Name:

Physics 122 – Spring 2012 – Test 3

Instructions:

There are some useful tables at the end of this exam paper.
You may use a calculator and your 3x5 index card. Please ATTACH your index card to the test afterwards. Problems 1–2 require *only* an answer, but you *may* provide an explanation for the possibility of partial credit. Problems 3–9 require work to be shown in an orderly fashion. *IDEA* method is recommended but not required. If I cannot easily follow your work, you will receive reduced credit.

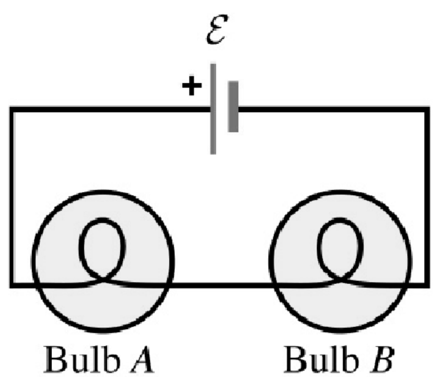


Figure 1: Question 1

1. *(5 pts.)* In the circuit shown (Figure 1), the two bulbs "A" and "B" are identical. Compare the brightness of bulb "A" and bulb "B":

(a) Bulb B glows more brightly.
(b) Bulb B glows less brightly.
(c) Bulb B glows just as brightly.
(d) Answer depends on whether the mobile charges in the wire are positively or negatively charged.

2. *(5 pts.)* Resistor A of resistance R is made from a cube of carbon of side length s. Resistor B is a cube made from the same carbon but with side length $2s$. Resistor B has:

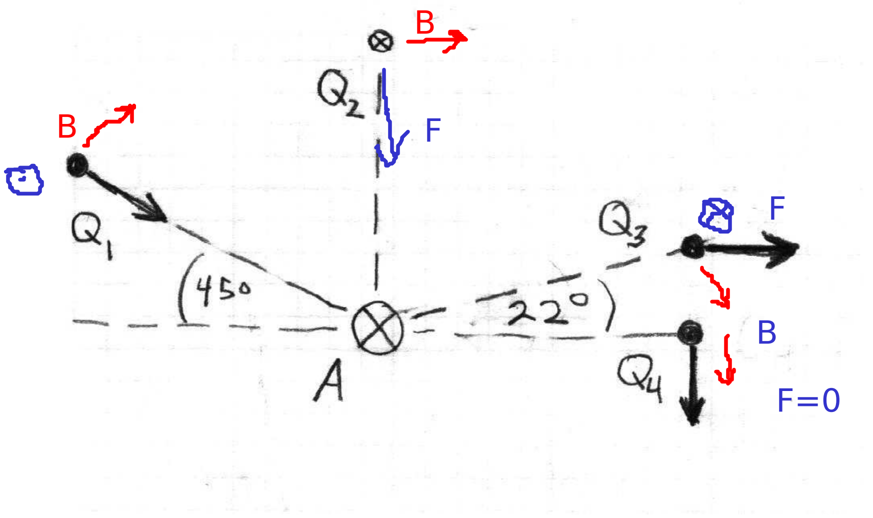
(a) Four times the resistance of A.
(b) Twice the resistance of A.
(c) The same resistance as A.
(d) Half the resistance of A.
(e) One quarter the resistance of A.

R = rho * L / A
R_A = rho * s/(s*s) = rho/s
R_B = rho *(2s)/(2s*2s)=rho/2s

(**NOTE:** This sort of thing is actually done to make the little resistors you will notice all over the circuit board of a cel-phone or other modern electronic device. Practically speaking, this means two opposite faces are coated with copper so that that they are equipotentials and so that the current will be distributed evenly between those two faces, but that's just a clarification to help you understand the problem; it does not affect the answer).

3. *(10 pts.)* Express the following units in terms of other SI units. You may use (only) Coulomb, Joule, Newton, Meter, Second, and Kilogram in your answers. Show your work. That is, show what equations you use to do the conversions. You get 1/2 credit for just showing the answer w/o the work.

(a) Ohm .... J s / C^2



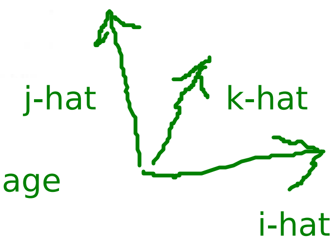


Figure 2: Problem 4

k-hat is into page

(b) Tesla ......N s / C m......

4. *(15 pts.)* In the diagram (Figure 2), the × at point A represents a 12 kA current flowing into the page in a long, straight wire. Q_1, Q_2, Q_3, and Q_4 are all 15 μC charges moving at the same speed; 34,000 km/sec. All charges are 2 cm from the wire, but moving in different directions, indicated by the dark arrows. Q_2 is moving into the page, as indicated by the ×.

B=0.12 T F1=-61.2 N k-hat , F2=-61.2 N j-hat, F4=0

(a) Draw a vector at each charge Q_1, Q_2, Q_3, Q_4 indicating the magnetic field direction from current "A" at their location. (Use a dotted line or label your vector with a B).

(b) Draw a vector at each charge indicating the direction of the force exerted by the magnetic field. (Use a solid line or label your vector with an F.)

(c) Calculate the magnitude and direction of the magnetic force on each charge (as a vector, expressed in component form.)

F3=61.2*sin(22) = 61.2*0.93=56.7 N k-hat

NOTE: The charges do exert electrostatic forces on each other. We are ignoring those. The question is only about the magnetic forces the charges feel from the wire.

5. *(10 pts.)* You are given a 9 V battery and three resistors with values, 1, 2, and 4 Ω.

(a) Draw a circuit diagram (circuit A) showing how to connect the battery and resistors for the maximum equivalent resistance
(b) Draw a circuit diagram (circuit B) showing how to connect the battery and resistors for the minimum equivalent resistance
(c) Calculate the maximum and minimum equivalent resistance
(d) What power is dissipated by the 2Ω resistor for circuit A.
(e) What power is dissipated by the 2Ω resistor for circuit B.

(c) Rmax=7 Ohms, Rmin=0.57 Ohm
(d) 3.33 W
(e) 40.5 W

6. *(10 pts.)* A square loop of wire with side s=3 meters lies on the ground above very long straight wire (1) as shown in figure 3. $I_1 = 12\ kA$. The battery voltage $\varepsilon = 300\ V$. The resistor $R = 3\Omega$.

(a) Indicate the direction of the magnetic force on each side of the square (on the diagram).
(b) Calculate the net magnetic force on the square exerted by wire 1.

(**HINT:** You can make this problem quite difficult if you forget to use symmetry arguments. You do NOT need to do an integral of any sort to solve this problem. **ALSO** – assume the resistor and battery do not change the fact that this acts like a plain square loop of wire.)

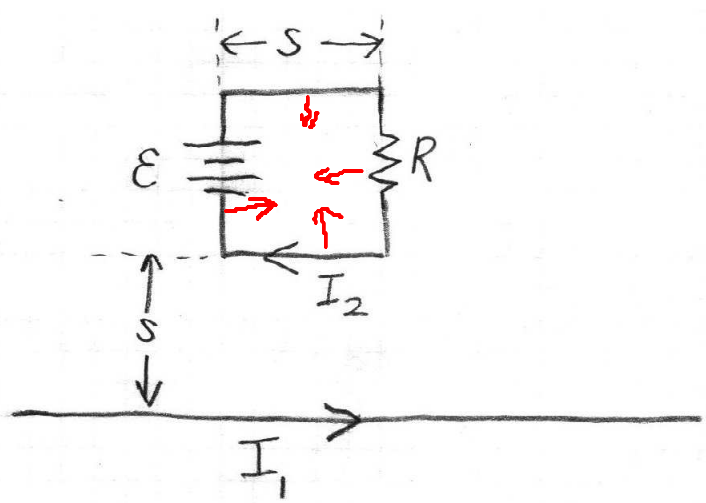


Figure 3: Problem 6

7. *(10 pts.)* In the circuit shown in Figure 4, the voltage drop on the 15 mF capacitor is 20 Volts before the switch is closed. At t=0, the switch is closed and a current I_0 is measured through resistor R. At t=10 s, the current has fallen by a factor of 2 (e.g. $I(10) = 0.5\ I_0$).

(a) What is the value of R?
(b) What is the charge on C at t=15 sec?

R=962 Ohms
Q(15) =0.11 C

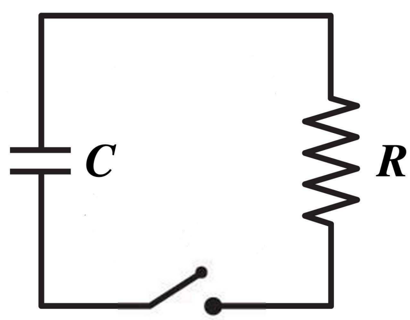


Figure 4: Problem 7

8. *(20 pts.)* In Figure 5, the battery voltage is $\varepsilon = 80\ V$. The resistor values are: (R_1=10 Ω, R_2=20 Ω, R_3=30 Ω, R_4=40 Ω) The negative terminal of the battery can be considered to be at ground potential (V=0). Answer the following.

(a) Redraw the schematic shown so that the series and parallel circuit elements are move obvious.
(b) Calculate the equivalent resistance of the resistors.
(c) What is the current through R_1?
(d) What is the current through R_4?
(e) What is the voltage at point "a" relative to ground?
(f) What is the voltage at point "b" relative to ground?

b) 25.5 Ohms
c) I=3.13 Amps
d) Va=80-3.13*10=48.7 V
I2 = 48.7/20=2.43 Amps
I2+I4=I1
I4=3.13-2.43=0.70 Amps
e) 48.7 V
f) Vb=0.7*R4=28 V

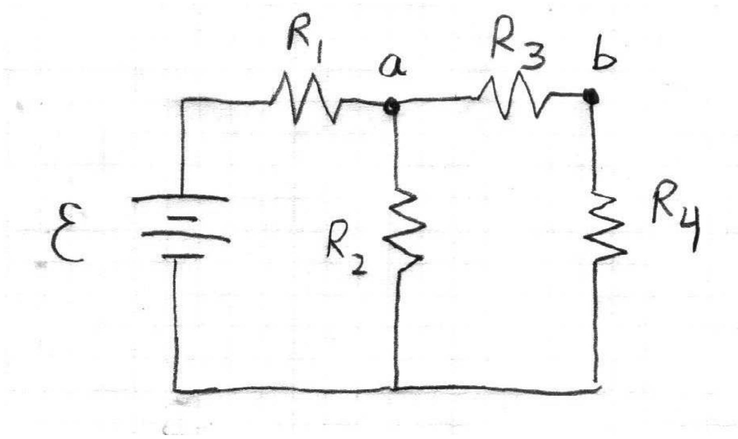


Figure 5: Problem 8

9. *(20 pts.)* You have a cylindrical piece of material 2.3 cm long and 2.0 mm in diameter. When you connect this cylinder into a circuit with a 440-V voltage supply, you get a current of 2.6 mA.

(a) What is the resistance of the cylinder?
(b) What is the current density?
(c) What is the material?
(d) What is the electron drift speed in this material? (Yes, it's considerably faster than the other examples we worked.)
(e) What is the electric field in this material?

a) 169 kOhms
b) 828 A/m^2
c) 23 Ohm-m (Si)
d) vdrive = 5.17E5 m/s
e) 19.1 kV/m

Material Properties

Material	Resistivity ($\Omega\ m$)	Charge carrier density ($number/m^3$)
Copper	1.7×10^{-8}	1.1×10^{29}
Iron	9.7×10^{-8}	2.1×10^{29}
Human Blood	0.7	–
Germanium	0.47	2.0×10^{19}
Silicon	2.3×10^{1}	1.0×10^{16}