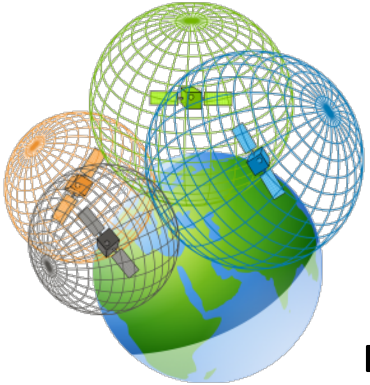
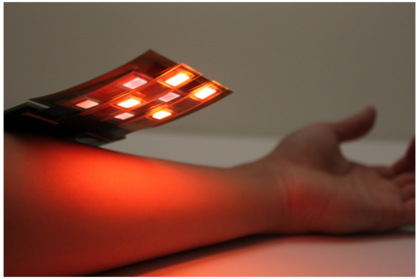




Welcome to EECS 16A!

Designing Information Devices and Systems I

Ana Claudia Arias and Miki Lustig

Fall 2021

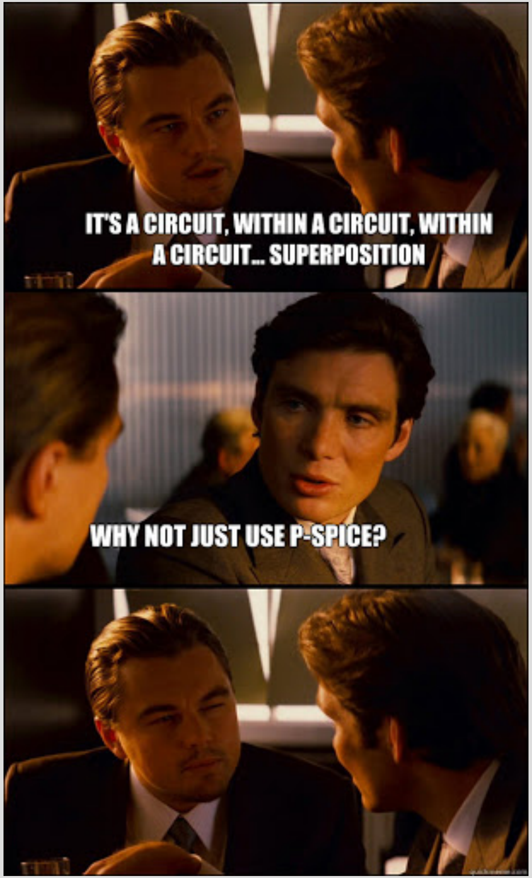
Module 2
Lecture 6
Capacitors
(Note 16)

Superposition

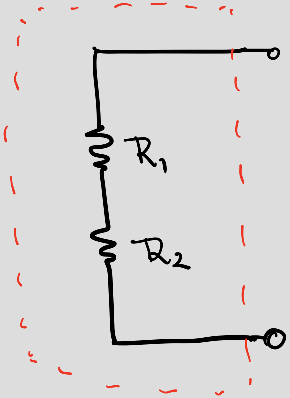
For each independent source k (either voltage source or current source)

- Set all other independent sources to 0
- Voltage source: replace with a wire
- Current source: replace with an open circuit
- Compute the circuit voltages and currents due to this source k
- Compute V_{out} by summing the $V_{out;k}$s for all k.

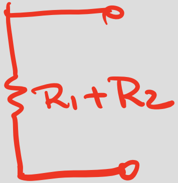
New technique!

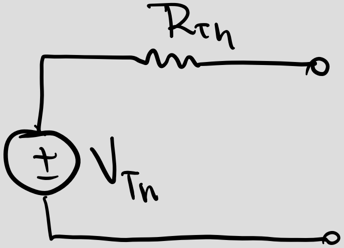


Practice – Example 1



$\Rightarrow$

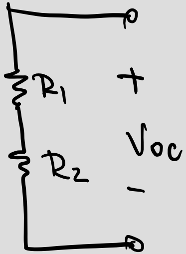




$$R_{Th} = \frac{V_{test}}{I_{test}} = (R_1 + R_2)$$

In series means that the same I flows trough the elements.

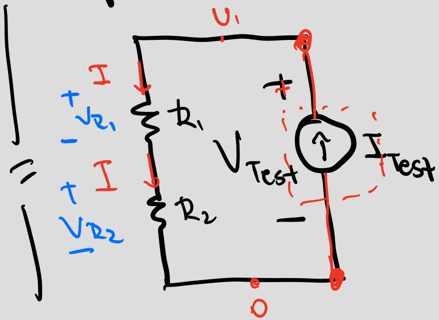
Step 1:



$V_{oc} = 0$

$V_{Th} = 0$

Step 2: No sources



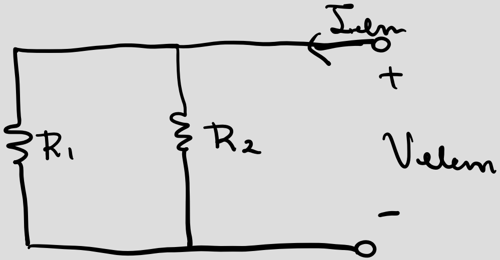
$$V_{TEST} = V_{R1} + V_{R2}$$

$$V_{Test} = IR_1 + IR_2$$

$$= I_{test} R_1 + I_{Test} R_2$$

$$V_{Test} = (R_1 + R_2) \cdot I_{Test}$$

Practice – Example 2

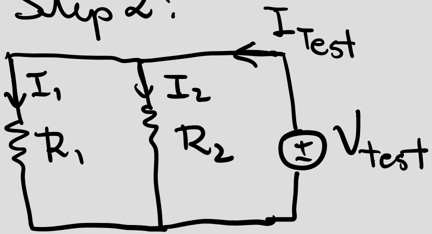


$\Rightarrow$

Step 1

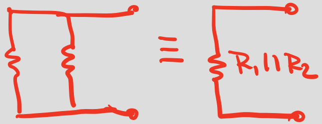
$V_{th} = 0$

Step 2:



$$I_1 = \frac{V_{test}}{R_1}$$

$$I_2 = \frac{V_{test}}{R_2}$$



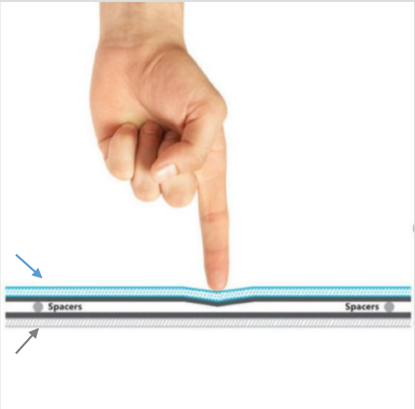
Parallel operator

$$I_{test} = I_1 + I_2 = V_{test}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

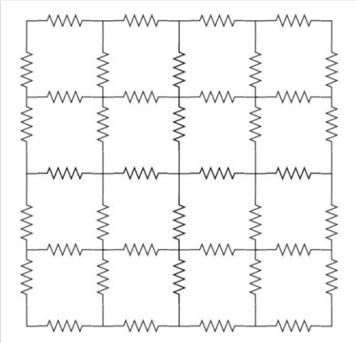
$$R_{Th} = \frac{V_{test}}{R_{test}} = \frac{V_{test}}{V_{test}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{R_1 R_2}{R_1 + R_2} = R_1 || R_2$$

Now that we understand 2D resistive touchscreen, let's change it!

resistive sheet



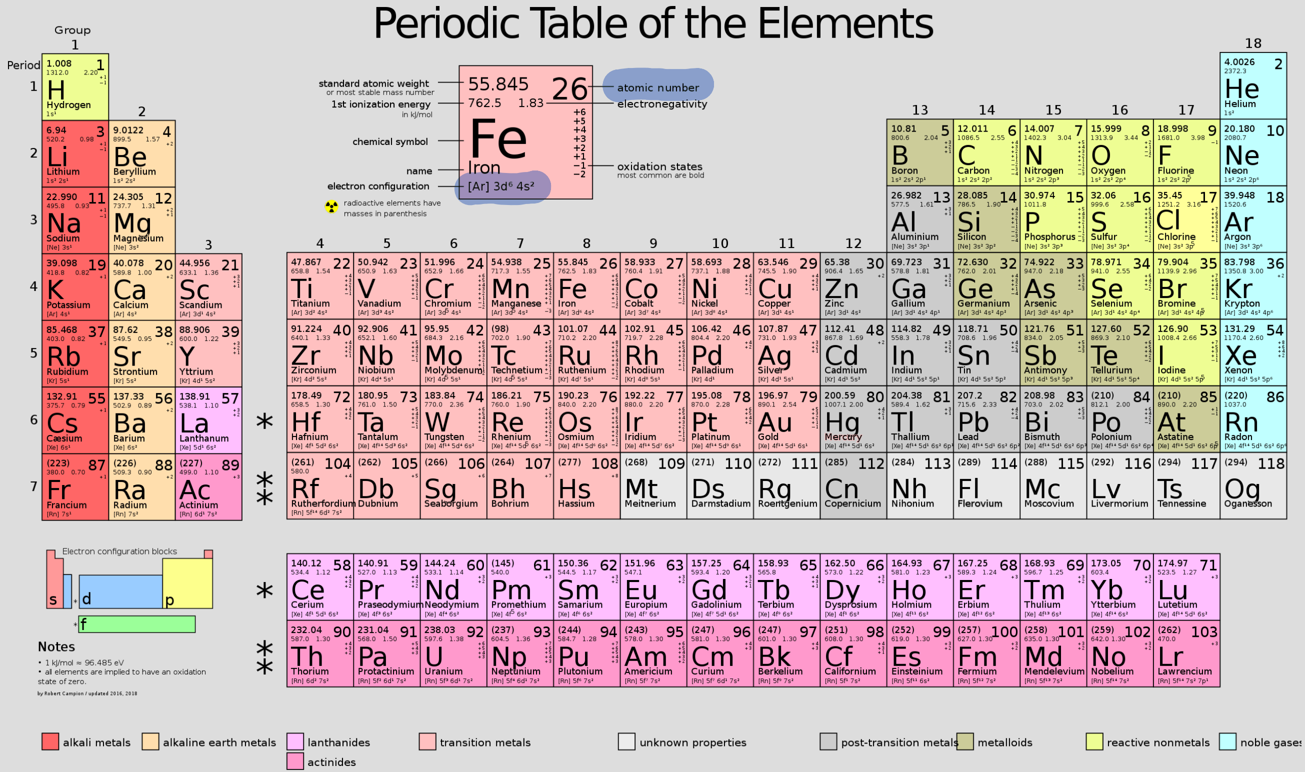
resistive sheet



Circuit model for each resistive sheet is a grid of resistors

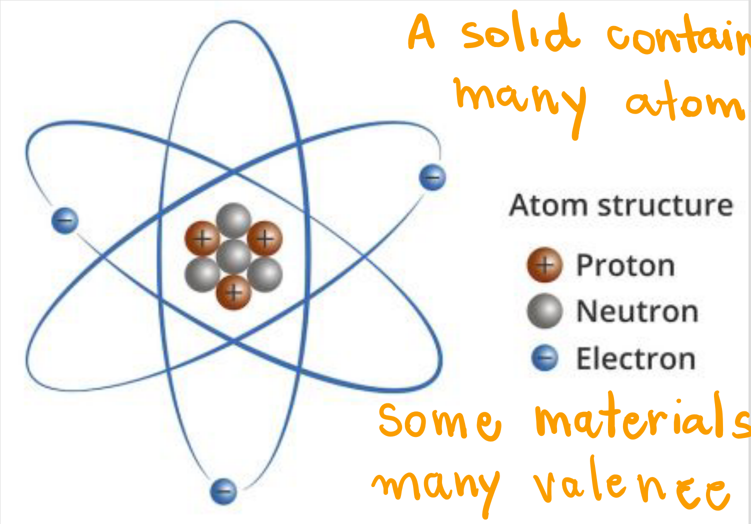
real-world touchscreens are usually capacitive, not resistive:
- **don't need to be flexible**
- **multi-touch is easier**
- **more sensitive**
- **increased contrast on screen**

First: Science Review



First: Science Review

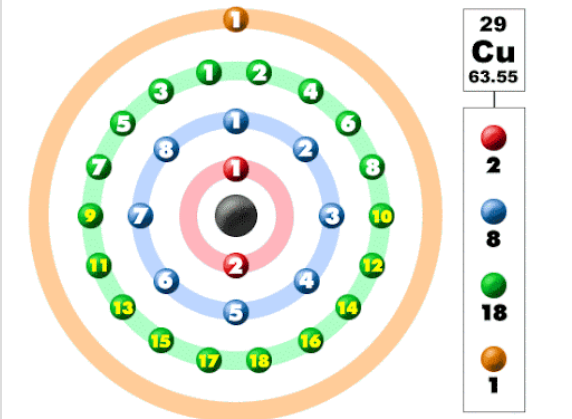
First: Science Review



A solid contains many atoms!

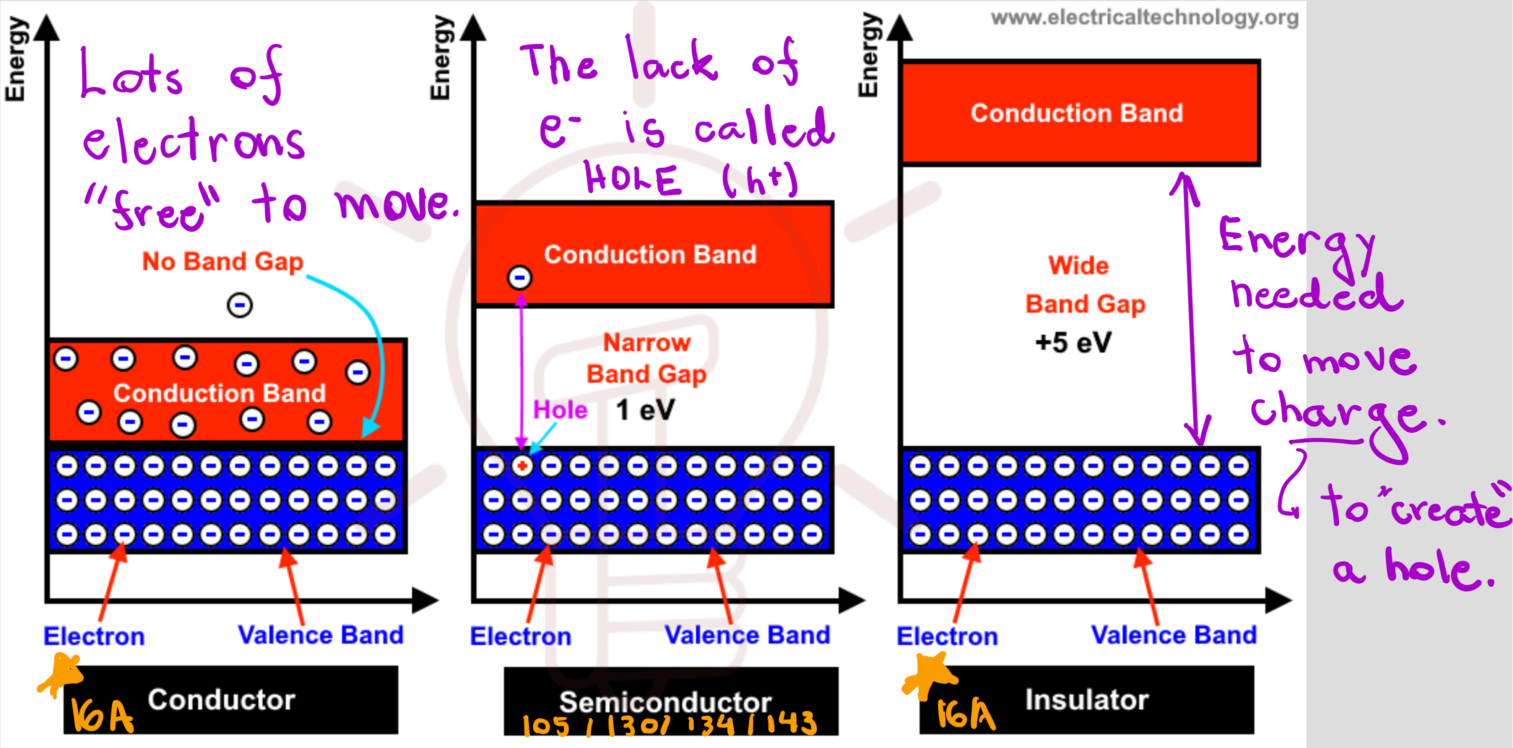
Some materials have many valence e^-.

				4s	3d				
Calcium	Ca	20	[Ar] $4s^2$	↑↓					
Iron	Fe	26	[Ar] $4s^2\ 3d^6$	↑↓	↑↓	↑	↑	↑	↑
Copper	Cu	29	[Ar] $4s^1\ 3d^{10}$	↑	↑↓	↑↓	↑↓	↑↓	↑↓



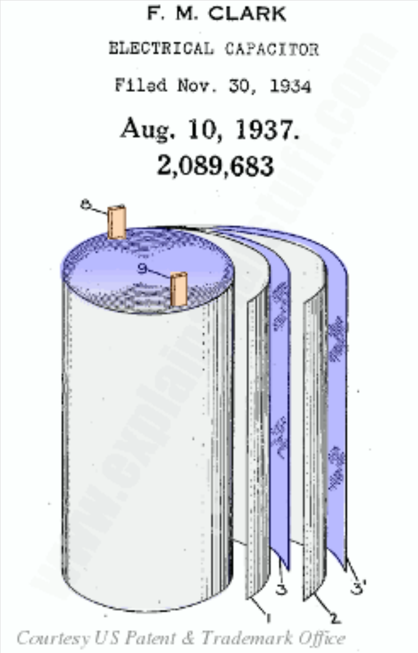
Element	Symbol	Electronic Configuration
Scandium	Sc	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1\ 4s^2$
Titanium	Ti	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$
Vanadium	V	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$
Chromium	Cr	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$
Manganese	Mn	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$
Iron	Fe	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$
Cobalt	Co	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$
Nickel	Ni	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$
Copper	Cu	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$
Zinc	Zn	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

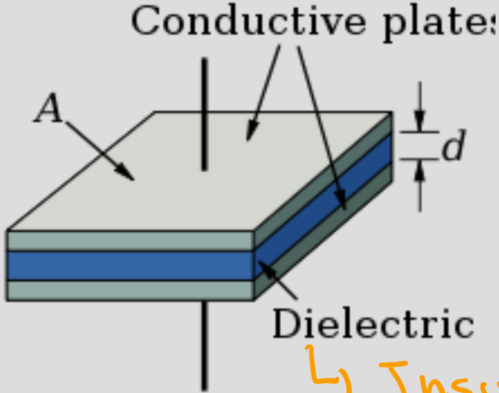
Second: a tiny bit of Solid-State Physics



Now, Capacitors!

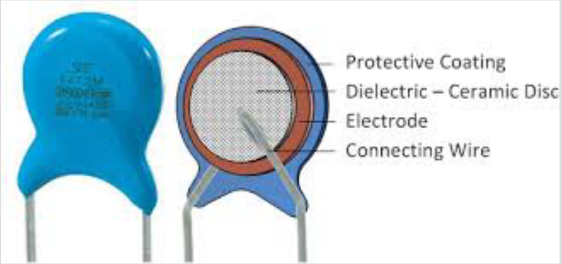
- Charge storage device (like a ‘bucket’ for charge)

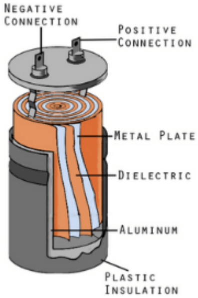


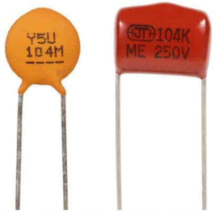


↳ Insulator

↳ Higher Energy is needed to move charge.

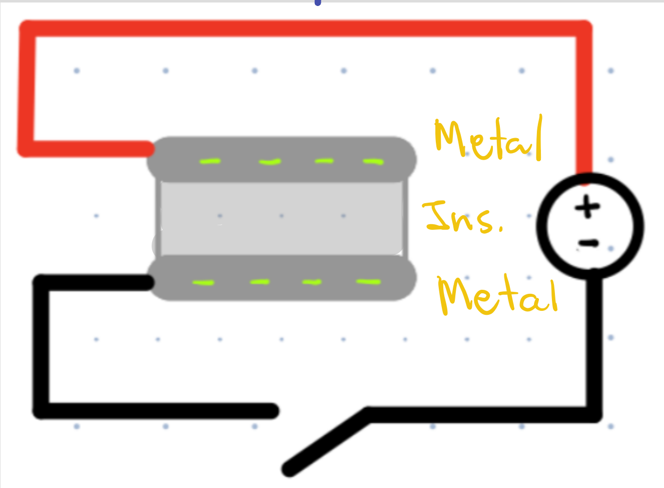






The Physics of a Capacitor

* Energy is needed to move charge.



e^-

→ No current across the capacitor plates

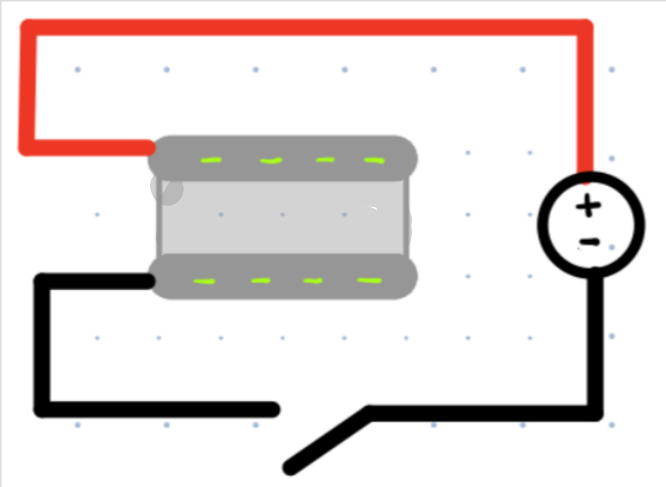
→ Voltage Source provides Energy needed for flow of charges(e^-)

https://www.youtube.com/watch?v=X4EUwTwZ110

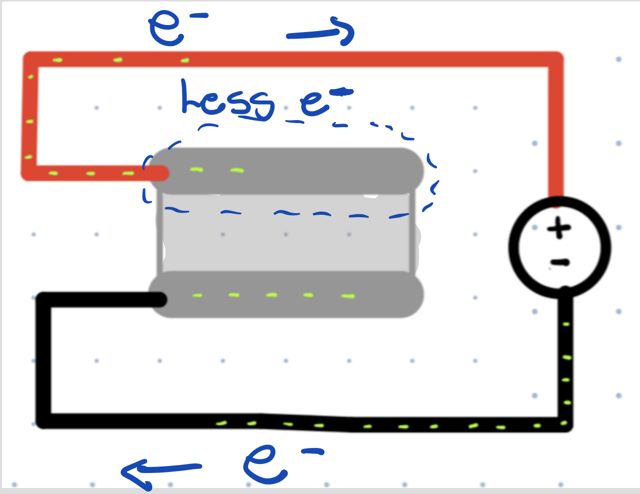
The Physics of a Capacitor

→ Once the switch is ON e⁻ flow!

t_0



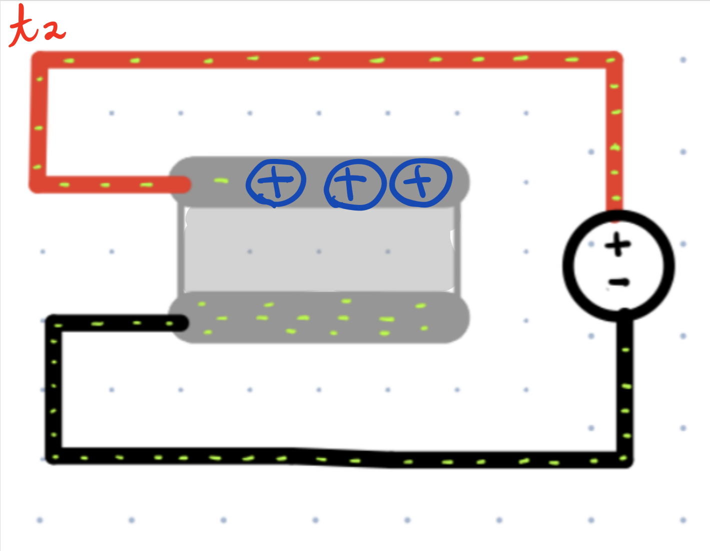
t_1

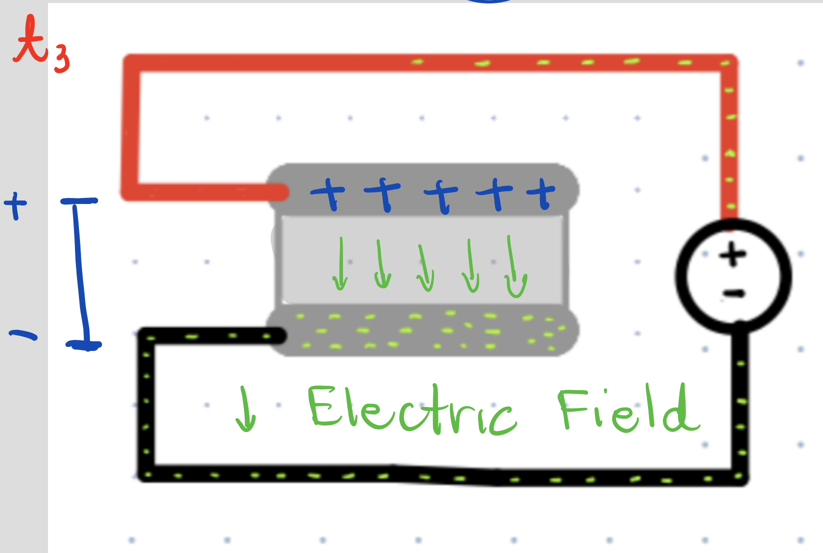


https://www.youtube.com/watch?v=X4EUwTwZ110

The Physics of a Capacitor

Lack of electrons means holes! (h+)

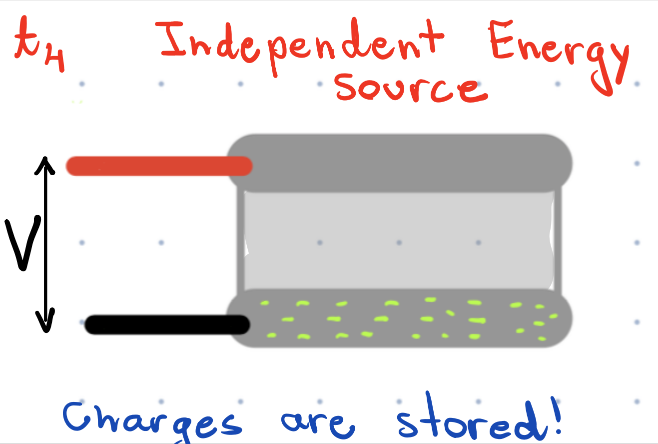


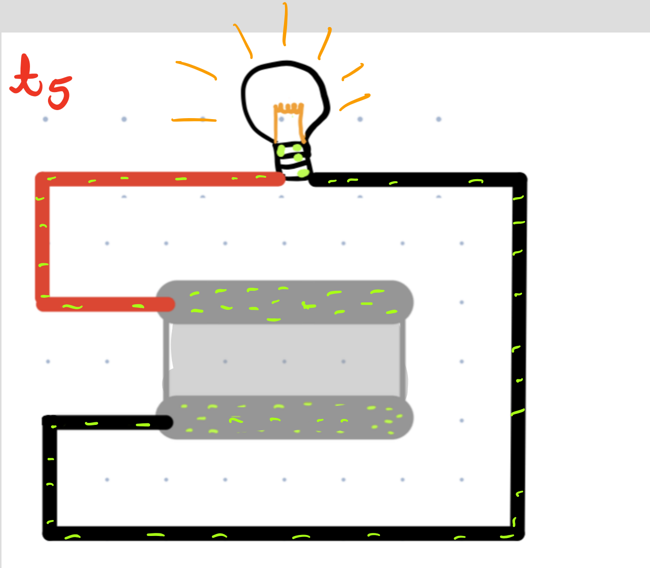


Potential difference between the two plates! } V

https://www.youtube.com/watch?v=X4EUwTwZ110

The Physics of a Capacitor





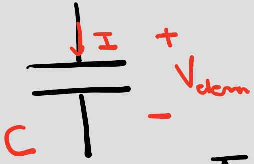
Every Capacitor can be charged up to a fixed Voltage.

The capacitor will charge a "load" until the charges on the plate are equalized. (No change in V)

https://www.youtube.com/watch?v=X4EUwTwZ110

Circuit Model: IV relationship

Capacitor Symbol



$$Q_{elem} = C \cdot V_{elem}$$

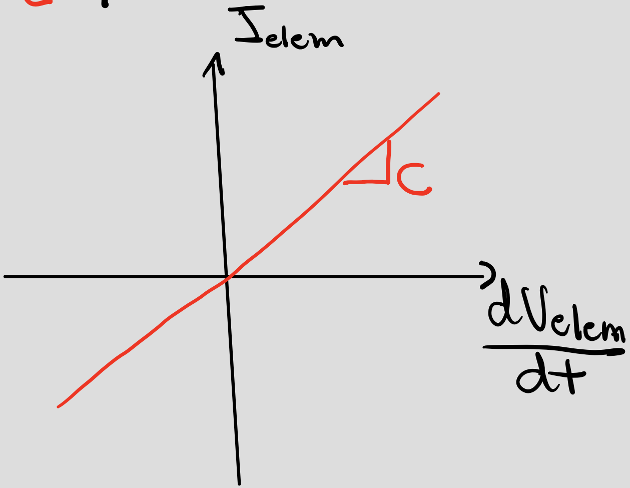
[C] [F] [V]

(Farad)

We know: $I_{elem} = \frac{dQ_{elem}}{dt}$

$$I_{elem} = \frac{d}{dt} C \cdot V_{elem}$$

C = constant over time



$$I_{elem} = C \cdot \frac{dV_{elem}}{dt}$$

↳ Can use the same 7-step analysis.