Problem Set 5: dc Circuits

Instructions:
- Answer all questions below. Show your work for full credit.
- Due before 5pm, 18 Feb 2008
- Problem sets may be turned in via email or hard copy
- Hard copies may be left in Dr. LeClair’s mailbox (Gallalee 206) or office (Bevill 228)
- You may collaborate, but everyone must turn in their own work

1. **5 points.** Are the two headlights of a car wired in series or in parallel? How can you tell?

2. **5 points.** What advantage might there be in using two identical resistors in parallel connected in series with another identical parallel pair, rather than just using a single resistor?

3. **15 points.** An electric heater is rated at 1500 W, a toaster at 750 W, and an electric grill at 1000 W. The three appliances are connected to a common 120 V household circuit. (a) How much current does each draw? (b) Is a circuit with a 25 A circuit breaker sufficient in this situation? Explain your answer.

4. **15 points.** A dead battery is charged by connecting it to the live battery of another car with jumper cables (see below). Determine the current in the starter and in the dead battery.

5. **20 points.** A group of students on spring break manages to reach a deserted island in their wrecked sailboat. They splash ashore with fuel, a European gasoline-powered 240 V generator, a box of North American 100 W, 120 V lightbulbs, a 500 W 120 V hot pot, lamp sockets, and some insulated wire. While waiting to be rescued they decide to use the generator to operate some bulbs.

(a) Draw a diagram of a circuit they can use, containing the minimum number of lightbulbs with 120 V across each bulb, and no higher output.

(b) One student catches a fish and wants to cook it in the hot pot. Draw a diagram of a circuit containing the hot pot and the minimum number of lightbulbs with 120 V across each device, and not more. Find the current in the generator and its power output.
6. **15 points.** Two resistors $R_1$ and $R_2$ are in parallel with each other. Together they carry total current $I$. (a) Determine the current in each resistor. (b) Prove that this division of the total current $I$ between the two resistors results in less power delivered to the combination than any other division. It is a general principle that current in a direct current circuit distributes itself so that the total power delivered to the circuit is a minimum.

7. **5 points.** A fully charged capacitor stores energy $U_0$. How much energy remains when its charge has decreased to half its original value?

8. **5 points.** A capacitor in an $RC$ circuit is charged to 60% of its maximum value in 0.900 s. What is the time constant of the circuit?

9. **10 points.** A capacitor of value $C$ is discharged through a resistor of value $R$. (a) After how many time constants is the charge on the capacitor one fourth of its initial value? (b) After how many time constants is the energy at one fourth of its initial value?

10. **5 points.** Two resistors connected in series have an equivalent resistance of 690 Ω. When they are connected in parallel, their equivalent resistance is 150 Ω. Find the resistance of each resistor.