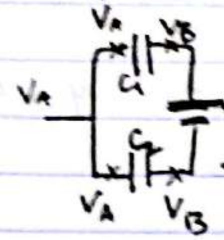
10/20/15

Parallel: total charge shared

$Q = Q_1 + Q_2$

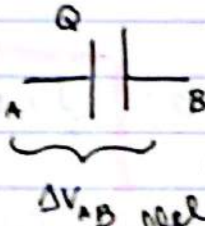


$\Delta V_1 = \Delta V_{AB}$

equal

$\Delta V_2 = \Delta V_{AB}$

Replace w/ Cequivalent



$Q = C_{eq} \Delta V_{AB}$ (Q: $Q_1 + Q_2$)

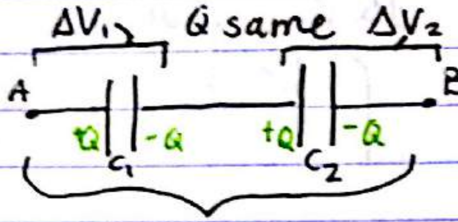
so,

$C_{eq} = \frac{Q_1}{\Delta V_{AB}} + \frac{Q_2}{\Delta V_{AB}}$ ($\frac{Q_1}{\Delta V_{AB}}$: C_1; $\frac{Q_2}{\Delta V_{AB}}$: C_2)

parallel

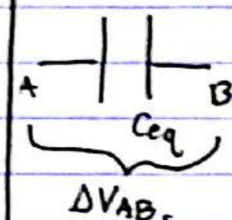
$$\boxed{C_{eq} = C_1 + C_2 + \dots + C_n}$$

Series: Total ΔV shared



$\Delta V_{AB} = \Delta V_1 + \Delta V_2$

Replace w/ Cequivalent



$\Delta V_{AB} = \frac{Q}{C_1} + \frac{Q}{C_2}$

$\frac{\cancel{Q}}{C_{eq}} = \frac{\cancel{Q}}{C_1} + \frac{\cancel{Q}}{C_2}$

series

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

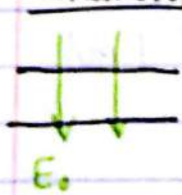
Dielectrics "insulating material"

A smaller $d \Rightarrow$ higher C

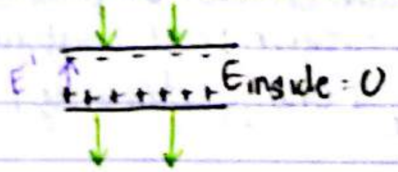
- put dielectric in middle to decrease d

We want a higher V (capacitors do have a Q-limit)

Conductor



$\Rightarrow$



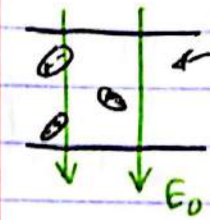
The charge redistributes, and so a field inside the capacitor is created.

$\vec{E}_{inside} = \vec{E}' + \vec{E}_0$

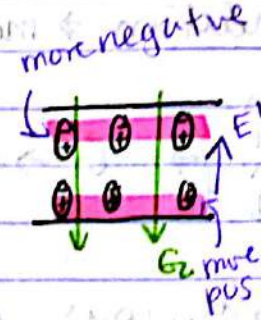
$= 0$, when $\vec{E}' = -\vec{E}_0$

- when no more charge flows, $\vec{E}' = -\vec{E}_0$

Insulator



← molecules randomly oriented ⇒



molecules reorient themselves in presence of E_0. (they do not "move".)

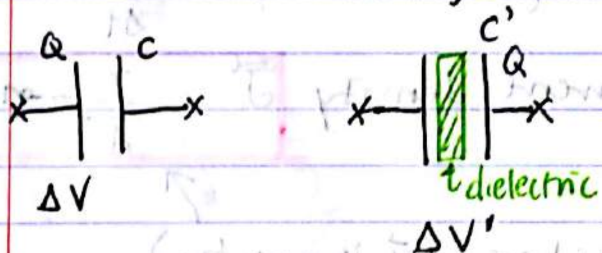
$\vec{E}'$ is polarizability field.

$\boxed{\vec{E}' < \vec{E}_0}$!! → $\vec{E}_{inside} = \vec{E}_0 + \vec{E}'$ (always smaller then $\vec{E}_0$)

Linear Dielectric

$\vec{E}' \propto \vec{E}_0 \Rightarrow \vec{E}_{inside} \propto \vec{E}_0 \Rightarrow \boxed{\vec{E}_0 = K_e \vec{E}_{inside}}$

Since $\vec{E}_{inside} < \vec{E}_0$, $K_e > 1$. Ke is the dielectric constant.



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

revisit this

$\Delta V'$ is different because of the dielectric.

- changing $\vec{E}_{inside}$ (weaker)

$\Delta V' = -\int \vec{E} \cdot d\vec{s} \Rightarrow$ $\Delta V'$ is decreasing $\therefore C' > C$.

$\vec{E}_0 = K_e \vec{E}_{inside} \Rightarrow \vec{E}_{inside} = \frac{\vec{E}_0}{K_e}$

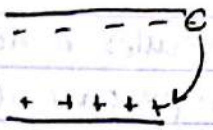
Material	Ke
vacuum	1
air	1.0059

Coulomb's: $\vec{E} = \frac{q}{4\pi\varepsilon_0 r^2}$ in a vacuum so $\underbrace{\varepsilon}_{\text{permittivity}} = \varepsilon_0 K_e$

$\vec{E} = \frac{q}{4\pi\varepsilon_0 r^2 K_e}$ in a dielectric

A general formula: $\vec{E} = \frac{q}{4\pi\varepsilon r^2}$

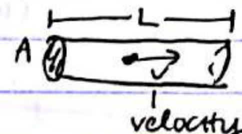
Dynamic Condition ⇒ moving charges ⇒ current



$\Delta V \rightarrow \vec{E} \rightarrow \vec{F} \Rightarrow q\vec{E}$

Current: continuous flow of charge

$* \; I = \frac{dq}{dt}$ $\quad [I] = \frac{[\text{Coulomb}]}{[\text{sec}]} = [\text{Ampere}] = A$



$q = ne\,\text{Volume}$

↑ chg. density

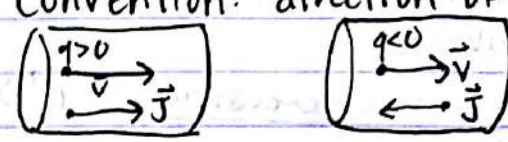
Volume $= AL = Av\Delta t$, so

$q = neAv\Delta t$, $I = \frac{q}{\Delta t}$

$\therefore \boxed{I = neAv}$, current density $\boxed{\vec{J} = \frac{I}{A} = ne\vec{v}}$

we define $\vec{J}$ as an vector. ($\vec{v}$ is a vector)

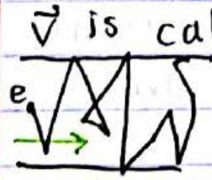
Convention: direction of $\vec{J}$ is defined by $q>0$ (pos. chg)



$\boxed{\vec{J} = -ne\vec{v} \text{ is convention}}$

$\vec{v}$ is called the drift velocity.

$\vec{F} = q\vec{E}$



due to collisions (a disordered motion)

1) atoms - important @ high temp.

2) impurities

So, $\vec{v}_{avg} = 0$ (no $\vec{E}$-field)

turn on external $\vec{E} \rightarrow \vec{v}_{drift}$ (gen. direction that particles move)

$\vec{E} \Rightarrow \vec{F} = q\vec{E} = m\vec{a}$, $\quad \vec{a} = \frac{q\vec{E}}{m}$ ← this is contradictory.

There is actually no $\vec{a}$ because of collisions.

Time between collisions matters. $\boxed{\overline{v(t)} = \overline{v_i(0)} + \overline{\frac{qE}{m}}\, t}$

so $\bar{v} = \frac{qE}{m}\tau$ (avg time between collisions)