Physics 9, Fall 2018, Homework #11.

Due at start of class on Friday, December 7, 2018

Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.

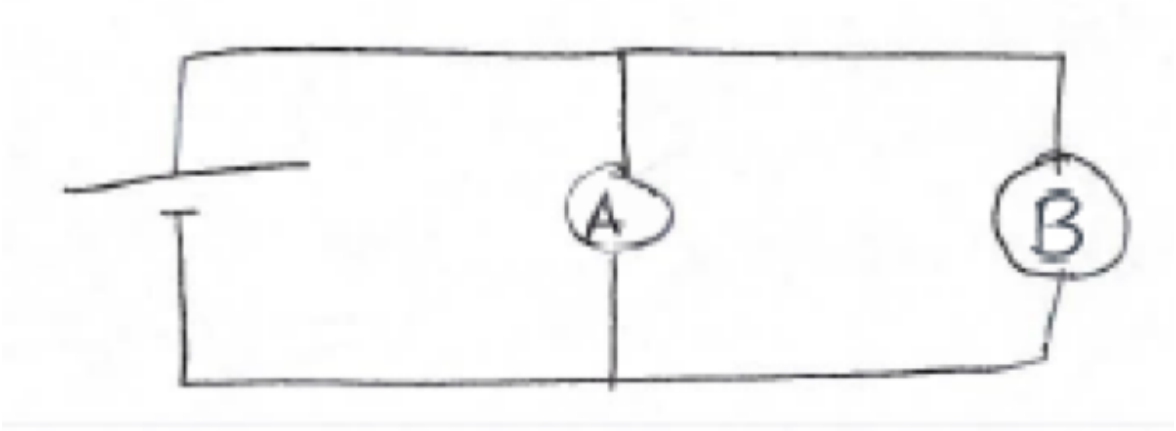
DC circuit problems

1*. A battery initially contains 3.0×10^{22} electrons inside its casing. This battery is used to power a light bulb for some time, pumping 1.1×10^{22} electrons through the bulb. After powering the bulb for this time, how many electrons are inside the battery? (Think!)

2. (a) Write one or two sentences clearly describing what *electric current* is — from a microscopic point of view and from the perspective of analyzing a circuit. (b) Write at least two sentences clearly describing what *voltage* is — from the point of view of an individual charged particle and from the perspective of analyzing a circuit.

3. A 9.0-volt battery is connected to a light bulb. When the circuit is completed, a steady current of 0.01 amps is drawn from the battery. What is the resistance of the light bulb?

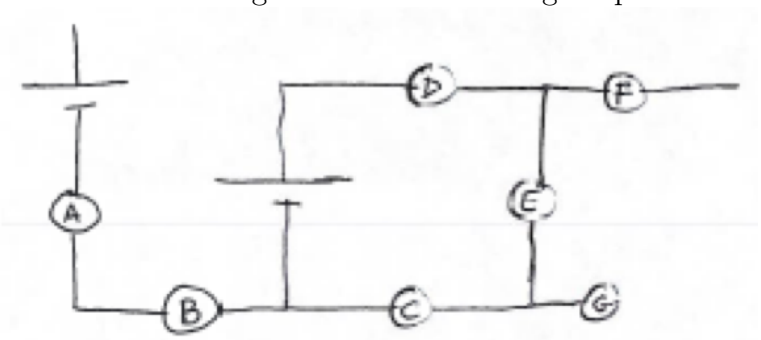
4*. Two light bulbs (of different types) and a battery are used to construct the circuit shown in the figure below. The bulb labeled **A** is bright, and the bulb labeled **B** is dim. (a) Which bulb has the greater potential difference across it, or are they the same? (b) Which bulb carries the greater current, or are they the same? (c) Which bulb has the greater resistance, or are they the same?

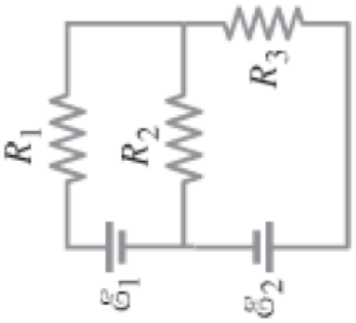


5. If a light bulb has a resistance of 5.5 Ω and is dissipating energy at a rate of 9.0 W, (a) how much current must be flowing through the light bulb? (b) What is the potential

difference across the light bulb?

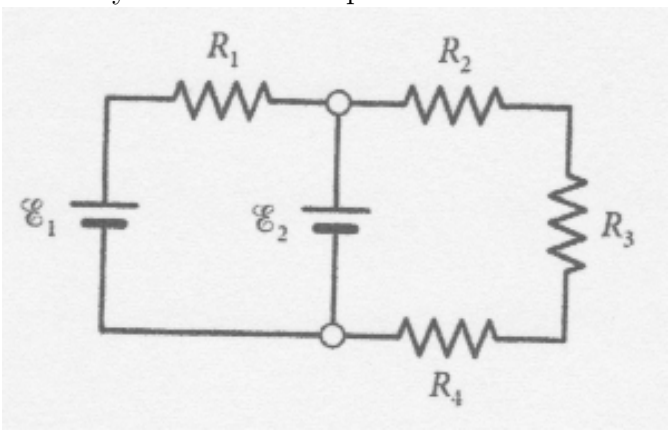
6. The left figure below is constructed from two batteries and seven lightbulbs which are called **A** through **G**. Which bulbs light up?

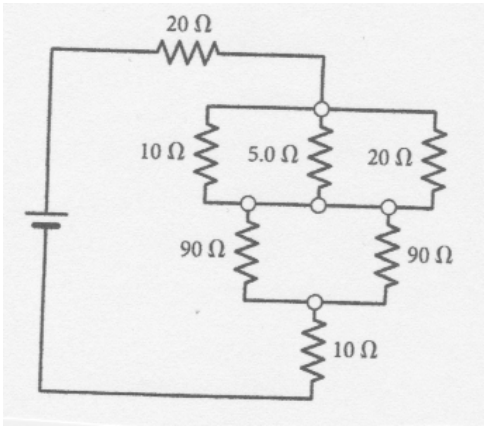




7*. Determine the magnitude and direction of the current in each resistor shown in the right figure above. The batteries' emfs (i.e. their "voltages") are $\mathcal{E}_1 = 9.0$ V and $\mathcal{E}_2 = 12.0$ V. The resistors have values $R_1 = 25\ \Omega$, $R_2 = 18\ \Omega$, and $R_3 = 35\ \Omega$. Be careful with the orientations of the batteries. You should draw your own diagram of the circuit so that you can label the currents.

8. In the left figure below, the first battery emf (i.e. its "voltage") is $\mathcal{E}_1 = 10$ V and the second battery emf is $\mathcal{E}_2 = 5V$. All resistors are 50 Ω. (a) Find the current through and the potential difference across each resistor. (b) What is the power dissipated in each resistor? (c) What is the power supplied by (or perhaps consumed by?) each battery? Don't forget to check that the sum of your answers for part b agrees with the sum of your answers for part c.





9. In the right figure above, the battery voltage is $\mathcal{E} = 10$ V. (a) How much current flows through the battery? (b) How much power is supplied by the battery?

10*. (a) Are the electrical outlets in a house wired in series with one another or in

parallel? What would be the undesirable consequence of doing it the other way? (b) Is a light switch wired in series or in parallel with the lamp that it controls? What would be the undesirable consequence of doing it the other way?

11. A copper wire of length $L = 1$ km and radius $r = 1.2$ mm carries a current of $I = 20$ A. (a) How much power is dissipated in the wire? (Use $\sigma = 6.0 \times 10^7$ A/Vm for the conductivity of copper.) (b) Why do long electrical transmission lines usually operate at very high voltage?

12*. Two light bulbs, $R_1 = 4\ \Omega$ and $R_2 = 6\ \Omega$, respectively, are connected in parallel to a battery with $\mathcal{E} = 8$ V. (a) How much power does each light bulb consume? (b) What is the total power consumption of the circuit? (c) How would the situation change if the two bulbs were in series instead?

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XC1*. Optional/extra-credit. Bulb A produces both light and heat. Bulb B produces twice as much light and heat as bulb A. Bulb C produces three times as much light and heat as bulb A. The three bulbs are connected in series to a 9 V battery, and the steady current through bulb A is 1.0 A. How much energy is dissipated by each bulb in one second?

XC2*. Optional/extra-credit. When you step on the brake pedal in your car, charge carriers flow from the battery to the rear brake lights. Suppose the wire connecting the switch at the pedal to the brake lights is made of copper and has a diameter of 1.0 mm and a length of 3.0 m. If the current through the wire is 2.0 A, how long on average does it take an electron to travel from the switch at the pedal to one of the brake lights? The number density of free electrons in copper is $n = 8.4 \times 10^{28}$ electrons/m^3. (This problem is surprisingly easy, once you consider the definition of electric current. You will be surprised by how slowly the electrons travel.)

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