Recitation Session 4

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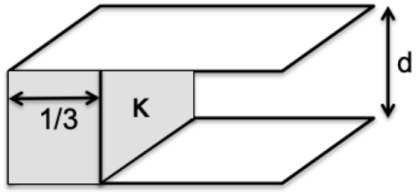
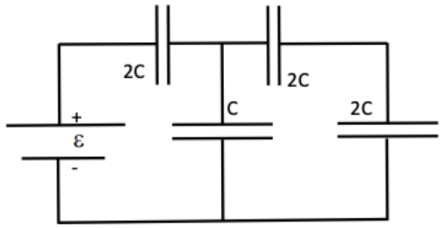
1. Consider a parallel plate capacitor with plated of area A each. The plates are separated by a distance d. A dielectric slab of thickness d and dielectric constant κ is introduced between the plates. The dielectric slab goes only one third of the way into the capacitor as shown. What is the capacitance of capacitor with the dielectric inserted?

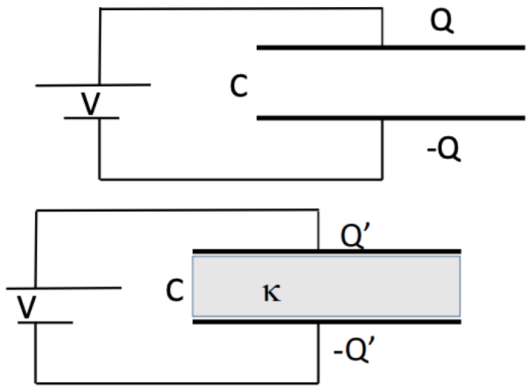


2. The diagram below shows an arrangement of four capacitors connected to a battery of EMF $\mathcal{E}$. The capacitors have their capacitances written next to them in the diagram. C is a positive constant. The questions below are about the capacitors when they are fully charged by the battery (i.e in electrostatic equilibrium). All your answers should be in terms of C and $\mathcal{E}$ as necessary.



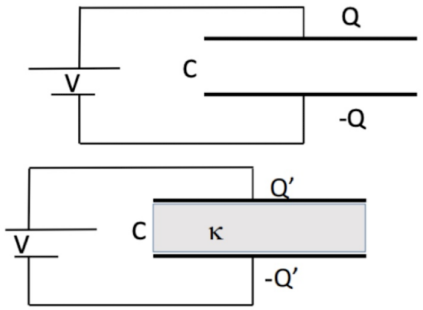
(a) On the diagram above label the plates of each capacitor with a plus or minus sign to indicate the sign of the plate charge.
(b) What is the effective capacitance of the system?
(c) What is the total electrostatic energy stored in the four capacitors?
(d) Find the charge on and potential difference across each of the capacitors.

3. Consider a capacitor of capacitance C which is connected to a battery of potential V_0 as shown below in the first diagram.



(a) Find the charge on the capacitor, the potential difference across the capacitor, and the energy stored in the capacitor when it is fully charged. Express all your answers in terms of C and V_0.

3. Consider a capacitor of capacitance C which is connected to a battery of potential V_0 as shown below in the first diagram.



(b) i. Consider the case when the capacitor is *is fully charged and then disconnected* from the battery. Once the capacitor is disconnected, a dielectric of dielectric constant κ is inserted to fill the space between the capacitor's plates. Compute the charge on the capacitor, the potential difference across the capacitor, and the energy stored in the capacitor. Express all your answers in terms of C, κ and V_0.

ii. Compute the change of energy of the capacitor, ΔU_{cap} and show that the final energy of the capacitor system is *lower* than the initial energy, which shows that the capacitor attracts the dielectric inside it. (Nature favours the lowest energy configuration).

(c) i. Consider the case the dielectric is inserted into the fully charged capacitor *while the capacitor is still connected* to the battery. Compute the charge on the capacitor, the potential difference across the capacitor, and the energy stored in the capacitor. Express all your answers in terms of C, κ and V_0.

ii. Compute the change of energy of the capacitor, ΔU_{cap} and show that the final energy of the capacitor and dielectric system is *higher* than the initial energy. This might suggest that you need to push the dielectric in this case.