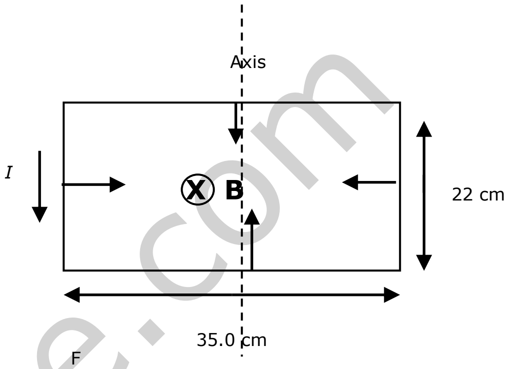
Q- A rectangular coil of wire, 22.0 cm by 35.0 cm and carrying a current 1.40 A, is oriented with the plane of its loop perpendicular to a uniform 1.50 T magnetic field in to the plane of the coil.

a) Calculate the net force and torque which the magnetic field exerts on the coil.

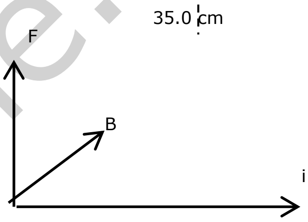
b) The coil is rotated through a 30.0º angle about the axis shown, the left side coming out of the plane of the figure and the right side going into the plane. Calculate the net force and torque which the magnetic field exerts on the coil.

Solution:



As the force acting on a current carrying conductor is given by $\vec{F} = i(\vec{l} \times \vec{B})$ the direction of force is given by the direction of cross product of *l* in the direction of current and B, the magnetic field. If the direction of current is perpendicular to that of magnetic field, this can be done in an easy way using Fleming's rule.

Fleming's left-hand rule-



If the forefinger, middle finger and the thumb of left hand are perpendicular to each other, forefinger shows pointing the direction of magnetic field, middle finger shows the direction of current in the wire then the direction of the force acting on the conductor is given by that pointed by thumb.

a) As the current in the opposite sides of the rectangle is in opposite directions the force acting of the sides are also in opposite directions, hence the net force on the coil will be zero.

As all the four forces are in the plane of coil, net torque due to them is zero.

b) Magnitude of force on each side on left and right = BiL = 1.50*1.40*0.22 =0.462 N

As the coil is rotated through 30^0, the torque due to forces on the upper and lower wire is still zero because they are parallel to the axis of rotation.

The force on left and right sides are still parallel, their magnitudes are same, but the perpendicular distance between them is not zero, it is now 0.35 $\sin 30^0$ = 0.175 m. Hence the torque on the coil will be

0.462*0.175 = 0.08085 Nm

The resultant of the four forces is still zero.

(The torque can be calculate directly using the formula BiA sin θ. The torque increases with angle till rotates by 90^0 and then decreases to zero again at 180^0. In initial state the coil is in unstable equilibrium while in flip position it is in stable equilibrium.)