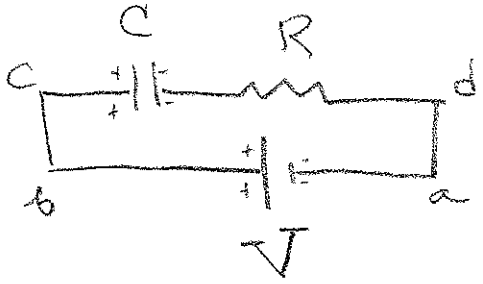


Loop abcda:

$$V - \frac{Q}{C} - IR = 0$$

$$I = \frac{dQ}{dt} \Rightarrow V - \frac{Q}{C} - R\frac{dQ}{dt} = 0$$

$$\frac{V}{R} - \frac{Q}{RC} - \frac{dQ}{dt} = 0 \Rightarrow \frac{V}{R} - \frac{Q}{RC} = \frac{dQ}{dt}$$

$$dt = \frac{dQ}{\frac{V}{R} - \frac{Q}{RC}} \Rightarrow \int_0^t d\tilde{t} = \int_{q_0}^{q} \frac{dQ}{\frac{V}{R} - \frac{Q}{RC}} \Rightarrow t = \int_{q_0}^{q} \frac{dQ}{\frac{V}{R} - \frac{Q}{RC}}$$

Let $u = \frac{V}{R} - \frac{Q}{RC}$, then $du = -\frac{1}{RC}\,dQ \Rightarrow dQ = -RC\,du$

$$t = \int -\frac{RC\,du}{u} = -RC\ln u = -RC\ln\left|\frac{V}{R} - \frac{Q}{RC}\right|\Big|_{q_0}^{q}$$

$$-\frac{t}{RC} = \underbrace{\ln\left|\frac{V}{R} - \frac{q}{RC}\right| - \ln\left|\frac{V}{R} - \frac{q_0}{RC}\right|}_{\ln a - \ln b = \ln\frac{a}{b}} = \ln\left|\frac{\frac{V}{R} - \frac{q}{RC}}{\frac{V}{R} - \frac{q_0}{RC}}\right|$$

$$\Rightarrow -\frac{t}{RC} = \ln\left|\frac{VC - q}{VC - q_0}\right| \qquad e^{\ln x} = x \Rightarrow$$

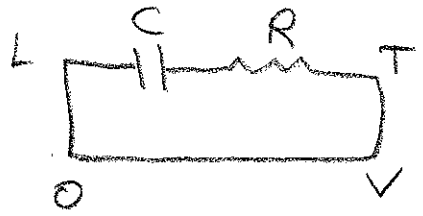
$$e^{-t/RC} = \frac{VC - q}{VC - q_0} \Rightarrow (VC - q_0)e^{-t/RC} = VC - q$$

$$q = VC - (VC - q_0)e^{-t/RC} \qquad \text{let } q_0 = 0$$

$$q = VC - VCe^{-t/RC} = VC(1 - e^{-t/RC})$$

$$\boxed{q = VC(1 - e^{-t/RC})}$$ Charging of capacitor.

Capacitor Discharging



Loop VOLTV: $-\frac{Q}{C} - IR = 0 \quad I = \frac{dQ}{dt} \Rightarrow$

$$-\frac{Q}{C} - R\frac{dQ}{dt} = 0 \Rightarrow -\frac{Q}{RC} = \frac{dQ}{dt}$$

$$\Rightarrow -\frac{1}{RC}dt = \frac{dQ}{Q} \Rightarrow -\frac{1}{Rc}\int_0^t d\tilde{t} = \int_{q_0}^{q}\frac{dQ}{Q}$$

$$-\frac{1}{RC}t = \ln Q\Big|_{q_0}^{q} = \ln q - \ln q_0 = \ln\left|\frac{q}{q_0}\right| \Rightarrow$$

$$e^{-t/RC} = e^{\ln(q/q_0)} = \frac{q}{q_0} \qquad (e^{\ln x} = x)$$

$$\Rightarrow \boxed{q = q_0 e^{-t/RC}}$$ Capacitor discharging

RC = time constant $\quad (1\Omega)(1F) = 1s.$

Units are seconds (time)