Exam # 2 – Physics 152
Current, Resistance, Circuits, and Capacitance

February 23, 2010

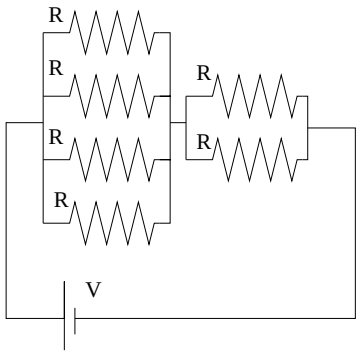
Be sure to include pictures, coordinate systems, etc. where reasonable. **Pick 5.**

1. In the first section of this course we dealt with charges at fixed locations, the forces on them and their potential energy (and by extension the electric fields and electric potentials that those charges experienced). In this second part of the course we have been interested in electric currents. Just what is an electric current? In answering this question please draw an example circuit and address the following:

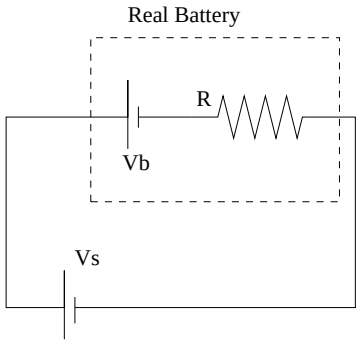
   (a) How does current relate to charge?

   (b) What causes a current to exist?

2. Find the current leaving the battery in the following circuit where $R = 100\Omega$. The battery has a voltage $12V$.



3. Your cell phone has died and you need to recharge the battery. The phone has a $4.5V$ battery that is capable of storing $3kJ$ of energy. As it is a real battery it has internal resistance. The real phone battery can be thought of as an ideal $4.5V$ battery in series with a 2Ω resistor. The phone charger is a $5.3V$ power supply. The complete charging circuit looks like this:



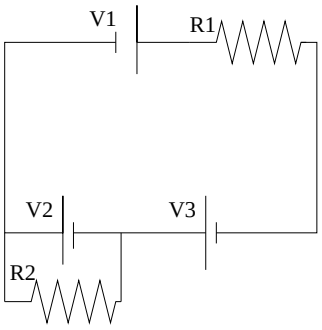
   (a) What is the current provided by the power supply?

   (b) At what rate is energy stored by the phone battery?

   (c) At what rate is thermal energy disappated by the internal resistance of the phone battery?

   (d) How long will it take to completely charge the dead battery? (A voltmeter shows that the battery voltage is always $4.5V$, it just cannot produce a current when it is dead.)

4. In the following circuit $R_1 = 100\Omega$, $R_2 = 50\Omega$, $V_1 = 6V$, $V_2 = 5V$, and $V_3 = 4V$.



   (a) Find the current through and voltage across R_1.

   (b) Find the current through and voltage across R_2.

   (c) Draw a new circuit diagram that shows how to attach a voltmeter and ammeter to test your results for R_1.

5. Use Gauss' law to calculate the capacitance of a pair of concentric spheres of radii a and b.

6. A thunder cloud $5km$ long and $2km$ wide hovers $100m$ above the ground. As the rain falls the cloud's bottom becomes negatively charged and the ground positively charged.

   (a) Treating the bottom of the cloud as a flat plate and the ground below the cloud as a flat plate of the same size calculate the capacitance of this parallel plate capacitor. Ignore any dielectric effects of the air and rain.

   (b) While the cloud was forming a potential difference of $300MV$ developed between the ground and the cloud. What is the excess charge on the capacitor?

   (c) A lightning bolt strikes from the cloud to the ground and the path from the could to the ground has a resistance of 30Ω. What is the excess charge on the cloud-ground capacitor as a function of time?

   (d) How long does it take for half of the potential energy in the cloud-ground capacitor to be discharged?