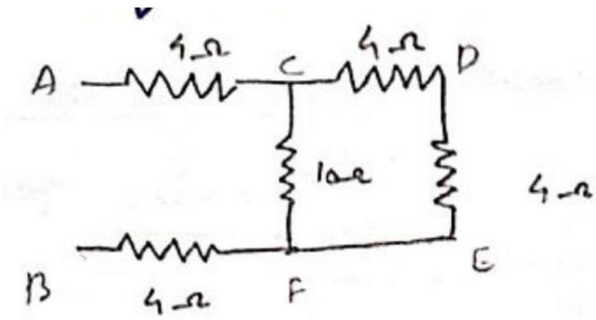
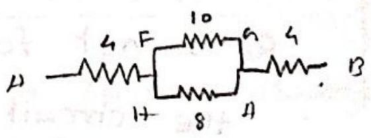
Elementary Concepts of Electric Circuits

1. Calculate equivalent resistance Across A & B



Answer

CDE contains resistors in series
∴ CDE combines to 8Ω.



FG & *HA* are in parallel.
∴ equivalent resistance $= \left(\frac{1}{10}+\frac{1}{8}\right)^{-1} = \frac{80}{18} = \frac{40}{9}\Omega$

Remaining resistors are in series:
∴ equivalent resistance $= 4 + 4 + \frac{40}{9} = \frac{102}{9} = 11.3\Omega$

Series Connection

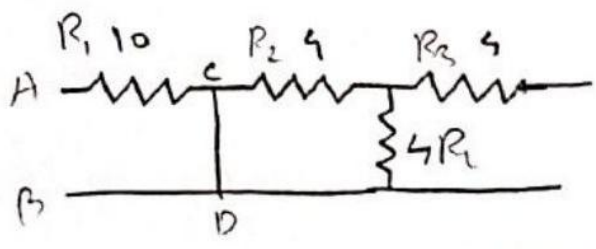
When two components are in series

- Current (I) flowing through them is same
- Have one common point & there are no intermediate element connected to common point
- (may) have potential drop

Parallel connection

- Have same potential across the component
- Two ends are joined by two common points wish no element in between

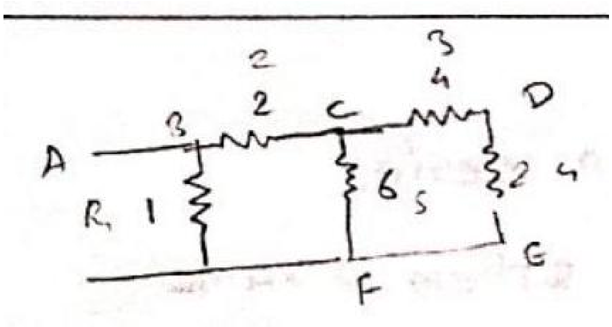
2. Find equivalent resistance across A & B



Answer
R_3 is not fully connected. Hence it has no effect in the circuit and can be ignored.
$R_2 \& R_4$ are in series.
$\therefore$ Their effective resistance $= 8\Omega$

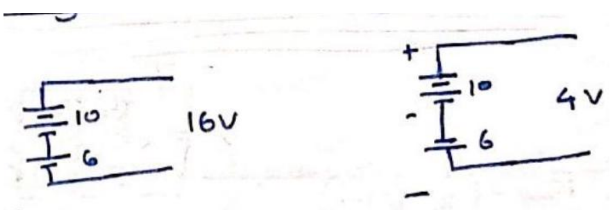
There is no resistance in CD and whole current flow through CD (this condition is called short circuit).
$\therefore$ net resistance is $R_1 = 10\Omega$

2. Find equivalent resistance across A & B



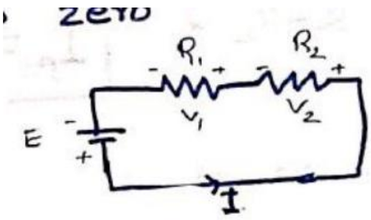
Answer
$R_3 \& R_4$ are in series, $\therefore$ their effective resistance is 6 Ω
Net resistance in CDEF $= 1/\left(\frac{1}{6}+\frac{1}{6}\right) = 3\Omega = R'$
$R_E \& R' = 2 + 3 = 5\Omega = R''$
$\therefore$ Voltage across A & B $= R_1 \| R'' = \left(1+\frac{1}{5}\right)^{-1} = \frac{5}{6}\Omega$

Voltage Source in series



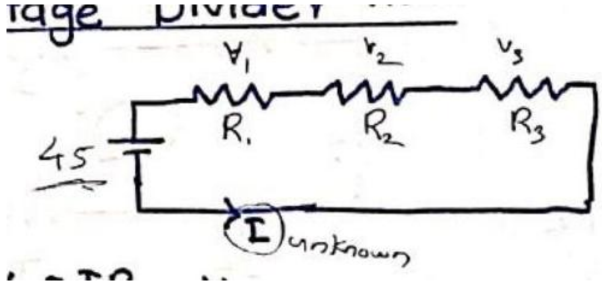
Kirchoff's voltage law: Algebraic sum of potential drop acre a loop is zero

$$
\begin{aligned}
E &= V_1 + V_2 \\
&= IR_1 + IR_2
\end{aligned}
$$



Kirchoff's Current law: Algebraic sum of current Howing through junction is zero ($I_{\text{in}} = I_{\text{our}}$)

Voltage Divider Rule (VDR)



$$
\begin{aligned}
R_1 &= 2K \\
R_2 &= 5K \\
R_3 &= 8K
\end{aligned}
$$

$$
\begin{aligned}
& V_n = IR_{n_0} \quad V \\
& \text{ or } V_n = \frac{R_n \times V}{R_T} \\
& R_T = \text{ total resistance} \\
& V = \text{ total voltage} \\
& \therefore \underbrace{V_1 = \frac{2k \times 4s}{15k} = 6V}_{\text{less}}, V_2 = \frac{5k \times 45}{15k} = 15V, \underbrace{V_3 = \frac{8k \times 4s}{15k} = 24V}_{\text{more}} \\
& V_1 < V_2 \because R_1 < R_2 \Rightarrow V_{\text{drop}} \propto R_{\text{rm}}
\end{aligned}
$$

*VDR is used in analysis of series circuit

Current divider rule

$$
R_{\text{net}} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \ldots\right)^{-1}
$$

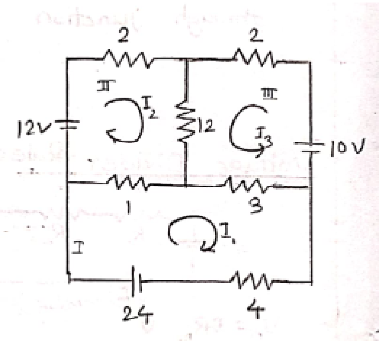
$$
\left.
\begin{aligned}
I_1 &= I \cdot R_1^{-1} \cdot \left(\tfrac{R_1+R_2}{R_1R_2}\right)^{-1} = I \cdot \tfrac{R_2}{R_1+R_2} \\
I_2 &= I \cdot R_2^{-1} \left(\tfrac{R_1+R_2}{R_1R_2}\right)^{-1} = I \cdot \tfrac{R_1}{R_1+R_2}
\end{aligned}
\right\} \quad \text{for } 2- \text{ branch circuits}
$$

$$
\boxed{I_n = I \cdot \frac{R_{\text{net}}}{R_n}}
$$

Maxwell's Loup Current Method

1. Determine current in 4Ω branch.

Answer
In loop I



$$\begin{aligned}
&1\times(I_1-I_2)+3\times(I_1+I_3)+4\times I_1=24\\
&8I_1-I_2+3I_3=24
\end{aligned}$$

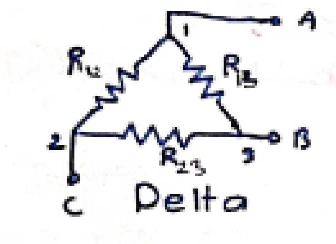
In loop II

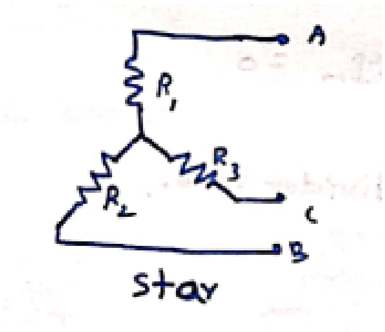
$$\begin{aligned}
&2\cdot I_2+(I_2+I_3)\,12+1\times(I_2-I_1)=12\\
&-I_1+15I_2+12I_3=12
\end{aligned}$$

In loop III

$$\begin{aligned}
&2I_3+12\,(I_2+I_3)+3\cdot(I_1+I_3)=10\\
&3I_1+12I_2+17I_3=10
\end{aligned}$$

Star Deltra transformation





$$\begin{aligned}
R_{AB}&=R_{13}\|\,(R_{12}+R_{23})\\
&=\frac{R_{13}\,(R_{12}+R_{23})}{R_{12}+R_{23}+R_{13}}
\end{aligned}
\qquad
\begin{aligned}
R_{AB}&=R_{13}\|\,(R_{12}+R_{23})\\
&=\frac{R_{13}\,(R_{12}+R_{23})}{R_{12}+R_{23}+R_{13}}
\end{aligned}
\qquad
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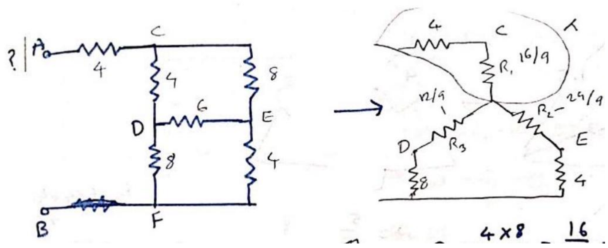
\end{aligned}$$

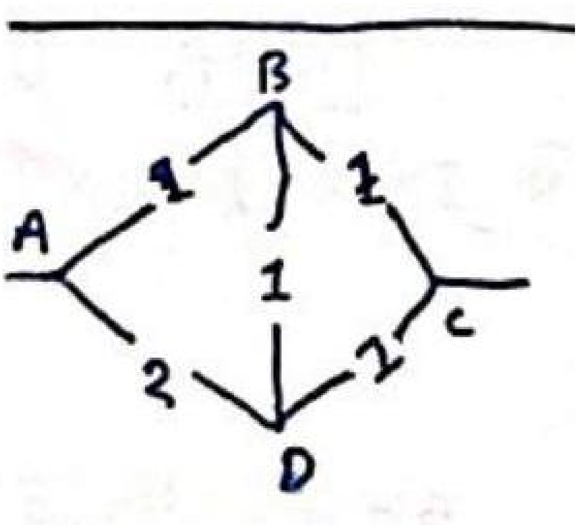


$$\begin{aligned}
R_1&=\frac{4\times 8}{4+8+6}=\frac{16}{9}\Omega\\
R_2&=\frac{6\times 8}{18}=\frac{8}{3}\Omega=\frac{24}{9}\Omega\\
R_3&=\frac{6\times 4}{18}=\frac{12}{9}\Omega\quad\frac{4}{9}
\end{aligned}$$

$$-4 - 16/9 - \begin{bmatrix} \frac{24}{9} - 4 \\ \frac{12}{9} - 8 \end{bmatrix}$$

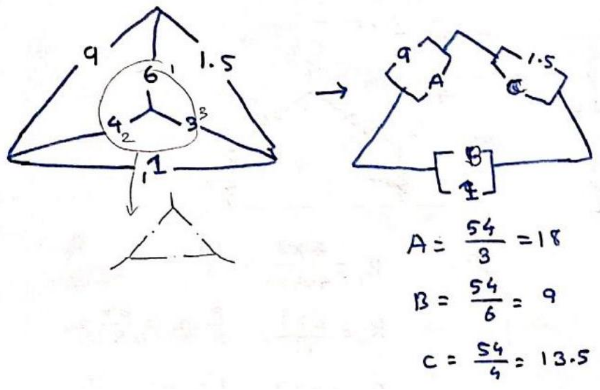
$$\rightarrow 4 + \frac{16}{9} + \left(\frac{23}{20} + \frac{3}{28}\right)^{-1} = 4 + \frac{16}{9} + \frac{560}{144}$$
$$= 47 + \frac{29}{3}\Omega$$

$$R_1 + R_2 = \frac{K(L+m)}{T}, R_1 + R_3 = \frac{M(K+K)}{T}, R_2 + R_3 = \frac{L(K+M}{T}$$
$$R_1 = \frac{C + (2) - (3)}{2} = \frac{KL + KM + KM + ML - KL - ML}{2T} = \frac{KM}{T} = \frac{R_{12} \times R_{13}}{R_{12} + R_{13} + R_{23}}$$
$$R_2 = \frac{(3) - (2) + (0)}{2} = \frac{KL + ML - KM - ML + KM + KL}{2T} = \frac{KL}{T} = \frac{R_{12} \times R_{23}}{R_{12} + R_{13} + R_{23}}$$
$$R_3 = \frac{(2) - (1)}{2} = \frac{KM + ML - KL - KM + KL + ML}{2T} = \frac{ML}{T} = \frac{R_{13} \times R_{23}}{R_{12} + R_{13} + R_{23}}$$

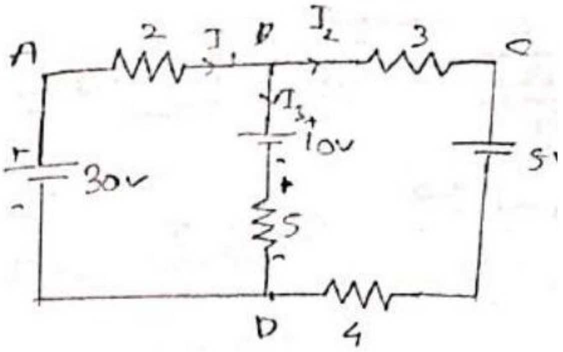


$$\rightarrow \underbrace{1/2}_{2} \rightarrow \underbrace{1/2}_{1/2}$$
$$A = \frac{1 \times 2}{4} = \frac{1}{2}$$
$$B = \frac{1}{2}$$
$$c = \frac{1}{4}$$
$$\rightarrow \frac{1}{2} + \left(\frac{2}{3} + \frac{5}{5}\right)^{-1} = \frac{1}{2} + \frac{15}{22} = \frac{52}{44} = \frac{26}{22}$$
$$= \frac{13}{11} - 3$$

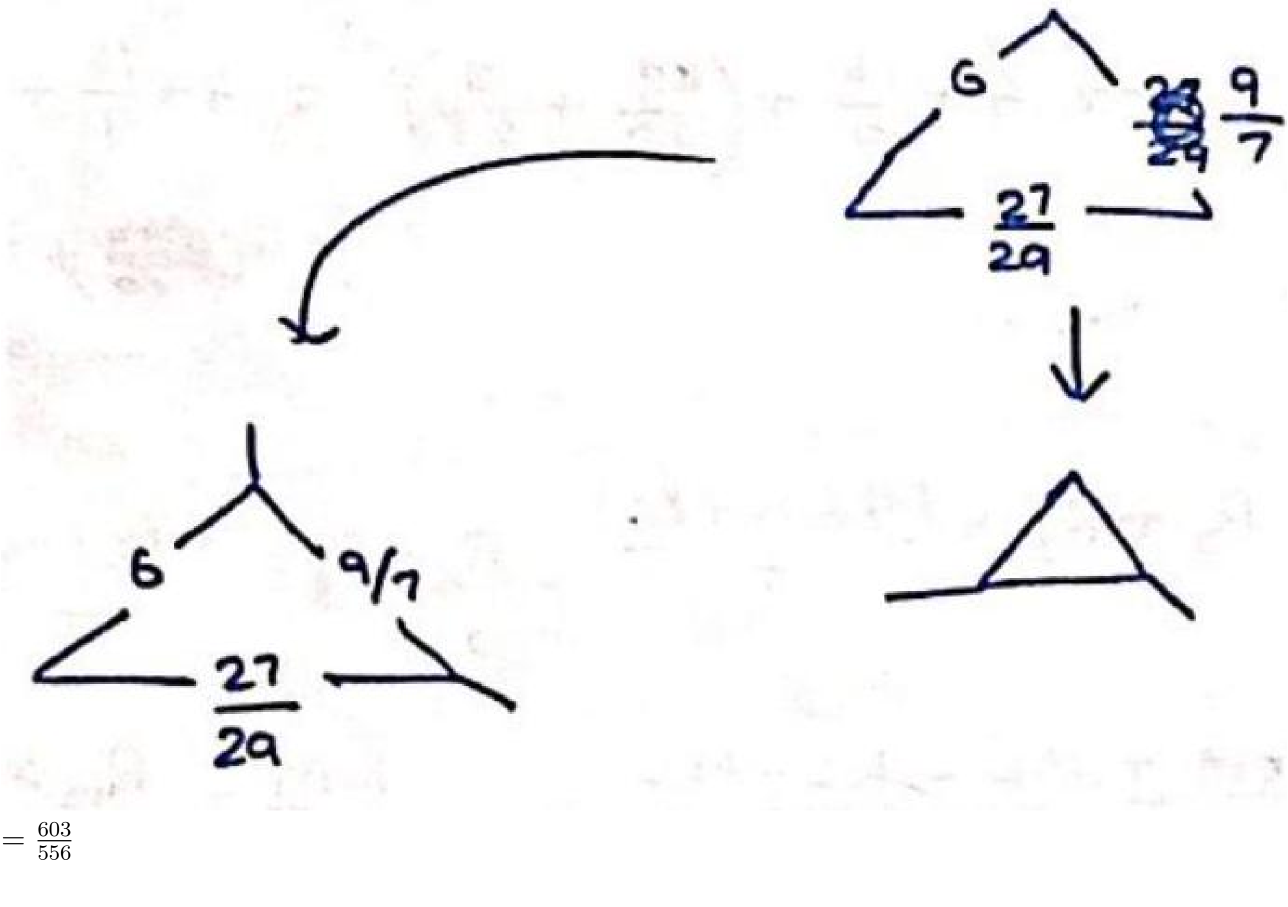
$$1 \rightarrow\rightarrow: R_{12} = \frac{R_\varphi}{R_3} \quad R_{23} = \frac{R_\psi}{R_p} \quad R_{13} = \frac{R_\psi}{R_2} \quad R_4 = R_1R_2 + R_2R_3 + R_1R_3$$



1.



$R_y = 6 \times 4 + 4 \times 3 +$
$= 24 + 12 + 18 \,:\, 54 \therefore$ reducabled: $\left(\frac{1}{9}+\frac{1}{18}\right)^{-1} = 6, \left(\frac{1}{1.5}+\frac{1}{9}\right)^{-1} = \frac{9}{7}$. $\frac{1}{1}+\frac{1}{13.5} = \frac{27}{29}$



$= \frac{603}{556}$

$\frac{458}{556}$

$$= \frac{225}{139}$$

mesh $\rightarrow \square$

Cromeristule

$$\therefore I_1 = \frac{\Delta_1}{\Delta} = \frac{265}{59}$$
$$I_2 = \frac{\Delta_2}{\Delta} = \frac{135}{59}$$

By KCL : $I_3 = I_1 - I_2$
ABDA:
$+30 - 2I_1 - 10 - 5I_3 = 0$
$\Rightarrow 20\ -7I_1 + 5I_2 + 20 = 0 \Rightarrow 7I_1 - 5I_2 = 20$

$BCDB$

$-3I_2 - 5 - 4I_2 + 8I_3 + 10 = 0$
$\Rightarrow 5I_1 - 12I_2 = -5$

$$\therefore \quad I_1 = \frac{265}{59}, \quad I_2 = \frac{135}{59}$$

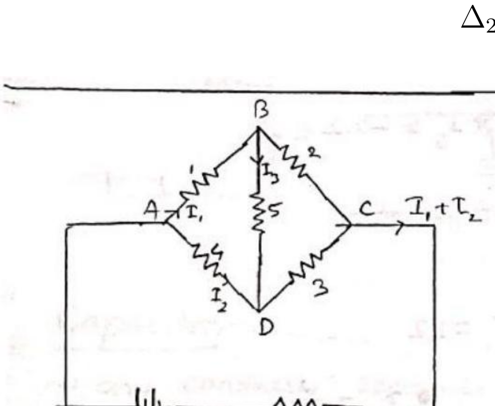
$$\begin{bmatrix} 7 & -5 \\ 5 & -12 \end{bmatrix} \begin{bmatrix} I_1 \\ T_2 \end{bmatrix} = \begin{bmatrix} 20 \\ C_1 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 7 & -5 \\ 5 & -12 \end{vmatrix} = -59$$

Replar C_n by R
$n^m Uv = \frac{U_n}{\Delta}$

$$\Delta_1 = \begin{vmatrix} 20 & -5 \\ -5 & -12 \end{vmatrix} = -265$$

$$\Delta_2 = \begin{vmatrix} 7 & 20 \\ 5 & -5 \end{vmatrix} = -135$$



1) Calculate magnitude & direction of I through 5Ω resistor

2) Resistance b/w A & C.

a) $\triangle BDA$: b) $BCDB$

$$I_1 + 5I_3 - 4I_2 = 0 - \omega \quad 2(I_1 - I_3) - 3(I_2 + I_3) - 5I_3 = 0$$

$$\Rightarrow 2I, -3I_2 - 10I_3 = 0$$

8. $ABCEFA$

$$I_1 + 2(T_1 - I_3) + I_1 + I_2 - 4 = 0$$
$$4I_1 - I_2 - 2I_3 - 4 = 0$$

$\Rightarrow I_1 = \frac{31}{28} \quad I_2 = -\frac{1}{28} - 0.34$
$I_3 = \frac{13}{56} \approx 0.232$ A $- 0.087 \therefore$ 1) from $B \rightarrow D$

$$2)\ R_{\text{net}} = \frac{V}{I} =$$
$$\frac{4}{\frac{15}{14} + 1} = \frac{56}{29} \approx 1.931.\mathrm{A}\Omega$$

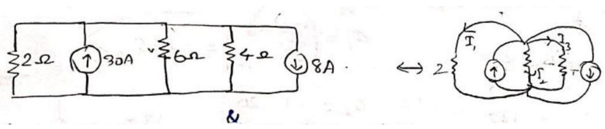
$$\begin{bmatrix} 1 & R_{\text{sol}} & - \\ 2 & -3 & -10 \\ 4 & -1 & -2 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 4 \end{bmatrix} \quad \frac{V}{I} = \frac{4 - 1\times(I_1 + I_2)}{15/14} = \frac{4 - 1.29}{\dots} \approx 1.3\text{A}\ 2.07$$

$$\Delta = -224$$

$$\begin{bmatrix} 1 & 5 & 0 \\ 2 & -3 & 0 \\ 4 & -1 & 4 \end{bmatrix} \quad \Delta_3 = -52 \Bigg] \begin{vmatrix} 0 & 5 & -4 \\ 0 & -3 & -10 \\ 4 & -1 & -2 \end{vmatrix} \quad \Delta_1 = \pm 248$$

$$\begin{vmatrix} 1 & 0 & -4 \\ 2 & 0 & -10 \\ 4 & 4 & -2 \end{vmatrix} \quad 0_2 = 8$$

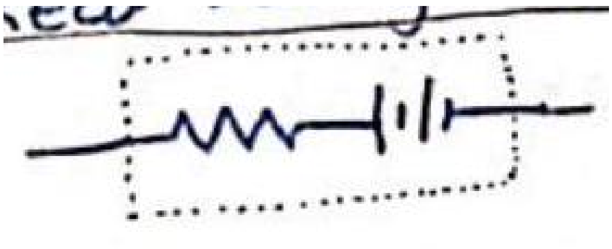
$$I_1 = \frac{\Delta_1}{\Delta_4} = +\frac{31}{28}, \quad I_2 = -\frac{1}{28}$$
$$I_3 = \frac{13}{56}$$



1. Find polarity & magnitude of v

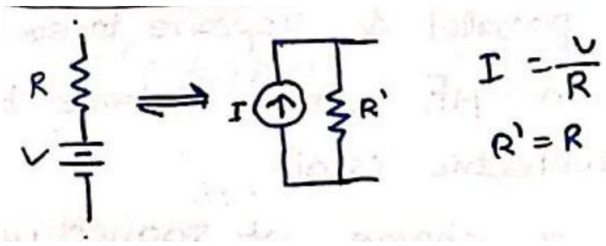
$$I_1 + I_2 + I_3 + 8 = 030 \Rightarrow I_1 + \frac{V}{2} + I_3 = 22$$
$$I_2 = \frac{V}{6}, \quad I_3 = \frac{V}{4}$$
$$\frac{V}{2} + \frac{U}{6} + \frac{U}{4} = 22$$
$$24V + 8V + 12V = 22 \times 48$$
$$\Rightarrow \quad U = 24V$$

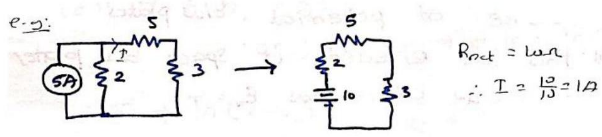
IDeal voltage source
→ zero internal vereristance
→ Supply constr. voltage at all currents
Real voltage source



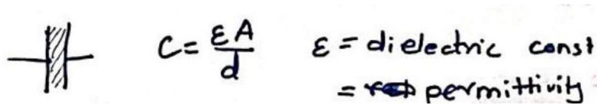
- voltage source with very low internal resistance. can be treated as constant voltage source

Ideal Current source ($-\Theta-$)
Real current Source.
→ ∞ internal resistance winy? M Θ
→ supply constr. Current at all loads
Source conversion



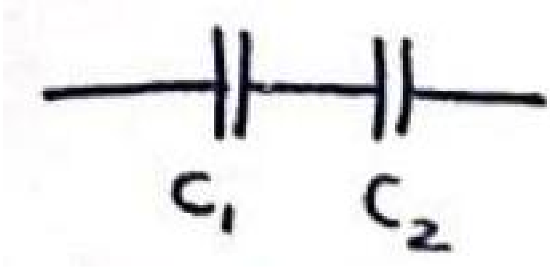


Capacitor
☒ any conductor separated by insulator (alielectsc)
Capacitance: Ability of capacitorto store energy. (change → Ublwiwn) Dielectrics: air, mica, waxedpaper, ceramic, electrolyte



$$= \text{ permittivity } = \varepsilon_0 \cdot \varepsilon_r.$$

Energy stored: $\frac{1}{2}Cv^2 = \frac{1}{2}Qv = \frac{1}{2}Q^2/C$



$$
\begin{aligned}
& c=\left(\frac{1}{c_1}+\frac{1}{c_2}\right)^{-1} \\
& v_1=\operatorname{pd}\left(c_1\right) \\
& v_2=\operatorname{pdd}\left(c_2\right) \\
& Q_1=Q_2=Q \\
& \therefore V=v_1+v_2 \\
& \frac{Q}{C}=\frac{Q_1}{c_1}+\frac{Q}{c_2} \\
& \Rightarrow C=\left(\frac{1}{c_1}+\frac{1}{c_2}\right)^{-1}
\end{aligned}
$$

1. A capacitor consists of two similar square Al. plates each 10 cm $\times$ 10 cm bounded parallel & opposite to each other. what is their capacitance in MF when distance blu them is 1 cm& deedielectric is air

ii) If capacitor is given a charge of soomfic what will be difference of potential blur plates
iii) How will this be effected if space bow plates is filled with wax which has $\varepsilon_r=4$
A.

$$
\begin{aligned}
c=\frac{\varepsilon_0 \varepsilon_r A}{d}=\frac{\varepsilon_0 \times \varepsilon_4^1 \times(10 \times 10) \times 10^{-4}}{10^2} & =8.85 \times 10^{-12} \text{ F} \\
& =8.85 \times 10^{-1} \mu \text{F}
\end{aligned}
$$

iii) $V=\frac{Q}{c}=\frac{500 \mu \mathrm{K}_4 c}{8.85 \times 10^{-1} / \mu F}=56.47$ V
iii) $v=\frac{Q}{C^{\prime}}=\frac{C Q}{4 C}=19.12 V$ At $t=R C$:

$$
\begin{aligned}
v_c & =v\left(1-e^{-R c / R_c}\right) \\
& =0.632 . v
\end{aligned}
$$

$$
\begin{aligned}
I_0 & =I_m \cdot e^{-R c / R c} \\
& =0.368 I_m
\end{aligned}
$$

RC : time cunstant:: Time at which the voltage across $G(\tau, \lambda)$ the capacitor reaches 63.2% of steady state T. voltage / current reaches 36.8% of initial value.
If $t=2 R C$:

$$
\begin{aligned}
& v_c=v\left(1-e^{-2}\right)=0.865 . \mathrm{V} \\
& t=S R C, v_c=0.993 \mathrm{~V}
\end{aligned}
$$

Rate of Rise of voltage.

$$v=RC\cdot\frac{dv_c}{dt}+v_c$$

at $t=0, v_c=0$

$$=0, v_c=0$$

$$\therefore v=RC\cdot\frac{dv_c}{dt}\Rightarrow\frac{dv_c}{dt}=\frac{v}{Rc}\qquad\text{initicl rate of-rise in voltage (acrosy capacion}$$

1.
A 2μf capacitor is connected by closing a switch to a supply of 100 V through a 1MΩ series resistance. Calculate.
i) Time constant ii) Initial charging current iii) $\left.\frac{dv_c}{dt}\right|_{t=0}$ iv) Voltaye across capacitor &s after the switch has been closed
v) Time token for capacitor to be fully charged
ii) $I_m=\frac{V}{R}=\frac{100}{10^6}=10^{-4}$ A $=109$ A iii) $\left.\frac{dv_c}{dt}\right|_{f=0}=\frac{v}{Rc}=\frac{100}{2}=50$ V/s
iv) $v_c=v\left(1-e^{-t/\tau}\right)$

$$=100\left(1-e^{-6/2}\right)=95.02\text{ V}$$

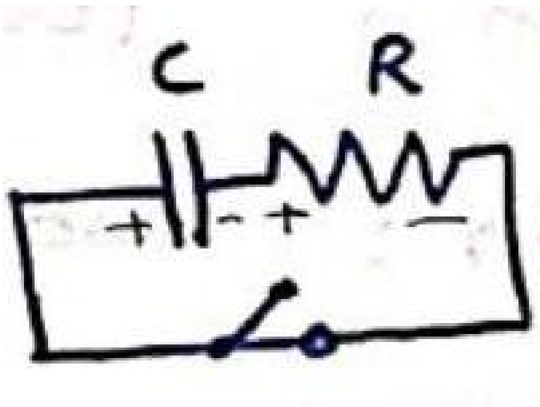
v) ∞ Q? I $a=cv\Rightarrow cv\left(1-e^{-t/\tau}\right)=c\cdot v$ (to fully charge)

$$\Rightarrow 1-e^{-t/\tau}=1$$

$$-e^{-t/\tau}=0\Rightarrow t=\infty$$

llor take 5 T = 105
Discharging of Capacitor
At $t=0: V_c=V$

$$I=0$$



$t>0:$

Applying KvL:

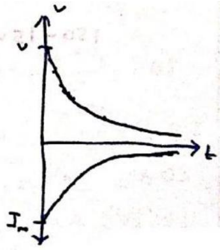
$$v_c + IR = 0 \Rightarrow v_c + Rc \cdot \frac{dv_c}{dt} = 0$$
$$\Rightarrow \frac{dv_c}{v_c} = -\frac{dt}{Rc}$$
$$\Rightarrow \int \frac{dv_c}{v_c} = -\int \frac{dt}{Rc}$$
$$= \ln(v_c) = -t/Rc + k$$

to find $k, t = 0, v_c = v$

$$\ln(x_0) = k$$

$$\therefore (1) \equiv \ln(v_c) = -t/RC + \ln(v)$$

$$\Rightarrow \ln\left(\frac{v_c}{v}\right) = -t/RC$$
$$\boxed{V_c = V \cdot e^{-t/RC}}$$
$$i = -I_m e^{-t/RC}$$



2. A cable lo km long and of capacitance 2.5μF discharges through its insulation resistance of $50\text{M}\Omega$ By what percentage the corvoltage would have fallen 1,2, & 5 mons. respectively. After disconnection from bus-bars A) $V_c = V\left(1 - e^{-L/\tau}\right)$ $\quad T = RC = 50 \times 10^6 \times 10^{-6} \times 2.5 = 1255$ at 1min: $\frac{v_- - v_2}{v^{10100}} = 100\left(1 - e^{-60/125}\right) = 37.12\%$ at 2 min : $100\left(1 - e^{-120/125}\right) = 61.71\%$ at 5 min : $100\left(1 - e^{-300/125}\right) = 90.93\%$ Nodal Analysis Potential at A : By $K \subset L : I_3 = I_1 + I_2$

$$I_1 = \frac{V_{2A}0}{2} = \frac{V_B - V_A}{2Q} = \frac{10 - V_A}{2}$$
$$I_2 = \frac{5 - V_A}{5}, I_3 = \frac{V_A - 0}{3}$$
$$\therefore 5 - \frac{V_A}{2} + 1 - \frac{V_A}{5} = \frac{V_A}{3}$$
$$150 - 15V_A + 30 - 6V_A = 10V_A \Rightarrow V_A = \frac{-280}{31} = 2\frac{180}{31}.V$$

ut A:

$$10 = I_1 + I_2 + I_3$$
$$10 = \frac{V_A - V_C}{5} + \frac{V_A - V_B}{3} + \frac{V_A}{2}$$
$$300 = 6V_A - 6V_C + 10V_A - 10V_B + 15V_A$$

$10A$

$$31v_A - 10v_B - 6v_C = 300$$

At B:

$$
\begin{aligned}
&I_2 + I_4 + I_5 = 0 \\
&\frac{V_A - V_B}{3} \pm \frac{V_B}{5} + \frac{V_B - V_C}{1} = 0 \\
&5V_A - 5V_B \pm 3V_B + 15V_B - 15V_C = 0 \\
&-5V_A + 83V_B + 15V_C = 0\text{-}(2)
\end{aligned}
$$

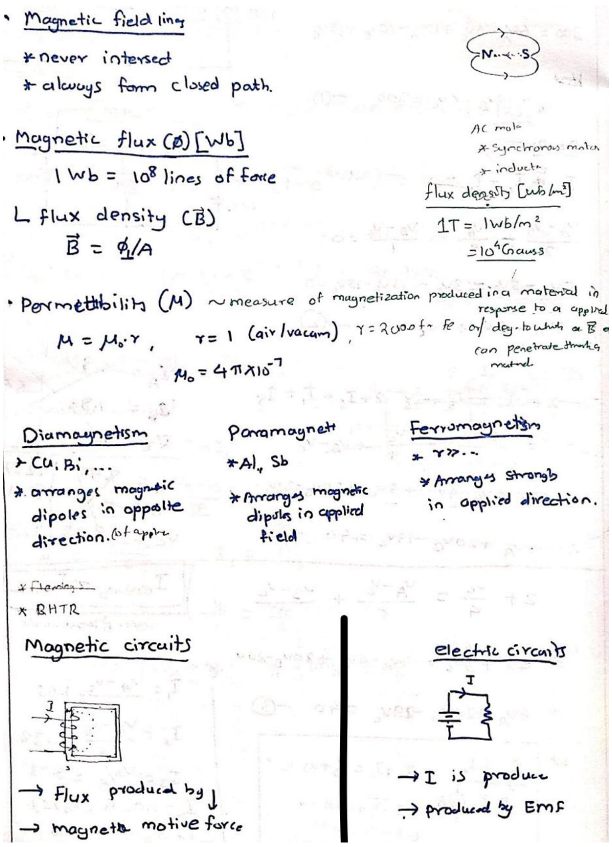
At c:

$$
\begin{gathered}
2 + I_6 = I_1 + I_5 \\
(2.\ 1 \\
5. -1 \\
3.8
\end{gathered}
$$

$$
2 + \frac{v_C}{4} = \frac{v_A - v_C}{5} + \frac{v_B - v_C}{1}
$$

$$
\begin{aligned}
&\Rightarrow 40 + 5v_c = 4v_A - 4v_C + 20v_B - 20v_c \\
&\Rightarrow 4v_A + 20v_B - 29v_C = 40
\end{aligned}
$$

(also true, but ∞ into. About ign)



Here, there's resistarlo:

$$
R = p_2
$$

$\sim$ Reluctance

eryg's of anducto

$$S=\frac{2}{\mu a} \text{ y aroa of erross section of ming circuit}$$

$\rightarrow \phi=\frac{mmf}{s}=\frac{NI}{s1}\cdot\mu\cdot a\cdot\mu.$
$=\frac{M\cdot NI_a}{2}$
$\rightarrow$ Tows deroun n ? matenat:
$\rightarrow$ No drop in fower
due to flum
$\rightarrow$ Permeance
$\rightarrow$ Permeabilly
$\rightarrow$ doesn't flow actually
$\rightarrow$ No magnetrc insulator ?
$\rightarrow$ Permeability depends on the max. flux density (B_{mea}) and it isn't constam

- Magnetir field intersllts (H)

$$H=\frac{B}{\mu}=\frac{NI}{2}$$

men $\phi=\frac{\mu\cdot\Lambda I_a}{2} \Rightarrow B=\frac{\mu NI}{2}$
or $1t=\frac{\omega f}{y}$
$\therefore mmt=H^{*}2 \rightarrow$ opposition to I
$\rightarrow \quad I=\frac{V}{R}$
$\rightarrow$ flocors strerish the
conductors
$\rightarrow$ Poterea drop is
presen. uto res siake.
$\rightarrow$ conductance.
$\rightarrow$ conductivity
$\rightarrow$ Poes flow
$\rightarrow$ electric insulators.
$\rightarrow$ Resistivits of a material is almost constawt etcept for slight change due to change in temp.

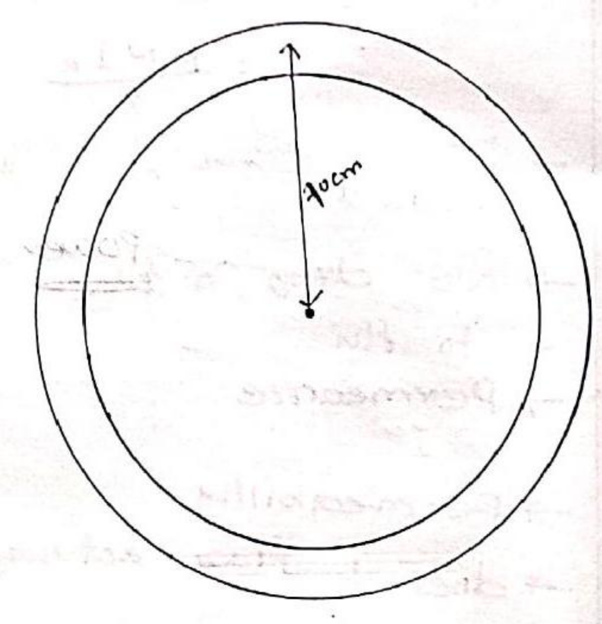
1. An Iron ring of circular cross sectional area: of 3 cm^2 and mean diameter of 20 cm is wound with a 500 tums of wire and carries a curves of 2.09 A. to produce the magnetic flux of o.smuls in the ring. Determine the pormabills of the matoriod

A) Given:

$$a=3 \text{ cm}^3 \equiv 3\times10^{-9} \text{ m}^2$$
$$d=20 \text{ cm}, N=500$$
$$I=2.09 \text{ A}, \phi=0.5\times10^{-3}\text{wb}$$

reluctance $s=\frac{2}{\mu a}$

$$\begin{aligned} Z= \text{ mean length } &=\pi\cdot d \\ &=0.2\pi\text{m}^{*} \end{aligned}$$



$$\therefore s = \frac{l}{\mu \cdot a}$$

$$\phi = \frac{mmf}{s} = \frac{NI}{s} = \Rightarrow 0.5 \times 10^{-3} = \frac{500 \times 2.09}{s}$$

$$\Rightarrow s = 500 \times 2.09 \times 2 \times 10^3$$

$$= 2090000$$

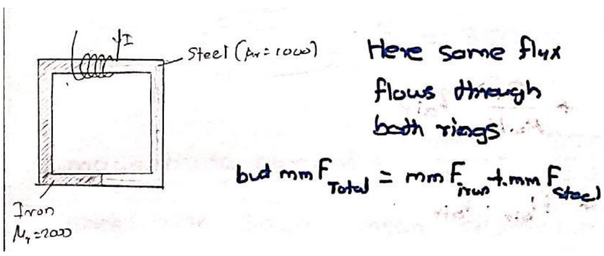
$$\therefore \mu = \frac{l}{s \cdot a} = \frac{0.2\pi}{2090000 \times 63 \times 10^{-4}} = 0.0010021$$

$$\mu_r = \frac{\mu}{4\pi \times 10^{-7}} = 797$$

Linear circus: liner rel. bu vuraye & Current output ($V\&I$) ane lina function of input ($VQI), \sim n, -A$
non-liner: rel bu Vax. is a non-liner function didos, transistors, transform whose core is sutuch
Unilateral: allows flow sf current in one direction only bilateral: ares cunt in both direction
Active elem: require eternal power to operate produce enarys, semiconductor,

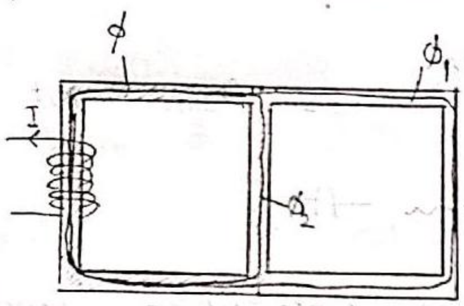
- passive element: doresnt generate but dissappats, stores/releors it. R, c, I

Series magnetic circuits



$$\text{but } mmF_{\text{Total}} = mmF_{\text{item}} + .mmF_{\text{steel}}$$

Just like ina series $e^{\text{c circuits.}}$ $v = v_1 + v_2$
Parallel circuits

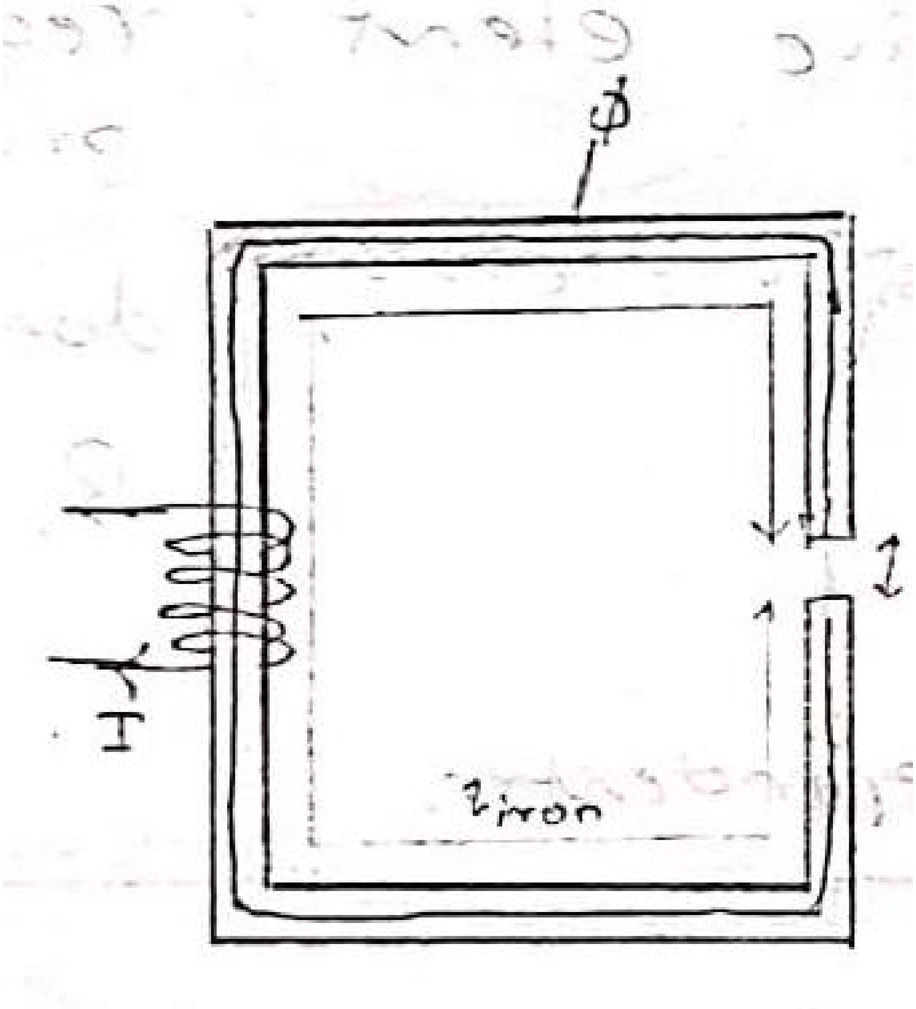


$$\begin{aligned} mmf_T &= mmf_\phi + mmF_\phi \\ &= mmf_\phi + mmf_{\phi_2} \end{aligned}$$

$$\begin{aligned} & mmf_{\phi_1} = mmf_{\phi_2} \\ & \phi = \phi_1 + \phi_2 \end{aligned}$$

$$\begin{aligned} mmF_T &= mmf_{aiv} + mmf_{i\text{ ron}} = \underset{\text{reductome}}{\phi} \\ &= \phi \cdot s_{\text{iron}} + \phi \cdot s_{\text{air}} \quad s = \frac{2}{\mu a} \\ &= \frac{\phi}{\mu_0 a}\left(\frac{\tau_{\text{iron}}}{\mu_{\text{iron}}} + \frac{\tau_{\text{air}}}{\mu_{\text{air}}}\right) \\ &= \frac{B}{\mu_0}(\cdots) \\ &= \frac{B}{\mu_0} \cdot \tau_{\text{ron}} + \frac{B.}{\mu_0 \cdot \mu_{aiv}} \tau_{\text{air}} \\ (A \cdot \text{ tummy mm } &= H_{\text{iron}} \cdot \tau_{\text{iron}} + H_{\text{air}} \cdot \tau_{\text{air}} \end{aligned}$$

leakage flux: flow not flowing through desired



magnetic path
Useful flux: oflut through air gap/airflut.

- leakage factor $(\lambda) = \frac{\mu \text{ setal}}{\text{total}}$ Hus
- Fringing: Bulging of flux cot air gap

I111). A cast steel a electromagnet a hos an air gap length of 3 mm and an iron path length of 40 cm. find number of ampere turns necessary to produce a flux density of 0.7 Wb/m^2 in the gap. neglect leakage A & fringing. Assume A-T for airgap to be 70% of tome AI
A) $AT_{\text{air}} = \phi \cdot S_{\text{air}} = \phi \cdot \frac{2}{\mu_0 \cdot \mu_r a} = B \frac{2}{\mu} = \frac{0.7 \times 3 \times 10^{-3}}{4 \times 3.14 \times 10^{-7}} = 1072A.$

$$\text{A.T } T_{\text{total}} = \frac{10}{7} \times 1672 = 2388 \text{ ATT}$$

ϕ - same here

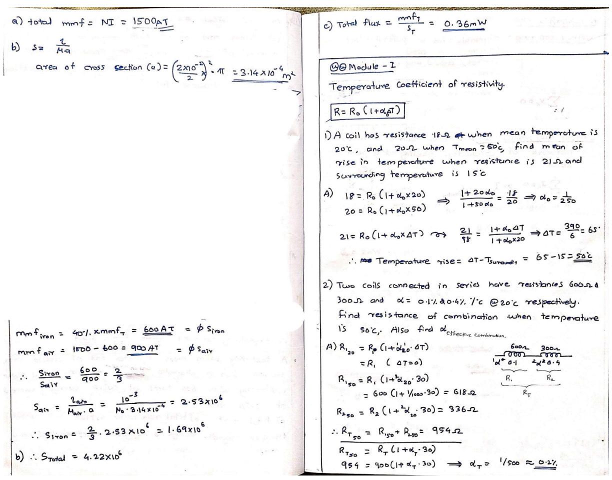
- An iron ring of crosse sectional area 6 cm^2 is wound with a wire of 100 turns. and has a saw-cut of 2 mm, calculate the magnetising current required to produce a flux of 0.1 mW if mean length of magnetic path is 30 cm. ard $\mu_{0,\text{ non}}\, \mu_0 .470$
  A)

$$
\begin{aligned}
mmf = \phi \cdot S_{\text{iron}} + \phi \cdot s_{\text{air}} &= \phi \cdot \left(\frac{\tau_{\text{air}}}{\mu_0 \cdot \mu_r \cdot a} + \frac{\eta_{\text{iron}}}{\mu_0 \mu_{\text{inn}}\, a} \right) \\
&= 0.1 \times 10^{-3} \times \left(\frac{2 \times 10^{-3}}{4\pi \times 10^{-1} \times 6 \times 10^{-4}} + \frac{0.3}{4\pi \times 10^{-7} \cdot 470 \times 10^4_0} \times \right) \\
&\approx 350 \\
&= NI
\end{aligned}
$$

$\therefore$ magnetising current $= \frac{mmf}{N} = \frac{350}{100} = 3.5$ A

- A steel ring 30 cm mean diameter and of circular cross section 2 cm in diameter, and an sp ind long, it is s wound uniformly with 600 turns of wire carrying current of 2.5 A, find

a) total mmf
b) total reluctance
c) flux
A neglect magnetic leakage & mon path takes 40% of total mme.



a) total mmf = NI = 1500AT

b) $S = \frac{l}{\mu a}$

area of cross section (a) = $\left(\frac{2\times10^{-2}}{2}\right)^2 \cdot \pi = 3.14\times10^{-4}\, m^2$

$mmf_{iron} = 40\% \times mmf_T = 600\,AT = \phi S_{iron}$

$mmf_{air} = 1500 - 600 = 900\,AT = \phi S_{air}$

$\therefore \frac{S_{iron}}{S_{air}} = \frac{600}{900} = \frac{2}{3}$

$S_{air} = \frac{l_{air}}{\mu_{air} \cdot a} = \frac{10^{-3}}{\mu_0 \cdot 3.14\times10^{-4}} = 2.53\times10^6$

$\therefore S_{iron} = \frac{2}{3} \cdot 2.53\times10^6 = 1.69\times10^6$

b) $\therefore S_{Total} = 4.22\times10^6$

c) Total flux = $\frac{mmf_T}{S_T}$ = 0.36mW

Module - I

Temperature Coefficient of resistivity.

$\boxed{R = R_0(1+\alpha_0 \Delta T)}$

1) A coil has resistance 18Ω when mean temperature is 20°C, and 20Ω when T_{mean} = 50°C, find mean of rise in temperature when resistance is 21Ω and surrounding temperature is 15°C

A) $18 = R_0(1+\alpha_0\times20)$
$20 = R_0(1+\alpha_0\times50)$ $\Rightarrow \frac{1+20\alpha_0}{1+50\alpha_0} = \frac{18}{20} \Rightarrow \alpha_0 = \frac{1}{250}$

$21 = R_0(1+\alpha_0\times\Delta T) \Rightarrow \frac{21}{18} = \frac{1+\alpha_0\Delta T}{1+\alpha_0\times20} \Rightarrow \Delta T = \frac{390}{6} = 65°$

$\therefore$ Temperature rise = $\Delta T - T_{surrounding}$ = 65 − 15 = 50°C

2) Two coils connected in series have resistances 600Ω & 300Ω and α = 0.1% & 0.4% /°C @ 20°C respectively. Find resistance of combination when temperature is 50°C. Also find $\alpha_{\text{effective combination}}$.

A) $R_{1_{20}} = R_0(1+{}^1\alpha_{20}\cdot\Delta T)$
$= R_1 \quad (\Delta T = 0)$

$R_{1_{50}} = R_1(1+{}^1\alpha_{20}\cdot30)$
$= 600(1+1/1000\cdot30) = 618\Omega$

$R_{2_{50}} = R_2(1+{}^2\alpha_{20}\cdot30) = 336\Omega$

$\therefore R_{T_{50}} = R_{1_{50}} + R_{2_{50}} = 954\Omega$

$R_{T_{50}} = R_T(1+\alpha_T\cdot30)$
$954 = 900(1+\alpha_T\cdot30) \Rightarrow \alpha_T = 1/500 \approx 0.2\%$

600Ω 300Ω
${}^1\alpha = 0.1$ ${}^2\alpha = 0.4$
R_1 R_2
R_T

Kirchhoff's laws
Voltage loop rule: algebraic sum of potential differences 1 directed
(voltage) around any closed loop is zero.

$$
\sum_{\substack{k=1 \\ n=\infty}}^{n} v_k = 0
$$

Current law/junctionrale: Algebraic sum of currents in a network of conductors meeting at a point is zero.

$$
\sum_{k=1}^{n} I_k = 0 \quad \text{or } I_{\text{entonng}} = I_{\text{leaving}}
$$

$n =$ no. of branches
8 III

A cast steel magnetic structure made of a bar of (rose) section, 2×2 cm is shown in fig. Determine Current That the 500 tum magnetising coil. on the left limb should carry so that a flux of 2mWb is produced in the right limb. lake $\mu_{r_{\text{steel}}} = 600$, neglect leakage
A) $\operatorname{mmf}(AT) = NI$

$$
\begin{aligned}
& AT_{BD} = AT_{BCD}. \\
& \therefore AT_{\text{total }} = AT_{ABDA} + AT_{BD} = AT_{DEAB} + AT_{BCD} \\
& = \phi S_{BEAB} + \phi_2 \cdot S_{BCD} \\
& \phi_2 = 2 \text{ mW (given)} \\
& \phi_1 S_{BD} = \phi_2 S_{BCD} \\
& \therefore \phi_1 \cdot \frac{l_{\infty}}{\mu_0 \mu_7 a_0} = \phi_2 \cdot \frac{l_{BcP}}{\mu_0 H_2 a} \\
& \eta_{BD} = 15 \text{ cm} \\
& \therefore \phi_1 \cdot \phi_2 \cdot \frac{e_{BCD}}{e_{BD}} \\
& \tau_{BCD} = 25 \text{ cm} \\
& a = 2 \times 2 \times 10^{-4} \text{ m}^2 = 4 \times 10^{-4} \text{ m}^2 \\
& = \phi_2 \cdot \frac{RS}{15} \\
& = \phi_2 \cdot \frac{\cdot(0)}{3} = \frac{10}{3} \times 10^{-3} \mathrm{Wm} \\
& \therefore \phi = \phi_1 + \phi_2 = 2 + \frac{10}{3} = \frac{16}{3} \text{ mW} \\
& \therefore AT_{\text{total }} = \phi \cdot S_{D_{GAB}} + \phi_2 S_{BCD} \\
& = \frac{16}{3} \cdot \frac{2_{DEAB}}{\mu_0 \mu_4 \cdot a} + \frac{10}{3} \cdot \frac{2 R_{B\infty}}{\mu_0 \mu_2 a}
\end{aligned}
$$

$$
\begin{aligned}
& \left(\frac{16}{2} \cdot 25 + \frac{10}{3} \times .15\right) \frac{10^{-3}}{600 \times 4 \times 10^{-4} \times 4\pi \times 10^{-7}} = 6078 \text{ A} \cdot T \\
& AT_{\text{total }} = N \cdot I \\
& \therefore I = \frac{AT_{\text{tots}}}{N} = \frac{6078.8}{500} = 12.16 \text{ A}
\end{aligned}
$$

Electromagnetic Induction
The phenomenon of producing an emf in a conductor or coil whenever there's a magnetic flux linked with the coil or conductor is known as electromagnetic induction.
Faraday's laws of electromagnetic induction

1. Whenever there is a change in the fluxed linked with the coil or conductor, an emf is induced (known as induced emf).

if the coil is closed, a current will flow

2. magnitude of induced emf α rate of change is of flux linkage

flux linkage $= N\phi$.
change io flux linkage $= N\left(\phi_2 - \phi_1\right)$
According to Faraday's 2^{nd} law:

$$
\begin{aligned}
& e \propto N\left(\phi_2-\phi_2\right) / t \\
& e=k \cdot(\cdots) \quad k=1 \quad \text { in SI } \\
& e=\frac{N \phi_2-N \phi_1}{t}
\end{aligned}
$$

or $e=N \cdot \frac{d \phi}{d t}$ in diff. form

Len 2's law

Induced current will oppose its cause l it will produce a magnetic flux which is opposite to the flux producing a induced current

$$
e=-N \frac{d \phi}{d t}
$$

Self Inductance

property of a coil which opposes the change in current flowing through it

list method: $e=n \cdot \frac{d \phi}{d t} \cdot \frac{d \phi}{d t} \propto \frac{d}{d t}$

charge in I. induces change in flux producing self induced emf

$$
e=L \frac{d I}{d t}, L=e / \frac{d I}{d t} \quad L=\text { self inductance }
$$

$2^{\text {nd }}$ method:

$$
\begin{aligned}
e & =\frac{d}{d t}(N \phi)=\frac{d}{d t}(L I) \\
& \Rightarrow L=\frac{N \phi}{I} \quad[\text { wb.turns } / A]
\end{aligned}
$$

III meted:

$$
\begin{gathered}
L=\frac{N \phi}{\Delta I} \Rightarrow \phi=\frac{m m f}{s}=\frac{\phi I}{2 t} \frac{N I}{2 / \mu a}=\frac{N I_1}{\tau} \\
\therefore L=\frac{N^2 \mu_a}{2} \therefore L=\frac{N^2 / 4 a}{2}
\end{gathered}
$$

1. A coil wound on an iron core of permeability 400 has 150 turns & a cross sectional area of 5 cm^2 calculate inductance of coil given a steady current of 3 mA produces a magnetic field of 10 lines $/ \mathrm{cm}^2$ where air is present as the medium

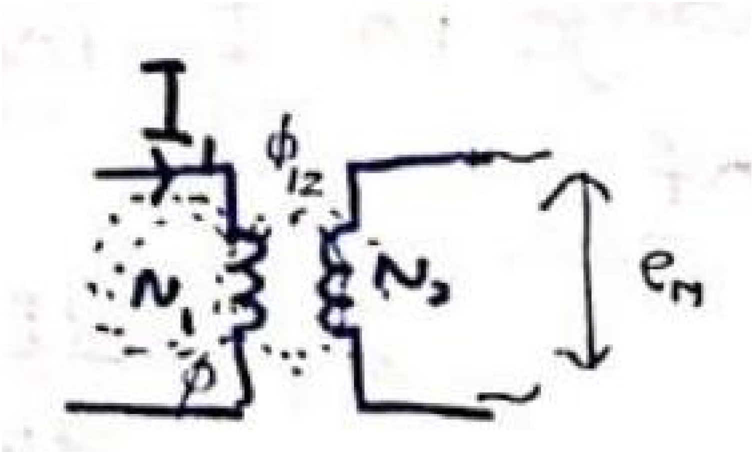
A)

$$
\begin{aligned}
& 1 w b=10^8 \text { lines } \\
& \phi=10^3 \times 5 \times 10^{-4} \\
& B=10 \times 10^{-8}=10^{-7} \text { lines } / \mathrm{cm}^2 \\
& \therefore B\left(\mathrm{wb} / \mathrm{cm}^2\right)=400 \times 10^{-7}=4 \times 10^{-5} \mathrm{wb} / \mathrm{cm}^2 \\
& \therefore \phi=B A=4 \times 10^{-5} \times 5=2 \times 10^{-4} \mathrm{hb} \\
& L=\frac{N \phi}{I}=\frac{150 \times 2 \times 10^{-4}}{3 \times 10^{-3}}=10 \mathrm{H}
\end{aligned}
$$

$$
a=5 \times 10^{-4} \quad \mu_r=400
$$

Mutual Inductance

production of in one coil due to flux change in



other coil.

$$e_M = N_2 \cdot \frac{d\phi_{12}}{dt} \equiv M \cdot \frac{dI_1}{db}$$

or mutual inductance $M = e_m / \frac{dI}{dt}$
or

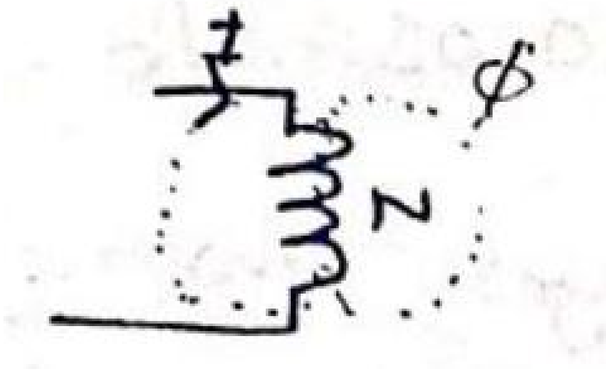
$$\begin{aligned} e_m &= N_2 \frac{d\phi_{12}}{dt} = \frac{d}{dt}\left(N_2\phi_{12}\right) \\ &= m\frac{dI_1}{dt} = \frac{d}{dt} \in (mI) \\ \therefore \quad N_2\phi_{12} &= mI_1 \Rightarrow m = \frac{N_2\phi_{12}}{I_1} \\ \phi &= \frac{mmf}{s} \quad \therefore \phi_{12} = \frac{N_1 I_1}{2/\mu a} \end{aligned}$$

$\phi_{12} = \frac{C1}{4\mu a}$

$$\text{since} \begin{aligned} M &= \frac{N_2\phi_{12}}{I_1}; M = \frac{N_1 N_2 \mu a}{2} = \frac{N_1 \dot{N}_2}{S} \\ &= \frac{N_2 N_1 I_1 \mu a}{2I_1}; \end{aligned}$$

$\therefore$ Inductance
self (L)
$e / \frac{dI}{dt}$
$\frac{\text{mutual } (M)}{e_n / \frac{dI}{dt}}$

$$\frac{N_2\phi_{12}}{I} \quad \because I_2$$

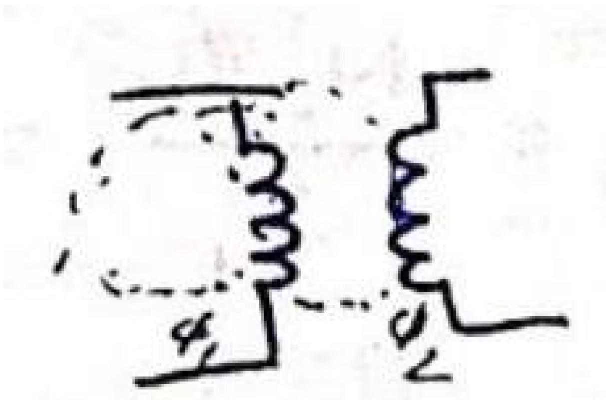


$\frac{N^2\mu 9}{2}$
$w^2/5$

$$\frac{N_1 N_2 \mu a}{2}$$
$$N_1 N_2/s$$

Coefficient of Coupling (k)

$$K = \frac{\text{flux linked with } 2^{\text{nd}} \text{ coil}}{\text{flux produced by } 1^{\text{st}} \text{ coil.}} \quad \frac{\phi_{12}}{\phi_1}$$

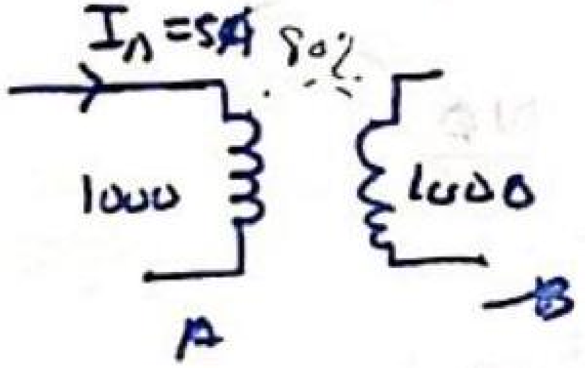


$\phi_{12} = k\phi_1 =$ A mount of flax produced in first ail linking with 2^{nd} coil.

$$M_{12} = \frac{N_2 k \phi_{12}}{I_1}, M_{21} = \frac{N_1 k \phi_{21}}{I_2}, L_1 = \frac{N_1 \phi_1}{I_1} \quad L_2 = \frac{N_2 \phi_2}{I_2}$$
$$\text{so } M_{12} = M_{21} = m$$
$$\therefore M_{12} \cdot M_{21} = \frac{k^2 N_1 M_2 \cdot \phi_1 \phi_2}{I_1 I_2} = k^2 L_1 L_2 = m^2$$
$$\therefore \quad M = K\sqrt{L_1 L_2}$$
$$\text{or } K = \frac{M}{\sqrt{L_1 L_2}}$$

1. Two identical coits A, B of 1000 turns is ewit lying parallel planes such that 80% of flux produced by one coil links with the other A current of 5 A flowing in coil A produces a flax of 0.05mWb is it. If the current in the coil A changes from $412A$ to $-12A$ in 0.023 . Calculcutr i) mutual indudane Ti) emf indused in coil 'B.

A) $I_A = SA, \quad \phi_A = 0.05mW, \quad N = 1000$



$\therefore L_A = \frac{N_1 \phi_1}{I_1} = \frac{1000 \times 0.05 \times 10^{-3}}{5}$
Coils A & B in a magnetic circuit havee 600$500 turns respectively, A carrent of $8A$ in coil A produces a flux of $0.04wb$. If $k = 0.2$, calculate
i) Self inductance of A iii) Avg.emf induced in B ii) flux linking with coil B & flux with it changes from
iv) mutual inductance
v) Avg emf in B when I_A changes from o to &A in 0.055
Aji)Self inductance $= \frac{M\phi_A}{I_A}$
ii) flux linked $\phi_B = k.\phi_A = 0.2 \times 0.04 = 0.008\text{WB} = 8\text{mWb}$
i) $M_{AB} = \frac{N_2 \Phi_{12}}{I_1} = \frac{1000 \times 0.0\$ \times 10^{-3}}{5} =$

$$\text{-}\ \varepsilon_B = N\frac{\Delta\phi}{\Delta t} = 500 \times \frac{8\text{mWb} - 0}{0.025} = \text{so0} \times \frac{0.008}{0.02} = 200$$

iv) $M = \frac{N_2 \phi_{12}}{I_1} = \frac{N_B \phi_B}{I_A} = \frac{500 \times 8 \times 10^{-3}}{8} = 0.51\text{H}$
v) When $I_A \in [0, 8]$

$$\phi_A \in [0, 40\text{mWb}], \phi_B \in [0, 8\text{mWb}]$$
$$\therefore \varepsilon_B = N\frac{d\phi_B}{dq} = 500 \cdot \frac{8\text{mWb} - 0}{0.05} = 500\frac{0.008}{0.05}.$$

ii) emf incluced $= m \cdot \frac{dI}{dt} = m\frac{(12+12)}{0.02}$
$\rightarrow M \cdot \frac{dL}{dt} = 0.5 \times \frac{8}{0.05} = \vdots$
Inductance in series

$$L_{eq} = \begin{cases} \sum_{v_i} L_i, & \text{wo mutual inductance} \\ L_1 + L_2 + 2m, & \text{w. mut. } E(\omega \cdot 2L). \end{cases}$$

fluxes are
"aiding"
$L_1 + L_2 + 2m$

Recons +855 Inductance in parallel

$$L_{\text{eq}} = \sum_{v_1} L_{U_{(2)}} \omega/0$$

$$L_{eq} = \frac{4L_2 - M^2}{L_1 + L_2 - \omega 2M}$$

$$L_{eq.} = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$$

$$w/0 \cdot M \cdot I$$

fluxes are aiding
Energy stored: $\frac{1}{2} L I^2$ AC-fundtamentals

$$v = V_m \sin(\omega t), i = I_m \sin(\omega t)$$

Advantages of sing. 1) Sinosoiclal signels produce less disturbance to elect. network compared with other generateling signals and the waveform is smooth and efficient 2) Sinusoidal signals applied to appropriately designed colils can produce a revolving field that can do the work. 3) mathematical calculations associated with a sinosoidal signals are much simpler 9). with the hap of fourier series, any alternating signal can be represented os the sum of different sinosoidal signals.
Parameters to represent alternating signal 1) Peak value ⊠ Amplitude 2) peak to peak $\sim V_{pp}$? 3) Average value. $/DC$ value.

$$= \frac{1}{T_0} \int_0^T f(t) dt$$

for symmetric, take 1/2 cycle. $\equiv \frac{2}{T} \int_0^{T/2} f(t) dt$ e.y: $\frac{2}{2\pi} \int_0^{\pi} v_m \sin(ut) dat = \frac{a}{\pi} \left(2 v_m\right)^0 = \frac{2}{\pi} v_m$
1.

$$= 25 \text{ V}$$

2 Area under cure

$$\begin{aligned} =&\frac{10 \times 0.2}{2} + 0.4 \times 10 + \frac{0.2 \times 10}{2} \\ &- \frac{0.2 \times 5}{2} \\ =&6.5 \end{aligned}$$

$$\therefore \text{ Aug val } = \frac{6.5}{1} = \underline{6.5 V}$$

3. FWR:

$$\begin{aligned} \text{Aug. val } &= \frac{1}{\pi} \int_0^{\pi} \sin(\theta) d\theta \\ &= \frac{\pi}{\pi} [-\cos\theta]_0^{\pi} \\ &= \frac{\pi}{\pi}(n) = 0.\pi 1 \end{aligned}$$

4. H'wR

$$\begin{aligned} \text{Avg val } &= \frac{1}{2\pi} \int_0^{\pi} \sin(\theta) d\theta \\ &= \frac{1}{\pi} \end{aligned}$$

FWR, HWR wave. RMS value. $\sim$ Rms value of on alternating current is thad steady current (dc current) flowing through a given resista for a given time which produces same heating effect as & by the a AC for the same resistance for the same tires. time Here tola heating effect

$$I \simeq \underbrace{\sqrt{\frac{1}{N}\sum_{k=1}^{N} i_{15}^{m=m^2}}}_{\text{root mew square}}$$

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

for symmetric wave: $R_{ms} = \sqrt{\frac{sq \cdot av0 \text{ of } 1/2c_y}{1/2T}}$. for sin.

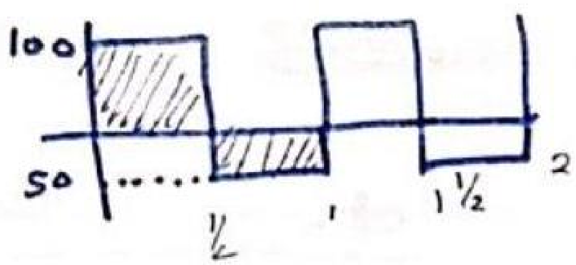
$$= \frac{v_{rms}}{v_{avg}}$$

$$\text{- form factor} \qquad \text{for } \sin H\omega = \frac{v_m}{\sqrt{2}} \cdot \frac{\pi}{2v_m} = \frac{\pi}{\sqrt{8}} = 1.111$$

$$\text{- Peak factor } = \frac{v_m}{v_{rms}} = v_m / \frac{v_m}{\sqrt{2}} = \sqrt{2} = 1.414$$

1.

$$\begin{aligned} A_{\text{vg. Val}} &= \frac{100 \times .5 \bar{\Phi} 50 \times .5}{1} \\ &= 25 \text{ V} \end{aligned}$$



2 Area under cure

$$\begin{aligned} &= \frac{10 \times 0.2}{2} + 0.4 \times 10 + \frac{0.2 \times 10}{2} \\ &- \frac{0.2 \times 5}{2} \\ &= 6.5 \end{aligned}$$

$$\therefore \text{ Aug val } = \frac{6.5}{1} = 6.5V$$

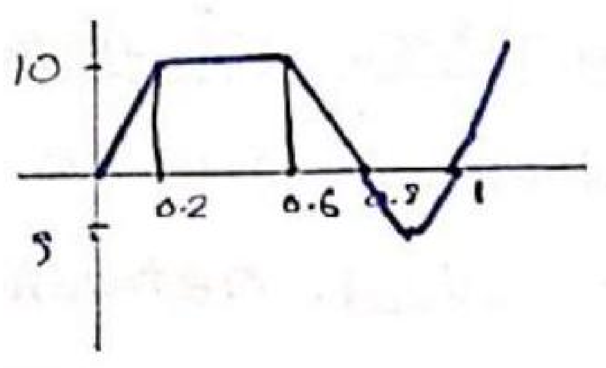
3. FWR:

Aug. val $= \frac{1}{\pi}\int_0^{\pi}\sin(\theta)d\theta$

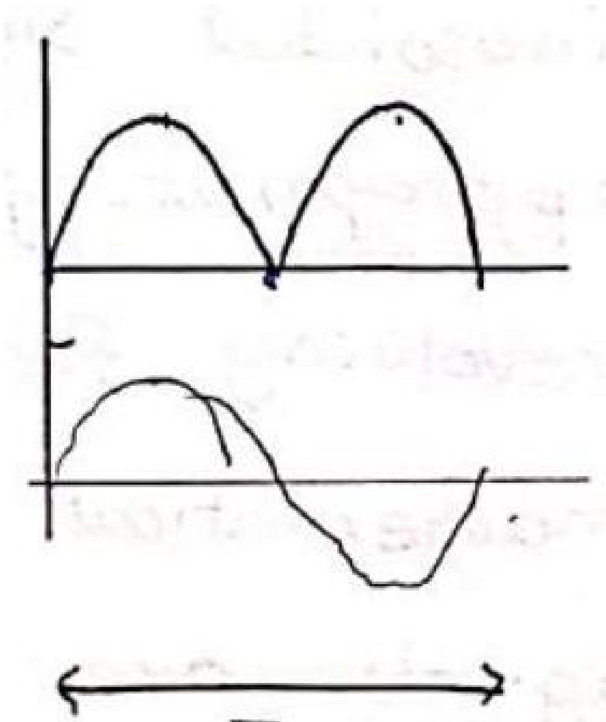
$$
\begin{aligned}
&= \frac{\pi}{\pi}[-\cos\theta]_0^{\pi} \\
&= 2/\pi \\
\pi(2) &= 0.64
\end{aligned}
$$

4. H'wR

$$
\begin{aligned}
\frac{HwR}{Avg}\text{ val } &= \frac{1}{2\pi}\int_0^{\pi}\sin(\theta)d\theta \\
&= \frac{1}{\pi} \quad = 0.BR
\end{aligned}
$$



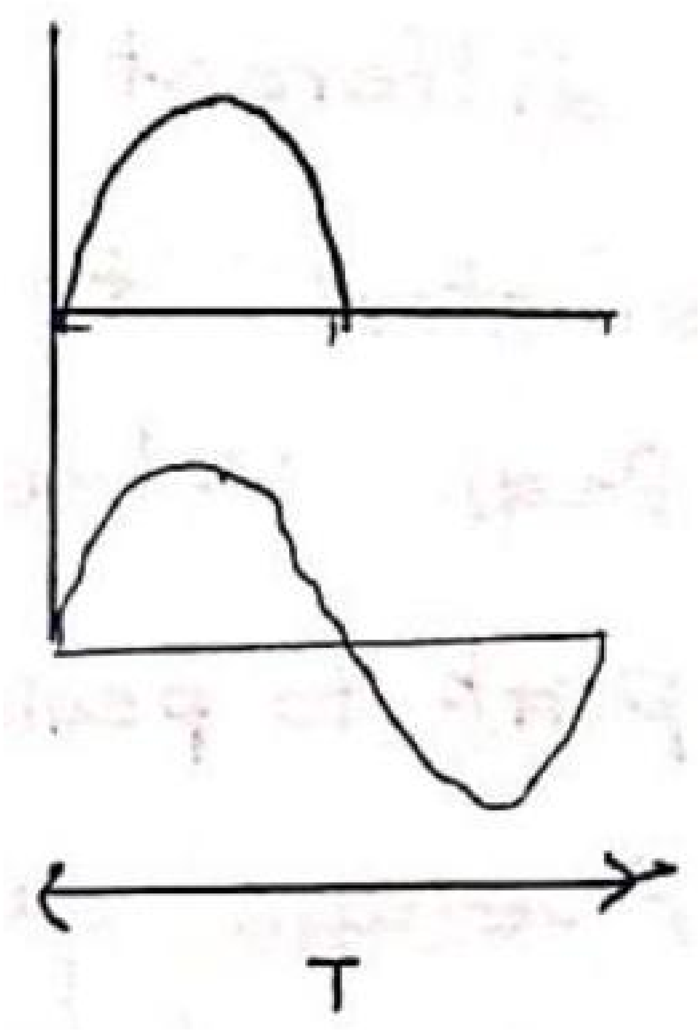
FWR, HWR wave.



$$I = \underbrace{\sqrt{\frac{1}{N}\sum_{k=1}^{N} i_{15}^{m_m^2}}}_{\text{root mew square}}$$

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

for symmetric wave: $R_{ms} = \sqrt{\frac{sq \cdot a00011/2cy}{1/2T}}$.
for sin.

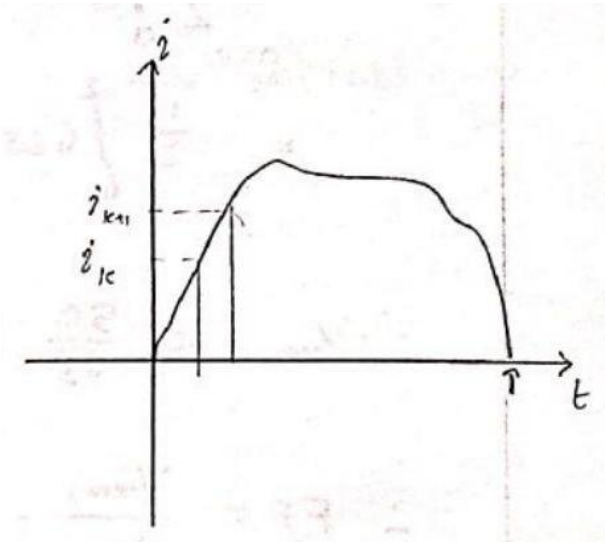


the same tire time
Here total heating effect

$$\underbrace{I^2}_{\text{dc eqiv heating}} RT = \frac{1}{N}\sum_{k=1}^{N}\left(\frac{i_{k+1} - i_k}{2}\right)^2 R.T$$

RMS value.

$\sim$ Rms value of on alternating current is shad steady current (dc current) flowing through a given resista for a given time which produces same heating effect as by the a AC for the same resistance for



$$J_{vns} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} v_m^2 \sin^2(\theta) d\theta} =$$
$$= \sqrt{\frac{V_m^2}{2\pi}\int_0^{2\pi}\left(\frac{1}{2} - \frac{\cos(2\theta)}{2}\right)d\theta} = \sqrt{\frac{V_m^2}{4\pi}\left[\theta - \frac{\sin(2\theta)}{2}\right]_0^{2\pi}}$$
$$= \sqrt{\frac{v_m^2}{4\pi}(2\pi)} = \frac{v_m}{\sqrt{2}}$$

- form factor $= \frac{V_{\mathrm{rms}}}{V_{\mathrm{avg}}}$

for $\sin H\omega = \frac{v_m}{\sqrt{2}} \cdot \frac{\pi}{2v_m} = \frac{\pi}{\sqrt{8}} = 1.111$

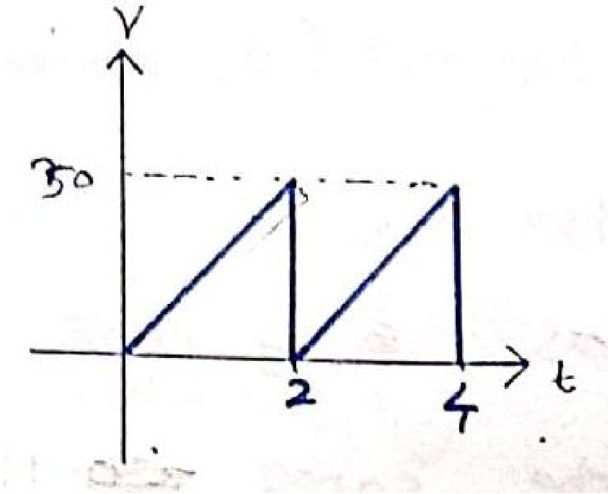
- Peak factor $= \frac{v_m}{v_{rms}} = v_m / \frac{v_m}{\sqrt{2}} = \sqrt{2} = 1.414$
- RmS of $FWR, T = \pi \quad HWR \quad T = 2\pi$

RMS of a complex ware

1. find FF of given waveform

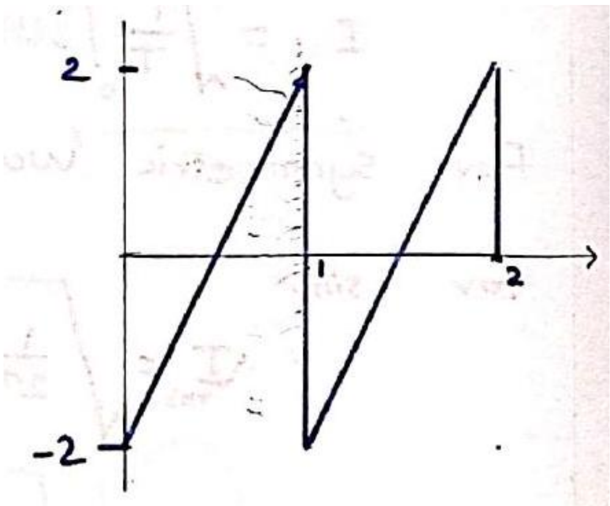
A)

$$
\begin{aligned}
V_{\text{Avg }} & =\frac{50 \times 2}{4}=25 V \\
V_{rms}^{2} & =\frac{1}{T} \int_{0}^{T} v(t) d b \\
& =\frac{1}{2} \int_{0}^{2}(25 t)^{2} d t \\
& =\frac{1}{2} \int_{0}^{2} 625 t^{2} d t=\frac{625}{2}\left[\frac{t^{3}}{3}\right]_{0}^{2}=\frac{625}{6} \times 8=\frac{4 \times 25^{2}}{3} \\
\therefore V_{rms} & =\frac{50}{\sqrt{3}}=\underline{28.87 V} \\
\therefore F F & =\frac{V_{rms}}{V_{vuv}}=\frac{28.87}{25}=1.155
\end{aligned}
$$



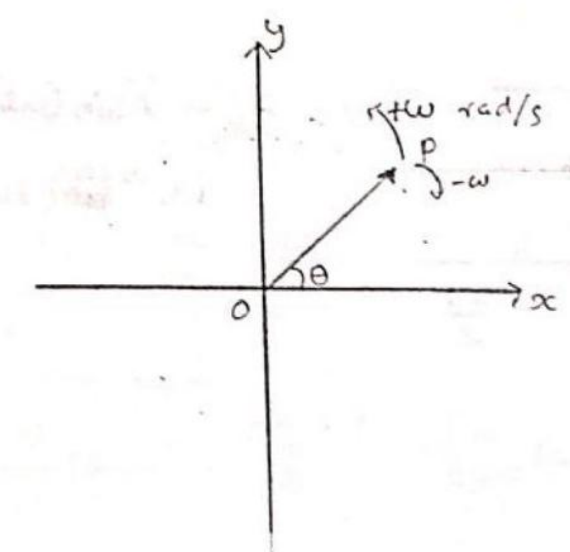
2. $V_{\text{Avg }}=0$? 1

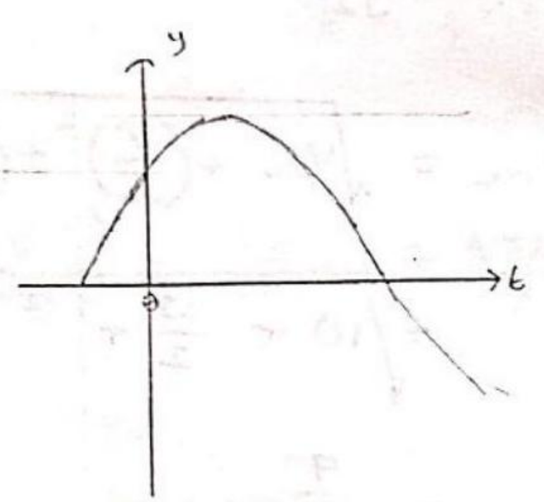
$$
\begin{aligned}
V_{\text{RmS }}^{2} & =\frac{1}{1} \int_{0}^{1}(4 t-2)^{2} d t=\int_{0}^{1}\left(16 t^{2}+4-18 t\right) d t \\
0 & \\
& =\left[8 \frac{16 t^{3}}{3}+4 t-8 t^{2}\right]_{0}^{1}=\frac{16}{3}+4-8=\frac{4}{3} \\
\therefore V_{\text{Taos }} & =\frac{2}{\sqrt{3}}=1.155
\end{aligned}
$$

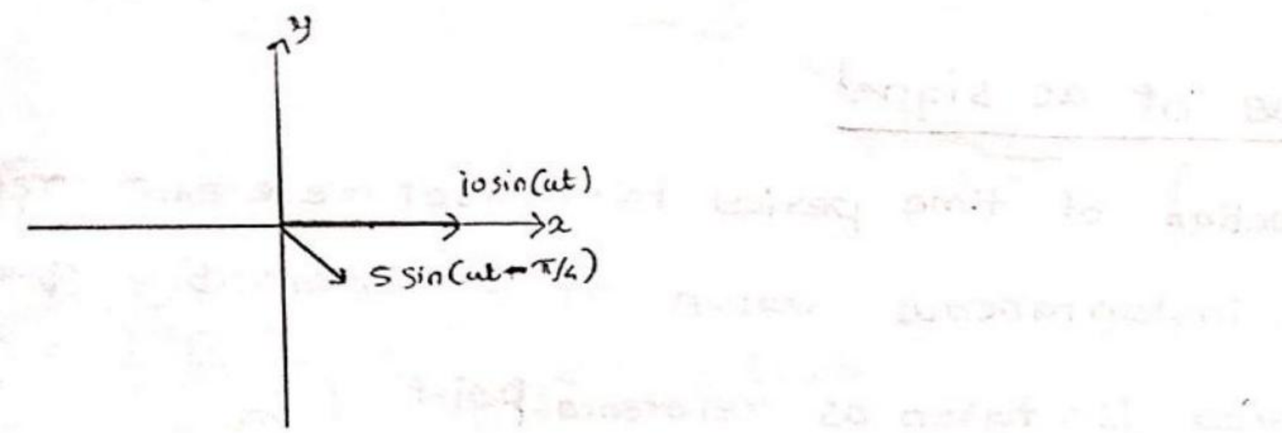


- Every alternating sign waveform can be representol completely if we hove.

i) Amplitade ii) frequency iii) phase difference phasor representation
VAF arert scalu nor vec but phasor-

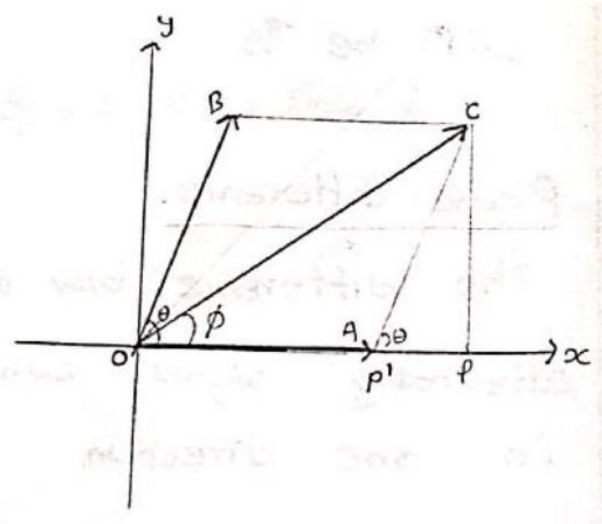




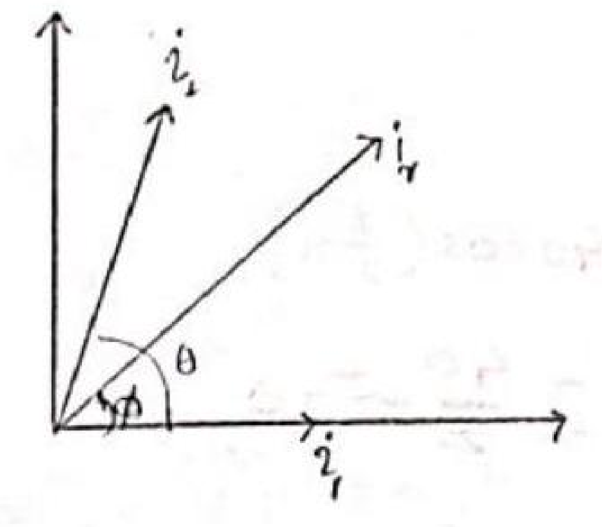


Addition of phasors
$oc = \sqrt{op^2 + \rho c^2}$
$= \sqrt{\left(0p' + p'p\right)^2 + pc^2}$

$= \sqrt{(|A| + |B| \cdot \cos(\theta))^2 + (|B| \cdot \sin(\theta))^2}$
$= \sqrt{|A|^2 + |B|^2 + 2|A||B| \cdot \cos(\phi)}$

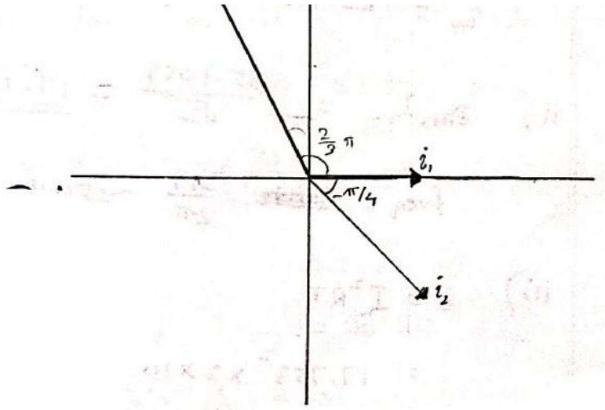


$\phi = \tan^{-1} \frac{|B|\sin(\theta)}{|A|+|B|\cos(\theta)}$ methud of components.



Split phasor to x, y camponents.
$\therefore$ Resultant $= \sqrt{x^2 + y^2}$
$\dot{i}_1(x) = \dot{i}_1, \dot{i}_1(y) = 0$
$\dot{i}_2(x) = \dot{i}_2 \cos(\theta), \dot{i}_2(y) = \dot{z}_2 \sin(\theta)$
$\phi = \tan^{-1}\left(\frac{x}{g}\right) = \tan\left(\frac{\dot{z}_2 \sin(\theta)}{z_1 + \dot{i}_2^2 \cos\theta)}\right) \dot{i}_\gamma = \sqrt{\left(i_1 + \dot{i}_2 \cos(\theta)\right)^2 + \left(0 + \dot{i}_2 \sin(\theta)\right)^2}$
$= \sqrt{\dot{i}_1^2 + \dot{i}_2^2 + 2\dot{i}_1 \dot{z}_2 \cos(\theta)}$
$\Leftrightarrow$
Three circuils in parallel take the follouing currens
$i_1 = 20\sin(314t), i_2 = 30\sin(314t - \pi/4), i_3 = 40\cos\left(314t + \frac{\pi}{6}\right)$
find
i) expression for resultant current

ii) its rms value and frequency.
iii) If the circuit has a resistarce of 2Ω what is the enorgy loss in lohour
A) $i_2 = 40\sin\left(314t + \frac{\pi}{2} + \frac{\pi}{6}\right)$
$= 40\sin\left(314t + \frac{2}{3}\pi\right)$
$\dot{z}$
i
i



Phasor algebra (⊠)

$$\odot\vec{B} = j^2\vec{A}$$
$$\vec{C} = j\vec{A}$$

$$i_1(x) = 20, \quad i_2(x) = 30\cos(-\pi/4) \quad i_3(x) = 40\cos\left(\frac{2}{3}\pi\right)$$
$$= \frac{30}{\sqrt{2}} \qquad = -\frac{40}{2} = -20$$
$$\therefore \dot{z}_r(x) = 20 + \frac{30}{\sqrt{2}} - 20 = \frac{30}{\sqrt{2}}$$
$$i_2(y) = 0 \quad \dot{i}_2(y) = 30\sin(-\pi/4), i_3(y) = 40\sin\left(\frac{2}{3}\pi\right)$$
$$= -\frac{30}{\sqrt{2}} \qquad = 40 \cdot \boxtimes \frac{\sqrt{3}}{2}$$
$$\therefore \dot{i}_7(y) = 40\frac{\sqrt{3}}{2} - \frac{30}{\sqrt{2}} = \frac{40\sqrt{6} - 30\sqrt{2}}{2}$$
$$\therefore \left|\dot{i}_r\right| = \sqrt{\dot{i}_r(x)^2 + \dot{i}_r(y)^2} = \sqrt{\frac{900}{2} + (\cdots)^2} = 25.1059$$
$$\theta = \frac{\eta_r(y)}{i_r(x)} \tan^1\theta = 32.3°$$

$$\therefore i_r = 25.1059\sin(314t + 32.3°)\text{ A}$$

ii) ج reos $I_{rms} = \frac{25.1059}{\sqrt{2}} = 17.753$ A

$$f_{\text{req}} = \frac{314}{2\pi} \simeq 50 \text{ Hz}$$

iii).

$$
\begin{aligned}
E &= I_m^2 RT \\
&= 17.753^2 \times 2 \times 10 \times 60 \times 60 = 22.69\text{MJ} \\
&= 17.753^2 \times 2 \times 10^{710^{-9}} = 6.303\text{kwh}
\end{aligned}
$$

$$
\begin{aligned}
&= 4000\left(\cos(\pi/4 - \pi/6) + \cos\left(2\omega t + \frac{\pi}{4} + \frac{\pi}{6}\right)\right) \\
P &= 4000\left(\cos\left(\frac{\pi}{12}\right) + \cos\left(2\omega t + \frac{5}{12}\pi\right)\right) \\
\therefore P &= \int_0^{\pi/50} 4000\left(\cos\frac{\pi}{12}\% + \cos\left(2\omega t + \frac{5}{12}\pi\right)\right) dt \\
&= 4000 \times \frac{\pi}{50} \cos\frac{\pi}{12} + \left[\frac{\sin\left(2\omega t + \frac{5}{12}\pi\right)}{2\omega} \times 4000\right]_0^{\pi/50} \\
&= 80\pi \cos\pi/12 \\
&= \frac{242.76}{=}
\end{aligned}
$$

2 phosors are given in the rectangle form as: $\eta_1 = (15 + 10j)A$ ard $\eta_2 = (12 + 6j)A$, perform $\eta_1 + \eta_2$ and $\eta_1 - \eta_2$

A) $z_1 + \eta_2 = 26 + 16j, \quad \eta_1 - \eta_2 = 3 + 4j$

3. Determine the resultant voltage of two sinosoidal generators in series whose voltages are, $v_1 = 25\angle 15°\text{V}, v_2 = 15 < 60°\text{V}$

A)

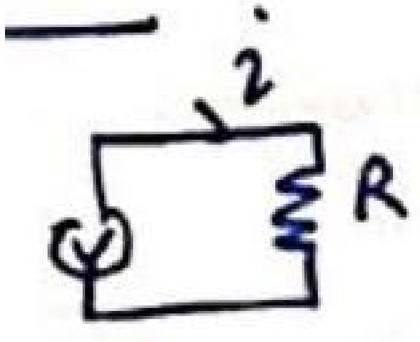
$$
\begin{aligned}
&v_1(x) = 25\cos\left(15°\right), \quad v_2(x) = 15\cos^3\left(60°\right) \\
&v_1(y) = 25\sin\left(15°\right) \quad u_2(y) = 15\sin\left(0°\right) \\
&R(x) = \\
&|R| = 85) = 19.46
\end{aligned}
$$

$$\therefore R = 37.15 < 31.59°$$

AC circuits

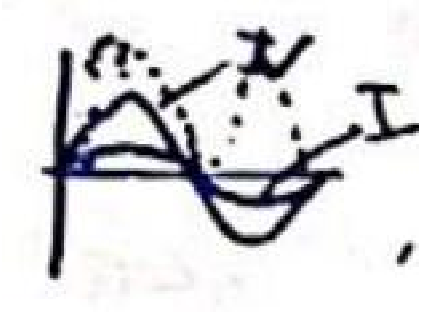
Pure resistive circuit

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



Q inst. caners. valise
. ins .t. current:

$$i = \frac{V_m}{R}\sin(\omega t)$$
$$:= N/R$$



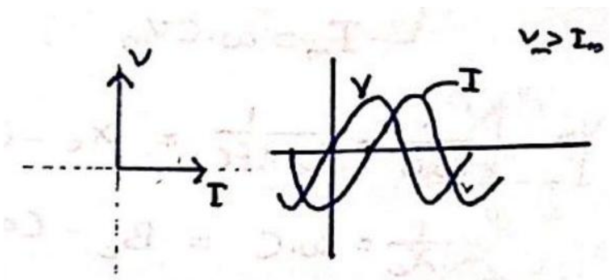
Here both voltage & current case in phase.
Instantaneous power $= v \cdot i$

$$= \frac{v_m^2}{R}\sin^2(\omega t)$$
$$= \frac{V_m I_m}{2} - \frac{V_m I_m \cos(2\omega t)}{2}$$

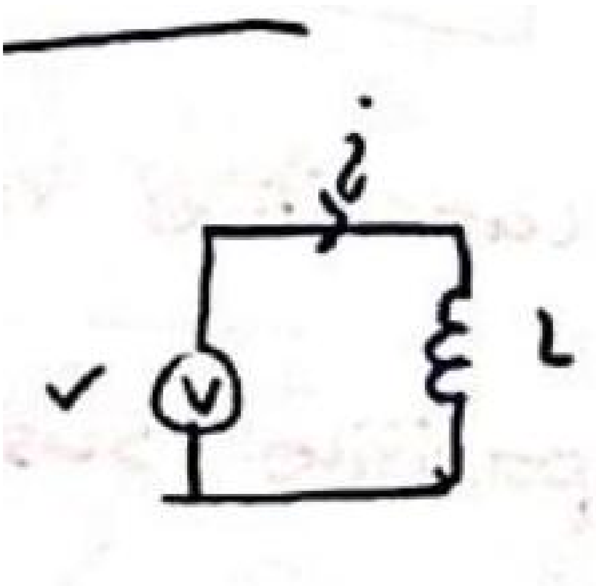
Avg. power $= \frac{1}{2\pi}\int_0^{2\pi} P\,dt = \frac{1}{2\pi}\int_0^{2\pi}\left[\frac{V_m I_m}{2} - \underbrace{\frac{V_m I_m}{2}\cos(2\omega t)}_{0}\right]dt$

$$= \frac{V_m I_n}{2} = \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}} = \underline{\underline{VI}} \text{ Rms values.}$$

Purely inductive circuit



$$v = v_m \sin(\omega t)$$
$$= v_i = L\frac{di}{dt}$$
$$\therefore i = \int \frac{v_L}{L}dt = \frac{V_m}{\omega L}\cos^2(\omega t) = \frac{v_m}{L\omega}\cdot\sin\left(\omega t - \frac{\pi}{2}\right) = I_m \sin\left(\omega t - \frac{\pi}{2}\right)$$



$\therefore i$ is ben lagging behind V ben

$$I_m = \frac{v_m}{\omega L} \therefore \frac{\dot{V}_m}{I_m} = \omega L = 2\pi f L = X_c$$
$$\therefore G = \frac{1}{x_C} = \frac{1}{\omega L} = \frac{1}{2\pi f L} = B_L \text{ susceptanco}$$

Instantaneous power : $p = V_i$

$$\begin{aligned} P &= V_i \\ &= V_m J_m \sin(\omega t) \sin\left(\omega t - \frac{\pi}{2}\right) \\ &= \frac{U_m I_n}{2} \cdot 2 \sin(\omega t) \sin\left(\omega t - \frac{\pi}{2}\right) \\ &= \frac{V_m I_m}{2} [-2 \sin(\omega t) \cos(\omega t)] \\ &= -\frac{V_m I_m}{2} \sin(2\omega t) \end{aligned}$$

$\therefore$ Avg. Power $= \frac{1}{2}\frac{1}{\pi} \int_0^{2\pi} -\frac{V_m I_m}{2} \sin(2\omega t) dt$

$$= \frac{1}{2\pi} \left[\frac{y_m I_m}{2 \times 2\omega} \cdot \cos(\omega t)\right]_0^{2\pi} = 0$$

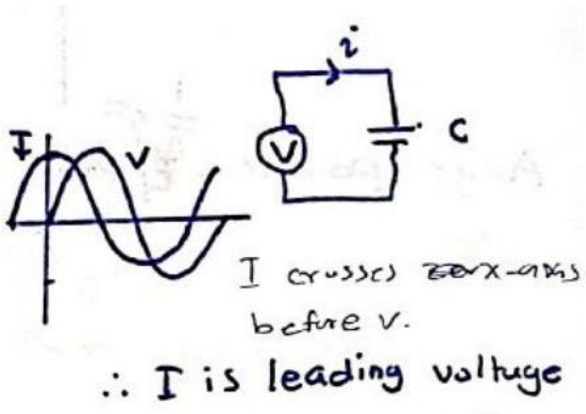
$\therefore$ no power is consumed in purely inductive resistance

Purely capacitive circuit

$$v = v_m \sin(\omega t)$$

Instantaneous charge shred:

$$\begin{aligned} q &= Cv \\ &= C \cdot v_m \sin(\omega t) \end{aligned}$$



$\therefore$ inst .t. current: $i = \frac{da}{dt} = C\omega v_m \cos(\omega t) = C\omega \cdot v_m \sin\left(\omega t + \frac{\pi}{2}\right)$

$$\frac{V_m}{I_m} = \frac{1}{\omega C} = \frac{1}{2\pi f c} = x_c - \text{ (capacitive reactances)}$$

$$\frac{1}{x_c} = \omega \cdot C = B_c \text{ - (apacitive susceptance.}$$

Instantaneous power: $p = vi = v_m I_m \sin(\omega t)\cos(\omega t)$

$$= \frac{V_m I_m}{2} \sin(2\omega t)$$

Average power $= \frac{1}{2\pi}\int_0^{2\pi} \frac{V_m I_m}{2} \sin(2\omega t) dt = 0$
$\therefore$ Here no power drawn

1. A pure inductive coil allows a current of LOA to flow from a $230V 50H_2$ supply. rms find x_C, L, power absorbed, $i(t) = ?$ $v(t) = ?$

A))

$$v(t) = \frac{230\sqrt{2}}{\sqrt{2}} \sin(100\pi t) = 325.3 \sin(100\pi t)$$

$$i(t) = 10 \sin\left(\omega t - \frac{\pi}{2}\right) = 104 \sin\left(100\pi t - \frac{\pi}{2}\right)$$

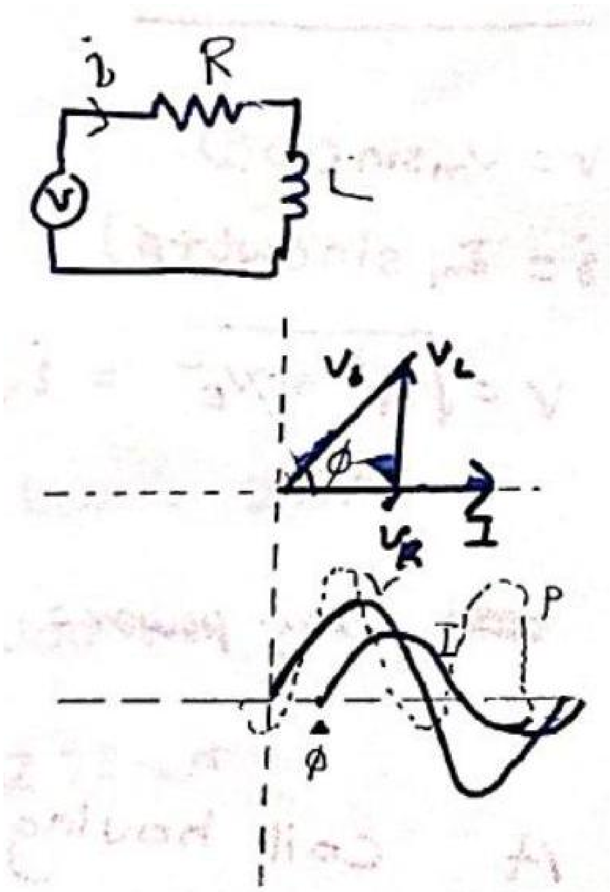
$$x_c = \frac{v_m}{I_m} = \frac{230\sqrt{2}}{10\sqrt{2}} = 230 \quad 2\pi f L$$

$$\therefore L = \frac{23\%}{2\pi f} = \frac{234\sqrt{4}}{100\pi} = . \quad = 73\text{mH}$$

power absorbed = 0.
Series Ac circuit
R l circuit

- all -real coils, liteally * Choke coil

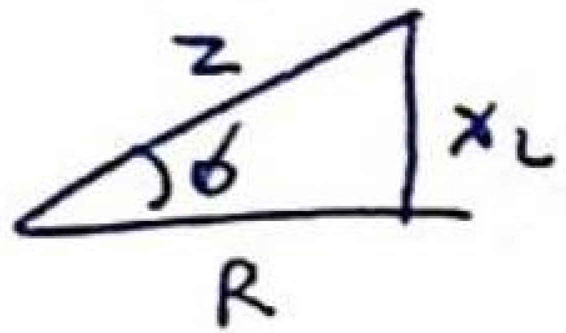
$$\vec{v} = \vec{v}_R + \vec{v}_L$$
$$v = \sqrt{u_R^2 + v_i^2} = \sqrt{(iR)^2 + (ix_L)^2}$$
$$= i\sqrt{\sqrt{R^2 + x_L^2}}$$
Z Cimpedence
$$i = I_m \sin(\omega t - \phi), \quad \phi = \tan^{-1}\left(\frac{x_L}{R}\right)$$



Instantaneous power:

$$p = V_i = \frac{v_m I_m}{2} \cdot 2\sin(\omega t) \cdot \sin(\omega t - \phi)$$
$$= \frac{V_m I_m}{2}[\cos(\phi) - \cos(2\omega t - \phi)]$$

Avg. Power: $\frac{1}{2\pi}\int_0^{2\pi} \frac{v_m J_m}{2}(\cdots)dt = \frac{v_m I_m}{2}\cos(\phi) = V \cdot I \cos(\phi)$ $\cos(\phi) =$ as. angle blu applied voltage and resultant current $= \frac{v_R}{v} = \frac{iR}{i2} = R/2$
Impedence triangle Power triangle



$S=$ apparent power
$=$ pow thills assumed to be drawn from suarce to eirearit load

$$= V_{m;} \cdot I_{2ms}\, [v_{01} t\text{-ampere}]$$

$P=$ active power true power
$=$ power actively consumed /done useful work

$$= V_{\text{rms}} \cdot I_{\text{m.}} \cdot \cos(\phi)$$

$Q=$ reactive power
[watt]
$=$ power not corsumad I not done useful work

$$= v_{rms} \cdot I_{r-s} \cdot \sin\phi)$$

$\sim$ consumed by capacter/indede
[volt-ampere-reaction (VAR)]

$$P = vI\cos(\phi)$$

$$\therefore I = \frac{230}{12.21} = 18.8 \text{ A}$$

$$\phi = \tan^{-1}\left(\frac{X_L}{R}\right) = 58^\circ$$

$$\begin{aligned} &\cos(\phi) = 0.57 \\ &\text{PeC. VI } \cos(\phi) \simeq 2.5\text{kw} \\ &V_R = I.R. = 131.6 \\ &v_L = \quad = 188 \end{aligned}$$

$$\therefore \text{ powerfuctor } = \frac{\text{Active pour}}{\text{Apparent pour r}} \text{ a } \frac{p}{S} \quad = I^2 R \text{ no z \$} \because \text{ con desist}$$

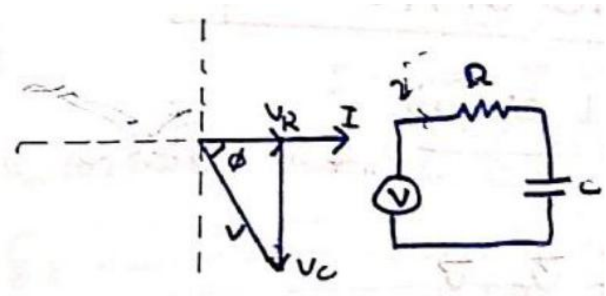
$RC -$ circuit

$v = v_m \sin(\omega t)$

$i = I_m \sin(\omega t + \phi)$

$v = \sqrt{v_R^2 + v_E^2} = i \underbrace{\sqrt{x_c^2 + R^2}}_{2}.$

$$\text{arg. power } = \frac{1}{2\pi} \int_a^{2\pi} v_i dt = \frac{1}{2\pi} \cdots \quad = VI\cos(\phi)$$



2. A coil having resistance of 7Ω and a inductance of 31.8mH is connected to 230 V5 Hz supply. Calculate, $Q\dot{Q}I, \phi, \cos(\phi)$, power consumed, $V_R d V_L$

A). =

$$x_L = L\omega = 2\pi f L = 100\pi \times 0.0318$$
$$= 9.989. = 10.$$
$$\therefore z = \sqrt{7^2 + 10^2} = 12.21\Omega$$

3. A choke coil takes a current of $2A$ lagging 60° behind

A the applied voltage of 200 V QSoHz, Calculate Z, R_r L of c01. Also find power consumed when coil is connected reross 100 aU, 25 Hz supply.

$$z = \frac{A}{I} = \frac{200}{2} = 100\Omega$$
$$= \frac{1}{2} \Rightarrow \quad = 50$$

$$\cos(\phi) = R/z$$

$$\cos(60) = \text{ loot z, } = \frac{1}{2} \Rightarrow = 50$$

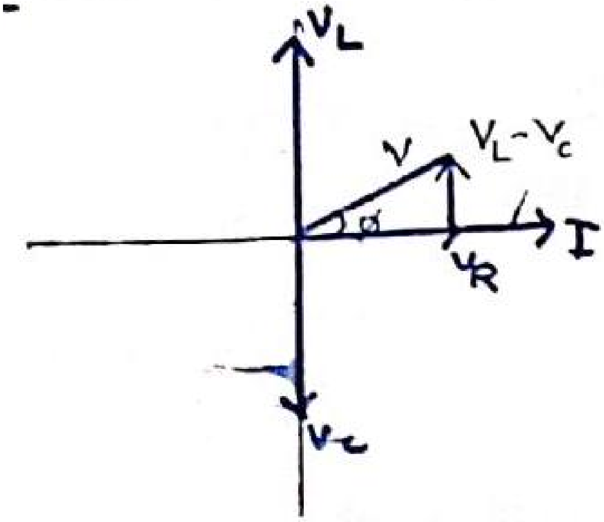
$$\therefore z = \sqrt{R^2 + X_L^2} \Rightarrow x_k = \begin{matrix} Z^2 - R^2 \\ 80.6 \\ 173.2 \end{matrix} = 100\pi L$$

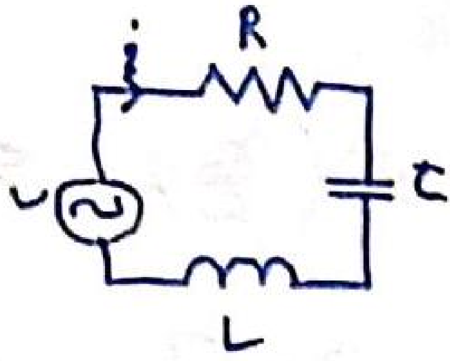
$$X_L \text{ at } 100 \text{ V}25H_2: \quad X_L = 2\pi f L = \quad 43.3\Omega$$

$$\therefore z = \sqrt{R^2 + X_L^2} = \sqrt{50^2 + 93.3^2} = 66.1\Omega$$

$$\therefore I = \frac{100}{66.1} = 1.51, \quad \Rightarrow \because \quad P = I^2 \times R = 112.5$$

Series LCR





- if $x_L > x_c$. inductive in nature (I lags v)

$x_c > x_L$, capacitive " (I leads v)
$x_C = x_L$. resistive , (I in phase V)

$$v = \sqrt{v_R^2 + (v_L - v_R)^2} \text{ or } z = \sqrt{R^2 + (x_L - x_C)^2}$$
$$\cos(\beta) = \frac{R}{\sqrt{R^2 + (x_L - x_{2^2}}}$$

1. A 230 V, 50 Hz AC supply is applied to a coil of 0.06H inductance, and 2.5Ω, resistance connected in series with a 6.8μF, calculate Impetere, current prose angl$'(\forall - 5)$ pow. factor; power consumed.

A)

$$x_L = 2\pi f L = 18.85\Omega$$
$$z = \sqrt{R^2 + (X_L - X_0)^2}$$
$$x_c = \frac{1}{2\pi f c} = 468.1\Omega$$
$$= \sqrt{2 \cdot 5^2 + C \cdot \cdot)^2} = 499.26\Omega$$
$$I = \tfrac{V}{2} = \tfrac{230}{499.26} = \tfrac{0.51A}{x-1} + \cdots \left(\tfrac{x_L - x_2}{R}\right)$$
$$-1(R) = 89.68^\circ \rightarrow 1 \text{ pow consumed } = 0.63 \text{ W}$$
$$\phi = \cos^{-1}\left(\frac{R}{2}\right) = 89.68^\circ \rightarrow \text{ leadiry}$$

pour factor $= 0.56 \times 10^{-3}, \rightarrow$ leading
Resonance
A crrcust consisting of LQC is said to be in resunace when circuit power factor is unity.
Resonaes condition: $x_L = x_c \Rightarrow$ vI ore in phat & $pf = 1$
Here impedes is minimum, I is max.

$$L\omega = 2\pi f L = \frac{1}{2\pi f c} \Rightarrow f_r = \frac{1}{2\pi\sqrt{Lc}}$$

Quality / voltage umpltication factor

$$Q = \frac{V_L}{V} = \frac{I_r x_L}{I_r R} \text{ (@Resnone) } = \frac{x_L}{R} = \frac{V_C}{V_L} = \frac{x_L}{R}$$

$$\text{Q } \frac{I_r x_L}{I_r z} \leftarrow \text{ fircoil}$$

$$Q = \frac{\omega L}{R} = \frac{1}{\omega C R}$$

$$Q = \frac{L}{R} \cdot \frac{1}{\sqrt{LC}} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

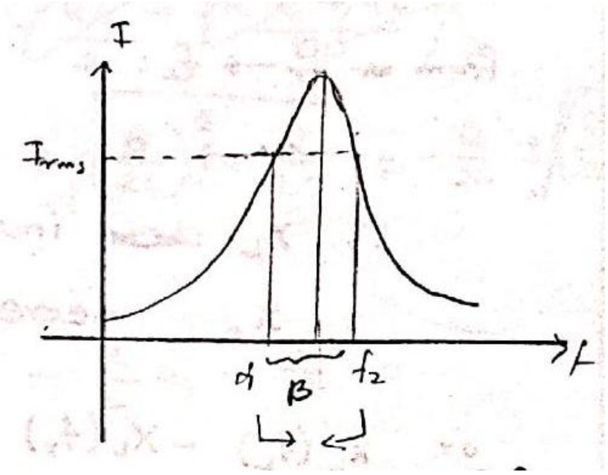
Band width

$$\beta = f_2 - f_1$$

H_1 - Lower cutest freq
f. - uppa
$f_1; E =$ half pour frow $/ - 3dR$ freq

$$P = J^2 Rs, \quad P_{f_1} = I_h^2 R = \frac{P_{\max}}{2}$$

$$\Rightarrow \left(\frac{I_n}{s_2}\right)^2,$$



$$x_L - x_c = R$$

$$1z = R\sqrt{2}$$

Power in decibels: $P_r = 10 \log P_{\max}$ $P_{\gamma_{1,22}} = 10 \log \frac{P_{\max}}{2}$
$\therefore$ Recharge in row from fo to tiu:

$$= 10 \log P_{mm} / (P_{mm\alpha}/2) = 10 \log 2 \approx 3dB \text{ from ream}$$

2 A coil of resistance $100\Omega, \&1+ = 100\mu H$ is connected in series with 100pF capacitor, circuit is connected to a low variable frequency source, calculate, resonant freq.

I at resonance, voltage across LQC at resoncac, Q fact, $y = 104$
A) $f = \frac{1}{2\pi\sqrt{LC}} = 1.59\mathrm{MH}/2$
$\therefore$ at resonce; $\quad z = R$

$$\begin{aligned} \therefore \quad I &= \frac{V}{2} = \frac{10}{100} = 0.1 \text{ A} \\ V_R &= Ix_L = 0.1 \times 2\pi f L = 1000 \\ V_C &= Ix_C = \frac{0.1}{2\pi f C} = 1000 \\ Q &= \frac{V_R}{V} = \frac{100}{10} = 10 \end{aligned}$$

Expression for $f_1 \& f_2$
At upper cut of :

$$x_L - x_c = R$$

from $\sim f_r \rightarrow f_2$:

$$0 \rightarrow R$$

$\therefore X_L$ der. increases by $R/2$ x_C decreases by $R/2$
or $x_L\left(f_2\right) - x_L\left(f_r\right) = \frac{R}{2}$
or $2\pi L_{f_2} f_2 - 2\pi L_{f_r} f_r = R/2$
or $f_2 - f_r = \frac{R}{4\pi L} \Rightarrow f_2 = f_2 + \frac{R}{4\pi L}$ for lower cutorit.

$$x_2 f_r - x_L\left(f_Y\right) = R/2$$

es.

$$\begin{aligned} f_2 - f_1 &= \frac{R}{4\pi L} \\ f_1 &= f_\gamma - \frac{R}{4\pi L} \end{aligned}$$

$\therefore \beta = f_2 - f_1 = \frac{R}{2\pi L} \leftarrow$ bandwidth

$$\text{or } \frac{f_r}{r_r} \cdot (-) \quad \frac{R}{2\pi L f_v} \cdot f_- = \frac{f_v}{Q} = \beta \quad \frac{2\pi f_r L}{R} = Q$$

$f = \sqrt{f_1 f_2}$

$$x_L - x_c = R \quad \text{(e eatsff)}$$

for $f_1 =$

$x_L - x_C = -R$
$\omega_1 L - \frac{1}{\omega_1 c} = -R \Rightarrow \omega_1 / L \quad \omega_1^2 + \frac{R}{L}\omega_1 - \frac{L}{LC} = 0$
$R \to \Gamma /$

$$\Rightarrow \omega_1 = \frac{-\frac{R}{L} \pm \sqrt{\left(\frac{R}{L}\right)^2 + \frac{4L}{LC}}}{2}$$

$=$

$$= -\frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}} = -\frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{C_2^2}{r}}$$

In the sarre lug for f_2 :

$$\omega_2 L - \frac{1}{\omega_2 C} = R \Rightarrow \omega_2^2 - \frac{R}{L}\omega_2 - \frac{1}{LC} = 0$$
$$\Rightarrow \omega_2 = \frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 \to -\frac{1}{LC}}$$
$$= \frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 - \omega_r^2}$$

$$\omega_1 \omega_2 = \left(\frac{R}{2L}\right)^2 + \omega_r^2 - \left(\frac{R}{2L}\right)^2 = \omega_r^2 \Rightarrow \omega_r = \sqrt{\omega_1 \omega_2}$$
$$\therefore \quad f_r = \sqrt{f_1 f_2}$$

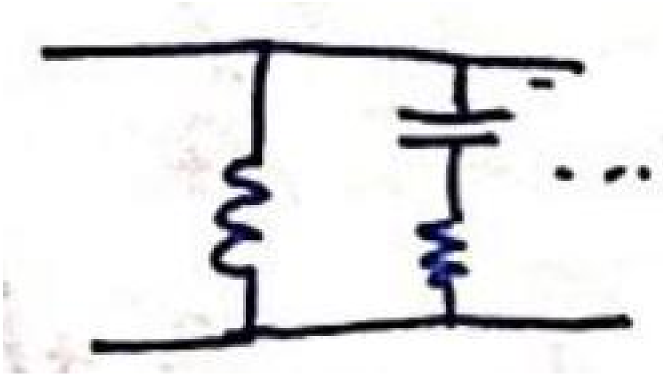
1. A series RLC circuit bos $R = 5\Omega, L = 0 \cdot 2H, C = 50\mu F$. The for unity powr-factor. $I_1(y) = I_2(y)$ applied voltage is 200 V. find resonant frequency, Q-facter. $\beta, f_1 \& f_2, I_r, I_{f_1, f_2}), V_L(f_r)$.

☒)

$$f_r = \frac{1}{2\sqrt{Lc}} =$$
$$x_C = \frac{1}{2 - \pi f C}$$
$$Q = \frac{x_c}{R} = \frac{63.3}{5} = 12.65$$
$$= 63.3\Omega$$
$$\beta = \frac{f_r}{Q} = \frac{3.97 \text{ Hz}}{48.3 \mathrm{H}_2}$$
$$f_1 = f_r - B_2 =$$
$$I_{f_2} = I_{f_1} = \frac{V}{2} = \frac{V}{R\sqrt{2}} = \frac{200}{5\sqrt{2}} = 28.28 = \frac{I_r}{\sqrt{2}}$$
$$V_L(f_r) = I_{f_r} \cdot X_L = \frac{V}{R} \times 2\pi f_r \times L = 2528 \text{ V}$$
$$= 6 \times 2$$
$$I_r = \frac{v}{R} = \frac{200}{5} = 40\theta$$

Parallel AC circut

- equivatent inpedeno masw

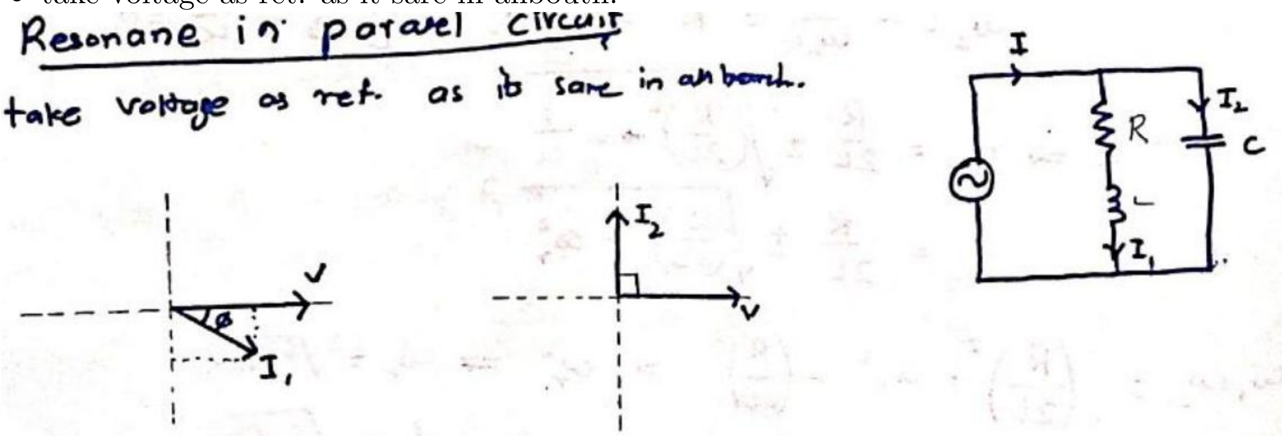


+admidance

$$z_{nd} = Z_1 \| z_2 \| \cdots \quad z_n = \sqrt{\cdots}$$

Resonane in pararel circuit

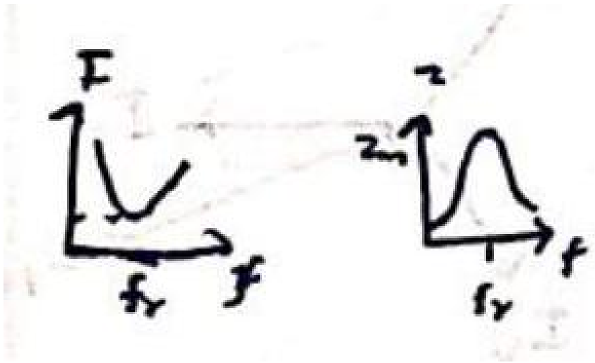
- take voltage as ret. as it sare in anbouth.



$$\begin{aligned}
&\therefore I_1(y) = I_1 \sin(\phi), I_2(y) = I_2 \\
&\therefore I_1 \sin(\phi) = I_2 \\
&\frac{V}{Z_4}\frac{x_L}{Z_1} = \frac{V}{x_c} \Rightarrow \frac{x_L}{Z_1^2} = \frac{1}{x_c} \\
&= \frac{x_L}{R^2 + x_L^2} = \frac{1}{x_c} \Rightarrow x_c x_2 = R^2 + x_L^2 \\
&= \frac{1}{\omega C} \cdot \omega L = \underline{\frac{L}{C} = R^2 + \omega^2 L^2} \Rightarrow 2\pi f_V = \sqrt{\frac{L'}{LC} - \left(\frac{R}{L}\right)^2} \\
&f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \left(\frac{R}{L}\right)^2}
\end{aligned}$$

if $R \gg\ll L, \quad f_r = \frac{1}{2\pi}\sqrt{\frac{1}{L}}$
Curment
at resonance: $I_L \sin(p) = I_L$

$$\therefore J_r = I_K \cos(\phi)$$
$$\frac{v}{z_r} = \frac{v}{z_L} \cdot \frac{R}{z_Z} \Rightarrow z_r = \frac{z_L^2}{R} \quad z_L = \sqrt{L}/c$$
$$Z_r = \frac{L}{CR} < \text{ gurely resistive}$$



at resonace, I is min. z is max.
Q-factor
$Q = \frac{I_c}{I_r}$ Turrent multiplicatia foctor

$$= \frac{v}{x_c} / \frac{v}{Z_r} = \frac{Z_r}{x_c} = \frac{L}{CR} \cdot C\omega = \omega \cdot \frac{L}{R}$$

Bandwidth

$$\beta = f_2 - f_1$$