2. We note that $\vec{B}$ must be along the x axis because when the velocity is along that axis there is no induced voltage. Combining Eq. 28-7 and Eq. 28-9 leads to

$$d = \frac{V}{E} = \frac{V}{vB}$$

where one must interpret the symbols carefully to ensure that $\vec{d}$, $\vec{v}$, and $\vec{B}$ are mutually perpendicular. Thus, when the velocity if parallel to the y axis the absolute value of the voltage (which is considered in the same "direction" as $\vec{d}$) is 0.012 V, and

$$d_z = \frac{0.012 \text{ V}}{(3.5 \text{ m/s})(0.020 \text{ T})} = 0.17 \text{ m}.$$

On the other hand, when the velocity is parallel to the z axis the absolute value of the appropriate voltage is 0.018 V, and

$$d_y = \frac{0.018 \text{ V}}{(3.5 \text{ m/s})(0.020 \text{ T})} = 0.26 \text{ m}.$$

Thus, our answers are

(a) d_x = 32 cm (which we arrive at "by elimination," since we already have figured out d_y and d_z),

(b) d_y = 26 cm, and
(c) d_z = 17 cm.

7. We use Eq. 28-37 where $\vec{\mu}$ is the magnetic dipole moment of the wire loop and $\vec{B}$ is the magnetic field, as well as Newton's second law. Since the plane of the loop is parallel to the incline the dipole moment is normal to the incline. 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 F_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

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

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 $\mu B \sin\theta$, 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

$$fr - \mu B\sin\theta = I\alpha.$$

Since we want the current that holds the cylinder in place, we set a = 0 and α = 0, and use one equation to eliminate f from the other. The result is $mgr = \mu B$. The loop is rectangular with two sides of length L and two of length $2r$, so its area is $A = 2rL$ and the dipole moment is $\mu = NiA = Ni(2rL)$. Thus, $mgr = 2NirLB$ and

$$i = \frac{mg}{2NLB} = \frac{(0.150\,\text{kg})(9.8\,\text{m/s}^2)}{2(13.0)(0.100\,\text{m})(0.920\,\text{T})} = 0.615\,\text{A}.$$

8. We consider the point at which it enters the field-filled region, velocity vector pointing downward. The field points out of the page so that $\vec{v} \times \vec{B}$ points leftward, which indeed seems to be the direction it is "pushed''; therefore, $q > 0$ (it is a proton).

(a) Equation 28-17 becomes $T = 2\pi m_\text{p} / e|\vec{B}|$, or

$$2\left(160\times10^{-9}\right) = \frac{2\pi\left(1.67\times10^{-27}\right)}{\left(1.60\times10^{-19}\right)|\vec{B}|}$$

which yields $\left|\vec{B}\right| = 0.204\,\text{T}$.

(b) Doubling the kinetic energy implies multiplying the speed by $\sqrt{2}$. Since the period T does not depend on speed, then it remains the same (even though the radius increases by a factor of $\sqrt{2}$). Thus, $t = T/2 = 160$ ns.

28.
Let a = 30.0 cm, b = 20.0 cm, and c = 10.0 cm. From the given hint, we write

$$\vec{\mu} = \vec{\mu}_1 + \vec{\mu}_2 = iab\left(-\hat{\mathrm{k}}\right) + iac\left(\hat{\mathrm{j}}\right) = ia\left(c\hat{\mathrm{j}} - b\hat{\mathrm{k}}\right) = (5.00\,\mathrm{A})(0.300\,\mathrm{m})\left[(0.100\,\mathrm{m})\,\hat{\mathrm{j}} - (0.200\,\mathrm{m})\,\hat{\mathrm{k}}\right]$$

$$= \boxed{\left(0.900\hat{\mathrm{j}} - 0.180\hat{\mathrm{k}}\right)\ \mathrm{A}\cdot\mathrm{m}^2}$$

31. Straight-line motion will result from zero net force acting on the system; we ignore gravity. Thus, $\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right) = 0$. Note that $\vec{v} \perp \vec{B}$ so $\left|\vec{v} \times \vec{B}\right| = vB$. Thus, obtaining the speed from the formula for kinetic energy, we obtain

$$B = \frac{E}{v} = \frac{E}{\sqrt{2K/m_e}} = \frac{100\ \text{V}/(16\times10^{-3}\text{m})}{\sqrt{2\left(2.5\times10^{3}\text{V}\right)\left(1.60\times10^{-19}\text{C}\right)/\left(9.11\times10^{-31}\text{kg}\right)}} = 2.11\times10^{-4}\text{T}.$$

(a) In unit-vector notation, $\vec{B} = -(2.11\times10^{-4}\,\text{T})\hat{\text{k}}$.

(b) Increasing the potential difference would increase the electrostatic force $\vec{F}_e$ which points up, so the electron will move up toward the upper plate.

32. (a) The magnetic force on the wire is $F_B = idB$, pointing to the left. Thus

$$v = at = \frac{F_B t}{m} = \frac{idBt}{m} = \frac{(9.13\times10^{-3}\,\text{A})(2.56\times10^{-2}\,\text{m})(7.35\times10^{-2}\,\text{T})(0.0611\,\text{s})}{2.41\times10^{-5}\,\text{kg}}$$
$$= 4.36\times10^{-2}\,\text{m/s}.$$

(b) The direction is to the left (away from the generator).