P29.8 Gravitational force:

$$F_g = mg = \left(9.11\times10^{-31}\text{ kg}\right)\left(9.80\text{ m/s}^2\right) = \boxed{8.93\times10^{-30}\text{ N down}}.$$

Electric force: $F_e = qE = \left(-1.60\times10^{-19}\text{ C}\right)\left(100\text{ N/C down}\right) = \boxed{1.60\times10^{-17}\text{ N up}}.$

Magnetic force:

$$\mathbf{F}_B = q\mathbf{v}\times\mathbf{B} = \left(-1.60\times10^{-19}\text{ C}\right)\left(6.00\times10^{6}\text{ m/s }\hat{\mathbf{E}}\right)\times\left(50.0\times10^{-6}\text{ N}\cdot\text{s/C}\cdot\text{m }\hat{\mathbf{N}}\right).$$

$$\mathbf{F}_B = -4.80\times10^{-17}\text{ N up} = \boxed{4.80\times10^{-17}\text{ N down}}.$$

P29.10 $q\mathbf{E} = \left(-1.60\times10^{-19}\text{ C}\right)\left(20.0\text{ N/C}\right)\hat{\mathbf{k}} = \left(-3.20\times10^{-18}\text{ N}\right)\hat{\mathbf{k}}$

$$\sum\mathbf{F} = q\mathbf{E} + q\mathbf{v}\times\mathbf{B} = m\mathbf{a}$$

$$\left(-3.20\times10^{-18}\text{ N}\right)\hat{\mathbf{k}} - 1.60\times10^{-19}\text{ C}\left(1.20\times10^{4}\text{ m/s }\hat{\mathbf{i}}\right)\times\mathbf{B} = \left(9.11\times10^{-31}\right)\left(2.00\times10^{12}\text{ m/s}^2\right)\hat{\mathbf{k}}$$

$$-\left(3.20\times10^{-18}\text{ N}\right)\hat{\mathbf{k}} - \left(1.92\times10^{-15}\text{ C}\cdot\text{m/s}\right)\hat{\mathbf{i}}\times\mathbf{B} = \left(1.82\times10^{-18}\text{ N}\right)\hat{\mathbf{k}}$$

$$\left(1.92\times10^{-15}\text{ C}\cdot\text{m/s}\right)\hat{\mathbf{i}}\times\mathbf{B} = -\left(5.02\times10^{-18}\text{ N}\right)\hat{\mathbf{k}}$$

The magnetic field $\boxed{\text{may have any } x\text{-component}}$. $B_z = \boxed{0}$ and $B_y = \boxed{-2.62\text{ mT}}$.

P29.14

$$\frac{|\mathbf{F}_B|}{\ell} = \frac{mg}{\ell} = \frac{I|\boldsymbol{\ell}\times\mathbf{B}|}{\ell}$$

$$I = \frac{mg}{B\ell} = \frac{\left(0.040\,0\text{ kg/m}\right)\left(9.80\text{ m/s}^2\right)}{3.60\text{ T}} = \boxed{0.109\text{ A}}$$

The direction of I in the bar is $\boxed{\text{to the right}}$.

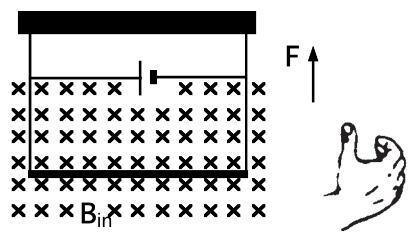

FIG. P29.14

P29.27 (a) $\tau = \boldsymbol{\mu}\times\mathbf{B}$, so $\tau = |\boldsymbol{\mu}\times\mathbf{B}| = \mu B\sin\theta = NIAB\sin\theta$

$$\tau_{\max} = NIAB\sin 90.0^\circ = 1\left(5.00\text{ A}\right)\left[\pi\left(0.050\,0\text{ m}\right)^2\right]\left(3.00\times10^{-3}\text{ T}\right) = \boxed{118\ \mu\text{N}\cdot\text{m}}$$

(b) $U = -\boldsymbol{\mu}\cdot\mathbf{B}$, so $-\mu B \le U \le +\mu B$

Since $\mu B = (NIA)B = 1\left(5.00\text{ A}\right)\left[\pi\left(0.050\,0\text{ m}\right)^2\right]\left(3.00\times10^{-3}\text{ T}\right) = 118\ \mu\text{J}$,

the range of the potential energy is: $\boxed{-118\ \mu\text{J} \le U \le +118\ \mu\text{J}}$.

P29.34 (a) We begin with $qvB = \frac{mv^2}{R}$

or $qRB = mv$.

But $L = mvR = qR^2B$.

Therefore, $R = \sqrt{\frac{L}{qB}} = \sqrt{\frac{4.00 \times 10^{-25}\ \text{J} \cdot \text{s}}{\left(1.60 \times 10^{-19}\ \text{C}\right)\left(1.00 \times 10^{-3}\ \text{T}\right)}} = 0.050\ 0\ \text{m} = \boxed{5.00\ \text{cm}}$.

(b) Thus, $v = \frac{L}{mR} = \frac{4.00 \times 10^{-25}\ \text{J} \cdot \text{s}}{\left(9.11 \times 10^{-31}\ \text{kg}\right)\left(0.050\ 0\ \text{m}\right)} = \boxed{8.78 \times 10^6\ \text{m/s}}$.

P29.41 $K = \frac{1}{2}mv^2 = q(\Delta V)$ so $v = \sqrt{\frac{2q(\Delta V)}{m}}$

$$|\mathbf{F}_B| = |q\mathbf{v} \times \mathbf{B}| = \frac{mv^2}{r} \qquad r = \frac{mv}{qB} = \frac{m}{q}\frac{\sqrt{2q(\Delta V)/m}}{B} = \frac{1}{B}\sqrt{\frac{2m(\Delta V)}{q}}$$

(a) $r_{238} = \sqrt{\frac{2\left(238 \times 1.66 \times 10^{-27}\right)2\ 000}{1.60 \times 10^{-19}}}\left(\frac{1}{1.20}\right) = 8.28 \times 10^{-2}\ \text{m} = \boxed{8.28\ \text{cm}}$

(b) $r_{235} = \boxed{8.23\ \text{cm}}$

$$\frac{r_{238}}{r_{235}} = \sqrt{\frac{m_{238}}{m_{235}}} = \sqrt{\frac{238.05}{235.04}} = 1.006\ 4$$

The ratios of the orbit radius for different ions are independent of ΔV and B.

P29.48 (a) $R_H \equiv \frac{1}{nq}$ so $n = \frac{1}{qR_H} = \frac{1}{\left(1.60 \times 10^{-19}\ \text{C}\right)\left(0.840 \times 10^{-10}\ \text{m}^3/\text{C}\right)} = \boxed{7.44 \times 10^{28}\ \text{m}^{-3}}$

(b) $\Delta V_H = \frac{IB}{nqt}$

$$B = \frac{nqt(\Delta V_H)}{I} = \frac{\left(7.44 \times 10^{28}\ \text{m}^{-3}\right)\left(1.60 \times 10^{-19}\ \text{C}\right)\left(0.200 \times 10^{-3}\ \text{m}\right)\left(15.0 \times 10^{-6}\ \text{V}\right)}{20.0\ \text{A}} = \boxed{1.79\ \text{T}}$$

P29.55 The magnetic force on each proton, $\mathbf{F}_B = q\mathbf{v}\times\mathbf{B} = qvB\sin 90°$ downward perpendicular to velocity, causes centripetal acceleration, guiding it into a circular path of radius r, with

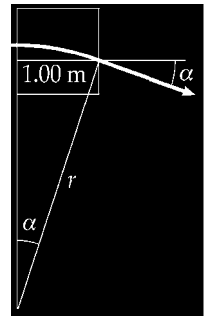

FIG. P29.55

$$qvB = \frac{mv^2}{r}$$

and $$r = \frac{mv}{qB}.$$

We compute this radius by first finding the proton's speed:

$$K = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2(5.00\times10^6\ \text{eV})(1.60\times10^{-19}\ \text{J/eV})}{1.67\times10^{-27}\ \text{kg}}} = 3.10\times10^7\ \text{m/s}.$$

Now, $$r = \frac{mv}{qB} = \frac{(1.67\times10^{-27}\ \text{kg})(3.10\times10^7\ \text{m/s})}{(1.60\times10^{-19}\ \text{C})(0.050\,0\ \text{N}\cdot\text{s/C}\cdot\text{m})} = 6.46\ \text{m}.$$

(b) From the figure, observe that

$$\sin\alpha = \frac{1.00\ \text{m}}{r} = \frac{1\ \text{m}}{6.46\ \text{m}}$$

$$\boxed{\alpha = 8.90°}$$

(a) The magnitude of the proton momentum stays constant, and its final y component is

$$-(1.67\times10^{-27}\ \text{kg})(3.10\times10^7\ \text{m/s})\sin 8.90° = \boxed{-8.00\times10^{-21}\ \text{kg}\cdot\text{m/s}}.$$

Chapter 30

P30.1 $B = \frac{\mu_0 I}{2R} = \frac{\mu_0 q(v/2\pi R)}{2R} = \boxed{12.5 \text{ T}}$

P30.20 The separation between the wires is

$a = 2(6.00 \text{ cm})\sin 8.00° = 1.67 \text{ cm}.$

(a) Because the wires repel, the currents are in

$\boxed{\text{opposite directions}}$.

(b) Because the magnetic force acts horizontally,

$$\frac{F_B}{F_g} = \frac{\mu_0 I^2 \ell}{2\pi amg} = \tan 8.00°$$

$$I^2 = \frac{mg2\pi a}{\ell \mu_0}\tan 8.00° \text{ so } I = \boxed{67.8 \text{ A}}.$$

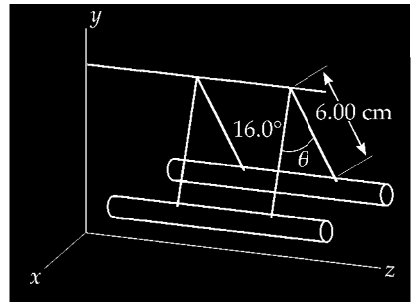

FIG. P30.20