1. **SSM** ***REASONING*** According to Equation 21.1, the magnitude of the magnetic force on a moving charge is $F=|q_0|vB\sin\theta$. Since the magnetic field points due north and the proton moves eastward, $\theta = 90.0°$. Furthermore, since the magnetic force on the moving proton balances its weight, we have $mg=|q_0|vB\sin\theta$, where m is the mass of the proton. This expression can be solved for the speed v.

   SOLUTION Solving for the speed v, we have

$$v=\frac{mg}{|q_0|B\sin\theta}=\frac{(1.67\times10^{-27}\text{ kg})(9.80\text{ m/s}^2)}{(1.6\times10^{-19}\text{ C})(2.5\times10^{-5}\text{ T})\sin 90.0°}=\boxed{4.1\times10^{-3}\text{ m/s}}$$

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3. ***REASONING AND SOLUTION*** The speed of the electron can be determined using $eV = (1/2)mv^2$ so that

$$v = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2\left(1.60\times10^{-19}\ \text{C}\right)\left(19\,000\ \text{V}\right)}{9.11\times10^{-31}\ \text{kg}}} = 8.17\times10^{7}\ \text{m/s}$$

The magnetic force is given by

$$F = |q|\,vB\sin\theta = (1.60\times10^{-19}\ \text{C})(8.17\times10^{7}\ \text{m/s})(0.28\ \text{T})\sin 90.0^{\circ} = \boxed{3.7\times10^{-12}\ \text{N}}$$

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5. $\boxed{\text{SSM}}$ ***REASONING AND SOLUTION*** The magnitude of the force can be determined using Equation 21.1, $F = |q|vB\sin\theta$, where θ is the angle between the velocity and the magnetic field. The direction of the force is determined by using Right-Hand Rule No. 1.

a. $F = |q|vB\sin 30.0° = (8.4 \times 10^{-6}\ \text{C})(45\ \text{m/s})(0.30\ \text{T})\sin 30.0° = \boxed{5.7\times10^{-5}\ \text{N}}$, directed $\boxed{\text{into the paper}}$.

b. $F = |q|vB\sin 90.0° = (8.4 \times 10^{-6}\ \text{C})(45\ \text{m/s})(0.30\ \text{T})\sin 90.0° = \boxed{1.1\times10^{-4}\ \text{N}}$, directed $\boxed{\text{into the paper}}$.

c. $F = |q|vB\sin 150° = (8.4 \times 10^{-6}\ \text{C})(45\ \text{m/s})(0.30\ \text{T})\sin 150° = \boxed{5.7\times10^{-5}\ \text{N}}$, directed $\boxed{\text{into the paper}}$.

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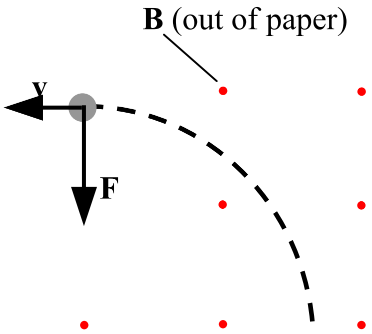
11. ***REASONING***



a. The drawing shows the velocity **v** of the particle at the top of its path. The magnetic force **F**, which provides the centripetal force, must be directed toward the center of the circular path. Since the directions of **v**, **F**, and **B** are known, we can use Right-Hand Rule No. 1 (RHR-1) to determine if the charge is positive or negative.

b. The radius of the circular path followed by a charged particle is given by Equation 21.2 as $r = mv/|q|B$. The mass m of the particle can be obtained directly from this relation, since all other variables are known.

SOLUTION

a. If the particle were positively charged, an application of RHR-1 would show that the force would be directed straight up, opposite to that shown in the drawing. Thus, the charge on the particle must be $\boxed{\text{negative}}$.

b. Solving Equation 21.2 for the mass of the particle gives

$$m = \frac{|q|Br}{v} = \frac{\left(8.2\times10^{-4}\ \text{C}\right)\left(0.48\ \text{T}\right)\left(960\ \text{m}\right)}{140\ \text{m/s}} = \boxed{2.7\times10^{-3}\ \text{kg}}$$

15. **SSM** ***REASONING AND SOLUTION*** The radius of curvature for a particle in a mass spectrometer is discussed in Section 21.4. According that discussion, the radius for a charged particle with a charge of +*e* ($e = 1.60 \times 10^{-19}$ C) is $r = \sqrt{\dfrac{2mV}{eB^2}}$. In this problem, the charged particle has a charge of +2*e*, so that the radius becomes $r = \sqrt{\dfrac{2mV}{2eB^2}}$. Thus, the desired radius is

$$r = \sqrt{\frac{2mV}{2eB^2}} = \sqrt{\frac{2\left(3.27\times10^{-25}\text{ kg}\right)\left(1.00\times10^{3}\text{ V}\right)}{2\left(1.60\times10^{-19}\text{ C}\right)\left(0.500\text{ T}\right)^2}} = \boxed{0.0904\text{ m}}$$

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23. **SSM** **WWW** ***REASONING*** The particle travels in a semicircular path of radius r, where r is given by Equation 21.2 $\left(r = \dfrac{mv}{|q|B}\right)$. The time spent by the particle in the magnetic field is given by $t = s/v$, where s is the distance traveled by the particle and v is its speed. The distance s is equal to one-half the circumference of a circle ($s = \pi r$).

SOLUTION We find that

$$t = \frac{s}{v} = \frac{\pi r}{v} = \frac{\pi}{v}\left(\frac{mv}{|q|B}\right) = \frac{\pi m}{|q|B} = \frac{\pi(6.0\times10^{-8}\text{ kg})}{(7.2\times10^{-6}\text{ C})(3.0\text{ T})} = \boxed{8.7\times10^{-3}\text{ s}}$$

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27. **SSM** ***REASONING AND SOLUTION*** The force on a current-carrying wire is given by Equation 21.3: $F = ILB\sin\theta$. Solving for the angle θ, we find that the angle between the wire and the magnetic field is

$$\theta = \sin^{-1}\left(\frac{F}{ILB}\right) = \sin^{-1}\left[\frac{5.46\text{ N}}{(21.0\text{ A})(0.655\text{ m})(0.470\text{ T})}\right] = \boxed{57.6°}$$

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29. ***REASONING AND SOLUTION*** The force on each side can be found from $F = ILB \sin \theta$. For the top side, $\theta = 90.0°$, so

$$F = (12\text{ A})(0.32\text{ m})(0.25\text{ T}) \sin 90.0° = \boxed{0.96\text{ N}}$$

The force on the bottom side ($\theta = 90.0°$) is the same as that on the top side, $F = \boxed{0.96\text{ N}}$.

For each of the other two sides $\theta = 0°$, so that the force is $F = \boxed{0\text{ N}}$.

36. ***REASONING*** According to Equation 21.4, the torque τ that the circular coil experiences is $\tau = NIAB\sin\phi$, where N is the number of turns, I is the current, A is the area of the circle, B is the magnetic field strength, and ϕ is the angle between the normal to the coil and the magnetic field. To use this expression, we need the area of the circle, which is πr^2, where r is the radius. We do not know the radius, but we know the length L of the wire, which must equal the circumference of the single turn. Thus, $L = 2\pi r$, which can be solved for the radius.

SOLUTION Using Equation 21.4 and the fact that the area A of a circle is $A = \pi r^2$, we have that

$$\tau = NIAB\sin\phi = NI\left(\pi r^2\right)B\sin\phi \tag{1}$$

Since the length of the wire is the circumference of the circle, or $L = 2\pi r$, it follows that the radius of the circle is $r = \frac{L}{2\pi}$. Substituting this result into Equation (1) gives

$$\tau = NI\left(\pi r^2\right)B\sin\phi = NI\left[\pi\left(\frac{L}{2\pi}\right)^2\right]B\sin\phi = \frac{NIL^2B}{4\pi}\sin\phi$$

The maximum torque $\tau_{\max}$ occurs when $\phi = 90.0°$, so that

$$\tau_{\max} = \frac{NIL^2B}{4\pi}\sin 90.0° = \frac{(1)(4.30\text{ A})\left(7.00\times10^{-2}\text{ m}\right)^2(2.50\text{ T})}{4\pi}\sin 90.0° = \boxed{4.19\times10^{-3}\text{ N}\cdot\text{m}}$$

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41. **SSM** **WWW** ***REASONING*** The torque on the loop is given by Equation 21.4, $\tau = NIAB\sin\phi$. From the drawing in the text, we see that the angle ϕ between the normal to the plane of the loop and the magnetic field is $90° - 35° = 55°$. The area of the loop is $0.70\text{ m} \times 0.50\text{ m} = 0.35\text{ m}^2$.

SOLUTION

a. The magnitude of the net torque exerted on the loop is

$$\tau = NIAB\sin\phi = (75)(4.4\text{ A})(0.35\text{ m}^2)(1.8\text{ T})\sin 55° = \boxed{170\text{ N}\cdot\text{m}}$$

b. As discussed in the text, when a current-carrying loop is placed in a magnetic field, the loop tends to rotate such that its normal becomes aligned with the magnetic field. The normal to the loop makes an angle of 55° with respect to the magnetic field. Since this angle decreases as the loop rotates, the $\boxed{35°\text{ angle increases}}$.
