Chapter 29

3. (a) Eq. 29-3 leads to

$$v = \frac{F^{\text{mag}}}{eB\sin\phi} = \frac{6.50\times10^{-17}\ \text{N}}{\left(1.60\times10^{-19}\ \text{C}\right)\left(2.60\times10^{-3}\ \text{T}\right)\left(\sin 23.0°\right)} = 4.00\times10^{5}\ \text{m/s}.$$

(b) The kinetic energy of the proton is

$$K = \tfrac{1}{2}mv^2 = \tfrac{1}{2}\left(1.67\times10^{-27}\,\text{kg}\right)\left(4.00\times10^{5}\ \text{m/s}\right)^2 = 1.34\times10^{-16}\ \text{J}.$$

In electron-volts, this is $K = \left(1.34\times10^{-16}\ \text{J}\right)\big/\left(1.60\times10^{-19}\ \text{J/eV}\right) = 835\text{eV}.$

10. (a) The speed of the alpha particle is found from Eq. 29-7:

$$v = \frac{2eBr}{m_\alpha} = \frac{2\left(1.60\times10^{-19}\ \text{C}\right)\left(1.20\,\text{T}\right)\left(4.50\times10^{-2}\ \text{m}\right)}{\left(4.00\,\text{u}\right)\left(1.66\times10^{-27}\ \text{kg/u}\right)} = 2.60\times10^{6}\ \text{m/s}\ .$$

(b) The period is

$$T = \frac{\pi m_\alpha}{eB} = \frac{\pi\left(4.00\,\text{u}\right)\left(1.66\times10^{-27}\ \text{kg/u}\right)}{\left(1.60\times10^{-19}\ \text{C}\right)\left(1.20\,\text{T}\right)} = 1.09\times10^{-7}\ \text{s}.$$

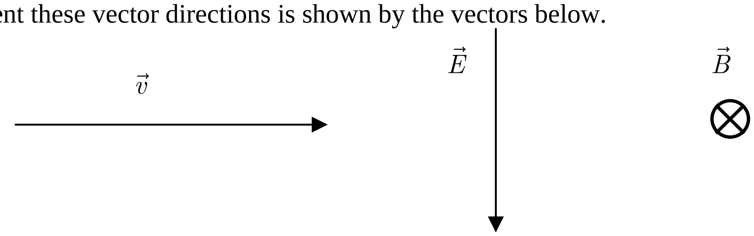
(c) The kinetic energy of the alpha particle is

$$K = \tfrac{1}{2}m_\alpha v^2 = \frac{\left(4.00\,\text{u}\right)\left(1.66\times10^{-27}\ \text{kg/u}\right)\left(2.60\times10^{6}\ \text{m/s}\right)^2}{2\left(1.60\times10^{-19}\ \text{J/eV}\right)} = 1.41\times10^{5}\ \text{eV}\ .$$

(d) The required accelerating potential is $\Delta V = K/2e = \left(1.41\times10^{5}\text{eV}\right)\big/2e = 7.03\times10^{4}\,\text{V}.$

24. (a) The electric force has a magnitude of $\left|\vec{F}^{\text{elec}}\right| = eE$, while the magnetic force has a magnitude of $\left|\vec{F}^{\text{mag}}\right| = e\left|\vec{v}\right|B\sin\phi,$ where ϕ is the angle between the magnetic field and the electron's velocity vector. For these two magnitudes to be equal (and thus have zero net force), we require $\left|\vec{v}\right| = E/(B\sin\phi)$. The smallest value of the speed is obtained when $\sin\phi = 1$ (at ϕ=90°). So $\left|\vec{v}\right|_{\text{min}} = E/B = \left(1.50\times10^{3}\ \text{V/m}\right)\big/(0.400\text{T}) = 3.75\times10^{3}\ \text{m/s}.$

(b) Having noted already that $\vec{v}\perp\vec{B}$, we now point out that $\vec{v}\times\vec{B}$ must be in the direction opposite to $\vec{E}$. One way to represent these vector directions is shown by the vectors below.



29. For a free charge q inside the metal strip with velocity $\vec{v}$ we have $\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right)$. We set this force equal to zero and use the relation between (uniform) electric field and potential difference. Thus,

$$|\vec{v}| = \frac{E}{B} = \frac{\left|\Delta V_{xy}\right|/d_{xy}}{B} = \frac{\left(3.90\times10^{-9}\,\text{V}\right)/\left(0.850\times10^{-2}\,\text{m}\right)}{\left(1.20\times10^{-3}\,\text{T}\right)} = 0.382\,\text{m/s}.$$

33. The magnetic force on the wire must be upward and have a magnitude equal to the gravitational force mg on the wire. Applying the right-hand rule reveals that the current must be from left to right in the figure. Since the field and the current are perpendicular to each other the magnitude of the magnetic force is given by $F^{\text{mag}} = |i|\,LB,$ where L is the length of the wire. Thus,

$$|i|\,LB = mg \quad \Rightarrow \quad |i| = \frac{mg}{LB} = \frac{\left(0.0130\,\text{kg}\right)\left(9.8\,\text{m/s}^2\right)}{\left(0.620\,\text{m}\right)\left(0.440\,\text{T}\right)} = 0.467\,\text{A}.$$

43. The forces acting on the cylinder are the force of gravity mg, acting downward from the center of mass, the normal force of the incline N, acting perpendicularly to the incline through the center of mass, and the force of friction f, acting up the incline at the point of contact. We take the x axis to be positive down the incline. Then the x component of Newton's second law for the center of mass yields

$$mg\sin\theta - f = ma_x.$$

For purposes of calculating the torque, we take the axis of the cylinder to be the axis of rotation. The magnetic field produces a torque with magnitude $N\,|i|\,AB\sin\theta,$ and the force of friction produces a torque with magnitude fr, where r is the radius of the cylinder. The first tends to produce an angular acceleration in the counterclockwise direction, and the second tends to produce an angular acceleration in the clockwise direction. Newton's second law for rotation about the center of the cylinder, $\tau = I\alpha$, gives

$$fr - N\,|i|\,AB\sin\theta = I\alpha.$$

Since we want the current that holds the cylinder in place, we set $a = 0$ and $\alpha = 0$, and use one equation to eliminate f from the other. The result is $mgr = N\,|i|\,AB.$ The loop is rectangular with two sides of length L and two of length $2r$, so its area is $A = 2rL.$ Therefore, the current needed is

$$|i| = \frac{mg}{2NLB} = \frac{\left(0.250\,\text{kg}\right)\left(9.8\,\text{m/s}^2\right)}{2\,(10.0)\left(0.100\,\text{m}\right)\left(0.500\,\text{T}\right)} = 2.45\,\text{A}.$$