RC circuits

- Charging: when the capacitor is charging or storing electrity
- discharging: when the capacitor is losing electrity

Charging: Charge and Voltage rise and current decays

$Q = C\mathcal{E}(1-e^{-t/RC})$

- Q = electric charge (C)
- $\mathcal{E}$ = emF
- C = capacitor
- R = resistance

$I(t) = \frac{\mathcal{E}}{R} e^{-t/RC}$

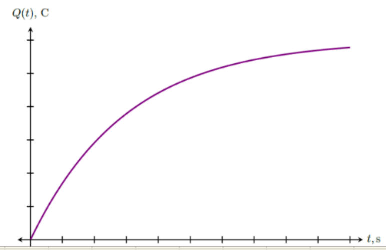
- I = charge (amps)
- $\mathcal{E}$ = em F
- C = Capacitor
- R = resistance

$\Delta V(t) = \mathcal{E}(1-e^{-t/RC})$

- V = Voltage drop (V)
- $\mathcal{E}$ = em f
- R = resistor
- C = capacitor

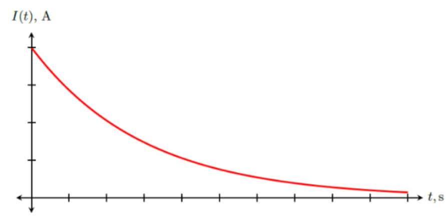
Q vs. T

The resulting plots look something like this:



I vs. T

- The resulting plots look something like this:



- $\Delta V = \frac{Q}{C}$ you can apply this equation on charging or discharging its always true

☆ this only works For charging capacitors

When T (time) goes to inFinte $\Delta V = \mathcal{E}$

$$\Delta V(\infty) = \mathcal{E}(1-e^{-t/RC}) \Rightarrow \Delta V(\infty) = \mathcal{E}(1-\cancel{e^{-\infty/RC}}^{\,0})$$

$$\Delta V = \mathcal{E}$$

• discharging: Charge and Voltage decay to zero

$Q(t) = Q_0 e^{-t/RC}$

$Q_0 = C\mathcal{E}$

Plug it in

$Q(t) = C\mathcal{E} e^{-t/RC}$

$I(t) = \frac{\mathcal{E}}{R} e^{-t/RC}$

$I(t) = \frac{Q_0}{\tau} e^{-t/\tau}$

- I = current (amps)
- $\mathcal{E}$ = emf
- R = resistance
- C = capacitor

$\Delta V(t) = \mathcal{E} e^{-t/RC}$

- ΔV = voltage drop (V)
- $\mathcal{E}$ = emf
- R = resistance
- C = capacitor

• time constant and half life

time constant = $\tau = RC$ half life = $t_{1/2}$ = $\tau = \frac{t_{1/2}}{LN(2)}$

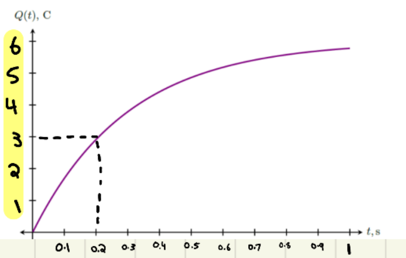
the half life helps you get the time constant once you get the half life ($t_{1/2}$) you can solve for the time constant

☆ you can use the half life equation on a discharging graph or a charging capacitor graph

how to get the half life:

Q vs. T

The resulting plots look something like this:



take the charge and divide it by 2

$6Q/2 = 3$

now go to three (3Q) and see where the the graph will cross or the time at the point is

so the half life ($t_{1/2} = 0.2$) now plug that into:

$\tau = \frac{t_{1/2}}{LN(2)}$

- Capacitor in circuts

- Capacitor in Series

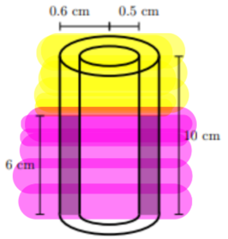
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$$

☆ Capacitors in series have the Same charge Q

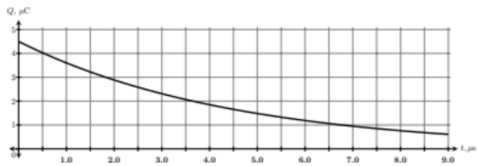
- Capacitors in Series

$$C_{eq} = C_1 + C_2 + C_3 + \cdots$$

☆ Capacitors in Parallel have the Same Voltage V



At time $t = 0$, this capacitor is attached to a resistor of unknown resistance R, and the charge Q on the capacitor as a function of time is plotted in the graph below.



1. What is the capacitance of this cylindrical capacitor? Hint: use your notes from last lab, and treat this capacitor as two capacitors!
2. What is the resistance R of the unknown resistor?
3. What is the initial current I in this discharging RC circuit?

the best way to solve is to break it in two Parts into this Part and the Second Part you will use this equation:

$$C = \frac{2\pi L \varepsilon_0}{\ln(b/a)} \quad \text{and} \quad C = \frac{2\pi L K \varepsilon_0}{\ln(b/a)}$$

as the second part has dieletric

☆ you can add capacitors togther

1

$$C = \frac{2\pi(0.04)(8.85\times10^{-12})}{\ln\left(\frac{0.006}{0.005}\right)} + \frac{2\pi(0.06)(20.7)(8.85\times10^{-12})}{\ln\left(\frac{0.006}{0.005}\right)} = \boxed{3.79\times10^{-10}\ F}$$

to Find R we will use half life

② $t_{1/2} = \frac{4.5}{2} = 2.25\ \mu Q = 3.0\times10^{-6}$

$$\tau = \frac{t_{1/2}}{\ln(2)} = \frac{3.0\times10^{-6}}{\ln(2)} = 4.32\times10^{-6}\ s$$

$\tau = RC$

$4.32\times10^{-6} = R(3.79\times10^{-10})$

$\boxed{R = 11419\ \Omega}$

③

$$I(t) = \frac{Q_0}{\tau}e^{-t/\tau} = \frac{4.5\times10^{-6}}{4.47\times10^{-6}} \cdot e^{-0/4.47\times10^{-6}} = \boxed{1.0\ A}$$