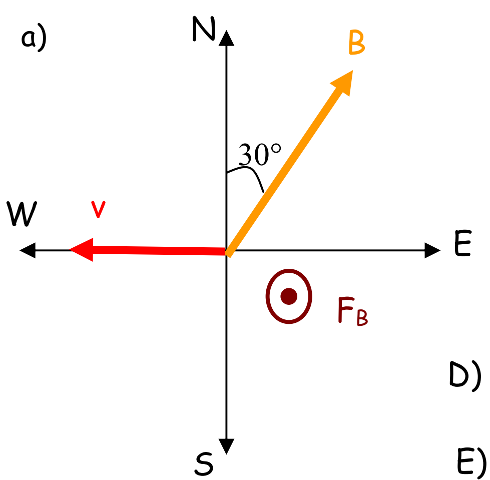
Physics 104 Exam 2 Name____________

1. An electron moves with a velocity of 7.0 x 10^6 m/s due west in a uniform magnetic field of magnitude 4.0 T at an angle of 30° East of North. At the same point an electric field of magnitude 9.0 x 10^6 N/C points due South.

a. Draw the velocity **and** magnetic field vectors on a coordinate system so that they lie in the plane of the page. A set of axes is provided for you below.
b. Find the magnitude of the magnetic force on the electron.
c. Find the direction of the magnetic force on the electron.
d. Find the magnitude of the electric force on the electron.
e. Find the direction of the electric force on the electron.
f. Sketch the direction of the electric field **and** the electric force on the axes provided below. Be sure to include labels on the vectors and the axes!

a)



B) $F = qvxB = qvB\sin\theta$

$= 1.6x10^{-19}C(7x10^6 m/s)(4.0T)\sin(90+30)$

$= 3.9x10^{-12}N$

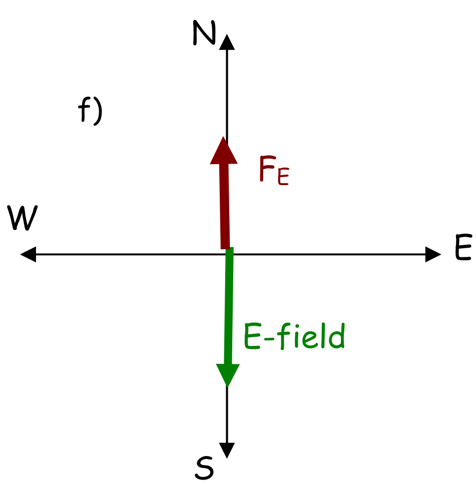
C) vxB is into the page, so the force on an electron is out of the page

Point finger along v, palm with B, Thumb points along F for +

D) $F_E = qE = (1.6x10^{-19}C)(9x10^6 N/C) = 1.44x10^{-12}N$

E) The electric field points south. The electric force points in the direction of the electric field for a positive charge and opposite the direction of the electric field for a negative charge.

f)



2. You captured a space Alien, named Zork. To determine what sort of fluid is inside him, you put a sample of the fluid through a mass spectrometer as seen below where the ions are moving downwards and the magnetic field is 3.0 T pointing out of the page. You discover that the ions reaching the detector at point A have a mass of 5.0×10^{-25} kg and are singly ionized (charge |e|).

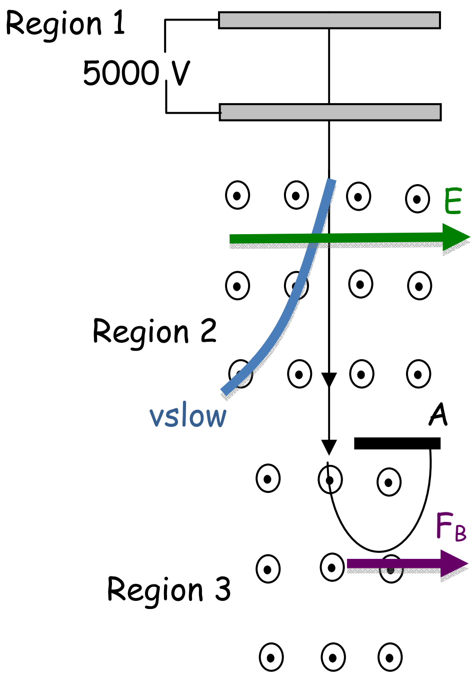
a) Are the ions positive or negative?

b) What is the velocity of these ions as they leave 5000 V accelerating voltage due to the parallel plates in region 1?

c) Indicate the magnitude and direction of the Electric Field in region 2 that allows the region to act as a velocity selector for the velocity you determined in part (b).

d) What is the radius of the circular path in region 3.

e) Sketch a path an ion would take in the velocity selector of region 2 if it were moving too slow. (label it)



a) we can tell that the ions are negative because vxB points to the left, and the ions curve to the right.

b)

$$U = KE$$

$$qV = \tfrac{1}{2} mv^2$$

$$v = \sqrt{\frac{2qV}{m}} = \sqrt{\frac{2(1.6x10^{-19}C)(5000V)}{5x10^{-25}kg}} = 5.66x10^4 m/s$$

c)

$$F_E = F_B$$

$$qE = qvB\sin\theta \quad \theta = 90°$$

$$E = vB = (5.66x10^4 m/s)(3.0T) = 1.7x10^5 V/m$$

d) In region 3, the only force is the magnetic force,

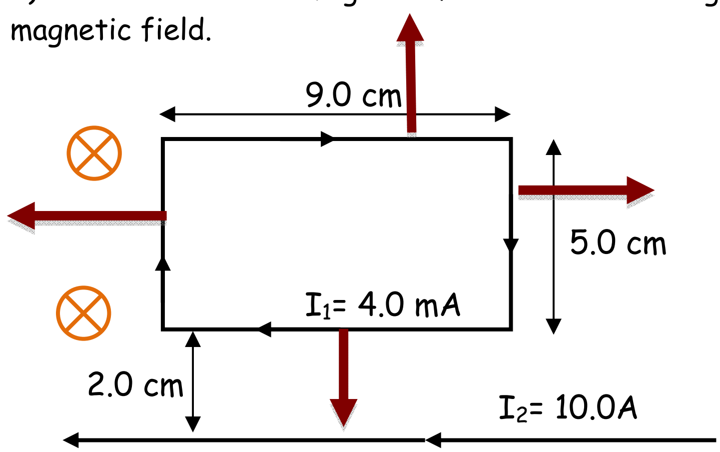
since F $\perp$ v, the motion is in circles

$$F_B = ma \rightarrow qvB = m\frac{v^2}{r}$$

$$r = \frac{mv}{qB} = \frac{(5.0x10^{-25}kg)(5.66x10^4 m/s)}{(1.6x10^{-19}C)(3.0T)} = 5.9x10^{-2} m$$

e) the magnetic force on the electrons points to the right. If a negative ion was going too slow, FB would get smaller, and the electric force would push it to the left.

3. A rectangular loop of wire (wire 1) carrying a current I_1 = 4.0 mA in the clockwise direction is next to a very long wire (wire 2) carrying a current I_2= 10.0 A to the left.
   a) Find the magnitude **and** direction of the magnetic field due to wire 2 at a distance 2.0 cm above the wire.
   b) Find the magnitude **and** direction of the magnetic field due to wire 2 at a distance 7.0 cm above the wire.
   c) Indicate the direction of the magnetic force on each of the four sides of the rectangle due to the long wire's magnetic field? Sketch them on the diagram below.
   d) Calculate the NET magnetic force on the rectangular loop due to the long wire's magnetic field.



a)
$$B_{2bottom} = \frac{\mu_o I}{2\pi r} = \frac{(4\pi x10^{-7}\,Tm/A)(10.0A)}{2\pi(0.02m)} = 1.00x10^{-4}\,T \otimes$$ Into the page

b)
$$B_{2top} = \frac{\mu_o I}{2\pi r} = \frac{(4\pi x10^{-7}\,Tm/A)(10.0A)}{2\pi(0.07m)} = 2.86x10^{-5}\,T \otimes$$ Into the page

c) Using the right hand rule by pointing our fingers along I with our palm in the direction of B, we see that the force on each side of the loop is outward, perpendicular to the loop.

d) The left and right side of the loop are equidistant from the wire, so they experience the same B-field and therefore, the same force, only in opposite directions, so they cancel.

The bottom side

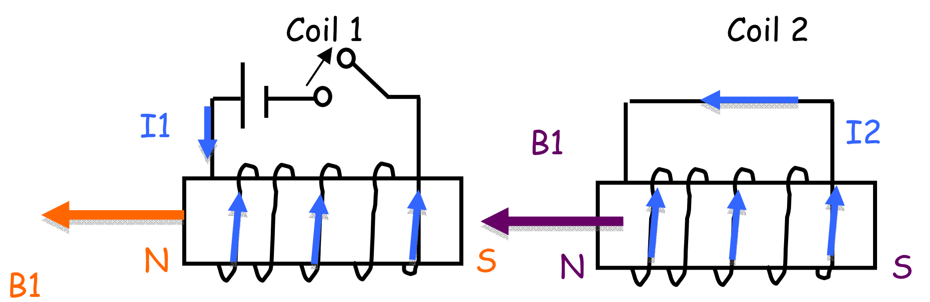
$$F_{bottom} = I_1 L B_{2bottom} \sin\theta$$
$$= (0.004A)(0.09m)(1.00x10^{-4}\,T)$$
$$= 3.6x10^{-8}\,N$$ downward = $-3.6x10^{-8}\,N$

the top side

$$F_{top} = I_1 L B_{2top} \sin\theta$$
$$= (0.004A)(0.09m)(2.86x10^{-5}\,T)$$
$$= 1.03x10^{-8}\,N$$ upward

$$F = F_{top} + F_{Bottom}$$
$$= 1.03x10^{-8}\,N - 3.6x10^{-8}\,N = 2.57x10^{-8}\,N$$ downward

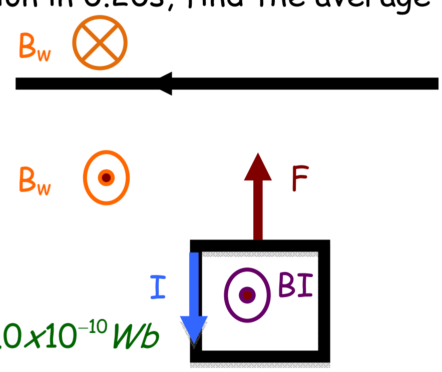
4. Below are two coils. Coil 1 is on the left and Coil 2 is on the right. At the moment the switch is opened on Coil 1
   a. Sketch an arrow representing the flow of current in Coil 1
   b. Indicate the direction of the magnetic field in Coil 1 that occurs when the switched is opened by drawing an arrow AND indicating the pole on each side of the coil.
   c. Indicate the direction of the induced magnetic field in Coil 2 that occurs when the switched is opened in coil 1 by drawing an arrow AND indicating the pole on each side of the coil.
   d. Sketch an arrow indicate the direction of the current in Coil 2.



c) Since the switch is being opened, the flux is decreasing. TO oppose the change a current is induced in coil 2 that produces a B-field in the same direction as the field in coil 1

5. Below a long current carrying wire with a current of 5.0 A is 8.0 cm from a square conducting loop that is 0.40 cm on each side. The current travels to the left in the long wire.

a) Sketch vectors representing the direction of the magnetic field due to the long wire. Clearly lable them B_w. Find the magnitude of B_w at the center of the loop.
b) Find the average magnetic flux in the loop.
c) If the current in the long wire is decreasing, what is the direction of the magnetic field induced in the loop? Clearly indicate the direction in the sketch below and lable it B_I.
d) Is the induced current in the loop clockwise or counterclockwise?
e) Will the loop experience a force due to the long wire? If so, in what direction?
f) If the current in the long wire changes direction in 0.20s, find the average EMF in the loop.



$$B_w = \frac{\mu_o I}{2\pi r} = \frac{(4\pi x10^{-7}\,Tm/A)(5.0A)}{2\pi(0.082m)} = 1.22x10^{-5}\,T$$

b) $\Phi = BA\cos\theta = (1.22x10^{-5}\,T)(0.004m)^2\cos 0 = 2.0x10^{-10}\,Wb$

c) Since the current is decreasing, B_w is decreasing, so the magnetic flux in the loop is decreasing. To oppose the change a current is induced in coil 2 that produces a B-field in the same direction as the B_w-field inside the loop

d) I_{loop} is counter clockwise: using the right hand rule, we point our thumb along B, and our fingers curl in I

e) yes, the loop experiences a force. It is outward on all sides of the loop.
Two ways to think about it
1) F=ILxB use the right hand rule on each side of the loop
2)to oppose the decrease in flux, the loop tries to get bigger to oppose the change. So the force is outward on each side of the loop. the left and right sides experience the same B_w, so the forces cancel. the top side is closer to the wire where B_w is stronger, so the upward force is largest. This is consistent with the loop trying to increase its flux, since moving the loop towards the wire increases the magnetic field inside it.

f) Now that the current has changed direction the final flux is opposite the initial flux

$$|EMF| = \left|-N\frac{\Delta\Phi}{\Delta t}\right| = \frac{|\Phi_f - \Phi_i|}{0.2s} = \frac{|-2.0x10^{-10} - 2.0x10^{-10}|}{0.2s} = 2.0x10^{-9}\,V$$