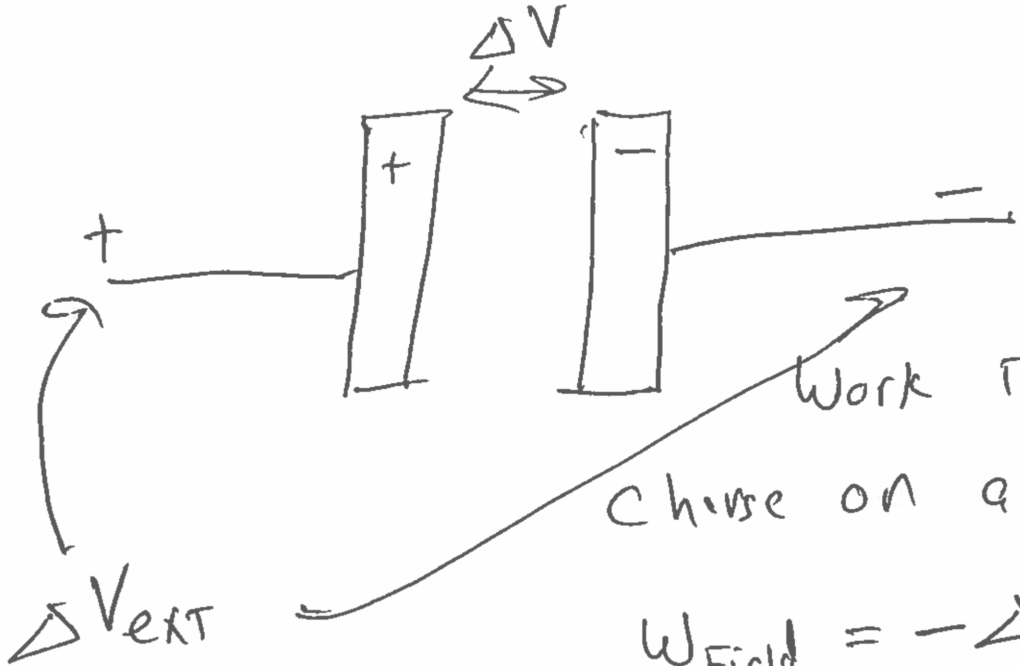


Work to put a charge on a plate

$$W_{Field} = -\Delta U$$

$$W_{ext} = +\Delta U = Q\Delta V$$

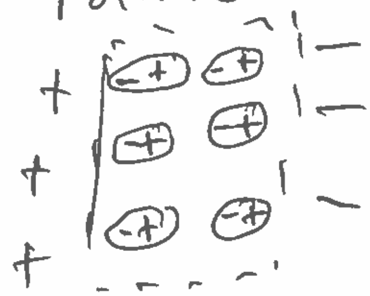
When no charge on plates $\Delta V = 0$

Therefore work to put 1st charge = 0

As charges build on plates ΔV_{cap} increases

Charges stop going when $\Delta V_{cap} = \Delta V_{ext}$

A Dielectric is a material which can be polarized.



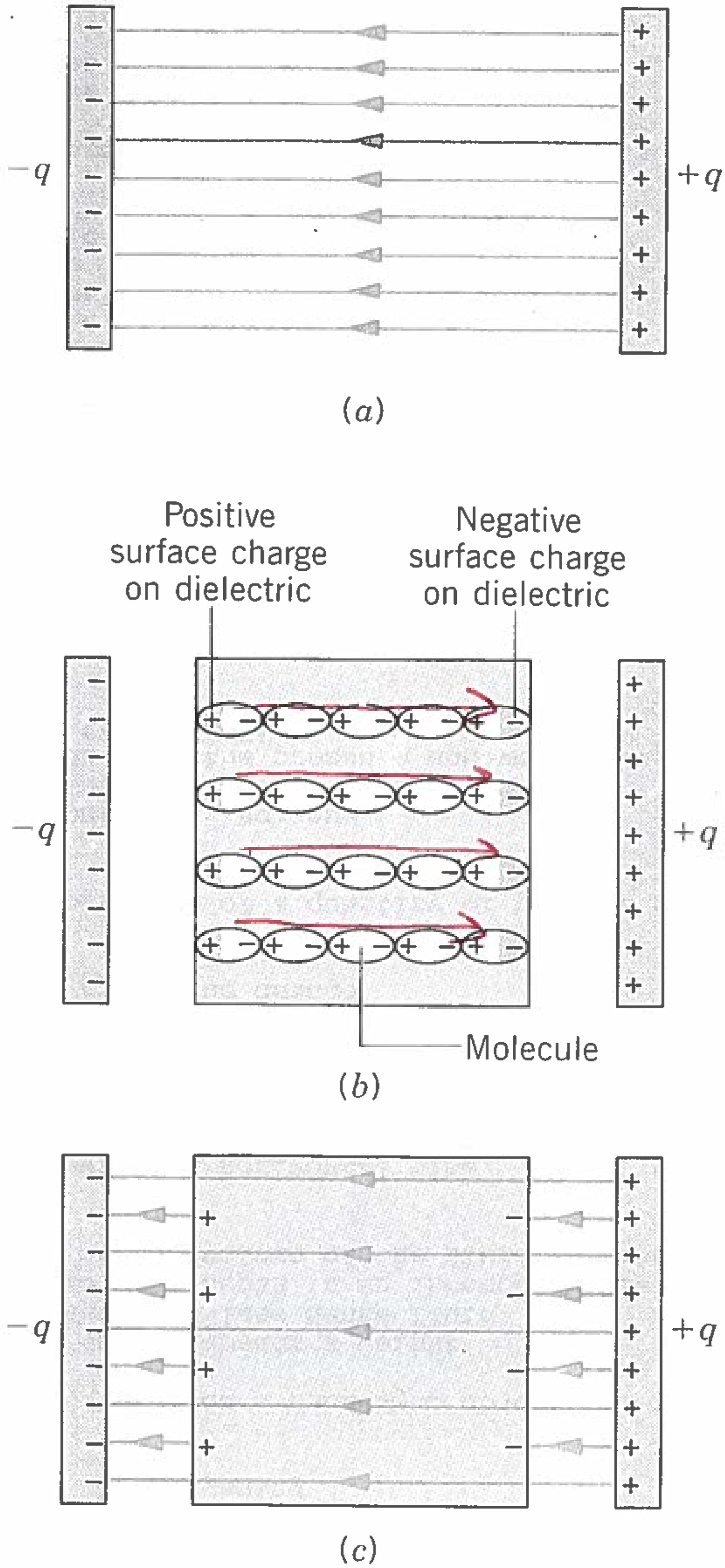


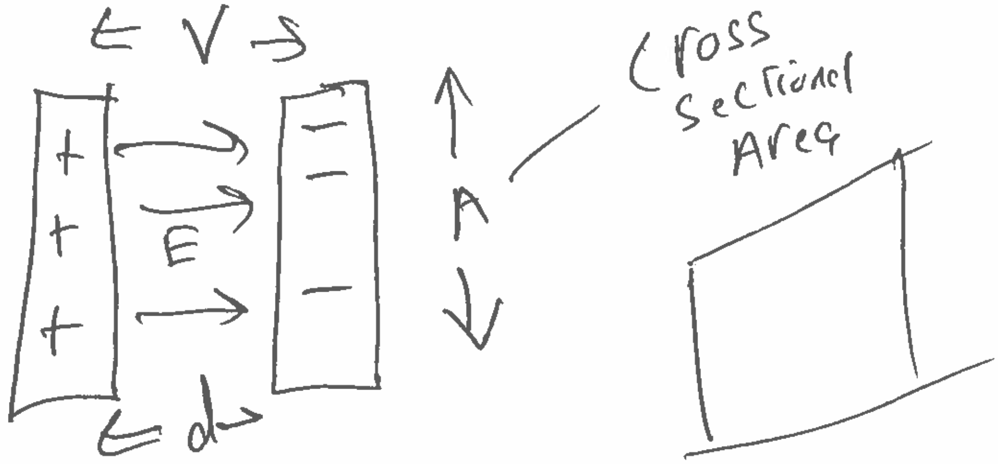
FIGURE 19.15 a, b, c

Kappa

κ - dielectric constant

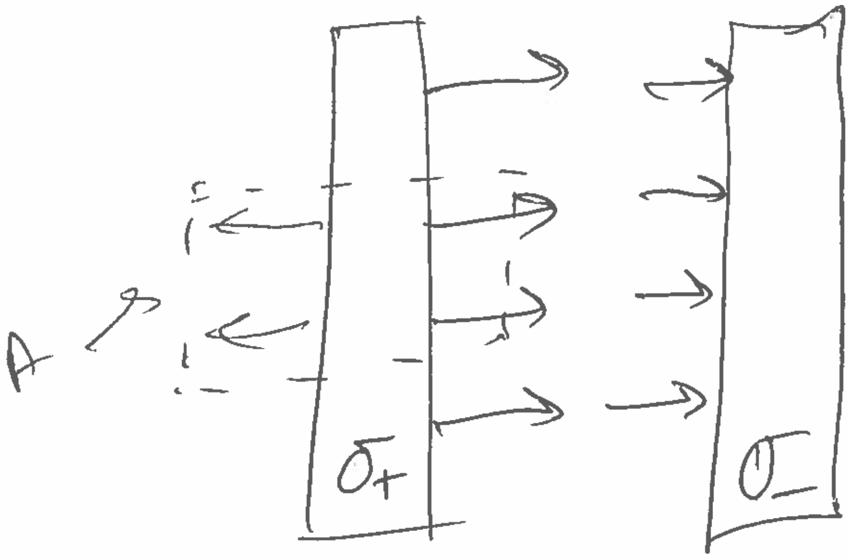
$$\kappa = \frac{E_{out}}{E_{in}}$$

κ	Substance
1	Vacuum
1.00054	air
2.1	Teflon
3.3	Paper
80.4	water



$$E = \frac{V}{d}$$

Large Area of Charge $\sigma = \frac{Q_{tot}}{A_{tot}}$



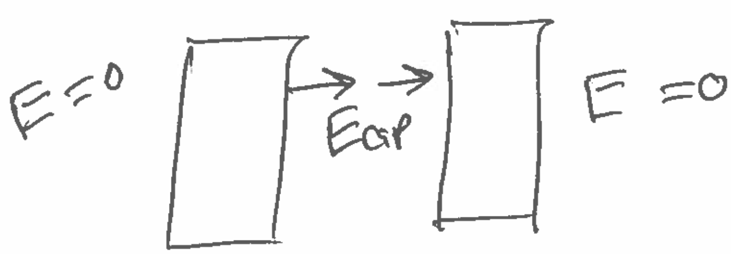
$$\Phi_+ = E_+ A = \frac{Q_{enc}}{\varepsilon_0}$$

$$2E_+ A = \frac{Q}{\varepsilon_0}$$

$$E_+ = \frac{Q}{2\varepsilon_0 A} = \frac{\sigma}{2\varepsilon_0}$$

$$\Phi_- = E_- A \Rightarrow 2E_- A = \frac{Q}{\varepsilon_0}$$

$$E_- = \frac{Q}{2\varepsilon_0 A} = \frac{\sigma}{2\varepsilon_0}$$



$$E_{cap} = E_+ + E_-$$

$$= \frac{Q}{2\varepsilon_0 A} + \frac{Q}{2\varepsilon_0 A}$$

$$\boxed{E_{cap} = \frac{Q}{\varepsilon_0 A}}$$

$$E_{cap} = \frac{V_{cap}}{d} = \frac{Q}{\varepsilon_0 A}$$

$$\boxed{Q = \frac{\varepsilon_0 A}{d} V}$$

$$Q_{cap} = C\, V_{source}$$

C = capacitance — material parameter that indicates how much charge is stored per voltage

$$\boxed{C_{parallel\ plate} = \frac{\varepsilon_0 A}{d}}$$

Capacitance depends on geometry: size of conductors, spacing of conductors, and what fills in between.

Add a dielectric

$$K = \frac{E_0}{E_i} \qquad E_i = \frac{E_0}{K} \qquad E_0 = \frac{Q}{\varepsilon_0 A}$$

$$E_i = \frac{Q}{K \varepsilon_0 A}$$

$$E_i = \frac{V}{d}$$

$$\frac{Q}{K\varepsilon_0 A} = \frac{V}{d}$$

$$Q = \frac{K\varepsilon_0 A}{d} V$$

$$Q_{diel} = \frac{\varepsilon A}{d} V \qquad C_{diel} = \frac{\varepsilon A}{d}$$

$\varepsilon = K\varepsilon_0$ — Permittivity of the material

ε_0 - Permittivity of free space (Vacuum)
is measure of how easily an electric field propagates in free space

ε Permittivity of a medium is the measure of how easily an electric field propagates in the medium

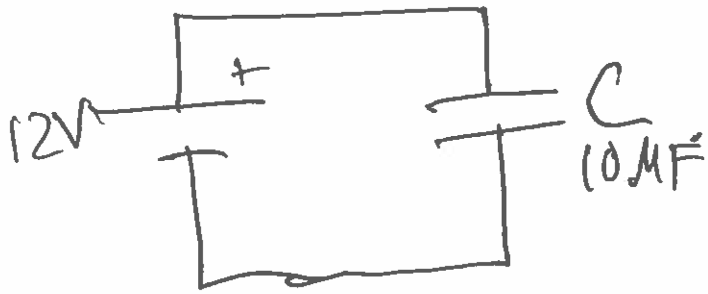
$$\boxed{\varepsilon = K\varepsilon_0}$$

c speed of light

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

$$v_{med} = \frac{1}{\sqrt{\varepsilon \mu}}$$

A 10 μF capacitor hooked up to 12 V battery



$Q_{final} = ?$

$Q = CV = (10\,\mu F)(12\,V)$

$Q = 120\,\mu C$

$1\,C = (1\,F)(V)$

$1\,C\ (1\,F)(1\,\frac{J}{C})$

$1\,F = 1\,\frac{C^2}{J} = 1\,\frac{C^2 s^2}{kg\,m^2}$

Now insert a dielectric slab with $K = 6.0$. Leave battery attached.

$Q \to ?$ $\quad C_K = K C_0 \Rightarrow 60\,\mu F$

$Q = (60\,\mu F)(12\,V) = 720\,\mu C$

Start with $10\,\mu F$ capacitor
charged to $12V \Rightarrow 120\,\mu C$ of charge

Disconnect battery, then insert
$K = 6.0$ material

$Q = ?$ $\quad 120\,\mu C$

$$Q = CV \Rightarrow V = \frac{Q}{C}$$

$$V_K = \frac{Q}{C_K} = \frac{Q}{K C_0} = \frac{120\,\mu C}{(6.0)(10\,\mu F)}$$

$$\boxed{V_K = 2.0V}$$