Class 10- Magnetic effect of electric current Numerical problems with Solution

Q. A current of 10 A flows through a straight wire. Calculate the magnitude of magnetic field at a point 2 cm away from the wire. (the permeability of vacuum is 4π x 10^{-7} Tm/A)

Solution: $B = \frac{\mu_0}{2\pi} \times \frac{I}{r} = \frac{(4\pi \times 10^{-7}) \times 10}{2\pi \times 0.02} = 10^{-4}$ T

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

Ans: 3.5×10^{-5} T.

Q. A current of 10 A flows through a circular coil of 1000 turns and radius 0.1m. Find the magnitude of magnetic field at the centre of coil and at the end of coil.

Solution: $B_{\text{at the centre}} = \frac{\mu_0}{2} \times \frac{NI}{r} = \frac{(4\pi \times 10^{-7}) \times 1000 \times 10}{2 \times 0.1}$

$= (2\pi \times 10^{-2})$T $= 6.28 \times 10^{-2}$ T

$B_{\text{at the end}} = \frac{B_{\text{at the centre}}}{2} = (6.28 \times 10^{-2}\ T)/2 = (3.14 \times 10^{-2}\ T)$

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

Ans: 3.14×10^{-4} T

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

Solution:

Current in the wire, I = 50 A

A point is 2.5 m away from the East of the wire.

Magnitude of the distance of the point from the wire, r = 2.5 m.

Magnitude of the magnetic field at that point is given by the relation,

$B = \frac{\mu_0}{2\pi} \times \frac{I}{r} = \frac{(4\pi \times 10^{-7}) \times 50}{2\pi \times 2.5} = 4 \times 10^{-6}\ T$

The point is located normal to the wire length at a distance of 2.5 m. The direction of the current in the wire is vertically downward.

Hence, according to the Maxwell's right hand thumb rule, the direction of the magnetic field at the given point is vertically upward.

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

Solution: Current in the power line, I = 90 A

Point is located below the power line at distance, r = 1.5 m

$B = \frac{\mu_0}{2\pi} \times \frac{I}{r} = \frac{(4\pi \times 10^{-7}) \times 950}{2\pi \times 1.5} = 1.2 \times 10^{-5}\ T$

The current is flowing from East to West. The point is below the power line. Hence, according to Maxwell's right hand thumb rule, the direction of the magnetic field is towards the South.

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

Solution:

Current in the wire, I = 8 A

Magnitude of the uniform magnetic field, B = 0.15 T

Angle between the wire and magnetic field, θ = 30°.

Magnetic force per unit length on the wire is given as:

$f = BIL \sin\theta$

$= 0.15 \times 8 \times 1 \times \sin 30° = 0.15 \times 8 \times 1 \times ½ = 0.6$ N/m

Hence, the magnetic force per unit length on the wire is 0.6 N/m

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

Solution:

Length of the wire, l = 3 cm = 0.03 m

Current flowing in the wire, I = 10 A

Magnetic field, B = 0.27 T

Angle between the current and magnetic field, θ = 90°

Magnetic force exerted on the wire is given as:

$F = BIL\sin\theta = 0.27 \times 10 \times 0.03 \sin 90° = 0.27 \times 10 \times 0.03 \times 1 = 8.1 \times 10^{-2}$ N

Hence, the magnetic force on the wire is 8.1 × 10–2 N.

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

Solution:

Length of the solenoid, l = 80 cm = 0.8 m

There are five layers of windings of 400 turns each on the solenoid.

Total number of turns on the solenoid, $N = 5 \times 400 = 2000$

Diameter of the solenoid, D = 1.8 cm = 0.018 m

Current carried by the solenoid, *I* = 8.0 A

Magnitude of the magnetic field inside the solenoid near its centre

= B = $\frac{\mu_0 NI}{L}$ = $\frac{(4\pi \ x \ 10^{-7}) \ x \ 2000 \ x \ 8}{0.018}$ = 2.512 ×10^{-2} T.

Q. What will be the frequency of an alternating current, if its direction changes after every 0.05 s?

Solution:

The time period (T) of one cycle would be = 2 x (0.05 s) = 0.1 s.

frequency, f = 1/T. Hence, f = (1 / 0.1) = 10 Hz.

Numerical for practice:

1. The mains power supply of a house is through a 5-A fuse. How many 100-W bulbs can be used in this house at the correct voltage?
2. A wire 10 cm long and carrying a current of 1.5 A is held in a uniform magnetic field in which B=10-3 T. Calculate the force on the wire if it is held perpendicular to the lines of the magnetic field.
3. A current of 10 A flows in a circular coil of 1000 turns and radius 0.1 m. Find the magnitude of the magnetic field at the centre of the coil.
4. At what distance from a straight conductor carrying a current of 2.8 A, will the magnetic induction be 2.8×10-5 T?
5. Find the strength of the current which will produce a magnetic field of 10-4 T at the centre of a coil of mean radius 0.10 m. The coil comprises 20 turns.
6. A 0.4 m wire, stretched horizontally, carries an electric current of 15 A from East to West, in a magnetic field whose magnetic field intensity is 0.1 N/Am, directed vertically downwards. What is (a) the magnitude of the magnetic deflecting force on the wire, and (b) its direction?