Chapter 28

11. (a) We seek the electrostatic field established by the separation of charges (brought on by the magnetic force). With Eq. 28-10, we define the magnitude of the electric field as

$$|\vec{E}| = v|\vec{B}| = (27.0 \text{ m/s})(0.0375 \text{ T}) = 1.01 \text{ V/m} .$$

Its direction may be inferred from Figure 28-8; its direction is opposite to that defined by $\vec{v} \times \vec{B}$. In summary,

$$\vec{E} = -(1.01 \text{V/m})\hat{\text{k}}$$

which insures that $\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right)$ vanishes.

(b) Equation 28-9 yields $V = Ed = (1.01 \text{ V/m})(3.00\times10^{-2} \text{ m}) = 3.04\times10^{-2} \text{ V}$.

12. 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

$$d = d_z = \frac{0.012 \text{ V}}{(5.0 \text{ m/s})(0.020 \text{ T})} = 0.12 \text{ m}.$$

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

$$d = d_y = \frac{0.018 \text{ V}}{(5.0 \text{ m/s})(0.020 \text{ T})} = 0.18 \text{ m}.$$

Thus, our answers are

(a) d_x = 25 cm (which we arrive at "by elimination," since we already have figured out d_y and d_z),

(b) d_y = 18 cm, and

(c) d_z = 12 cm.

13. 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

$$2\left(212\times10^{-9}\right) = \frac{2\pi\left(1.67\times10^{-27}\right)}{\left(1.60\times10^{-19}\right)|\vec{B}|}$$

which yields $\left|\vec{B}\right| = 0.155\,\text{T}$.

(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, $t = T/2 = 212$ ns.

24. We use $d\vec{F}_B = i d\vec{L} \times \vec{B}$, where $d\vec{L} = dx\hat{\mathrm{i}}$ and $\vec{B} = B_x\hat{\mathrm{i}} + B_y\hat{\mathrm{j}}$. Thus,

$$\vec{F}_B = \int i\, d\vec{L} \times \vec{B} = \int_{x_i}^{x_f} i\, dx\, \hat{\mathrm{i}} \times \left(B_x\hat{\mathrm{i}} + B_y\hat{\mathrm{j}}\right) = i\int_{x_i}^{x_f} B_y\, dx\, \hat{\mathrm{k}}$$

$$= (-3.0\,\mathrm{A})\left(\int_{1.0}^{3.0}\left(6.0x^2\,dx\right)(\mathrm{m}\cdot\mathrm{mT})\right)\hat{\mathrm{k}} = (-0.16\ \mathrm{N})\hat{\mathrm{k}}.$$

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

$$\begin{aligned}\vec{\mu} &= \vec{\mu}_1 + \vec{\mu}_2 = iab\left(-\hat{k}\right) + iac\left(\hat{j}\right)\\ &= ia\left(c\hat{j} - b\hat{k}\right) = (7.80\ \text{A})(0.300\ \text{m})\left[(0.100\ \text{m})\hat{j} - (0.200\ \text{m})\hat{k}\right]\\ &= \left(0.234\hat{j} - 0.468\hat{k}\right)\text{A}\cdot\text{m}^2.\end{aligned}$$

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

$$v = at = \frac{F_B t}{m} = \frac{idBt}{m} = \frac{(9.13\times10^{-3}\,\text{A})(2.56\times10^{-2}\,\text{m})(4.20\times10^{-2}\,\text{T})(0.0611\,\text{s})}{3.69\times10^{-5}\,\text{kg}}$$
$$= 1.63\times10^{-2}\,\text{m/s}.$$

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