PHYS 121 Feb. 26, 2024

<u>To do</u>: ✓ Complete HW7 by 23:59 on Friday

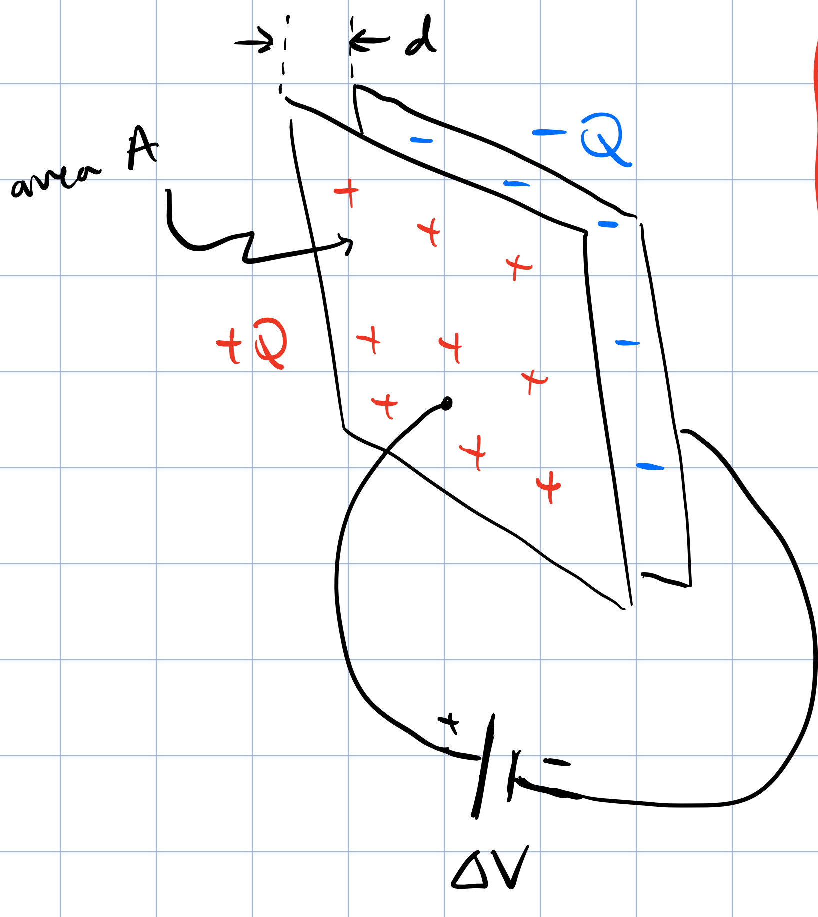
✓ Complete Pre-Lab #4 before Lab #4

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

✓ No tutorials this week

Before the break:

Parallel-Plate cap.



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

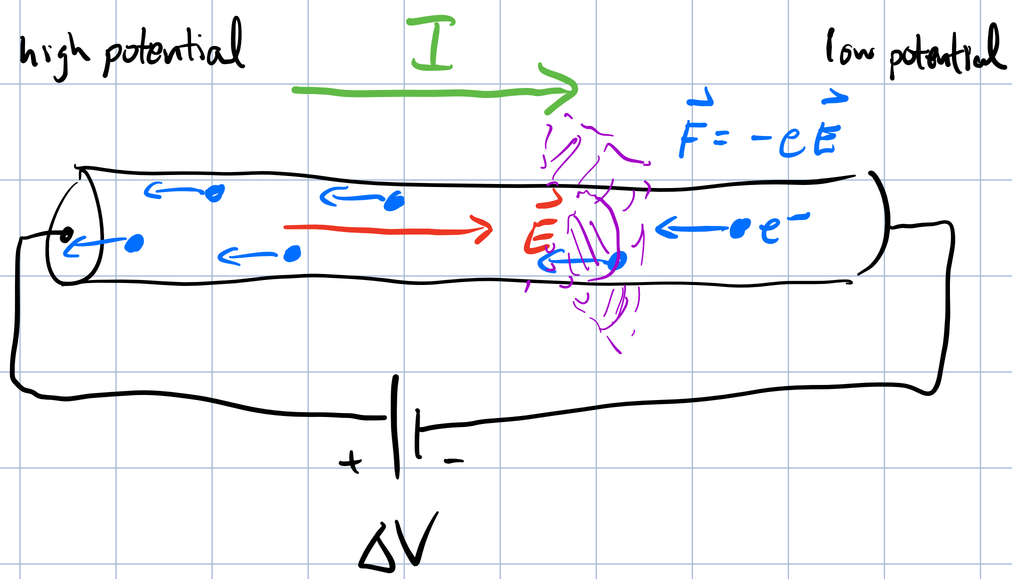
$$C = \frac{Q}{\Delta V}$$

Energy stored by a charged capacitor

$$\boxed{U = \frac{Q^2}{2C} = \frac{1}{2}Q|\Delta V| = \frac{1}{2}C|\Delta V|^2}$$

Lab #4

Imagine connecting a battery across a cylindrical conductor or wire.



Recall that $\vec{E}$-fields point from high-to-low potential.

Since $\vec{E} \neq 0$ in conductor, this is a non-equil. situation. → Can have a net flow of charge.

$\vec{E}$-field in conductor exterts forces on mobile e^- causing a flow of charge or a <u>curret</u>.

Imagine keeping track of amount of charge Δq that crosses a surface intersecting the wire during time interval Δt.

Define average current as

$$I_{avg} = \frac{\Delta q}{\Delta t} \qquad [I] = \frac{[\Delta q]}{[\Delta t]} = \frac{C}{s}$$

current

$$[I] = \frac{C}{s} \equiv A$$

$$1 \text{ amp} = \frac{1 \text{ Coulomb}}{1 \text{ sec.}}$$

If we shrink $\Delta t \to 0$, get the instantaneous current I:

$$I = \lim_{\Delta t \to 0} \frac{\Delta q}{\Delta t} = \frac{dq}{dt}$$

In circuits, current is the dir'n of pos. charge flow. For a conductor it is electrons (neg) that flow. ∴ the current is in the opp. dir'n of the electron flow.

Suppose we connect the same battery to different wires (diff. types of material, or diff. length, diff. diameters ...)

Will find that for the same voltage, get a different current.

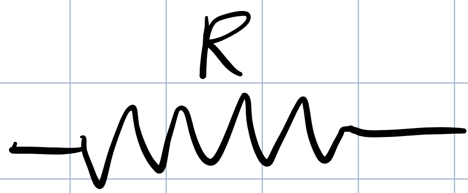
The resistance R of a wire is defined as

$$R = \frac{\Delta V}{I} \qquad [R] = \frac{V}{A} = \Omega$$

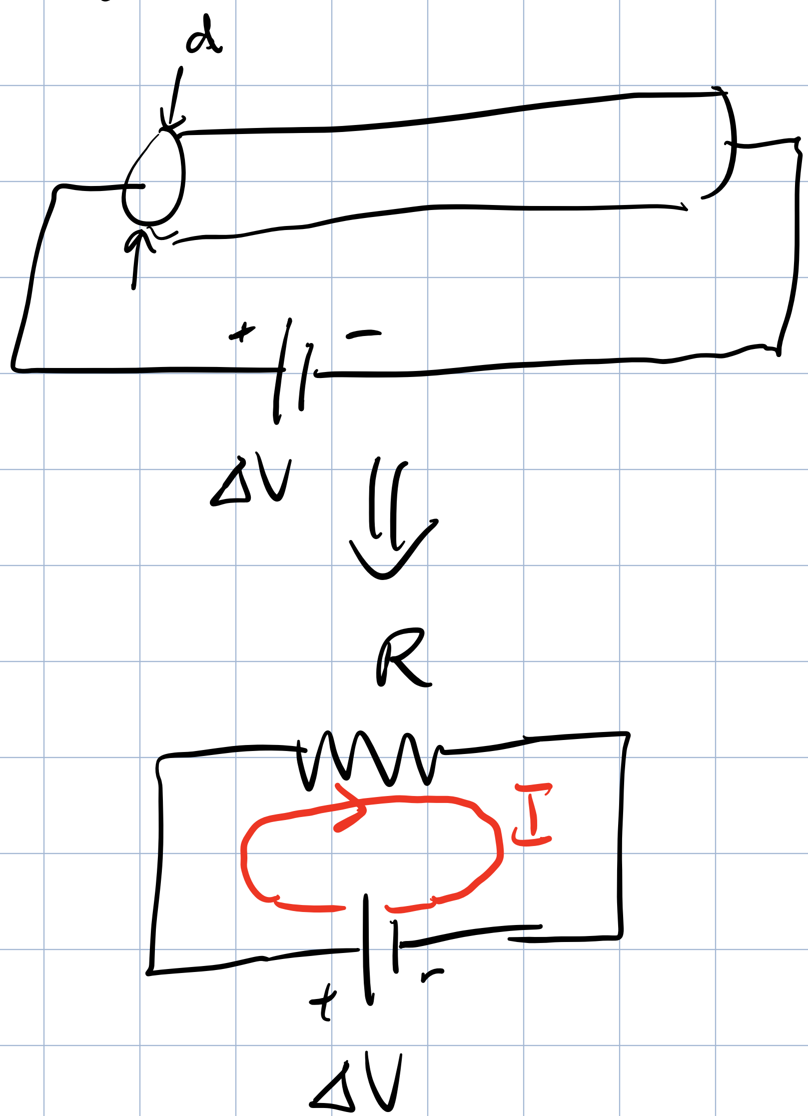
"ohm"

$$1\,\Omega = \frac{1\,V}{1\,A}.$$

Circuit symbol for a resistor is:



Circuit diagram for our wire connected to a battery is:



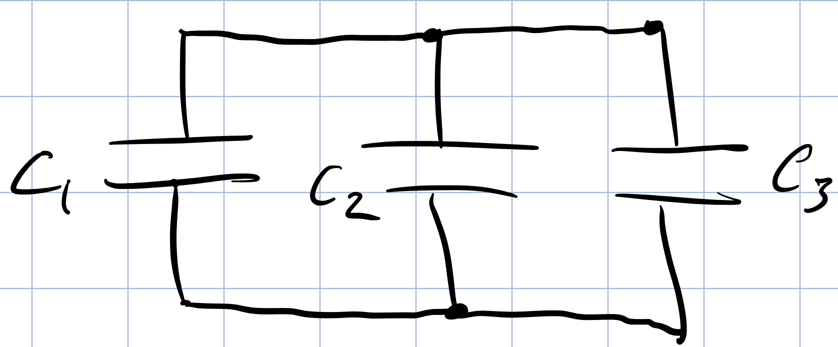
$$R = \frac{\Delta V}{I}$$

In Lab #4, you will investigate how the resistance of a wire depends on its diameter d.

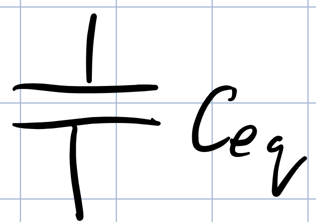
Back to capacitors.

Combinations of Capacitors.

Parallel Combinations



Connect together all top plates & all btm plates.



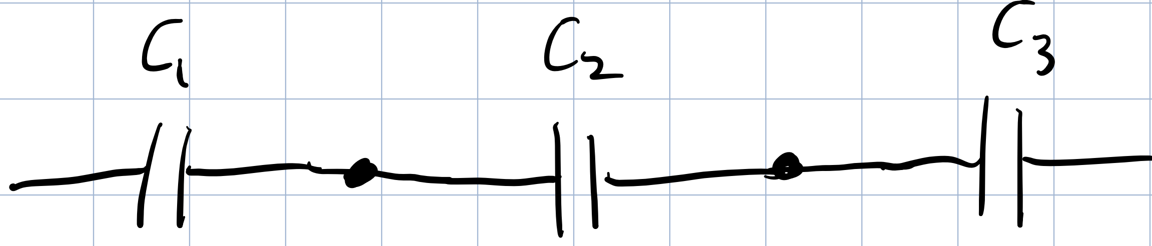
Want to represent the parallel combo as a single "equivalent" capacitor C_{eq}.

Result:

$$\boxed{C_{eq} = C_1 + C_2 + C_3}$$

C_{eq} is given by sum of each of parallel capacitances.

Series combination



$\Downarrow$

In a series combination, line up capacitors & connect nearest plates to one another.

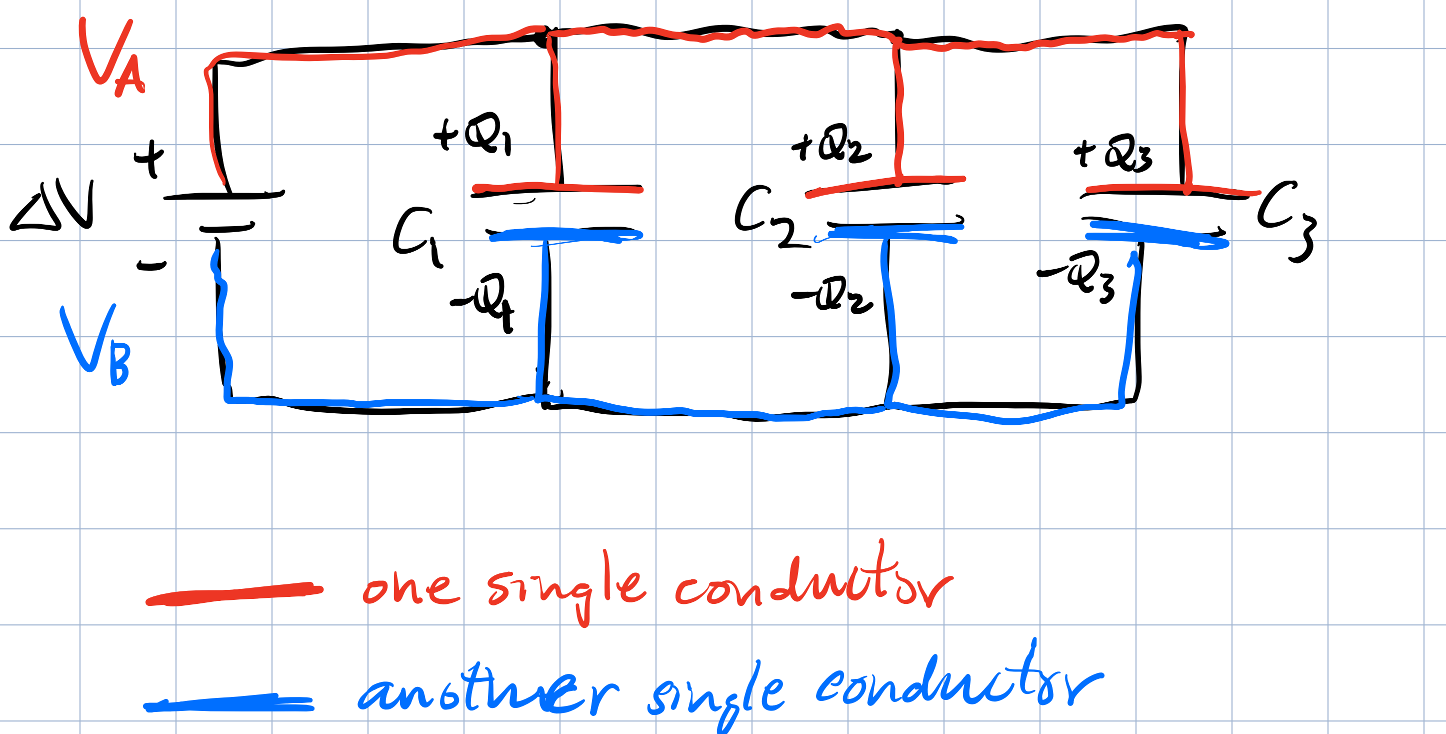
In this case, we will find

$$\boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

Inverses of individual capacitances add to give the inverse of C_{eq}.

In series combination, it will always be the case that $C_{eq} < C_1, C_2, C_3$

Parallel combination of capacitors.



After the capacitors charge up, there is no more flow charge $\Rightarrow$ conductors are in equil.

$\Rightarrow$ Each conductor is at a uniform or constant potential.

$\therefore$ top plates of each capacitor is at same potential V_A

btm plates are all @ pot. V_B.

$\therefore$ Potential difference across each parallel cap is the same:

$$\Delta V_1 = \Delta V_2 = \Delta V_3 = V_A - V_B \equiv \Delta V$$

Recall, by definition, $C = \dfrac{Q}{\Delta V} \Rightarrow Q = C\Delta V$

$$Q_1 = C_1 \Delta V$$

$$Q_2 = C_2 \Delta V$$

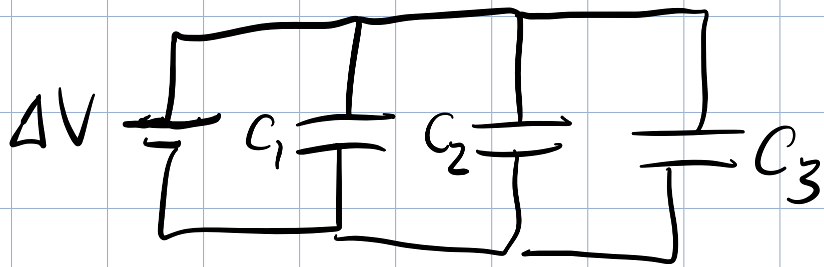
$$Q_3 = C_3 \Delta V$$

$\therefore$ total charge Q stored by the parallel combination is

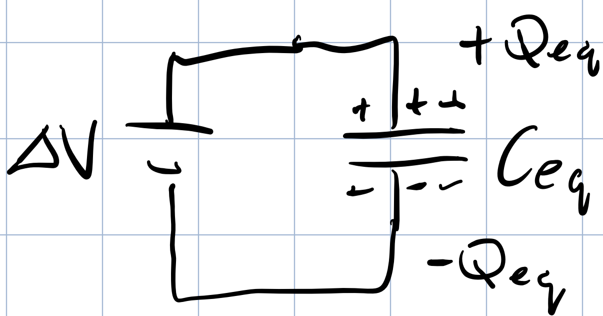
$$Q = Q_1 + Q_2 + Q_3$$

$$\therefore Q = C_1 \Delta V + C_2 \Delta V + C_3 \Delta V$$

$$\boxed{Q = (C_1 + C_2 + C_3)\Delta V} \quad ①$$



$$\Downarrow$$



For C_{eq}, the stored charge is

$$Q_{eq} = C_{eq} \Delta V$$

C_{eq} <u>must</u> stored same total charge

$$\therefore Q_{eq} = \boxed{Q = C_{eq} \Delta V} \quad ②$$

Eqs. 1 & 2 each calculate the stored charge Q & must be equal.

$$1 = 2$$

$$(C_1+C_2+C_3)\cancel{\Delta V} = C_{eq}\cancel{\Delta V}$$

$$\boxed{\therefore C_{eq} = C_1 + C_2 + C_3}$$ Parallel capacitors.