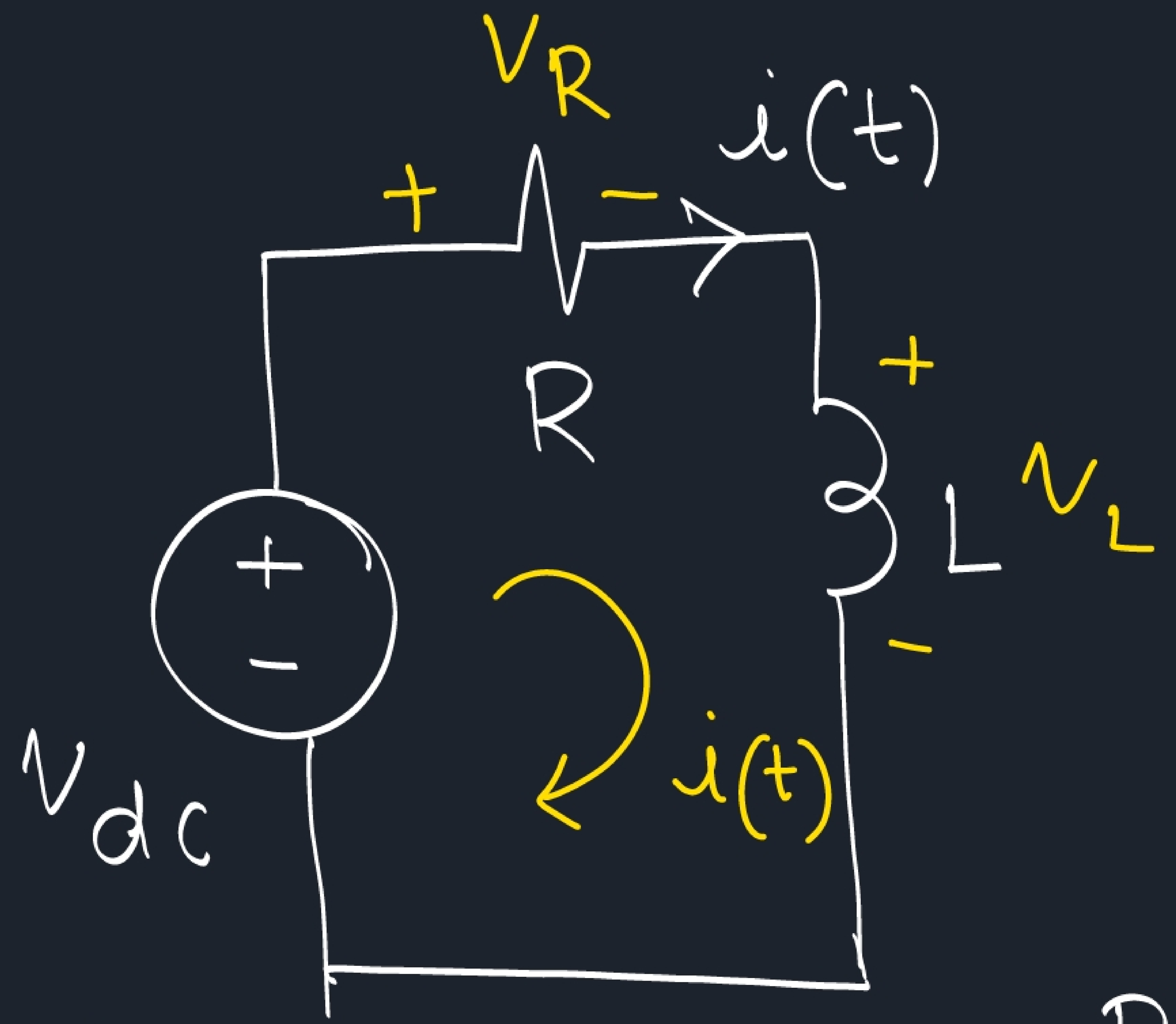
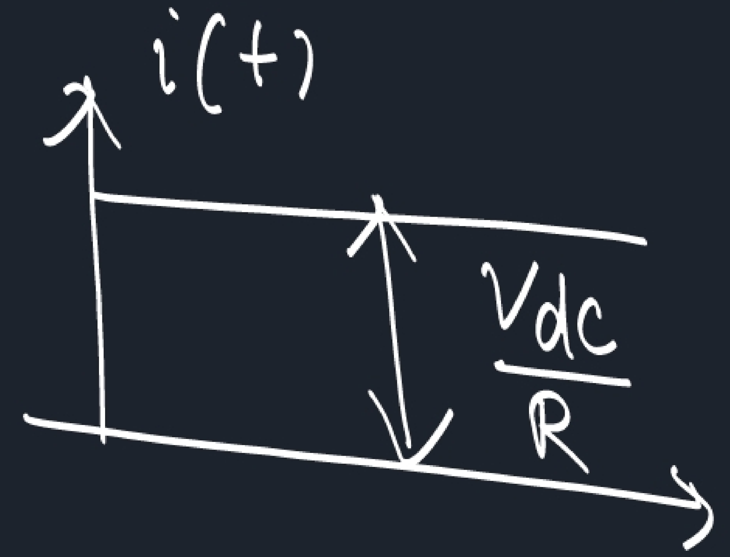
# Basics:-








$$V_{dc} = V_R + V_L$$

$$\Rightarrow L\frac{di(t)}{dt} + R\,i(t) = V_{dc}$$

$$\Rightarrow \frac{di(t)}{dt} + \underbrace{\frac{R}{L}}_{P}\,i(t) = \underbrace{\frac{V_{dc}}{L}}_{Q}$$

$$e^{R/L\,t}\frac{di(t)}{dt} + e^{\frac{R}{L}t}\frac{R}{L}\,i(t) = e^{R/L\,t}\frac{V_{dc}}{L}$$

$$\Rightarrow \frac{d}{dt}\left(e^{R/L\,t}\,i(t)\right) = e^{R/L\,t}\cdot\frac{V_{dc}}{L}$$

$$e^{R/L\,t}\,i(t) = A + \frac{V_{dc}}{L}\int e^{R/L\,t}\,dt$$

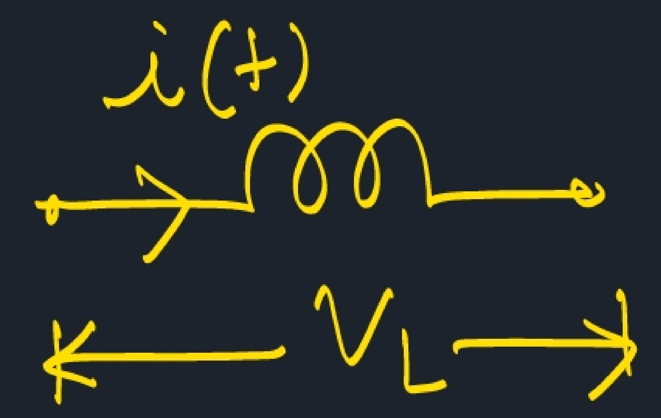
$$i(t) = Ae^{-R/L\,t} + \frac{V_{dc}}{L}e^{-R/L\,t}\underbrace{\int e^{R/L\,t}\,dt}$$

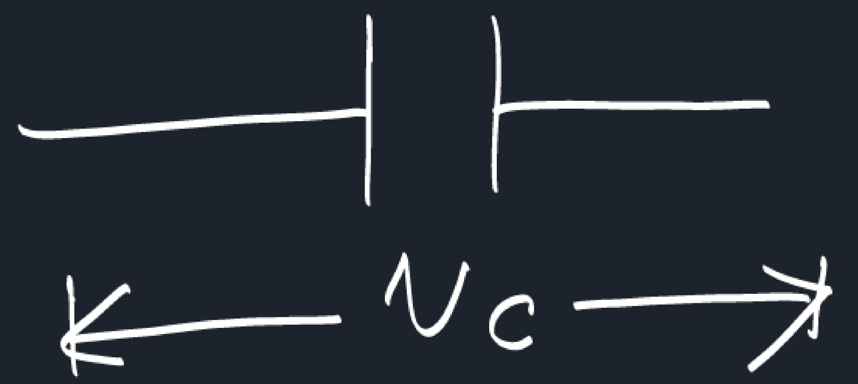
$$\boxed{i(t) = Ae^{-R/L\,t} + \frac{V_{dc}}{R}}$$

@ $t=0$ $i(t) = I_0$

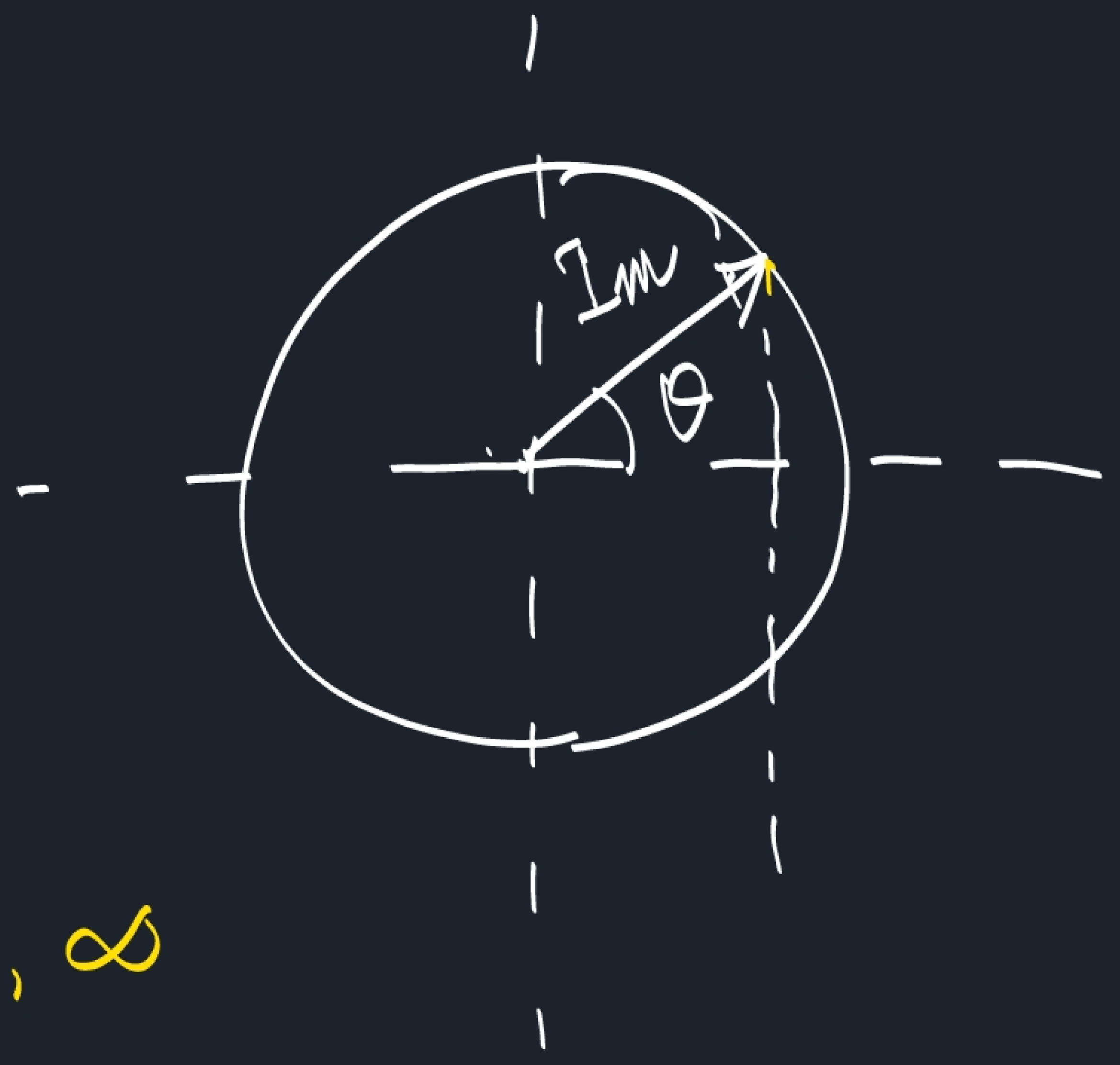
$$I_0 = A + \frac{V_{dc}}{R} \Rightarrow A = I_0 - \frac{V_{dc}}{R}$$

$$\boxed{i(t) = \frac{V_{dc}}{R}\left(1-e^{-R/L\,t}\right) + I_0e^{-R/L\,t}}$$




$f \propto -x$




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

$$i_c(t) = C\frac{dv_c(t)}{dt}$$

$$v_c(t) = \frac{1}{C}\int i_c(t)\,dt$$

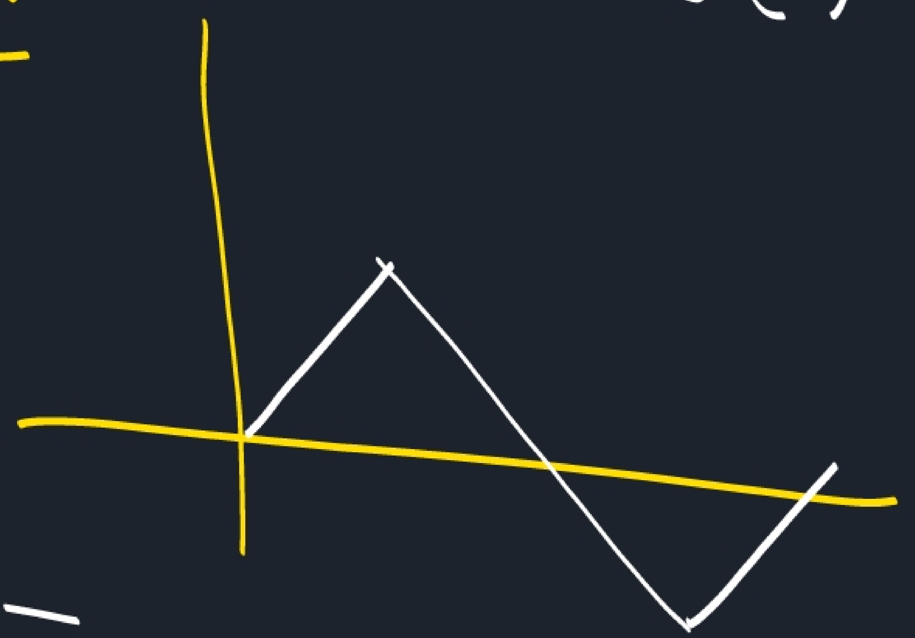
$n = 1, 2, \ldots, \infty$

$i(t) = e^{\pm\alpha t}$ $\alpha$ is integer.

$i(t) = \sin\omega t$

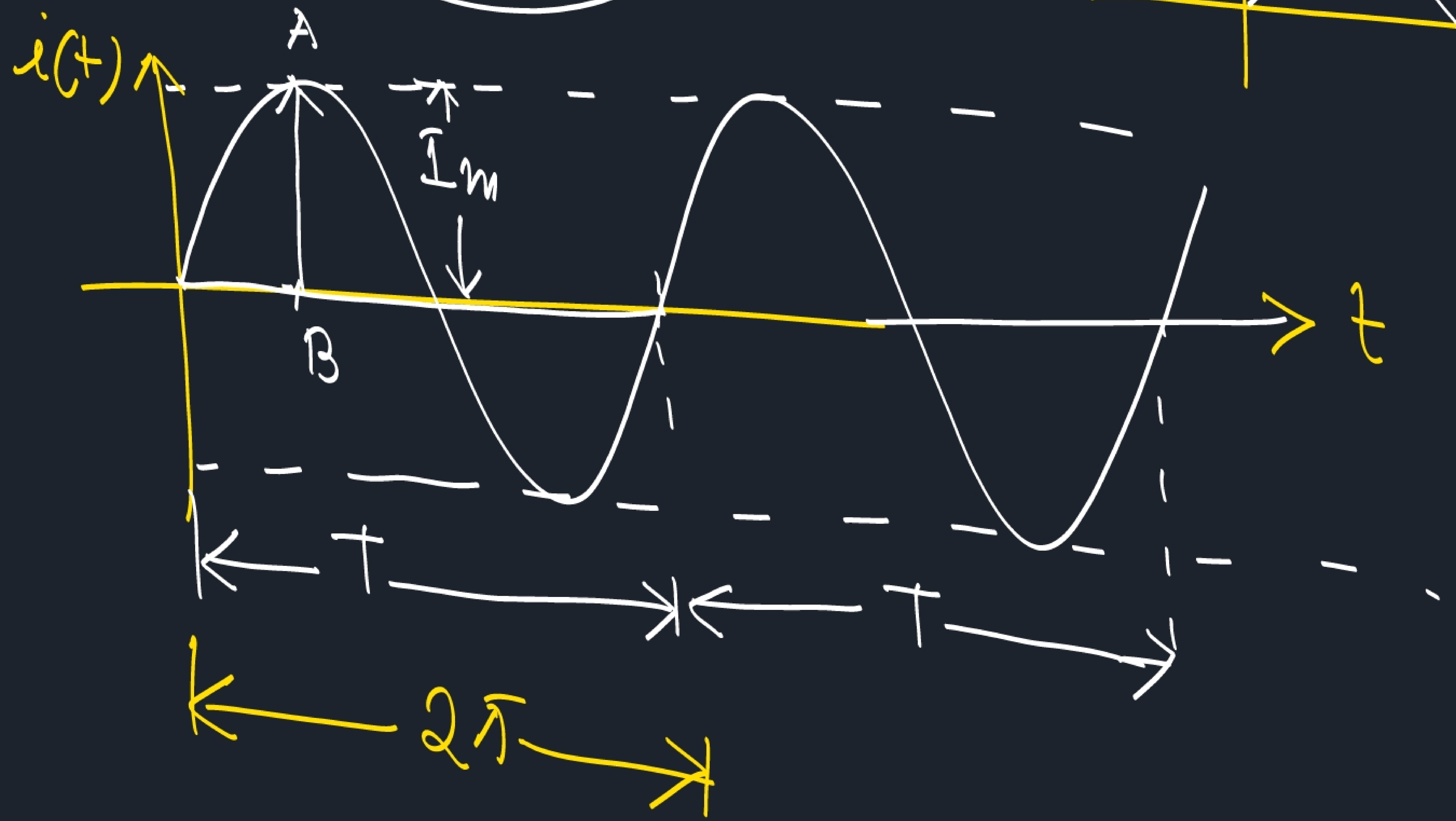
$I_m \sin\theta$

$I_m \sin\omega t$



$f(t)$ $\boxed{f(t \pm nT) = f(t)}$

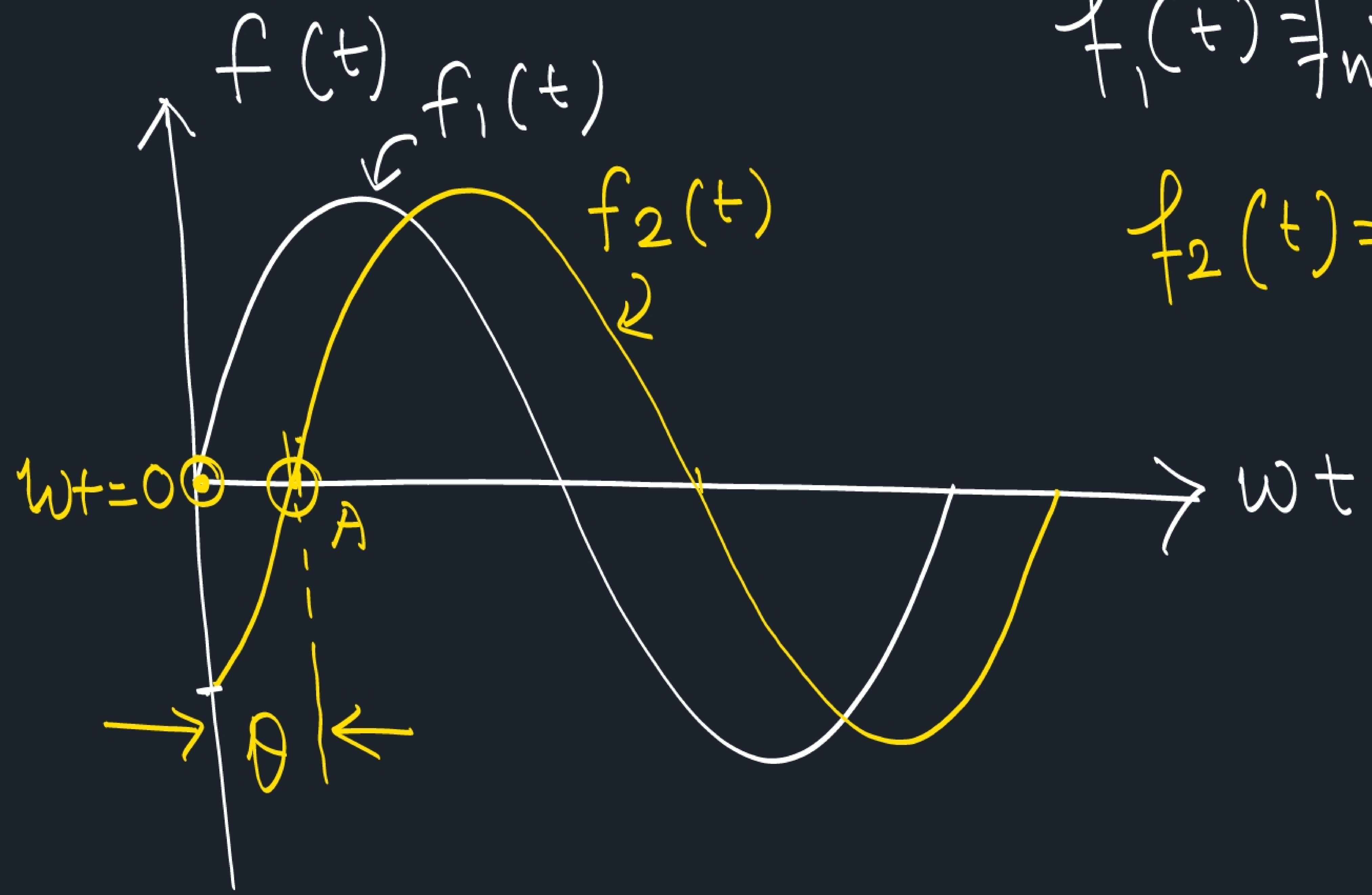
periodic waveform.




$$\text{freq} = \frac{1}{T} = 50\text{ Hz}.$$

$$\omega t\,(t = T) = 2\pi$$

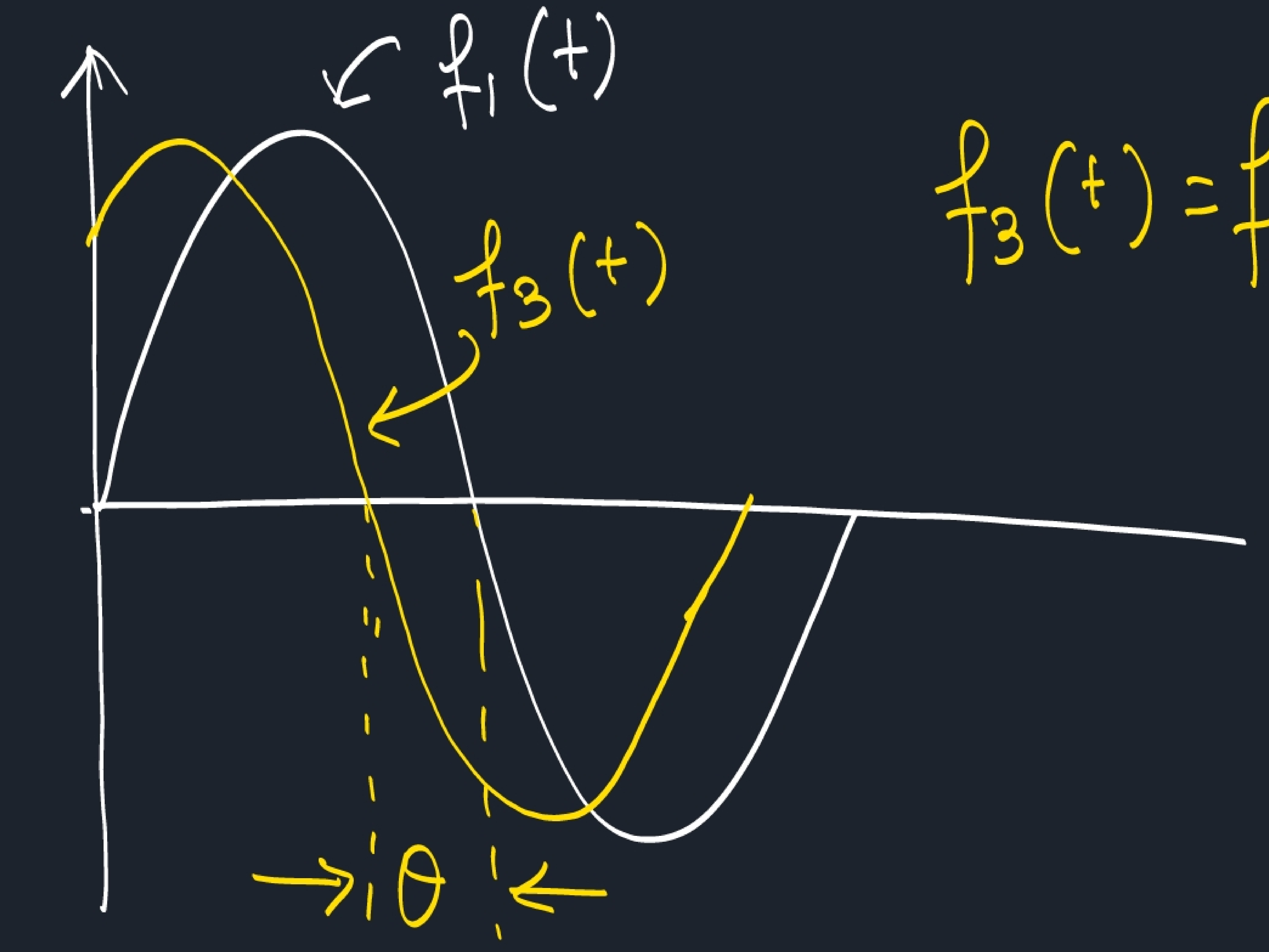
# Concept of Lagging & Leadings :-




$f_1(t) = f_m \sin(\omega t)$

$f_2(t) = f_m \sin(\omega t - \theta)$

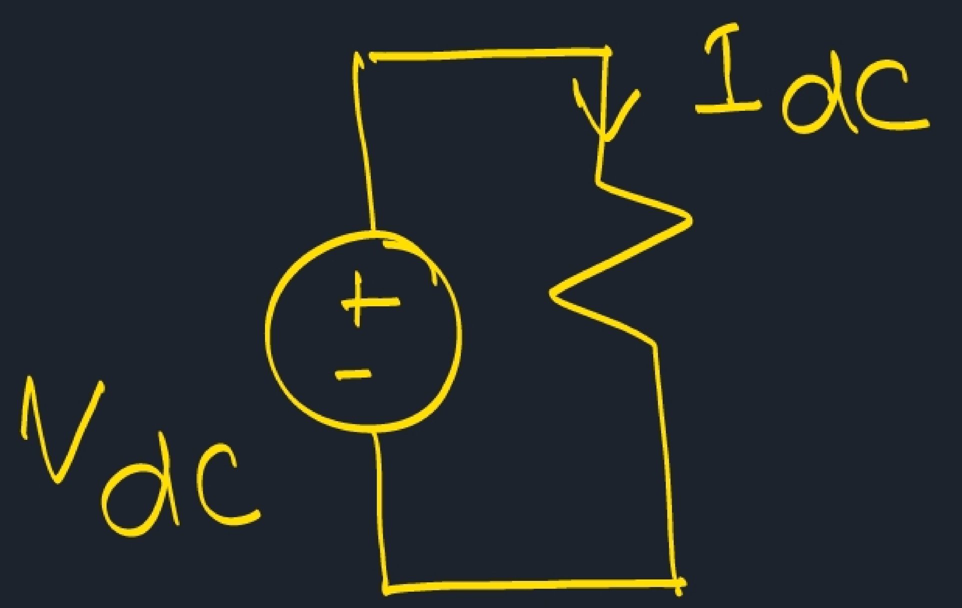
$f_2(t)$ is lagging behind $f_1(t)$ by an angle of $\theta$.

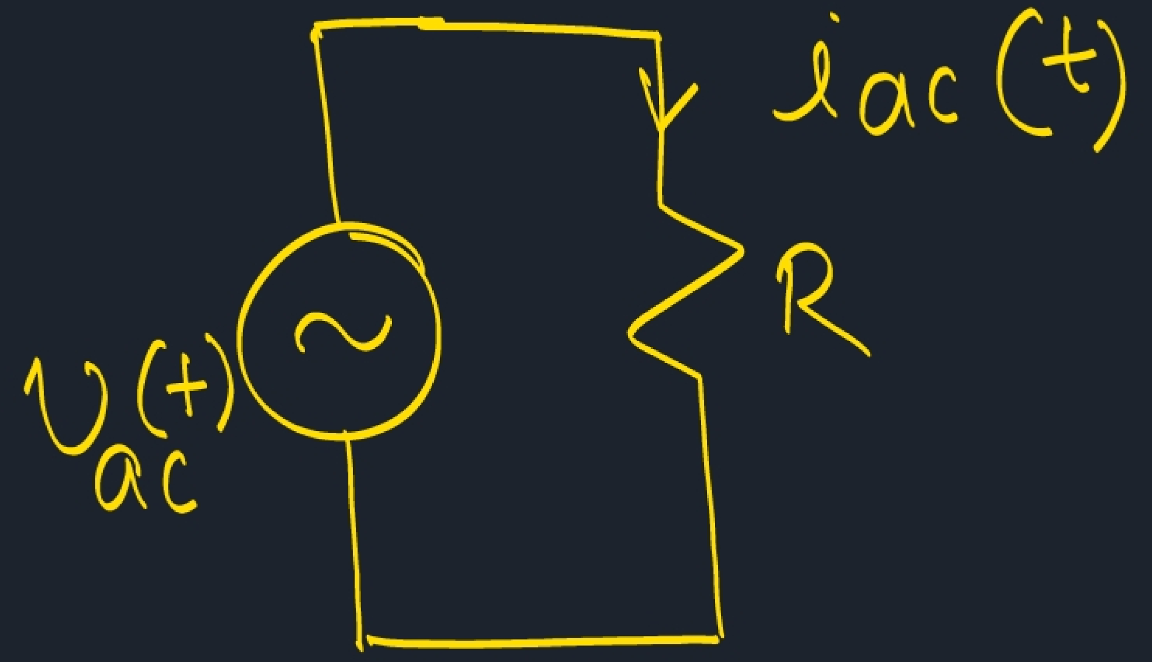



$f_3(t) = f_m \sin(\omega t + \theta)$

$f_3(t)$ is leading $f_1(t)$ by an angle of $\theta$.

# Rms value:-




$$I_{rms} = \sqrt{\frac{1}{T}\int_0^T \{i(t)\}^2 dt}$$

→ Effective value.

$$E_{dc} = I_{dc}^2 \cdot R \cdot T$$

$$E_{AC} = \int_0^T i_{ac}^2 R \, dt$$

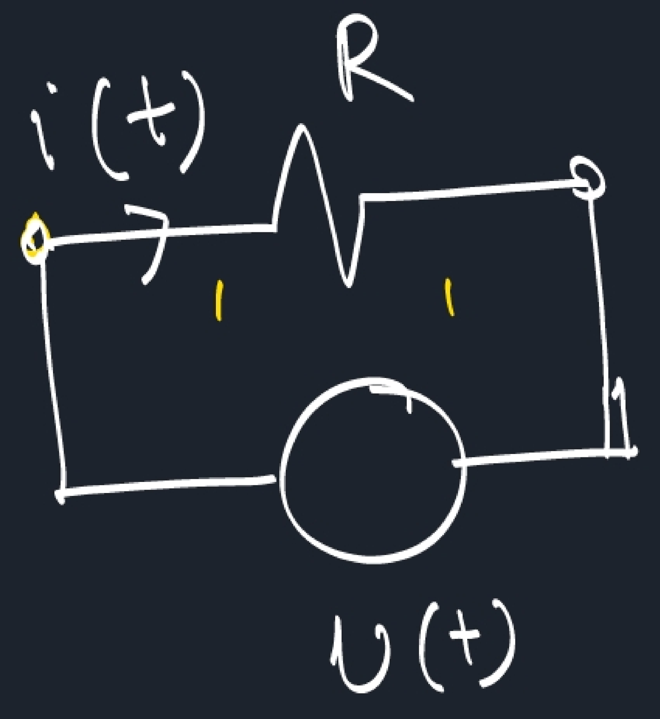
# AVERAGE VALUE:-

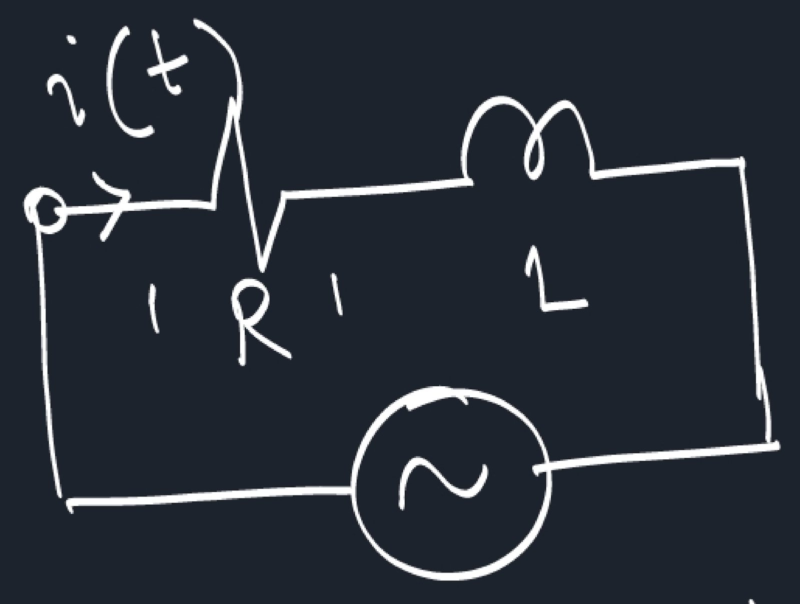
$$I_{avg} = \frac{1}{T}\int_t^{t+T} i(t)\,dt$$

$$I_{dc}^2 R \cdot T = \int_0^T i_{ac}^2(t) R \, dt$$

$$\boxed{I_{dc} = \left(\frac{1}{T}\int_0^T i_{ac}^2(t)\,dt\right)^{1/2}} = \underline{I_{ac}^{rms.}}$$

## Sinusoidal Forced Response:-




$v(t) = V_m \cos\omega t$

$$L\frac{di}{dt} + Ri = v(t)$$
$$= V_m \cos\omega t$$

$$\frac{di}{dt} + \frac{R}{L}i = \frac{V_m}{L}\cos\omega t$$

$$e^{R/L\,t}\cdot\frac{di}{dt} + \frac{R}{L}e^{R/L\,t}\cdot i = \frac{V_m}{L}\cos\omega t\cdot e^{R/L\,t}$$

$$\Rightarrow \frac{d}{dt}\left(e^{R/L\,t}\,i(t)\right) = \frac{V_m}{L}e^{R/L\,t}\cdot\cos\omega t$$

$$e^{R/L\,t}\,i(t) = A + \int_0^t \frac{V_m}{L}e^{R/L\,t}\cos\omega t\,dt$$

$$i(t) = Ae^{-R/L\,t} + e^{-R/L\,t}\int\frac{V_m}{L}e^{R/L\,t}\cos\omega t\,dt$$

$$\int \frac{V_m}{L} e^{R/L\,t} e^{j\omega t} = \int \frac{V_m}{L} e^{(R/L + j\omega)t}$$

$$= \frac{V_m}{L} \cdot \frac{e^{R/L\,t} \cdot e^{j\omega t}}{\frac{R}{L} + j\omega}$$

$$= V_m \cdot \frac{e^{R/L\,t} \cdot e^{j\omega t}}{R + j\omega L}$$

$$\cos \omega t = \mathrm{Re}\{e^{j\omega t}\}$$

$$e^{j\omega t} = \cos \omega t + j \sin \omega t$$

$$\frac{e^{j\omega t} + e^{-j\omega t}}{2}$$

$$a + jb = |z| \angle \theta$$

$$|z| = \sqrt{a^2 + b^2}$$

$$\theta = \tan^{-1}\left(\frac{b}{a}\right)$$

$$a + jb = |z| e^{j\theta}$$

$$\mathrm{Re}\left\{ V_m \cdot \frac{e^{j\omega t}}{R + j\omega L} \right\} = \frac{V_m \cdot e^{j\omega t}}{|z| e^{j\theta}}$$

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

$$= \frac{V_m}{|z|} e^{j(\omega t - \theta)}$$

$$\frac{V_m}{\sqrt{R^2 + (\omega L)^2}} \cos(\omega t - \theta)$$

$$i(t) = Ae^{-R/L\,t} + \frac{V_m}{\sqrt{R^2+\omega^2L^2}}\cos(\omega t - \theta)$$

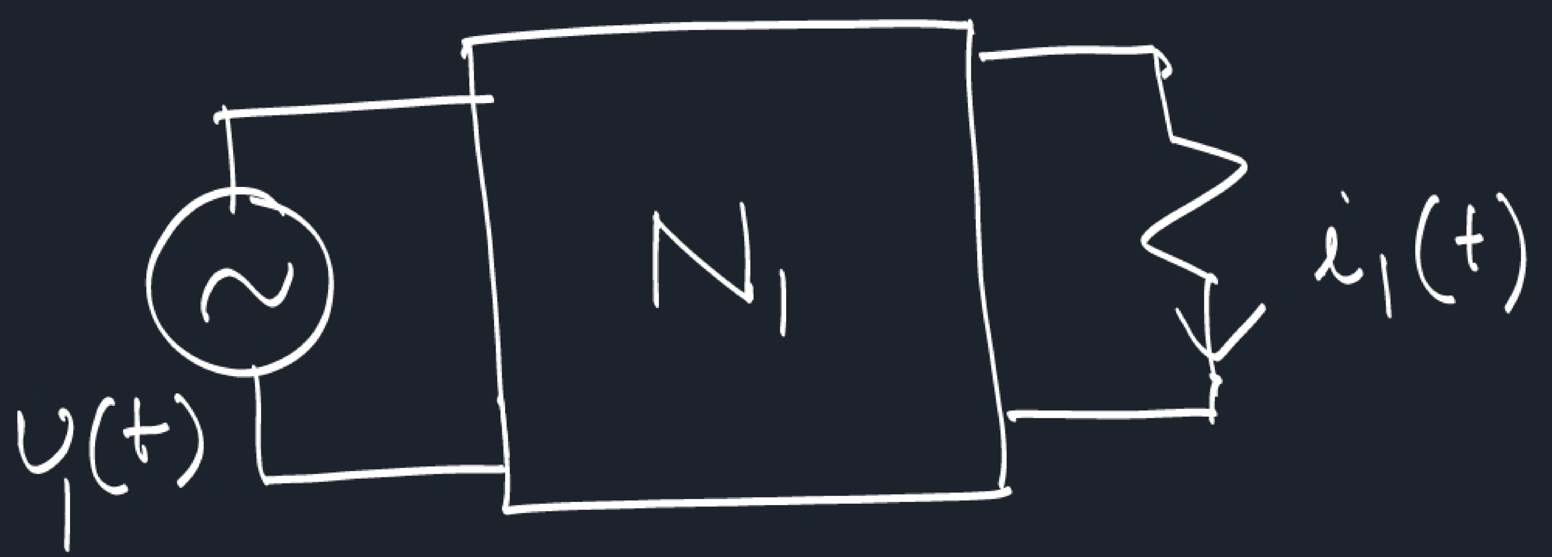
Initial Condⁿ

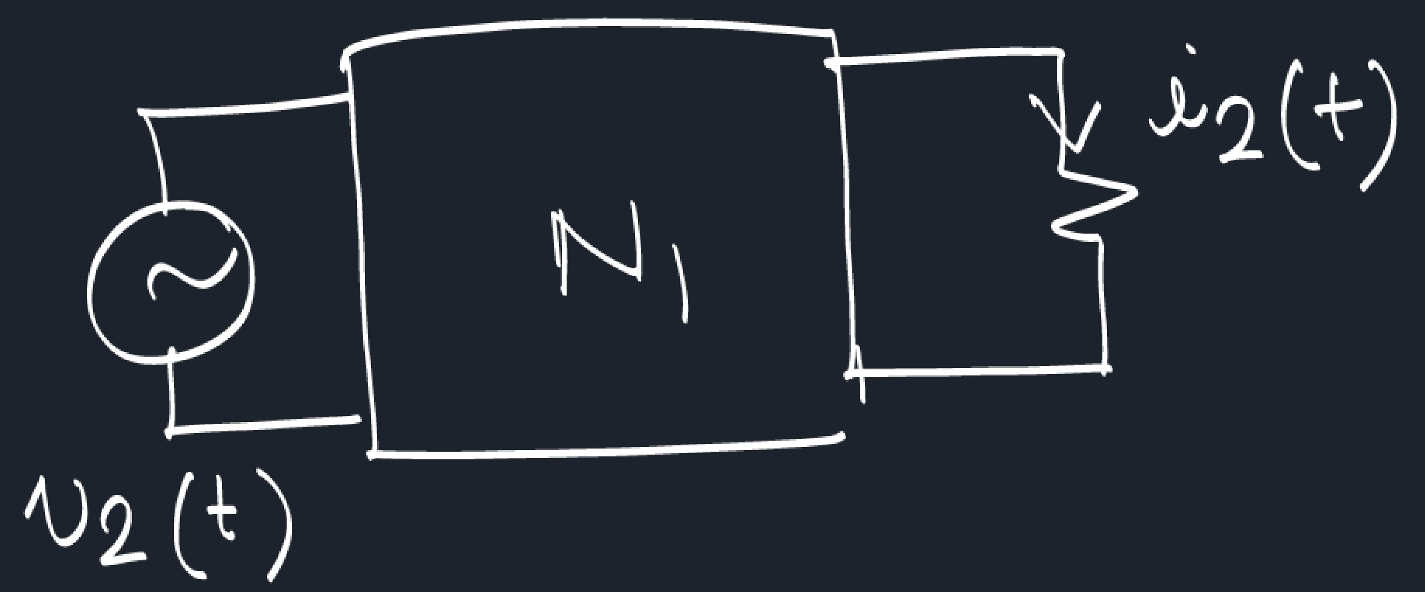
@ $t = 0$

$$0 = A + \frac{V_m}{\sqrt{R^2+(\omega L)^2}}\cos\theta$$

$$A = -\frac{V_m}{\sqrt{R^2+(\omega L)^2}}\cos\theta$$

$$i(t) = -\frac{V_m}{\sqrt{R^2+(\omega L)^2}}e^{-\frac{R}{L}t} + \underbrace{\frac{V_m}{\sqrt{R^2+(\omega L)^2}}\cos(\omega t - \theta)}_{\text{Steady State}}$$





$$v_2(t) = V_m \sin \omega(t)$$

$$i_2(t) = I_m \sin(\omega t \pm \theta)$$

$$v_1(t) = V_m \cos \omega t$$

$$i_1(t) = I_m \cos(\omega t \pm \theta)$$



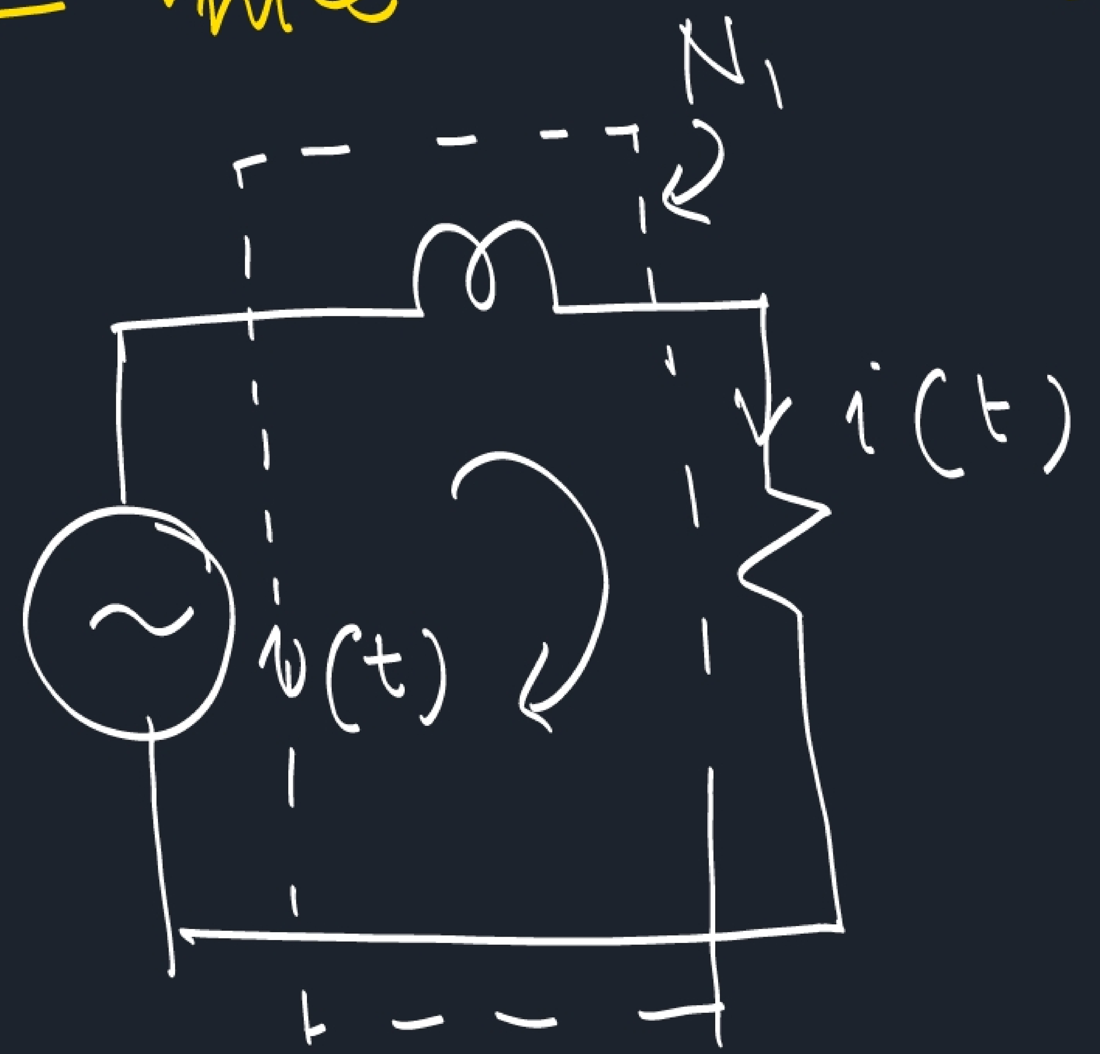
$$i(t) = I_m e^{j(\omega t \pm \theta)}$$

$$v_1(t) + jv_2(t) = V_m \cos \omega t + j V_m \sin \omega t$$

$$= V_m e^{j\omega t}.$$


$v(t) = V_m e^{j\omega t}$

$i(t) = I_m e^{j(\omega t+\theta)}$




$$v(t) = R\,i(t) + L\frac{di(t)}{dt}$$

$$\Rightarrow j\omega L\, I_m e^{j(\omega t+\theta)} + R I_m e^{j(\omega t+\theta)} = V_m e^{j\omega t}$$

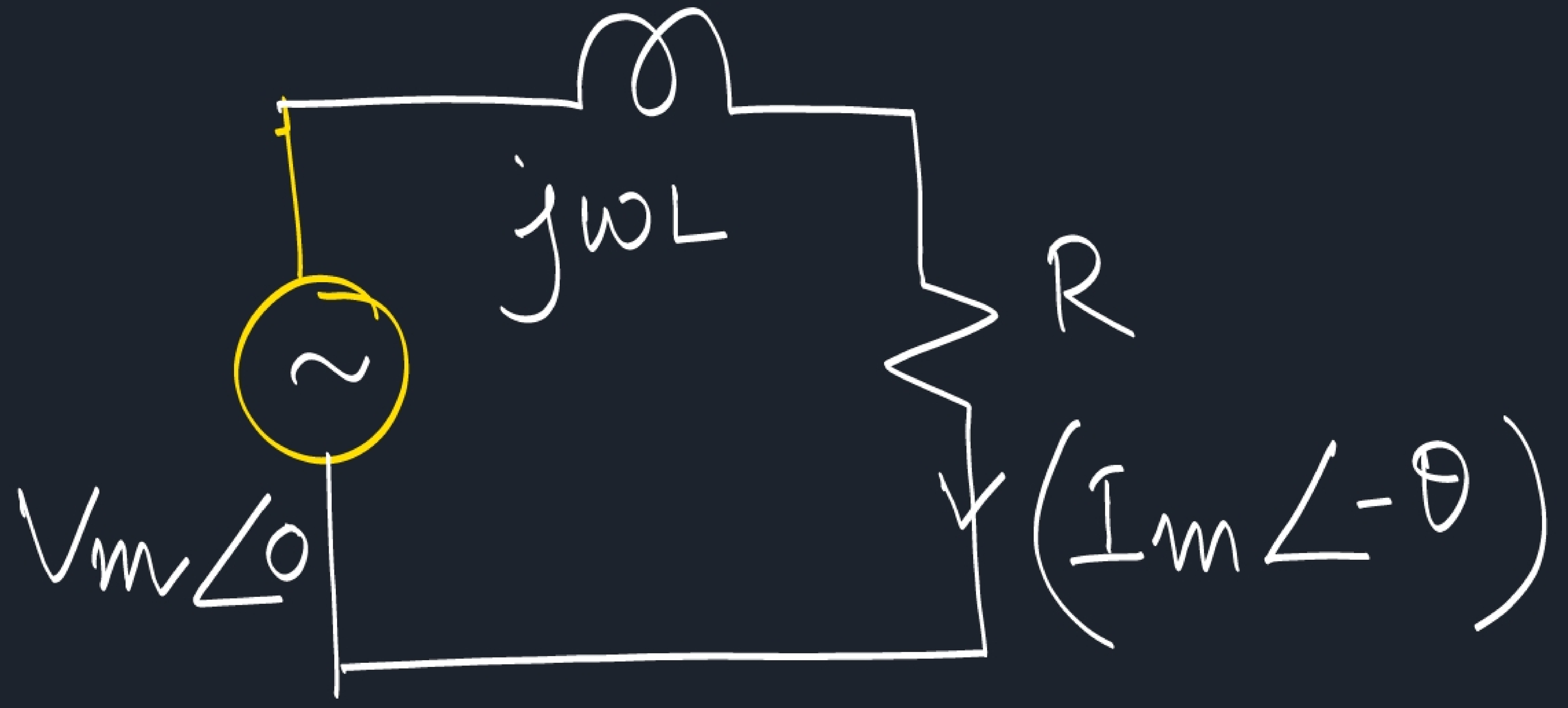
$$\Rightarrow j\omega L\, I_m e^{j\theta} + R I_m e^{j\theta} = V_m$$

$$\Rightarrow I_m e^{j\theta}(R+j\omega L) = V_m$$

$$\boxed{I_m e^{j\theta} = \frac{V_m}{R+j\omega L}}$$

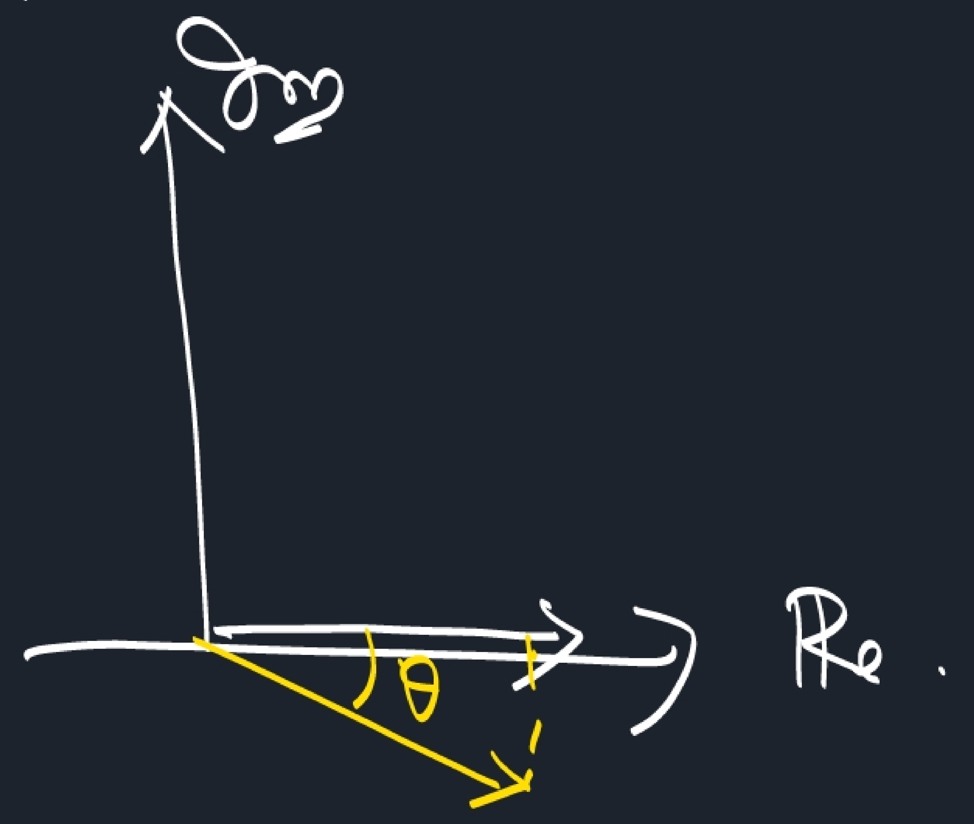
$$I_m = \left| I_m e^{j\theta} \right| = \left| \frac{V_m}{R+j\omega L} \right| = \frac{V_m}{\sqrt{R^2+(\omega L)^2}}$$

$$\theta = \angle I_m e^{j\theta} = \angle \frac{V_m}{R+j\omega L} = -\tan^{-1}\left(\frac{\omega L}{R}\right)$$





⇒ Phasor Representation.

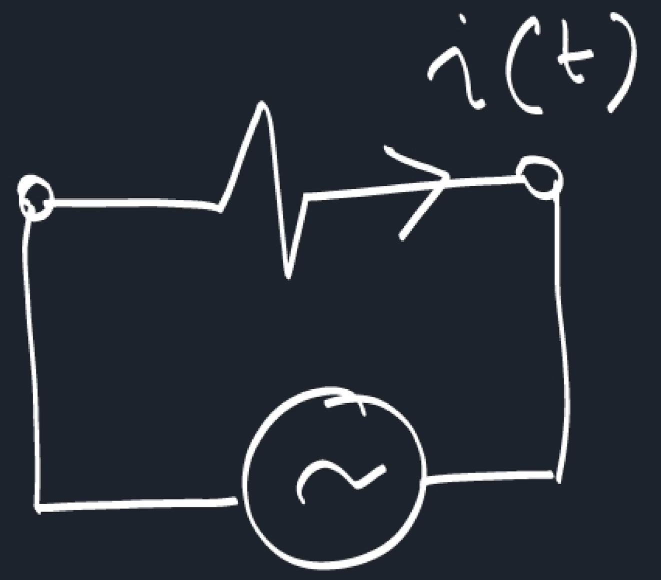



$$I_m \angle -\theta = \frac{V_m \angle 0}{R + j\omega L} \qquad \left(\theta = \tan^{-1}\frac{\omega L}{R}\right)$$

$\vec{V}$ $\quad$ $\tilde{V}$

$V_m \sin \omega t$

$I_m \sin(\omega t - \theta)$




$$v(t) = V_m \cos(\omega t + \phi)$$

$$\Downarrow$$

$$v(t) = R\, i(t)$$

$$i(t) = \frac{V_m}{R} \cos(\omega t + \phi)$$

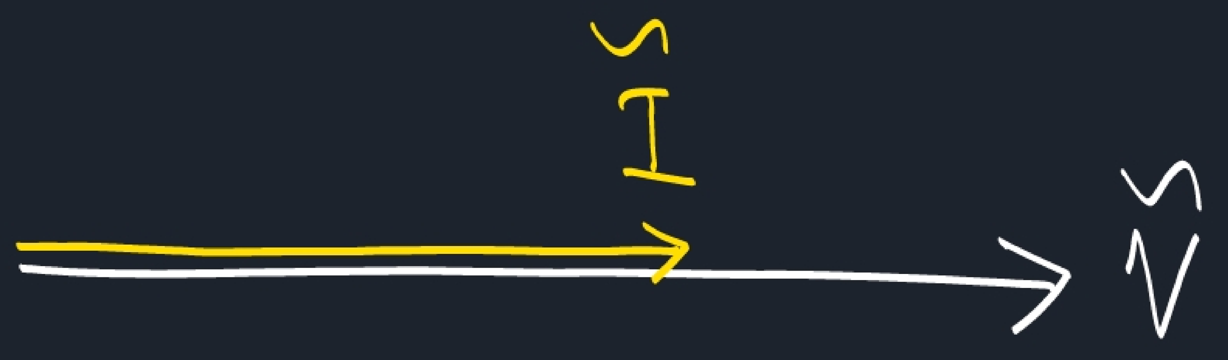
$$v(t) = V_m e^{j(\omega t + \phi)}$$

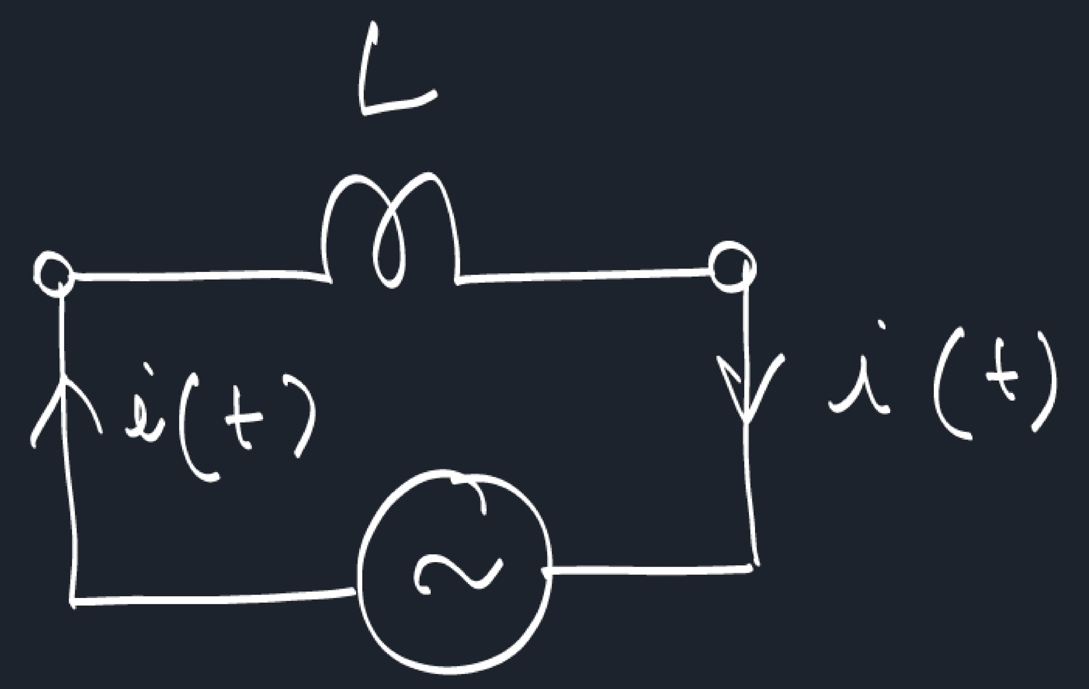
$$i(t) = I_m e^{j(\omega t + \phi)}$$


$$\hat{V} = V_m \angle +\phi = V_m e^{j\phi}$$

$$\hat{I} = I_m \angle +\phi = I_m e^{j\phi}$$

$(R > 1)$






$$v(t) = V_m \cos(\omega t + \phi)$$

$$i(t) = \frac{1}{L}\int v(t)\,dt$$

$$= \frac{1}{L}\int V_m \cos(\omega t + \phi)$$

$$= \frac{1}{\omega L} V_m \sin(\omega t + \phi)$$

$$v(t) = L\frac{di(t)}{dt}$$

$$\hat{V} = j\omega L \hat{I}$$

$\frac{d}{dt}$ is replaced by $(j\omega)$

$$v(t) = V_m e^{j(\omega t + \phi)}$$

$$i(t) = \frac{1}{L}\int V_m e^{j(\omega t + \phi)}\,dt$$

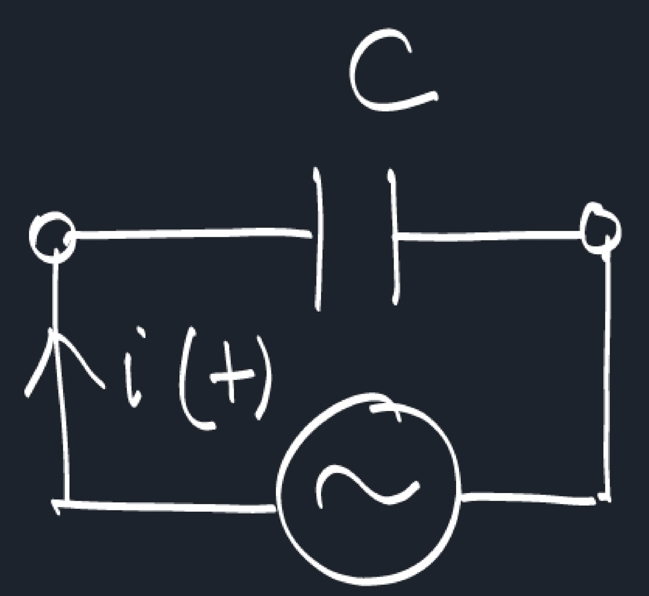
$$= \frac{1}{j\omega L} V_m e^{j(\omega t + \phi)}$$

$$\hat{V} = V_m \angle +\phi = V_m e^{j\phi}$$

$$\hat{I} = \frac{V_m}{j\omega L} \cdot e^{j\phi} = \frac{V_m}{jX_L} e^{j\phi}$$

$X_L = \omega L$ = Inductive Resistance.

$$\hat{V} = (j\omega L)\hat{I}$$




$$v(t) = V_m \cos(\omega t + \phi) \Leftrightarrow V_m e^{j(\omega t + \phi)}$$

$$i(t) = C \frac{dv(t)}{dt}$$

$$= -C\omega \sin(\omega t + \phi)$$

$$i(t) = j\omega C V_m e^{j(\omega t + \phi)}$$


$$\hat{V} = \hat{I} \cdot \left(\frac{1}{j\omega C}\right)$$

$$= -jI(X_C)$$

$$\hat{V} = V_m \angle +\phi$$

$$\hat{I} = j\omega C V_m e^{j\phi}$$

$$= j\omega C \hat{V}$$

$X_C$ = Capacitive Resistance.

$$= \left(\frac{1}{\omega C}\right)$$

$$a_2 \frac{d^2 i(t)}{dt^2} + a_1 \frac{d i(t)}{dt} + b_1 \int i(t)\,dt + a_0 = C$$

$$a_2 (jw)^2 \hat{I} + a_1 (jw)\hat{I} + \frac{b_1}{jw} \cdot \hat{I} + a_0 = \hat{C}$$

$$\hat{I} = \frac{\hat{C}}{a_2 \cdot (jw)^2 + a_1 \cdot (jw) + \frac{b_1}{jw} + a_0}$$