12. Magnetic Effect of Electric Current

HOMEWORK SOLUTION

1. Given :

$r = 5 \times 10^{-2}$ m

$I = 5A$

To Find :

$B = ?$

Formula :

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

Solution :

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

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

$B = 2 \times 10^{-5}$ Wb/m²

2. Given :

$r = 8 \times 10^{-2}$

$I = 4A$

To Find :

$B = ?$

Formula :

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

$$= \frac{4\pi \times 10^{-7} \times 4}{2\pi \times 8 \times 10^{-2}}$$

$B = 1 \times 10^{-5}$ Wb/m²

3. Given :

$n = 70$

$r = 10 \times 10^{-2}$

$B = 0.003$ Wb/m²

To Find :

$I = ?$

Formula :

$$B = \frac{\mu_0 nI}{2r}$$

$$\therefore I = \frac{B \times 2r}{\mu_0 n}$$

Solution :

$$I = \frac{B \times 2r}{\mu_0 \times n}$$

$$= \frac{0.003 \times 2 \times 10 \times 10^{-2}}{4\pi \times 10^{-7} \times 70}$$

$$= \frac{0.006 \times 10^{-1}}{4\pi \times 70 \times 10^{-7}}$$

$$= \frac{6 \times 10^{-4}}{879.2 \times 10^{-7}}$$

$= 0.00682 \times 10^{3}$

$I = 6.82$ A

4. Given :

$B = 12.56 \times 10^{-4}$

$r = 7.5$ cm $= 7.5 \times 10^{-2}$ m

$n = 50$

To Find :

$I = ?$

Formula :

$$B = \frac{\mu_0 nI}{2r}$$

$$\therefore I = \frac{B \times 2r}{\mu_0 n}$$

Solution :

$$I = \frac{12.56 \times 10^{-4} \times 2 \times 7.5 \times 10^{-2}}{4\pi \times 10^{-7} \times 50}$$

$$= \frac{15}{50} \times 10^{1}$$

$I = 3A$

5. Given :

$n = 10$

$a = 8 \times 10^{-2}$ m

$I = 5A$

$x = 6 \times 10^{-2}$ m

To Find :

$B = ?$

Formula :

$$B = \frac{\mu_0 nIa^2}{2\left(a^2 + x^2\right)^{\frac{3}{2}}}$$

Solution :

$$B = \frac{4\pi \times 10^{-7}}{2} \times \frac{10 \times 5 \times \left(8 \times 10^{-2}\right)^2}{\left[\left(8 \times 10^{-2}\right)^2 + \left(6 \times 10^{-2}\right)\right]^{\frac{3}{2}}}$$

$$= \frac{2\pi \times 10^{-7} \times 50 \times 64 \times 10^{-4}}{\left(100 \times 10^{-4}\right)^{\frac{3}{2}}}$$

$= 2 \times 10^{-4}$ Wb/m²

6. Given :

$a = 3 \times 10^{-2}$ m

$n = 25$

$B = 10\pi \times 10^{-5}$ Wb/m²

$x = 4 \times 10^{-2}$ m

To Find :

$I = ?$

Formula :

$$B = \frac{\mu_0 nIa^2}{2\left(a^2 + x^2\right)^{\frac{3}{2}}}$$

$$10\pi \times 10^{-5} = \frac{4\pi \times 10^{-7} \times 25 \times I \times \left(3 \times 10^{-2}\right)^2}{2 \times \left[9 \times 10^{-4} + 16 \times 10^{-4}\right]^{\frac{3}{2}}}$$

$$\therefore 10\pi \times 10^{-5} = \frac{2\pi \times 10^{-7} \times 25 \times I \times 9 \times 10^{-4}}{\left[25 \times 10^{-4}\right]^{\frac{3}{2}}}$$

$$\therefore I = \frac{10\pi \times 10^{-5} \times \left[25 \times 10^{-4}\right]^{\frac{3}{2}}}{2\pi \times 10^{-7} 10\pi \times 25 \times 9 \times 10^{-4}}$$

$I = 2.78$ A

7. Given :

$r = 10 \times 10^{-2}$ m

$I = 0.1A$; $n = 1$

To Find :

$M = ?$

Formula :

$M = nIA$

Solution :

$M = nIA$

$= 1 \times 0.1 \times \pi \times 100 \times 10^{-4}$

$M = 3.14 \times 10^{-3} Am^2$

8. Given :

$V = 2 \times 10^7$ m/s

$B = 1.6 \times 10^{-6}$ wb/m²

$q = 1.6 \times 10^{-19}$ C

$\theta = 90^0$

To Find :

$F = ?$

Formula :

$F = qVB \sin\theta$

Solution :

$F = 1.6 \times 10^{-19} \times 2 \times 10^7 \times 1.6 \times 10^{-6} \times \sin 90^0$

$F = 5.12 \times 10^{-18}$ N

9. Given :

$V = 3 \times 10^6$ m/s

$\theta = 90^0$

$B = 0.005T$

$F = 2 \times 10^{-2}$ N

To Find :

$q = ?$

Formula :

$F = q.V\beta \sin\theta$

Solution :

$$\therefore q = \frac{F}{v\beta \sin\theta}$$

$$= \frac{2\times10^{-2}}{3\times10^{6}\times0.005\sin 90}$$

$$= \frac{2\times10^{-2}}{3\times10^{6}\times5\times10^{-3}}$$

$q = 1.333\times10^{-6}C$

10. Given :

$l = 25\times10^{-2}$ m

$B = 2T$

$q = 1C$

$t = 5s$

To Find :

$F_{parallel} = ?$

$F_{perpendicalor} = ?$

$F_{30} = ?$

Formula :

$F = B\,i\,l\sin\theta$

$$= \frac{B.q.l}{t}\sin\theta$$

Solution :

a) $\theta = 0^0$ ($\because$ conductor to parallel)

$$F_{parallel} = \frac{B.q.l}{t}\times\sin\theta$$

$\therefore F_{parallel} =$ zero N

b) $\theta = 90^0$ ($\because$ conductor to perendicular)

$$F_{perendicular} = \frac{B.q.l}{t}\sin 90$$

$$= \frac{B.q.l}{t}$$

$$= \frac{2\times1\times25\times10^{-2}}{5}$$

$$= 10\times10^{-2}$$

$F_{perendicular} = 0.1$ N

c) $\theta = 30^0$

$$= \frac{2\times1\times25\times10^{-2}}{5}\times\frac{1}{2}$$

$$= \frac{0.1}{2}$$

$F_{30} = 0.05$N

11. Given :

$a = 0.1$m

$I_1 = 2A$

$I_2 = 3A$

To Find :

force per unit length 'f' = ?

Formula :

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

Solution :

$$f = \frac{4\pi\times10^{-7}\times2\times3}{2\pi\times0.1}$$

$f = 12\times10^{-6}$N/m

since the currents are flowing in same direction, the force will be attractive

12. Given :

$I_1 = 2A$

$I_2 = 5A$

$f = 4\times10^{-5}$ N/m

To Find :

$a = ?$

Formula :

$$f = \frac{\mu_0 I_1 I_2}{2\pi a}$$

Solution :

$$f = \frac{\mu_0 I_1 I_2}{2\pi a}$$

$$\therefore a = \frac{\mu_0 I_1 I_2}{2\pi f}$$

$$a = \frac{4\pi\times10^{-7}\times2\times5}{2\pi\times4\times10^{-5}}$$

$\therefore a = 5\times10^{-2}$m