

#ref

## 1 | Capacitors vs. Batteries

**Batteries** => Converting  $PE_{chem}$  => Eletrical energy

**Capacitors** => Converting  $PE_{elec}$  => Eletrical energy

When you are discharging a battery, they remain at constant voltage until they are used up, at which point the voltage drop like a plate.

When you are discharging a capacitor, there is a linear fall in voltage that is constant.

Charge remaining: capacitance times voltage

## 2 | Energy on a Capacitor

A little bit #disorganized

Energy stored on a capacitor:  $E = \frac{V_c * Q}{2}$ .

Charge on a capacitor:  $Q = C \times V_c$

Farads:  $F = \frac{C}{V}$

So, putting this together, the energy stored on a capacitor would be...

[as  $Q = C \times V_c$ ] Energy stored in a capacitor  $\{E = \frac{V \times Q}{2} = \frac{CV^2}{2}\}$   $Q_{cap} \propto V$ . In fact  $Q_{cap} = C \times V_c$ .

## 3 | Capacitors interacting with Resistance

As you increase the KBhPHYS201ResistanceConductivity, the a capacitor of the same capacitance would charge slower. (*"Less charge flows in"*)

As you fix the Resistance, the capacitor of a higher capacitance would charge slower. (*"Need more change to fill"*)

*Charging time* is in fairly good agreement with *resistance times capacitance*.

So... #disorganized

Experimentally, "Charging time",  $\tau \approx R \times C$ .

Let's check the units!

- $V = IR$
- $R = \frac{V}{I}$
- So  $R = \omega = \frac{V * s}{Q}$
- $Q = CV$
- So  $\frac{Q}{V} = C$

Hence,  $R \times C = \frac{V \times s}{Q} = \frac{Q}{Q}$ , indeed, has a unit Seconds!

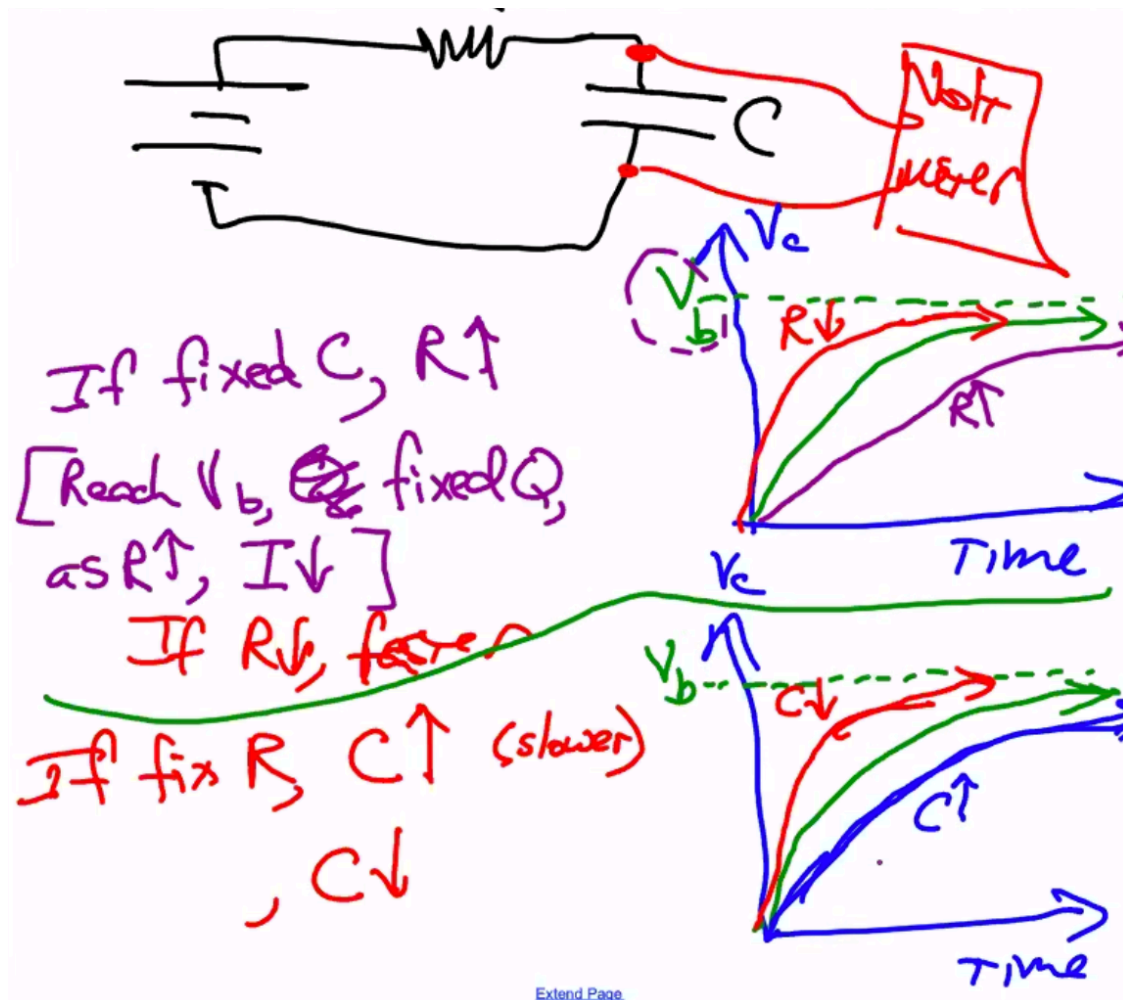


Figure 1: Screen Shot 2020-09-30 at 10.42.44 AM.png

## 4 | Equations modeling charging a capacitor

[where  $R$  is the resistance,  $C$  is the capacitance] Time Constant  $\tau = RC$  — time constant to be able to change the capacitor to a useful voltage; aka how much does the capacitor need to noticeably charge/discharge. Now that we have this value, we could also represent the full charge process using the equations as follows:

[where  $V_b$  is the battery voltage,  $t$  is time elapsed,  $R$  is resistance, and  $C$  is the capacitance] Current in circuit as you charge a capacitor  $\{I(t) = \frac{V_b}{R} \times e^{-\frac{t}{RC}}\}$  As you start to charge a capacitor, the current starts at  $\frac{V_b}{R}$  — current just without the resistor. Then, it will slowly drop down to 0.

[where  $V_b$  is the battery voltage,  $t$  is time elapsed,  $R$  is resistance, and  $C$  is the capacitance] Voltage before and after a capacitor as you charge a capacitor  $\{V(t) = V_b \times (1 - e^{-\frac{t}{RC}})\}$  #disorganized

## 5 | Capacitors in series and parallel

Helpful to see: KBhPHYS201CombiningResistors

### 5.1 | Capacitors in Parallel

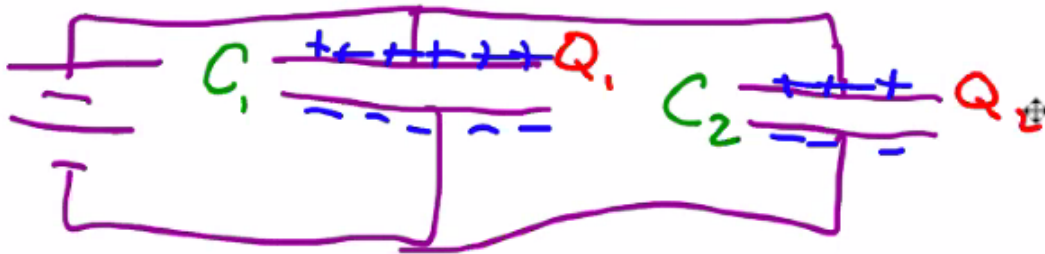


Figure 2: Screen Shot 2020-10-07 at 10.20.06 AM.png

$$Q_{tot} = Q_1 + Q_2.$$

And, because of the fact that  $C = \frac{Q}{V}$ ,  $V \times C_{eq} = V \times C_1 + V \times C_2$

Dividing  $V$  out of the previous equations  $C_{eq} = C_1 + C_2$ .

**Capacitors in parallel act like resistors in series.**

### 5.2 | Capacitors in Series

Because of the fact that the middle wire does not carry any charges, it is "neutral" and simply polarized — making  $Q_1$  equaling  $Q_2$ .

Why is this? If the middle bit is neutral, the  $Q^+$  on one end would equal to the  $Q^-$  on the other. Correspondingly, the other side of the plates of the capacitor would have the opposite of the same values  $Q^-$  and  $Q^+$  on the neutral middle plate.

By the transitive property,  $Q_1 = Q_2$ .

Because  $V_1 + V_2 = V_b$  — see KBhPHYS201CombiningResistors &  $C = \frac{Q}{V}$ ,  $\frac{Q_1}{V} + \frac{Q_2}{V} = \frac{Q_{tot}}{V}$ .



Figure 3: Screen Shot 2020-10-07 at 10.23.08 AM.png

Given  $Q_1 = Q_2$ .

So

### 5.3 | Construction of Capacitors

A diagram of the plates inside a polar capacitor before being rolled up.

