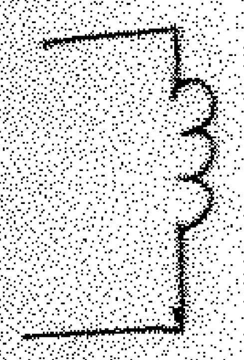
ELECTRICAL MACHINES.

* winding



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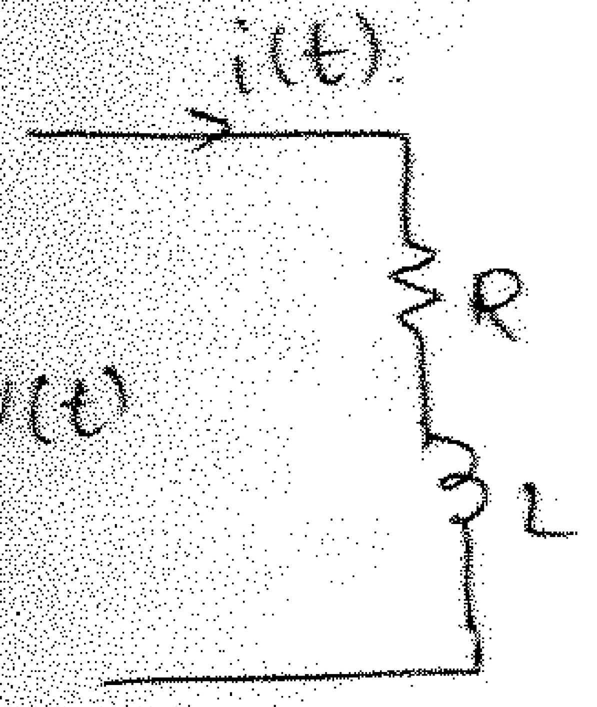
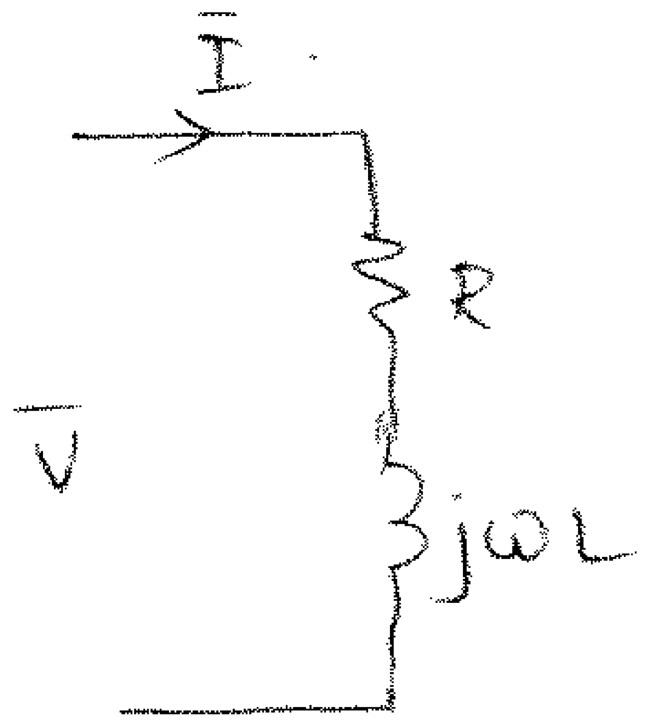
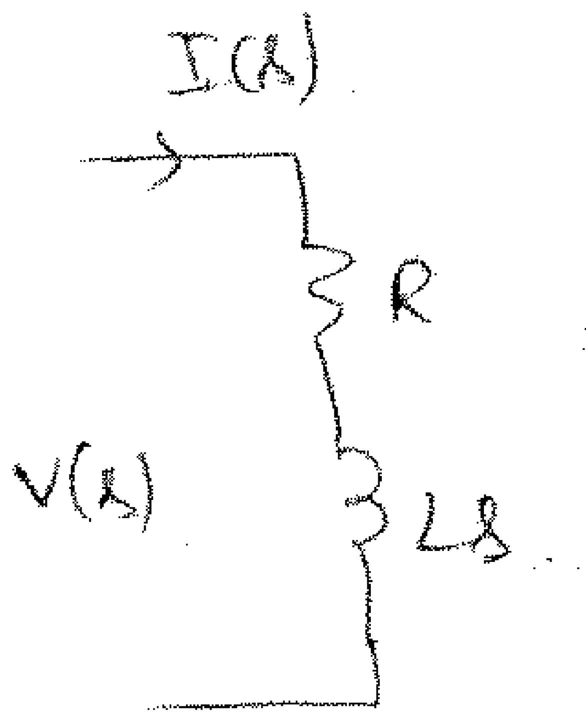






$v(t) = Ri(t) + L\frac{di(t)}{dt}$

TIME-DOMAIN ANALYSIS

$\bar{V} = \bar{I}(R + j\omega L)$

PHASOR-ANALYSIS

$V(s) = (R + Ls)I(s)$

LAPLACE TRANSFORM

* Speed of the fan with time

Time constant = $\tau = 2s$.

Time by which the output will be 66% of steady state value.

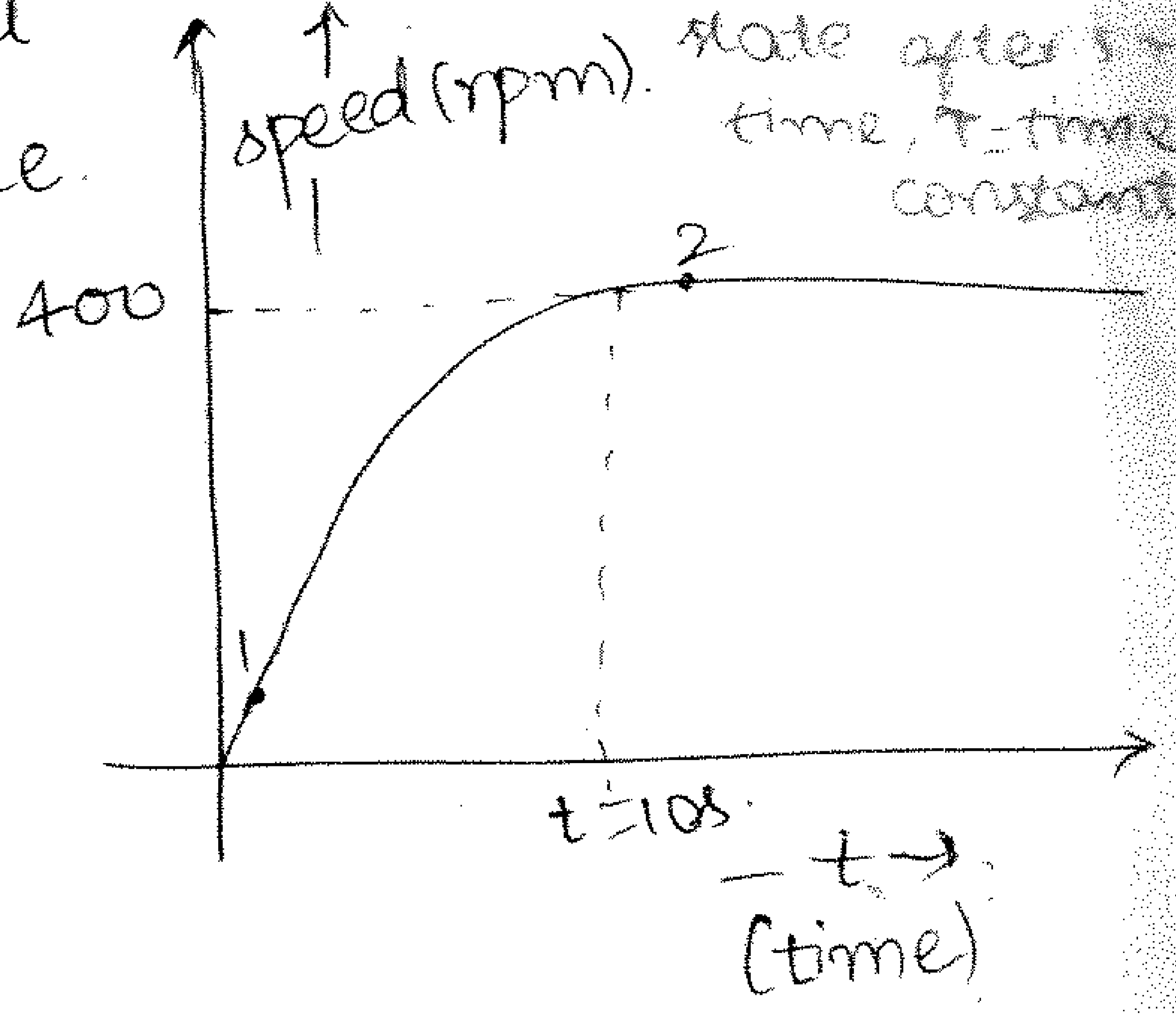
$N = N_0(1 - e^{-t/\tau_0})$

N = speed,

N_0 = final speed.

$N = N_0(1 - e^{-t/\tau_0})$, $\tau_0 = \frac{L}{R}$

The system will reach steady state after 5τ time, τ = time constant



$t = 5\tau$.

$e^{-1} = 36.5\%$

$e^{-2} = 13.5\%$

$e^{-3} = 5\%$

$e^{-4} = 2\%$

$e^{-5} = 1\%$

$I_1 > I_2$

$\tau = \frac{J}{B}$

J = Moment of Inertia (kgm^2),

B = Friction coefficient

Torque(τ) = $\frac{J}{B}$

Torque(τ) = $\frac{J}{B}$

τ → N.m

$T = B.\omega$

$N.m = B\frac{rad}{s}$

$\Rightarrow B = \frac{N.m.s}{rad}$

*

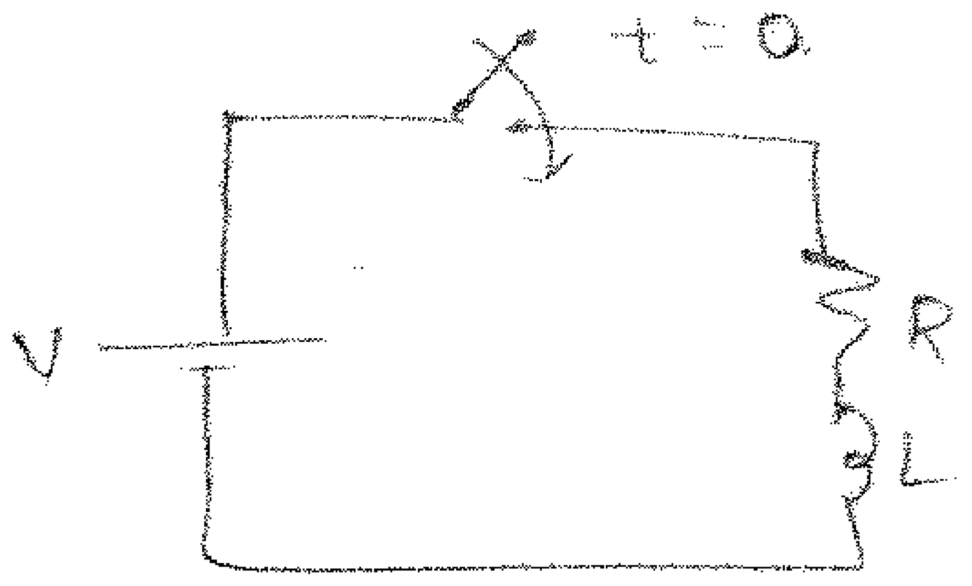
$$V = iR + L\frac{di}{dt}$$

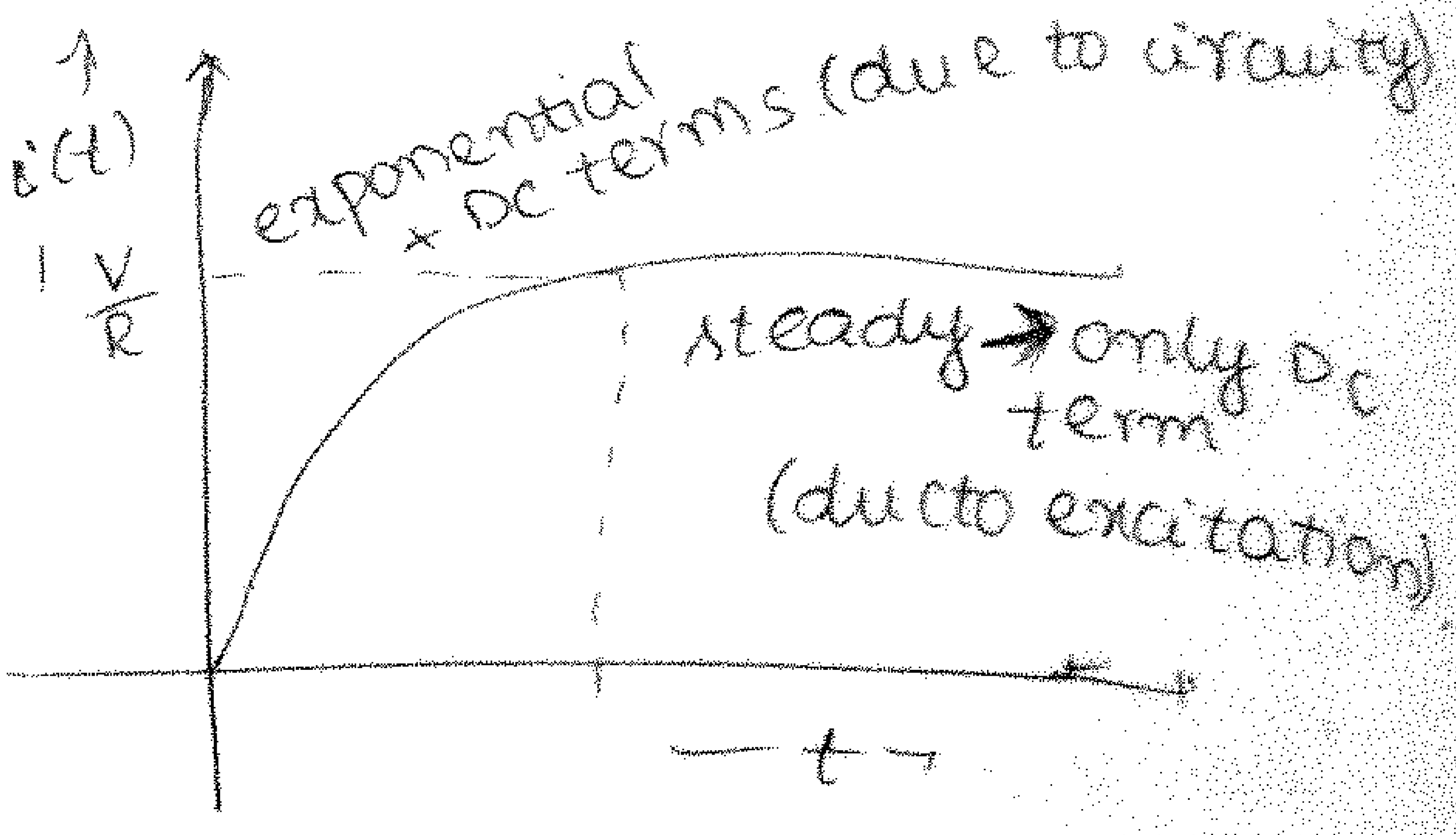
$$V - iR = L\frac{di}{dt}$$

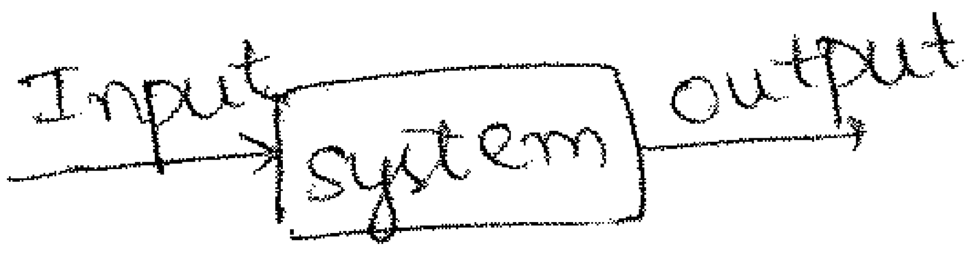
$$\frac{1}{V-iR}\,di = \frac{1}{L}\,dt$$

$$\frac{-1}{R}\left\{\ln(V-iR)\right\}_0^{i} = \frac{1}{L}t$$

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







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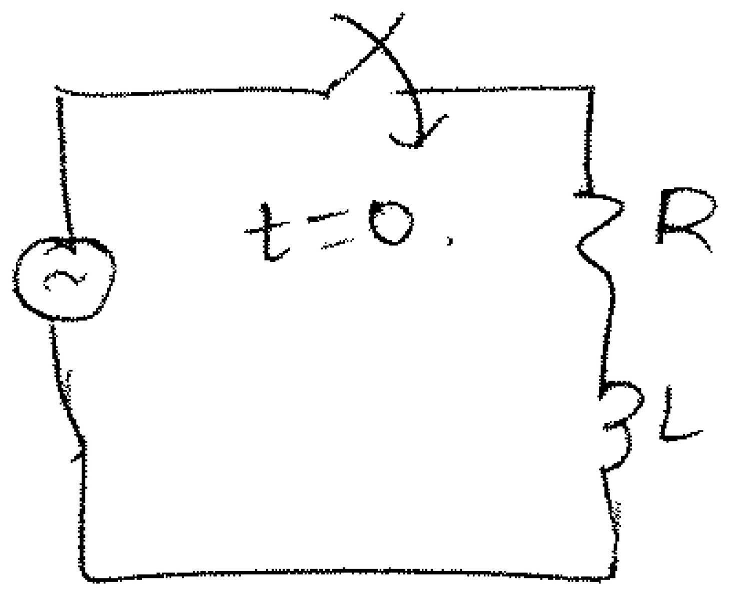
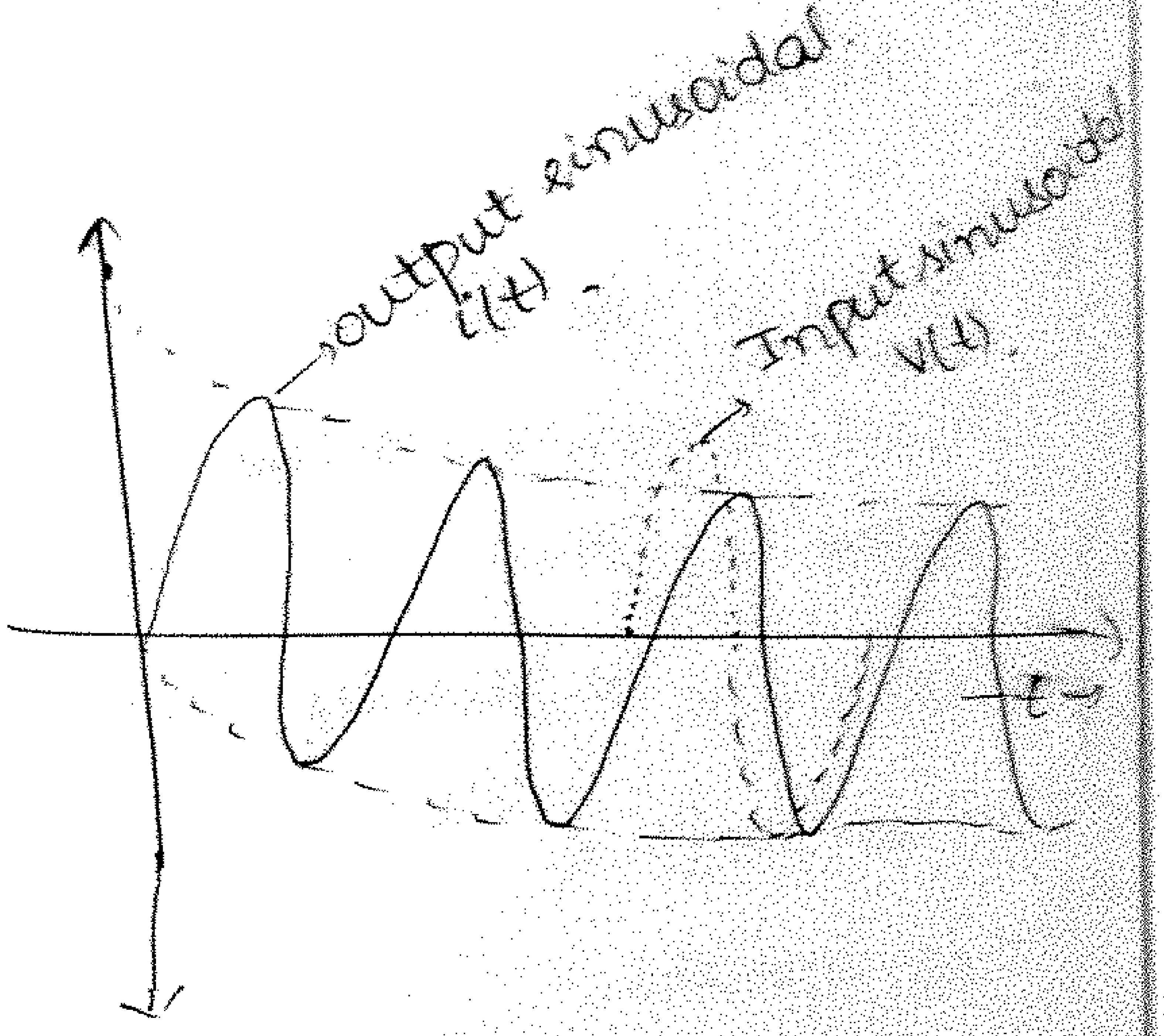
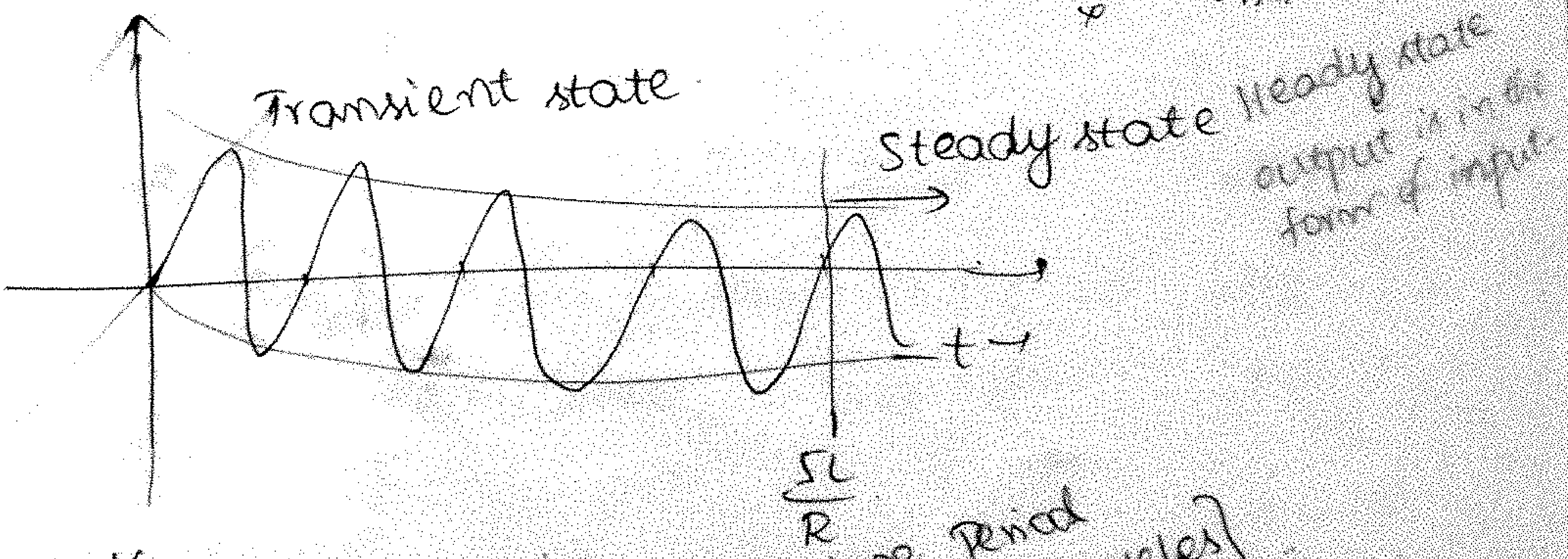


$$\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

current lags voltage by phase ϕ.



Steady state :- The state at which the final response is sinusoidal that of the excitation.



$\tau = L/R$. $f = 50\,Hz$.

Four × time period [∵ Four cycles]

$R = 10\,\Omega$

$$\therefore 5\times\frac{L}{R} = 4\times\frac{1}{50}$$

$$\frac{5}{10}\times L = \frac{4}{50} \Rightarrow L = \frac{4}{25} = 160\,mH = 0.16\,H$$

Electrical Time constant = 16ms. [∵ t = 80/5 = 16ms].

Mechanical time constant = 2s

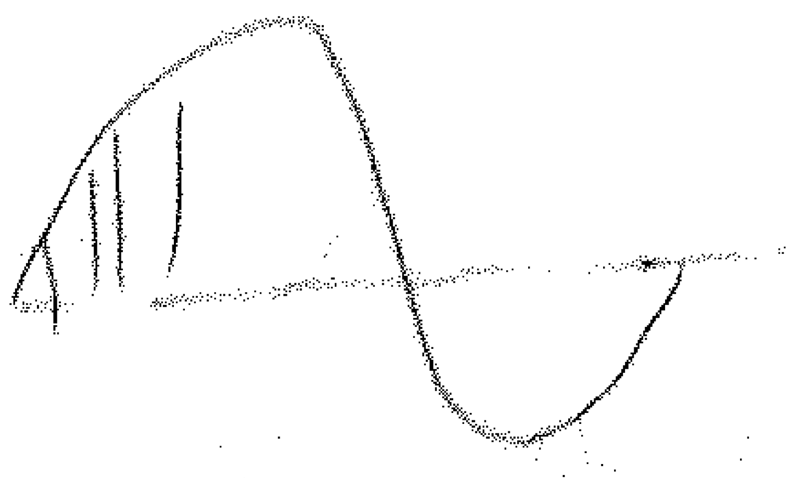
Phase Analysis is applied for

1. Sinusoidal excitation
2. Steady-state analysis

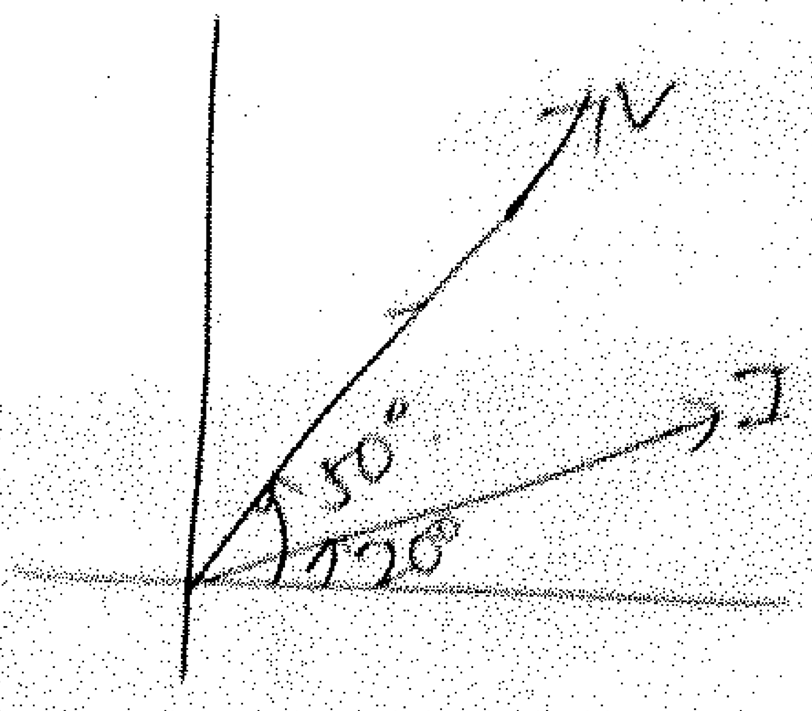
It provides mathematical simplification.

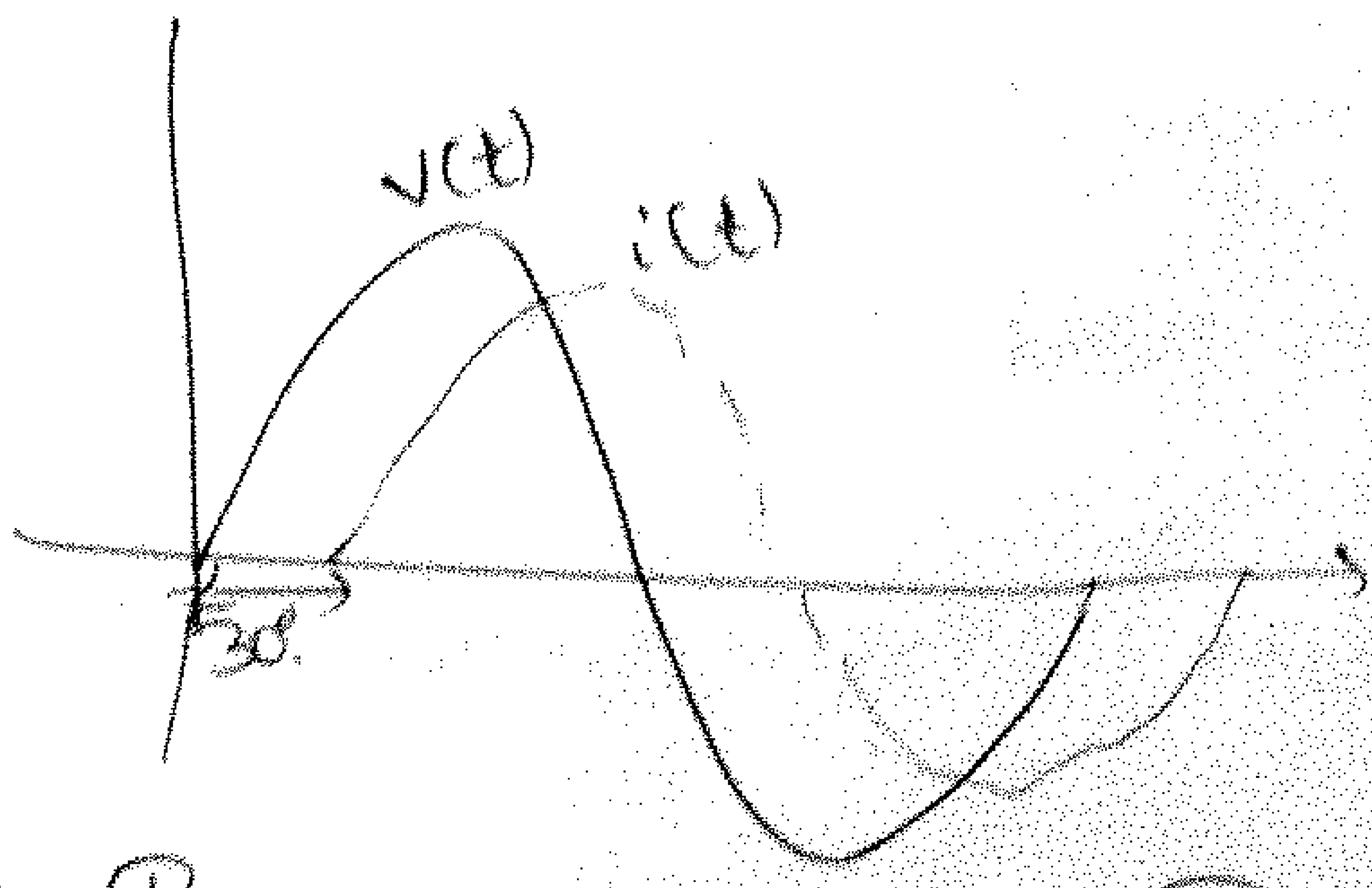
$$\frac{di}{dt} \to j\omega \bar{I} \qquad \int v(t)\,dt \to \frac{\bar{V}}{j\omega}$$

t	$i(t)$	$\frac{di}{dt}$
t_1	I_1	
t_2	I_2	$\frac{I_2 - I_1}{t_2 - t_1}$
⋮	⋮	⋮
t_n	I_n	$\frac{I_n - I_{n-1}}{t_n - t_{n-1}}$



* $\bar{I} = I\angle\theta_i = 5\angle 20^\circ$, $\bar{V} = V\angle\theta_v = 10\angle 50^\circ$ f = 50Hz.





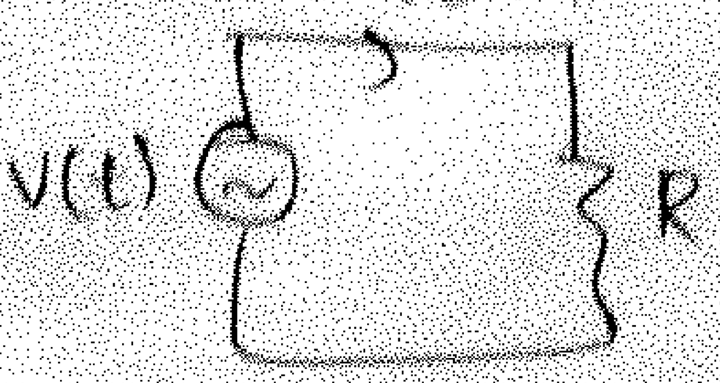
Active Power and Reactive Power..

$P(t) = v(t).i(t)$.

$v(t) \to$ sinusoidal

$i(t) = \frac{v(t)}{R}$

✓ Sinusoidal

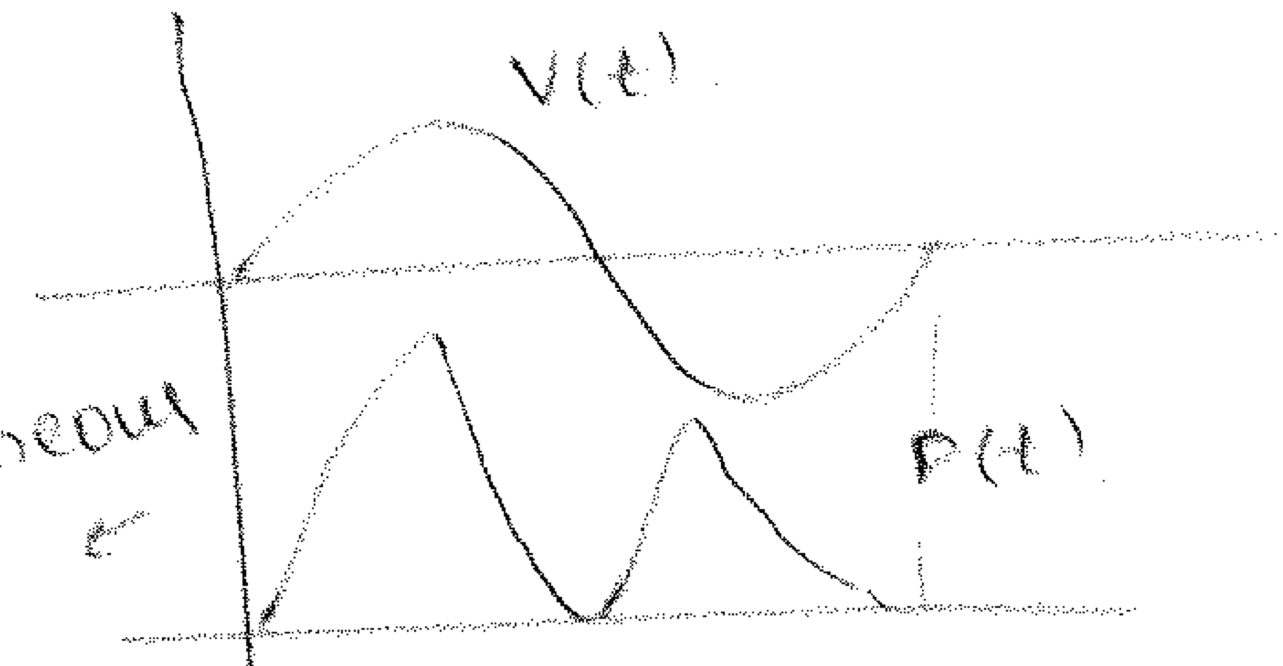


Active Power = v(t).i(t)

Reactive Power

$$P(t) = v(t).i(t) = \frac{A^2 \sin^2\omega t}{R} = \frac{A^2}{2R}(1 - \cos 2\omega t)$$

When voltage covers 1 cycle, power covers 2 cycles.



Instantaneous Active Power.

$\boxed{\text{Active Power} = VI\cos\phi}$ Active Power = $VI\cos\phi$, Reactive Power = $VI\sin\phi$

Average power → commonly used.

Active Power = Avg {Instantaneous Active Power}

Uni-directional → Active Power. P(t)

Active Power = Avg{Instantaneous Active Power}

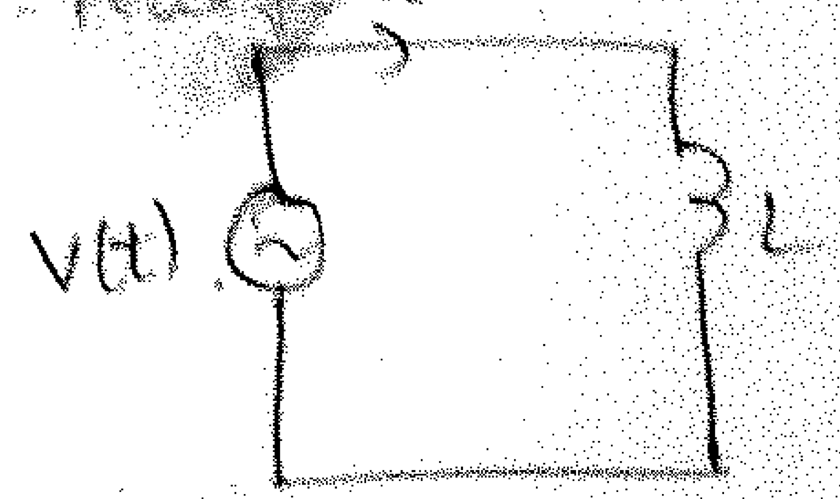
Reactive Power = Peak{Instantaneous Reactive Power}

* $P(t) = V(t) \cdot i(t)$

$V(t) = V_m \sin\omega t$,

$i(t) = I_m \sin(\omega t - \pi/2)$

$P(t) = \dfrac{-V_m I_m \sin 2\omega t}{2}$



Source giving power to inductor (+ve), and then inductor giving power back to ~~inductor~~ source (-ve)

Reactive Power = Peak {Instantaneous Reactive Power}.

bi-directional

$\boxed{R.P = VI\sin\phi}$

* For RL, state the instantaneous power, instantaneous A.P, instantaneous R.P, A.P, R.P

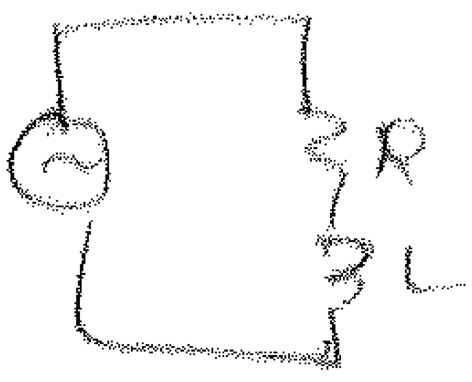
* In steady state, capacitor acts as open circuit (after a long time after the switch is closed)

* Steady state response — forced response.

* Steady state response – forced response
Transcient response – normal response

* A) $i(t) = i_n(t) + i_f(t) = \frac{V}{R} e^{-t/\tau} + \frac{V}{R}$ — (a)

$= -\frac{V}{R} e^{-t/\tau} + \frac{V}{R}$ — (b).

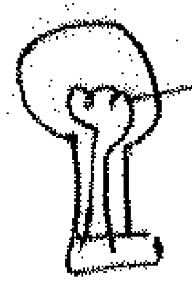


B) $v(t) = V_m \sin \omega t$,

$i(t) = \frac{V_m}{|Z|} \sin\phi \, e^{-t/\tau} + \frac{V_m}{|Z|} \sin(\omega t - \phi)$.

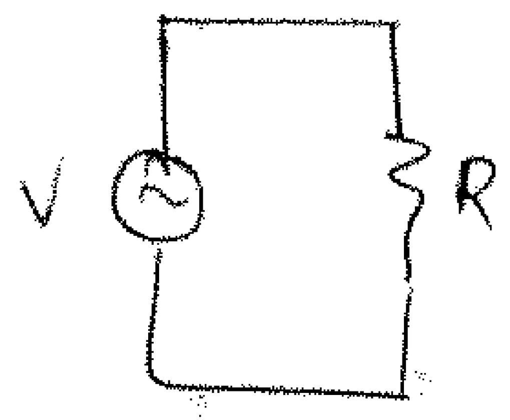
* In bulbs, we indicate power by average value
* In a bulb, electrical bulb is filled with inert gas.
  temperature of the filament = 4500°C
* Tip of the cigarette, temperature = 2500°C

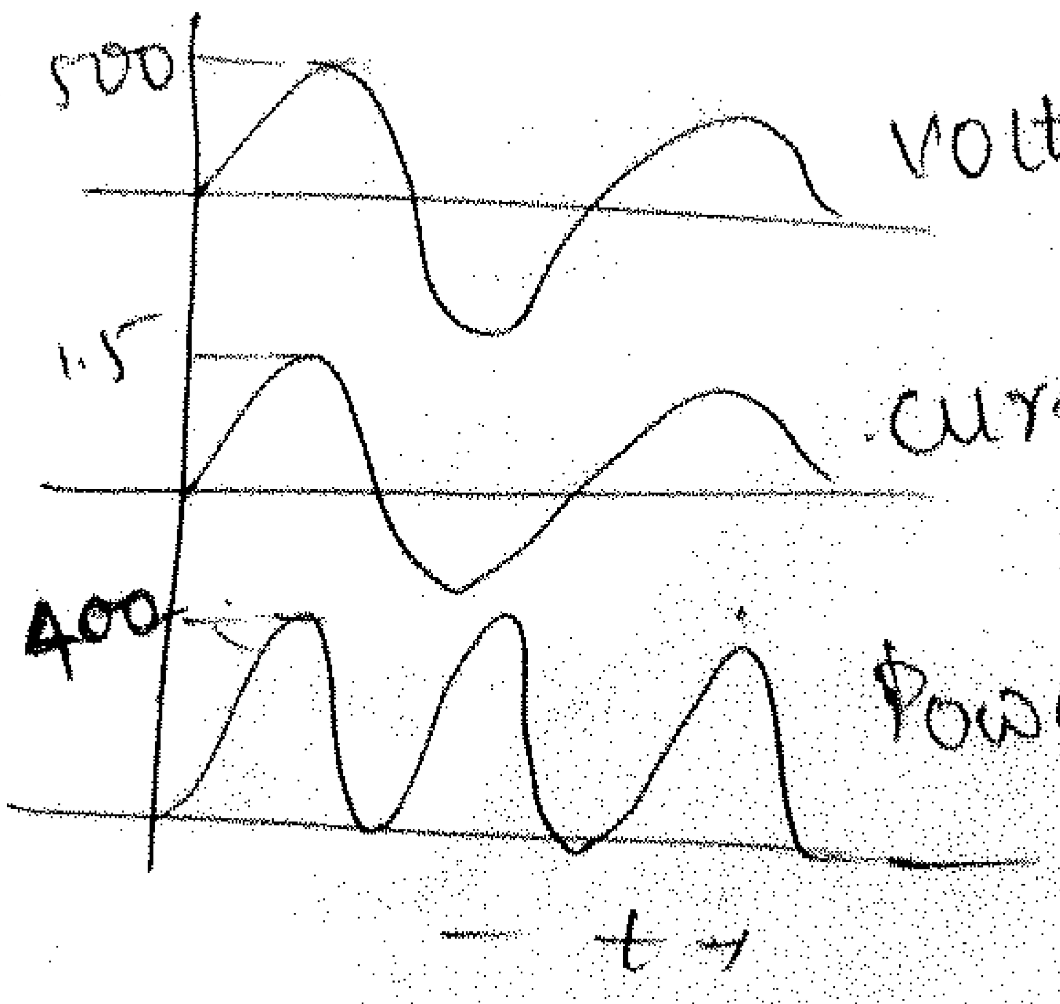
* $\Delta R = \alpha \Delta T R_0$
  Temperature coefficient :



filament.
(made of tungsten acts as resistance).

* $V = V_m \sin \omega t$





Power – Instantaneous power (unidirectional, +ve)
* Active Power – Avg{Instantaneous Active Power}.
  unidirectional.
  Reactive Power. – ~~Avg~~ Peak {Instantaneous Reactive Power}
  bidirectional.

* In R-L circuit.

$P = V_m I_m \sin\omega t \sin(\omega t - \phi)$

$= V_m I_m \{\sin^2\omega t \cos\phi - \sin\omega t \cos\omega t \sin\phi\}$

$= V_m I_m \left[\left(\frac{1-\cos 2\omega t}{2}\right)\cos\phi - \frac{\sin\phi}{2}\sin 2\omega t\right]$

$= V_m I_m \cos\phi \frac{(1-\cos 2\omega t)}{2} - \cancel{\sin} \frac{V_m I_m}{2}\sin 2\omega t \sin\phi$.

↓ Active Power term

$V_m = V/\sqrt{2}$, $I_m = I/\sqrt{2}$

$\therefore P = VI\cos\phi(1-\cos 2\omega t) - VI \sin 2\omega t \sin\phi$.

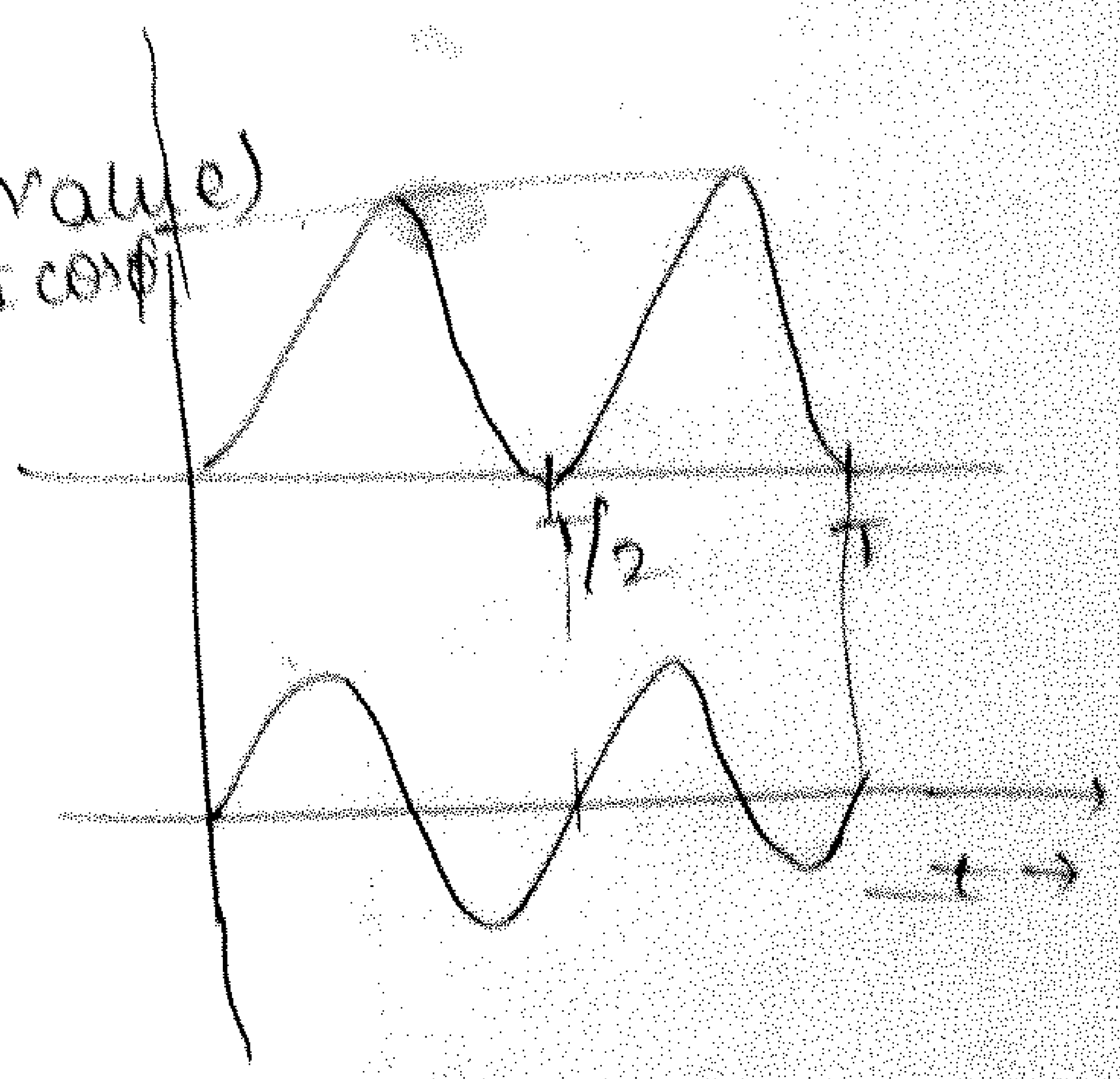
Instantaneous Power wave form.

$P_a = VI\cos\phi$

Instantaneou ~~In~~ Active Power (Average value)

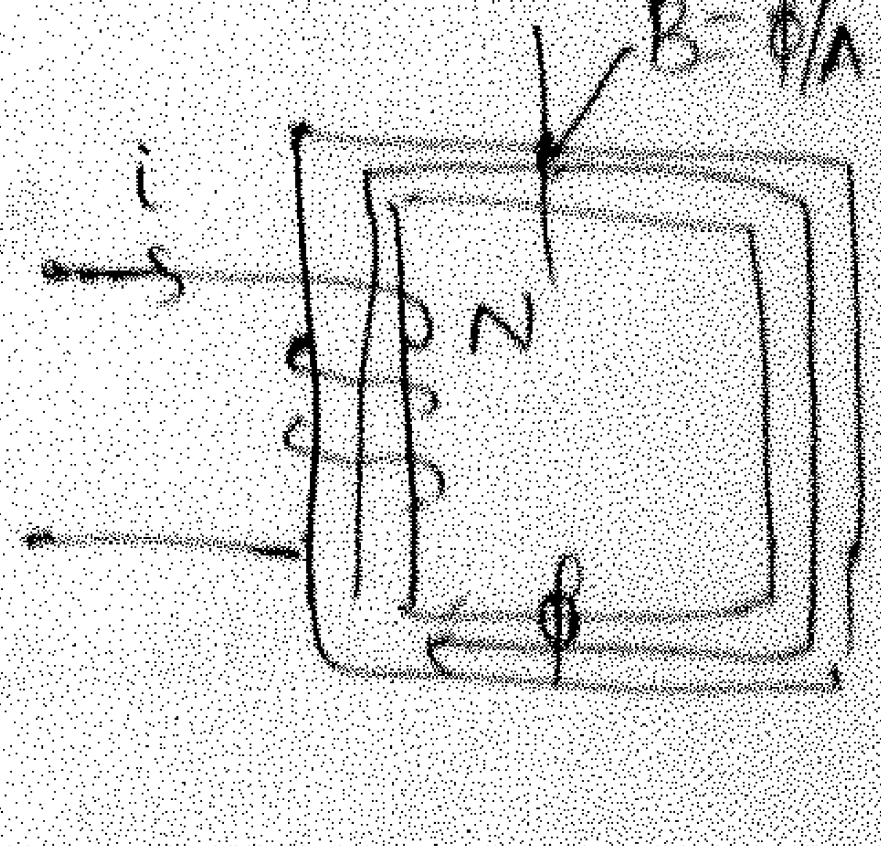
$P_r(t) = VI\sin\phi$

Instantaneous Reactive Power. (Peak Value)



* Inductor.

Inductor is not just a winding, but a coil wound around iron core.



Iron core is used because flux will be more.

Magneto Motive Force (MMF) = No. of turns × current

$F = Ni$

MMF

$F = \phi \times R$ → reluctance.

Flux

Magnetic field Intensity (H) = $\frac{MMF}{length} = \frac{F}{l} = \frac{Ni}{l}$

$H \rightarrow \frac{\text{Amp-turns}}{\text{meter}}$.

Electric field Intensity = $\frac{EMF}{length}$

l = length of the core.

[∵ Along the core, flux has to be distributed].

In case of permanent magnet,

units of $H \rightarrow \frac{Amp}{meter}$ [∵ No. of turns are not considered].

* Electromagnetic → Permanent magnet.

$\frac{B}{H}$ = Permeability.

$= \mu$

$= \mu_0 \mu_r$.

* $H = \frac{MMF}{l} = \frac{Ni}{l}$

$B = \mu H$,

$\mu = \mu_0 \mu_r$

permeability of free space

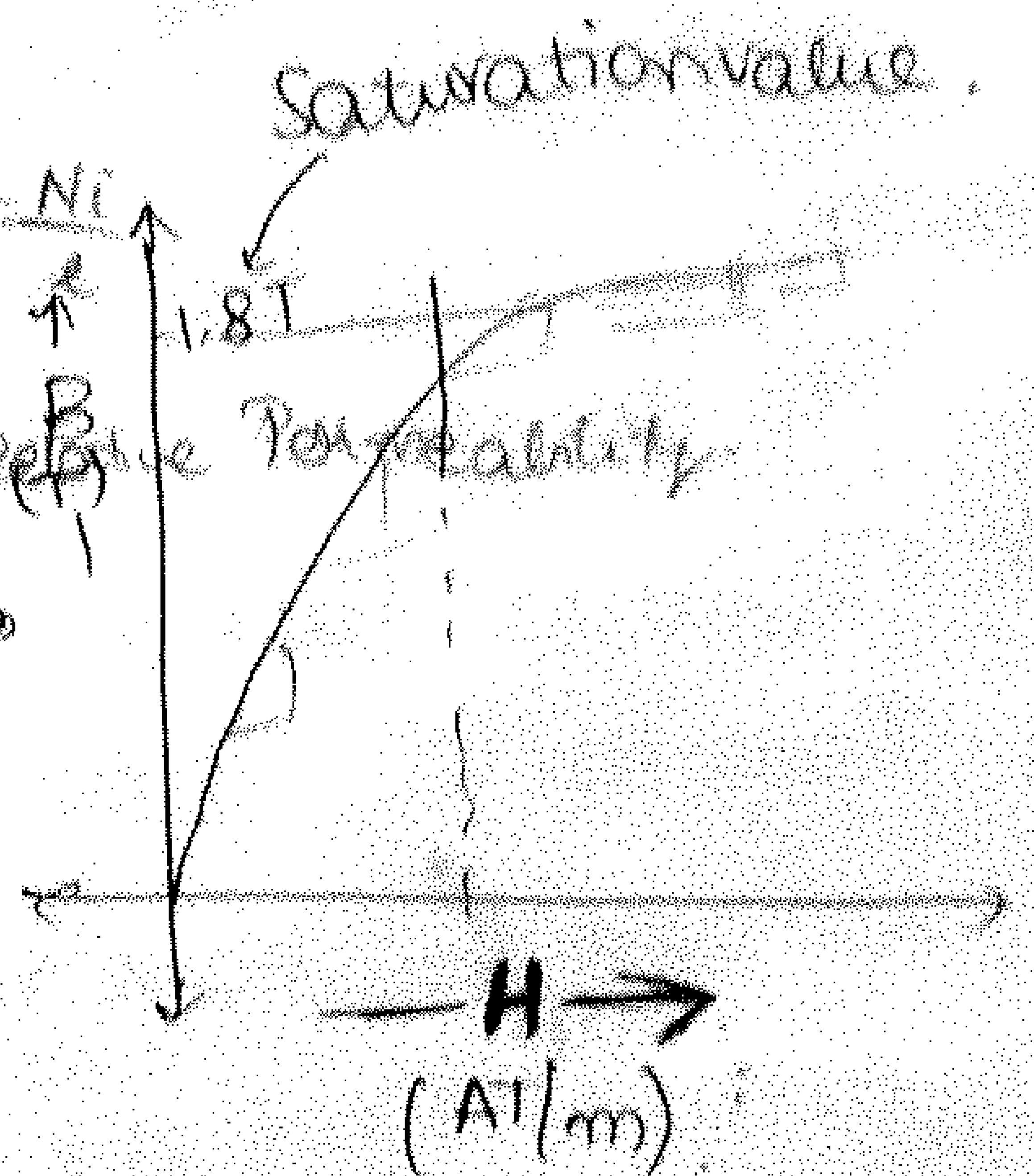
Permeability of medium

where,

μ_0 = permeability of free space,

$= 4\pi \times 10^{-7}$.

μ_r = relative permeability.

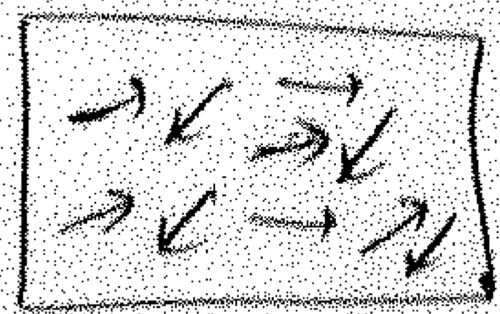


For a material, μ_r changes.

$V = iR + L\frac{di}{dt}$.

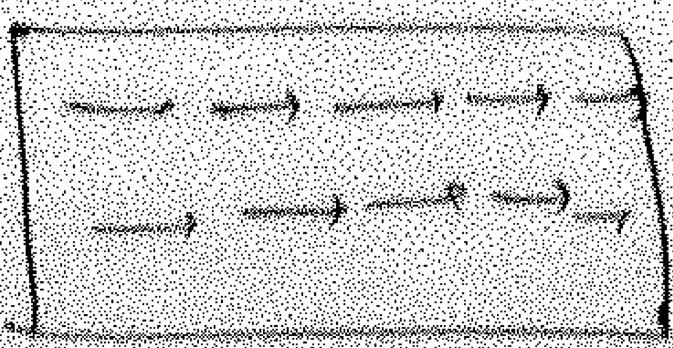
Inductance goes on changes [Non-linearity - saturation].

* Initially, in ~~iron core~~ iron core.



magnetic domain.
(randomly alligned).

After * Increase the current slowly, after sometime,

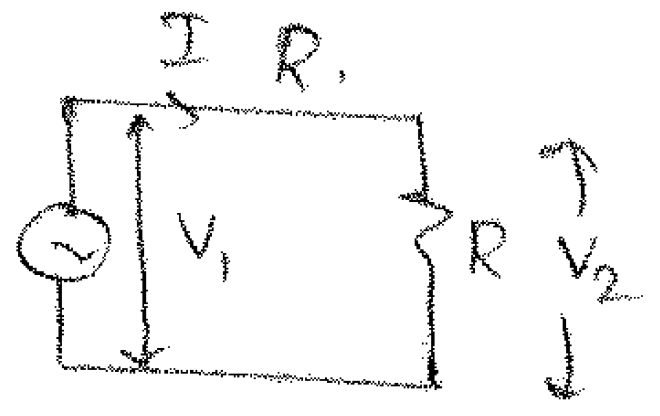


Aligned in one direction.

After reaching the above condition, if we furthur increase the current, there will not be any change in magnetic domain, $L = \frac{N^2 \mu A}{l}$.

*

$$\text{Loss} = \frac{(V_1 - V_2)^2}{R}$$



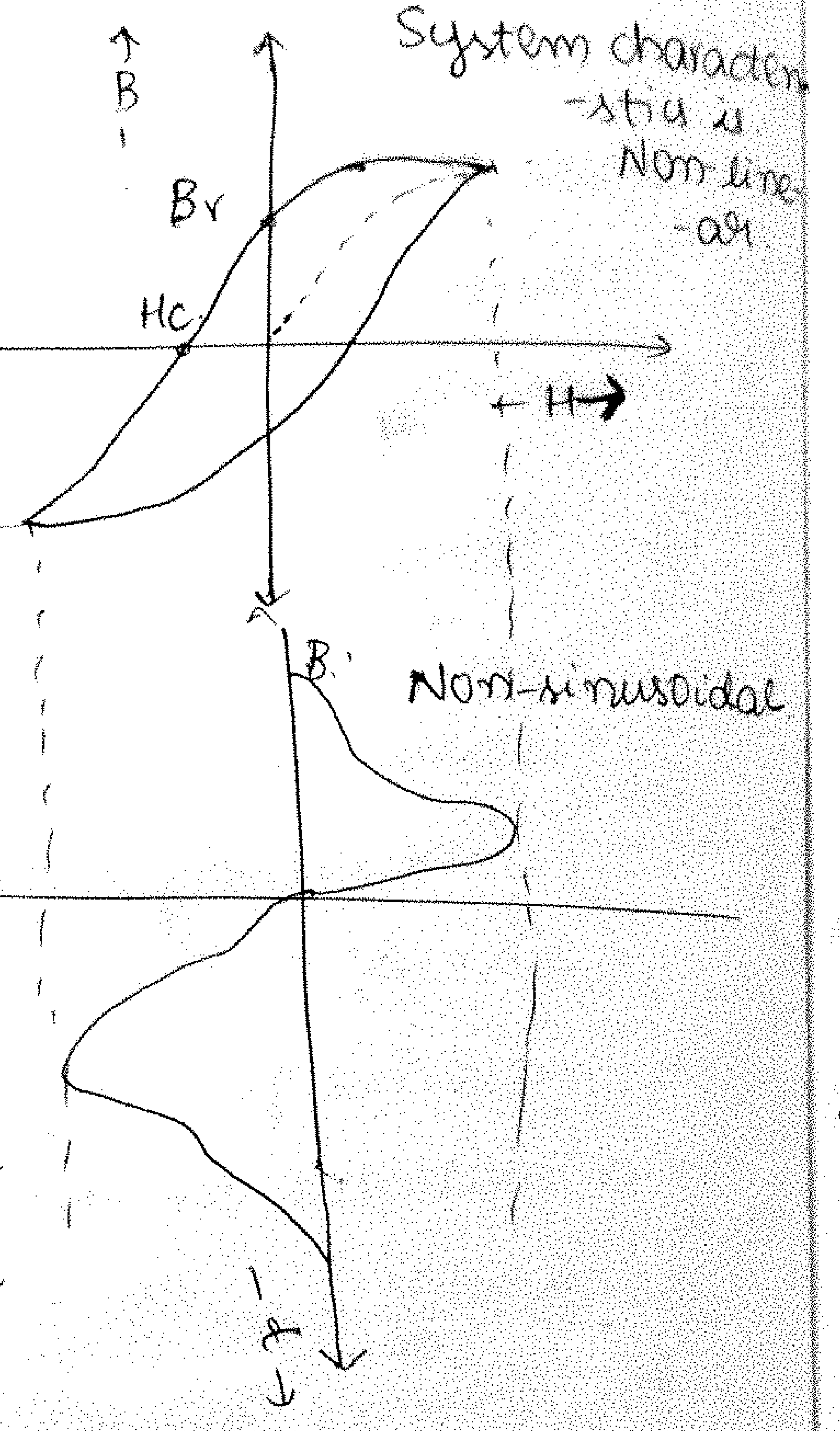
* AC Voltage.

Magnetic systems store power.

Area under graph is loss of energy → Hysteresis loss.

~~If frequency~~

The energy lost is used ~~as~~ to do the mechanical work



Residual flux density.

Remenac.

Although you ~~have~~ remove the external field, the magnetic material retains some magnetism.

Coercive force.

Amount of reverse field to be applied so that the magnetic field will loose its magnetism

Energy lost during 1 cycle of magnetism → Hysteresis loss.

H_c = Coersive force,

B_r = Residual flux density.

B → input

If B and H are sinusoidal, then, the resulting plot/graph has to a straight line passing through origin.

Input will be voltage (for the transformer).

$H = \frac{ni}{l}$

where, i will be decided by the transformer.

If input is sinusoidal, B is sinusoidal.

why??

$v(t) = \frac{N d\phi}{dt}$

$= V_m \sin\omega t$

$\therefore \phi(t) = \frac{1}{N}\int v(t)dt$

Magnetic Field Intensity

$H = \frac{ni}{l}$

$v = N\frac{d\phi}{dt}$

$\phi(t)$ → Sinusoidal,

$B(t)$ → Sinusoidal then,

$H(t)$ → Non-Sinusoidal.

* To establish sinusoidal flux in the core, the source has to inject non-sinusoidal input.

Friday

26-01-18.

Motor :-

Machine which converts electrical to mechanical energy

* Machines which provide Mechanical energy are Turbine, Engine.

~~Ho~~ Current carrying conductor placed in a magnetic field, it experiences some force.

$\vec{F} = i\vec{l} \times \vec{B}$ ⟶ lorentz force.

$\vec{l}$ → length of the conductor in the direction of current.