cable
(b) inside the inner conductor
(c) inside the outer conductor
(d) in between the two conductors.

7. A steady electric current is flowing through a cylindrical conductor.
(a) The electric field at the axis of the conductor is zero.
(b) The magnetic field at the axis of the conductor is zero.
(c) The electric field in the vicinity of the conductor is zero.
(d) The magnetic field in the vicinity of the conductor is zero.

## EXERCISES

1. Using the formulae $\vec{F} = q\vec{v}\times\vec{B}$ and $B = \frac{\mu_0 i}{2\pi r}$, show that the SI units of the magnetic field B and the permeability constant $\mu_0$ may be written as N/A–m and N/A$^2$ respectively.

2. A current of 10 A is established in a long wire along the positive $Z$-axis. Find the magnetic field $\vec{B}$ at the point (1 m, 0, 0).

3. A copper wire of diameter 1·6 mm carries a current of 20 A. Find the maximum magnitude of the magnetic field $\vec{B}$ due to this current.

4. A transmission wire carries a current of 100 A. What would be the magnetic field $B$ at a point on the road if the wire is 8 m above the road?

5. A long, straight wire carrying a current of 1·0 A is placed horizontally in a uniform magnetic field $B = 1{\cdot}0 \times 10^{-3}$ T pointing vertically upward (figure 35-E1). Find the magnitude of the resultant magnetic field at the points $P$ and $Q$, both situated at a distance of 2·0 cm from the wire in the same horizontal plane.

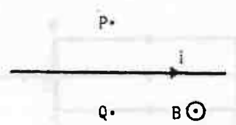



Figure 35-E1

6. A long, straight wire of radius $r$ carries a current $i$ and is placed horizontally in a uniform magnetic field $B$ pointing vertically upward. The current is uniformly distributed over its cross-section. (a) At what points will the resultant magnetic field have maximum magnitude? What will be the maximum magnitude? (b) What will be the minimum magnitude of the resultant magnetic field?

7. A long, straight wire carrying a current of 30 A is placed in an external, uniform magnetic field of $4{\cdot}0 \times 10^{-4}$ T parallel to the current. Find the magnitude of the resultant magnetic field at a point 2·0 cm away from the wire.

8. A long, vertical wire carrying a current of 10 A in the upward direction is placed in a region where a horizontal magnetic field of magnitude $2{\cdot}0 \times 10^{-3}$ T exists from south to north. Find the point where the resultant magnetic field is zero.

9. Figure (35-E2) shows two parallel wires separated by a distance of 4·0 cm and carrying equal currents of 10 A along opposite directions. Find the magnitude of the magnetic field $B$ at the points $A_1$, $A_2$, $A_3$ and $A_4$.

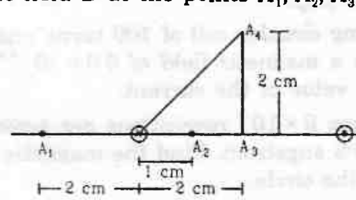



Figure 35-E2

10. Two parallel wires carry equal currents of 10 A along the same direction and are separated by a distance of 2·0 cm. Find the magnetic field at a point which is 2·0 cm away from each of these wires.

11. Two long, straight wires, each carrying a current of 5 A, are placed along the $X$- and $Y$-axes respectively. The currents point along the positive directions of the axes. Find the magnetic fields at the points (a) (1 m, 1 m), (b) (− 1 m, 1 m), (c) (− 1 m, − 1 m) and (d) ( 1 m, − 1 m).

12. Four long, straight wires, each carrying a current of 5·0 A, are placed in a plane as shown in figure (35-E3). The points of intersection form a square of side 5·0 cm. (a) Find the magnetic field at the centre $P$ of the square. (b) $Q_1$, $Q_2$, $Q_3$ and $Q_4$ are points situated on the diagonals of the square and at a distance from $P$ that is equal to the length of the diagonal of the square. Find the magnetic fields at these points.

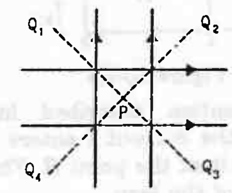



Figure 35-E3

13. Figure (35-E4) shows a long wire bent at the middle to form a right angle. Show that the magnitudes of the magnetic fields at the points $P$, $Q$, $R$ and $S$ are equal and find this magnitude.

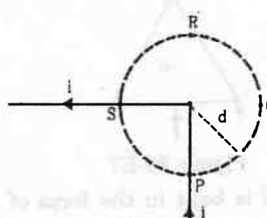



Figure 35-E4

14. Consider a straight piece of length $x$ of a wire carrying a current $i$. Let $P$ be a point on the perpendicular bisector of the piece, situated at a distance $d$ from its middle point. Show that for $d >> x$, the magnetic field at $P$ varies as $1/d^2$ whereas for $d << x$, it varies as $1/d$.

15. Consider a 10 cm long piece of a wire which carries a current of 10 A. Find the magnitude of the magnetic field due to the piece at a point which makes an equilateral triangle with the ends of the piece.

16. A long, straight wire carries a current $i$. Let $B_1$ be the magnetic field at a point $P$ at a distance $d$ from the wire. Consider a section of length $l$ of this wire such that the point $P$ lies on a perpendicular bisector of the section. Let $B_2$ be the magnetic field at this point due to this section only. Find the value of $d/l$ so that $B_2$ differs from $B_1$ by 1%.

17. Figure (35-E5) shows a square loop $ABCD$ with edge-length $a$. The resistance of the wire $ABC$ is $r$ and that of $ADC$ is $2r$. Find the magnetic field $B$ at the centre of the loop assuming uniform wires.

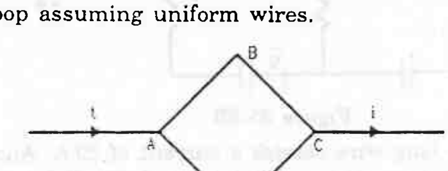



Figure 35-E5

18. Figure (35-E6) shows a square loop of edge $a$ made of a uniform wire. A current $i$ enters the loop at the point $A$ and leaves it at the point $C$. Find the magnetic field at

the point $P$ which is on the perpendicular bisector of $AB$ at a distance $a/4$ from it.

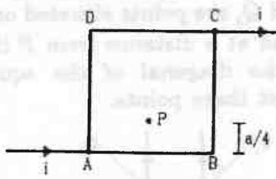



Figure 35-E6

19. Consider the situation described in the previous problem. Suppose the current $i$ enters the loop at the point $A$ and leaves it at the point $B$. Find the magnetic field at the centre of the loop.

20. The wire $ABC$ shown in figure (35-E7) forms an equilateral triangle. Find the magnetic field $B$ at the centre $O$ of the triangle assuming the wire to be uniform.

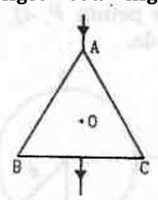



Figure 35-E7

21. A wire of length $l$ is bent in the form of an equilateral triangle and carries an electric currrent $i$. (a) Find the magnetic field $B$ at the centre. (b) If the wire is bent in the form of a square, what would be the value of $B$ at the centre ?

22. A long wire carrying a current $i$ is bent to form a plane angle $\alpha$. Find the magnetic field $B$ at a point on the bisector of this angle situated at a distance $x$ from the vertex.

23. Find the magnetic field $B$ at the centre of a rectangular loop of length $l$ and width $b$, carrying a current $i$.

24. A regular polygon of $n$ sides is formed by bending a wire of total length $2\pi r$ which carries a current $i$. (a) Find the magnetic field $B$ at the centre of the polygon. (b) By letting $n \to \infty$. deduce the expression for the magnetic field at the centre of a circular current.

25. Each of the batteries shown in figure (35-E8) has an emf equal to 5 V. Show that the magnetic field $B$ at the point $P$ is zero for any set of values of the resistances.

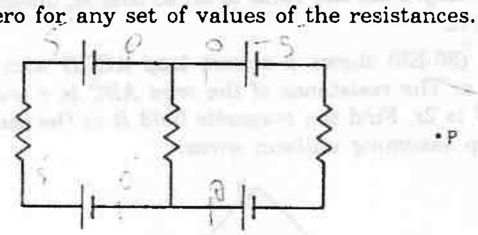



Figure 35-E8

26. A straight, long wire carries a current of 20 A. Another wire carrying equal current is placed parallel to it. If the force acting on a length of 10 cm of the second wire is 2·0 × $10^{-5}$ N, what is the separation between them ?

27. Three coplanar parallel wires, each carrying a current of 10 A along the same direction, are placed with a separation 5·0 cm between the consecutive ones. Find the magnitude of the magnetic force per unit length acting on the wires.

28. Two parallel wires separated by a distance of 10 cm carry currents of 10 A and 40 A along the same direction. Where should a third current be placed so that it experiences no magnetic force ?

29. Figure (35-E9) shows a part of an electric circuit. The wires $AB$, $CD$ and $EF$ are long and have identical resistances. The separation between the neighbouring wires is 1·0 cm. The wires $AE$ and $BF$ have negligible resistance and the ammeter reads 30 A. Calculate the magnetic force per unit length of $AB$ and $CD$.

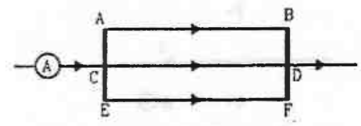



Figure 35-E9

30. A long, straight wire is fixed horizontally and carries a current of 50·0 A. A second wire having linear mass density 1·0 × $10^{-4}$ kg/m is placed parallel to and directly above this wire at a separation of 5·0 mm. What current should this second wire carry such that the magnetic repulsion can balance its weight ?

31. A square loop $PQRS$ carrying a current of 6·0 A is placed near a long wire carrying 10 A as shown in figure (35-E10). (a) Show that the magnetic force acting on the part $PQ$ is equal and opposite to that on the part $RS$. (b) Find the magnetic force on the square loop.

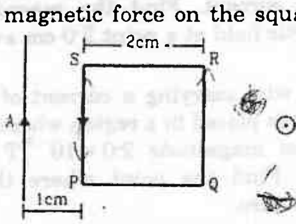



Figure 35-E10

32. A circular loop of one turn carries a current of 5·00 A. If the magnetic field $B$ at the centre is 0·200 mT, find the radius of the loop.

33. A current-carrying circular coil of 100 turns and radius 5·0 cm produces a magnetic field of 6·0 × $10^{-3}$ T at its centre. Find the value of the current.

34. An electron makes 3 × $10^{5}$ revolutions per second in a circle of radius 0·5 angstrom. Find the magnetic field $B$ at the centre of the circle.

35. A conducting circular loop of radius $a$ is connected to two long, straight wires. The straight wires carry a current $i$ as shown in figure (35-E11). Find the magnetic field $B$ at the centre of the loop.

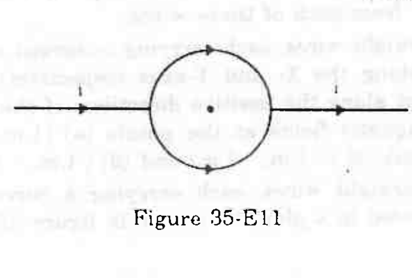



Figure 35-E11

**36.** Two circular coils of radii 5·0 cm and 10 cm carry equal currents of 2·0 A. The coils have 50 and 100 turns respectively and are placed in such a way that their planes as well as the centres coincide. Find the magnitude of the magnetic field $B$ at the common centre of the coils if the currents in the coils are (a) in the same sense (b) in the opposite sense.

**37.** If the outer coil of the previous problem is rotated through 90° about a diameter, what would be the magnitude of the magnetic field $B$ at the centre?

**38.** A circular loop of radius 20 cm carries a current of 10 A. An electron crosses the plane of the loop with a speed of $2 \cdot 0 \times 10^{6}$ m/s. The direction of motion makes an angle of 30° with the axis of the circle and passes through its centre. Find the magnitude of the magnetic force on the electron at the instant it crosses the plane.

**39.** A circular loop of radius $R$ carries a current $I$. Another circular loop of radius $r$ ($<< R$) carries a current $i$ and is placed at the centre of the larger loop. The planes of the two circles are at right angle to each other. Find the torque acting on the smaller loop.

**40.** A circular loop of radius $r$ carrying a current $i$ is held at the centre of another circular loop of radius $R$($>> r$) carrying a current $I$. The plane of the smaller loop makes an angle of 30° with that of the larger loop. If the smaller loop is held fixed in this position by applying a single force at a point on its periphery, what would be the minimum magnitude of this force?

**41.** Find the magnetic field $B$ due to a semicircular wire of radius 10·0 cm carrying a current of 5·0 A at its centre of curvature.

**42.** A piece of wire carrying a current of 6·00 A is bent in the form of a circular arc of radius 10·0 cm, and it subtends an angle of 120° at the centre. Find the magnetic field $B$ due to this piece of wire at the centre.

**43.** A circular loop of radius $r$ carries a current $i$. How should a long, straight wire carrying a current $4i$ be placed in the plane of the circle so that the magnetic field at the centre becomes zero?

**44.** A circular coil of 200 turns has a radius of 10 cm and carries a current of 2·0 A. (a) Find the magnitude of the magnetic field $\vec{B}$ at the centre of the coil. (b) At what distance from the centre along the axis of the coil will the field $B$ drop to half its value at the centre? ($\sqrt[3]{4}$ = 1·5874 ...)

**45.** A circular loop of radius 4·0 cm is placed in a horizontal plane and carries an electric current of 5·0 A in the clockwise direction as seen from above. Find the magnetic field (a) at a point 3·0 cm above the centre of the loop (b) at a point 3·0 cm below the centre of the loop.

**46.** A charge of $3 \cdot 14 \times 10^{-6}$ C is distributed uniformly over a circular ring of radius 20·0 cm. The ring rotates about its axis with an angular velocity of 60·0 rad/s. Find the ratio of the electric field to the magnetic field at a point on the axis at a distance of 5·00 cm from the centre.

**47.** A thin but long, hollow, cylindrical tube of radius $r$ carries a current $i$ along its length. Find the magnitude of the magnetic field at a distance $r/2$ from the surface (a) inside the tube (b) outside the tube.

**48.** A long, cylindrical tube of inner and outer radii $a$ and $b$ carries a current $i$ distributed uniformly over its cross-section. Find the magnitude of the magnetic field at a point (a) just inside the tube (b) just outside the tube.

**49.** A long, cylindrical wire of radius $b$ carries a current $i$ distributed uniformly over its cross-section. Find the magnitude of the magnetic field at a point inside the wire at a distance $a$ from the axis.

**50.** A solid wire of radius 10 cm carries a current of 5·0 A distributed uniformly over its cross-section. Find the magnetic field $B$ at a point at a distance (a) 2 cm (b) 10 cm and (c) 20 cm away from the axis. Sketch a graph of $B$ versus $x$ for $0 < x < 20$ cm.

**51.** Sometimes we show an idealised magnetic field which is uniform in a given region and falls to zero abruptly. One such field is represented in figure (35-E12). Using Ampere's law over the path $PQRS$, show that such a field is not possible.

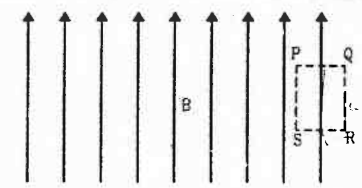



Figure 35-E12

**52.** Two large metal sheets carry surface currents as shown in figure (35-E13). The current through a strip of width $dl$ is $Kdl$ where $K$ is a constant. Find the magnetic field at the points $P$, $Q$ and $R$.

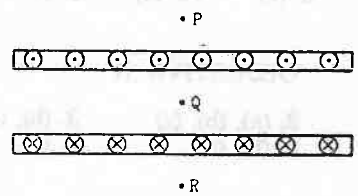



Figure 35-E13

**53.** Consider the situation of the previous problem. A particle having charge $q$ and mass $m$ is projected from the point $Q$ in a direction going into the plane of the diagram. It is found to describe a circle of radius $r$ between the two plates. Find the speed of the charged particle.

**54.** The magnetic field $B$ inside a long solenoid, carrying a current of 5·00 A, is $3 \cdot 14 \times 10^{-2}$ T. Find the number of turns per unit length of the solenoid.

**55.** A long solenoid is fabricated by closely winding a wire of radius 0·5 mm over a cylindrical nonmagnetic frame so that the successive turns nearly touch each other. What would be the magnetic field $B$ at the centre of the solenoid if it carries a current of 5 A?

**56.** A copper wire having resistance 0·01 ohm in each metre is used to wind a 400-turn solenoid of radius 1·0 cm and length 20 cm. Find the emf of a battery which when connected across the solenoid will cause a magnetic field of $1{\cdot}0 \times 10^{-2}$ T near the centre of the solenoid.

57. A tightly-wound solenoid of radius $a$ and length $l$ has $n$ turns per unit length. It carries an electric current $i$. Consider a length $dx$ of the solenoid at a distance $x$ from one end. This contains $n\,dx$ turns and may be approximated as a circular current $i\,n\,dx$. (a) Write the magnetic field at the centre of the solenoid due to this circular current. Integrate this expression under proper limits to find the magnetic field at the centre of the solenoid. (b) Verify that if $l >> a$, the field tends to $B = \mu_0 ni$ and if $a >> l$, the field tends to $B = \frac{\mu_0 nil}{2a}$. Interpret these results.

58. A tightly-wound, long solenoid carries a current of 2·00 A. An electron is found to execute a uniform circular motion inside the solenoid with a frequency of $1{\cdot}00 \times 10^{8}$ rev/s. Find the number of turns per metre in the solenoid.

59. A tightly-wound, long solenoid has $n$ turns per unit length, a radius $r$ and carries a current $i$. A particle having charge $q$ and mass $m$ is projected from a point on the axis in a direction perpendicular to the axis. What can be the maximum speed for which the particle does not strike the solenoid ?

60. A tightly-wound, long solenoid is kept with its axis parallel to a large metal sheet carrying a surface current. The surface current through a width $dl$ of the sheet is $Kdl$ and the number of turns per unit length of the solenoid is $n$. The magnetic field near the centre of the solenoid is found to be zero. (a) Find the current in the solenoid. (b) If the solenoid is rotated to make its axis perpendicular to the metal sheet, what would be the magnitude of the magnetic field near its centre ?

61. A capacitor of capacitance 100 μF is connected to a battery of 20 volts for a long time and then disconnected from it. It is now connected across a long solenoid having 4000 turns per metre. It is found that the potential difference across the capacitor drops to 90% of its maximum value in 2·0 seconds. Estimate the average magnetic field produced at the centre of the solenoid during this period.

□

## ANSWERS

### OBJECTIVE I

| | | | | | |
|---|---|---|---|---|---|
| 1. (c) | 2. (c) | 3. (a) | 4. (d) | 5. (b) | 6. (d) |
| 7. (c) | 8. (c) | 9. (c) | 10. (b) | 11. (c) | 12. (a) |

### OBJECTIVE II

| | | |
|---|---|---|
| 1. (c), (d) | 2. (a), (b), (c) | 3. (b), (c), (d) |
| 4. (b), (c) | 5. (b), (c) | 6. (a) |
| 7. (b), (c) | | |

### EXERCISES

2. 2 μT along the positive $Y$-axis
3. 5·0 mT
4. 2·5 μT
5. 20 μT, zero
6. (a) looking along the current, at the leftmost points on the wire's surface, $B = \frac{\mu_0 i}{2\pi r}$

   (b) zero if $r < \frac{\mu_0 i}{2\pi B}$, $B = \frac{\mu_0 i}{2\pi r}$ if $r > \frac{\mu_0 i}{2\pi B}$
7. $5 \times 10^{-4}$ T
8. 1·0 mm west to the wire
9. (a) $0{\cdot}67 \times 10^{-4}$ T (b) $2{\cdot}7 \times 10^{-4}$ T

   (c) $2{\cdot}0 \times 10^{-4}$ T (d) $1{\cdot}0 \times 10^{-4}$ T
10. $1{\cdot}7 \times 10$ [illegible] T in a direction parallel to the plane of the wires and perpendicular to the wires
11. (a) zero (b) 2 μT along the $Z$-axis

    (c) zero and (d) 2 μT along the negative $Z$-axis
12. (a) zero (b) $Q_1 : 1{\cdot}1 \times 10^{-4}$ T, $\odot$, $Q_2$ : zero,

    $Q_3 : 1{\cdot}1 \times 10^{-4}$ T, $\otimes$, and $Q_4$ : zero
13. $\frac{\mu_0 i}{4\pi d}$
15. 11·5 μT
16. 0·07
17. $\frac{\sqrt{2}\,\mu_0 i}{3\pi a}$, $\odot$
18. $\frac{2\mu_0 i}{\pi a}\left(\frac{1}{\sqrt{5}} - \frac{1}{3\sqrt{13}}\right)$, $\odot$
19. zero
20. zero
21. (a) $\frac{27\mu_0 i}{2\pi l}$ (b) $\frac{8\sqrt{2}\mu_0 i}{\pi l}$
22. $\frac{\mu_0 i}{2\pi x}\cot\frac{\alpha}{4}$
23. $\frac{2\mu_0 i\sqrt{l^2 + b^2}}{\pi l b}$
24. (a) $\frac{\mu_0 i n^2 \sin\frac{\pi}{n}\tan\frac{\pi}{n}}{2\pi^2 r}$

26. 40 cm
27. zero on the middle wire and $6.0 \times 10^{-4}$ N towards the middle wire on each of the rest two
28. 2 cm from the 10 A current and 8 cm from the other
29. $3 \times 10^{-3}$ N/m, downward zero
30. 0·49 A in opposite directiom
31. (b) $1.6 \times 10^{-?}$ N towards right
32. 1·57 cm
33. 48 mA
34. $6 \times 10^{-10}$ T
35. zero
36. (a) $8\pi \times 10^{-4}$ T (b) zero
37. 1·8 mT
38. $16\pi \times 10^{-11}$ N
39. $\frac{\mu_0 \pi i I r^2}{2R}$
40. $\frac{\mu_0 \pi i I r}{4R}$
41. $1.6 \times 10^{-?}$ T
42. $1.26 \times 10^{-5}$ T
43. at a distance of $4r/\pi$ from the centre in such a way that the direction of the current in it is opposite to that in the nearest part of the circular wire
44. (a) 2·51 mT (b) 7·66 cm
45. $4.0 \times 10^{-5}$ T, downwards in both the cases
46. $1.88 \times 10^{15}$ m/s
47. (a) zero (b) $\frac{\mu_0 i}{3\pi r}$
48. (a) zero (b) $\frac{\mu_0 i}{2\pi b}$
49. $\frac{\mu_0 i a}{2\pi b^2}$
50. (a) 2·0 μT (b) 10 μT (c) 5·0 μT
52. 0, $\mu_0 K$ towards right in the figure, 0
53. $\frac{\mu_0 K q r}{m}$
54. 5000 turns/m
55. $2\pi \times 10^{-3}$ T
56. 1 V
57. (a) $\frac{\mu_0 n i}{\sqrt{1 + \left(\frac{2a}{l}\right)^2}}$
58. 1420 turns/m
59. $\frac{\mu_0 q r n i}{2m}$
60. (a) $\frac{K}{2n}$ (b) $\frac{\mu_0 K}{\sqrt{2}}$
61. $16\pi \times 10^{-8}$ T

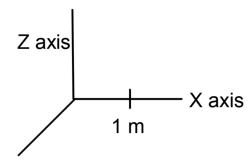
□

# CHAPTER – 35
# MAGNETIC FIELD DUE TO CURRENT

1. $F = q\vec{\upsilon} \times \vec{B}$ or, $B = \frac{F}{q\upsilon} = \frac{F}{IT\upsilon} = \frac{N}{A.\sec./\sec.} = \frac{N}{A-m}$

$B = \frac{\mu_0 I}{2\pi r}$ or, $\mu_0 = \frac{2\pi r B}{I} = \frac{m \times N}{A - m \times A} = \frac{N}{A^2}$

2. i = 10 A, d = 1 m



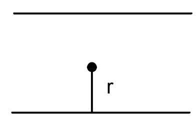

$B = \frac{\mu_0 i}{2\pi r} = \frac{10^{-7} \times 4\pi \times 10}{2\pi \times 1}$ = 20 × $10^{-6}$ T = 2 $\mu$T

Along +ve Y direction.

3. d = 1.6 mm

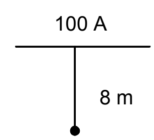
So, r = 0.8 mm = 0.0008 m

i = 20 A




$\vec{B} = \frac{\mu_0 i}{2\pi r} = \frac{4\pi \times 10^{-7} \times 20}{2 \times \pi \times 8 \times 10^{-4}}$ = 5 × $10^{-3}$ T = 5 mT

4. i = 100 A, d = 8 m

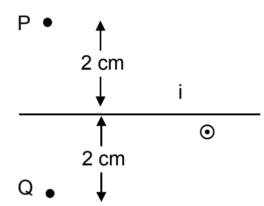



$B = \frac{\mu_0 i}{2\pi r}$

$= \frac{4\pi \times 10^{-7} \times 100}{2 \times \pi \times 8}$ = 2.5 $\mu$T

5. $\mu_0$ = 4$\pi$ × $10^{-7}$ T-m/A

r = 2 cm = 0.02 m, $I$ = 1 A, $\vec{B}$ = 1 × $10^{-5}$ T




We know: Magnetic field due to a long straight wire carrying current = $\frac{\mu_0 I}{2\pi r}$

$\vec{B}$ at P = $\frac{4\pi \times 10^{-7} \times 1}{2\pi \times 0.02}$ = 1 × $10^{-5}$ T upward

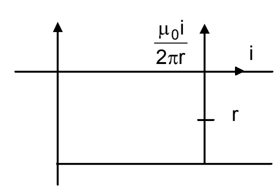
net B = 2 × 1 × $10^{-7}$ T = 20 $\mu$T

B at Q = 1 × $10^{-5}$ T downwards

Hence net $\vec{B}$ = 0

6. (a) The maximum magnetic field is $B + \frac{\mu_0 I}{2\pi r}$ which are along the left keeping the sense along the direction of traveling current.

(b)The minimum $B - \frac{\mu_0 I}{2\pi r}$

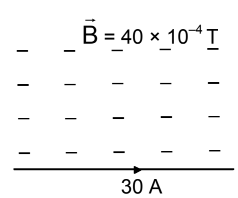



If r = $\frac{\mu_0 I}{2\pi B}$ B net = 0

r < $\frac{\mu_0 I}{2\pi B}$ B net = 0

r > $\frac{\mu_0 I}{2\pi B}$ B net = $B - \frac{\mu_0 I}{2\pi r}$

7. $\mu_0$ = 4$\pi$ × $10^{-7}$ T-m/A, $I$ = 30 A, B = 4.0 × $10^{-4}$ T Parallel to current.




$\vec{B}$ due to wore at a pt. 2 cm

$= \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 30}{2\pi \times 0.02}$ = 3 × $10^{-4}$ T

net field = $\sqrt{\left(3 \times 10^{-4}\right)^2 + \left(4 \times 10^{-4}\right)^2}$ = 5 × $10^{-4}$ T

8. $i = 10\text{ A. }(\hat{K})$

$B = 2 \times 10^{-3}$ T South to North $(\hat{J})$

To cancel the magnetic field the point should be choosen so that the net magnetic field is along $-\hat{J}$ direction.

$\therefore$ The point is along $-\hat{i}$ direction or along west of the wire.

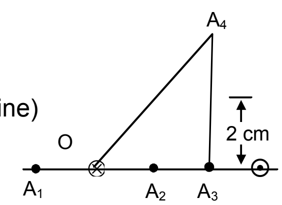
$$B = \frac{\mu_0 I}{2\pi r}$$

$$\Rightarrow 2 \times 10^{-3} = \frac{4\pi \times 10^{-7} \times 10}{2\pi \times r}$$

$$\Rightarrow r = \frac{2 \times 10^{-7}}{2 \times 10^{-3}} = 10^{-3}\text{ m} = 1\text{ mm.}$$

9. Let the tow wires be positioned at O & P

$R = OA, = \sqrt{(0.02)^2 + (0.02)^2} = \sqrt{8 \times 10^{-4}} = 2.828 \times 10^{-2}$ m




(a) $\vec{B}$ due to Q, at $A_1 = \dfrac{4\pi \times 10^{-7} \times 10}{2\pi \times 0.02} = 1 \times 10^{-4}$ T ($\perp$r towards up the line)

$\vec{B}$ due to P, at $A_1 = \dfrac{4\pi \times 10^{-7} \times 10}{2\pi \times 0.06} = 0.33 \times 10^{-4}$ T ($\perp$r towards down the line)

net $\vec{B} = 1 \times 10^{-4} - 0.33 \times 10^{-4} = 0.67 \times 10^{-4}$ T

(b) $\vec{B}$ due to O at $A_2 = \dfrac{2 \times 10^{-7} \times 10}{0.01} = 2 \times 10^{-4}$ T $\perp$r down the line

$\vec{B}$ due to P at $A_2 = \dfrac{2 \times 10^{-7} \times 10}{0.03} = 0.67 \times 10^{-4}$ T $\perp$r down the line

net $\vec{B}$ at $A_2 = 2 \times 10^{-4} + 0.67 \times 10^{-4} = 2.67 \times 10^{-4}$ T

(c) $\vec{B}$ at $A_3$ due to O $= 1 \times 10^{-4}$ T $\perp$r towards down the line

$\vec{B}$ at $A_3$ due to P $= 1 \times 10^{-4}$ T $\perp$r towards down the line

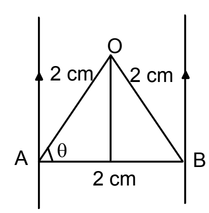
Net $\vec{B}$ at $A_3 = 2 \times 10^{-4}$ T

(d) $\vec{B}$ at $A_4$ due to O $= \dfrac{2 \times 10^{-7} \times 10}{2.828 \times 10^{-2}} = 0.7 \times 10^{-4}$ T towards SE

$\vec{B}$ at $A_4$ due to P $= 0.7 \times 10^{-4}$ T towards SW

Net $\vec{B} = \sqrt{\left(0.7 \times 10^{-4}\right)^2 + \left(0.7 \times 10^{-4}\right)^2} = 0.989 \times 10^{-4} \approx 1 \times 10^{-4}$ T

10. $\cos\theta = ½$, $\theta = 60°$ & $\angle AOB = 60°$



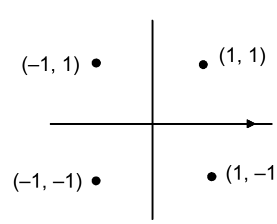

$$B = \frac{\mu_0 I}{2\pi r} = \frac{10^{-7} \times 2 \times 10}{2 \times 10^{-2}} = 10^{-4}\text{ T}$$

So net is $[(10^{-4})^2 + (10^{-4})^2 + 2(10^{-8})\cos 60°]^{1/2}$

$= 10^{-4}[1 + 1 + 2 \times ½]^{1/2} = 10^{-4} \times \sqrt{3}\text{ T} = 1.732 \times 10^{-4}$ T

11. (a) $\vec{B}$ for X = $\vec{B}$ for Y

Both are oppositely directed hence net $\vec{B} = 0$




(b) $\vec{B}$ due to X = $\vec{B}$ due to X both directed along Z–axis

Net $\vec{B} = \dfrac{2 \times 10^{-7} \times 2 \times 5}{1} = 2 \times 10^{-6}\text{ T} = 2\ \mu\text{T}$

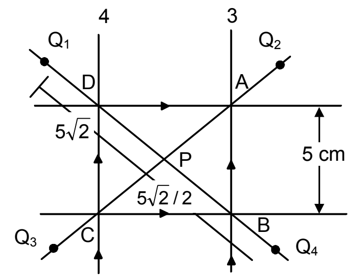
(c) $\vec{B}$ due to X = $\vec{B}$ due to Y both directed opposite to each other.

Hence Net $\vec{B} = 0$

(d) $\vec{B}$ due to X = $\vec{B}$ due to Y $= 1 \times 10^{-6}$ T both directed along (–) ve Z–axis

Hence Net $\vec{B} = 2 \times 1.0 \times 10^{-6} = 2\ \mu$T

12. (a) For each of the wire




Magnitude of magnetic field

$= \frac{\mu_0 i}{4\pi r}(\text{Sin}45° + \text{Sin}45°) = \frac{\mu_0 \times 5}{4\pi \times (5/2)} \frac{2}{\sqrt{2}}$

For AB ⊙ for BC ⊙ For CD ⊗ and for DA ⊗.

The two ⊙ and 2⊗ fields cancel each other. Thus $B_{net} = 0$

(b) At point $Q_1$

due to (1) $B = \frac{\mu_0 i}{2\pi \times 2.5 \times 10^{-2}} = \frac{4\pi \times 5 \times 2 \times 10^{-7}}{2\pi \times 5 \times 10^{-2}} = 4 \times 10^{-5}$ ⊙

due to (2) $B = \frac{\mu_0 i}{2\pi \times (15/2) \times 10^{-2}} = \frac{4\pi \times 5 \times 2 \times 10^{-7}}{2\pi \times 15 \times 10^{-2}} = (4/3) \times 10^{-5}$ ⊙

due to (3) $B = \frac{\mu_0 i}{2\pi \times (5 + 5/2) \times 10^{-2}} = \frac{4\pi \times 5 \times 2 \times 10^{-7}}{2\pi \times 15 \times 10^{-2}} = (4/3) \times 10^{-5}$ ⊙

due to (4) $B = \frac{\mu_0 i}{2\pi \times 2.5 \times 10^{-2}} = \frac{4\pi \times 5 \times 2 \times 10^{-7}}{2\pi \times 5 \times 10^{-2}} = 4 \times 10^{-5}$ ⊙

$B_{net} = [4 + 4 + (4/3) + (4/3)] \times 10^{-5} = \frac{32}{3} \times 10^{-5} = 10.6 \times 10^{-5} \approx 1.1 \times 10^{-4}$ T

At point $Q_2$

due to (1) $\frac{\mu_o i}{2\pi \times (2.5) \times 10^{-2}}$ ⊙

due to (2) $\frac{\mu_o i}{2\pi \times (15/2) \times 10^{-2}}$ ⊙

due to (3) $\frac{\mu_o i}{2\pi \times (2.5) \times 10^{-2}}$ ⊗

due to (4) $\frac{\mu_o i}{2\pi \times (15/2) \times 10^{-2}}$ ⊗

$B_{net} = 0$

At point $Q_3$

due to (1) $\frac{4\pi \times 10^{-7} \times 5}{2\pi \times (15/2) \times 10^{-2}} = 4/3 \times 10^{-5}$ ⊗

due to (2) $\frac{4\pi \times 10^{-7} \times 5}{2\pi \times (5/2) \times 10^{-2}} = 4 \times 10^{-5}$ ⊗

due to (3) $\frac{4\pi \times 10^{-7} \times 5}{2\pi \times (5/2) \times 10^{-2}} = 4 \times 10^{-5}$ ⊗

due to (4) $\frac{4\pi \times 10^{-7} \times 5}{2\pi \times (15/2) \times 10^{-2}} = 4/3 \times 10^{-5}$ ⊗

$B_{net} = [4 + 4 + (4/3) + (4/3)] \times 10^{-5} = \frac{32}{3} \times 10^{-5} = 10.6 \times 10^{-5} \approx 1.1 \times 10^{-4}$ T

For $Q_4$

due to (1) $4/3 \times 10^{-5}$ ⊗

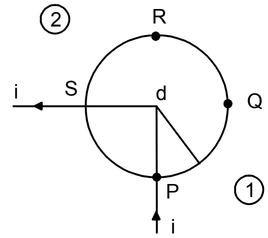
due to (2) $4 \times 10^{-5}$ ⊗

due to (3) $4/3 \times 10^{-5}$ ⊗

due to (4) $4 \times 10^{-5}$ ⊗

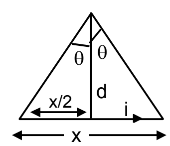
$B_{net} = 0$

13. Since all the points lie along a circle with radius = ‘d’
Hence ‘R’ & ‘Q’ both at a distance ‘d’ from the wire.
So, magnetic field $\vec{B}$ due to are same in magnitude.
As the wires can be treated as semi infinite straight current carrying conductors. Hence magnetic field $\vec{B} = \dfrac{\pi_0 i}{4\pi d}$




At P
$B_1$ due to 1 is 0
$B_2$ due to 2 is $\dfrac{\pi_0 i}{4\pi d}$
At Q
$B_1$ due to 1 is $\dfrac{\pi_0 i}{4\pi d}$
$B_2$ due to 2 is 0
At R
$B_1$ due to 1 is 0
$B_2$ due to 2 is $\dfrac{\pi_0 i}{4\pi d}$
At S
$B_1$ due to 1 is $\dfrac{\pi_0 i}{4\pi d}$
$B_2$ due to 2 is 0

14. $B = \dfrac{\pi_0 i}{4\pi d}\ 2\ \text{Sin}\ \theta$




$$= \frac{\pi_0 i}{4\pi d}\frac{2\times x}{2\times\sqrt{d^2+\dfrac{x^2}{4}}} = \frac{\mu_0 ix}{4\pi d\sqrt{d^2+\dfrac{x^2}{4}}}$$

(a) When d >> x
Neglecting x w.r.t. d

$$B = \frac{\mu_0 ix}{\mu\pi d\sqrt{d^2}} = \frac{\mu_0 ix}{\mu\pi d^2}$$

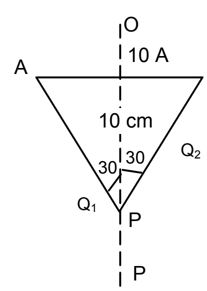
$\therefore B \propto \dfrac{1}{d^2}$

(b) When x >> d, neglecting d w.r.t. x

$$B = \frac{\mu_0 ix}{4\pi dx/2} = \frac{2\mu_0 i}{4\pi d}$$

$\therefore B \propto \dfrac{1}{d}$

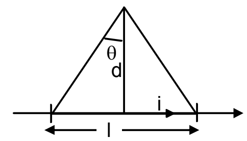
15. I = 10 A, a = 10 cm = 0.1 m




$r = OP = \dfrac{\sqrt{3}}{2}\times 0.1$ m

$$B = \frac{\mu_0 I}{4\pi r}(\text{Sin}\phi_1 + \text{Sin}\phi_2)$$

$$= \frac{10^{-7}\times 10\times 1}{\dfrac{\sqrt{3}}{2}\times 0.1} = \frac{2\times 10^{-5}}{1.732} = 1.154 \times 10^{-5}\ \text{T} = 11.54\ \mu\text{T}$$




16. $B_1 = \frac{\mu_0 i}{2\pi d}$, $B_2 = \frac{\mu_0 i}{4\pi d}(2 \times \text{Sin}\theta) = \frac{\mu_0 i}{4\pi d}\frac{2\times\ell}{2\sqrt{d^2+\frac{\ell^2}{4}}} = \frac{\mu_0 i\ell}{4\pi d\sqrt{d^2+\frac{\ell^2}{4}}}$

$B_1 - B_2 = \frac{1}{100}B_2 \Rightarrow \frac{\mu_0 i}{2\pi d} - \frac{\mu_0 i\ell}{4\pi d\sqrt{d^2+\frac{\ell^2}{4}}} = \frac{\mu_0 i}{200\pi d}$

$\Rightarrow \frac{\mu_0 i\ell}{4\pi d\sqrt{d^2+\frac{\ell^2}{4}}} = \frac{\mu_0 i}{\pi d}\left(\frac{1}{2}-\frac{1}{200}\right)$

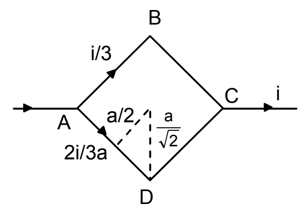
$\Rightarrow \frac{\ell}{4\sqrt{d^2+\frac{\ell^2}{4}}} = \frac{99}{200}$ $\Rightarrow \frac{\ell^2}{d^2+\frac{\ell^2}{4}} = \left(\frac{99\times4}{200}\right)^2 = \frac{156816}{40000} = 3.92$

$\Rightarrow \ell^2 = 3.92\, d^2 + \frac{3.92}{4}\ell^2$

$\left(\frac{1-3.92}{4}\right)\ell^2 = 3.92\, d^2 \Rightarrow 0.02\, \ell^2 = 3.92\, d^2 \Rightarrow \frac{d^2}{\ell^2} = \frac{0.02}{3.92} = \frac{d}{\ell} = \sqrt{\frac{0.02}{3.92}} = 0.07$

17. As resistances vary as r & 2r

Hence Current along ABC = $\frac{i}{3}$ & along ADC = $\frac{2}{3i}$

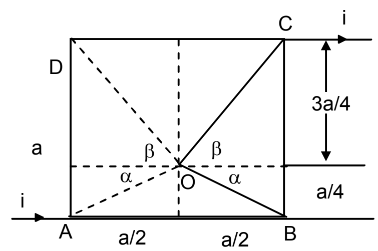



Now,

$\vec{B}$ due to ADC = $2\left[\frac{\mu_0 i \times 2\times 2\times\sqrt{2}}{4\pi 3a}\right] = \frac{2\sqrt{2}\mu_0 i}{3\pi a}$

$\vec{B}$ due to ABC = $2\left[\frac{\mu_0 i \times 2\times\sqrt{2}}{4\pi 3a}\right] = \frac{2\sqrt{2}\mu_0 i}{6\pi a}$

Now $\vec{B} = \frac{2\sqrt{2}\mu_0 i}{3\pi a} - \frac{2\sqrt{2}\mu_0 i}{6\pi a} = \frac{\sqrt{2}\mu_0 i}{3\pi a}$ $\otimes$




18. $A_0 = \sqrt{\frac{a^2}{16}+\frac{a^2}{4}} = \sqrt{\frac{5a^2}{16}} = \frac{a\sqrt{5}}{4}$

$D_0 = \sqrt{\left(\frac{3a}{4}\right)^2+\left(\frac{a}{2}\right)^2} = \sqrt{\frac{9a^2}{16}+\frac{a^2}{4}} = \sqrt{\frac{13a^2}{16}} = \frac{a\sqrt{13}}{4}$

Magnetic field due to AB

$B_{AB} = \frac{\mu_0}{4\pi}\times\frac{i}{2(a/4)}(\text{Sin}\,(90-i) + \text{Sin}\,(90-\alpha))$

$= \frac{\mu_0\times 2i}{4\pi a}2\text{Cos}\alpha = \frac{\mu_0\times 2i}{4\pi a}\times 2\times\frac{(a/2)}{a(\sqrt{5}/4)} = \frac{2\mu_0 i}{\pi\sqrt{5}}$

Magnetic field due to DC

$B_{DC} = \frac{\mu_0}{4\pi}\times\frac{i}{2(3a/4)}2\text{Sin}\,(90° - B)$

$= \frac{\mu_0 i\times 4\times 2}{4\pi\times 3a}\text{Cos}\beta = \frac{\mu_0 i}{\pi\times 3a}\times\frac{(a/2)}{(\sqrt{13a}/4)} = \frac{2\mu_0 i}{\pi a 3\sqrt{13}}$

The magnetic field due to AD & BC are equal and appropriate hence cancle each other.

Hence, net magnetic field is $\frac{2\mu_0 i}{\pi\sqrt{5}} - \frac{2\mu_0 i}{\pi a 3\sqrt{13}} = \frac{2\mu_0 i}{\pi a}\left[\frac{1}{\sqrt{5}} - \frac{1}{3\sqrt{13}}\right]$

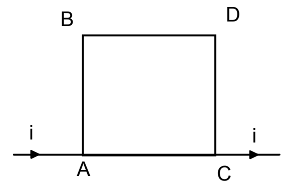
19. $\vec{B}$ due t BC &

$\vec{B}$ due to AD at Pt 'P' are equal ore Opposite

Hence net $\vec{B}$ = 0

Similarly, due to AB & CD at P = 0

$\therefore$ The net $\vec{B}$ at the Centre of the square loop = zero.



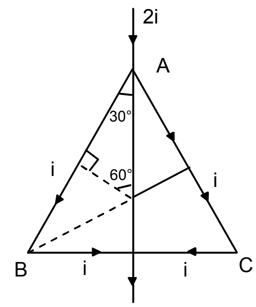

20. For AB B is along $\odot$ $B = \frac{\mu_0 i}{4\pi r}(\text{Sin}60° + \text{Sin}60°)$

For AC B $\otimes$ $B = \frac{\mu_0 i}{4\pi r}(\text{Sin}60° + \text{Sin}60°)$

For BD B $\odot$ $B = \frac{\mu_0 i}{4\pi r}(\text{Sin}60°)$

For DC B $\otimes$ $B = \frac{\mu_0 i}{4\pi r}(\text{Sin}60°)$

$\therefore$ Net B = 0




21. (a) $\Delta$ABC is Equilateral

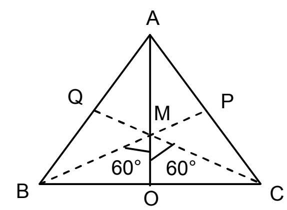
AB = BC = CA = $\ell/3$

Current = i

$AO = \frac{\sqrt{3}}{2}a = \frac{\sqrt{3}\times\ell}{2\times 3} = \frac{\ell}{2\sqrt{3}}$

$\phi_1 = \phi_2 = 60°$

So, $MO = \frac{\ell}{6\sqrt{3}}$ as AM : MO = 2 : 1



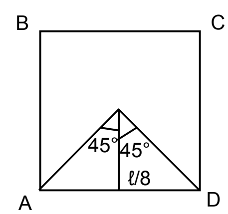

$\vec{B}$ due to BC at <.

$= \frac{\mu_0 i}{4\pi r}(\text{Sin}\phi_1 + \text{Sin}\phi_2) = \frac{\mu_0 i}{4\pi} \times i \times 6\sqrt{3} \times \sqrt{3} = \frac{\mu_0 i \times 9}{2\pi\ell}$

net $\vec{B} = \frac{9\mu_0 i}{2\pi\ell} \times 3 = \frac{27\mu_0 i}{2\pi\ell}$

(b) $\vec{B}$ due to AD $= \frac{\mu_0 i \times 8}{4\pi \times \ell}\sqrt{2} = \frac{8\sqrt{2}\mu_0 i}{4\pi\ell}$

Net $\vec{B} = \frac{8\sqrt{2}\mu_0 i}{4\pi\ell} \times 4 = \frac{8\sqrt{2}\mu_0 i}{\pi\ell}$




22. $\text{Sin}(\alpha/2) = \frac{r}{x}$

$\Rightarrow r = x\,\text{Sin}(\alpha/2)$

Magnetic field B due to AR

$\frac{\mu_0 i}{4\pi r}\left[\text{Sin}(180 - (90 - (\alpha/2))) + 1\right]$

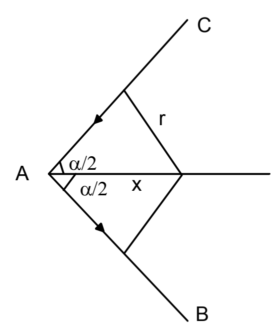
$\Rightarrow \frac{\mu_0 i[\text{Sin}(90 - (\alpha/2)) + 1]}{4\pi \times \text{Sin}(\alpha/2)}$

$= \frac{\mu_0 i(\text{Cos}(\alpha/2) + 1)}{4\pi \times \text{Sin}(\alpha/2)}$

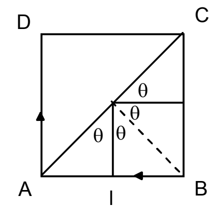
$= \frac{\mu_0 i 2\text{Cos}^4(\alpha/4)}{4\pi \times 2\text{Sin}(\alpha/4)\text{Cos}(\alpha/4)} = \frac{\mu_0 i}{4\pi x}\text{Cot}(\alpha/4)$

The magnetic field due to both the wire.

$\frac{2\mu_0 i}{4\pi x}\text{Cot}(\alpha/4) = \frac{\mu_0 i}{2\pi x}\text{Cot}(\alpha/4)$



23. $\vec{B}AB$




$$\frac{\mu_0 i \times 2}{4\pi b} \times 2\text{Sin}\theta = \frac{\mu_0 i \text{Sin}\theta}{\pi b}$$

$$= \frac{\mu_0 i \ell}{\pi b\sqrt{\ell^2 + b^2}} = \vec{B}DC \qquad \therefore \text{Sin}\,(\ell^2 + b) = \frac{(\ell/2)}{\sqrt{\ell^2/4 + b^2/4}} = \frac{\ell}{\sqrt{\ell^2 + b^2}}$$

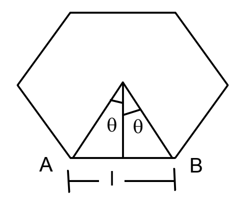
$\vec{B}BC$

$$\frac{\mu_0 i \times 2}{4\pi\ell} \times 2 \times 2\text{Sin}\theta' = \frac{\mu_0 i \text{Sin}\theta'}{\pi\ell} \qquad \therefore \text{Sin}\,\theta' = \frac{(b/2)}{\sqrt{\ell^2/4 + b^2/4}} = \frac{b}{\sqrt{\ell^2 + b^2}}$$

$$= \frac{\mu_0 i b}{\pi\ell\sqrt{\ell^2 + b^2}} = \vec{B}AD$$

$$\text{Net } \vec{B} = \frac{2\mu_0 i \ell}{\pi b\sqrt{\ell^2 + b^2}} + \frac{2\mu_0 i b}{\pi\ell\sqrt{\ell^2 + b^2}} = \frac{2\mu_0 i(\ell^2 + b^2)}{\pi\ell b\sqrt{\ell^2 + b^2}} = \frac{2\mu_0 i\sqrt{\ell^2 + b^2}}{\pi\ell b}$$

24. $2\theta = \dfrac{2\pi}{n} \Rightarrow \theta = \dfrac{\pi}{n}$, $\qquad \ell = \dfrac{2\pi r}{n}$




$$\text{Tan}\,\theta = \frac{\ell}{2x} \Rightarrow x = \frac{\ell}{2\text{Tan}\theta}$$

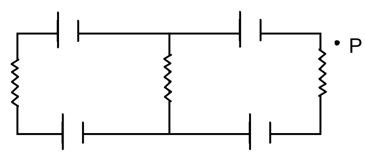
$$\frac{\ell}{2} = \frac{\pi r}{n}$$

$$B_{AB} = \frac{\mu_0 i}{4\pi(x)}(\text{Sin}\theta + \text{Sin}\theta) = \frac{\mu_0 i 2\text{Tan}\theta \times 2\text{Sin}\theta}{4\pi\ell}$$

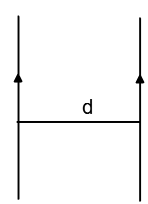
$$= \frac{\mu_0 i 2\text{Tan}(\pi/n)2\text{Sin}(\pi/n)n}{4\pi 2\pi r} = \frac{\mu_0 i n\text{Tan}(\pi/n)\text{Sin}(\pi/n)}{2\pi^2 r}$$

For n sides, $B_{net} = \dfrac{\mu_0 i n\text{Tan}(\pi/n)\text{Sin}(\pi/n)}{2\pi^2 r}$

25. Net current in circuit = 0
Hence the magnetic field at point P = 0
[Owing to wheat stone bridge principle]




26. Force acting on 10 cm of wire is $2 \times 10^{-5}$ N



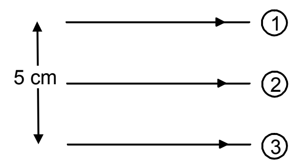

$$\frac{dF}{dl} = \frac{\mu_0 i_1 i_2}{2\pi d}$$

$$\Rightarrow \frac{2 \times 10^{-5}}{10 \times 10^{-2}} = \frac{\mu_0 \times 20 \times 20}{2\pi d}$$

$$\Rightarrow d = \frac{4\pi \times 10^{-7} \times 20 \times 20 \times 10 \times 10^{-2}}{2\pi \times 2 \times 10^{-5}} = 400 \times 10^{-3} = 0.4 \text{ m} = 40 \text{ cm}$$

27. i = 10 A
Magnetic force due to two parallel Current Carrying wires.

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

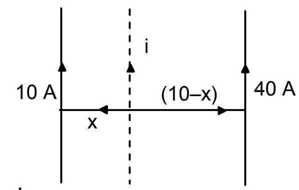



So, $\vec{F}$ or 1 = $\vec{F}$ by 2 + $\vec{F}$ by 3

$$= \frac{\mu_0 \times 10 \times 10}{2\pi \times 5 \times 10^{-2}} + \frac{\mu_0 \times 10 \times 10}{2\pi \times 10 \times 10^{-2}}$$

$$= \frac{4\pi \times 10^{-7} \times 10 \times 10}{2\pi \times 5 \times 10^{-2}} + \frac{4\pi \times 10^{-7} \times 10 \times 10}{2\pi \times 10 \times 10^{-2}}$$

$$= \frac{2 \times 10^{-3}}{5} + \frac{10^{-3}}{5} = \frac{3 \times 10^{-3}}{5} = 6 \times 10^{-4} \text{ N} \quad \text{towards middle wire}$$

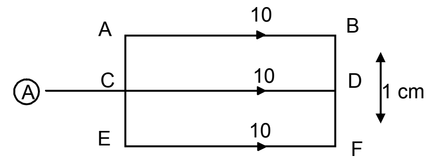



28. $\frac{\mu_0 10i}{2\pi x} = \frac{\mu_0 i40}{2\pi(10-x)}$

$\Rightarrow \frac{10}{x} = \frac{40}{10-x} \Rightarrow \frac{1}{x} = \frac{4}{10-x}$

$\Rightarrow 10 - x = 4x \Rightarrow 5x = 10 \Rightarrow x = 2$ cm

The third wire should be placed 2 cm from the 10 A wire and 8 cm from 40 A wire.



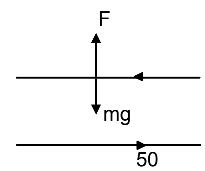

29. $F_{AB} = F_{CD} + F_{EF}$

$= \frac{\mu_0 \times 10 \times 10}{2\pi \times 1 \times 10^{-2}} + \frac{\mu_0 \times 10 \times 10}{2\pi \times 2 \times 10^{-2}}$

$= 2\times 10^{-3} + 10^{-3} = 3 \times 10^{-3}$ downward.

$F_{CD} = F_{AB} + F_{EF}$

As $F_{AB}$ & $F_{EF}$ are equal and oppositely directed hence F = 0



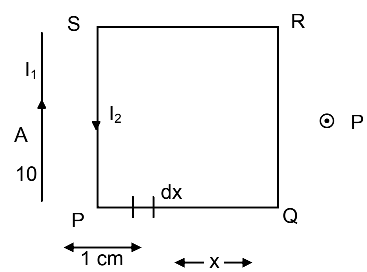

30. $\frac{\mu_0 i_1 i_2}{2\pi d}$ = mg (For a portion of wire of length 1m)

$\Rightarrow \frac{\mu_0 \times 50 \times i_2}{2\pi \times 5 \times 10^{-3}} = 1 \times 10^{-4} \times 9.8$

$\Rightarrow \frac{4\pi \times 10^{-7} \times 5 \times i_2}{2\pi \times 5 \times 10^{-3}} = 9.8 \times 10^{-4}$

$\Rightarrow 2 \times i_2 \times 10^{-3} = 9.3 \times 10^{-3} \times 10^{-1}$

$\Rightarrow i_2 = \frac{9.8}{2} \times 10^{-1} = 0.49$ A




31. $I_2 = 6$ A

$I_1 = 10$ A

$F_{PQ}$

'F' on dx $= \frac{\mu_0 i_1 i_2}{2\pi x} dx = \frac{\mu_0 i_1 i_2}{2\pi} \frac{dx}{x} = \frac{\mu_0 \times 30}{\pi} \frac{dx}{x}$

$\vec{F}_{PQ} = \frac{\mu_0 \times 30}{x} \int_1 \frac{dx}{x} = 30 \times 4 \times 10^{-7} \times [\log x]_1^2$

$= 120 \times 10^{-7} [\log 3 - \log 1]$

Similarly force of $\vec{F}_{RS} = 120 \times 10^{-7} [\log 3 - \log 1]$

So, $\vec{F}_{PQ} = \vec{F}_{RS}$

$\vec{F}_{PS} = \frac{\mu_0 \times i_1 i_2}{2\pi \times 1 \times 10^{-2}} - \frac{\mu_0 \times i_1 i_2}{2\pi \times 2 \times 10^{-2}}$

$= \frac{2 \times 6 \times 10 \times 10^{-7}}{10^{-2}} - \frac{2 \times 10^{-7} \times 6 \times 6}{2 \times 10^{-2}} = 8.4 \times 10^{-4}$ N (Towards right)

$\vec{F}_{RQ} = \frac{\mu_0 \times i_1 i_2}{2\pi \times 3 \times 10^{-2}} - \frac{\mu_0 \times i_1 i_2}{2\pi \times 2 \times 10^{-2}}$

$= \frac{4\pi \times 10^{-7} \times 6 \times 10}{2\pi \times 3 \times 10^{-2}} - \frac{4\pi \times 10^{-7} \times 6 \times 6}{2\pi \times 2 \times 10^{-2}} = 4 \times 10^{-4} + 36 \times 10^{-5} = 7.6 \times 10^{-4}$ N

Net force towards down

$= (8.4 + 7.6) \times 10^{-4} = 16 \times 10^{-4}$ N

32. B = 0.2 mT, i = 5 A, n = 1, r = ?

$B = \frac{n\mu_0 i}{2r}$

$\Rightarrow r = \frac{n \times \mu_0 i}{2B} = \frac{1 \times 4\pi \times 10^{-7} \times 5}{2 \times 0.2 \times 10^{-3}} = 3.14 \times 5 \times 10^{-3}$ m $= 15.7 \times 10^{-3}$ m $= 15.7 \times 10^{-1}$ cm $= 1.57$ cm

33. $B = \dfrac{n\mu_0 i}{2r}$

$n = 100$, $r = 5$ cm $= 0.05$ m

$\vec{B} = 6 \times 10^{-5}$ T

$i = \dfrac{2rB}{n\mu_0} = \dfrac{2 \times 0.05 \times 6 \times 10^{-5}}{100 \times 4\pi \times 10^{-7}} = \dfrac{3}{6.28} \times 10^{-1} = 0.0477 \approx 48$ mA

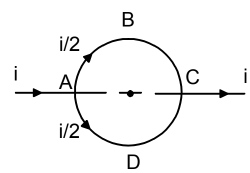
34. $3 \times 10^5$ revolutions in 1 sec.

1 revolutions in $\dfrac{1}{3 \times 10^5}$ sec

$i = \dfrac{q}{t} = \dfrac{1.6 \times 10^{-19}}{\left(\dfrac{1}{3 \times 10^5}\right)}$ A

$B = \dfrac{\mu_0 i}{2r} = \dfrac{4\pi \times 10^{-7} . 16 \times 10^{-19} 3 \times 10^5}{2 \times 0.5 \times 10^{-10}} \quad \dfrac{2\pi \times 1.6 \times 3}{0.5} \times 10^{-11} = 6.028 \times 10^{-10} \approx 6 \times 10^{-10}$ T

35. $I = i/2$ in each semicircle




$ABC = \vec{B} = \dfrac{1}{2} \times \dfrac{\mu_0 (i/2)}{2a}$ downwards

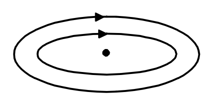
$ADC = \vec{B} = \dfrac{1}{2} \times \dfrac{\mu_0 (i/2)}{2a}$ upwards

Net $\vec{B} = 0$

36. $r_1 = 5$ cm $\qquad r_2 = 10$ cm

$n_1 = 50 \qquad n_2 = 100$

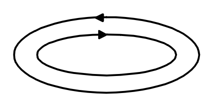
$i = 2$ A



(a) $B = \dfrac{n_1 \mu_0 i}{2r_1} + \dfrac{n_2 \mu_0 i}{2r_2}$

$= \dfrac{50 \times 4\pi \times 10^{-7} \times 2}{2 \times 5 \times 10^{-2}} + \dfrac{100 \times 4\pi \times 10^{-7} \times 2}{2 \times 10 \times 10^{-2}}$

$= 4\pi \times 10^{-4} + 4\pi \times 10^{-4} = 8\pi \times 10^{-4}$

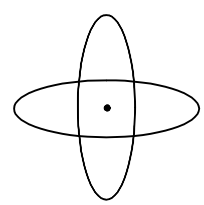


(b) $B = \dfrac{n_1 \mu_0 i}{2r_1} - \dfrac{n_2 \mu_0 i}{2r_2} = 0$

37. Outer Circle

$n = 100$, $r = 100$m $= 0.1$ m

$i = 2$ A



$\vec{B} = \dfrac{n\mu_0 i}{2a} = \dfrac{100 \times 4\pi \times 10^{-7} \times 2}{2 \times 0.1} = 4\pi \times 10^{-4}$ horizontally towards West.

Inner Circle

$r = 5$ cm $= 0.05$ m, $n = 50$, $i = 2$ A

$\vec{B} = \dfrac{n\mu_0 i}{2r} = \dfrac{4\pi \times 10^{-7} \times 2 \times 50}{2 \times 0.05} = 4\pi \times 10^{-4}$ downwards

Net $B = \sqrt{\left(4\pi \times 10^{-4}\right)^2 + \left(4\pi \times 10^{-4}\right)^2} = \sqrt{32\pi^2 \times 10^{-8}} = 17.7 \times 10^{-4} \approx 18 \times 10^{-4} = 1.8 \times 10^{-3} = 1.8$ mT

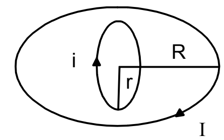
38. $r = 20$ cm, $\quad i = 10$ A, $\quad V = 2 \times 10^6$ m/s, $\quad \theta = 30°$

$F = e(\vec{V} \times \vec{B}) = eVB \sin\theta$

$= 1.6 \times 10^{-19} \times 2 \times 10^6 \times \dfrac{\mu_0 i}{2r} \sin 30°$

$= \dfrac{1.6 \times 10^{-19} \times 2 \times 10^6 \times 4\pi \times 10^{-7} \times 10}{2 \times 2 \times 20 \times 10^{-2}} = 16\pi \times 10^{-19}$ N

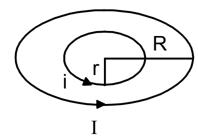
39. $\vec{B}$ Large loop = $\frac{\mu_0 I}{2R}$




'i' due to larger loop on the smaller loop

= i(A × B) = i AB Sin 90° = i × $\pi r^2 \times \frac{\mu_0 I}{2r}$

40. The force acting on the smaller loop

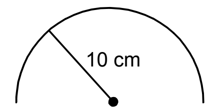



F = ilB Sin θ

= $\frac{i2\pi r \mu_o I1}{2R \times 2} = \frac{\mu_0 i I \pi r}{2R}$

41. i = 5 Ampere, r = 10 cm = 0.1 m

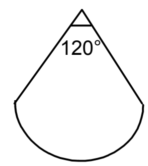
As the semicircular wire forms half of a circular wire,




So, $\vec{B} = \frac{1}{2}\frac{\mu_0 i}{2r} = \frac{1}{2} \times \frac{4\pi \times 10^{-7} \times 5}{2 \times 0.1}$

= 15.7 × $10^{-6}$ T ≈ 16 × $10^{-6}$ T = 1.6 × $10^{-5}$ T

42. B = $\frac{\mu_0 i}{2R}\frac{\theta}{2\pi} = \frac{2\pi}{3 \times 2\pi} \times \frac{\mu_0 i}{2R}$

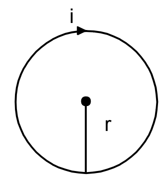



= $\frac{4\pi \times 10^{-7} \times 6}{6 \times 10^{t10^{-2}}}$ = 4π × $10^{-6}$

= 4 × 3.14 × $10^{-6}$ = 12.56 × $10^{-6}$ = 1.26 × $10^{-5}$ T

43. $\vec{B}$ due to loop $\frac{\mu_0 i}{2r}$

Let the straight current carrying wire be kept at a distance R from centre. Given I = 4i




$\vec{B}$ due to wire = $\frac{\mu_0 I}{2\pi R} = \frac{\mu_0 \times 4i}{2\pi R}$

Now, the $\vec{B}$ due to both will balance each other

Hence $\frac{\mu_0 i}{2r} = \frac{\mu_0 4i}{2\pi R} \Rightarrow R = \frac{4r}{\pi}$

Hence the straight wire should be kept at a distance 4π/r from centre in such a way that the direction of current in it is opposite to that in the nearest part of circular wire. As a result the direction will $\vec{B}$ will be oppose.

44. n = 200, i = 2 A, r = 10 cm = 10 × $10^{-2}$n

(a) B = $\frac{n\mu_0 i}{2r} = \frac{200 \times 4\pi \times 10^{-7} \times 2}{2 \times 10 \times 10^{-2}}$ = 2 × 4π × $10^{-4}$

= 2 × 4 × 3.14 × $10^{-4}$ = 25.12 × $10^{-4}$ T = 2.512 mT

(b) B = $\frac{n\mu_0 i a^2}{2(a^2 + d^2)^{3/2}}$ $\Rightarrow \frac{n\mu_0 i}{4a} = \frac{n\mu_0 i a^2}{2(a^2+d^2)^{3/2}}$

$\Rightarrow \frac{1}{2a} = \frac{a^2}{2(a^2+d^2)^{3/2}}$ $\Rightarrow (a^2 + d^2)^{3/2}\ 2a^3$ $\Rightarrow a^2 + d^2 = (2a^3)^{2/3}$

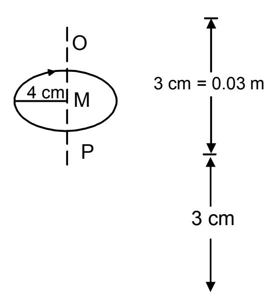
$\Rightarrow a^2 + d^2 = (2^{1/3} a)^2$ $\Rightarrow a^2 + d^2 = 2^{2/3} a^2$ $\Rightarrow (10^{-1})^2 + d^2 = 2^{2/3}\ (10^{-1})^2$

$\Rightarrow 10^{-2} + d^2 = 2^{2/3}\ 10^{-2}$ $\Rightarrow (10^{-2})(2^{2/3} - 1) = d^2$ $\Rightarrow (10^{-2})\ (4^{1/3} - 1) = d^2$

$\Rightarrow 10^{-2}(1.5874 - 1) = d^2$ $\Rightarrow d^2 = 10^{-2} \times 0.5874$

$\Rightarrow d = \sqrt{10^{-2} \times 0.5874}$ = $10^{-1}$ × 0.766 m = 7.66 × $10^{-2}$ = 7.66 cm.

45. At O P the $\vec{B}$ must be directed downwards




We Know B at the axial line at O & P

= $\frac{\mu_0 i a^2}{2(a^2 + d^2)^{3/2}}$ a = 4 cm = 0.04 m

= $\frac{4\pi \times 10^{-7} \times 5 \times 0.0016}{2((0.0025)^{3/2}}$ d = 3 cm = 0.03 m

= 40 × $10^{-6}$ = 4 × $10^{-5}$ T downwards in both the cases

46. $q = 3.14 \times 10^{-6}$ C, $r = 20$ cm $= 0.2$ m,

$w = 60$ rad/sec., $i = \frac{q}{t} = \frac{3.14 \times 10^{-6} \times 60}{2\pi \times 0.2} = 1.5 \times 10^{-5}$

$$\frac{\text{Electric field}}{\text{Magnetic field}} = \frac{\dfrac{xQ}{4\pi\varepsilon_0 (x^2+a^2)^{3/2}}}{\dfrac{\mu_0 i a^2}{2(a^2+x^2)^{3/2}}} = \frac{xQ}{4\pi\varepsilon_0 (x^2+a^2)^{3/2}} \times \frac{2(x^2+a^2)^{3/2}}{\mu_0 i a^2}$$

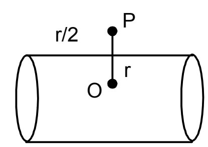
$$= \frac{9 \times 10^9 \times 0.05 \times 3.14 \times 10^{-6} \times 2}{4\pi \times 10^{-7} \times 15 \times 10^{-5} \times (0.2)^2}$$

$$= \frac{9 \times 5 \times 2 \times 10^3}{4 \times 13 \times 4 \times 10^{-12}} = \frac{3}{8}$$

47. (a) For inside the tube $\vec{B} = 0$

As, $\vec{B}$ inside the conducting tube = o

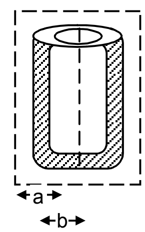
(b) For $\vec{B}$ outside the tube




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

$$\vec{B} = \frac{\mu_0 i}{2\pi d} = \frac{\mu_0 i \times 2}{2\pi 3r} = \frac{\mu_0 i}{2\pi r}$$

48. (a) At a point just inside the tube the current enclosed in the closed surface = 0.

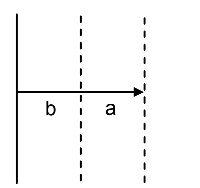



Thus $B = \frac{\mu_0 o}{A} = 0$

(b) Taking a cylindrical surface just out side the tube, from ampere's law.

$\mu_0 i = B \times 2\pi b \quad \Rightarrow B = \frac{\mu_0 i}{2\pi b}$

49. i is uniformly distributed throughout.




So, 'i' for the part of radius a $= \frac{i}{\pi b^2} \times \pi a^2 = \frac{ia^2}{b^2} = I$

Now according to Ampere's circuital law

$\oint B \times d\ell = B \times 2 \times \pi \times a = \mu_0 I$

$$\Rightarrow B = \mu_0 \frac{ia^2}{b^2} \times \frac{1}{2\pi a} = \frac{\mu_0 ia}{2\pi b^2}$$

50. (a) $r = 10$ cm $= 10 \times 10^{-2}$ m

$x = 2 \times 10^{-2}$ m, $i = 5$ A

i in the region of radius 2 cm

$$\frac{5}{\pi (10 \times 10^{-2})^2} \times \pi (2 \times 10^{-2})^2 = 0.2 \text{ A}$$

$B \times \pi\ (2 \times 10^{-2})^2 = \mu_0 (0\text{-}2)$

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

(b) 10 cm radius

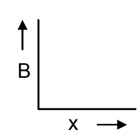
$B \times \pi\ (10 \times 10^{-2})^2 = \mu_0 \times 5$

$$\Rightarrow B = \frac{4\pi \times 10^{-7} \times 5}{\pi \times 10^{-2}} = 20 \times 10^{-5}$$

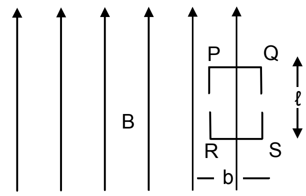
(c) x = 20 cm

$B \times \pi \times (20 \times 10^{-2})^2 = \mu_0 \times 5$

$$\Rightarrow B = \frac{\mu_0 \times 5}{\pi \times (20 \times 10^{-2})^2} = \frac{4\pi \times 10^{-7} \times 5}{\pi \times 400 \times 10^{-4}} = 5 \times 10^{-5}$$



51. We know, $\int B \times dl = \mu_0 i$. Theoritically B = 0 a t A



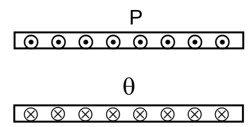

If, a current is passed through the loop PQRS, then

$B = \frac{\mu_0 i}{2(\ell + b)}$ will exist in its vicinity.

Now, As the $\vec{B}$ at A is zero. So there'll be no interaction

However practically this is not true. As a current carrying loop, irrespective of its near about position is always affected by an existing magnetic field.

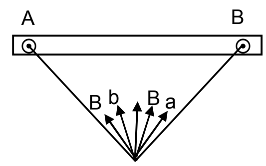
52. (a) At point P, i = 0, Thus B = 0

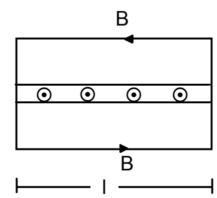



(b) At point R, i = 0, B = 0

(c) At point $\theta$,

Applying ampere's rule to the above rectangle



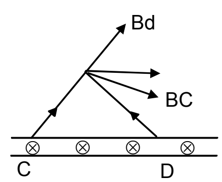



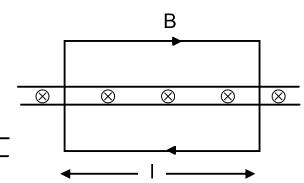

$B \times 2l = \mu_0 K_0 \int_o^l dl$

$\Rightarrow B \times 2l = \mu_0 kl \Rightarrow B = \frac{\mu_0 k}{2}$

$B \times 2l = \mu_0 K_0 \int_o^l dl$

$\Rightarrow B \times 2l = \mu_0 kl \Rightarrow B = \frac{\mu_0 k}{2}$




Since the $\vec{B}$ due to the 2 stripes are along the same direction, thus.

$B_{net} = \frac{\mu_0 k}{2} + \frac{\mu_0 k}{2} = \mu_0 k$

53. Charge = q, mass = m

We know radius described by a charged particle in a magnetic field B

$r = \frac{m\upsilon}{qB}$

Bit $B = \mu_0 K$ [according to Ampere's circuital law, where K is a constant]

$r = \frac{m\upsilon}{q\mu_0 k} \Rightarrow \upsilon = \frac{rq\mu_0 k}{m}$

54. i = 25 A, $B = 3.14 \times 10^{-2}$ T, n = ?

$B = \mu_0 ni$

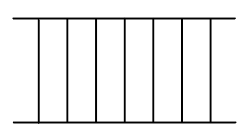
$\Rightarrow 3.14 \times 10^{-2} = 4 \times \pi \times 10^{-7}\ n \times 5$

$\Rightarrow n = \frac{10^{-2}}{20 \times 10^{-7}} = \frac{1}{2} \times 10^4 = 0.5 \times 10^4 = 5000$ turns/m

55. r = 0.5 mm, i = 5 A, $B = \mu_0 ni$ (for a solenoid)

Width of each turn = 1 mm = $10^{-3}$ m

No. of turns 'n' = $\frac{1}{10^{-3}} = 10^3$



So, $B = 4\pi \times 10^{-7} \times 10^3 \times 5 = 2\pi \times 10^{-3}$ T

56. $\frac{R}{l} = 0.01\ \Omega$ in 1 m, r = 1.0 cm Total turns = 400, $\ell$ = 20 cm,

$B = 1 \times 10^{-2}$ T, $n = \frac{400}{20 \times 10^{-2}}$ turns/m

$i = \frac{E}{R_0} = \frac{E}{R_0 / l \times (2\pi r \times 400)} = \frac{E}{0.01 \times 2 \times \pi \times 0.01 \times 400}$

$B = \mu_0 ni$

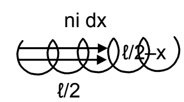
$\Rightarrow 10^2 = 4\pi \times 10^{-7} \times \dfrac{400}{20 \times 10^{-2}} \times \dfrac{E}{400 \times 2\pi \times 0.01 \times 10^{-2}}$

$\Rightarrow E = \dfrac{10^{-2} \times 20 \times 10^{-2} \times 400 \times 2\pi \times 10^{-2} 0.01}{4\pi \times 10^{-7} \times 400} = 1\ V$

57. Current at '0' due to the circular loop = $dB = \dfrac{\mu_0}{4\pi} \times \dfrac{a^2 indx}{\left[a^2 + \left(\dfrac{l}{2} - x\right)^2\right]^{3/2}}$

$\therefore$ for the whole solenoid $B = \int_0^B dB$

$= \int_0^{\ell} \dfrac{\mu_0 a^2 nidx}{4\pi\left[a^2 + \left(\dfrac{\ell}{2} - x\right)^2\right]^{3/2}}$



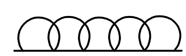

$= \dfrac{\mu_0 ni}{4\pi} \int_0^{\ell} \dfrac{a^2\, dx}{a^3\left[1 + \left(\ell - \dfrac{2x}{2a}\right)^2\right]^{3/2}} = \dfrac{\mu_0 ni}{4\pi a} \int_0^{\ell} \dfrac{dx}{\left[1 + \left(\ell - \dfrac{2x}{2a}\right)^2\right]^{3/2}} = 1 + \left(\ell - \dfrac{2x}{2a}\right)^2$

58. i = 2 a, f = $10^{8}$ rev/sec, n= ?, $m_e = 9.1 \times 10^{-31}$ kg,

$q_e = 1.6 \times 10^{-19}$ c, $B = \mu_0 ni \Rightarrow n = \dfrac{B}{\mu_0 i}$

$f = \dfrac{qB}{2\pi m_e} \Rightarrow B = \dfrac{f 2\pi m_e}{q_e} \Rightarrow n = \dfrac{B}{\mu_0 i} = \dfrac{f 2\pi m_e}{q_e \mu_0 i} = \dfrac{10^8 \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19} \times 2 \times 10^{-7} \times 2A}$ = 1421 turns/m

59. No. of turns per unit length = n, radius of circle = r/2, current in the solenoid = i,
Charge of Particle = q, mass of particle = m $\therefore B = \mu_0 ni$



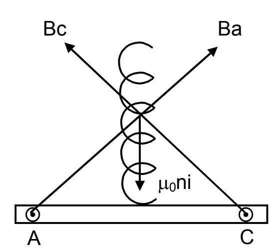
Again $\dfrac{mV^2}{r} = qVB \Rightarrow V = \dfrac{qBr}{m} = \dfrac{q\mu_0 nir}{2m} = \dfrac{\mu_0 niqr}{2m}$

60. No. of turns per unit length = ℓ
(a) As the net magnetic field = zero

$\therefore \vec{B}_{plate} = \vec{B}_{Solenoid}$

$\vec{B}_{plate} \times 2\ell = \mu_0 k d\ell = \mu_0 k \ell$

$\vec{B}_{plate} = \dfrac{\mu_0 k}{2}$ ...(1) $\vec{B}_{Solenoid} = \mu_0 ni$ …(2)




Equating both $i = \dfrac{\mu_0 k}{2}$

(b) $B_a \times \ell = \mu k \ell$ $\Rightarrow B_a = \mu_0 k$ $BC = \mu_0 k$

$B = \sqrt{B_a{}^2 + B_c{}^2} = \sqrt{2(\mu_0 k)^2} = \sqrt{2}\mu_0 k$

$2\mu_0 k = \mu_0 ni$ $i = \dfrac{\sqrt{2}k}{n}$

61. C = 100 μf, $Q = CV = 2 \times 10^{-3}$ C, t = 2 sec,
V = 20 V, V′ = 18 V, $Q' = CV = 1.8 \times 10^{-3}$ C,

$\therefore i = \dfrac{Q - Q'}{t} = \dfrac{2 \times 10^{-4}}{2} = 10^{-4}$ A n = 4000 turns/m.

$\therefore B = \mu_0 ni = 4\pi \times 10^{-7} \times 4000 \times 10^{-4} = 16\,\pi \times 10^{-7}$ T

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