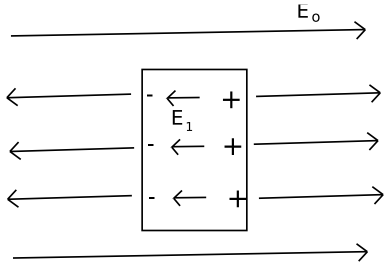
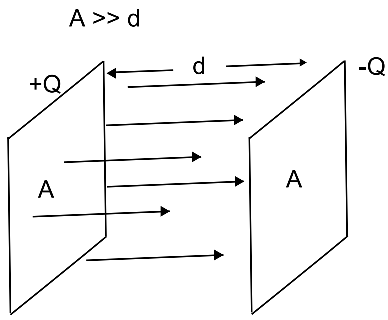
8.022 Lecture Notes Class 12 - 09/27/2006



$$\vec{E_1} + \vec{E_0} = \vec{0}$$



$$E = 2 \cdot \frac{\sigma}{2\epsilon_0} = \frac{\sigma}{\epsilon_0}$$

$$\vec{E_1} = \frac{\sigma}{2\epsilon_0}\vec{n}$$

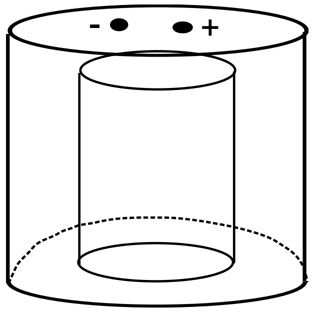
$$\Delta V = \int E \cdot dl = \frac{\sigma}{\epsilon_0} \cdot d$$

$$\Delta V = \frac{Qd}{A\epsilon_0} \qquad C = \frac{A\epsilon_0}{d} \text{ capacitance}$$

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

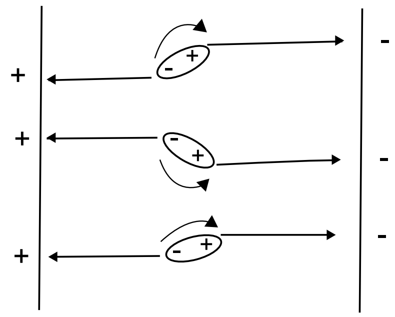
Want bigger C?

- decrease d (but if get too close, charge can jump across air)
- increase A (too big? curl it up its a cylinder)



Dielectrics

- Insulators with polar molecules!
- Can store energy in rotation of polar molecules
- Electric field lines also shorter, more energy!



Work

$$\begin{aligned}
W = & \int_a^b \vec{F} \cdot d\vec{l} \quad \vec{F} = -Q\vec{E} \\
W = & -\int_a^b Q\vec{E} \cdot d\vec{l} \\
= & -Q\int_a^b \vec{E} \cdot d\vec{l} \\
= & Q \cdot V|_a^b \\
= & Q[V(b) - V(a)] \\
W = & \tfrac{1}{4\pi\epsilon_0}\Sigma_{i=2}^{N}\Sigma_{j=1}\tfrac{Q_iQ_j}{d_{ij}} \\
= & \tfrac{1}{2} \cdot \tfrac{1}{4\pi\epsilon_0}\Sigma_{i=1}^{N}\Sigma_{j=1}^{N}\tfrac{Q_iQ_j}{d_{ij}}\delta_{ij} \\
= & \tfrac{1}{8\pi\epsilon_0}\Sigma_{i=1}^{N}Q_i(\Sigma_{j=1}^{N}\tfrac{Q_j\delta ij}{d_{ij}})
\end{aligned}$$

$$W = \frac{1}{2}\Sigma_{i=1}^{N}Q_iV(\vec{r_i}) \qquad (1)$$

$$W = \frac{1}{2}\int \rho \cdot V \cdot d\tau$$

$$
\begin{aligned}
\frac{\rho}{\epsilon_0} &= \vec{\nabla} \cdot \vec{E} \\
\rho &= \epsilon_0 \cdot (\vec{\nabla} \cdot \vec{E}) \\
W &= \tfrac{\epsilon_0}{2} \int \vec{\nabla} \cdot \vec{E} V d\tau \\
&= \tfrac{\epsilon_0}{2} (- \textstyle\int_V E \cdot \nabla V d\tau + \oint_S V \vec{E} \cdot d\vec{a}) \\
&= \tfrac{\epsilon_0}{2} [\textstyle\int_V E^2 d\tau + \oint_S V \vec{E} \cdot d\vec{a}] \\
W &= \tfrac{\epsilon_0}{2} \cdot \textstyle\int_V E^2 d\tau \qquad (2)
\end{aligned}
$$

So why does (1) not equal (2)? (Think for just one charge)