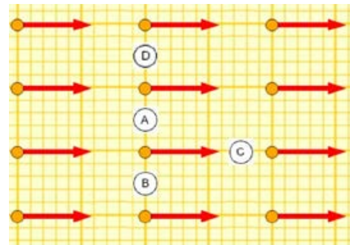
University of Maryland
Department of Physics

Physics 132

Spring 2014 **Sample exam 2 problems** **11 April 2014**

1. (25 points) *For the ranking questions below, use ">" to mean greater than and "=" to mean equal. Do* *__not__* *use "<" signs. Your answer should be a string of letters that looks something like E = F > G > H, meaning E and F are equal and bigger than G, and G is bigger than H. You, of course, should use the letters ABCD and the appropriate ranking.*

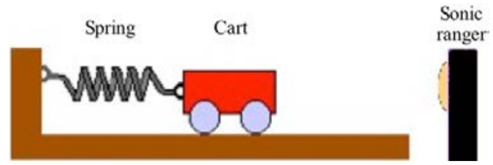
1.1 A negative charge might be placed at one of four spots in a region where there is a uniform electric field as shown by the red arrows. Rank the magnitude of the electrostatic field, *E*, felt by the charge at positions A, B, C, and D. (5 pts)

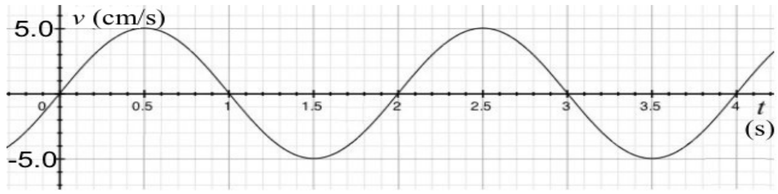


1.2 Rank the values of the electrostatic potential of the negative charge placed at the indicated positions. (5 pts)

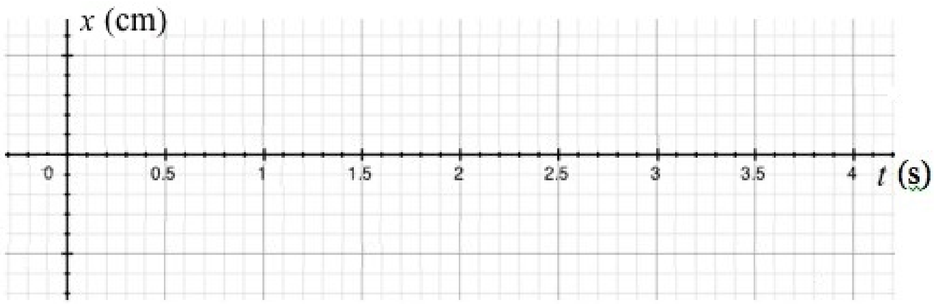
1.3 If the grid spacing on the graph is that 1 large box corresponds to 1 nm, and if the electric field displayed has a value of 10^7 N/C (= 10 milliVolts/nanometer), how much work would it take to move a single OH^- ion from position C to position D? (Show your work briefly at the left and put your answer in the box at the right.) (5 pts)

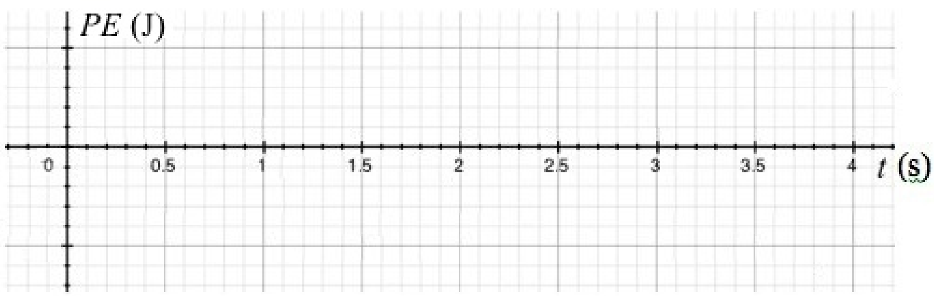
2. A sonic ranger is measuring the position of a wheeled cart connected to a spring as shown in the figure at the right. The cart of mass 200 g is pulled to the right and released. The ranger starts taking data a little bit later. The computer screen shows a graph of the cart's velocity that looks like this.





2.1 On the graphs below, sketch what the position of the cart and the potential energy stored in the spring would look like. (Be qualitative in the vertical plot but careful in the horizontal.)

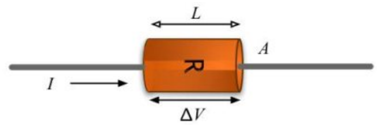




2.2 From the information given, can you tell what the maximum and minimum values of the x oscillation are? If you can, explain how you would calculate it (but don't). If you can't, explain why not.

2.3 From the information given, can you tell what the maximum and minimum values of the PE oscillation are? If you can, explain how you would calculate it (but don't). If you can't, explain why not.

3. A steady current is flowing through a resistor that is made out of an electrically uniform substance. It is well described by Ohm's law. The resistor has the dimensions and electrical measurements as indicated in the figure.



3.1 Suppose that the original resistor is replaced by a resistor of the same length and identical material but twice the cross sectional area. Further suppose that the potential drop across the resistor is the same as for the original. The current through the new resistor will be (5 pts)

(a) The same as for the original resistor.
(b) Twice as big as for the original resistor.
(c) Half as big as for the original resistor.
(d) Some other multiple of the original current.
(e) You can't tell from the information given.

3.2 Suppose that the original resistor is replaced by a resistor of the same cross sectional area and identical material but twice the length. Further suppose that the potential drop across the resistor is the same as for the original. The current through the new resistor will be (5 pts)

(a) The same as for the original resistor.
(b) Twice as big as for the original resistor.
(c) Half as big as for the original resistor.
(d) Some other multiple of the original current.
(e) You can't tell from the information given.

4. Consider the inside and outside of a cell, The outside starts off with a 1 mM (milli-Molar) concentration of NaCl and a 2mM concentration of KCl. The inside of the cell initially has a 10 μM (micro-Molar) concentration of NaCl and a 1 μM concentration of KCl. Now we add Na^+ ion channels to the membrane that let Na^+ freely pass from side to side.

4.1 The Nernst potential can be calculated from the following equation:

$$\Delta V = \frac{k_B T}{q} \ln\left(\frac{c_2}{c_1}\right)$$

a. Calculate the Nernst potential of Na^+.

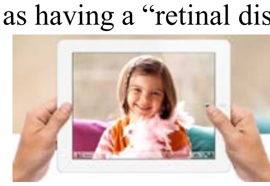
b. Calculate the Nernst potential of Cl^-.

c. Calculate the Nernst potential of K^+.

4.2 Which of the following statements are true about the system after the Na^+ channel is open

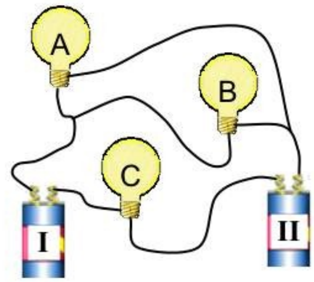
A. Some Cl^- accumulates on the membrane on the side with higher Cl^- concentration
B. Some Cl^- accumulates on the membrane on the side with lower Cl^- concentration
C. No Cl^- accumulates at the membrane
D. Some K^+ accumulates on the membrane on the side with higher K^+ concentration
E. Some K^+ accumulates on the membrane on the side with lower K^+ concentration
F. No K^+ accumulates

5. Apple is advertising its new 3 megapixel display iPad as having a "retinal display", i.e., the screen contains 3 x 10^6 dots that show color and is claimed to have as high a density of display pixels as your retina has detector pixels (cones). Let's see how good this statement is by estimating the number of pixels in your retina. Only consider the cone cells that detect color.



The drawing at the right shows how much of the eye is covered by the retina. The distance between cones on the retina is typically about 2-3 microns (micrometers). Compare the density (number/cm^2) of cones on your retina and on the iPad. Is "retinal display" a reasonable claim for the new iPad? *Be sure to clearly state your assumptions and how you came to the numbers you estimated, since grading on this problem will be mostly based on your reasoning, not on your answer.*

5. In the figure at the right is shown a circuit with two identical batteries and three identical resistors (bulbs). The batteries are shown so that the anode (positive terminal) is on the right of each battery. If one of these batteries were to be directly connected to one of these bulbs, it would light the bulb brightly.



For the following items, select the item that best completes the sentence and enter it in your answer sheet. If more than one answer is correct, give them all. Briefly explain your answers.

5.1 When the set of batteries and bulbs are connected as shown
- A. none of the bulbs will be lit.
- B. only one of the bulbs will be lit.
- C. all of the bulbs will be lit equally brightly.
- D. all of the bulbs will be lit but they will not be equally bright.
- E. you cannot tell which bulbs will be lit from the information given.

5.2. The current through bulb C
- A. equals zero.
- B. is the same as through the other two bulbs.
- C. is greater than through either of the other bulbs.
- D. is less than through either of the other bulbs.
- E. is the same as the current in battery I.
- F. is the same as the current in battery II.
- G. cannot be determined from the information given.

5.3. The potential drop across bulb B
- A. equals zero.
- B. is the same as that across bulb A.
- C. is the same as that across bulb C.
- D. is the same as that across one of the batteries.
- E. is double that across one of the batteries.
- F. cannot be determined from the information given.