Study Guide for Midterm 1 for Algebra-Based Physics-2: Electricity, Magnetism, and Modern Physics (PHYS135B-01)

Dr. Jordan Hanson - Whittier College Dept. of Physics and Astronomy

March 9, 2018

1. **Working with orders magnitude, and approximation.** Use the following information: there are 107 grams per mole of silver, $\approx 6 \times 10^{23}$ atoms per mole, and one conducting electron per silver atom.

   (a) Estimate the number of free electrons in 1 gram of silver.

   5.6×10^{21}

   (b) If 10^{10} conducting electrons are removed every 10^{-10} seconds, how long would it take to remove them all? (Think of this as a current).

   56 seconds

2. **The Coulomb force, and static charge.** The Coulomb force between two charges q_1 and q_2 separated by a distance r is

$$\vec{F}_C = k\frac{q_1 q_1}{r^2}\hat{r} \tag{1}$$

   The vector $\hat{r}$ is a unit vector pointing from one charge toward the other, and $k = 9 \times 10^9$ N C^{-2}m^2. Suppose $q_1 = 4.0\mu$C, and $q_2 = 4.0\mu$C, and $r = 4.0\mu$m.

   (a) What is the magnitude of the force between the charges, and in which direction does the force point?

   9×10^9 N

3. **Drawing electric field lines, 1.** Recall our experience with the PHeT simulation of charges and fields. (a) Create a charge distribution of two opposite charges $\pm q$. (b) Illustrate the correct electric field between the charge distributions by drawing electric field lines.

   Remember: test charges are positive. Electric field lines originate in positive charges and terminate on negative charges. This means that the Coulomb force $F = qE$ on a test charge q will push the positive test charge away from positive charges and pull them towards negative charges.

4. **Electric potential and electric field.** Recall that the relationship between a uniform electric field E and the associated change in voltage V is $V = Ed$, where d is a distance. Two uniformly charged plates with charges $+Q$ and $-Q$ create a uniform electric field E between them. Let the voltage at the negatively charged plate be 0 V.

   (a) If the distance between the plates is 80 mm, and the electric field has a value of 0.8 V/mm, what is the voltage at the positive plate?

   64 V

5. **Capacitors, and capacitance.** Recall that the charge Q stored on a capacitor is CV for a given potential V, and that the unit of capacitance is the *Farad*, F.

   (a) How much charge is stored on a capacitor with $C = 0.1\mu$F, if the voltage is $V = 12$ V?

   $1.2\mu C$

6. **Definition of current, resistance, and Ohm's Law** Recall that *current* is the change in charge per unit time, $I = \Delta Q/\Delta t$, and that the unit of current is the *amp*, A, which is 1 C/s. Also recall that Ohm's Law is $V = IR$, where V is the voltage, I is the current, and R is the total effective resistance.

   (a) How much current flows through a circuit that lights a lightbulb, if the voltage is 24 V, and the lightbulb has a resistance of 100 Ohms?

   240 mA

   (b) Recall that the relationship between the power P consumed by a resistor drawing a current I while being given a voltage V is $P = IV$. How many watts does the light bulb consume?

   5.76 W

   (c) Draw a graph of voltage versus current for the lightbulb in part (a), assuming the voltage can vary.

   Should be a linear plot, since resistance is constant. Resistance is the slope, if the plot is voltage versus current. If the plot is current versus voltage, then the slope is 1/R.

   (d) Suppose the second light bulb is instead connected *in parallel* with the first light bulb. What is the new current?

   The resistance is cut in half so the current must double, according to Ohm's law. Thus, the current is $2 * 240$ mA = 480 mA.

7. **Nerve signals.** Please review the section of Chapter 20 on nerve signal conduction. Pay special attention to the *action impulse*, which is a voltage versus time.

   (See reading)