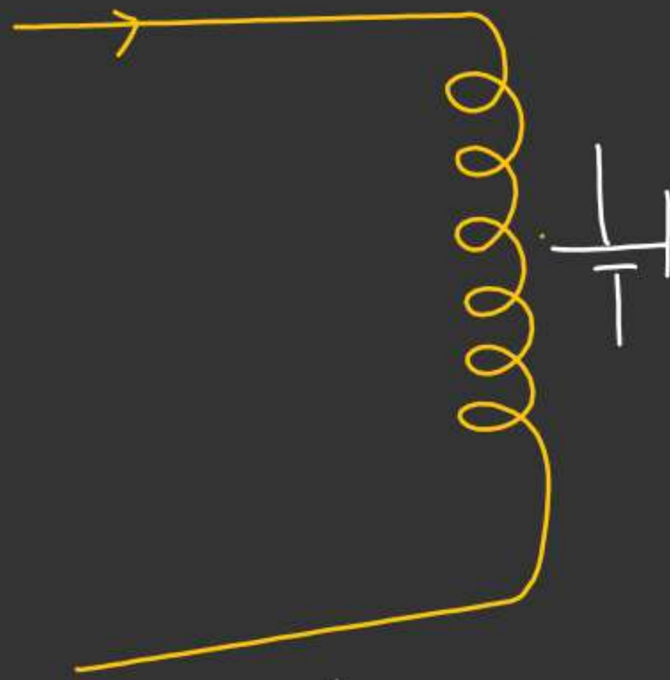
Nishant Jindal

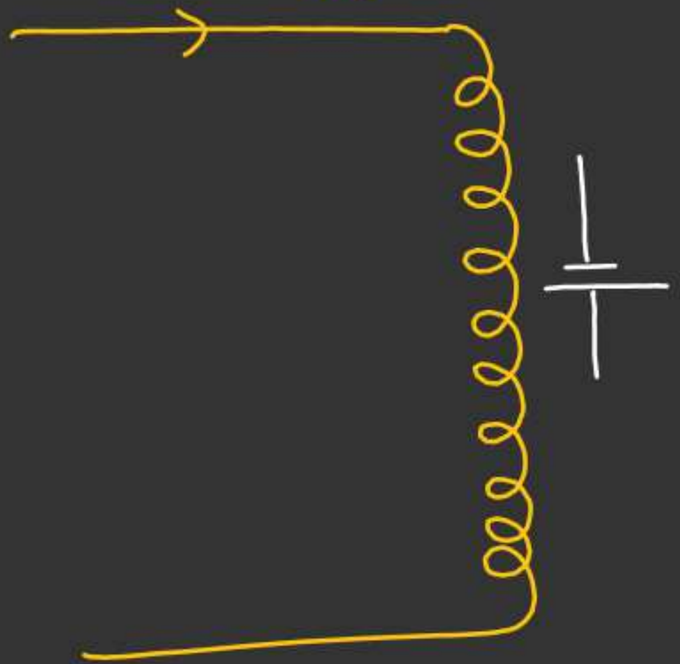
L-R Ckt

$i \nearrow \frac{di}{dt}$ increasing



$|\mathcal{E}_L| = L\frac{di}{dt}$

$i \rightarrow \frac{di}{dt}$ (decreasing)



$|\mathcal{E}_L| = L\frac{di}{dt}$

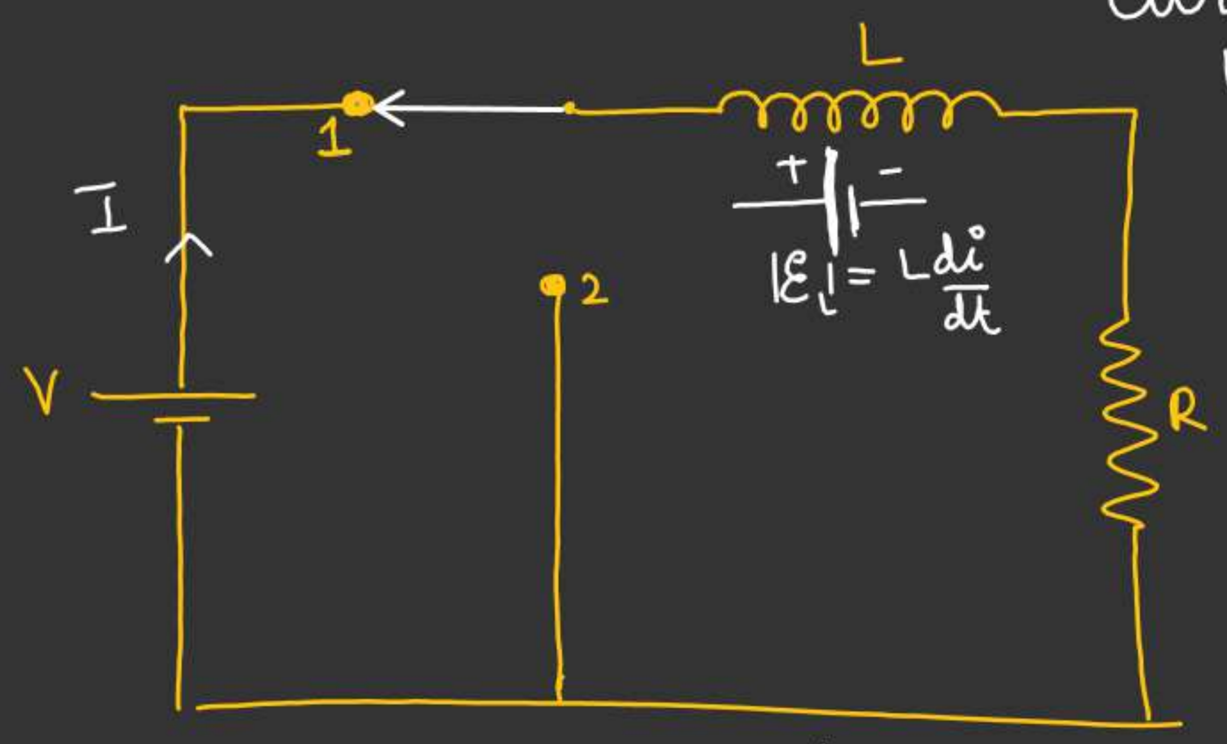
$$\phi_{self} = Li$$

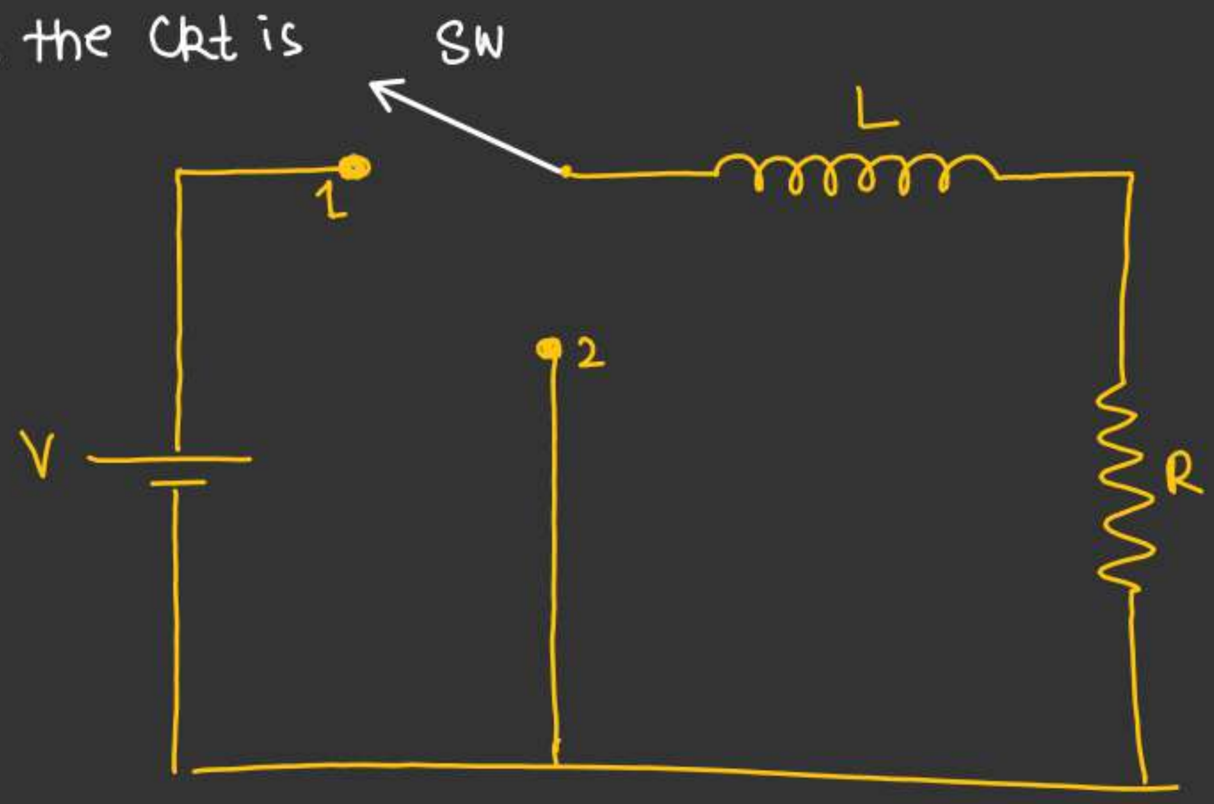
$$\mathcal{E}_{self} = -\frac{d\phi_{self}}{dt} = -L\frac{di}{dt}$$

Nishant Jindal

L-R Ckt → Growth of Current

At $t=0$, SW closed, let at $t=t$ current in the Ckt is i





K.V.L (At $t=t$)

$$V - L\frac{di}{dt} - iR = 0$$

$$(V - iR) = L\frac{di}{dt}$$

$$\int_0^i \frac{di}{V - iR} = \frac{1}{L}\int_0^t dt$$

$$\frac{\ln[V - iR]_0^i}{-R} = \frac{1}{L}t$$

Nishant Jindal

$$\ln\left[\frac{V - iR}{V}\right] = -\frac{R}{L}t$$

$$V - iR = Ve^{-\frac{R}{L}t}$$

$$\boxed{i = \frac{V}{R}\left(1 - e^{-\frac{R}{L}t}\right)}$$

$$i = \frac{V}{R}\left(1 - e^{-t/\tau}\right)$$

$$\frac{1}{\tau} = \frac{R}{L}$$

$$\boxed{\tau = L/R}$$

Time constant of L-R Ckt

Rate of Change of i

$$\frac{di}{dt} = -\frac{V}{R}e^{(-t/\tau)} \cdot \left(\frac{-1}{\tau}\right)$$

$$\frac{di}{dt} = \frac{V}{R\tau}e^{(-t/\tau)}$$

$$\frac{di}{dt} = \frac{V}{L}\left(e^{-t/\tau}\right)$$

$$L\left(\frac{di}{dt}\right) = Ve^{-t/\tau}$$

$$\Downarrow$$

$$\varepsilon_{self} = Ve^{-t/\tau}$$

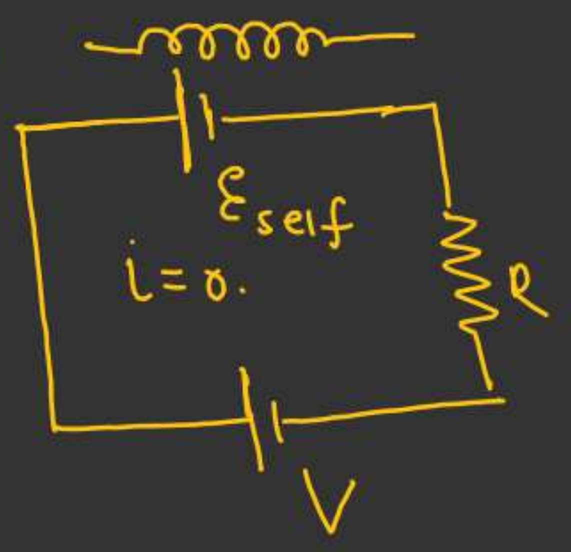
At $t = 0$,

$$\boxed{(\varepsilon_{self})_{max} = V}$$

Inductor behave as a open Ckt

$$\Downarrow$$

At $t = 0$



Nishant Jindal

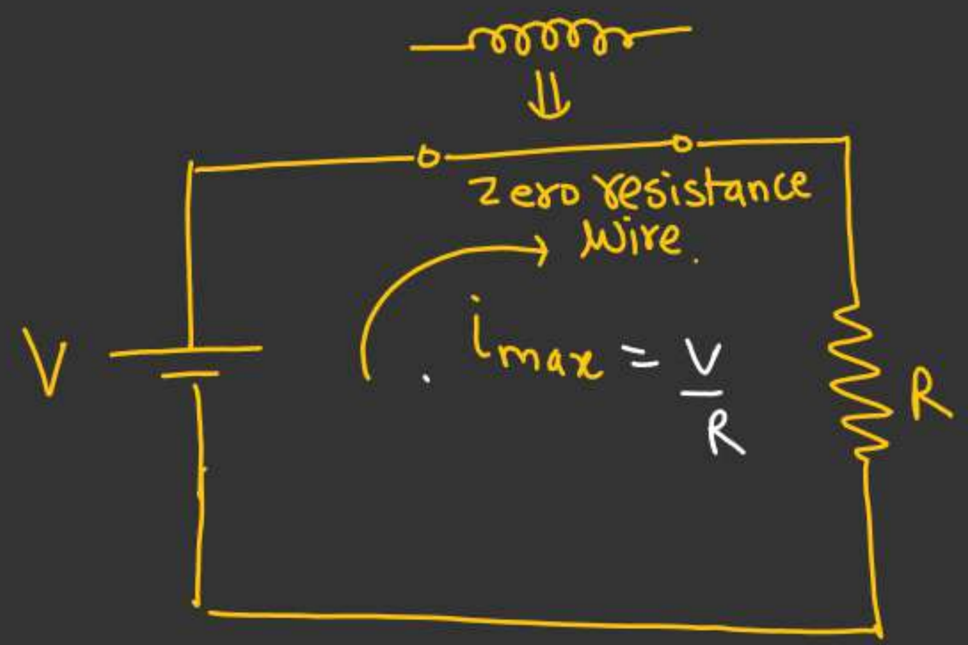
$$i = \frac{V}{R}\left(1 - e^{-t/\tau}\right)$$

$$\underline{i_{max} = \left(\frac{V}{R}\right)} \longrightarrow \text{At } t \to \infty$$

i.e very long time.

$$\mathcal{E}_{self} = Ve^{-t/\tau}$$

$$\left.\begin{array}{l}\text{At } t \to \infty \\ \mathcal{E}_{self} = 0.\end{array}\right\} \Rightarrow$$ After very long time inductor behave as a zero resistance wire.



Nishant Jindal

$$i = \frac{V}{R}\left(1 - e^{-t/\tau}\right) \quad \left(\tau = L/R\right)$$

$$V_R = iR = V\left(1 - e^{-t/\tau}\right)$$

$$\mathcal{E}_{self} = L\frac{di}{dt} = \left(Ve^{-t/\tau}\right)$$

Charge flow as a function of time.

$$\frac{dq}{dt} = \frac{V}{R}\left(1 - e^{-t/\tau}\right)$$

$$\int_0^Q dq = \frac{V}{R}\int_0^t \left(1 - e^{-t/\tau}\right) dt$$

Heat dissipiated across resistance

$$P = i^2 R.$$

$$\frac{dH}{dt} = \frac{V^2}{R}\left(1 - e^{-t/\tau}\right)^2$$

$$\int_0^H dH = \frac{V^2}{R}\int_0^t \left(1 - e^{-t/\tau}\right)^2 \cdot dt$$

$$\Downarrow$$

$$H = ??$$

Nishant Jindal

Avg power in L-R Ckt.

$$P_{inst} = i^2 R = \frac{V^2}{R^2}(1-e^{-t/\tau})^2 \times R$$

$$P_{inst} = \frac{V^2}{R}(1-e^{-t/\tau})^2$$

$$P_{avg} = \frac{\int_0^t P \cdot dt}{\int_0^\tau dt}$$

Ex:- Avg power in one time constant

$$P_{avg} = \frac{\left(\frac{V^2}{R}\right)\int_0^\tau (1-e^{-t/\tau})^2 \cdot dt}{\int_0^\tau dt}$$

$$P_{avg} = \frac{V^2}{\tau R}\left[\int_0^\tau (1 + e^{-2t/\tau} - 2e^{-t/\tau})\, dt\right]$$

$$P_{avg} = \frac{V^2}{\tau R}\left[\int_0^\tau dt + \int_0^\tau e^{-2t/\tau} \cdot dt - 2\int_0^\tau e^{-t/\tau} \cdot dt\right]$$

$$P_{avg} = \frac{V^2}{\tau R}\left[\tau + \frac{\left[e^{-2t/\tau}\right]_0^\tau}{(-2/\tau)} - 2\frac{\left(e^{-t/\tau}\right]_0^\tau}{(-1/\tau)}\right]$$

||

??

Nishant Jindal

Time Constant of L-R Ckt.

In terms of growth of Current.

$$I = \frac{V}{R}\left(1 - e^{-t/\tau}\right)$$

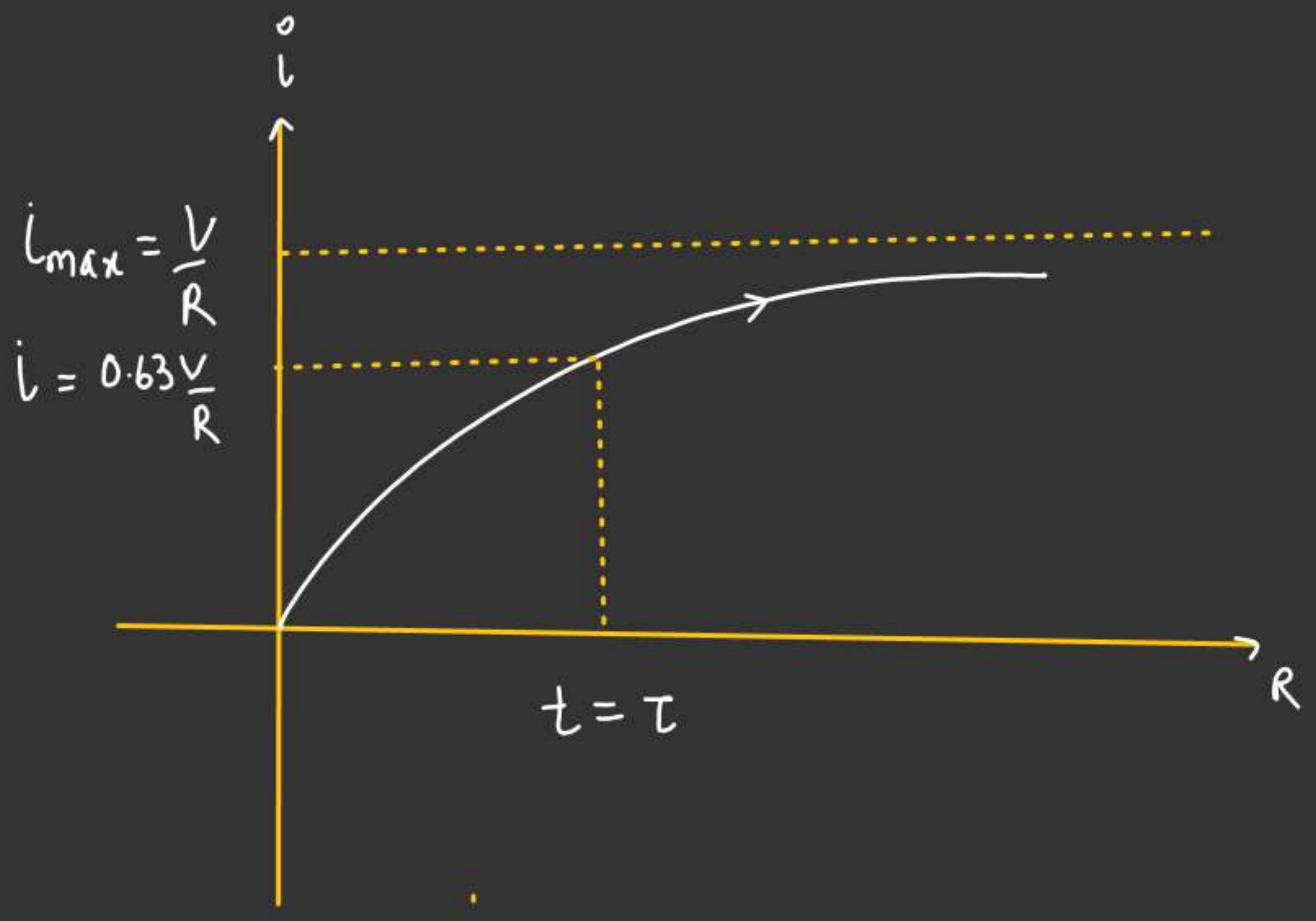
At $t = \tau$

$$I = \frac{V}{R}\left(1 - e^{-1}\right) = \underbrace{\frac{V}{R}}_{i_{max}}\left(1 - \frac{1}{e}\right)$$

$$\boxed{I = 63\% \text{ of } I_{max}}$$

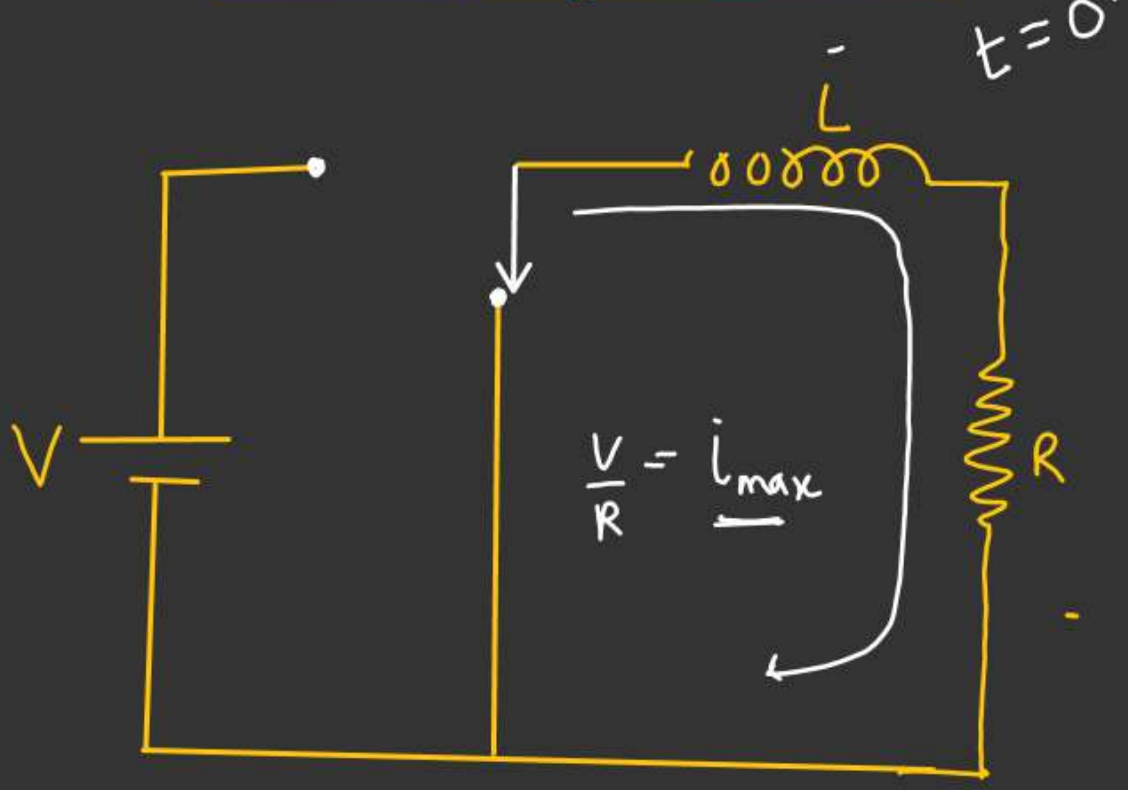
⇓

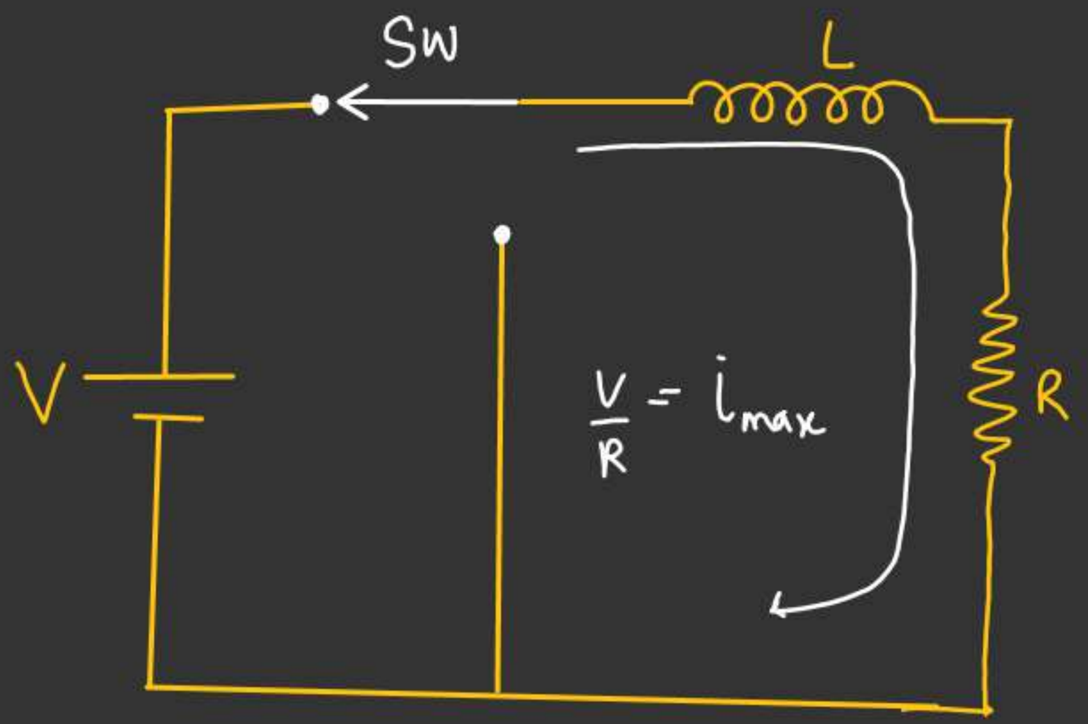
[Time when Current build-up in the Ckt is 63% of its maximum Value



Nishant Jindal

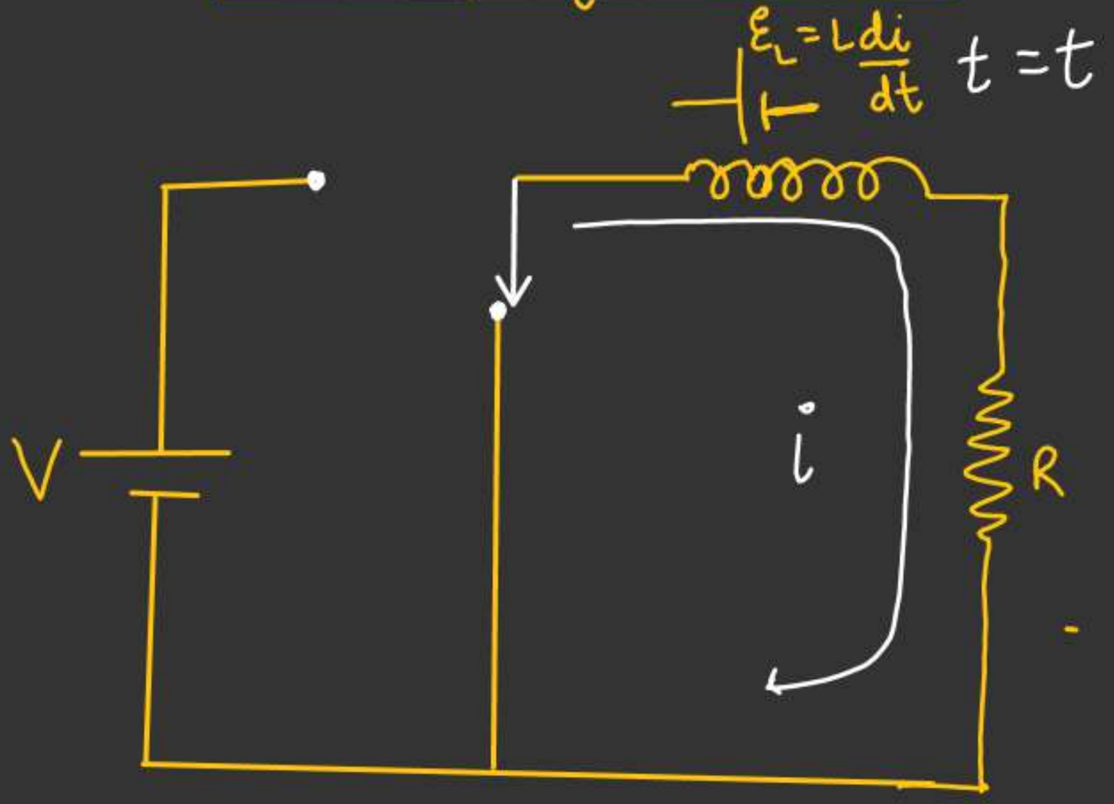
Decay of Current





Nishant Jindal

Decay of Current



K.V.L

$$-L\frac{di}{dt} - iR = 0$$

$$-L\frac{di}{i\,dt} = iR$$

$$-\int_{i_{max}}^{i} \frac{di}{i} = \frac{R}{L}\int_0^t dt$$

$$-\ln\left[\frac{i}{i_{max}}\right] = \frac{R}{L}t$$

present value in the ckt.

$$i = i_{max}e^{-R/L\,t}$$

Decay of Current in L-R Ckt ←

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

I. (Decay of Current).

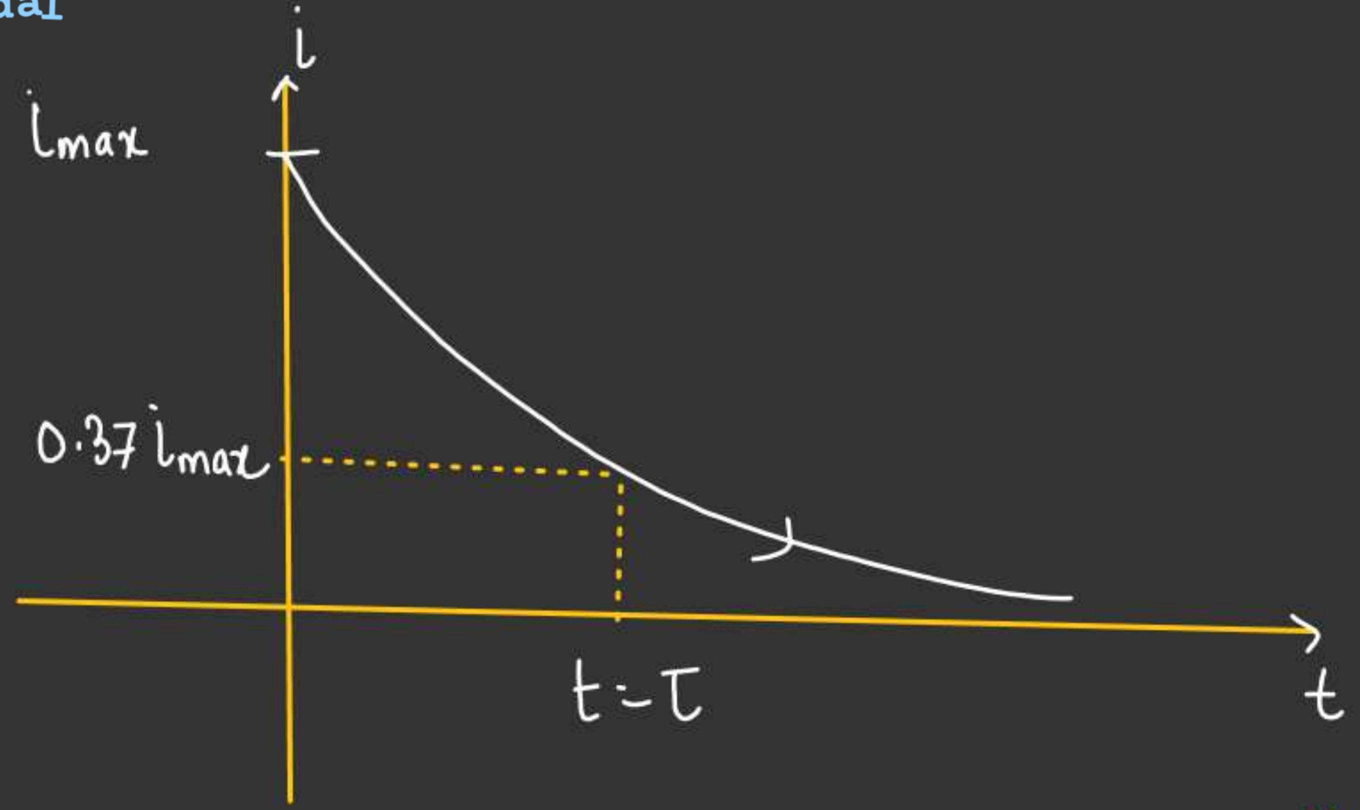
At $t = \tau$.

$$I = \frac{V}{R}\left(\frac{1}{e}\right)$$

$$I = 0.37\left(\frac{V}{R}\right) = 0.37\,I_{max}$$

Time when 63% of Current has been decayed. or 37% of current present.

Nishant Jindal



Ex: $i = \frac{V}{R} e^{-t/\tau}$.

Charge flow

$$\frac{dq}{dt} = \frac{V}{R} e^{-t/\tau}.$$

$$\int_0^q dq = \frac{V}{R}\int_0^t e^{-t/\tau}\cdot dt$$

Heat dissipisation

$$P = i^2 R$$

$$\frac{dH}{dt} = \frac{V^2}{R} e^{-2t/\tau}.$$

$$\int_0^H dH = \frac{V^2}{R}\int_0^t e^{-2t/\tau}\cdot dt$$

Avg. power

$$P_{avg} = \frac{\int_0^t P\cdot dt}{\int_0^t dt}$$

$$P_{avg} = \frac{\int_0^t i^2 R\, dt}{\int_0^t dt}$$