10

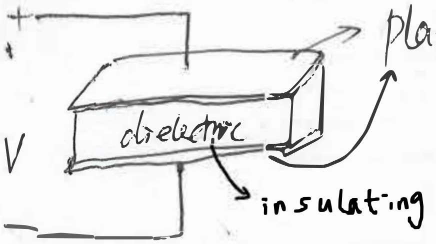
Capacitor:

Sack of charge → 'thought experiment'.

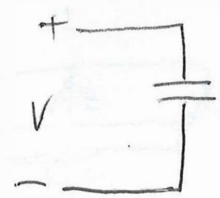
In reality, we have a capacitor that can store charges

In modern electronics, capacitor is very important., it is the Basic element in a transistor structure, or flash memory (gate/float gate)

Basic structure.



⇒



✓ capacitor.

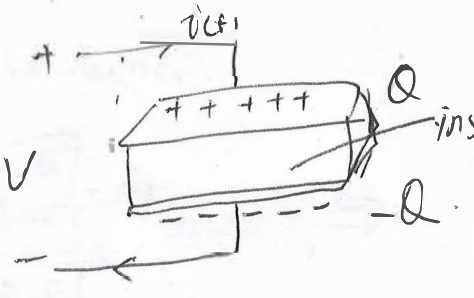
1. Charge (both positive & negative) can be stored on the plates
2. No charge/current can pass through the dielectric layer

Let's assume initially $V = 0$; instantly $V \to V_0$;

If it is a open-circuit, we know that there will be no current flow

But

Capacitor will still have initial current.:



Charge conservation.

Charge neutrality

Since the dielectric is an insulator, No current flow through the capacitor.

So $Q \to$ will reach to a saturation

$$Q = C \cdot V$$

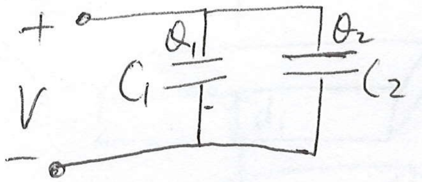
↳ capacitance. (Farads)

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

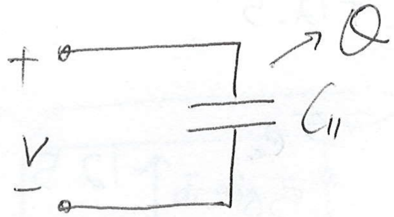
ε → permittivity; A → Area; d → separation

Basic properties:

Shunt/Parallel Connection



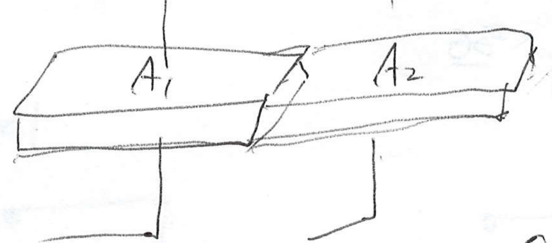
$\Rightarrow$



$$Q = Q_1 + Q_2 \Rightarrow C_{11} \cdot V = C_1 \cdot V + C_2 \cdot V$$

$$\Rightarrow C_{11} = C_1 + C_2.$$

How to understand.



total area is $A_1 + A_2$

$$C_{11} = \frac{\varepsilon A}{d} = \frac{\varepsilon (A_1 + A_2)}{d} = \frac{\varepsilon A_1}{d} + \frac{\varepsilon A_2}{d}$$

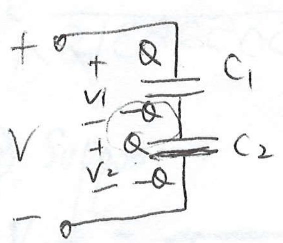
$$= C_1 + C_2.$$

In general

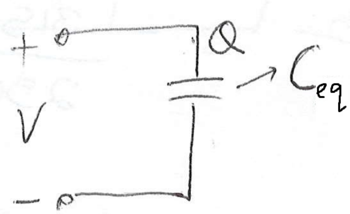
$\Rightarrow$

$$C_{11} = C_1 + C_2 + \cdots C_N.$$

2. Series Connection.



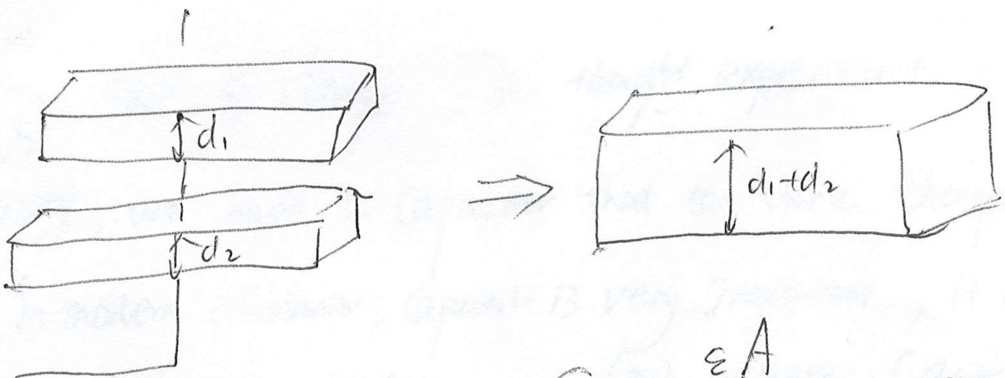
$\Rightarrow$



$$V_1 + V_2 = V$$

$$\frac{Q}{C_1} + \frac{Q}{C_2} = \frac{Q}{C_{eq}} \Rightarrow \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

How to understand.

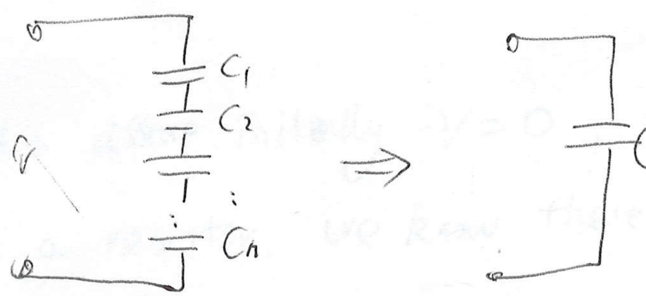


$$C_{eq}=\frac{\varepsilon A}{d_1+d_2} \Rightarrow \frac{1}{C_{eq}}=\frac{d_1+d_2}{\varepsilon A}$$

$$=\frac{d_1}{\varepsilon A}+\frac{d_2}{\varepsilon A}=\frac{1}{\frac{\varepsilon A}{d_1}}+\frac{1}{\frac{\varepsilon A}{d_2}}$$

$$=\frac{1}{C_1}+\frac{1}{C_2}$$

In general



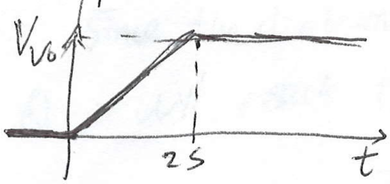
$$\frac{1}{C_{eq}}=\frac{1}{C_1}+\frac{1}{C_2}+\dots\frac{1}{C_n}$$

$$\boxed{i_{(t)}=\frac{dq_{(t)}}{dt}=\frac{d(C\cdot V_{(t)})}{dt}=C\cdot\frac{dV}{dt}} \quad \Leftrightarrow \text{Compare. } i=\frac{1}{R}V$$

Linear dependent on voltage change **Linear dependence on voltage**

e.g.

Suppose.



from $=(-\infty,0)$ $V=0$

from $(0, 2s)$ $V_{(t)}=\frac{V_0}{2}\cdot t$

from $(2,+\infty)$ $V=V_0$

I.