PHYS 121 Feb. 14, 2024

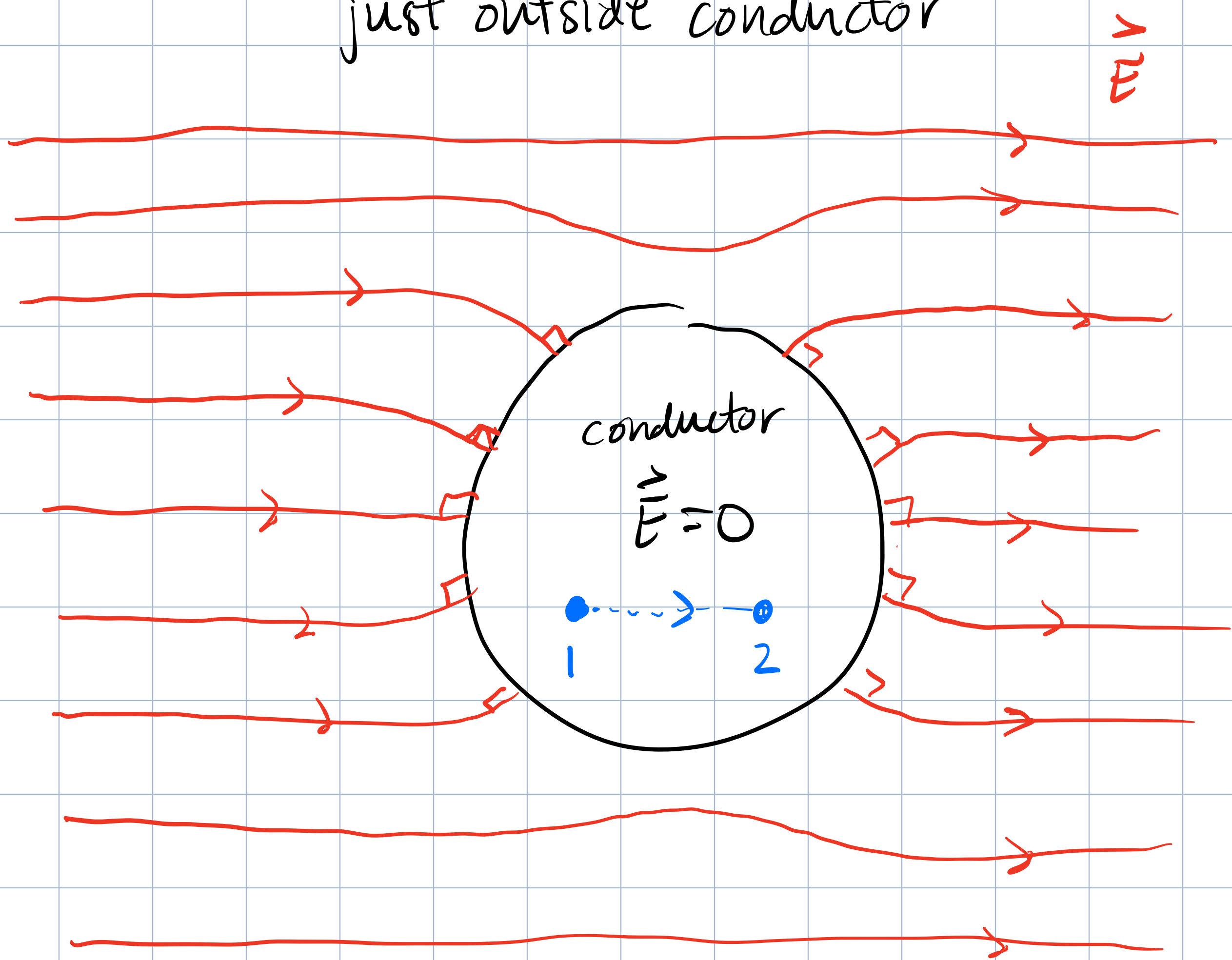
To do: ✓ Complete HW6 by 23:59 Friday

✓ Complete Pre-Lab #3 before your lab

✓ Midterm Wed. Feb. 28 (in person EME 0050)

Recall: Conductors in equilibrium

- $\vec{E} = 0$ inside conductor body
- $\vec{E} \perp$ to conductor surface just outside conductor



Potential difference from $\vec{E}$

$$\Delta V = \int_1^2 \vec{E} \cdot d\vec{s}$$

our pts 1 & 2 are inside the conductor where $\vec{E} = 0$

$$\Delta V = \int_1^2 \cancel{\vec{E}}^{\,0} \cdot d\vec{s}$$

$$V_2 - V_1 = 0$$

$$\therefore V_2 = V_1 .$$

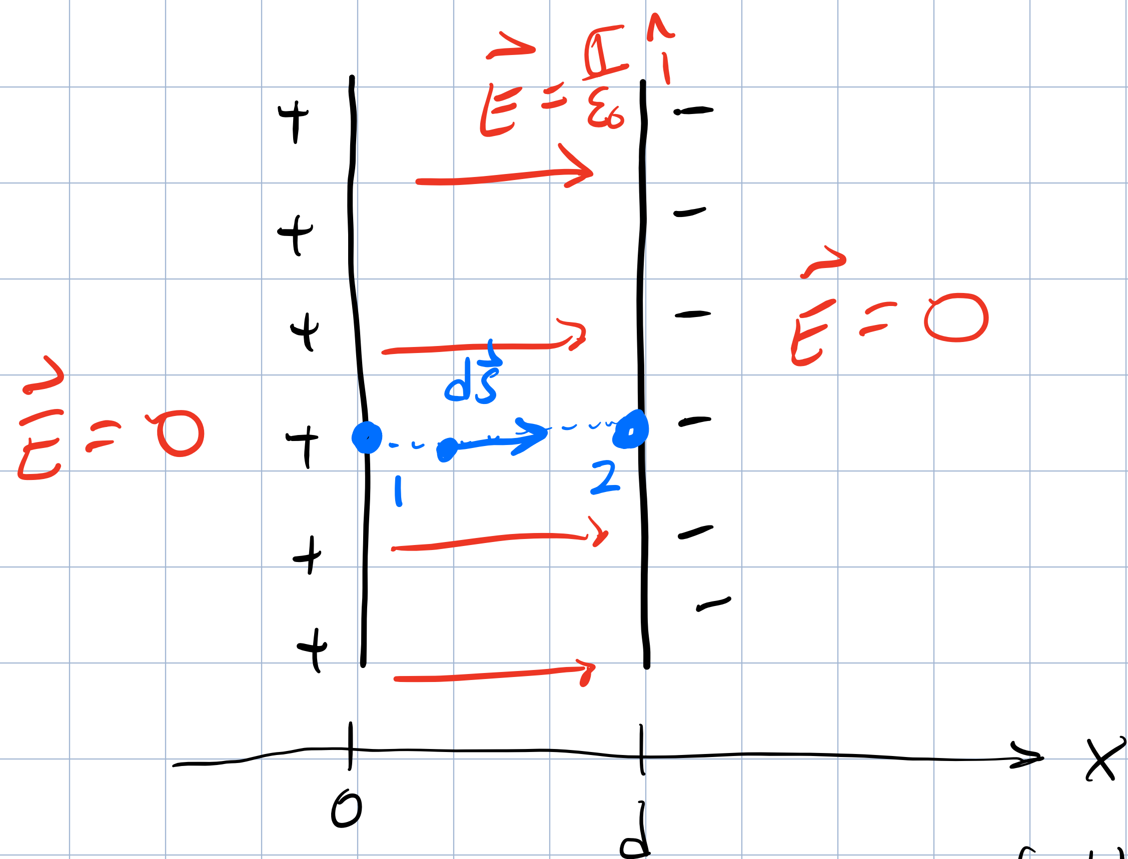
For <u>any</u> two points inside a conductor in equilibrium, we will find $\Delta V = 0$ or $V_1 = V_2$

$\therefore$ Potential inside a conductor in <u>equil.</u> is constant.

Note: The potential in the conductor is constant, but it does <u>not</u> have to be zero.

Eg. Consider a pair of large parallel plates with equal but opposite charge. charge per unit area $\sigma = \dfrac{Q}{A}$

Side View



Each plate creates an electric field of magnitude $E = \dfrac{\sigma}{2\varepsilon_0}$.

Outside the plates the two contributions cancel & they add between the plates.

(a) If the plates are separated by a dist. d, find the pot. diff. ΔV between the pair of plates.

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

$$\vec{E} = \frac{\sigma}{\varepsilon_0} \hat{\imath} \qquad d\vec{s} = dx\, \hat{\imath}$$

$$\therefore \vec{E} \cdot d\vec{s} = \left(\frac{\sigma}{\varepsilon_0} \hat{\imath}\right) \cdot \left(dx\, \hat{\imath}\right)$$

$$= \frac{\sigma}{\varepsilon_0} dx \underbrace{(\hat{\imath} \cdot \hat{\imath})}_{\underbrace{|\hat{\imath}|}_{1}\underbrace{|\hat{\imath}|}_{1}\underbrace{\cos 0}_{1}}$$

$$\vec{E} \cdot d\vec{s} = \frac{\sigma}{\varepsilon_0} dx$$

$$\therefore \Delta V = -\int_1^2 \underbrace{\frac{\sigma}{\varepsilon_0}}_{\text{const}} dx$$

$$= -\frac{\sigma}{\varepsilon_0} \underbrace{\int_1^2 dx}_{d}$$

$$\boxed{\therefore \Delta V = V_2 - V_1 = -\frac{\sigma}{\varepsilon_0} d}$$

Since $\Delta V < 0$, it must be the case that $V_1 > V_2$

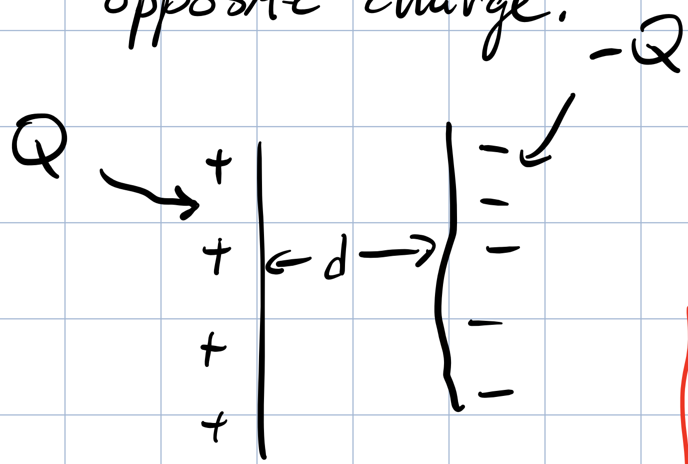
pos. plate (V_1) neg. plate (V_2)

Consistent w/ previous observation that $\vec{E}$ point from high to low potential.

Midterm Cutoff

OSUPv2 Chapter 8: Capacitors.

A capacitor is made from a pair of parallel conducting sheets w/ equal but opposite charge.



The definition of capacitance:

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

units $\quad [C] = \frac{[Q]}{[\Delta V]} = \frac{C}{V} = \underbrace{F}_{\text{Farad}}$

Capacitors can be used to store charge. For a fixed potential difference ΔV (provided by a battery), the charge stored by a capacitor is:

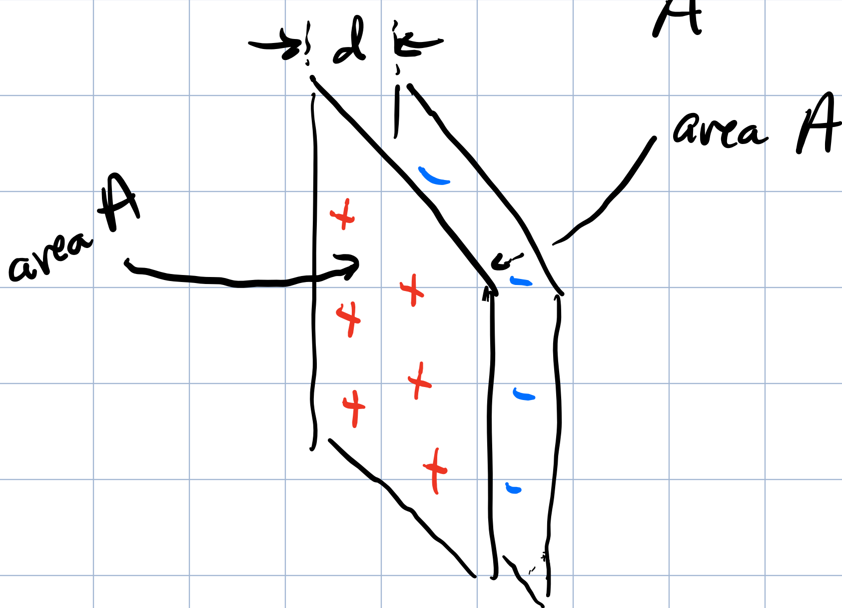
$$Q = C|\Delta V|.$$

Find the geometrical parameters that determine C.

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

We just found that $|\Delta V| = \frac{\sigma}{\varepsilon_0} d$

We also know $\sigma = \frac{Q}{A}$



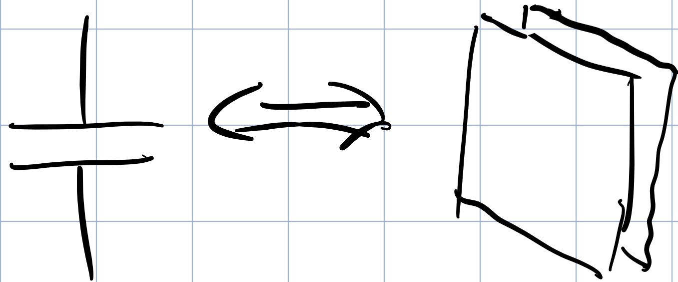
$$|\Delta V| = \frac{Q d}{A \varepsilon_0}$$

$$\therefore \quad C = \frac{Q}{|\Delta V|} = \frac{\cancel{Q}^{\,1}}{\frac{\cancel{Q} d}{A \varepsilon_0}} \Rightarrow \boxed{C = \varepsilon_0 \frac{A}{d}}$$

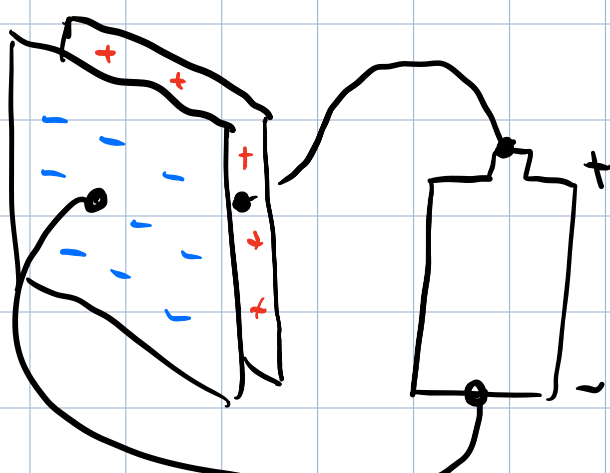
To make C large, want the plate area A to be big & the separation dist. d to be small.

Circuit Symbols

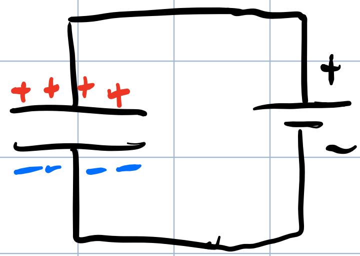
The schematic symbol for a capacitor is



The schematic symbol for a battery is

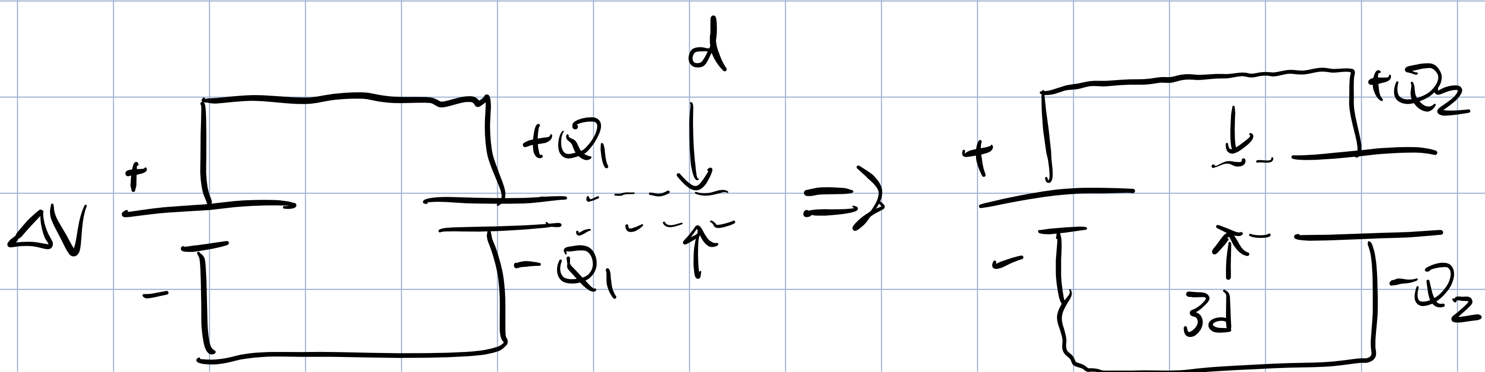


$\Downarrow$



Eg. A parallel plate cap. is connected to a battery of voltage ΔV. The charge on the plates is $\pm Q_1$.

With the battery still connected, the capacitors are pulled apart s.t. $d \to 3d$. What is the new charge $\pm Q_2$?



Since battery is always connected ΔV is the same in both cases.

$$Q = C|\Delta V| \qquad C = \varepsilon_0 \frac{A}{d}$$

$$Q_1 = \varepsilon_0 \frac{A}{d}|\Delta V|$$

$$Q_2 = \varepsilon_0 \frac{A}{3d}|\Delta V| = \frac{Q_1}{3}.$$