Physics 100: Homework Solutions #9

Chapter 23 and 24: due Dec 1

1) In class, we said that electrons flow very slowly through a circuit. Why then when you flip the switch on, a distant lamp lights up almost immediately?

How quickly a lamp lights up after an electrical switch is closed does not depend on the drift velocity of the conduction electrons, which is very slow, but rather depends on the speed at which the electric field propagates through the circuit which is about the speed of light.

2) Consider a flashlight connected to a battery. In the following, note that the brightness of a bulb measures power.

a) If you add a second identical flashlight in series, how does the brightness of each bulb compare to if only one was connected?

Brightness is related to power, and power = voltage x current. Two identical flashlights in series each gets half the voltage across it compared to if only one was connected. The current is also halved since the total resistance in the circuit is doubled, and current = voltage/resistance. So the power is one-quarter as much, so the brightness decreases.

b) If instead you added a second identical flashlight in parallel, then how does the brightness of each bulb compare if only one was connected?

In parallel, the voltage across the flashlight remains the same for each bulb, no matter how many are added. The current in each branch is voltage/resistance, so also remains the same. So the power dissipated in each bulb, and the brightness of each bulb are the same as when only one is connected.

c) Will the battery run down faster if the two bulbs are connected in series or in parallel?

The battery will run down faster when the bulbs are in parallel because this draws more power from the battery – more current is drawn out from the battery, as evident in the answers above.

3) Can an electron placed at rest in a magnetic field be set in motion by the magnetic field? What if were placed at rest in an electric field?

An electron at rest in a magnetic field experiences no force, so cannot be set in motion by the magnetic field. If it were placed at rest in an electric field, it will accelerate under the electrostatic force. The electrostatic force depends only on the charge and the field strength, while the magnetic force depends on the charge's velocity as well, and is zero if the velocity is zero, or if the charge moves parallel to the field.

4) Several paperclips dangle from the north pole of a magnet, forming a dangling chain. What is the induced pole in the bottom of the lowest paperclip: is it a north pole or south pole? Explain your answer.

The induced pole in the bottom of the lowest paperclip is a north pole. This is because the north pole of the magnet magnetizes the paperclips: it align the domain in the paper such that a south pole gets induced in the end of the paperclip that is closest to it, and so a north pole at the clip's other end, yielding a net attraction between the magnet and paper clip. The magnetization is then passed on to the next paperclip in the same way….so that the end of the final paperclip is a north pole.

5) Your own clicker question.