What is the equivalent capacitance, $C_{eq}$, of the combination below?

1) $C_{eq} = \frac{3}{2}C$
2) $C_{eq} = \frac{2}{3}C$
3) $C_{eq} = 3C$
4) $C_{eq} = \frac{1}{3}C$
5) $C_{eq} = \frac{1}{2}C$
How does the voltage $V_1$ across the first capacitor ($C_1$) compare to the voltage $V_2$ across the second capacitor ($C_2$)?

1) $V_1 = V_2$
2) $V_1 > V_2$
3) $V_1 < V_2$
4) all voltages are zero
How does the charge $Q_1$ on the first capacitor ($C_1$) compare to the charge $Q_2$ on the second capacitor ($C_2$)?

1) $Q_1 = Q_2$
2) $Q_1 > Q_2$
3) $Q_1 < Q_2$
4) all charges are zero
A charged capacitor stores electric energy; the energy stored is equal to the work done to charge the capacitor:

\[ dW = \Delta V \, dq \]

We can consider the energy stored in a capacitor as being stored in the electric field created between the plates as the capacitor is charged.

\[ U = \frac{1}{2} \frac{Q^2}{C} \]
A parallel-plate capacitor carries charge \( Q \) and is then disconnected from a battery. The two plates are initially separated by a distance \( d \). Suppose the plates are pulled apart until the separation is \( 2d \). How has the charge on the plates of this capacitor changed?

a) The charge is doubled.
b) It remains constant.
c) The charge is halved.
d) Increasing the plate separation has no effect on the charge.
e) Need more information.
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The plates of a parallel-plate capacitor have area $A = 0.100 \text{m}^2$, separation $x = 1.00 \text{mm}$, and are connected to a battery with voltage $V = 1.20 \times 10^2 \text{V}$.

After the capacitor is fully charged the plated are disconnected, then pulled apart to a separation of 3.00mm.

What is the magnitude of the charge (in nC) on each the capacitor plates before is pulled apart?
The plates of a parallel-plate capacitor have area \( A = 0.100 \text{m}^2 \), separation \( x = 1.00 \text{mm} \), and are connected to a battery with voltage \( V = 1.20 \times 10^2 \text{V} \).

After the capacitor is fully charged the plated are disconnected, then pulled apart to a separation of 3.00mm.

How much work is done (in \( \mu\text{J} \)) to increase the plate separation?
The energy density, defined as the energy per unit volume, is the same \textit{no matter} the origin of the electric field:

\[ u = \text{energy density} = \frac{1}{2} \varepsilon_0 E^2. \]

The sudden discharge of electric energy can be harmful or fatal. Capacitors can retain their charge indefinitely even when disconnected from a voltage source.
Dielectrics

A dielectric is an insulator, and is characterized by a dielectric constant $K$.

Capacitance of a parallel-plate capacitor filled with dielectric:

$$C = K \epsilon_0 \frac{A}{d}.$$  

[parallel-plate capacitor]

Using the dielectric constant, we define the permittivity:

$$\epsilon = K \epsilon_0.$$
Here are two experiments where we insert and remove a dielectric from a capacitor. In the first, the capacitor is connected to a battery, so the voltage remains constant. The capacitance increases, and therefore the charge on the plates increases as well.

\[ C_0 = \frac{Q_0}{V_0} \]

(a) Voltage constant

\[ C = \frac{Q}{V_0} = KC_0 \]
In this second experiment, we charge a capacitor, disconnect it, and then insert the dielectric. In this case, the charge remains constant.

\[ V_0, \quad C_0 = \frac{Q_0}{V_0} \]

\[ \begin{align*}
+Q_0 & \quad -Q_0 \\
\text{no dielectric} & \quad \text{battery disconnected} \\
C & = \frac{Q_0}{V_0} \\
& \quad \text{dielectric inserted}
\end{align*} \]

a) All quantities remain the same
b) \( Q \) remains constant but the potential across the plates increases
c) \( Q \) remains constant but the potential across the plates decreases
d) \( Q \) remains constant and the potential across remains constant.
The molecules in a dielectric, when in an external electric field, tend to become oriented in a way that reduces the external field.