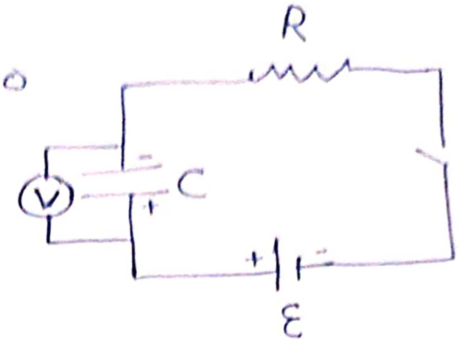
Exp 9: RC Circuit:

uncharged cpacitor: at $t=0$, $Q_0 = 0$



Part A: Charging

$\Sigma V_i = 0$

$\varepsilon - IR - \frac{Q}{C} = 0$, $V_R = IR$

$V_c = \frac{Q}{C}$

but, $I = \frac{dQ}{dt}$

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

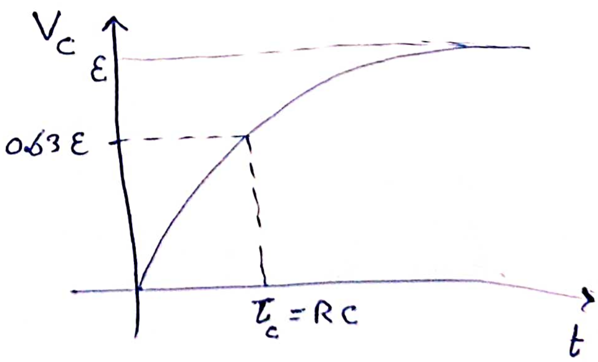
$$\boxed{Q(t) = \varepsilon C(1 - e^{-t/RC})}$$

$\Rightarrow V_c(t) = \frac{Q(t)}{C} = \varepsilon(1 - e^{-t/RC})$

* at $t=0$ $\Rightarrow V_c(0) = \varepsilon(1 - \underbrace{e^{0}}_{1}) = 0$
* at $t=\infty$ (long time) $\Rightarrow V_c(\infty) = \varepsilon(1 - \cancel{e^{-\infty}}^{0}) = \varepsilon$
* at $t = RC$ (time Const τ)

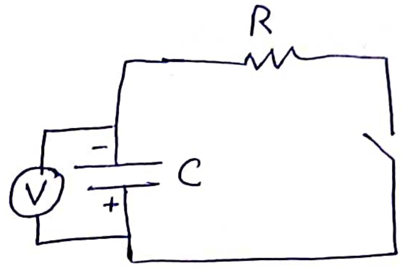
$\Rightarrow V_c(\tau) = \varepsilon(1 - \underbrace{e^{-1}}_{0.37})$

$$\boxed{V_c(\tau) = 0.63\,\varepsilon}$$



The time Const. of the circuit is the time needed for the Potential difference on the capacitor to reach 0.63 of the max. Voltage (ε). [its indication of how fast the charging is]

* Part B: Discharging.



$$\sum V_i = 0$$

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

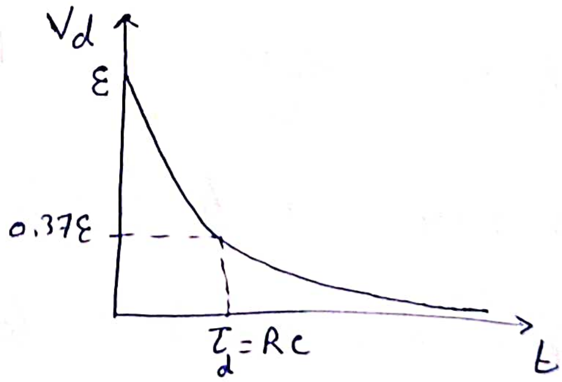
$$-\frac{dQ}{dt} R - \frac{Q}{C} = 0$$

$$\Rightarrow Q(t) = Q_o e^{-t/RC} = \varepsilon C e^{-t/RC}$$

$$\boxed{V_d(t) = \varepsilon e^{-t/RC}}$$

* at $t=0 \Rightarrow V_d(0) = \varepsilon e^{0} = \varepsilon$
* at $t=\infty \Rightarrow V_d(\infty) = \varepsilon e^{-\infty} = 0$
* at $t = RC$ (time Const.)

$$V_d(\tau) = \varepsilon e^{-1} = 0.37\varepsilon$$



$V_d(t) = \mathcal{E} e^{-t/RC}$ $\Rightarrow$ if we take ~~ln V(t)~~ natural logarithm of both sides

$$\ln V_d(t) = \ln(\mathcal{E} e^{-t/RC})$$

$$\ln V_d(t) = \ln \mathcal{E} + \ln(e^{-t/RC})$$

$$\boxed{\ln V_d(t) = \ln \mathcal{E} - \frac{t}{RC}}$$

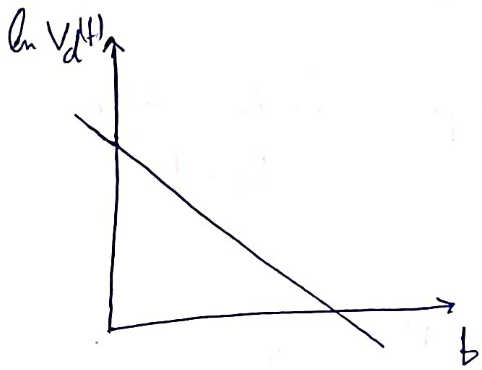
let $y = \ln V_d(t)$

$x = t$

$y = mx + y_{int}$

if we plot "$\ln V_d(t)$ Vs t"

$\Rightarrow$ slope $= \frac{-1}{RC} = \frac{-1}{\tau}$



$$\Rightarrow \boxed{\tau_s = \frac{-1}{\text{slope}}}$$

$y_{-int} = \ln \mathcal{E}$

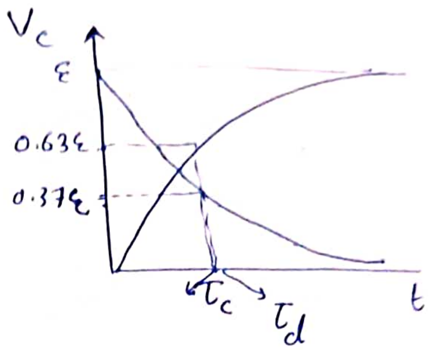
* we have three values of "τ" : τ_c , τ_d , τ_s

$\bar{\tau} = RC$ (unknown C)

$$C = \frac{\bar{\tau}}{R}$$

$$\frac{\Delta C}{C} = \frac{\Delta \bar{\tau}}{\bar{\tau}} + \frac{\Delta R}{R} \quad , \quad \Delta\bar{\tau} = \delta_m(\tau)$$

① plot $V_c(t)$ vs. t , Find τ_c

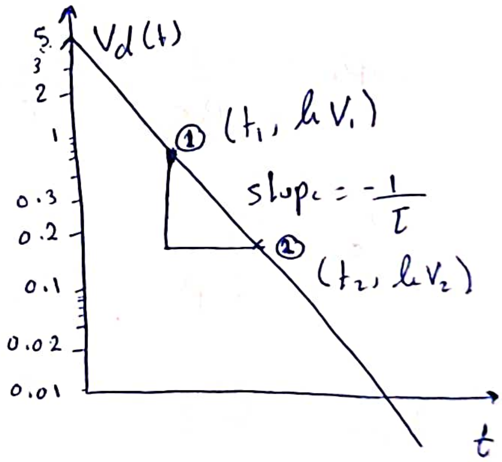


② plot $V_d(t)$ vs. t , Find τ_d

③ on a semi-log graph paper , plot $V_d(t)$ vs. t
[instead of $\ln V_d(t)$ vs. t]

$$\text{slope} = \frac{\ln V_2 - \ln V_1}{t_2 - t_1}$$

$$\text{slope} = \frac{-1}{\tau}$$



4) ~~R~~ $R \mp \Delta R$ from the color code.

5) C_{Theo} (from the picture)