University of Alabama
Department of Physics and Astronomy

PH 102-1 / LeClair Summer II 2008

Problem Set 3: dc Circuits, Magnetism

Instructions:

1. Answer all questions below. Show your work for full credit.
2. Due before 3pm, 29 July 2008
3. Email submission: pleclair@ua.edu
4. Hard copies: Gallalee 206 or Bevill 228; at the *beginning* of the lab period.
5. You may collaborate, but everyone must turn in their own work

1. 10 points. **(a)** What is the velocity of a beam of electrons which move undeflected in a region of space in which there exist both a uniform electric field $|\vec{\mathbf{E}}| = 3.4 \times 10^5\,\mathrm{V/m}$ and a uniform magnetic field of $|\vec{\mathbf{B}}| = 2 \times 10^{-3}\,\mathrm{T}$? **(b)** Show the orientation of the vectors $\vec{\mathbf{v}}$, $\vec{\mathbf{E}}$, and $\vec{\mathbf{B}}$ in a diagram. **(c)** What is the radius of the electron orbit when the electric field is removed, and only the magnetic field remains? You may ignore relativistic effects.

2. 15 points. Each of the twelve edges of the cube is a resistor of value R. What is the resistance between two *opposite corners*?

3. 10 points. Two resistors connected in series are measured to have an equivalent resistance of $1500\,\Omega$. The same two resistors in paral lel are measured to have an equivalent resistance of $350\,\Omega$. What are the values of the resistors?

4. 10 points. A wire with a weight per unit length of $0.10\,\mathrm{N/m}$ is suspended directly above a second wire. The top wire carries a current of $30\,\mathrm{A}$ and the bottom wire carries a current of $60\,\mathrm{A}$. Find the distance of separation between the wires so that the top wire will be held in place by magnetic repulsion.

5. 5 points. A proton moves with velocity $\vec{\mathbf{v}} = (2\hat{\mathbf{x}} - 4\hat{\mathbf{y}} + 1\hat{\mathbf{z}})\,\mathrm{m/s}$ in a region where the magnetic field is $\vec{\mathbf{B}} = (1\hat{\mathbf{x}} + 2\hat{\mathbf{y}} - 3\hat{\mathbf{z}})\,\mathrm{T}$. What is the magnitude and direction of the magnetic force this charge experiences?

6. 10 points. A lightbulb marked "75 W [at] 120 V" is screwed into a socket at one end of a long extension cord, in which each of the two conductors has a resistance of $0.800\,\Omega$. The other end of the extension cord is plugged into a $120\,\mathrm{V}$ outlet. Draw a circuit diagram and find the actual power delivered to the bulb in this circuit.

7. 15 points. Consider two parallel wires of infinite length, separated by a distance r, each with a uniform positive charge density λ. Both wires are moving in the same direction with velocity v, also parallel to the wires. If the electrical repulsion is exactly balanced by the magnetic attraction caused by the current, what is v? Remember that in chapter 3 of the notes, we derived the electric field from a long, charged wire. *Hint: find electric and magnetic forces per unit length of the wire.*

8. 10 points. Consider two solenoids, one of which is a tenth-scale model of the other. The larger solenoid is 2 m long, and 1 m in diameter, and is wound with 1 cm-diameter copper wire. When the coil is connected to a 120 V dc generator, the magnetic field at the center is exactly 0.1 T. The scaled-down version is exactly one-tenth the size in every linear dimension, including the diameter of the wire. The number of turns is the same in both coils, and both are designed to provide the same central field.

(a) Show that the voltage required is the same, namely, 120 V
(b) Compare the coils with respect to the power dissipated, and the difficulty of removing this heat by some cooling means.

9. 15 points. In the circuit below, determine the current in each resistor and the voltage across the 200 Ω resistor.