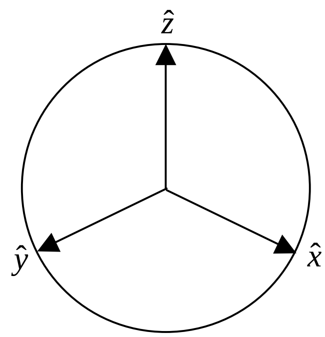
Physics 206b

Homework Assignment VIII
Due ***Wednesday*** *October 24, 2007*

Some important properties of the cross product for your reference:

$$\vec{a}\times\vec{b} = -\vec{b}\times\vec{a}$$
$$\vec{a}\times\vec{a} = 0$$
$$\hat{x}\times\hat{y} = \hat{z}$$
$$\hat{y}\times\hat{z} = \hat{x}$$
$$\hat{z}\times\hat{x} = \hat{y}$$



1. Consider a circular loop of wire in the plane of this sheet of paper (or, at least, the one you're writing your solutions on). If a constant current is flowing in the wire going clockwise, use Ampere's law and the Right Hand Rule to determine the direction of the magnetic field inside the circle and outside of the circle. Make a sketch showing this.
2. An electron is accelerated to a velocity $\vec{v}$ by passage through a potential difference of 589 V (consider its initial velocity to be zero). It then enters a region occupied by a constant magnetic field of magnitude 1.7 T with a direction perpendicular to the velocity. What is the radius of the circular path its trajectory will take? Choose directions for the velocity vector of the electron just prior to entering the magnetic field and the magnetic field vector. Sketch the vectors and indicate the path the electron will take after entering the field.
3. In a mass spectrometer, a molecular ion is accelerated through a potential difference of 400 V. Assume the ion is singly-ionized glucose ($C_6H_{12}O_6$)—i.e., one of its electrons has been removed. The ion then travels in the $\hat{x}$ direction through a constant magnetic field of 300 G oriented in the $\hat{y}$ direction. The region with the magnetic field is between the plates of a parallel-plate capacitor with a separation of 1 cm oriented in the $\hat{z}$ direction. What potential difference needs to be placed across the plates of the capacitor if the ion is to emerge from this "Wien filter" undeflected?
4. Consider again the electron in the previous problem. Now assume that there is an electric field parallel to the magnetic field and pointed in the same direction as the magnetic field. What electric field strength is necessary so that on its *first* "cycle" in the magnetic field the electron travels as far vertically as it does horizontally? (Take "vertical" to mean "parallel to the two fields" and "horizontally" to mean "in the plane perpendicular to the two fields.") This is a tough problem and you'll have to reach way back in your bag of tricks to do it!

5. A length of wire has a linear mass density of $\mu = 7.8\,\frac{grams}{meter}$. You wish to suspend a length of such a wire in midair (i.e., against the pull of gravity) by flowing a current through it while applying an external magnetic field to it. What direction does the magnetic field need to point to make this happen? Given this, what direction does the current need to travel? Make a sketch! What size current is needed if the external magnetic field is 41 milliteslas?
6. Two 1.4 m long wires oriented vertically and parallel to each other are separated by a distance of 7 cm. A current of 3 amperes flows through each of them. In both wires, the current flows from bottom to top. What is the size and direction of the force experienced by each wire due to this? If the direction of both currents is reversed, does this change? What about if the current in one of the two wires is reversed? (I.e., if one of them is flowing top-to-bottom while the other is flowing bottom-to-top.) Hint: Use Ampere's law.
7. Write down, in words, Faraday's Law.