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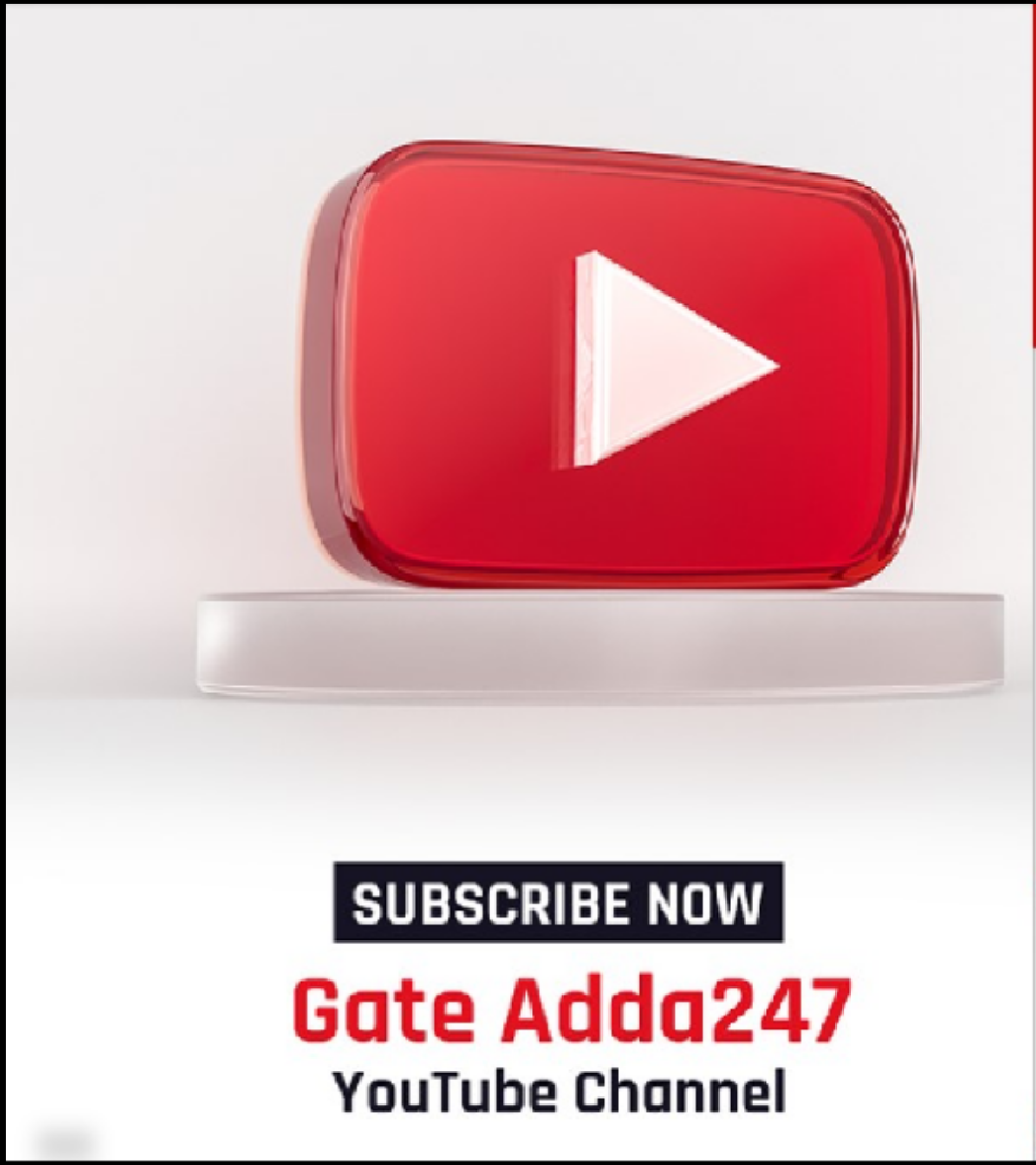
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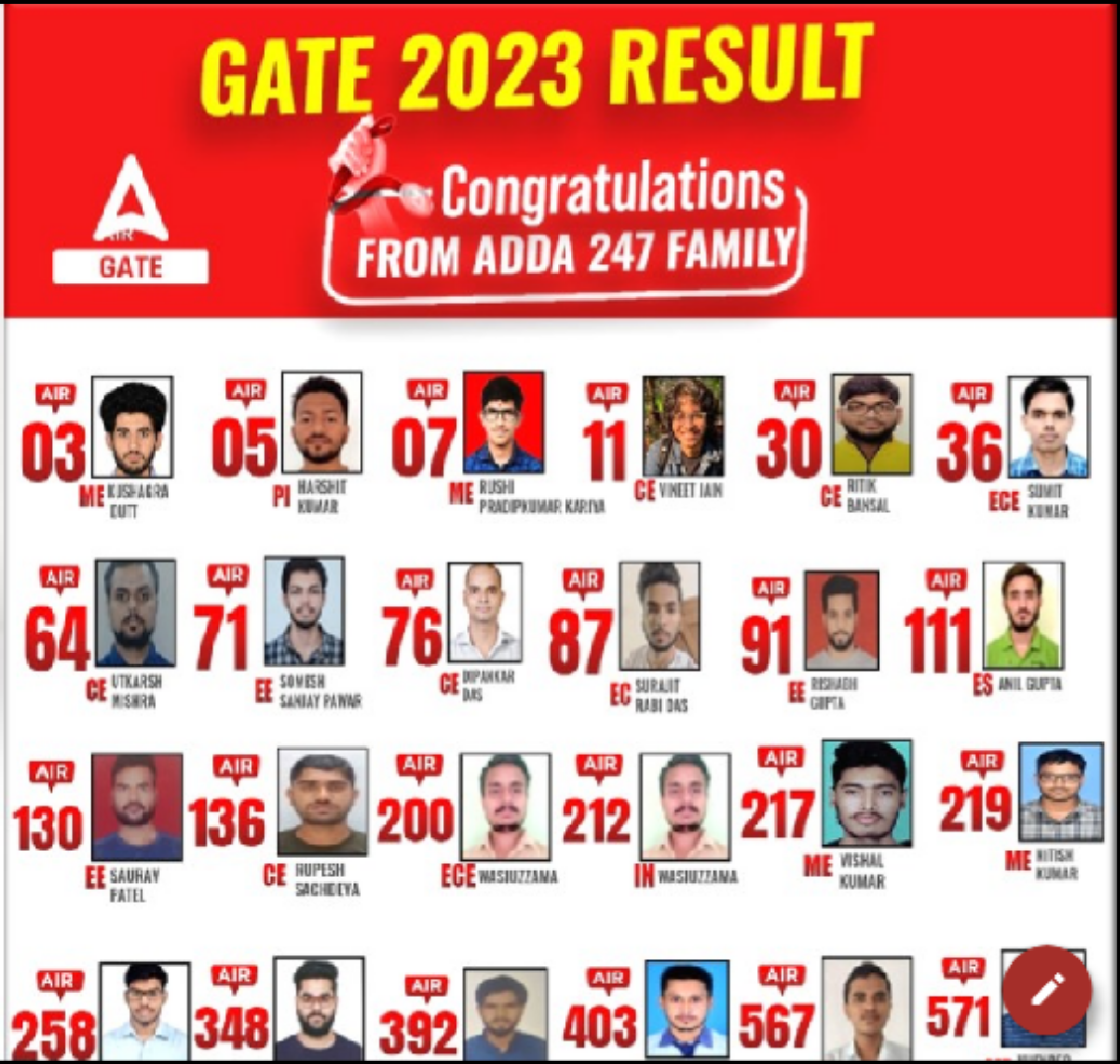
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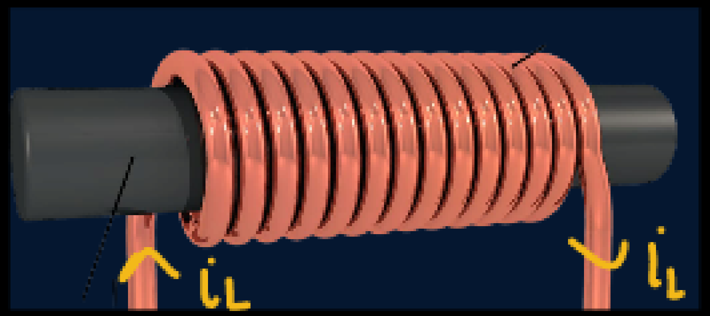
Inductor's Voltage

From Faraday's law of induction:-



$+ \quad V_L \quad -$

$$\mathcal{E} = N\frac{d\phi}{dt} \quad (I) \qquad [L i = N\phi] \quad (II)$$

partial diff^n. of eq^n:-

$$L\frac{di_L}{dt} + i_L\frac{dL}{dt}^{\nearrow 0} = N\frac{d\phi}{dt} + \phi\frac{dN}{dt}^{\nearrow 0}$$

We know that, L and N both are constant.

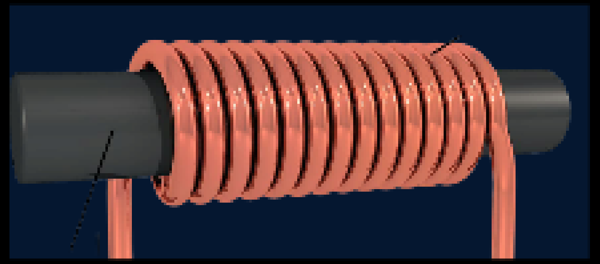
$$N\frac{d\phi}{dt} = L\frac{di_L}{dt}$$

$$\left[\mathcal{E} = L\frac{di_L}{dt}\right] = N\frac{d\phi}{dt}$$

v.v.imp

$$V_L(t) = L\frac{di_L}{dt}$$

Inductor's Current



We know that -

Inductor's Vol. is.

$$V_L(t) = L\frac{di_L}{dt} \quad (1)$$

Integ^n both side -

$$\int_{-\infty}^{t} \frac{V_L(t)}{L}\,dt = \int_{0}^{i_L} di_L$$

$$\therefore \; i_L(t) = \frac{1}{L}\int_{-\infty}^{t} V_L(t)\,dt$$

MCQ/MSQ

ex.

$i_L\big|_{t=0} = ?$

(a) 0A ✓ (b) -10A (c) 10A ✓ (d) 25A ✓

ex - At, what time instant, guaranteed inductor will be fully uncharged i.e. ($i_L = 0$ Amp).

a) $t = 0$ sec b) $t = 0^+$ sec

c) $t = 0^-$ sec (d) $t = -\infty$

$$i_L(t) = \frac{1}{L}\int_{-\infty}^{t} v_L(t)\,dt$$

$$i_L(t) = \frac{1}{L}\int_{-\infty}^{0^-} v_L(t)\,dt + \frac{1}{L}\int_{0}^{t} v_L(t)\,dt$$

$$i_L(t) = (\text{Initial value}) + \frac{1}{L}\int_{0}^{t} v_L(t)\,dt$$

Inductor equivalent circuit in freq. domain :-

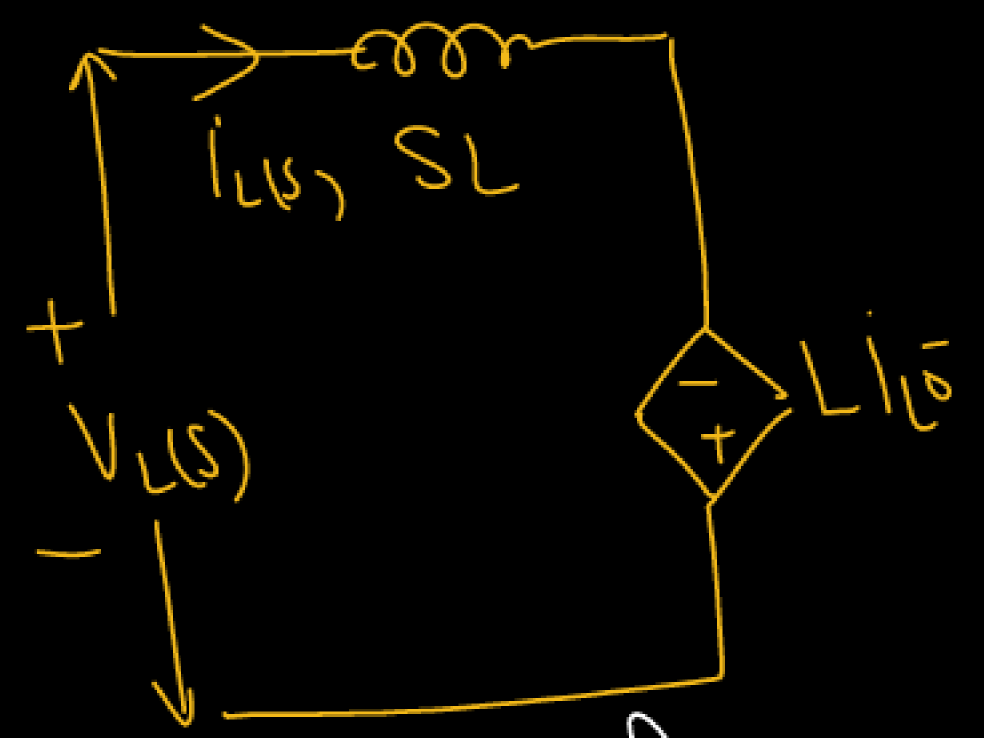
Inductor's Vol. eqn ⇒

$$V_L = L \frac{di_L(t)}{dt} \quad (1)$$

Take Lap. trafm of eqn (1)

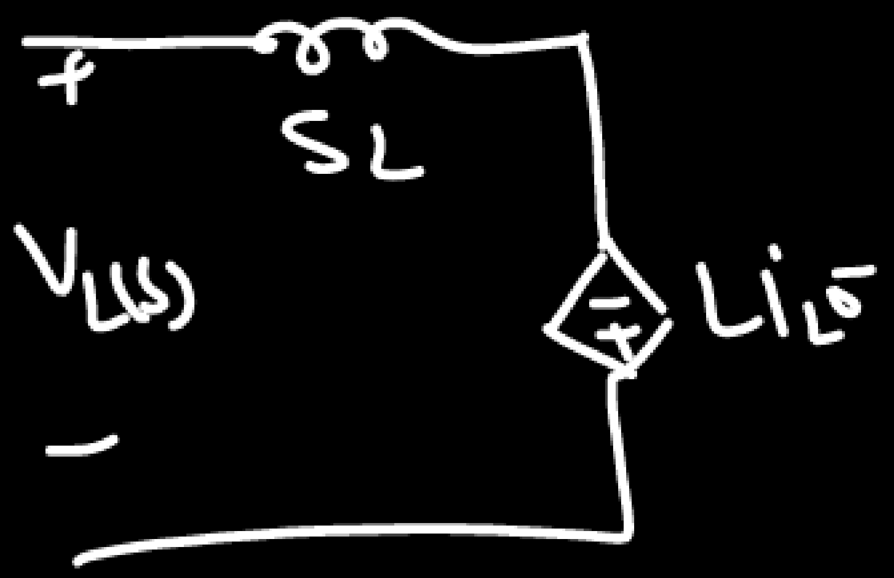
$$V_L(s) = L\left[s\, i_s - i_{L0^-}\right].$$

$$\left[V_L(s) = sL\, i_{L(s)} - L\, i_{L0^-}\right] \Rightarrow \text{KVL eqn}$$



Inductor ckt in freq. domain.

⇒ From Inductor Vol.



$$\rightarrow V_{L(s)} = L\left(s\,i_{L(s)} - i_{L0^-}\right).$$

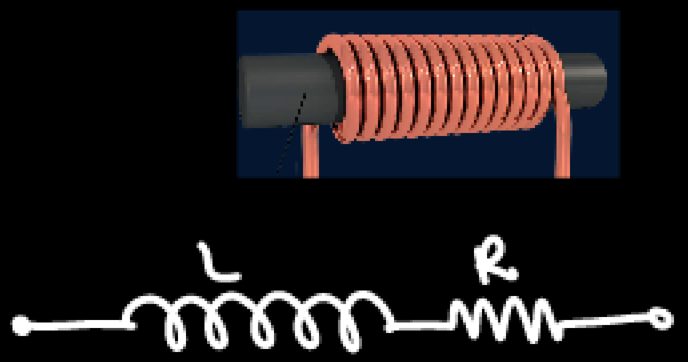
$$V_{L(s)} = SL\,i_{L(s)} - L\,i_{L0^-}$$

$$SL\,i_{L(s)} = V_{L(s)} + L\,i_{L0^-}$$

$$\therefore\; \boxed{i_{L(s)} = \frac{V_{L(s)}}{SL} + \frac{i_{L0^+}}{S}.}$$ KCL eqn)

Inductor's ckt in freq. domain.

Time constant



Inductive coil

* At low freq., Inductor will not introduce any o/p effect.

⇒ we know that, standard transfer function is -

$$T.F = \frac{K'(s+z_1)(s+z_2)\ldots}{s^n(s+p_1)(s+p_2)\ldots}$$

⇒ T.F., in time constant form.

$$T.F = \frac{K\left(\frac{s}{z_1}+1\right)\left(\frac{s}{z_2}+1\right)}{s^n\left(\frac{s}{p_1}+1\right)\left(\frac{s}{p_2}+1\right)\ldots}$$

$$T.F = \frac{K(s\tau_{z_1}+1)(s\tau_{z_2}+1)\ldots}{s^n(s\tau_{p_1}+1)(s\tau_{p_2}+1)\ldots}$$

Standard T.F. or Natural time constant form of T.F.

⇒ Natural time constant (N.T.C.) is always a (+) and non zero value.

⇒ N.T.C. will decide transient response of o/p.

time constant :-

$$\tau = L/R.$$

$$\tau = \frac{L\left(\frac{V}{A}\right)\sec}{R\left(\frac{V}{A}\right)}$$

$$\boxed{\tau = \frac{L}{R}\sec}$$

→ H.T.C.

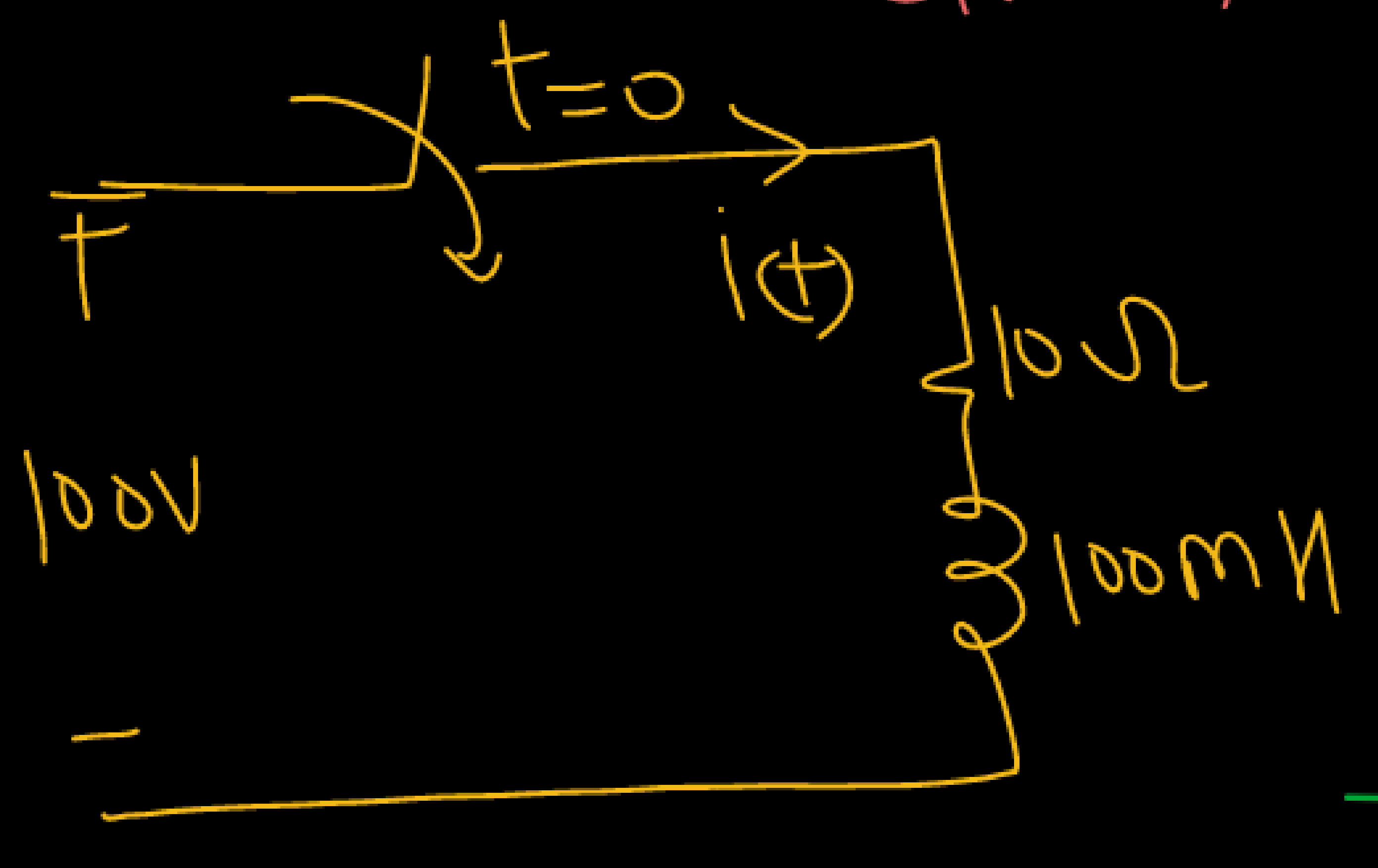
Inductive coil

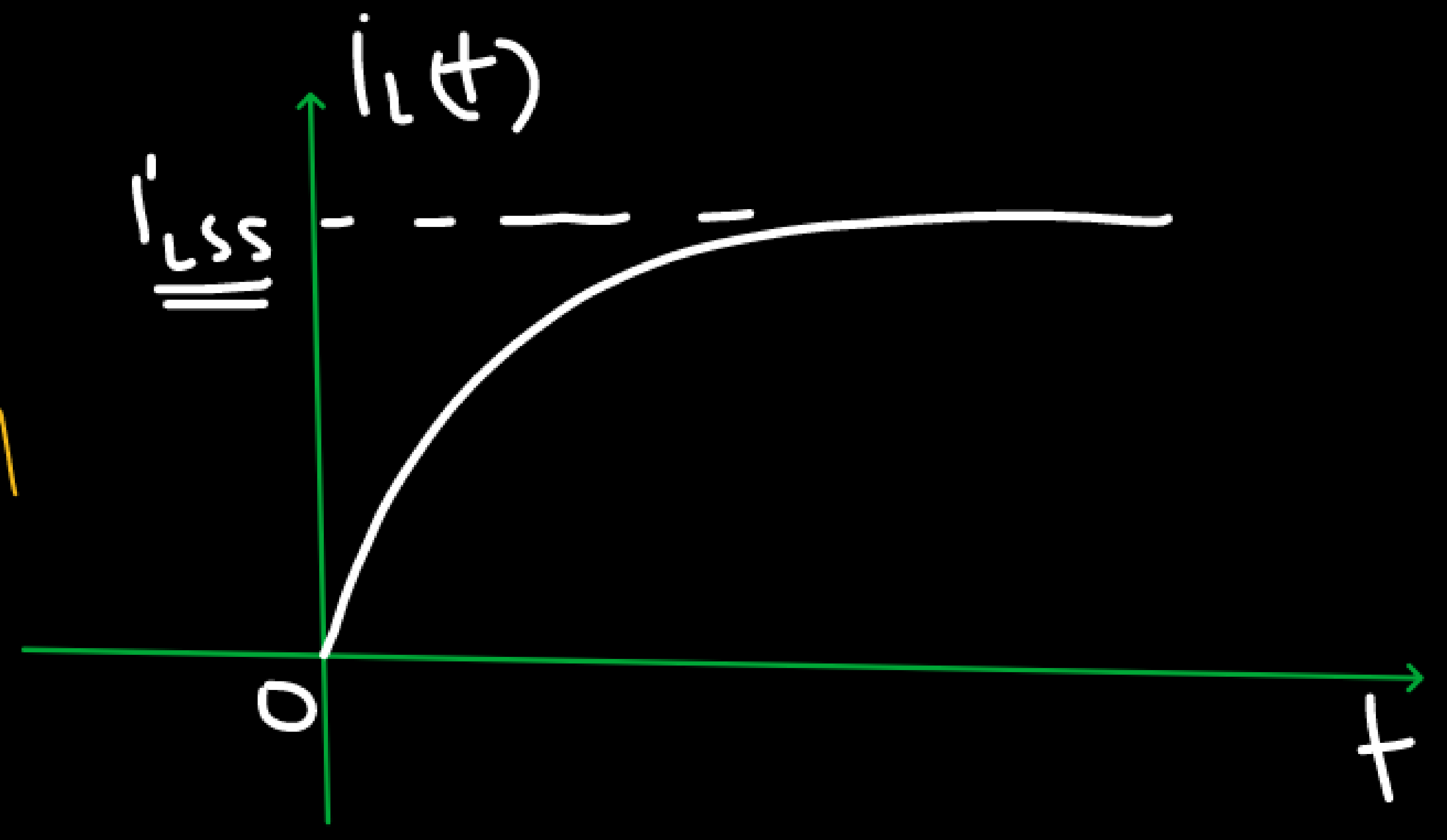
$$V_R = iR \qquad V_L = L\frac{di_L}{dt}$$

$$R = \left(\frac{V}{A}\right) \qquad \left(\frac{V}{A}\right)\sec = L.$$

ex- Draw the complete resp. of current, for the given circuit.

also determine T.C. of The circuit.





$\tau \Rightarrow$ it is mainly defined for first order system.

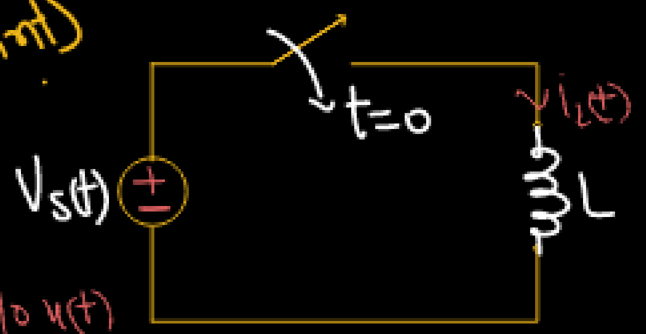
$\Rightarrow \tau = \frac{L_{eq}}{R_{eq}}$; R_{eq} Always measured across the L_{eq}.

$\tau = \frac{L}{R} = \frac{100m}{10} = 10\,msec$

First order System with pure Inductive loand DC excitation

let, R = 0 of ckt. (1mint)

and inductor is ideal.



and –

(I) $V_s(t) = 10\,\delta(t)$ (II) $V_s(t) = 10\,u(t)$

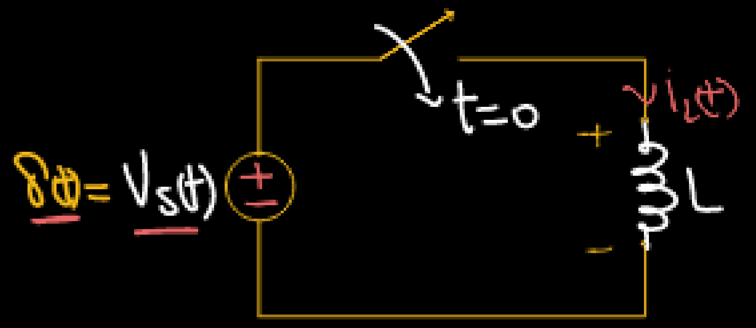
(III) $V_s = 10\sin t$ (IV) $V_s(t) = 0\,V$.

Draw $i_L(t)$ resp. for all cases.

case (I) $V_s(t) = \delta(t)$

here

$i_L(0^-) = 0$ Amp.

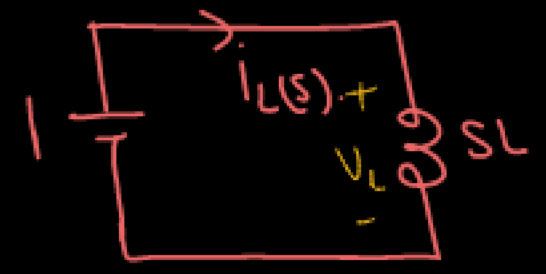


ckt in freq. domain.

By KVL –

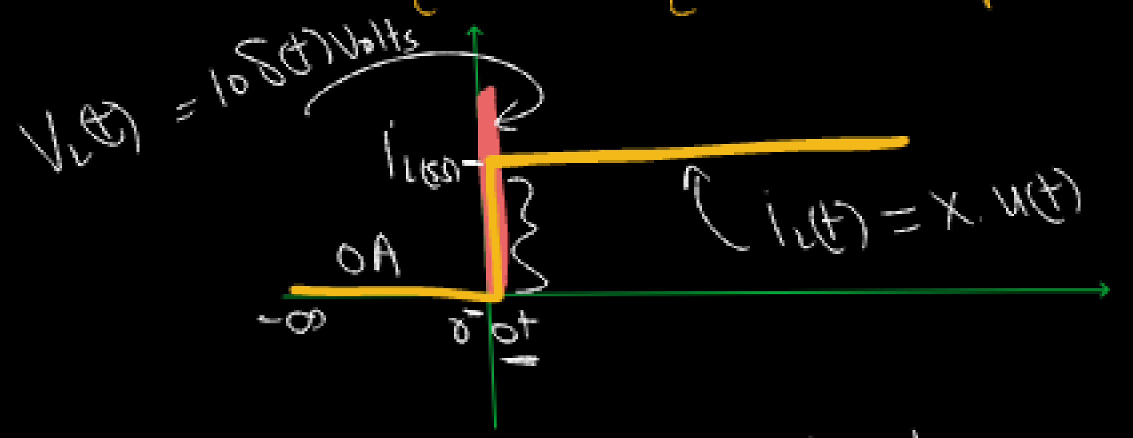
$1 = sL \cdot I_s$.

$I_L(s) = \frac{1}{L} \cdot \frac{1}{s}$.



Take inv. lap. trfm.

$i_L(t) = \frac{1}{L} u(t) = \frac{1}{L}, t \geq 0$ Amp.



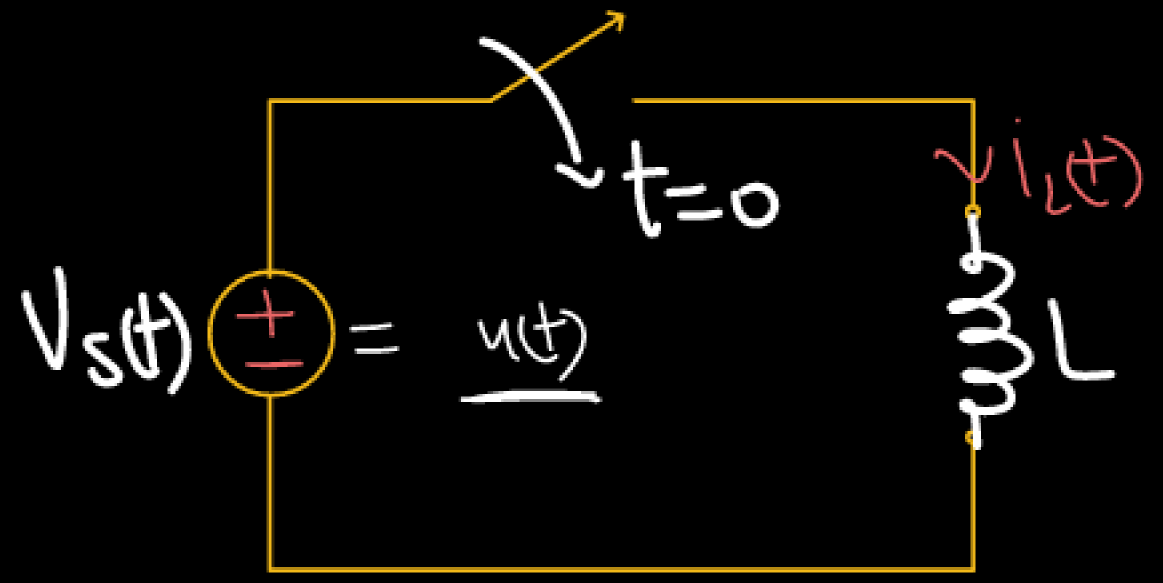
⇒ inductor current comes in to s.s., at ⇒ $t = 0^+$

if we applied an Impulsive vol across inductor

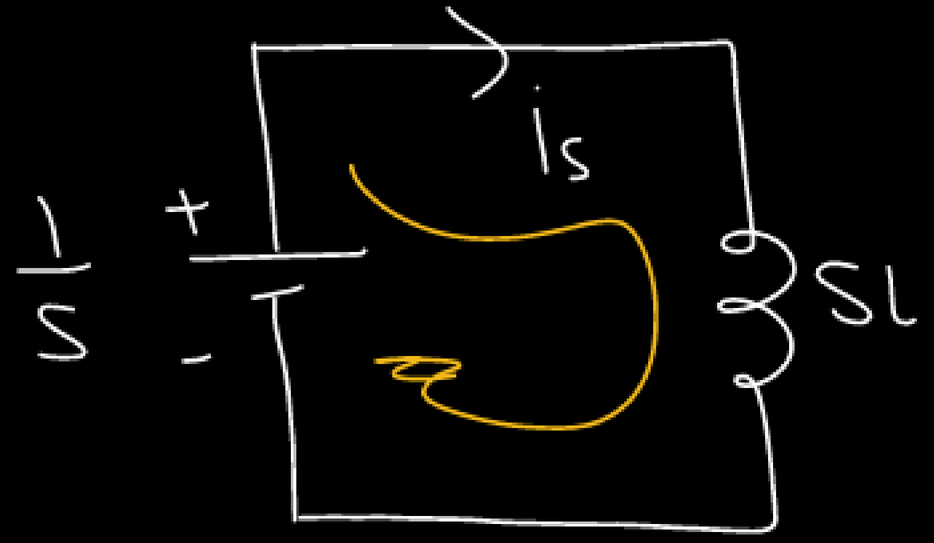
$i_L(0^-) \neq i_L(0^+)$

(ii) $V_s(t) = 10\,u(t)$

Circuit in freq. domain:-



$i_L(0^-) = 0$ Amp.

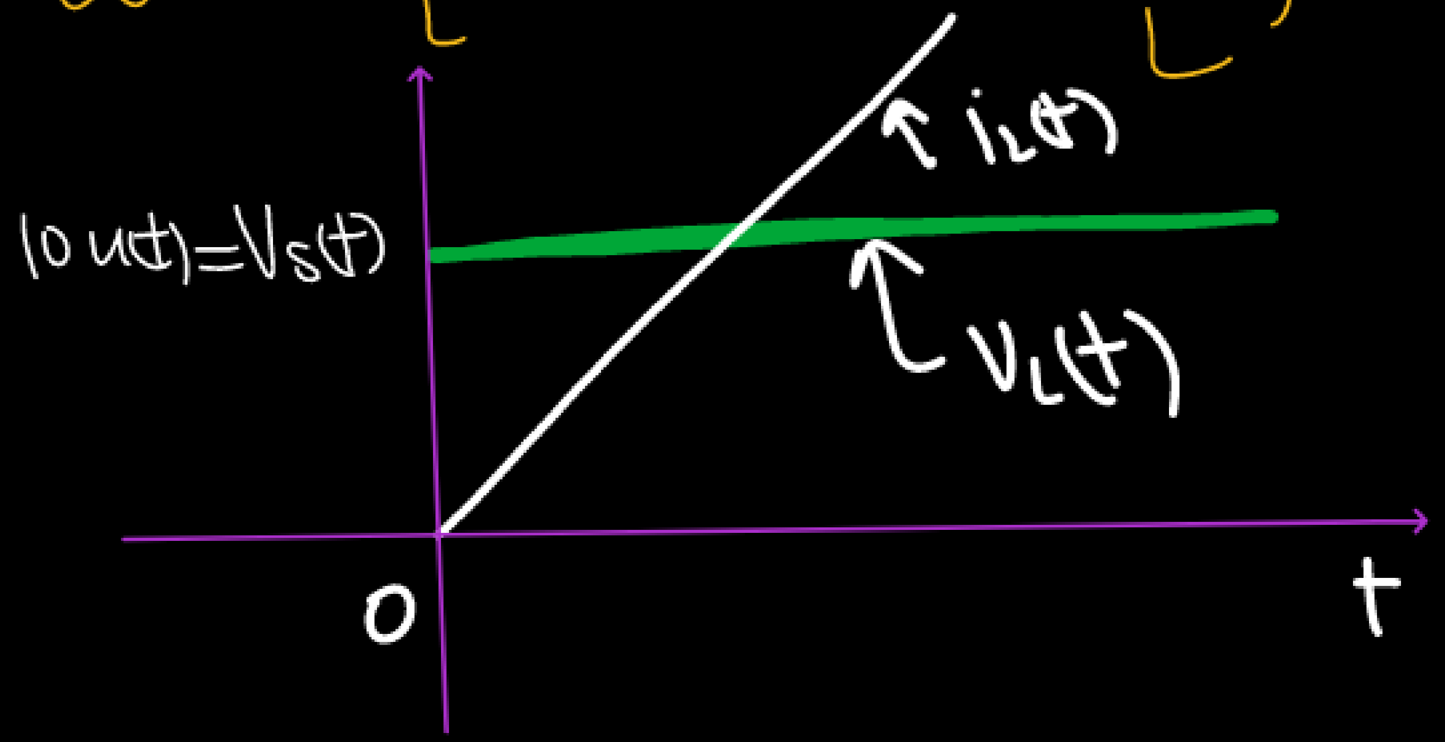


$$\frac{1}{s} = sL \cdot i_L(s)$$

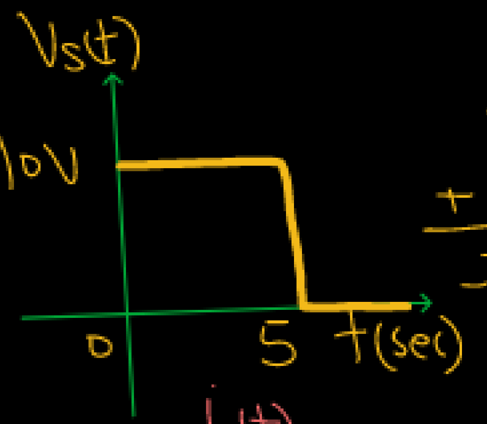
$$\therefore i_L(s) = \frac{1}{L}\cdot\frac{1}{s^2}$$

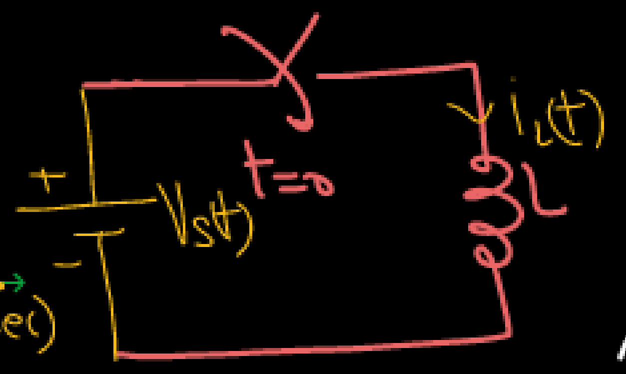
Take inv. lap. trfm.

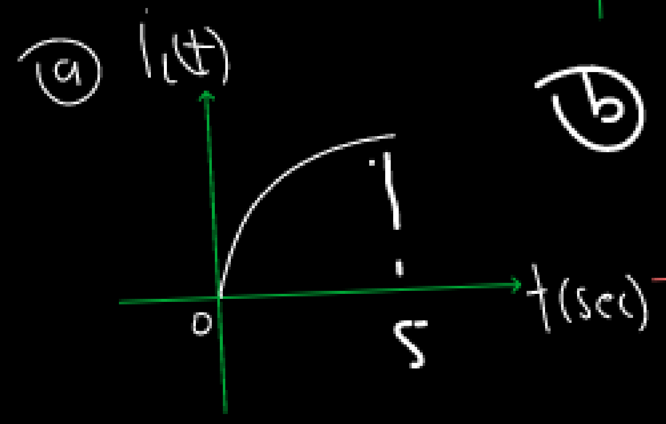
$$i_L(t) = \frac{1}{L}\cdot t\,u(t) = \frac{t}{L};\ t \geq 0.$$

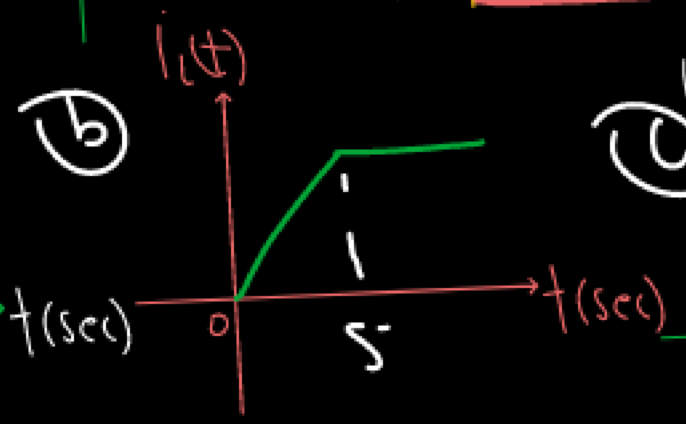


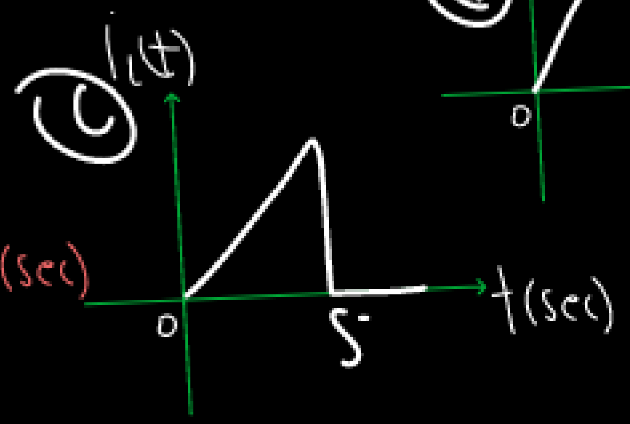
ex:- The response of inductor's current will be, for given ckt.

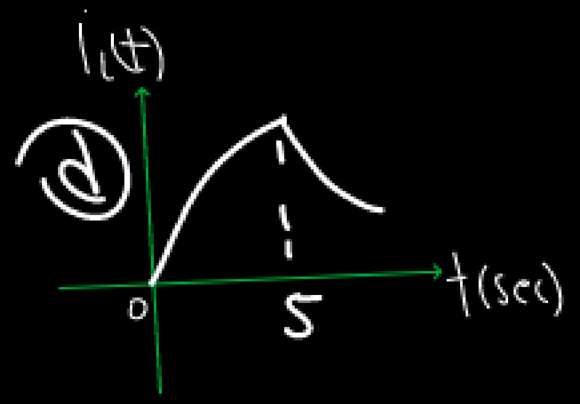






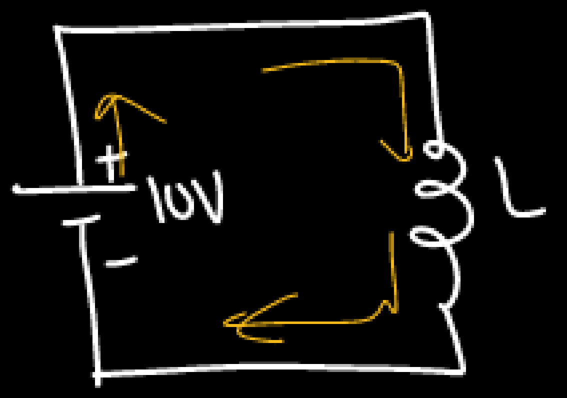




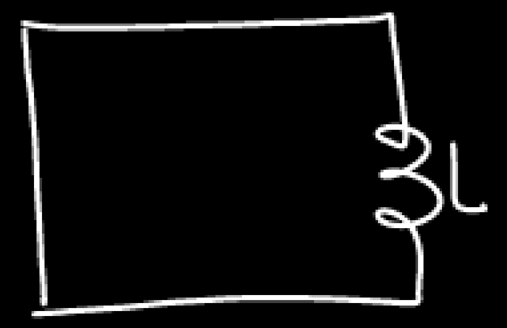


Soln:-

case I
0-5 sec



case II $t \geq 5\,sec^+$



$i_L(0^-) = 0A$

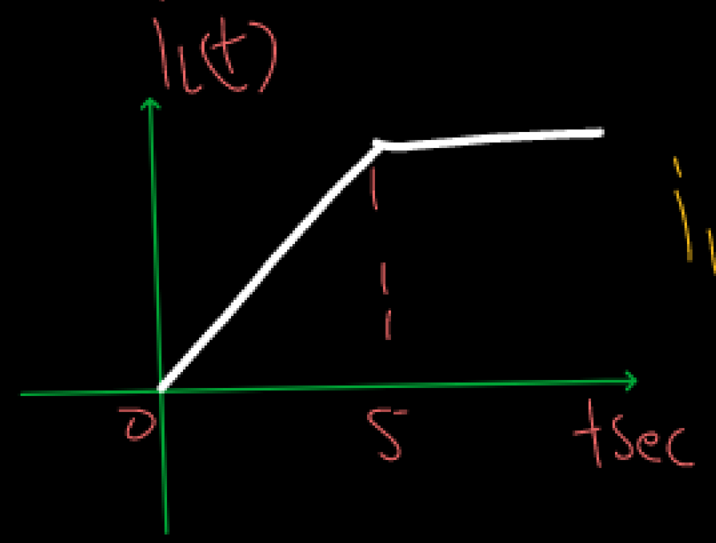
$$V_L = L\frac{di_L}{dt}$$

$$i_L(t) = \frac{1}{L}\int_{-\infty}^{t} V_L(t)\,dt$$

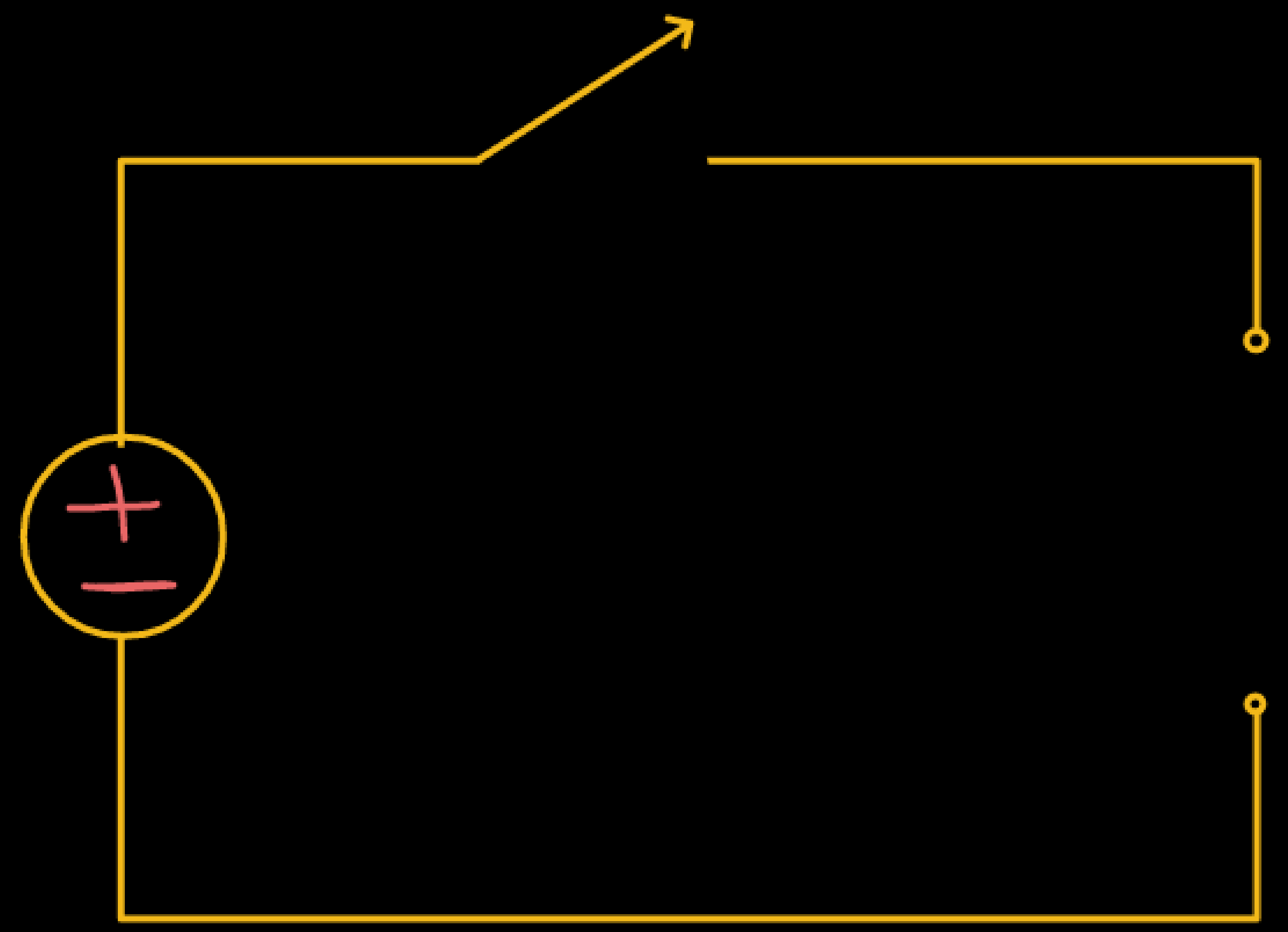
$$i_L(t) = \frac{1}{L}\int_{0}^{t} V_L(t)\,dt$$

$$= \frac{1}{L}\int_{0}^{t} 10\,dt \rightarrow 10\,u(t)$$

ramp funt



First order System with RL load and DC excitation



First order Source free System with RL load and DC excitation