Chapter 28

28.1 An electron that has velocity

$$\vec{v} = (2.0 \times 10^6 m/s)\hat{i} + (3.0 \times 10^6 m/s)\hat{j}$$

moves through a uniform magnetic field

$$\vec{B} = (0.030T)\hat{i} - (0.15T)\hat{j}$$

(a) Find the force on the electron. (b) Repeat your calculation for a proton having the same velocity.

a) The force is given by

$$\vec{F} = q\vec{v} \times \vec{B}$$

$$\vec{v} \times \vec{B} = \det\begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2.0 \times 10^6 m/s & 3.0 \times 10^6 m/s & 0 \\ 0.030 & -0.15 & 0 \end{bmatrix}$$

$$= (2.0 \times 10^6 m/s \cdot -0.15 - 3.0 \times 10^6 m/s \cdot 0.030)\hat{k}$$

$$= -3.9 \times 10^5 \hat{k}$$

$$\vec{F} = q\vec{v} \times \vec{B}$$

$$= (-1.6 \times 10^{-19}) \cdot -3.9 \times 10^5 \hat{k}$$

$$= 6.24 \times 10^{-14} N \hat{k}$$

For a proton, the force is

$$\vec{F} = q\vec{v} \times \vec{B}$$

$$\vec{v} \times \vec{B} = \det\begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2.0 \times 10^6 m/s & 3.0 \times 10^6 m/s & 0 \\ 0.030 & -0.15 & 0 \end{bmatrix}$$

$$= (2.0 \times 10^6 m/s \cdot -0.15 - 3.0 \times 10^6 m/s \cdot 0.030)\hat{k}$$

$$= -3.9 \times 10^5 \hat{k}$$

$$\vec{F} = q\vec{v} \times \vec{B}$$

$$= (1.6 \times 10^{-19}) \cdot -3.9 \times 10^5 \hat{k}$$

$$= -6.24 \times 10^{-14} N \hat{k}$$

28.5 An electron moves through a uniform magnetic field given by $\vec{\mathbf{B}} = B_x \hat{i} + (3 B_x)\hat{j}$. At a particular instant, the electron has a velocity $\vec{v} = 2.0\hat{i} + 4.0\hat{j}$ and the magnetic force acting on it is $\vec{\mathbf{F}} = 6.4 \times 10^{-19}\hat{k}$. Find B_x.

We can find the force by writing the dot product.

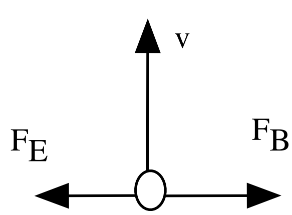
$$
\begin{aligned}
\vec{F} &= q\vec{v} \times \vec{B} \\
\vec{v} \times \vec{B} &= \det \begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2.0 m/s & 4.0\, m/s & 0 \\ B_x & 3B_x & 0 \end{bmatrix} \\
&= (2.0 \cdot 3B_x - 4.0 B_x)\hat{k} \\
&= 2B_x \hat{k} \\
\vec{F} &= q\vec{v} \times \vec{B} \\
&= (1.6 \times 10^{-19}) \cdot 2B_x \hat{k} \\
&= 6.4 \times 10^{-19} N \hat{k} \\
B_x &= 2T
\end{aligned}
$$

28.8 An electric field of 1.50 kV/m and a perpendicular magnetic field of 0.40 T act on a moving electron to produce no net force. What is the electron's speed.

$$
\begin{aligned}
qE &= qvB \\
v &= \frac{E}{B} = 3750 m/s
\end{aligned}
$$

28.14 A metal strip 6.5 cm long, .850 cm wide and 0.760 mm thick moves with a constant velocity v through a uniform magnetic field of 1.2 mT directed perpendicular to the strip as shown in Fig. 28.35. A potential difference of $3.90 \mu V$ is measured between the point x and y across the strip. Calculate the speed v.

If we consider the forces on an electron, when the system reaches a steady state, the forces are



$$
\begin{aligned}
&qE = qvB \\
&\quad v = \frac{E}{B} = \frac{V/d}{B} = \frac{3.90\times10^{-6}V/0.85\times10^{-2}m}{1.2\times10^{-3}T} \\
&\quad = 0.382 m/s
\end{aligned}
$$

28.17

28.25

28.39 A 13.0 g wire of length $L = 62.0cm$ is suspended by a pare of flexible leads in a uniform magnetic field of magnitude 0.440 T. What are the magnitude and direction of the current required to remove the tension in the leads.

We wish the magnetic force to exactly balance the weight of the bar. This means that the magnetic force must be upward. To get an upward force, the current must move to the right.

We can compute the size of the magnetic force from

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

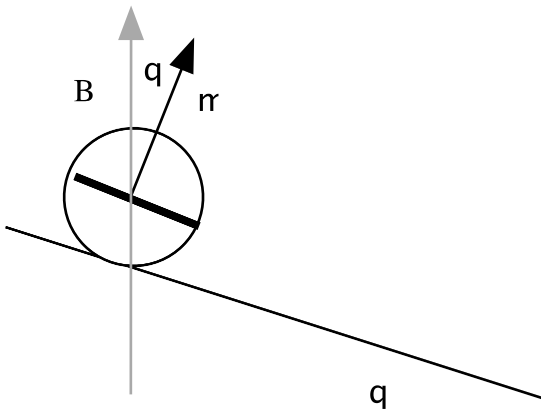
We then set this equal to the weight and solve for i

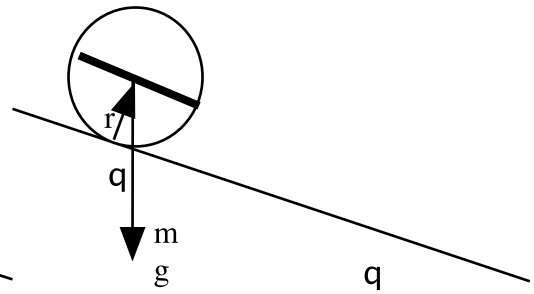
$$
\begin{aligned}
&i\,l\,B\sin\theta = mg \\
&\qquad i = \frac{mg}{l\,B\sin\theta} = \frac{0013kg\cdot 9.8m/s^2}{0.62m\cdot 0.440T\sin 90} \\
&\qquad = 0.467A
\end{aligned}
$$

For the magnetic force to be directed upward, the current must flow to the right

28.53 Figure 28-44 shows a wood cylinder of mass $m = 0.250kg$ and length $L = 0.100m$, with $N = 10.0$ turns of wire wrapped around it longitudinally, so that the plane of the wire coil contains the long central axis of the cylinder. The cylinder is released on a plane inclined at an angle θ to the horizontal, with the plane of the coil parallel to the incline plane. If there is a vertical uniform magnetic field 0.500 T, what is the least current i through the cylinder that keeps it from falling down the plane.

In this problem, the torque due to gravity is balanced by the magnetic torque. The magnetic torque is given by





$$\begin{aligned}\tau &= \mu B \sin\theta \\ &= N i A B \sin\theta \\ &= N i d L B \sin\theta\end{aligned}$$

$$\begin{aligned}\tau &= r F \sin\theta \\ &= \frac{d}{2} mg \sin\theta\end{aligned}$$

$$N i d L B \sin\theta = \frac{d}{2} mg \sin\theta$$

$$N i L B = \frac{1}{2} mg$$

$$i = \frac{mg}{2 N L B}$$

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