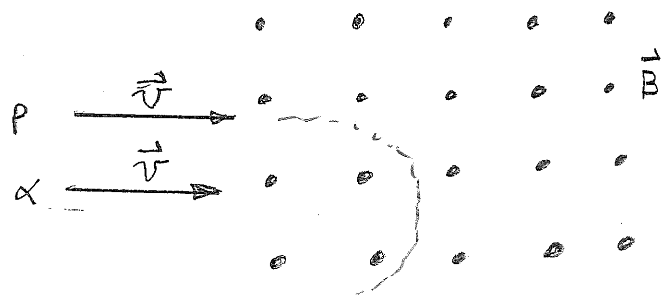
Physics 251 **Name:** key

- Show all of your work.
- Read the entire exam before starting.
- Calculators are allowed on this exam.

1. A proton and an α particle have equal velocities. They both enter a uniform magnetic field moving at a right angle to $\vec{B}$ as shown. The radius of the proton's circular path is 10 cm.
   (a) What is the radius of the α particle's circular path? (15)
   (b) From the figure, is the proton's orbit clockwise or counterclockwise? (5)



a.)

$$r_\alpha = \frac{m_\alpha v}{2eB} \qquad r_p = \frac{m_p v}{eB}$$

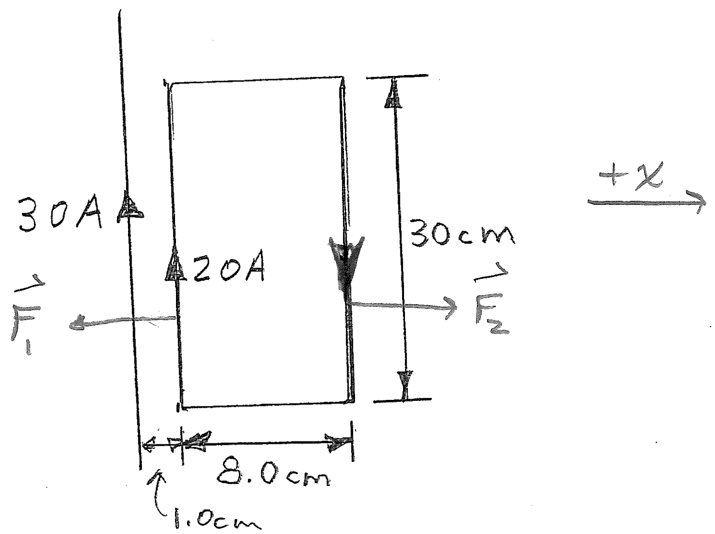
$$\frac{r_\alpha}{r_p} = \frac{m_\alpha}{2m_p} \qquad r_\alpha = r_p \frac{m_\alpha}{2m_p}$$

$$r_\alpha = (10.0\,\text{cm}) \frac{(6.644 \times 10^{-27}\,\text{kg})}{2(1.6726 \times 10^{-27}\,\text{kg})}$$

$$= \boxed{19.86\,\text{cm}}$$

b.) **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.



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

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

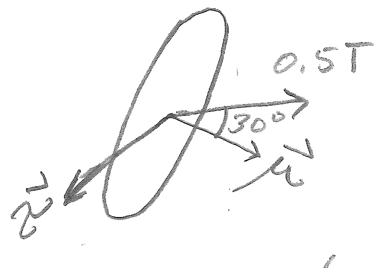
$$F_{1x} = -3.6 \times 10^{-3}\,N$$

$$F_{2x} = 4.0 \times 10^{-4}\,N$$

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

3.2×10^{-3} N toward the wire.

3. A single loop of copper wire has an area of $25.0\,\text{cm}^2$ 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°.
   (a) What is the torque on the loop? 12
   (b) How much potential energy is stored in this configuration? 4
   (c) What should the angle between the magnetic moment and the field be to have a potential energy of −1/2 that found in part (b)? 4



a.) $|\vec{\mu}| = IA = (15.0A)(25.0cm^2)\left(\frac{1m^2}{(100cm)^2}\right)$
$= 3.75 \times 10^{-2}\ A \cdot m^2$

$|\vec{\tau}| = \mu B \sin\theta = (3.75\times10^{-2} A\cdot m^2)(0.5T) \times (\sin 30°)$
$= \boxed{9.375\times10^{-3}\ N\cdot m}$ out of page.

b.) $U = -\vec{\mu}\cdot\vec{B} = -\mu B\cos\theta$
$= -(3.75\times10^{-2}A\cdot m^2)(0.5T)(\cos 30°)$
$= \boxed{-1.624\times10^{-2}\ J}$

c.) $\mu B\cos\theta = (1.624\times10^{-2}J)(0.5)$
$\cos\theta = \frac{(1.624\times10^{-2}J)(0.5)}{(3.75\times10^{-2}A\cdot m^2)(0.5T)}$
$\theta = \cos^{-1}(0.433)$
$\theta = 180 - 64.34° = \boxed{115.7° \text{ and } 244.34}$

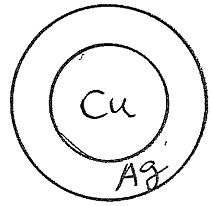
: A solenoid of length 100 cm and a diameter of 1.0 cm has 10000 turns of copper wire. The wire has a total resistance of 1.0 Ω. If 1.5 VDC is applied to the wire, what is the magnitude of the magnetic field at the center of the solenoid? (5 points)

$$|\vec{B}| = \mu_0 n I$$

$$= \left(4\pi \times 10^{-7} \frac{T \cdot m}{A}\right)\left(\frac{1000 \text{ Turns}}{m}\right)(1.5 A)$$

$$= \boxed{1.9 \times 10^{-3} T}$$

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?



$$R_{Cu} = \frac{(1.7\times10^{-8}\,\Omega\cdot m)(100\,m)}{\left(\frac{\pi(0.003m)^2}{4}\right)} = 0.24\,\Omega$$

$$R_{Ag} = \frac{(1.59\times10^{-8}\,\Omega\cdot m)(100\,m)}{\frac{\pi}{4}\left\{(0.005m)^2-(0.003m)^2\right\}} = 0.13\,\Omega$$

$$R_{Tot} = \frac{R_{Cu}R_{Ag}}{R_{Cu}+R_{Ag}} = \boxed{0.083\,\Omega}$$