Module 05 Homework

1. A phone battery pushes a 0.5 mA current through the phone and will “die” after moving 10 000.0 C of charge through the phone.

    1. How long will the phone run?
    2. How many electrons per minute will flow through the phone?
    3. What is the battery capacity in milli-ampere hour? (An ampere hour is the total charge moved by one ampere of current for one hour)?

2. You measure the potential difference between the terminals of a 9V battery to be 9.5 V when it is not connected to a resistor. You then connect a 2 Ω resistor to the battery and measure the potential difference across the battery terminals to be 9 V. What is the internal resistance of the battery?

3. A homemade thermostat uses a probe consisting of a cylindrical chunk of copper metal to monitor the temperature of a water bath used for cooking poached eggs. The thermostat measures the water temperature applying a constant voltage across the copper so that a current passes through it and then measuring the magnitude of this current. The ideal temperature for cooking the eggs is 185 $°_F$ahrenheit. If the thermostat measures a current of 0.01 mA when the probe is sitting at room temperature (70 $°_F$ahrenheit), what should the measured current be when the water is at the correct temperature?

4. A 100 W light bulb has a resistance of 9.6 Ω at room temperature (70 °F). The light bulb is called “100 W” because it will dissipated 100 W of power when it is connected to a 120 V potential difference. What is the temperature of the tungsten element in the light bulb when it is operating as normal?

5. Starting a car engine takes a lot of power. An electric starter turns the engine crank until it starts to run. The starter gets power from the car battery, which is a 12 volt battery, by pulling current form it. Assume that a car starter uses 2500.0 W of power while drawing 250 A of current from the battery.

    1. What is the terminal voltage of the battery while the starter draws current?
    2. What is the internal resistance of the battery?

6. Jack’s car battery has died. The starter in his car requires a minimum of 1500 W of power to start the engine, and it must draw a current of 200 A of when it does this. Jill has offered to jump start his car. Her car has a 12 V battery and she connects this to Jack’s car using a set of jumper cables. If the wire used in the jumper cables has a resistance of 1.00×10^{-2} Ω per 10 ft of cable, what is the longest set of jumper cables that Jill can use? (We can ignore the internal resistance of the battery if Jill has her car running while they do this).

7. A space heater dissipates 1200 W of power when connected directly to the wall. If a 100 ft extension cord made of 12 gauge copper wire (a diameter of 2.05 mm) is used instead, how much power will the heater dissipate?

Recall the model we used in the previous modules for the Hydrogen atom based on classical mechanics. If we treat the electron as a point charge orbiting the proton, then we have a charge in motion, which means we will have a current.

8. **Example Problem Write-up:** Use our classical model of the Hydrogen atom to show that the current associated with the oribiting electron as a function of orbit radius can be written as $i = \sqrt{\frac{k}{m_e}} \frac{e^2}{2\pi R^{3/2}}$, where m_e is the mass of the electron, and R is the orbital distance.

9. Recall from Module 01 homework that the Bohr radius, which gives the most probable distance between the electron and proton in a Hydrogen atom, is 5.29×10^{-11} m.

    1. What is the current associated with the electron orbit at distance equal to the Bohr radius from a proton?