1. A proton and an $\alpha$ particle have equal velocities. They both enter a uniform magnetic field moving at a right angle to $\mathbf{B}$ as shown. The radius of the proton's circular path is 10 cm.

(a) What is the radius of the $\alpha$ particle's circular path? (15)

(b) From the figure, is the proton's orbit clockwise or counterclockwise? (5)

\[ r_\alpha = \frac{m_\alpha v}{2eB} \quad r_p = \frac{m_p v}{eB} \]

\[ \frac{r_\alpha}{r_p} = \frac{m_\alpha}{2m_p} \quad r_\alpha = r_p \frac{m_\alpha}{2m_p} \]

\[ r_\alpha = (10.0 \text{ cm}) \left( \frac{6.644 \times 10^{-27} \text{ kg}}{1.6726 \times 10^{-27} \text{ kg}} \right) \]

\[ = 19.86 \text{ cm} \]

b.) \text{Clockwise}
2. The figure shows a long wire carrying a current of 30 A. The rectangular loop carries a current of 20 A. Calculate the force on the loop.

\[
F_{1x} = -\frac{\mu_0 (30A) (20A) (0.30 m)}{2 \pi (0.01 m)}
\]

\[
F_{2x} = \frac{\mu_0 (30A) (20A) (0.30 m)}{2 \pi (0.09 m)}
\]

\[
F_x = F_{1x} + F_{2x} = -3.2 \times 10^{-3} N
\]

\[
3.2 \times 10^{-3} N \text{ toward the wire.}
\]
3. A single loop of copper wire has an area of 25.0 cm\(^2\) and carries a current of 15.0 A. The loop is placed in a uniform magnetic field of 0.5 T such that the angle between the magnetic moment \(\vec{\mu}\) and the magnetic field \(\vec{B}\) is 30\(^\circ\).

(a) What is the torque on the loop? 
\[ \tau = I A = (15.0 \text{ A})(25.0 \text{ cm}^2) \left( \frac{1 \text{ m}^2}{100 \text{ cm}^2} \right) \]
\[ = 3.75 \times 10^{-2} \text{ A} \cdot \text{m}^2 \]
\[ |\vec{\tau}| = \mu B \sin \theta = (3.75 \times 10^{-2} \text{ A} \cdot \text{m}^2)(0.5 \text{ T}) \times (\sin 30^\circ) \]
\[ = 9.375 \times 10^{-3} \text{ N} \cdot \text{m} \] out of page.

(b) What is the potential energy stored in this configuration? 
\[ U = -\vec{\mu} \cdot \vec{B} = -\mu B \cos \theta \]
\[ = -(3.75 \times 10^{-2} \text{ A} \cdot \text{m}^2)(0.5 \text{ T})(\cos 30^\circ) \]
\[ = -1.624 \times 10^{-2} \text{ J} \]

(c) What should the angle between the magnetic moment and the field be to have a potential energy of \(-\frac{1}{2}\) that found in part (b)?
\[ \mu B \cos \theta = \left( \frac{1.624 \times 10^{-2} \text{ J}}{3.75 \times 10^{-2} \text{ A} \cdot \text{m}^2}(0.5 \text{ T}) \right) \]
\[ \cos \theta = \left( \frac{1.624 \times 10^{-2} \text{ J}}{3.75 \times 10^{-2} \text{ A} \cdot \text{m}^2}(0.5 \text{ T}) \right) \]
\[ \theta = \cos^{-1}(0.433) \]
\[ \theta = 180 - 64.34^\circ = 115.7^\circ \text{ and } 244.34^\circ \]
A solenoid of length 100 cm and a diameter of 1.0 cm has 10000 turns of copper wire. The wire has a total resistance of 1.0 Ω. If 1.5 VDC is applied to the wire, what is the magnitude of the magnetic field at the center of the solenoid? (5 points)

\[
|\vec{B}| = \mu_0 n I \\
= \left(4\pi \times 10^{-7} \frac{T \cdot m}{A}\right) \left(\frac{1000 \text{ turns}}{m}\right) (1.5 \text{ A}) \\
= 1.9 \times 10^{-3} T
\]
2. A certain wire is constructed from copper and silver. The wire has an overall diameter of 5.0 mm. The core of the wire is copper with a 3.0 mm diameter. If the wire is 100 m in length, what is its total resistance?

\[
R_{Cu} = \frac{1.7 \times 10^{-8} \cdot \Omega \cdot m \cdot (100 \, m)}{\pi \left( 0.003 \, m \right)^2} = 0.24 \, \Omega
\]

\[
R_{Ag} = \frac{1.59 \times 10^{-8} \cdot \Omega \cdot m \cdot (100 \, m)}{\pi \left( 0.005 \, m \right)^2 \left( 0.003 \, m \right)^2} = 0.13 \, \Omega
\]

\[
R_{Tot} = \frac{R_{Cu} \cdot R_{Ag}}{R_{Cu} + R_{Ag}} = 0.083 \, \Omega
\]