PHYS 216 – Assignment #6 – Due Nov 4

Chapters 9–10: Current, Resistance & DC Circuits

Problem 1. A 30.0 m two-conductor extension cord is made of 16-gauge copper wire (diameter 1.291 mm, $\rho = 1.72 \times 10^{-8}\,\Omega\,\text{m}$). It carries 10.0 A to a space heater from a 120 V outlet.

a. Find the total resistance of the cord. (Remember that the current goes out along one conductor and returns along the other.)

b. Find the voltage drop along the cord and the power dissipated in it. What voltage reaches the heater?

c. Aluminum has $\rho = 2.65 \times 10^{-8}\,\Omega\,\text{m}$. What wire diameter would an aluminum cord need to have the same resistance?

d. Why do cord manufacturers warn against using long, thin cords with heaters?

Problem 2. An incandescent bulb rated at 100 W when operated at 120 V has a tungsten filament that operates at 2550 °C. Tungsten has resistivity $5.6 \times 10^{-8}\,\Omega\,\text{m}$ at 20 °C and temperature coefficient $\alpha = 4.5 \times 10^{-3}\,^{\circ}\text{C}^{-1}$. Assume the linear model $R = R_0[1 + \alpha(T - T_0)]$ holds over the whole range, and neglect thermal expansion.

a. Find the filament's resistance and current at normal operation.

b. Find the filament's resistance at room temperature (20 °C).

c. At the instant the bulb is switched on the filament is still cold. Find the initial ("inrush") current and power. Use this to explain why incandescent bulbs usually burn out at switch-on.

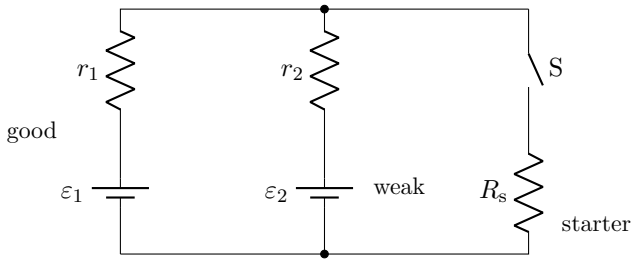
d. Is the bulb an ohmic device? Sketch the I–V curve of the bulb from 0 to 120 V and compare it with that of an ohmic resistor having the same resistance at 120 V.

Problem 3. A car with a weak battery ($\varepsilon_2 = 11.0\,\text{V}$, internal resistance $r_2 = 0.100\,\Omega$) is jump-started from a healthy one ($\varepsilon_1 = 12.6\,\text{V}$, $r_1 = 0.030\,\Omega$). The jumper cables connect positive to positive and negative to negative, putting the batteries in parallel across the starter motor, which behaves as a resistance $R_\text{s} = 0.060\,\Omega$ when switch S is closed (see below). Neglect the resistance of the cables.

a. With S open, find the current that flows between the batteries and the common terminal voltage. At what rate is electrical energy converted into chemical energy in the weak battery, and at what rate is thermal energy produced in the two batteries?

b. S is closed. Use Kirchhoff's rules to find the current through each battery and through the starter, and the voltage across the starter. Is the weak battery now charging or discharging?

c. Find the power delivered to the starter. Compare it with the power the weak battery could deliver on its own.



Problem 4. An initially uncharged $220\,\mu\text{F}$ capacitor is charged through a $47.0\,\text{k}\Omega$ resistor by a $9.00\,\text{V}$ battery (ideal).

a. Find the time constant and the initial current.

b. Find the capacitor voltage after one and after two time constants.

c. Find the capacitor voltage and the current $10.0\,\text{s}$ after the switch is closed.

d. How long does the capacitor take to reach half its final voltage?

e. Find the final charge and stored energy.

f. The fully charged capacitor is disconnected from the battery and connected across a $10.0\,\text{k}\Omega$ resistor. Find the new time constant, the initial discharge current, and the capacitor voltage $5.00\,\text{s}$ later.