DPP – 05

SOLUTION

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1. Force per unit length $= \frac{\mu_0 I_1 I_2}{2\pi d}$

$\because$ d = 30 cm = 0.3 m

$$\text{Force/length} = \frac{4\pi \times 10^{-7} \times 10 \times 15}{2\pi \times 0.3} = \frac{2 \times 10 \times 15 \times 10 \times 10^{-7}}{3} = 10 \times 100 \times 10^{-7}$$

$\text{Force/length} = 10^{-4}$ N/m.

on 5 m segment

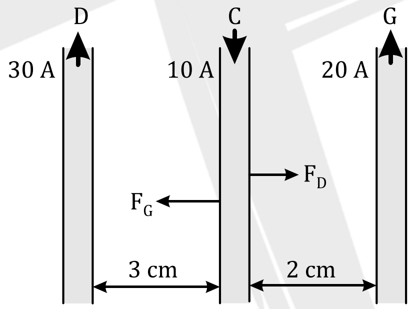
$F = 5 \times 10^{-4}$

i.e. $x = 5$

2. Force on wire C due to wire D

$$F_D = 10^{-7} \times \frac{2 \times 30 \times 10}{2 \times 10^{-2}} \times 25 \times 10^{-2} = 5 \times 10^{-4}\ \text{N}$$

(Towards right)



Force on wire C due to wire G

$$F_G = 10^{-7} \times \frac{2 \times 20 \times 10}{2 \times 10^{-2}} \times 25 \times 10^{-2} = 5 \times 10^{-4}\ \text{N}$$

(Towards left)

$\Rightarrow$ Net force on wire C is $F_{net} = F_D - F_G = 0$

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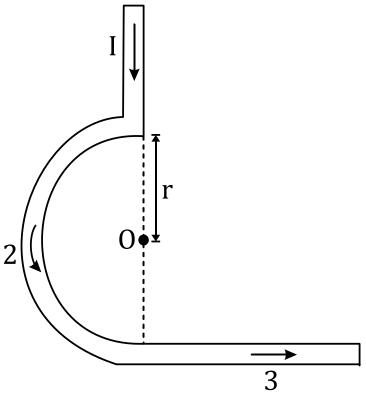
3.



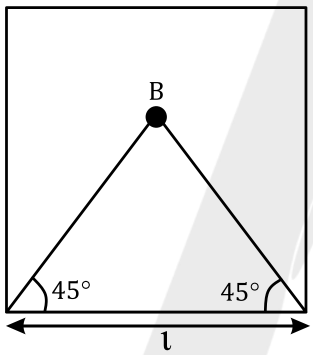
Magnetic field due to different parts are $B_1 = 0]$

$$B_2 = \frac{\mu_0}{4\pi} \cdot \frac{\pi I}{r} \odot$$

$$B_3 = \frac{\mu_0}{4\pi} \cdot \frac{I}{r} \odot$$

$$\therefore \ B_{net} = B_2 + B_3 = \frac{\mu_0 I}{4r} + \frac{\mu_0 I}{4\pi r}$$

4.



We have $2\pi r = 4l \Rightarrow r = \frac{2l}{\pi}$

Hence, field at the center of the circular coil, $B = \frac{\mu_0 i}{2r}$

$$B = \frac{\mu_0 \pi i}{4l}$$

Field at the center of square frame

$$= 4 \times \frac{\mu_0 i}{4\pi \cdot l/2}(\cos\ 45^\circ - \cos\ 135^\circ)$$

$$B' = 4 \times \frac{\mu_0 i}{2\pi l} \cdot \frac{2}{\sqrt{2}} = \frac{4\mu_0 i}{\pi\sqrt{2}l}$$

$$\frac{B'}{B} = \frac{4\mu_0 i}{\pi\sqrt{2}l} \cdot \frac{4l}{\mu_0 \pi i} = \frac{8\sqrt{2}}{\pi^2}$$

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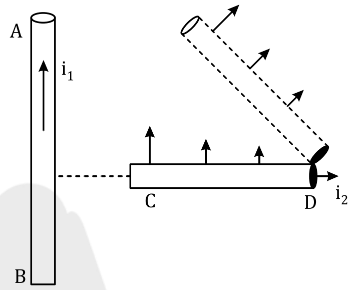
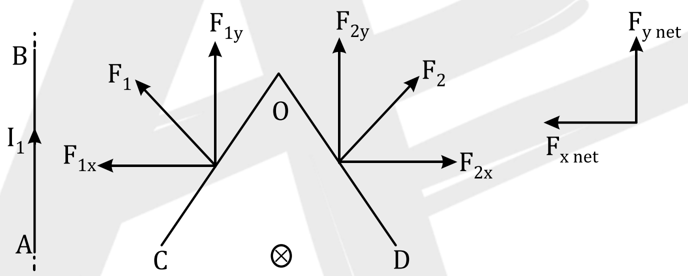
5. By using Fleming left hand rule.

6. Since the force on the rod CD is non-uniform, it will experience force and torque. From the left-hand side, it can be seen that the force will be upward and torque is clockwise.

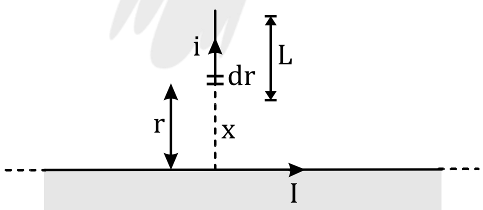


7. Magnetic forces F_1 and F_2 act on section CO and OD respectively in direction normal to the wires as shown in figure.



Resolve F_1 and F_2 along x and y axis. $F_{1x} > F_{2x}$ (Wire CO is nearer to AB than OD) Hence the net force on wire CD has a component along x axis and another component along y-axis.

8.



Magnetic field at dr, $B = \frac{\mu_0 I}{2\pi r}$

Force on small element at a distance R of wire of length L is

$$dF = i(dr)\left(\frac{\mu_0 I}{2\pi r}\right)$$

$$F = \frac{\mu_0 iI}{2\pi}\int_x^{x+L}\frac{dr}{r} = \frac{\mu_0 iI}{2\pi}\ln\left(\frac{x+L}{x}\right)$$

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9. Take an elementary strip of width dx on the sheet at a distance x from the wire. Force on this element is:

$$dF = \frac{\mu_0 I_1}{2\pi x} I_2 dx$$

Total force on unit length of sheet is

$$F = \int_a^{a+b} \frac{\mu_0 I_1}{2\pi x} I_2 dx$$

$$F = \frac{\mu_0 I_1 I_2}{2\pi} \int_a^{a+b} \frac{1}{x} dx = \frac{\mu_0 I_1 I_2}{2\pi a} \log \frac{(a+b)}{b}$$