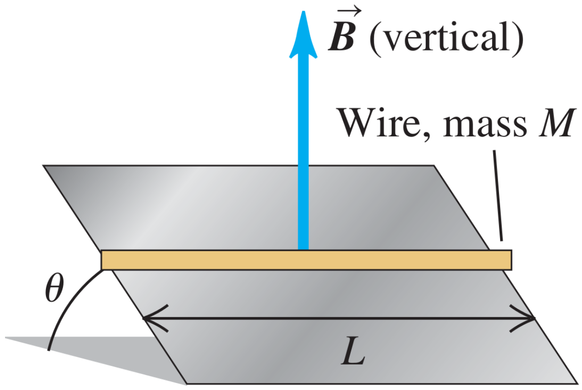
Problem 1

University Physics, Problem 69 A straight piece of conducting wire with mass M and length L is placed on a frictionless incline tilted at an angle θ from the horizontal. There is a uniform, vertical magnetic field $\vec{\mathbf{B}}$ at all points (produced by an arrangement of magnets not shown in the figure). To keep the wire from sliding down the incline, a voltage source is attached to the ends of the wire. When just the right amount of current flows through the wire, the wire remains at rest. Determine the magnitude and direction of the current in the wire that will cause the wire to remain at rest.



Solution

To keep the wire at rest, we need the current to cause a force directed upwards along the plane. This means that the current needs to flow from right to left (out of the page) on the given figure. The downward force on the wire is $Mg\sin\theta$ and the upward force is caused by the veritcal component of the field.

$BIL\cos\theta = Mg\sin\theta$

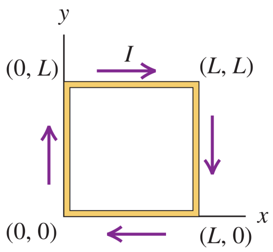
$I = \frac{MG\tan\theta}{BL}$

Problem 2

University Physics, problem 85 The figure shows a square loop of wire that lies in the xy-plane. The loop has corners at $(0,0),(0,L),(L,0),(L,L)$ and carries a constant current I in the clockwise direction. The magnetic field has no x-component but has both y- and z-components: $\vec{\mathbf{B}} = (B_0 z/L)\hat{j} + (B_0 y/L)\hat{k}$ where B_0 is a positive constant.

a. Find the magnitude and direction of the magnetic force exerted on each of the sides of the loop.

b. Find the magnitude and direction of the net magnetic force on the loop.



Solution

Since the problem deals with a loop in the xy-plane, thus $z = 0$ for all sides. Thus we can simplify the magnetic field expression to $\vec{\mathbf{B}} = (B_0 y/L)\hat{k}$. We can use the expression $F = I\int d\vec{\mathbf{l}} \times \vec{\mathbf{B}}$ to find the force on each side, then get the vector sum of the forces to find the net force. The sides are labelled as follows: leftmost side is 1, upper side is 2, right side is 3 and bottom side is 4.

Part (a)

The sides are labelled as follows: leftmost side is 1, upper side is 2, right side is 3 and bottom side is 4.

Side 1

$d\vec{\mathbf{l}} = dy\hat{j}$

$$F = I\int d\vec{\mathbf{l}} \times \vec{\mathbf{B}} = I\int_0^L dy(B_0 y/L)(\hat{j}\times\hat{k}) = \frac{IB_0L}{2}\hat{i}$$

Side 2

$d\vec{\mathbf{l}} = dx\hat{i}, y = l;$

$$F = I\int d\vec{\mathbf{l}} \times \vec{\mathbf{B}} = I\int_0^L dx(B_0 y/L)(\hat{i}\times\hat{k}) = -IB_0L\hat{j}$$

Side 3

$d\vec{\mathbf{l}} = -dy\hat{j}$

$$F = I\int d\vec{\mathbf{l}} \times \vec{\mathbf{B}} = I\int_L^0 -dy(B_0 y/L)(\hat{j}\times\hat{k}) = -\frac{IB_0L}{2}\hat{i}$$

Side 4

$d\vec{\mathbf{l}} = -dx\hat{i}, y = 0;$

$$F = I\int d\vec{\mathbf{l}} \times \vec{\mathbf{B}} = I\int_0^L dy(B_0 y/L)(\hat{j}\times\hat{k}) = 0$$

Part (b)

Forces on sides 3 and 4 cancel out and we end up with $F_{net} = -IB_0L\hat{j}$