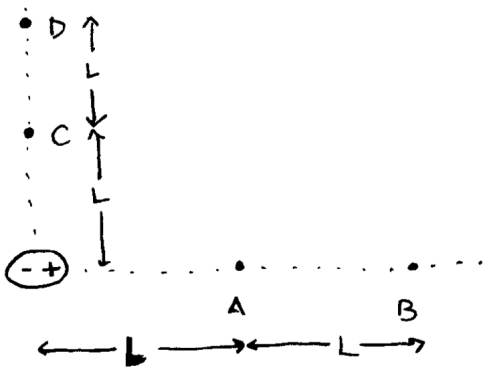
**Physics 4L, Spring 2010— Problem set 6**
**Due Tuesday 16 March in class**
**Self-test problem due Thursday 18 March in class**
**(Thursday lab may turn it in on Friday at my office).**


**Problems and questions from Wolfson:**
Chapter 23: problem 60
Chapter 24: problems 41 (for the ionic solution, you may assume the drift speed for both types of ions is the same), 46, 52
Chapter 25: problems 20 (include a diagram showing the arrangement of resistors as part of your answer), 43, 48

Also complete problem 1 (all parts) on the attached worksheets on capacitors. (You might find it useful to do problem 2 but you don't need to hand it in). For the first part you can just write down the expression for the capacitance of a parallel plate capacitor; you don't need to derive it.

Additional problem:

1. The following problem makes use of the same ideas as the analysis in the electrocardiography lab (potential differences in the field of a dipole), *except* that the points are not located equidistant on either side of the dipole as they were for the electrocardiogram.



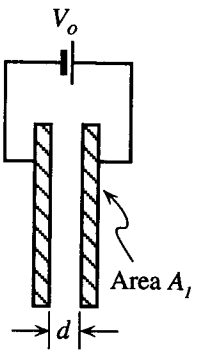

(*a*) Find the potential difference $\Delta V_{AB}$ between points *A* and *B* near a dipole shown to the right, in terms of the dipole moment *p* of the dipole and the distance *L* from the center of the dipole. The dipole is much smaller than *L*.

(*b*) Find $\Delta V_{CD}$ in the same situation as part (*a*).

(*c*) Find numerical values for $\Delta V_{AB}$ and $\Delta V_{CD}$ if the dipole is a water molecule with $p = 6.2 \times 10^{-30}$ C m and the distance *L* is 1 nm.

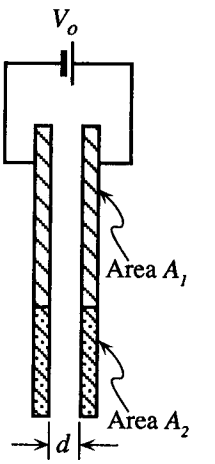
(*d*) Find the change in electric potential energy of a $Ca^{2+}$ ion moving from *A* to *B* using the parameters of part (*c*).

1. Two large flat plates are separated by a distance $d$. The plates are connected to a battery.




   a. The surface area of the face of each plate is $A_1$.

      Write an expression for the capacitance in terms of $A_1$ and $d$.




   b. A new capacitor is formed by attaching two uncharged metal plates, each with area $A_2$, to the capacitor as shown. The battery remains connected.

      i. When the new plates are attached, does the electric potential difference between the plates *increase, decrease,* or *remain the same?* Explain.

      ii. Write an expression for the work done by the electric field on a charge $+q_o$ as it travels from the left plate of the capacitor to the right. Express your answer in terms of the given variables. Explain.

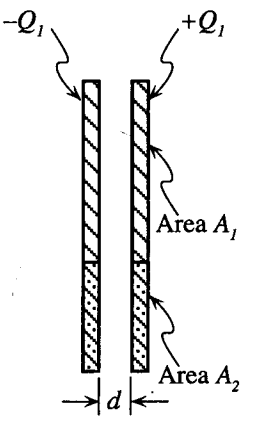
      iii. Write an expression for the magnitude and direction of the electric field between the plates. Is the magnitude of the electric field *greater than, less than,* or *equal to* the magnitude of the electric field between the plates before the new plates were attached?

      iv. Write an expression for the charge density on the plates of the capacitor. Is the charge density *greater than, less than,* or *equal to* the charge density on the plates before the new plates were attached? Explain.

v. Write an expression for the total charge on one of the plates of the capacitor. Is this total charge *greater than, less than,* or *equal to* the total charge on one of the original plates? Explain.

vi. Use the definition of capacitance to find the capacitance of the enlarged pair of plates. Has the capacitance *increased, decreased,* or *remained the same?*

2. Two plates with area $A_1$ are held a distance $d$ apart and have a net charge $+Q_1$ and $-Q_1$, respectively. Assume that all the charge is uniformly distributed on the inner surfaces of the plates.




Two initially uncharged plates of surface area $A_2$ are then attached to the original plates as shown.

a. Find the charge density on the plates. Explain.

b. Find the electric potential difference between the plates. Explain.

c. Show that the capacitance of the enlarged plates in this case is the same as the capacitance you found in problem 1 of this homework.

Self-test problem, PS 6 DUE THURS March 18 Name _____

You may spend up to 30 minutes on this problem. Do your work on this sheet and turn it in separately. Do not work with others or refer to the textbook, though you may consult the equation sheet posted online. Your score on this problem will not be included in your homework grade; it is solely for feedback to you. (However, you *will* receive credit for one homework problem for completing it.)

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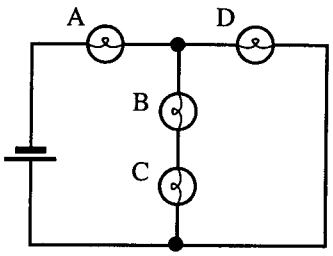
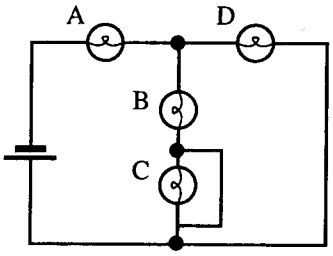
**The circuit shown has four identical light bulbs and an ideal battery.**




**a. Rank the brightness of the bulbs. Explain your reasoning.**

**b. A wire is now added to the circuit as shown.**




**i. Does the brightness of bulb C *increase*, *decrease*, or *remain the same?* Explain your reasoning.**

**ii. Does the brightness of bulb A *increase*, *decrease*, or *remain the same?* Explain.**

*Problem continues on the back.*

iii. Does the current through the battery increase, decrease, or remain the same? Explain briefly.

iv. If the bulbs have a resistance of 100 Ω each and the battery has emf 9 V, find the current in bulb D for the circuit in part (a).