Homework for the week of November 3. 6th week of classes.
Ch. 27: 6, 8, 16, 20, 23, 33, 35, 36

6. The magnetic force must be equal in magnitude to the force of gravity on the wire. The maximum magnetic force is applicable since the wire is perpendicular to the magnetic field. The mass of the wire is the density of copper times the volume of the wire.

$$F_B = mg \;\rightarrow\; Il B = \rho\pi\left(\tfrac{1}{2}d\right)^2 l g \;\rightarrow$$

$$I = \frac{\rho\pi d^2 g}{4B} = \frac{\left(8.9\times10^3\,\mathrm{kg/m^3}\right)\pi\left(1.00\times10^{-3}\,\mathrm{m}\right)^2\left(9.80\,\mathrm{m/s^2}\right)}{4\left(5.0\times10^{-5}\,\mathrm{T}\right)} = \boxed{1400\,\mathrm{A}}$$

This answer does not seem feasible. The current is very large, and the resistive heating in the thin copper wire would probably melt it.

8. We find the force per unit length from Eq. 27-3. Note that while the length is not known, the direction is given, and so $\vec{l} = l\,\hat{\mathbf{i}}$.

$$\vec{\mathbf{F}}_B = I\vec{l}\times\vec{\mathbf{B}} = Il\,\hat{\mathbf{i}}\times\vec{\mathbf{B}} \;\rightarrow$$

$$\frac{\vec{\mathbf{F}}_B}{l} = I\,\hat{\mathbf{i}}\times\vec{\mathbf{B}} = (3.0\,\mathrm{A})\begin{vmatrix}\hat{\mathbf{i}} & \hat{\mathbf{j}} & \hat{\mathbf{k}}\\ 1 & 0 & 0\\ 0.20\,\mathrm{T} & -0.36\,\mathrm{T} & 0.25\,\mathrm{T}\end{vmatrix} = \left(-0.75\hat{\mathbf{j}} - 1.08\hat{\mathbf{k}}\right)\mathrm{N/m}\left(\frac{1\,\mathrm{m}}{100\,\mathrm{cm}}\right)$$

$$= \boxed{-\left(7.5\hat{\mathbf{j}} + 11\hat{\mathbf{k}}\right)\times10^{-3}\,\mathrm{N/cm}}$$

16. Since the charge is negative, the answer is the OPPOSITE of the result given from the right hand rule
applied to the velocity and magnetic field.
(*a*) left
(*b*) left
(*c*) upward
(*d*) inward into the paper
(*e*) no force
(*f*) downward

20. The velocity of each charged particle can be found using energy conservation. The electrical
potential energy of the particle becomes kinetic energy as it is accelerated. Then, since the particle is moving perpendicularly to the magnetic field, the magnetic force will be a maximum. That force will cause the ion to move in a circular path, and the radius can be determined in terms of the mass and charge of the particle.

$$E_{\text{initial}} = E_{\text{final}} \;\rightarrow\; qV = \tfrac{1}{2}mv^2 \;\rightarrow\; v = \sqrt{\frac{2qV}{m}}$$

$$F_{\max} = qvB = m\frac{v^2}{r} \;\rightarrow\; r = \frac{mv}{qB} = \frac{m\sqrt{\frac{2qV}{m}}}{qB} = \frac{1}{B}\sqrt{\frac{2mV}{q}}$$

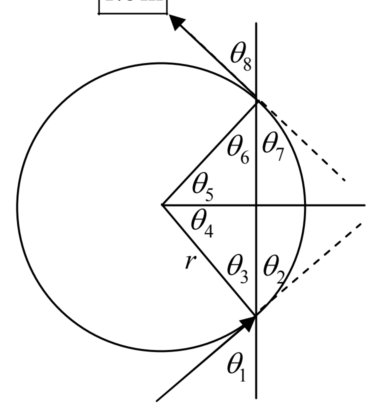
$$\frac{r_d}{r_p}=\frac{\frac{1}{B}\sqrt{\frac{2m_dV}{q_d}}}{\frac{1}{B}\sqrt{\frac{2m_pV}{q_p}}}=\frac{\sqrt{\frac{m_d}{m_p}}}{\sqrt{\frac{q_d}{q_p}}}=\frac{\sqrt{2}}{\sqrt{1}}=\sqrt{2}\ \rightarrow\ \boxed{r_d=\sqrt{2}r_p}$$

$$\frac{r_\alpha}{r_p}=\frac{\frac{1}{B}\sqrt{\frac{2m_\alpha V}{q_\alpha}}}{\frac{1}{B}\sqrt{\frac{2m_pV}{q_p}}}=\frac{\sqrt{\frac{m_\alpha}{m_p}}}{\sqrt{\frac{q_\alpha}{q_p}}}=\frac{\sqrt{4}}{\sqrt{2}}=\sqrt{2}\ \rightarrow\ \boxed{r_\alpha=\sqrt{2}r_p}$$

23. The kinetic energy of the proton can be used to find its velocity. The magnetic force produces centripetal acceleration, and from this the radius can be determined.

$$K=\tfrac{1}{2}mv^2\ \rightarrow\ v=\sqrt{\frac{2K}{m}}\qquad qvB=\frac{mv^2}{r}\ \rightarrow\ r=\frac{mv}{qB}$$

$$r=\frac{mv}{qB}=\frac{m\sqrt{\frac{2K}{m}}}{qB}=\frac{\sqrt{2Km}}{qB}=\frac{\sqrt{2\left(6.0\times10^{6}\,\text{eV}\right)\left(1.60\times10^{-19}\,\text{J/eV}\right)\left(1.67\times10^{-27}\,\text{kg}\right)}}{\left(1.60\times10^{-19}\,\text{C}\right)\left(0.20\,\text{T}\right)}=\boxed{1.8\,\text{m}}$$



33. (*a*) In the magnetic field, the proton will move along an arc of a circle. The distance *x* in the diagram is a chord of that circle, and so the center of the circular path lies on the perpendicular bisector of the chord. That perpendicular bisector bisects the central angle of the circle which subtends the chord. Also recall that a radius is perpendicular to a tangent. In the diagram, $\theta_1=\theta_2$ because they are vertical angles. Then $\theta_2=\theta_4$, because they are both complements of θ_3, so $\theta_1=\theta_4$. We have $\theta_4=\theta_5$ since the central angle is bisected by the perpendicular bisector of the chord. $\theta_5=\theta_7$ because they are both complements of θ_6, and $\theta_7=\theta_8$ because they are vertical angles. Thus $\theta_1=\theta_2=\theta_4=\theta_5=\theta_7=\theta_8$, and so in the textbook diagram, the angle at which the proton leaves is $\boxed{\theta=45^\circ}$.

(*b*) The radius of curvature is given by $r=\frac{mv}{qB}$, and the distance *x* is twice the value of $r\cos\theta$.

$$x=2r\cos\theta=2\frac{mv}{qB}\cos\theta=2\frac{\left(1.67\times10^{-27}\,\text{kg}\right)\left(1.3\times10^{5}\,\text{m/s}\right)}{\left(1.60\times10^{-19}\,\text{C}\right)\left(0.850\,\text{T}\right)}\cos45^\circ=\boxed{2.3\times10^{-3}\,\text{m}}$$

35. The work required by an external agent is equal to the change in potential energy. The potential energy is given by Eq. 27-12, $U=-\vec{\mu}\cdot\vec{B}$.

(*a*)

$$W=\Delta U=\left(-\vec{\mu}\cdot\vec{B}\right)_{\text{final}}-\left(-\vec{\mu}\cdot\vec{B}\right)_{\text{initial}}=\left(\vec{\mu}\cdot\vec{B}\right)_{\text{initial}}-\left(\vec{\mu}\cdot\vec{B}\right)_{\text{final}}=NIAB\left(\cos\theta_{\text{initial}}-\cos\theta_{\text{final}}\right)$$

$$= NIAB\left(\cos 0^\circ - \cos 180^\circ\right) = \boxed{2NIAB}$$

(*b*) $$W = NIAB\left(\cos\theta_{\text{initial}} - \cos\theta_{\text{final}}\right) = NIAB\left(\cos 90^\circ - \cos\left(-90^\circ\right)\right) = \boxed{0}$$

36. With the plane of the loop parallel to the magnetic field, the torque will be a maximum. We use Eq. 27-9.

$$\tau = NIAB\sin\theta \quad\rightarrow\quad B = \frac{\tau}{NIAB\sin\theta} = \frac{0.185\,\text{m}\cdot\text{N}}{(1)(4.20\,\text{A})\pi(0.0650\,\text{m})^2\sin 90^\circ} = \boxed{3.32\,\text{T}}$$