Physics 2401 Honors second exam, Spring 2006

$e = 1.609 \times 10^{-19}$ C, m(electron) = 9.11×10^{-31} kg, $\varepsilon_0 = 8.845 \times 10^{-12}$ C^2/Nm^2, $\mu_0 = 4\pi \times 10^{-7}$ T/A-m
$k_e = 9.0 \times 10^9$ Nm^2/C^2, m(proton) = 1.67×10^{-27} kg. μ = micro = 10^{-6}, m = milli = 10^{-3}

Short questions (5 points each, drop the low one)

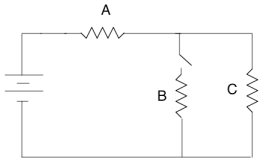
1. A capacitor is charged, then disconnected from a battery. The plate separation is then tripled. By what factor does the stored energy in the capacitor change?

2. A 20 μF capacitor is initially charged to a voltage of 12 V by a battery, then disconnected. If it is now connected to a 6.0 μF capacitor in parallel, what is the common voltage across them after charge has stopped moving?

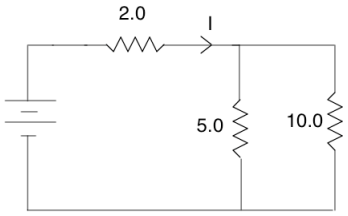
3. An incandescent light bulb has a resistance which is very different when it is off from that when it is on. In which condition is it lower, and why?

4. Car batteries are often rated in ampere-hours. Does this represent the amount of current, charge, energy or power that the battery can deliver?

5. When the switch is closed, does the current in resistor C increase or decrease?

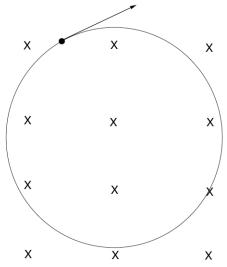


6. Find the current I_1 in the circuit on the right. Resistances are in Ohms, and the battery voltage is 12 V.

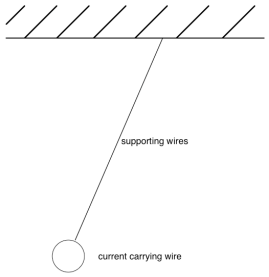


7. Why should a good voltmeter have a very large effective resistance?

8. The particle in the picture is moving clockwise in a magnetic field pointing into the paper. Is it positively or negatively charged?



9. The wire shown on the right carries current out of the paper and feels a downward gravitational force. It hangs at the angle shown from wires. What direction is the magnetic field if the wire is feeling the maximum possible value of the force?



Long problems (20 points each, drop the low one)

1. A capacitor consists of two plates with areas of 1.50 m^2 and a separation of 0.25 mm. It is initially charged to a charge of 2.2 pC, then disconnected from the battery.

a) Find its capacitance when it is empty.

b) We now take a sheet of dielectric with K=3.67 that fills the capacitor laterally and a thickness of 0.125 mm and place it in the capacitor. Find the new capacitance. (hint: it is like a combination of two capacitors)

c) What is the potential difference across the plates with the dielectric inserted?

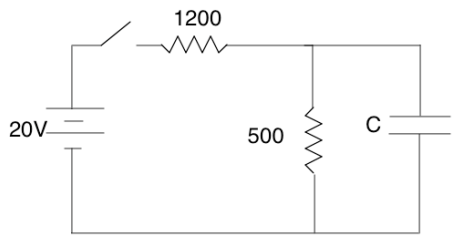
2. Copper has a resistivity of 1.7×10^{-8} Ohm-m and a temperature coefficient of 3.9×10^{-3} 1/K at 20 degrees C. We have a volume of 2.0×10^{-6} m^3 of copper to make wires with.

a) find the dimensions of a wire using the copper that has a square cross section and a resistance of 5.5 Ohms.

b) At what temperature will the resistance be 5.0 Ohms?

c) If the wire in a) is horizontal and carries a current of 100 A in a vertical magnetic field with a strength of 0.35 T, what is the total magnetic force acting on it?

3. The circuit on the right has the switch closed at t=0. The capacitor is initially uncharged. Resistances are in Ohms and the capacitance is 20 microFarads.
a) What is the current through the battery just after the switch is closed?



b) After the switch has been closed for a long time, what is the current through the battery?

c) If the switch is opened again, how long will it be after it is opened before the current in the capacitor drops to 0.10 A?

4. A 100 turn, 0.35 m radius coil of wire lies in the xy plane and carries a current of 25 A, clockwise as viewed from the +z direction.

a) Find the vector magnetic moment of the coil.

b) The coil is in a magnetic field given by $\vec{B} = (0.20\hat{i} - 0.35\hat{j} + .22\hat{k})T$. Find the vector torque on the coil.