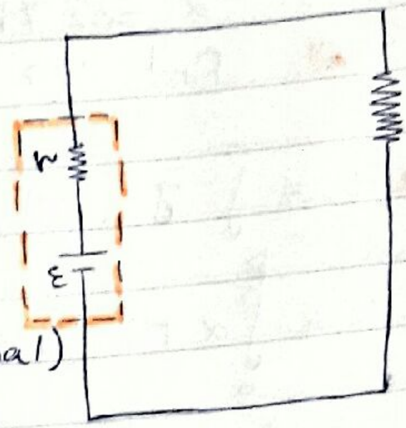
27- Circuits

→ Electromotive force ($\mathcal{E}$)

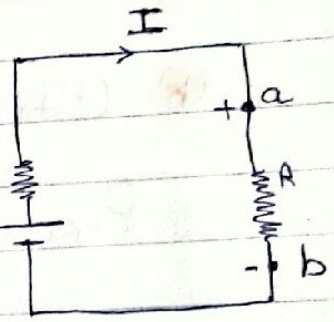


Emf = work done by the Power source (Battery) in moving +1C. ((-1) terminal to (+1) terminal) in inside the source.

→ $\frac{dw}{dt} = \frac{\mathcal{E}\, dq}{dt}$

- Power by $\mathcal{E}$ = $\mathcal{E} i$ watt

→ Energy transfer in the Circuit:



- Electric energy transfer $(a \to b) = \Delta q\, V$ (Joul)

- Energy transfer = $\Delta q\, V$

- Power transfer = $\frac{\Delta q\, V}{\Delta t}$ watt

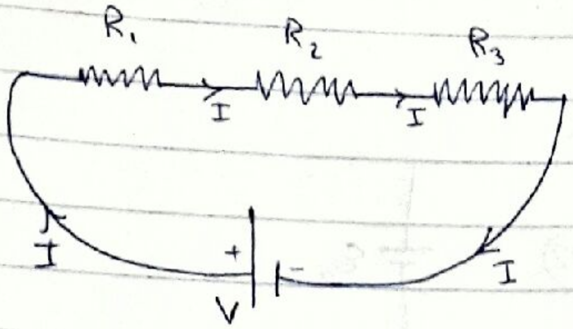
$P_R = Vi = Ri^2 = ri$

- From Conservation of energy:

$$\mathcal{E} i = i^2 R + i^2 r$$

$$\mathcal{E} = i(R + r) \Rightarrow i = \frac{\mathcal{E}}{R+r}$$

* R in Series :



$\Rightarrow I_1 = I_2 = I_3$

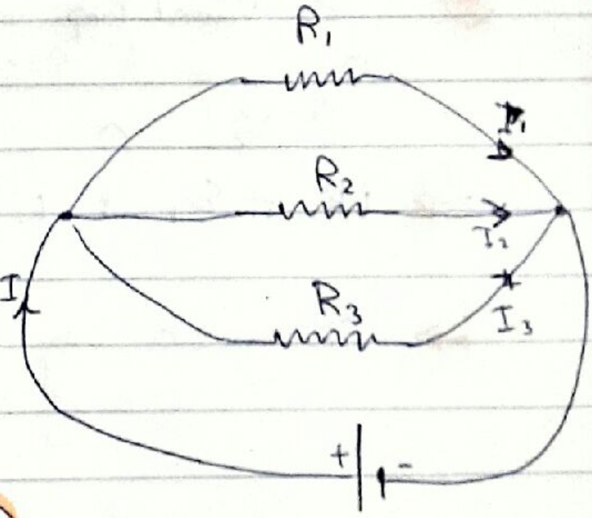
$\Rightarrow V = V_1 + V_2 + V_3$

$V = R_1 I + R_2 I + R_3 I$

$\frac{V}{I} = R_1 + R_2 + R_3$

$$\boxed{R_{eq} = R_1 + R_2 + R_3}$$

* R in Parallel



$\Rightarrow V_1 = V_2 = V_3 = V$

$I_1 R_1 = I_2 R_2 = I_3 R_3$

$\Rightarrow I = I_1 + I_2 + I_3$

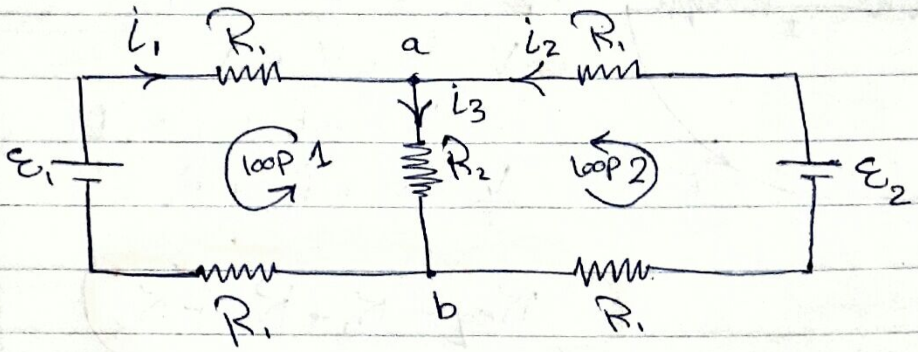
$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$

$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$$\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

* Multi loop circuits :-

Sample Problem (24.04):-



Kirchoff's rules :-

① $\sum I_{in} = \sum I_{out}$

$I_1 + I_2 = I_3$ —— ①

② $\sum V_{closed\ loop} = 0$

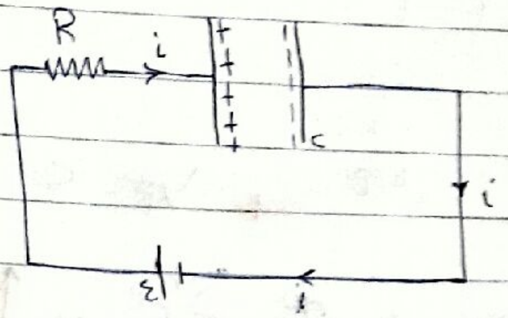
$\sum V_{aa} = 0$

$\Rightarrow i_1R_1 - \varepsilon_1 + i_1R_1 + i_3R_2 = 0$ (loop 1)

$\Rightarrow \sum V_{aa} = 0 \Rightarrow -R_2i_3 - R_1i_2 + \varepsilon_2 - i_2R_1 = 0$ (loop 2)

RC - Circuits

① Charging a Capacitor :-



$$\varepsilon = V_R + V_c$$

$$\varepsilon = Ri + \frac{q}{c}$$

- At $t=0$ → $q = 0$; → $i = \frac{\varepsilon}{R}$
- After along time → $q_{max} = C\varepsilon$; → $i = 0$
- find $q(t)$, $i(t)$; $V_c(t)$, $V_R(t)$?

$$\sum V_{aa} = 0$$

$$\varepsilon - Ri - \frac{q}{c} = 0$$

$$\varepsilon - \frac{R\,dq}{dt} - \frac{q}{c} = 0$$

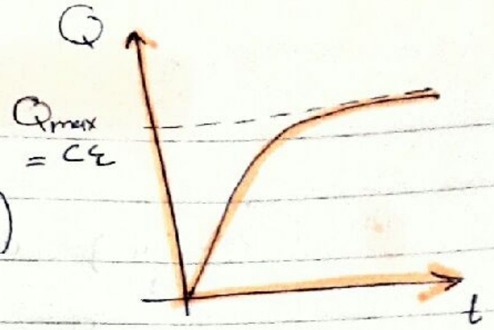
$$-R\frac{dq}{dt} = \frac{q}{c} - \varepsilon$$

$$\int_0^Q \frac{dq}{q - C\varepsilon} = \int_0^t \frac{-dt}{RC}$$

$$\ln(q - C\varepsilon)\Big|_0^Q = \frac{-t}{RC}$$

$$\ln(Q - C\varepsilon) - \ln - C\varepsilon = \frac{-t}{RC}$$

$$\Rightarrow \ln\left(\frac{Q - C\varepsilon}{-C\varepsilon}\right) = \frac{-t}{RC} \Rightarrow$$



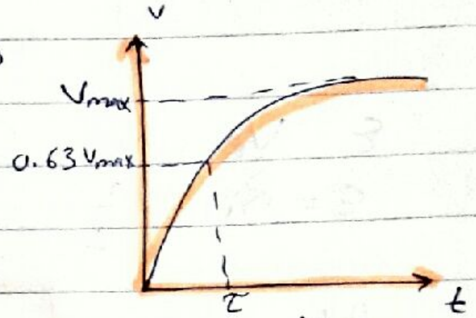
$$Q(t) = C\varepsilon\left(1 - e^{-t/RC}\right)$$

$$V_c(t) = \varepsilon\left(1 - e^{-t/\tau}\right)$$

$$\Rightarrow i(t) = \frac{dQ}{dt} = \frac{-C\varepsilon \, e^{-t/RC}}{-RC}$$

$$i(t) = -\frac{\varepsilon}{R} \cdot e^{-t/\tau} \Rightarrow V_R = \varepsilon e^{-t/\tau}$$

- Find q at $\Rightarrow t = \tau$??



charghing

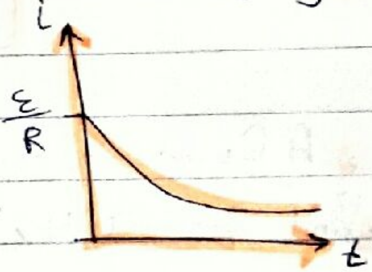
$$q = C\varepsilon\left(1 - e^{-\tau/\tau}\right)$$

$$= C\varepsilon\left(1 - e^{-1}\right)$$

$$= C\varepsilon\left(1 - 0.37\right)$$

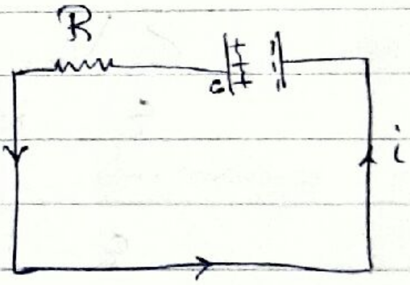
$$q(\tau) = 0.63\, C\varepsilon$$

$$V_c(\tau) = 0.63\, \varepsilon$$



② Dischargbing a Capacitor:

$$\int_{q_0}^{q} \frac{dq}{q} = \int_0^t \frac{dt}{RC}$$



$$q(t) = q_0\, e^{-t/\tau}$$

$$V(t) = V_0\, e^{-t/\tau}$$