Homework-#6

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

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

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

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6. ***REASONING*** A moving charge experiences no magnetic force when its velocity points in the direction of the magnetic field or in the direction opposite to the magnetic field. Thus, the magnetic field must point either in the direction of the $+x$ axis or in the direction of the $-x$ axis. If a moving charge experiences the maximum possible magnetic force when moving in a magnetic field, then the velocity must be perpendicular to the field. In other words, the angle θ that the charge's velocity makes with respect to the magnetic field is $\theta = 90°$.

SOLUTION The magnitude B of the magnetic field can be determined using Equation 21.1:

$$B = \frac{F}{|q| v \sin\theta} = \frac{0.48 \text{ N}}{\left(8.2\times10^{-6} \text{ C}\right)\left(5.0\times10^{5} \text{ m/s}\right)\sin 90°} = \boxed{0.12 \text{ T}}$$

In this calculation we use $\theta = 90°$, because the 0.48-N force is the maximum possible force. Since the particle experiences no magnetic force when it moves along the +*x* axis, we can conclude that the magnetic field points

either in the direction of the +*x* axis or in the direction of the –*x* axis.

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7. ***REASONING*** When a charge q_0 travels at a speed v and its velocity makes an angle θ with respect to a magnetic field of magnitude B, the magnetic force acting on the charge has a magnitude F that is given by $F = |q_0| vB\sin\theta$ (Equation 21.1). We will solve this problem by applying this expression twice, first to the motion of the charge when it moves perpendicular to the field so that θ = 90.0° and then to the motion when θ = 38°.

SOLUTION When the charge moves perpendicular to the field so that $\theta = 90.0°$, Equation 21.1 indicates that

$$F_{90.0°} = |q_0| vB\sin 90.0°$$

When the charge moves so that θ = 38°, Equation 21.1 shows that

$$F_{38°} = |q_0| vB\sin 38°$$

Dividing the second expression by the first expression gives

$$\frac{F_{38°}}{F_{90.0°}} = \frac{|q_0| vB\sin 38°}{|q_0| vB\sin 90.0°}$$

$$F_{38°} = F_{90.0°}\left(\frac{\sin 38°}{\sin 90.0°}\right) = \left(2.7\times10^{-3} \text{ N}\right)\left(\frac{\sin 38°}{\sin 90.0°}\right) = \boxed{1.7\times10^{-3} \text{ N}}$$

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14. ***REASONING*** The time t that it takes the particle to complete one revolution is the time to travel a distance $d = 2\pi r$ equal to the circumference of a circle of radius r at a speed v. From Equation 2.1, we know that speed is the ratio of distance to elapsed time $\left(v = \frac{d}{t}\right)$, so the elapsed time is the ratio of distance to speed:

$$t = \frac{d}{v} = \frac{2\pi r}{v} \qquad (1)$$

Because the particle follows a circular path that is perpendicular to the external magnetic field of magnitude B, the radius of the path is given by $r = \frac{mv}{|q|B}$ (Equation 21.2), where m is the mass and $|q|$ is the magnitude of the charge of the particle. We will use Equation 21.2 to determine the speed of the particle, and then Equation (1) to find the time for one complete revolution.

SOLUTION Solving $r = \frac{mv}{|q|B}$ (Equation 21.2) for v yields

$$v = \frac{|q|Br}{m} = \frac{|q|}{m}Br \qquad (2)$$

In the last step of Equation (2), we have expressed the speed v explicitly in terms of the charge-to-mass ratio $|q|/m$ of the particle. Substituting Equation (2) into Equation (1), we obtain

$$t = \frac{2\pi r}{v} = \frac{2\pi \cancel{r}}{\frac{|q|}{m}B\cancel{r}} = \frac{2\pi}{\frac{|q|}{m}B} = \frac{2\pi}{\left(5.7\times10^{8}\text{ C/kg}\right)\left(0.72\text{ T}\right)} = \boxed{1.5\times10^{-8}\text{ s}}$$

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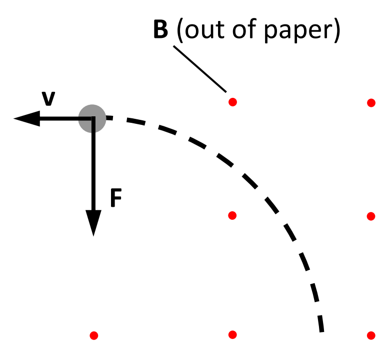
15. ***REASONING***



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

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

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33. ***REASONING AND SOLUTION*** The force on each side can be found from *F* = *ILB* sin θ. For the top side, θ = 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 (θ = 90.0°) is the same as that on the top side, *F* = $\boxed{0.96\,\text{N}}$.

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

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37. ***REASONING*** A maximum magnetic force is exerted on the wire by the field components that are perpendicular to the wire, and no magnetic force is exerted by field components that are parallel to the wire. Thus, the wire experiences a force only from the *x*- and *y*-components of the field. The *z*-

component of the field may be ignored, since it is parallel to the wire. We can use the Pythagorean theorem to find the net field in the *x*, *y* plane. This net field, then, is perpendicular to the wire and makes an angle of $\theta = 90°$ with respect to the wire. Equation 21.3 can be used to calculate the magnitude of the magnetic force that this net field applies to the wire.

SOLUTION According to Equation 21.3, the magnetic force has a magnitude of $F = ILB \sin \theta$, where I is the current, B is the magnitude of the magnetic field, L is the length of the wire, and θ is the angle of the wire with respect to the field. Using the Pythagorean theorem, we find that the net field in the *x*, *y* plane is

$$B = \sqrt{B_x^2 + B_y^2}$$

Using this field in Equation 21.3, we calculate the magnitude of the magnetic force to be

$$F = ILB \sin\theta = IL\sqrt{B_x^2 + B_y^2}\,\sin\theta$$

$$= (4.3\text{ A})(0.25\text{ m})\sqrt{(0.10\text{ T})^2 + (0.15\text{ T})^2}\,\sin 90° = \boxed{0.19\text{ N}}$$