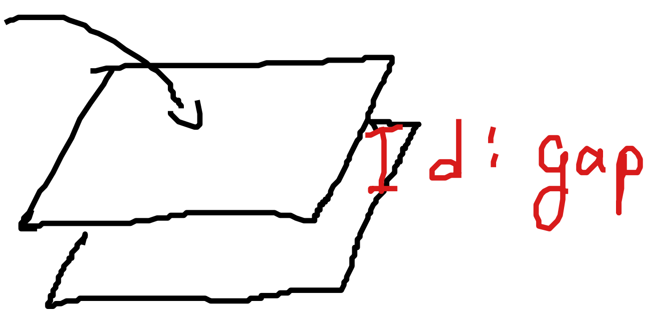
Parallel - Plate capacitor

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

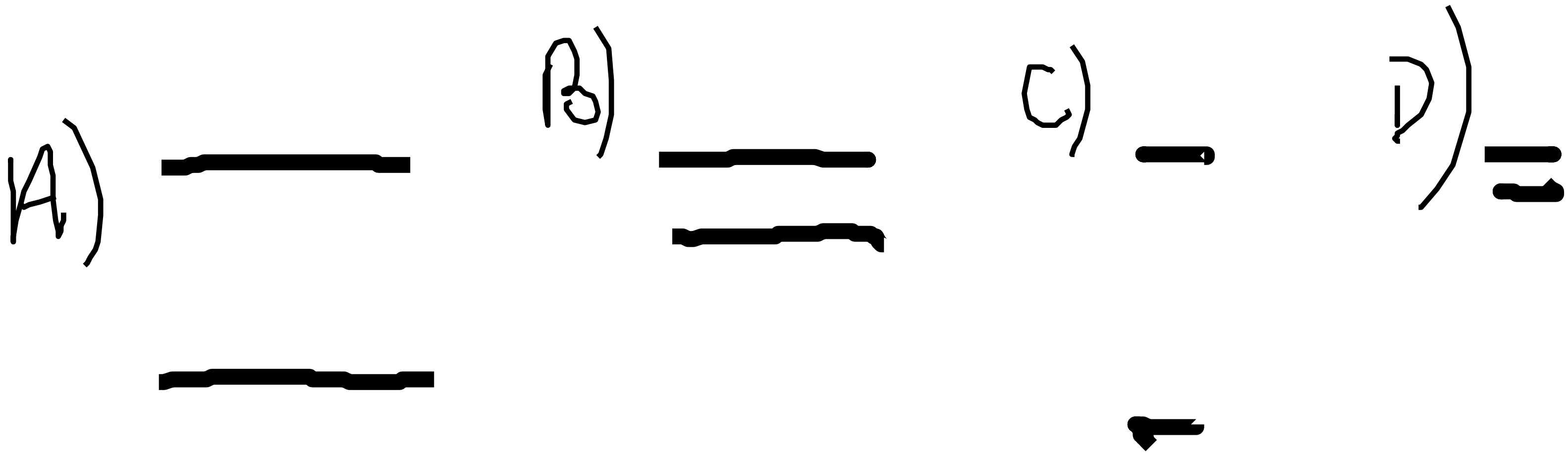
$$\epsilon_0 = 8.85 \times 10^{-12} \frac{F}{m}$$

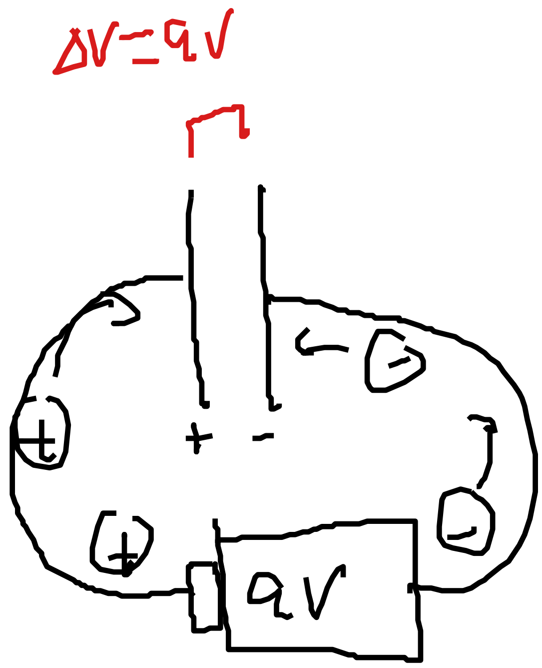
A = area



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

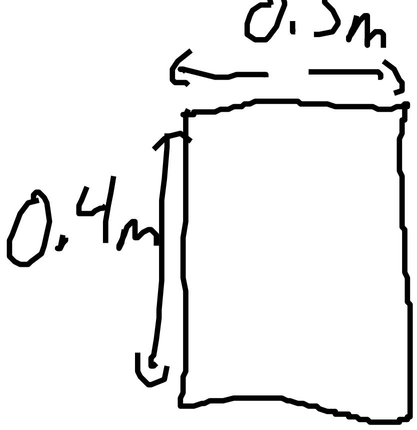
definition

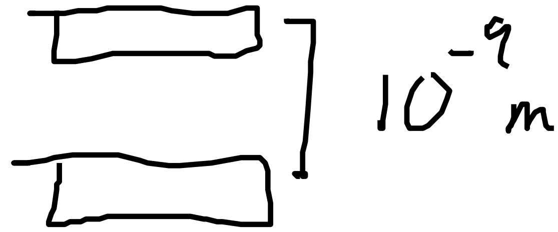




The battery pushes + charge into the + plate until the repulsive force prevents it.

The negative plate helps cancel some of that repulsive force. The smaller the gap, the more the cancellation.



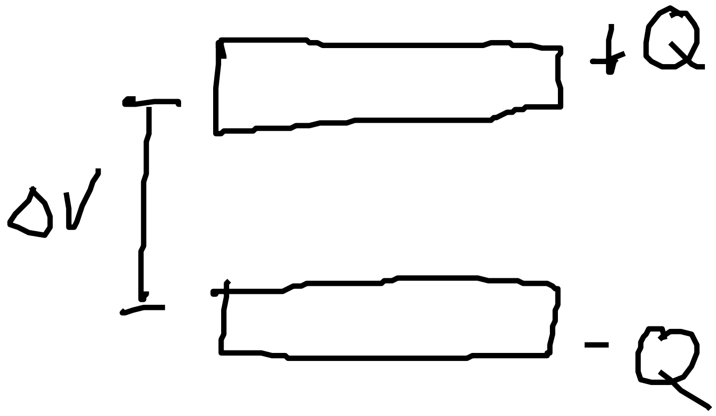


$$C = \epsilon_0 \frac{A}{d} \qquad \epsilon_0 = 8.85 \times 10^{-12}$$

$$= (8.85 \times 10^{-12}) \frac{(0.4)(0.3)}{10^{-9}}$$

$$= 0.001\,F$$

$$= 1\,mF$$



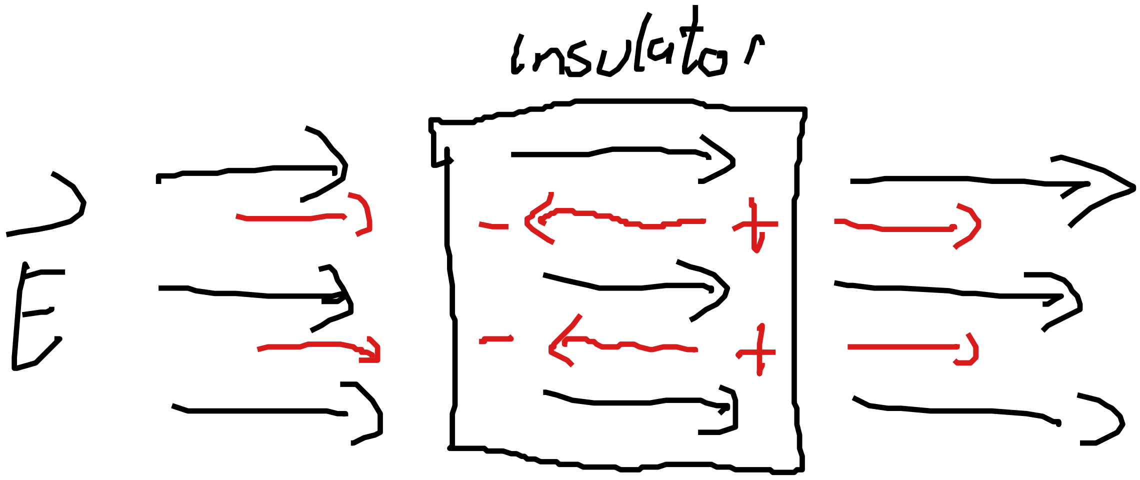
$\uparrow \hat{z}$

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

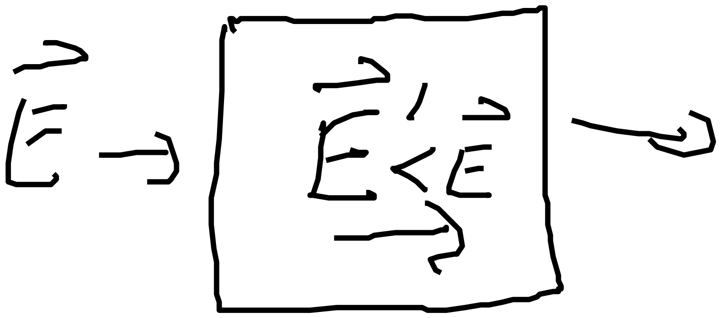
if we can reduce ΔV,
we can increase C

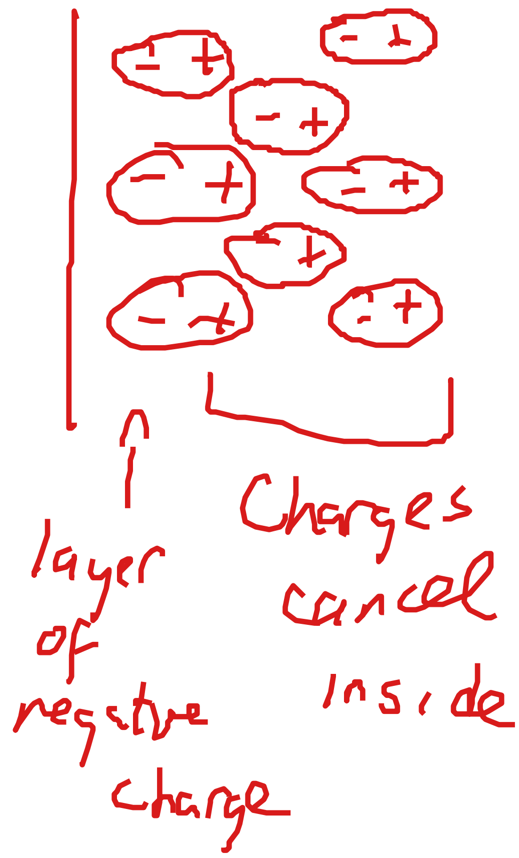
$$\Delta V = -\int E_z \, dz$$

Maybe a polarized insulator
could reduce E?



result





$$\vec{E}' = \frac{1}{\kappa} \vec{E}$$

kappa

κ : dielectric constant of the insulator

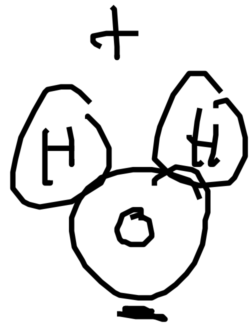
$$\kappa \geq 1$$

vacuum $\kappa = \underline{1}$

air $\kappa = 1.00054 \approx 1$

paper $\kappa = 3.5$

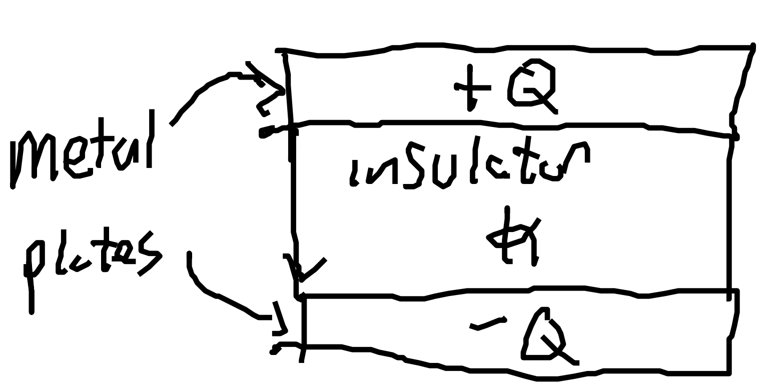
pure water (no ions) $\kappa = 80$



pre-polarized molecules,

perfect conductor $\kappa = \infty$

easier to polarize material



$$E' = \frac{1}{\kappa} E$$

with insulator

original

$$\Delta V = -\int \vec{E} \cdot d\vec{r}$$

$$\Delta V' = \frac{1}{\kappa} \Delta V$$

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

"dielectric" = "insulator"

$$C' = \kappa C$$

capacitance is increased by the dielectric constant of the insulator

Example: two 10cm x 10cm plates are separated by a 1nm-thick chunk of calcium copper titanate

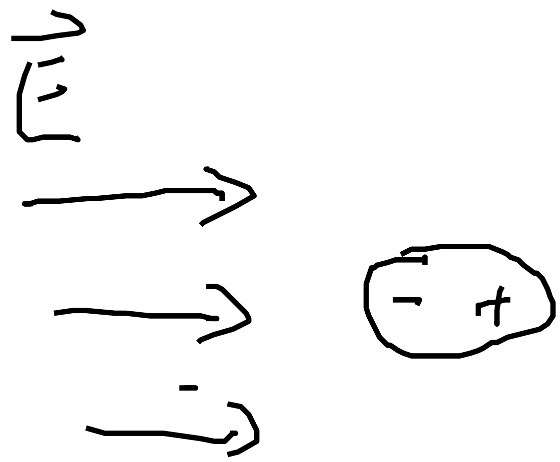
$$\kappa = 12{,}000$$

$$C = \kappa \epsilon_0 \frac{A}{d}$$

$$= (12{,}000)(8.85 \times 10^{-12}) \frac{(0.1\,m)^2}{10^{-9}}$$

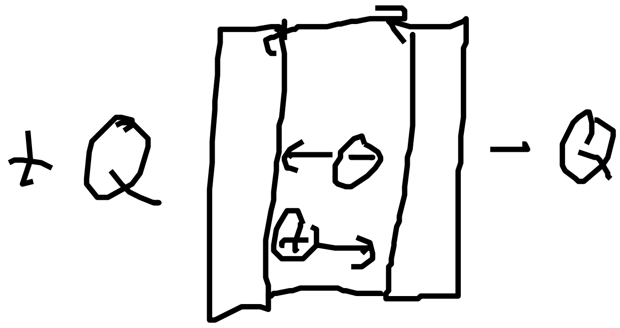
$$= 1.06\,F$$

Electric Breakdown



If $\vec{E}$ gets too strong, it can tear an electron off of atoms

insulator becomes a conductor because of these suddenly free electrons : capacitor discharges



want insulators w/
- high K
- high breakdown threshold