

## Answer on Question 50957, Physics, Electromagnetism

### Question:

A rectangular coil of dimensions  $20\text{cm}$  by  $15\text{cm}$  lies with its plane parallel to a magnetic field of  $0.5 \frac{\text{W}}{\text{m}^2}$ . The coil, carrying a current of  $10\text{A}$  experiences a torque of  $4.5\text{Nm}$  in the field. How many loops has the coil?

- a) 100
- b) 60
- c) 30
- d) 20

### Solution:

Let us consider a rectangular loop of coil carrying a current  $I$  in the presence of a uniform magnetic field  $B$  directed parallel to the plane of the loop:

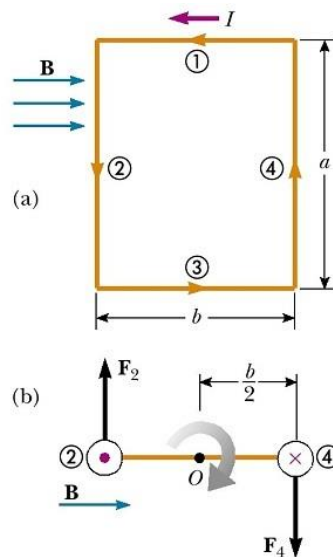


Figure 1.

We see in the Fig. 1a, that no magnetic forces act on sides 1 and 3 because these wires are parallel to the field. However, magnetic forces do act on sides 2 and 4 because these sides are oriented perpendicular to the field. We can obtain the magnitude of this forces from the equation  $F_B = IL \times B$ , where  $F_B$  is the magnetic force,  $I$  is the current in the wire,  $L$  is a vector that points in the direction of the current  $I$  and has a

magnitude equal to the length  $L$  of the wire,  $\mathbf{B}$  is the magnetic field. So, the magnitude of this forces is:

$$F_2 = F_4 = IaB$$

The direction of  $F_2$ , the force exerted on wire 2 is out of the page in the view shown in the Fig. 1a, and that of  $F_4$ , the force exerted on wire 4, is into the page in the same view. If we view the loop from side 3 and sight along sides 2 and 4, we see the view shown in Fig. 1b, and the two forces  $F_2$  and  $F_4$  are directed as shown. So, these two forces produce about point  $O$  a torque and the magnitude of this torque  $\tau$  is:

$$\tau = F_2 \frac{b}{2} + F_4 \frac{b}{2} = (IaB) \frac{b}{2} + (IaB) \frac{b}{2} = IabB$$

where the moment arm about point  $O$  is  $\frac{b}{2}$  for each force.

Because the torque increases proportionally according to number of loops  $N$  we obtain:

$$\tau = NIabB$$

Finally, we can find the number of loops of a rectangular coil:

$$N = \frac{\tau}{IabB} = \frac{4.5Nm}{10A \cdot 0.2m \cdot 0.15m \cdot 0.5 \frac{W}{m^2}} = 30 \text{ loops.}$$

**Answer:**

c) 30 loops