Module 08 Homework

1. The large power lines we see out in the country carrying electricity over long distances are called "transmission lines". These lines are high voltage (typically around 345 kV) and can carry as much as 4000 A of current (that means one line can carry deliver as much as 1380.0 MW of electrical power, which is 13.8 times the amount of power produced by the Goodman Energy Center north of Hays). The large metal towers used to suspend these lines are usually about 30 m (or more) tall.

    1. If you stood directly under one of these lines and measured the maximum strength of the magnetic field produced by the power line, what would it be? Assume that the lines are 30 m in the air and carry maximum current.

    2. If the power lines ran north-south and you measured the field while current was traveling north, what direction would the field point?

    3. The magnetic field strength of Earth varies over the surface of the Earth, but ranges between 25 µT and 65 µT. How does the magnetic field you calculated for the power line compare to the magnetic field of Earth? Is it much larger, much smaller, or about the same? Would you expect it to deflect a compass needle?

2. Consider Figure 1. The figure shows three currents that run into the board. Assume that the wires carrying the currents are *long* and perpendicular to the page. Compute the magnitude and direction (i.e. compute the angle that the field makes with the $+x$ axis) of the net magnetic field produced by the three currents at the position P. Assume that the currents are all the same, and that they sit at the corners of a square with side length L.

3. A circular loop of radius R_1 lies in the $x-y$ plane, centered on the origin, and has a current i running through it clockwise when viewed *from* the positive z direction. A second loop with radius R_2 sits above the first, centered on the positive z axis and parallel to the first.

    1. If the second loop is centered at the point $z = R_1$, what must the current be (direction and magnitude) in order for the net magnetic field at the center of the second loop to be zero.

    2. If the second loop is centered at the point $z = R_1$, what must the current be (direction and magnitude) in order for the net magnetic field at the center of the first loop to be zero.

4. Figure 2 below shows a wire loop composed of two circular arcs, and two straight pieces. The two circular arcs are concentric, meaning they sit on the perimeter of two circles that share a common center, and both arcs span 90°. Assume that the loop is in the $x-y$ plane, with the origin at the position where the two dashed lines intersect, and that the $+z$-axis points out of the board.

    1. Determine the strength of the magnetic field at the origin.

    2. Determine the direction of the magnetic field at the origin.

5. The large solenoid that we saw in our class demonstration has 3400 loops with a diameter of 10.0 cm. When we ran a 200 mA current through the solenoid, we saw the compass needle snap into position.

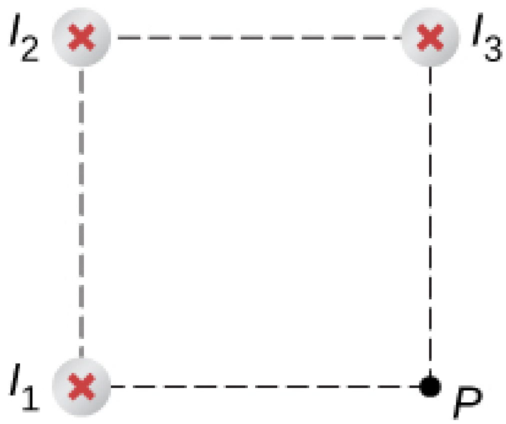

Figure 1:

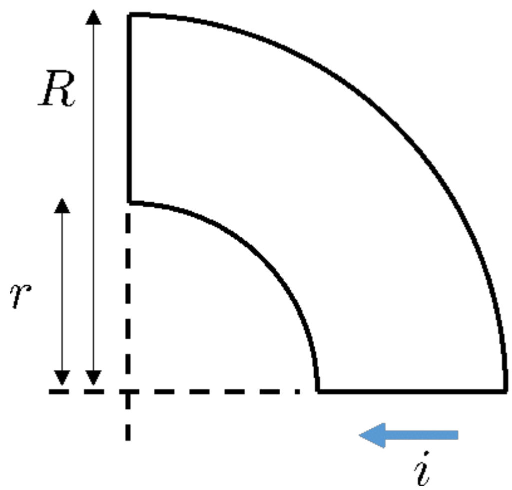

Figure 2:

Let's estimate the strength of the magnetic field that was produced by the solenoid by ignoring the fact that the loops are spread out over the length of the solenoid. Compute the strength of the magnetic field produced by a single loop, at the center of the loop, and multiply this by the number of loops.

6. Recall that in our classical model of the Hydrogen atom, there will be a current associated with orbit of the electron.

   1. **Example Problem Writeup:** Determine the strength of the magnetic field produced an electron in orbit around a proton, at the position of the proton (i.e. at the center of the orbit).

   2. How far from the atom will the magnetic field produced by the electron orbit drop below $25\,\mu T$ (i.e. weaker than Earth's magnetic field')?