Dielectrics

- insert an insulator between plates
- increases capacitance
- allows for more charge to be stored at a given charging voltage
- weakens E-fields

Constant Charge Q

- no battery connected
- $Q = C \uparrow V \downarrow$, V decreases
- $U = \frac{1}{2}\frac{Q^2}{C\uparrow}$, U decreases
- $u = \frac{1}{2}\varepsilon_0 (E\downarrow)^2$, u decreases

Constant Voltage V

- inserted when batter still connected
- $C \uparrow = \frac{Q\uparrow}{V}$, Q increases
- $U = \frac{1}{2}C \uparrow V^2$, U increases
- $u = \frac{1}{2}\varepsilon_0 (E\downarrow)^2$, u decreases

κ = dielectric constant, a measure of how well an insulator reduces V

$$\kappa = \frac{V_0}{V}$$

$\kappa \geq 1$

Different materials have different κ values

$\vec{E}_d = \text{displacement field}$

$\vec{E}_{\text{total}} = \vec{E}_0 - \vec{E}_d$

$$\sigma_d = \sigma\left(\frac{k-1}{k}\right)$$

$\varepsilon = \text{permittivity of the dielectric}$

$\varepsilon = \kappa\varepsilon_0$

$C = \kappa C_0$

$$E = \frac{E_0}{\kappa}$$

$$C = \kappa\varepsilon_0\frac{A}{d}$$

$V_{\max} = E_{\max} d$

Dielectric Strength

- maximum $\vec{E}$-field that a dielectric can tolerate before breaking down
- Dry air: $E_{\max}$ = 3.0×10^6 V/m

Energy Density

u = energy density = $\frac{U}{\text{volume between plates}}$

$$u = \frac{1}{2}\varepsilon_0 E^2$$