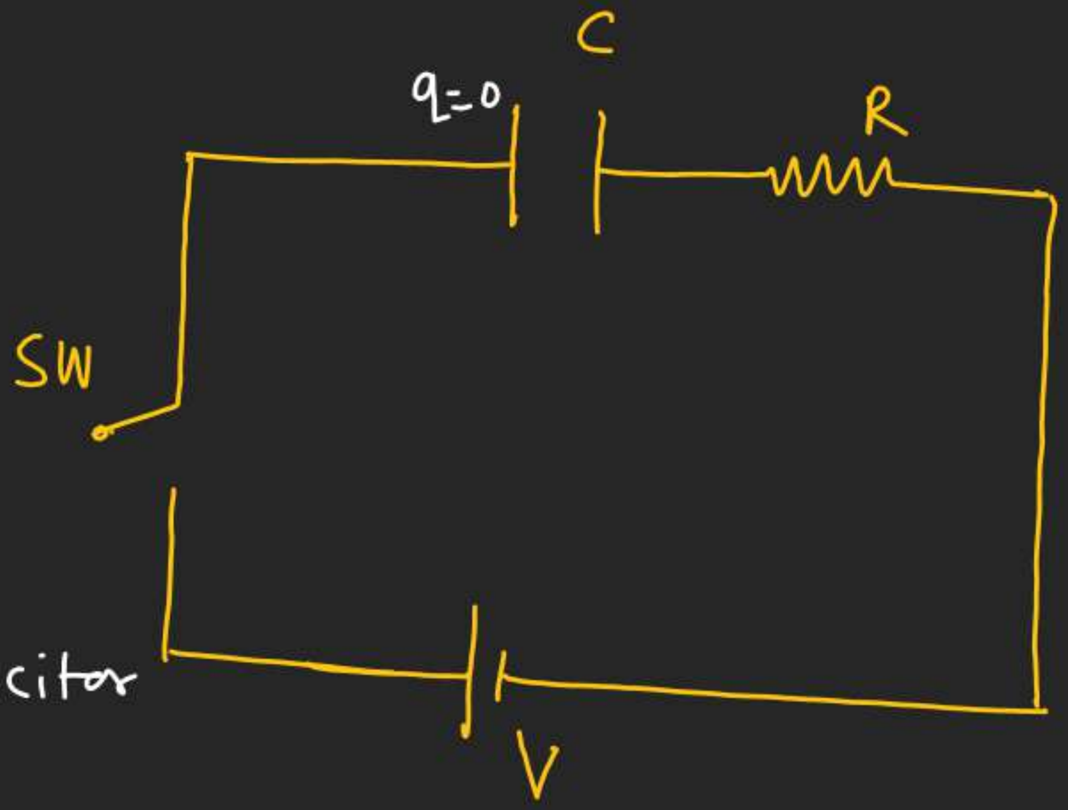
RC ckt

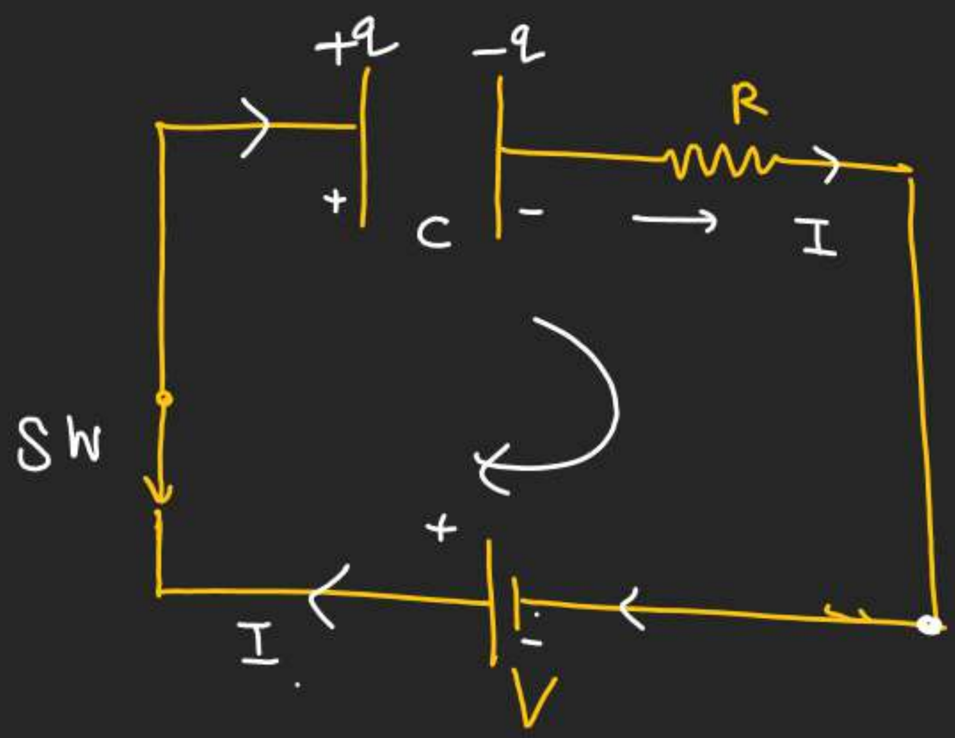
CURRENT ELECTRICITY

(*) Growth of Current in R.C Ckt

Initially Capacitor is uncharged
At $t=0$, SW is Closed.



When SW Closed:- When SW closed, Charging of Capacitor start.



At $t=t$, let charge on the capacitor is q.
During charging of Capacitor
$I = \left(+\frac{dq}{dt}\right)$

K.V.L

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

Nishant Jindal

RC ckt

CURRENT ELECTRICITY

$$\int \frac{dx}{a+bx} = \frac{\ln(a+bx)}{b}$$

a & b constant

$$V - \frac{q}{C} - iR = 0$$

$$V - \frac{q}{C} = iR$$

$$CV - q = RC\, i$$

$$(CV - q) = RC\left(\frac{dq}{dt}\right)$$

$$\int_0^q \frac{dq}{\underbrace{CV}_{a} - \underbrace{q}_{x}} = \frac{1}{RC}\int_0^t dt$$

a (-1) x

b

$$\frac{\ln[CV-q]_0^q}{(-1)} = \frac{1}{RC}t$$

$$\ln[CV-q] - \ln[CV] = -\frac{1}{RC}t$$

$$\ln\left[\frac{CV-q}{CV}\right] = -\frac{t}{RC}$$

$$\frac{CV-q}{CV} = e^{-t/RC}$$

$$CV - q = CV e^{-t/RC}$$

$$\boxed{q = CV\left(1 - e^{-t/RC}\right)}$$ **

$q_{max} = CV$ at $t \to \infty$

[At $t=0$, $q=0$]

Nishant Jindal

RC ckt

CURRENT ELECTRICITY

Time Constant of RC Ckt.

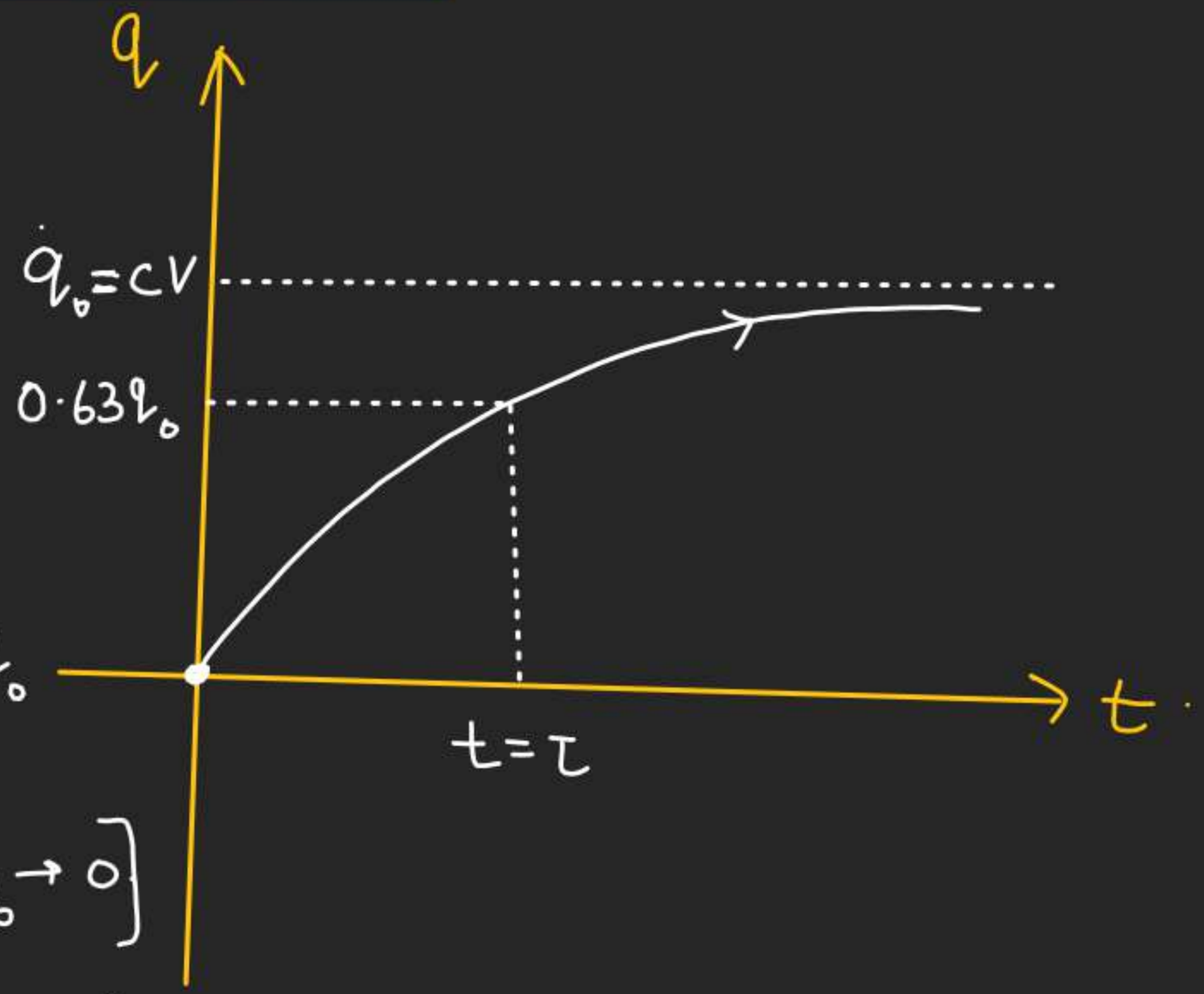
$$q = \underline{q_0}\left(1 - e^{-t/\tau}\right)$$

$$\boxed{\tau = RC}$$

$\downarrow$ Time Constant of R-C Ckt.

$$\boxed{q_0 = \underline{\underline{CV}}}$$

$\Rightarrow$ (Maximum charge on the Capacitor)



$$q = \lim_{t \to \infty} \underline{\underline{q_0}}\left(1 - \underset{\downarrow 0}{\underline{e}^{-t/\tau}}\right) \Rightarrow q = q_0$$

$$\left[e^{-\infty/\tau} \rightarrow e^{-\infty} \rightarrow \frac{1}{e^{\infty}} \rightarrow 0\right]$$

At $t = \tau$

$$q = q_0\left(1 - e^{-\tau/\tau}\right)$$

$$q = q_0\left(1 - \frac{1}{e}\right)$$

$$\boxed{q = 0.63q_0}$$

Def^n (τ) $\rightarrow$ It is time when Capacitor is charged to 63% of its maximum Value

Nishant Jindal

RC ckt

CURRENT ELECTRICITY

$I = f(t).$

$$q = q_0\left(1 - e^{-t/\tau}\right)$$

$\tau = RC$

$q_0 = CV$

$$\boxed{\frac{d}{dx}\left(e^{\alpha x}\right) = \alpha e^{\alpha x}}$$

$\alpha =$ Constant.

For Charging

$$I = \left(+\frac{dq}{dt}\right)$$

$$I = q_0 \frac{d}{dt}\left(1 - e^{-t/\tau}\right).$$

$$I = q_0\left[-\frac{d}{dt}\left(e^{-t/\tau}\right)\right]$$

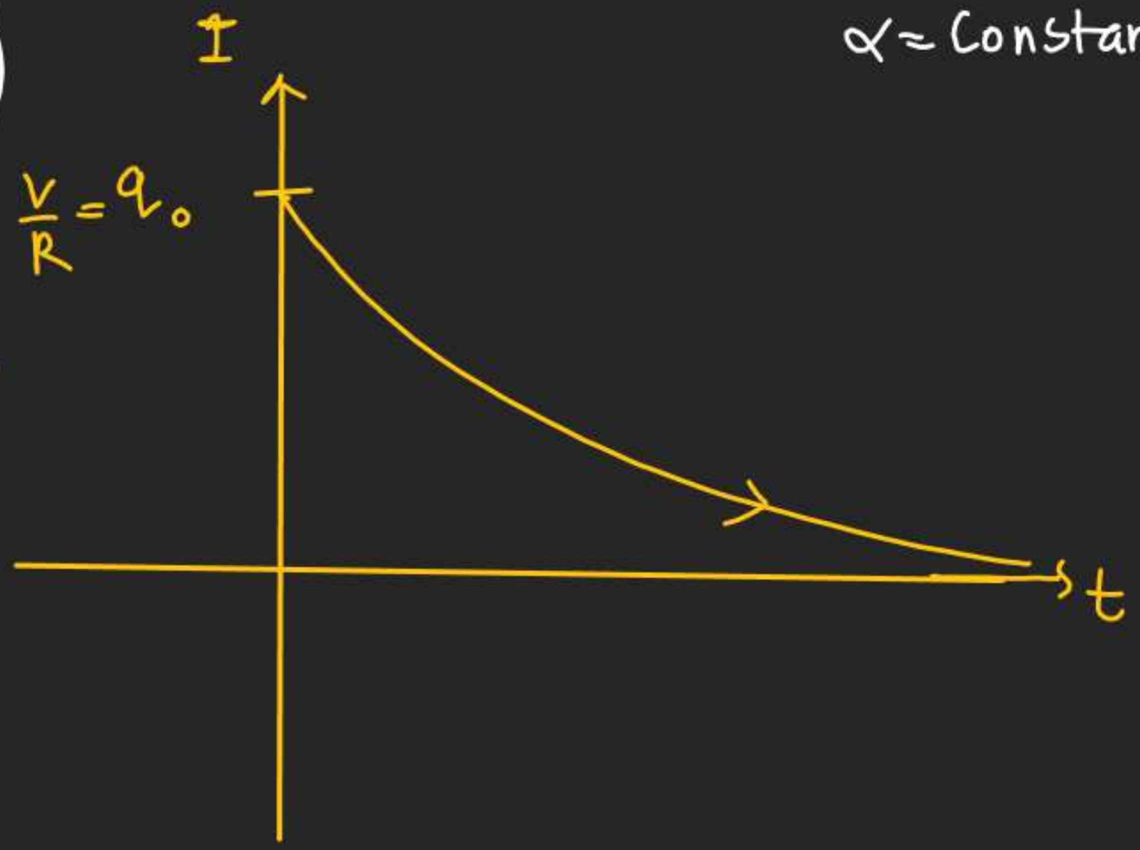
$$I = q_0\left[(-1)\left(\frac{-1}{\tau}\right)\left(e^{-t/\tau}\right)\right]$$

$$I = \frac{q_0}{\tau}\left(e^{-t/\tau}\right)$$

$$I = \frac{CV}{RC}\left(e^{-t/\tau}\right)$$

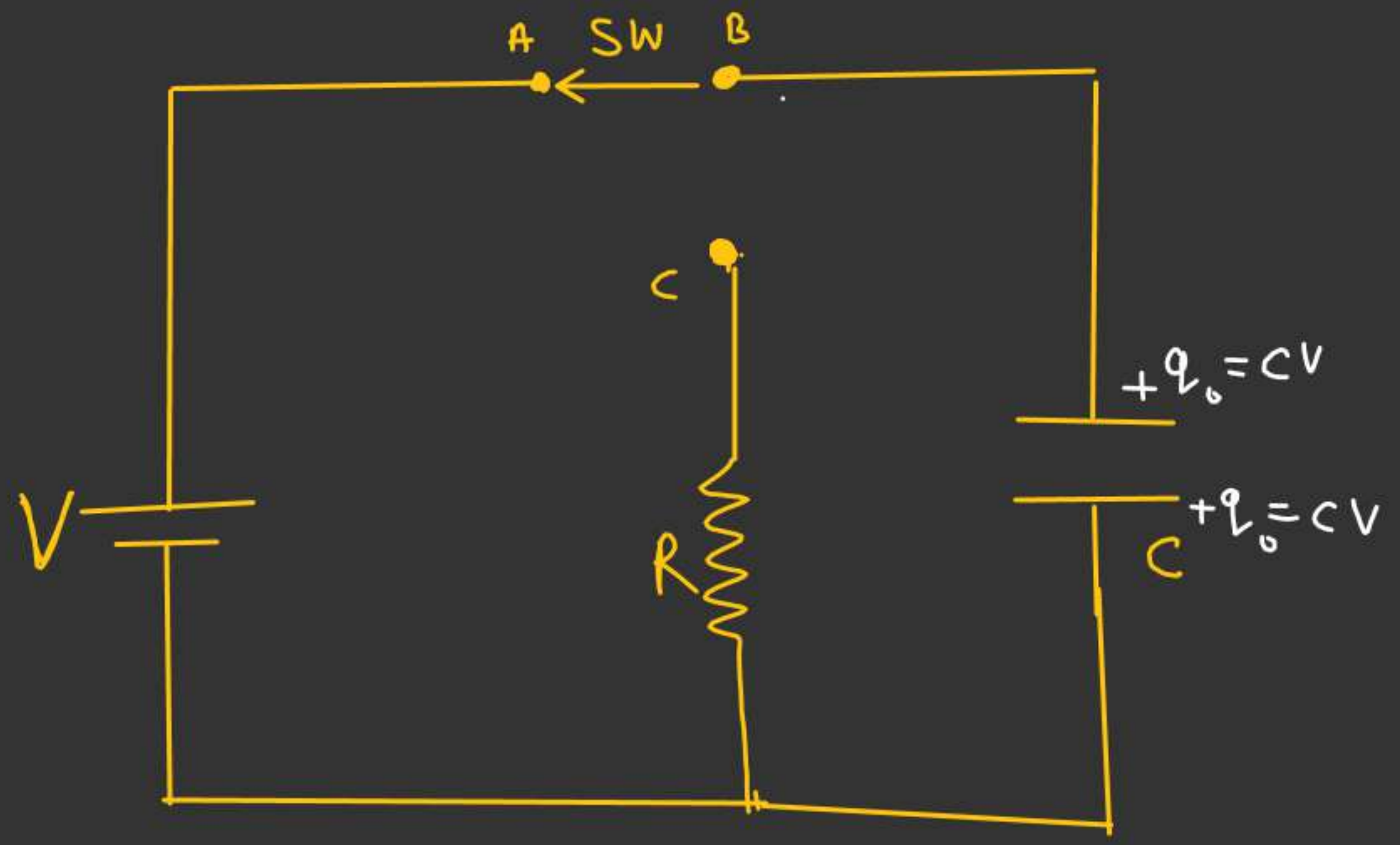
$$I = \left(\frac{V}{R}\right)e^{-t/\tau}$$

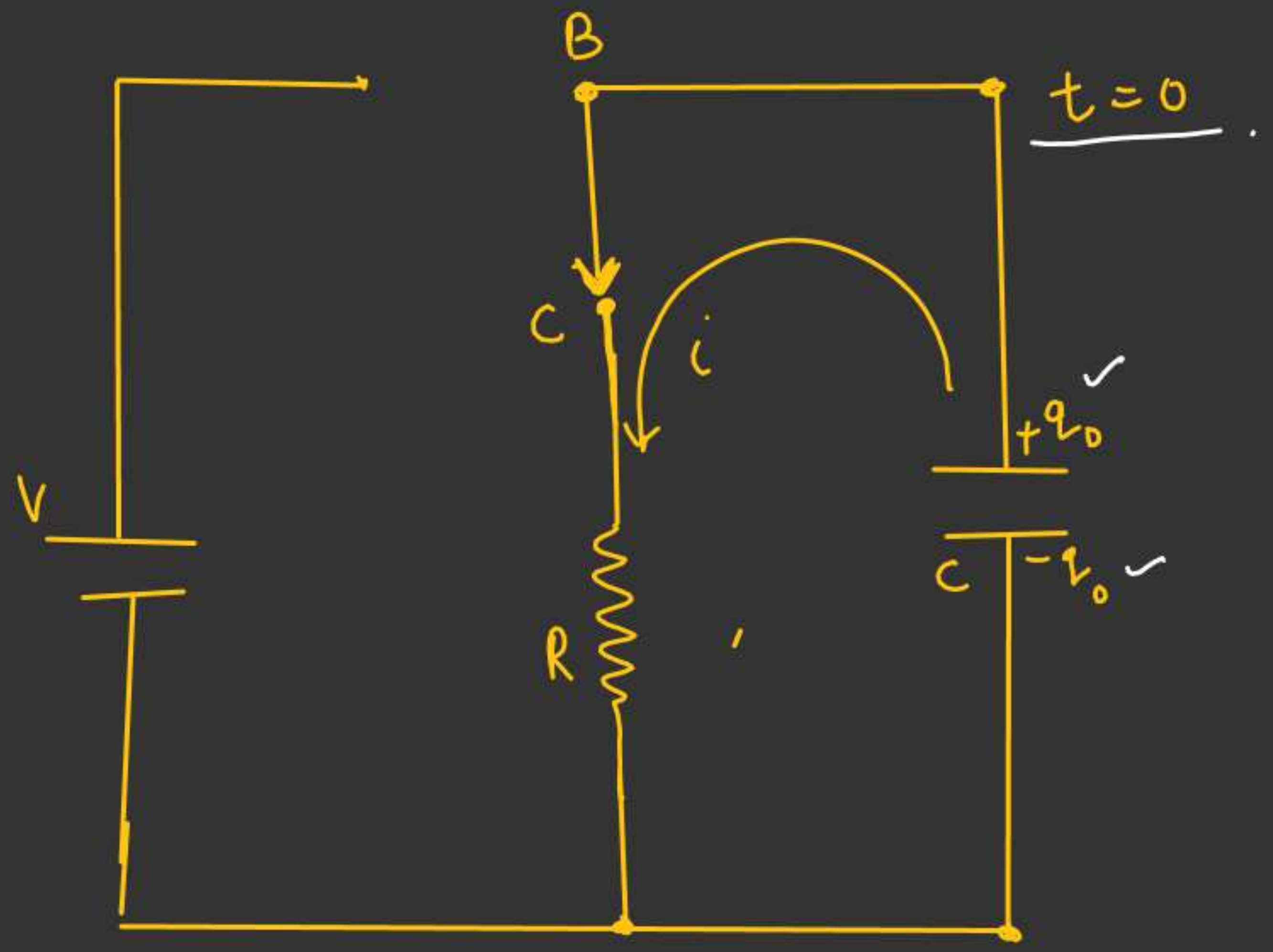
$$\boxed{I = I_0 e^{-t/\tau}} \quad **$$



(*) Discharging of Capacitor :→

SW Closed for a very long time.
i.e Capacitor become fully charged.
let, at, $t=0$, SW moved from A to C.





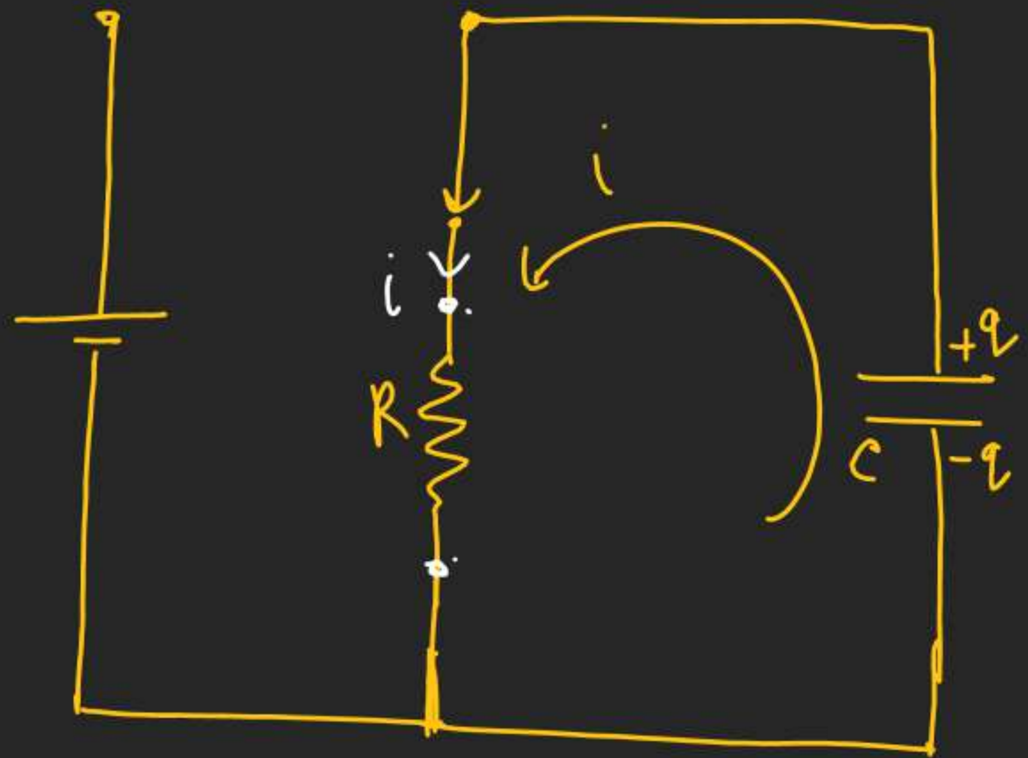
Nishant Jindal

RC ckt

CURRENT ELECTRICITY

$$\boxed{\int \frac{dx}{x} = \ln(x)}$$

Let, at any time $t = t$, Charge on the Capacitor be q.



K.V.L

$$\frac{q}{c} - iR = 0$$

$$\frac{q}{c} = iR$$

$$i = -\frac{dq}{dt}$$

During discharging q decreases w.r.t time.

$$\frac{q}{RC} = \left(-\frac{dq}{dt}\right)$$

$$\int_{q_0}^{q} \frac{dq}{q} = \frac{-1}{Rc}\int_0^t dt$$

$$\ln[q]_{q_0}^{q} = -\frac{t}{RC}$$

$$\ln(q/q_0) = -\frac{t}{RC}$$

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

$$\boxed{RC = \tau}$$

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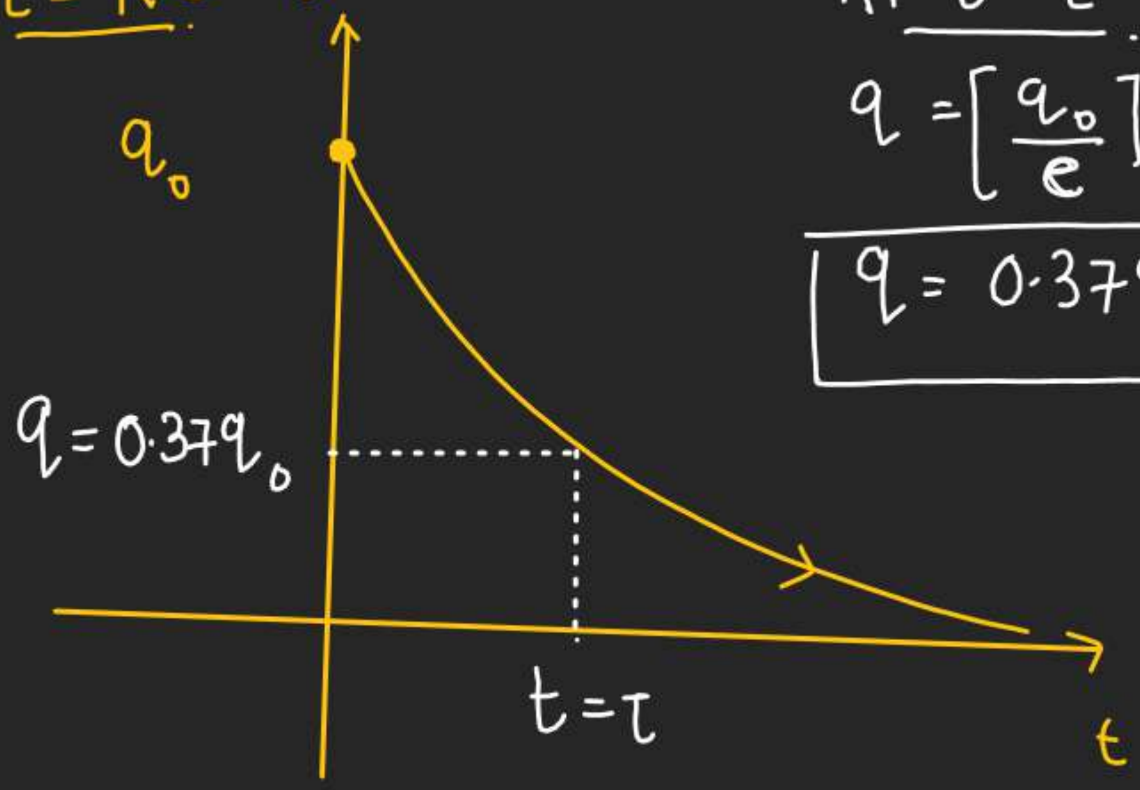
CURRENT ELECTRICITY

RC ckt

$$\boxed{q = q_0 e^{-t/\tau}}$$

$q \to$ (present value on the Capacitor)

$\tau = RC$



At $t = \tau$ $\longrightarrow$ [Time when Capacitor discharge to 63%]

$$q = \left[\frac{q_0}{e}\right]$$

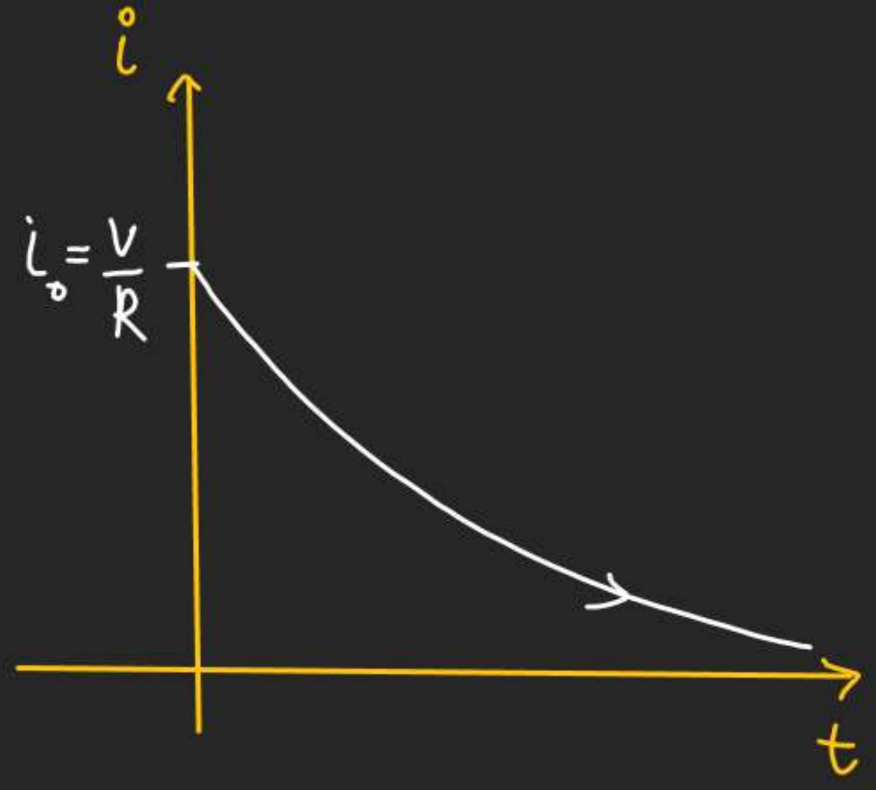
$$\boxed{q = 0.37 q_0}$$

$$\boxed{I = -\left(\frac{dq}{dt}\right)}$$

$$I = -q_0 \frac{d}{dt}\left(e^{-t/\tau}\right)$$

$$I = \frac{q_0}{\tau} e^{-t/\tau}$$

$$\boxed{I = \frac{V}{R} e^{-t/\tau}}$$



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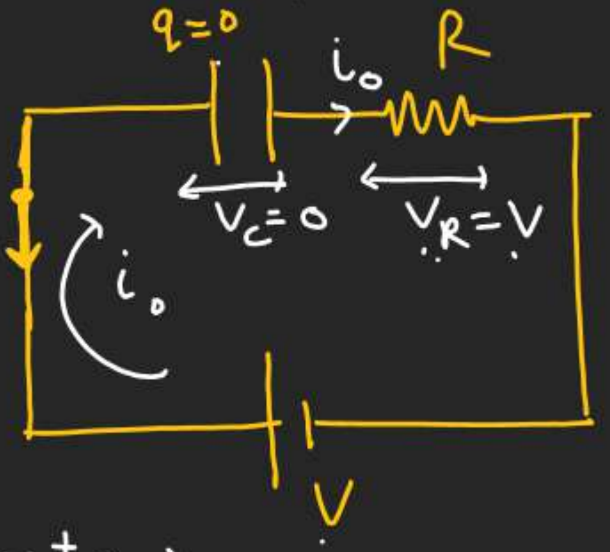
RC ckt

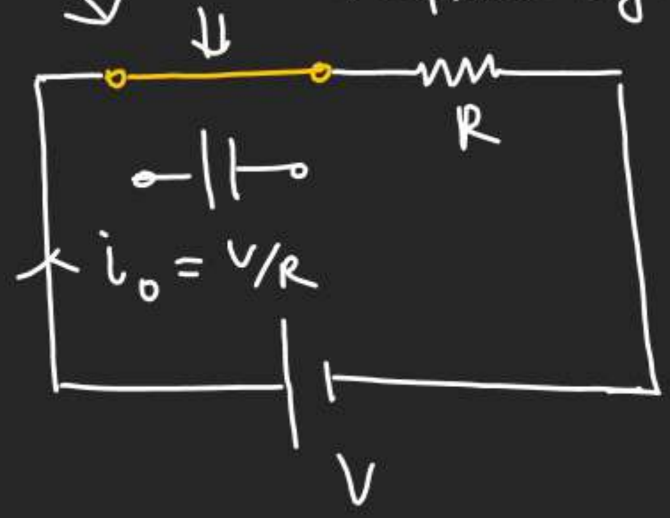
CURRENT ELECTRICITY

Behaviour of Capacitor in R-C Ckt :-

At $t = 0$



Capacitor can be replace by a zero resitance wire.



At $t = t$

$$q = q_0(1 - e^{-t/\tau})$$

$$i = i_0 e^{-t/\tau} = \left(\frac{V}{R} e^{-t/\tau}\right), \quad V_c = 0$$

At $t = 0$

$$\boxed{i = i_0} \quad \left(i_0 = \frac{V}{R}\right)$$

Behaviour of Capacitor at $[t \to \infty]$

$[t \to \infty] \Rightarrow$ Very long time.
$\Rightarrow$ Capacitor fully charged.
$\Rightarrow$ [Steady state of Capacitor]

$$\left[\begin{array}{l} q = q_0(1 - e^{-t/\tau}) \\ i = i_0 e^{-t/\tau} \end{array}\right]$$

At $t \to \infty$ (Steady state)

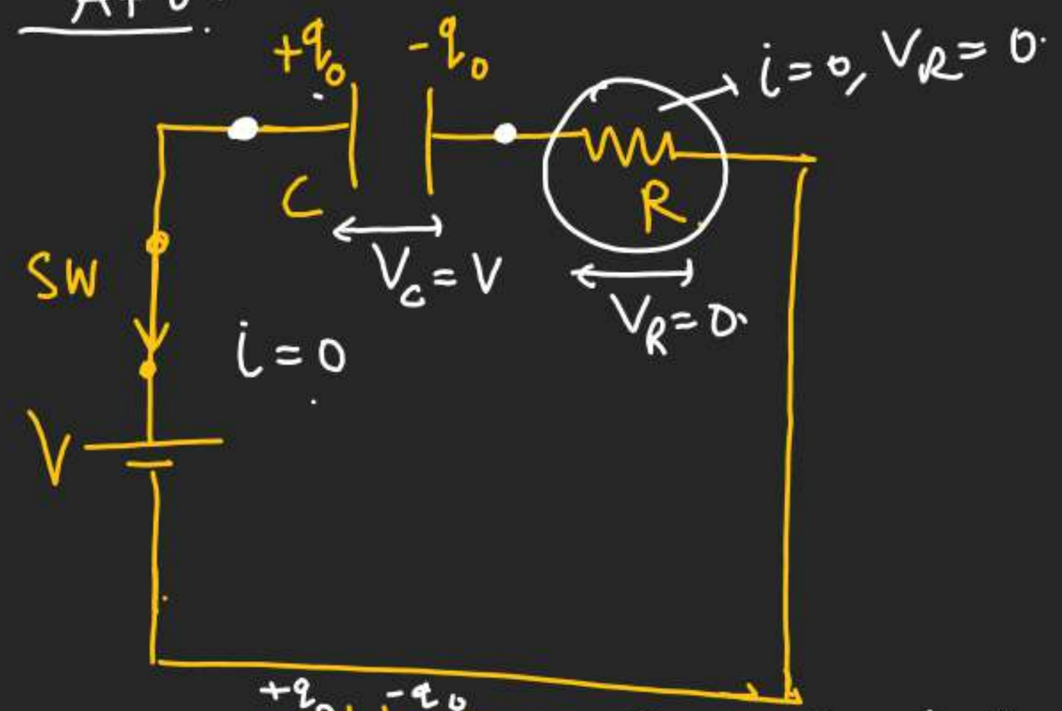
$q = q_0 = \boxed{CV}$

$t \to \infty$

$i = i_0 e^{-\infty/\tau} = \frac{i_0}{e^{\infty}} = \frac{i_0}{\infty} \to 0$

$\boxed{i \to 0}$

At $t \to \infty$



$+q_0$ $-q_0$ $\Rightarrow$ Capacitor behave as open ckt