Section	Group	Name	Signature
Grade			
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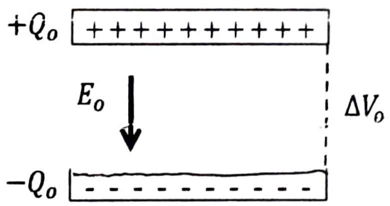
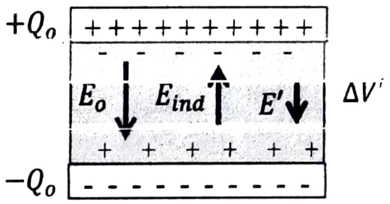
After this activity you should know: • *how a dielectric affects the capacitance, electric field, charge on and voltage difference across a capacitor.* • *Difference between changing a capacitor when it is unhooked from the circuit and when it remains attached directly across an EMF.*

1. A parallel plate capacitor has a charge Q_o and a voltage difference ΔV_o. The gap is air-filled with an electric field E_o.



The capacitor is then disconnected from the circuit so that there is no path for the electrons to move from one plate to another. An insulator of dielectric constant $\kappa > 1$ is then inserted to fill the entire gap.

The electric field in the gap will cause the charges in the dielectric to separate slightly. This leaves an excess layer of negative charges on the top of the insulator and an excess layer of positive charges at the bottom surface of the insulator. This induced surface charge creates an induced electric field opposite the direction of the original electric field.



a. The new net electric field is $\vec{E}' = \vec{E}_o + \vec{E}_{induced}$. Which is true of E', the magnitude of the new net field? Choose one.

- $E' = \kappa E_o$ (since $\kappa > 1$, this implies the net electric field is larger than the original electric field).
- $E' = E_o$ (the net electric field is the same as the original electric field)
- $E' = E_o/\kappa$ (the net electric field is smaller than the original field.)

b. Which is true of the new voltage difference $\Delta V'$ across the plates?

- $\Delta V' = \kappa \Delta V_o$
- $\Delta V' = \Delta V_o$
- $\Delta V' = \Delta V_o/\kappa$

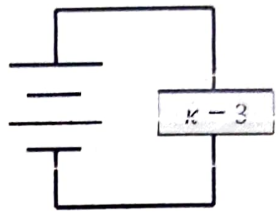
c. Since the capacitor has been disconnected from the rest of the circuit, the charge cannot change: $Q' = Q_o$. What is the true of the capacitance C' of the dielectric filled capacitor compared to C_o, the original capacitance?

- $C' = \kappa C_o$
- $C' = C_o$
- $C' = C_o/\kappa$

2. In order to make a parallel plate capacitor with the largest capacitance, one should use

- ~~Small plates with~~ a narrow air-filled gap.
- ~~Small plates with~~ a wide air-filled gap.
- Large plates with a narrow ~~air-filled~~ gap.
- Large plates with a wi~~de air-filled gap~~.
- ~~Small plates with~~ a narrow paper filled gap.
- ~~Small plates with~~ a wide paper filled gap.
- Large plates with a narrow paper filled gap.
- Large plates with a ~~wide~~ paper filled gap.

3. Consider the case where the capacitor remains connected to the EMF while the dielectric is inserted. Note that the result that $C' = \kappa C_{vac}$ is true in general.



A parallel plate capacitor with an air filled gap is connected to an EMF and charged to Q_o and voltage difference ΔV_o. With the EMF still connected, a ceramic with $\kappa = 3$ is placed into the gap.

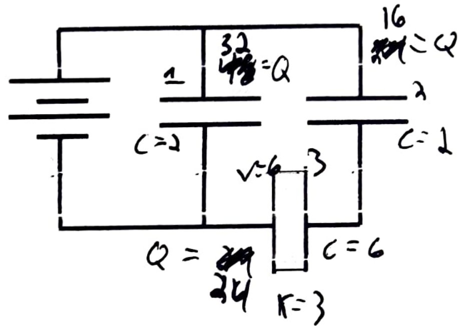
a. What is true of the voltage difference $\Delta V'$ after the dielectric is inserted?

- $\Delta V' = 3\Delta V_o$
- $\Delta V' = \Delta V_o$
- $\Delta V' = \Delta V_o/3$

b. What is true of the charge on the capacitor Q' after the dielectric is inserted?

- $Q' = 3Q$
- $Q' = Q$
- $Q' = Q_o/3$

4. Three capacitors are connected to an EMF as shown. The capacitors are identical except that the first two have air-filled caps and the last capacitor has a ceramic with $\kappa = 3$ entirely filling the gap. The capacitance of the ceramic filled capacitor is 6 μF and the voltage across that capacitor is 4 Volts.



a. Determine equivalent capacitance of the circuit.

$$C_{123} = \left(\frac{1}{6} + \frac{1}{2}\right)^{-1} + 2$$

$$= 3\tfrac{1}{2}\ \mu F$$

b. Determine the EMF.

$\mathcal{E} = \frac{E}{Q}$ $\quad E = \frac{1}{2}QV$ $\quad \mathcal{E} = \frac{1}{2}V^2C$

$V_3 = 4\cdot 3 = 12$

$V_1 = V_3 + V_2 = 16$

$\mathcal{E} = 16$

$\frac{1}{2}(16\cdot 6 + 144\cdot 2 + 144\cdot 2)$

=

c. Determine the total energy stored in the circuit. *Hint: there is an easier and harder way to do this!*

$E = \frac{1}{2} C V^2 =$

$Q = 2\cdot 16 + 6\cdot 4$ (32, 24)

$= 58$

=

$\frac{1}{2}(10)$