PHYS 122: Eighth Homework Assignment

March 18, 2009

This homework due in Box outside of Rock 207: 5:00 PM Sharp, Monday, March 23, 2009

Announcements:

- **Don't forget: Special Homework #07 is due Wednesday, March 18th, 5 PM. See Document #10 for details!**
- **Third Hour Exam is Friday, April 10, 9:30 AM.** Worth 10% of your grade. Mark your calendar now.
- Students can pick up their Second Hour Exam any time after Monday, March 16th.

Problem 1 starts next page...

Problem 1::

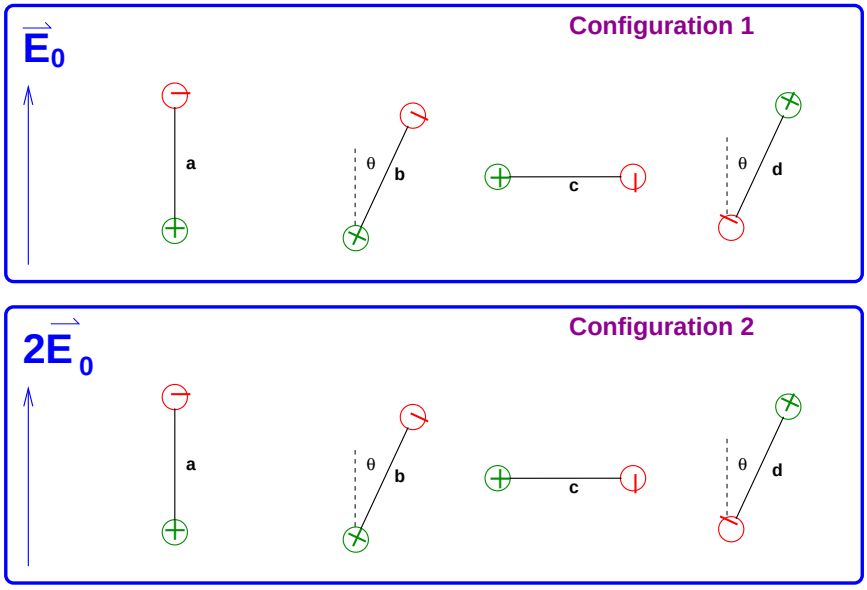
Note that the following problem will be graded for "effort" not content. Students who coherently address the following problem can expect to receive full credit.

The Second Hour Exam (with solutions) will be posted online soon at:

`http://www.phys.cwru.edu/courses/p122/hour_02.pdf`

- Please compare carefully the work that you have done on the exam against the posted solutions. Do this first.
- For each problem where you earned less than 80% of the available points, re-work the assigned problem, and submit this re-work with your homework. For example, if you earned a score of 23 points or less on Problem 1, then take a blank sheet of paper and work Problem 1 on that blank sheet. Do this for each of the three problems.
- Be sure to check your new solution against the posted solution to be sure you have done the problem correctly. If not, correct your work.
- Write a **short** paragraph (200 words or less) addressing the following: if you performance on the exam was less than what you expected, please describe one or two things that could have been done to improve your score. This would include actions that could have been taken by you, or by the course staff. Alternatively, if you did as well or better than you expected, describe one or two things done that were most important for your success. This would include actions that could have been taken by you, or by the course staff. Possible subjects for discussion might include, for example, lectures (your attendance, my presentations), homeworks, practice problems, solution sets, clicker problems, SI sessions, review sheets, crib sheets, etc. Feel free also to compare and contrast your experiences with the First Hour Exam vs. the Second Hour Exam.

Problem 2::

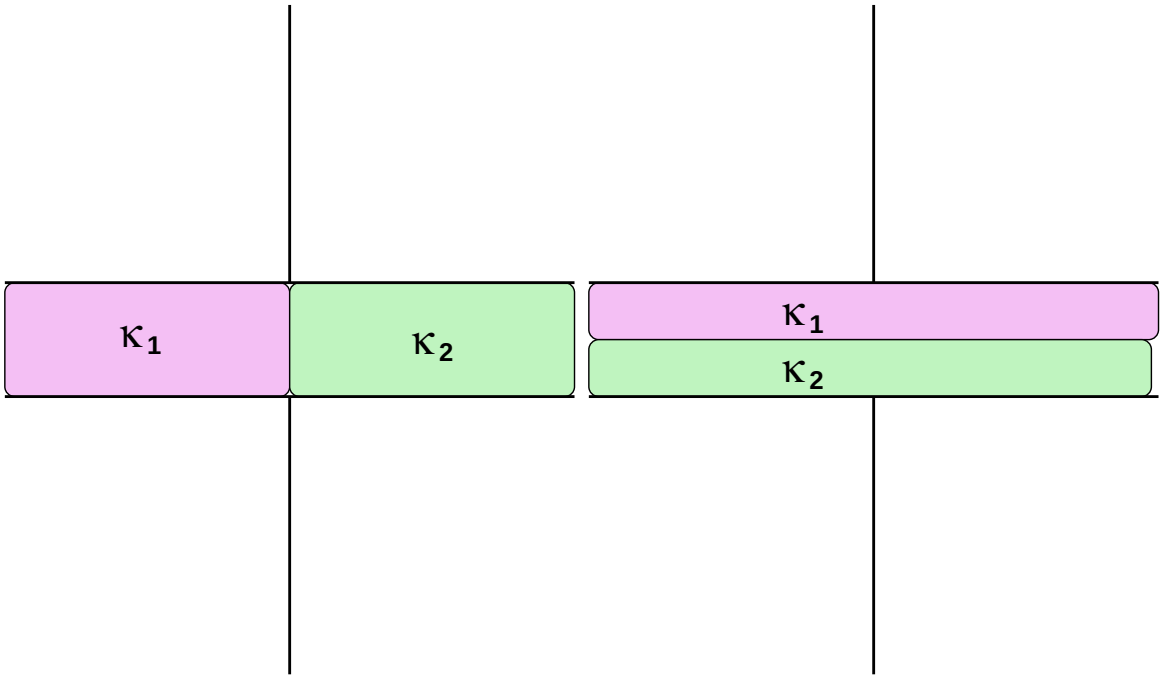


Consider the two configurations of eight dipoles above. Each dipole has two charges $+q_0$ and $-q_0$ separated by a fixed distance D. In Configuration 1, the applied field is E_0. In Configuration 2, the applied field is twice this.

Part (a): Calculate the total potential energy of each configuration in terms of the given parameters. Which of the two configurations has the greatest potential energy? Assume that θ corresponds to an acute angle as shown.

Part (b): Calculate the total net torque applied to all of the dipoles for each configuration. In each case, what is the direction of the net torque vector?

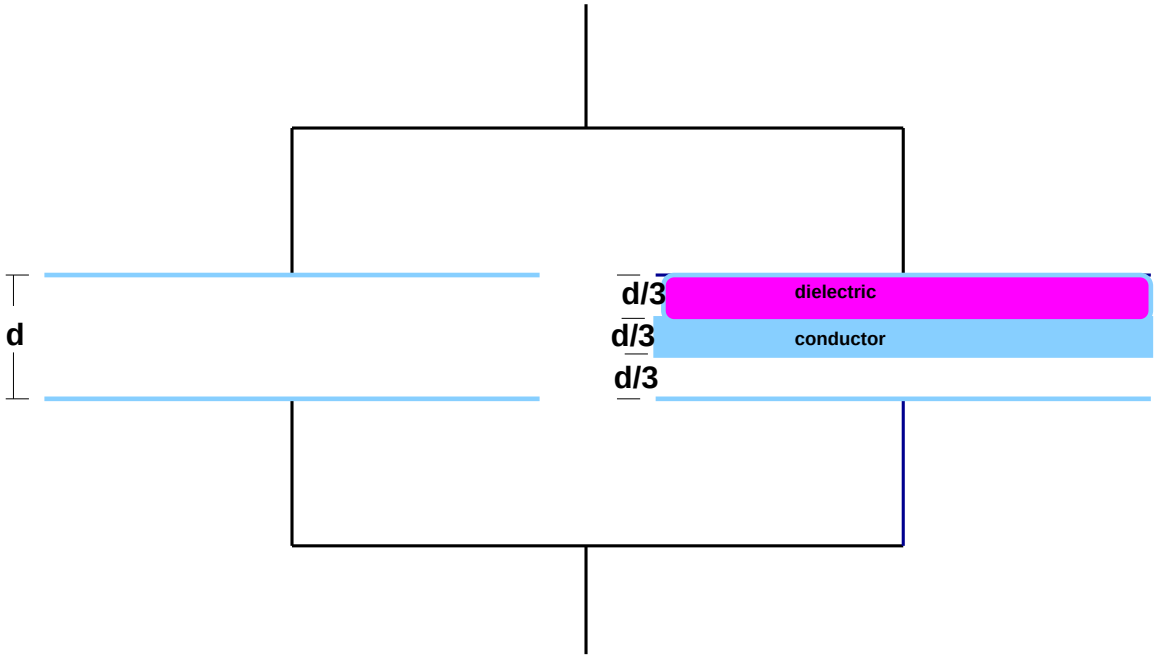
Problem 3::



Suppose we construct two parallel plate capacitors as shown Each capacitor has plate area A and plate separation d. We place two dielectric materials between the plates, with dielectric constants κ_1 and κ_2.

Calculate the capacitance of these two configurations. If $\kappa_1 < \kappa_2$ then which of these two configurations gives the greatest capacitance?

Problem 4.



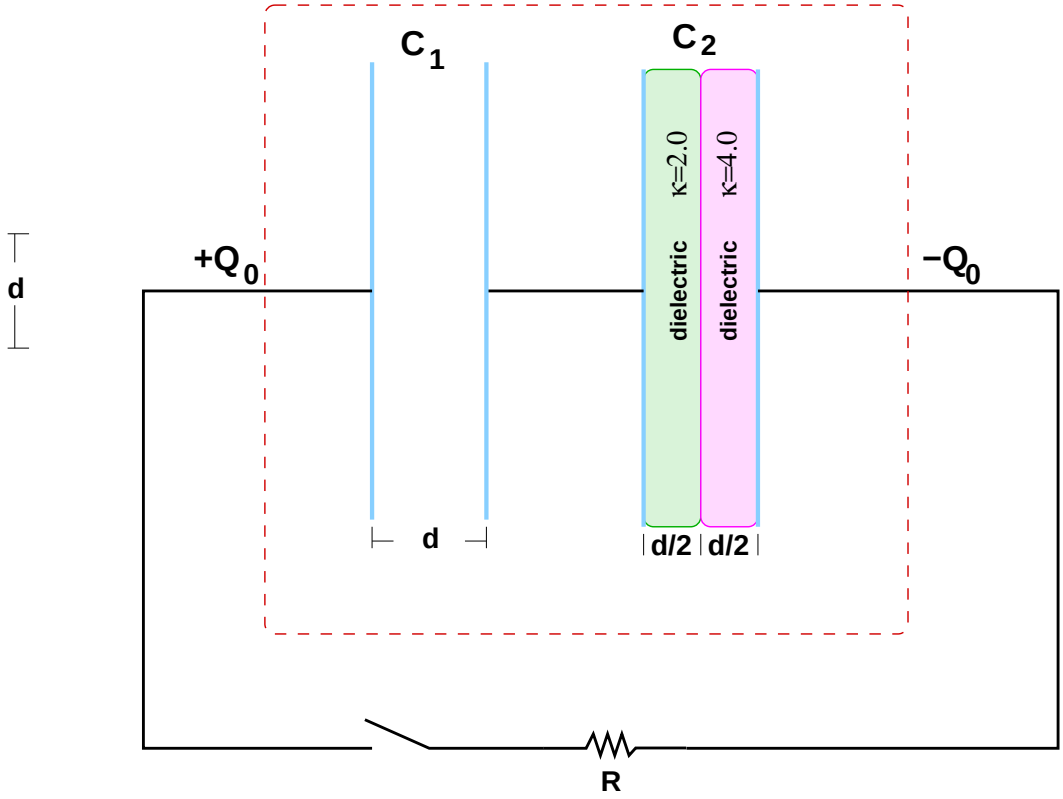
Consider the configuration above. If the dielectric has a value κ and the area of each plate is A, what is the equivalent capacitance of the entire arrangement above?

Problem 5.

Part (a): Suppose we place an uncharged capacitor C in series with a resistor R and a voltage source V_0 and an open switch. If the switch is closed at $t = 0$, write down an expression for the voltage across *each* of these three components (cap, resistor, voltage source) as a function of time. Also write down an expression for the charge on the cap as a function of time. Your expressions should be written in terms of fundamental constants, C, R, and V_0.

Part (b): Suppose now we change the problem so that the instead of starting uncharged, the capacitor we use starts with a given charge of Q_i. Again, if the switch is thrown closed at $t = 0$, write down an expression for the voltage across *each* of these three components (cap, resistor, voltage source) as a function of time and also the charge on the capacitor as a function of time. Hint: Consider what you expect if the voltage source applies a voltage of zero volts (corresponding to a simple conducting wire.)

Problem 6: A funny capacitor



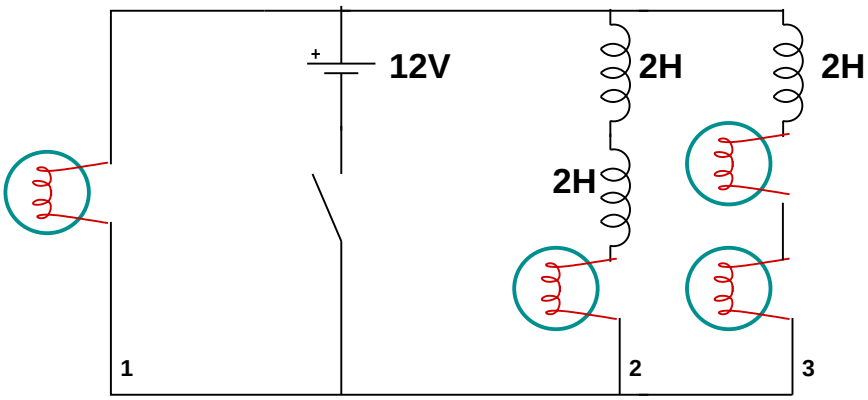
Two capacitors are connected in series as shown above. The left capacitor labeled C_1 is a simple parallel plate capacitor with plate area A and separation d. The right capacitor, labeled C_2 has the same geometry as C_1, however, the gap is filled with two different dielectric materials, one with κ=2.0 and the other with κ=4.0 each filling half the gap as shown above.

a) Consider the combined device which is C_1 and C_2 in series as shown. What is the *equivalent capacitance* C_{eq} of this object? How does this compare to the capacitance of the left capacitor C_1?

b) Suppose we have previously charged up the combined device in such a way that we have a charge of $+Q_0$ on the left terminal and $-Q_0$ on the right terminal. We subsequently install the charged capacitor into the circuit as shown and then we close the switch at time $t = 0$. Write down an expression that gives the current as a function of time $I(t)$ for the resistor in term of fundamental parameters Q_0, A, d and R (and also dielectric constants if relevant).

c) What is the total energy dissipated into the resistor?

Problem 7: A Circuit



A circuit is assembled as above using a 12 volt battery and a set of four identical light-bulbs and three identical inductors ($L = 2.0$ H). At $t = 0$ the switch is closed. You are told that any one of these light bulbs will draw 36 watts of power at 12 volts DC. Assume that you can treat the bulbs as resistors.

Part (a): Calculate the total current through the battery if measured during the instant immediately after the switch is closed.

Part (b): Calculate the total current through the battery if measured several minutes after the switch is closed.

Part (c): Calculate the total current through the switch at precisely $t = 1.0$ second.

Part (d): Explain *qualitatively* in one or two *short* sentences what a person will *see* when the switch is closed. Use language a shoe salesman would understand (no equations!). Be specific as to the relative brightness of the bulbs.