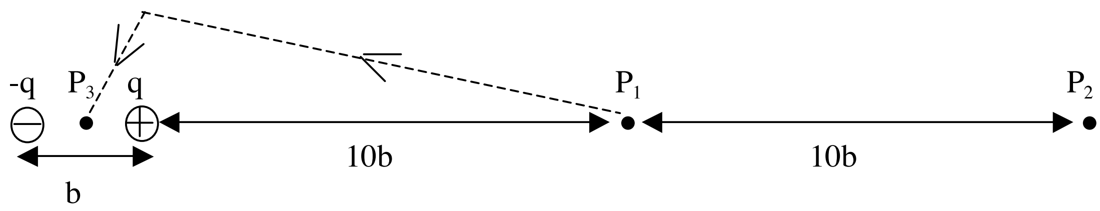
PHYSICS 4C QUIZ 2 (open book) Fall QUARTER 2011
PROF. HIRSCH OCTOBER 21

**Problem 1** (10 pts)



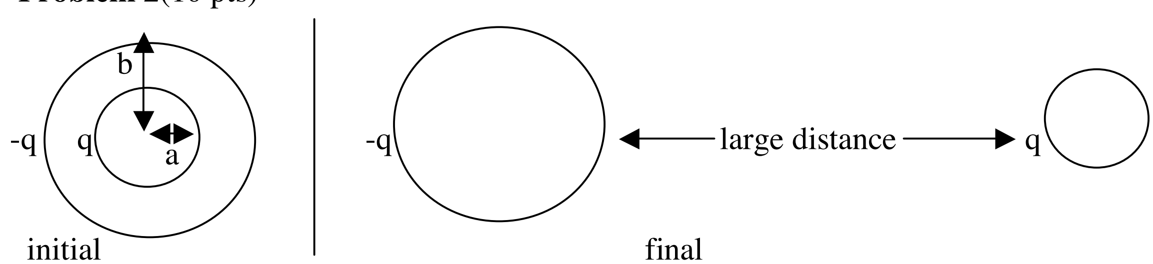

Consider the diagram above. There are two point charges, q and -q, a distance b apart. The point $P_1$ is at distance 10b from the charge q along the line connecting the charges, the point $P_2$ is at distance 10b from point $P_1$ along the same line, and the point $P_3$ is in-between and equidistant from the two charges along the same line. There are no charges at points $P_1$, $P_2$ and $P_3$. For the meaning of the dashed line see part (c). The electric potential at infinity is zero, and at point $P_1$ it is 5V.

(a) Find the value of the electric potential at point $P_2$, in V.

(b) If instead you just wanted to get a rough estimate of the potential at point $P_2$ by approximating the charges by a dipole, what would be the estimate for the potential at $P_2$, in V, given that the potential at $P_1$ is 5V?

(c) Assume a charge of magnitude -3C is moved from point $P_1$ to point $P_3$ along the trajectory shown by the dashed line in the figure. The charges q and -q are kept at the same position. Find the work that you have to do in this process, in J. Is it positive or negative? Explain.

**Problem 2**(10 pts)




A spherical capacitor has shells with inner radius a, outer radius b and charges q and -q respectively. The capacitance is $C = 4\pi\varepsilon_0 \frac{ab}{b-a}$

(a) Give an expression for the energy stored in this capacitor in terms of q, a and b.

(b) Suppose the shells are pulled apart to a large distance of each other as shown in the figure, without changing their charges. Find an expression for how much work has to be done to do this.

(c) Draw a diagram with electric field lines for the initial situation (capacitor) and the final situation (shells far apart), paying attention that the density of field lines is consistent for each case. Find an expression for the difference in energy between the two cases using the expression for the energy $U = \frac{1}{2}\varepsilon_0 \int E^2 dV$ and the diagrams you drew. There is no need to do an integral. Explain why the expression found agrees or doesn't agree with the result found in (b).

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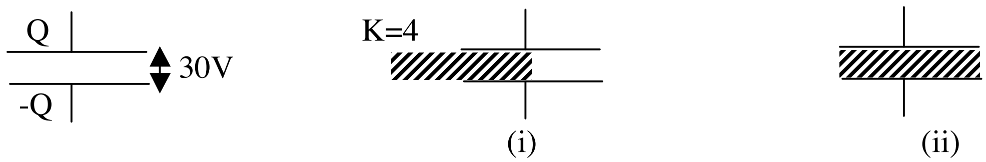
**Problem 3** (10 pts)




A parallel plate capacitor isolated from voltage sources has charge Q and voltage difference 30 V between its plates. A slab of dielectric material of dielectric constant K=4 and thickness equal to the distance between the capacitor plates is inserted (i) half way and (ii) fully between the plates as shown in the figure.
(a) Find the voltage difference (in V) between the plates when the dielectric is fully inserted (case (ii)).
(b) Assume the energy stored in the capacitor initially is 10 J. Find the work done by the person inserting the slab (in J) in the process of fully inserting the dielectric slab. Is it positive or negative? Explain why the sign you obtained is physically correct, or why it is not correct.
(c) Find the voltage difference (in V) between the plates when the dielectric is half way inserted (case (i)).
Hint: consider (i) as two capacitors, each with plates with half the area as the original one, connected in parallel. The part of the slab that is not between the capacitor plates can be ignored.

**Justify all your answers to all problems**