Lecture # 13

Capacitors
The definition of capacitance is:
Battery transfers charge and establishes potential difference between plates.
between metal sheets.

Thin insulating sheet is sandwiched

aluminum

plastic

aluminum
To provide large capacitance in a small volume, sheets of large area are rolled up.
...and terminals attached to plates represent connecting wires.

Parallel lines represent plates of capacitor...
Connected in parallel is the same.

...and another at the two bottom plates, so voltage across capacitors...
For any number of capacitors connected in parallel, the net capacitance $C$ is the sum $C = C_1 + C_2 + C_3 + \ldots$.
Find equivalent capacitance $C_{eq}$
For capacitors connected in series, the inverse of the net capacitance is the sum of the inverses of individual capacitances,

\[
\frac{1}{C_{\text{net}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_n}
\]
\[ C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} \]

\[ 4.0 \text{ pF} = C_3 \]

\[ 4.0 \text{ pF} = C \]

\[ 6.0 \text{ pF} = C_1 \]

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To determine the net capacitance of a group of capacitors...
\[ C = C_0 \]

"Charges on plates will respond to force..."

"Charges in dielectric..."

"Capacitor plates..."

"When a dielectric is placed between charged..."
\[ \vec{E} = \frac{\vec{X}}{\vec{E}_0} \]

Dipoles Align Along Electric Field
that from parallel plates alone.

Resisting in a field inside the dielectric that is smaller than parallel plates.

Electric field of induced charge layer opposes this field from parallel plates.

\[ C = \frac{K}{\varepsilon_0} \]
\[ W = \frac{1}{2} \frac{Q^2}{C} = \frac{1}{2} CV^2 = \frac{1}{2} QV \]

\[ V = \frac{Q}{C} \]

\[ Q = CV \]

\[ \frac{Q}{\varepsilon_0 A} = E \]

\[ Q = \varepsilon_0 A E \]

\[ V = Ed \]

\[ \frac{1}{2} QV = \frac{1}{2} \frac{Q^2}{C} \]

\[ \frac{1}{2} CV^2 \]

\[ \frac{1}{2} QV = \varepsilon_0 \frac{E^2}{2} A d \]

\[ W = \varepsilon_0 \frac{E^2}{2} Vd \]

**Energy Density**

\[ = \frac{\text{Energy}}{\text{Volume}} = \frac{\varepsilon_0 E^2}{2} \]