Source: [[KBhPHYS201CircuitsIndex]]

1 | Capacitors

1.1 | 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

1.2 | 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…

Definition 1 · **Energy stored in a capacitor** $E = \frac{V \times Q}{2} = \frac{CV^2}{2}$
as $Q = C \times V_c$

$Q_{cap} \propto V$. In fact $Q_{cap} = C \times V_c$.

1.3 | Capacitors interacting with Resistance

As you increase the [[KBhPHYS201Resistance]], 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"*)

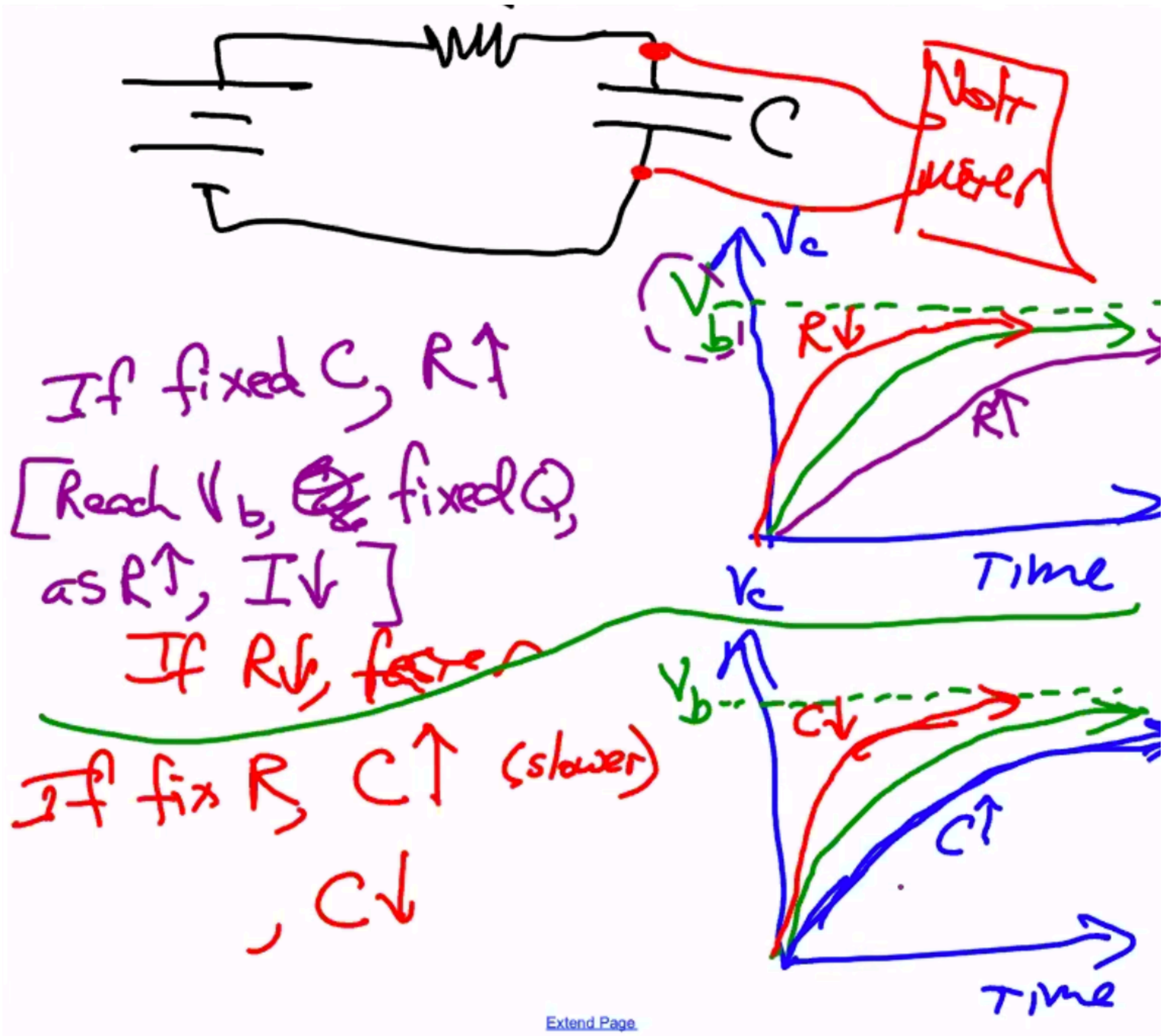

Figure 1: Screen Shot 2020-09-30 at 10.42.44 AM.png

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

1.4 | **Equations modeling charging a capacitor**

Definition 2 · **Time Constant Tau** $RC = \tau$ — time constant to be able to change the capacitor to a useful voltage; aka how much does the capacitor need to noticeably charge/discharge.
where R is the resistance, C is the capacitance

Now that we have this value, we could also represent the full charge process using the equations as follows:

Definition 3 · **Current in circuit as you charge a capacitor** $I(t) = \frac{V_b}{R} \times e^{\frac{-t}{RC}}$
where V_b is the battery voltage, t is time elapsed, R is resistance, and C is the capacitance

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.

Definition 4 · **Voltage before and after a capacitor as you charge a capacitor** $V(t) = V_b \times (1 - e^{\frac{-t}{RC}})$
where V_b is the battery voltage, t is time elapsed, R is resistance, and C is the capacitance

#disorganized

1.5 | **Capacitors in series and parallel**

Helpful to see: [[KBhPHYS201CombiningResistors]]

1.5.1 | **Capacitors in Parallel**

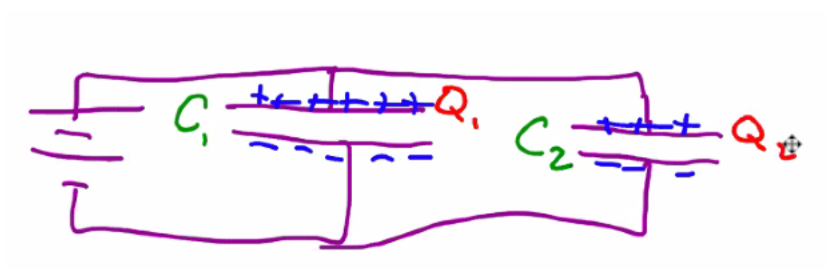

Figure 2: Screen Shot 2020-10-07 at 10.20.06 AM.png

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

1.5.2 | **Capacitors in Series**

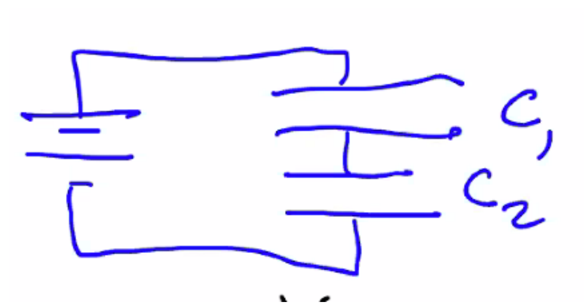

Figure 3: Screen Shot 2020-10-07 at 10.23.08 AM.png

Because of the fact that the middle wire does not carry any changes, 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]] & $C = \frac{Q}{V}$, $\frac{Q_1}{V} + \frac{Q_2}{V} = \frac{Q_{tot}}{V}$.

Given $Q_1 = Q_2$.

So

1.6 | **Construction of Capacitors**

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

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