ST. LAWRENCE HIGH SCHOOL

A JESUIT CHRISTIAN MINORITY INSTITUTION

STUDY MATERIAL - 5 (PART - II)

Subject : PHYSICS

Topic : Electromagnetism

CLASS : XII Date : 27.6.20

B. Numericals

1. A test charge of 1.6 x 10^{-19}C is moving with a velocity $\vec{v} = 2\hat{i} + 3\hat{j}$ m.s^{-1} in a magnetic field $\vec{B} = 2\hat{i} + 3\hat{j}$ wb-m^{-2}. Find the force acting on it. [2012]

   The force acting on the charge,

   $$F = q(\vec{v} \times \vec{B})$$

   $$= 1.6 \times 10^{-19}[(2\hat{i} + 3\hat{j}) \times (2\hat{i} + 3\hat{j})] = 0$$

2. A wire of length 314 cm is used to form a circular coil of radius 2 cm. If the coil carries a current of 1A, find the magnetic field at the centre of the coil. [2013]

   Radius of the coil, r = 2 cm = 2 x 10^{-2} m = 0.02 m

   $\therefore$ Cross sectional area of the coil

   $$= \pi r^2 = \pi \times (0.02)^2 = \pi \times 4 \times 10^{-4} m^2$$

   If number of turns of the coil be n then,

   $$2\pi r \times n = 314 \quad \text{or,} \quad 2\pi \times 2 \times n = 314$$

   $\therefore$ $n = 25$

   $\therefore$ Magnetic field at the centre of the coil,

   $$B = \frac{\mu_0 nl}{2r} = \frac{4\pi \times 10^{-7} \times 25 \times 1}{2 \times 2 \times 10^{-2}} = 7.85 \times 10^{-4} T$$

3. Two parallel straight wires X and Y carrying currents of 10A and 5A respectively in opposite directions are separated by a distance of 0.5 m in air. Calculate the magnitude and direction of the force on 20 cm length of the wire Y. [2013]

   The force acting per unit length of the wire Y

   $$= \frac{\mu_0}{4\pi} \cdot \frac{2I_1 I_2}{r} = \frac{10^{-7} \times 2 \times 10 \times 5}{2}$$

   = 2 x 10^{-5}M

   $\therefore$ The force acting on a length of 20 cm of the wire Y

   = 2 x 10^{-5} x 0.2 = 4 x 10^{-6}N

   The force acting between the two wires will be repulsive in nature.

4. A electron is moving with a velocity $\vec{v} = (\hat{i} + 2\hat{j})$ m.s^{-1} in the magnetic field $\vec{B} = (2\hat{i} + 2\hat{j})$ Wb.m^{-2}. Determine the magnitude and direction of the force acting on the electron. Charge of an electron is -1.6×10^{-19} C. [2014]

The force acting on the electron,

$$\vec{F} = q(\vec{v} \times \vec{B}) = 1.6 \times 10^{19}[(\hat{i} + 2\hat{j}) \times (2\hat{i} + 2\hat{j})]$$

$$= 1.6 \times 10^{19} \times [-2\hat{k}] = -3.2 \times 10^{19}\,\hat{k}N$$

So the magnitude of the force = 3.2×10^{-19}N and the direction is along negative z-zxis.

5. In a compact coil of 50 turns, the current strength is 10A and the radius of the coil is 25×10^{-2} m. Find the magnitude of the magnetic field at its centre. [2016]

Ans : Number of turns, $N = 50$; radius of the coil, $r = 25 \times 10^{-2}$ m; current strength, $I = 10$A.

$\therefore$ Magnetic field at the centre of the coil,

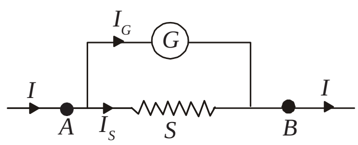
$$B = \frac{\mu_0 NI}{2r} = \frac{4\pi \times 10^{-7} \times 50 \times 10}{2 \times 25 \times 10^{-2}}$$

$= 1.256 \times 10^{-3}$T.

6. A galvanometer of resistance 10 Ω gives full scale deflection for a current of 10 mA. How can this galvanometer be used (i) as an ammeter to measure current of range 0–2A and (ii) as a voltmeter having voltage range 0–5 V? [2001]

Solution : Resistance of the galvanometer, $G = 10\,\Omega$; maximum current, $I_G = 10$ mA = 0.01 A

(i) Connecting a shunt S in parallel to the galvanometer in the fig., if the instrument is used between the points A and B, an ammeter of current-range 0–I will be obtained. In the given question, $I = 2A$.

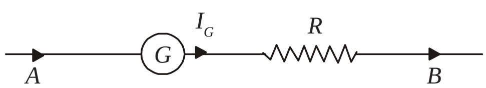


Now, $I_S \,.\, S = I_G \,.\, G$

or, $$S = \frac{I_G}{I_S}G = \frac{I_G}{I - I_G}.G \quad = \frac{0.01}{2 - 0.01} \times 10 = 0.0503\Omega$$

This is the required value of the shunt-resistance.

(ii) A voltmeter having voltage range of zero to $(V_A - V_B)$ is obtained if a resistance R is connected in series with the galvanometer and the instrument is used between the points A and B in the fig.



In the given problem, $V_A - V_B = 5\ V$

Now, $V_A - V_B = I_G(G + R)$

or, $$R = \frac{V_A - V_B}{I_G} - G = \frac{5}{0.01} - 10$$

$= 500 - 10 = 490\,\Omega$

This is the required value of the resistance R.

7. An electron is not deflected in passing through a certain region of space. Can we be sure that there is no magnetic field in that region?

   Answer : The magnetic force on the electron would be zero if its velocity $\vec{v}$ is along the magnetic field $\vec{B}$, because $\vec{F}_m = e\vec{v} \times \vec{B}$. Then the electron would not be deflected even if a non-zero magnetic field is present.

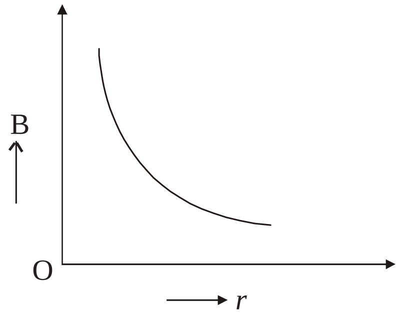
8. How will the magnetic field intensity at the centre of a circular coil carrying current change, if the current through the coil is doubled and radius of the coil is halved?

   Answer : We know, $B = \frac{\mu_0 NI}{2r}$

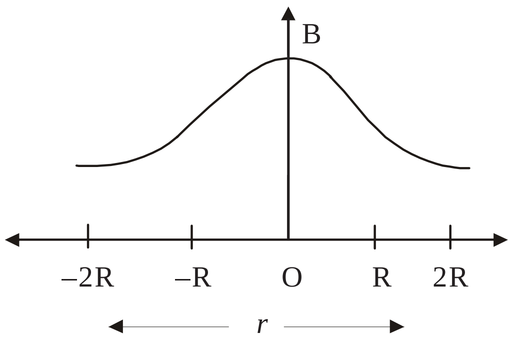
   $\therefore \frac{B_1}{B_2} = \frac{I_1}{I_2} \cdot \frac{r_2}{r_1} = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$ or, $B_2 = 4B_1$

C. Graphs

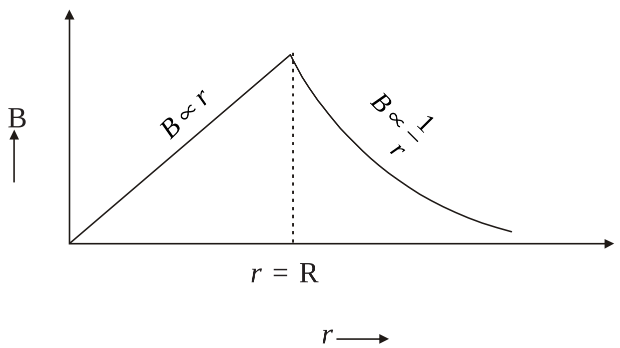
1. The variation of magnetic field (B) due to infinite long current carrying conductor with distance (*r*) from the conductor



2. Variation of magnetic field of a current carrying loop along its axis.



3. The variation of magnetic field (B) with distance (*r*) from the axis of a wire



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