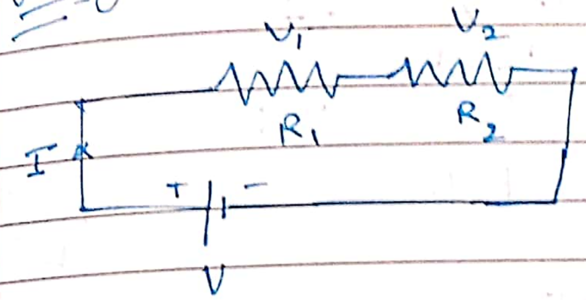
$V = V_1 + V_2$ $R = R_1 + R_2$

$V = IR$

$V = I(R_1+R_2)$ $\frac{V_1}{R_1}$

$V_1 = \frac{V R_1}{R_1+R_2}$

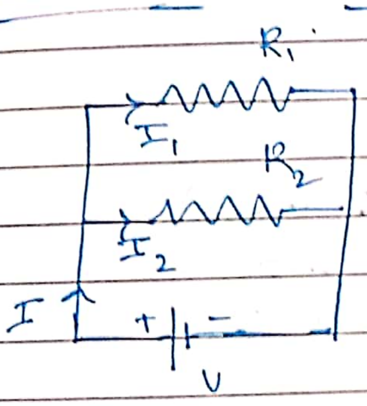
* Votage Division



$$V_1 = \frac{R_1}{(R_1+R_2)} V$$

$$V_2 = \frac{R_2}{(R_1+R_2)} V$$

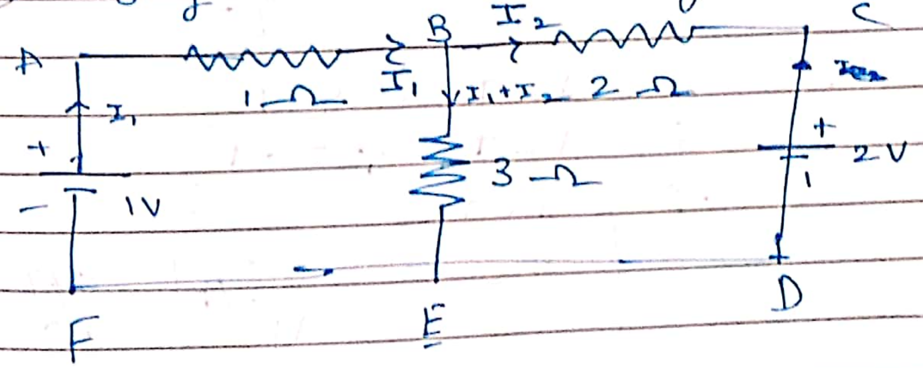
* Current Division



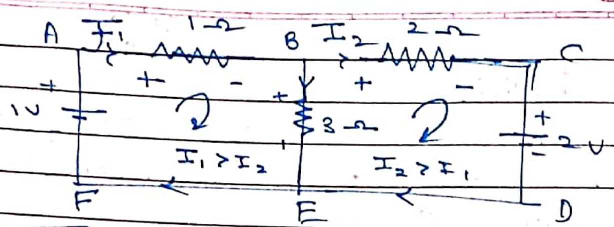
$$I_1 = \frac{R_2}{(R_1+R_2)} I$$

$$I_2 = \frac{R_1}{R_1+R_2} I$$

Q. Find current in 3 Ω resistance
(a) Using KVL (b) using KCL

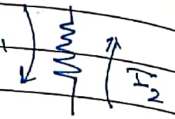


→



(a)

In loop ABEFA



$+1 - I_1 - 3(I_1 - I_2) = 0$

$1 = I_1 + 3I_1 - 3I_2$

$1 = 4I_1 - 3I_2$ —— (1)

$I = (I_1 - I_2)$

$I = (I_2 - I_1)$

In loop BCDEB

$-2I_2 - 2 - 3(I_2 - I_1) = 0$

$\therefore -5I_2 + 3I_1 = 2$ —— (2)

solving (1) & (2)

$\cancel{3 = 12I_1 - 9I_2}$

$\cancel{8 = -12I_1 + 4I_2}$

$\cancel{11 = -5I_2}$

$\cancel{I_2 = -\frac{11}{5}}$

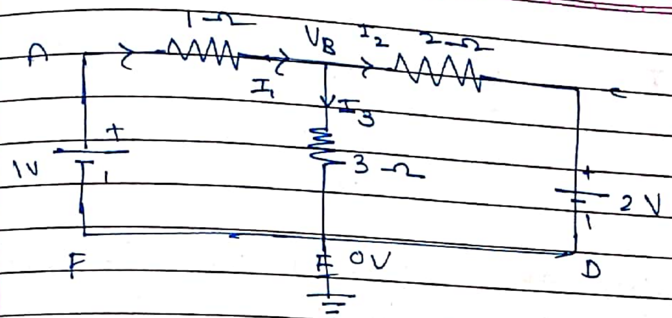
$\therefore 3 = 12I_1 - 9I_2$

$8 = -12I_1 + 20I_2$

$-5 = 11I_2$

$\boxed{I_2 = -\frac{5}{11}A}$ oppo directn of B to C

$\therefore \boxed{I_1 = \frac{-1}{11}A}$ A to B



$I_1 - I_2 - I_3 = 0$ --- Applying KCl to node B

$I_1 = I_2 + I_3$ → High potential — low Potential / Resistance

$I_1 = \frac{V}{R} = \frac{1 - V_B}{1\Omega}$

$I_2 = \frac{V}{R} = \frac{V_B - 2}{2}$

$I_3 = \frac{V_B}{3}$

$\frac{1 - V_B}{1} = \frac{V_B - 2}{2} + \frac{V_B}{3}$

$6 - 6V_B = 3V_B - 6 + 2V_B$

$\therefore 6 + 6 = 11V_B$

$\frac{12}{11} = V_B$

$\boxed{V_B = 1.09\ V}$

$I_1 = \frac{1 - 1.09}{1} = -0.09A$

$I_2 = \frac{1.09 - 2}{2} = -0.455A$

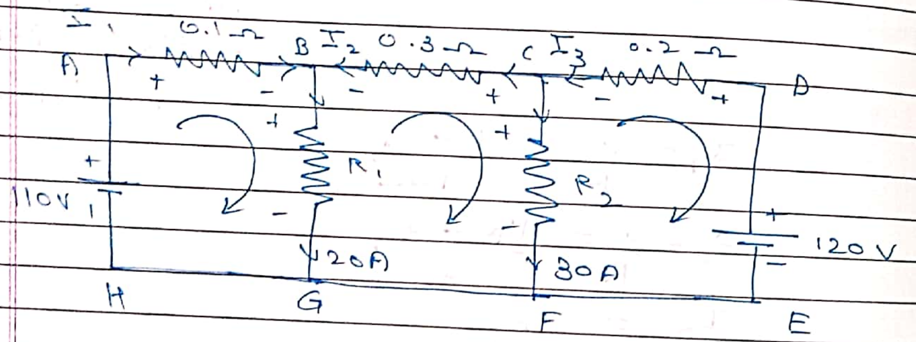
$I_3 = \frac{V_D}{3} = 0.363\ A$ (B to A]

is current through 3Ω resister.

Q. Solve the network for following

(a) Unknown resistance R_1 & R_2

(b) Unknown current in variance branches



→ Apply KCl to node B & C

$\cancel{I_1 = \frac{110 - V_B}{0.1\Omega}}$ $\therefore\ I_1 + I_2 = 20$ — (1)

$I_3 - I_2 = 30$ — (2)

Apply KVL to loop ABGHA

$110 - 0.1 I_1 - 20 R_1 = 0$

$0.1 I_1 + 20 R_1 = 110$ — (3)

Apply KVL to loop BCFGB

$\therefore\ 0.3 I_2 - 30 R_2 + 20 R_1 = 0$

$\therefore\ 0.3 I_2 + 20 R_1 = 30 R_2$ — (4)

Apply KVL to CDEFC

$\therefore\ 0.2 I_3 - 120 + 30 R_2 = 0$

$\therefore\ 0.2 I_3 + 30 R_2 = 120$ — (5)

Put $30 R_2 = 120 - 0.2 I_3$ in (4)

$0.3 I_2 + 20 R_1 = 120 - 0.2 I_3$

$0.3 I_2 + 0.2 I_3 = 120 - 20 R_1$

from (1) $20 R_1 = 110 - 0.1 I_1$

$\therefore\ 0.3 I_2 + 0.2 I_3 = 120 - 110 + 0.1 I_1$

$\therefore\ 0.3 I_2 + 0.2 I_3 - 0.1 I_1 = 10$

$\therefore\ 3 I_2 + 2 I_3 - I_1 = 100$

$60 - 3 I_1 + 2 I_3 - I_1 = 100$

$\cancel{-3 I_1 + 2}$

$-4 I_1 + 2 I_3 = 40$

$30 + I_2$

$-4 I_1 + 60 + 2 I_2 = 40$

$-4(20 - I_2) + 60 + 2 I_2 = 40$

$-80 + 4 I_2 + 60 + 2 I_2 = 40$

$6 I_2 = 60$

$\boxed{I_2 = 10\ A}$

$\boxed{I_1 = 10\ A}$ $\therefore$ $\boxed{I_3 = 40\ A}$

$0.1 I_1 + 20R_1 = 110$

$1 + 20R_1 = 110$

$\boxed{R_1 = 5.45\ \Omega}$

$0.3 \times 10 + 20 \times 5.45 = 30R_2$

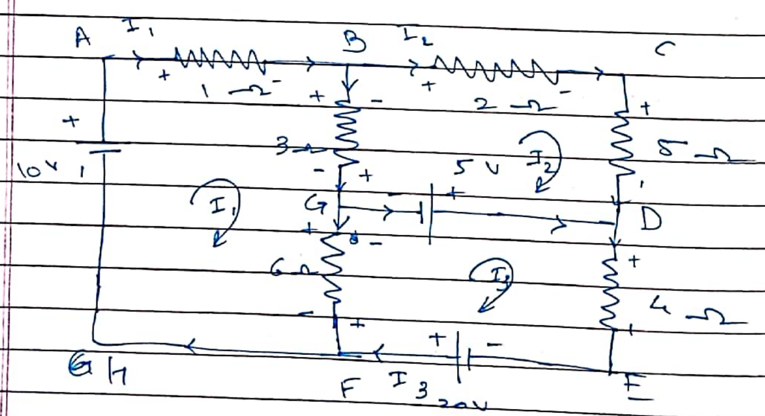
$\therefore\ R_2 = \cancel{\frac{3 + 1800}{30}}\quad \frac{30 + 109}{30}$

$= \cancel{\frac{1803}{30}}$

$\cancel{\boxed{R_2 = 60.1\ \Omega}}$

$\boxed{R_2 = 3.733\ \Omega}$

Q Find current in $5\ \Omega$ & $6\ \Omega$ resistor using KVL



Apply KVL to ABGFHA

$\therefore\ -1I_1 - 3(I_1 - I_2) - 6(I_1 - I_3) + 10 = 0$

$\therefore\ 10 = I_1 + 3I_1 - 3I_2 + 6I_1 - 6I_3$

$10 = 10I_1 - 3I_2 - 6I_3 \quad \text{— (1)}$

Apply KVL to BCDGB

$-2I_2 - 5I_2 - 5 - 3(I_2 - I_1) = 0$

$2I_2 + 5I_2 + 5 + 3I_2 - 3I_1 = 0$

$\therefore\ 10I_2 - 3I_1 = -5$

$3I_1 - 10I_2 = 5 \quad \text{— (2)}$

Apply KVL to GDEFG

$5 - 4I_3 + 20 - 6(I_3 - I_1) = 0$

$\therefore\ 25 - 4I_3 - 6I_3 + 6I_1 = 0$

$\therefore\ 25 = 10I_3 - 6I_1 \quad \text{— (3)}$

From (1) & (2) & (3)

$\cancel{I_1 = 5 + 10I_2}\quad I_2 = \frac{3I_1 - 5}{10}$

$I_3 = \frac{25 + 6I_1}{10}$ in (1)

$10 = 10I_1 - 3\left(\frac{3I_1 - 5}{10}\right) - 6\left(\frac{25 + 6I_1}{10}\right)$

$$10 = 10I_1 - \frac{9I_1 + 15}{10} - \frac{75 - 18I_1}{5}$$

$$100 = 100I_1 - 9I_1 + 15 - 150 - 36I_1$$

$$\therefore 250 - 15 = 100I_1 - 45I_1$$

$$235 = 55I_1$$

$$\boxed{I_1 = 4.27\ A}$$

Put in (2)

$$\therefore 3 \times 4.27 - 10I_2 = 5$$

$$\frac{3 \times 4.27 - 5}{10} = I_2$$

$$\boxed{I_2 = 0.781\ A}$$

Put in (3)

$$I_3 = \frac{25 + 6 \times 4.27}{10}$$

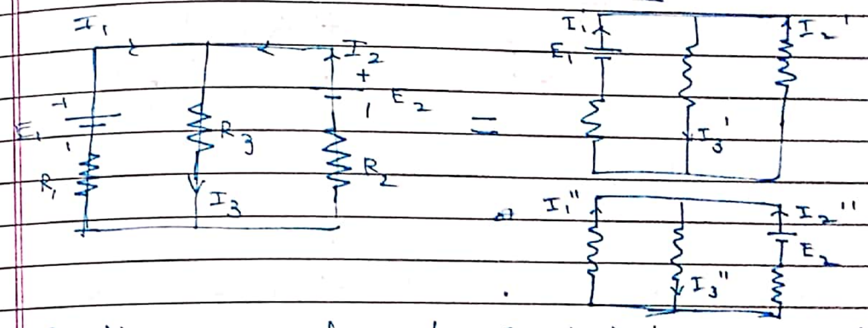
$$\boxed{I_3 = 5.062\ A}$$

$$I \text{ from } 6\Omega = I_1 - I_3 = 4.27 - 5.06$$

$$= -0.79A$$

$$= 0.79A \text{ from F to G}$$

* Superposition Theorem :-

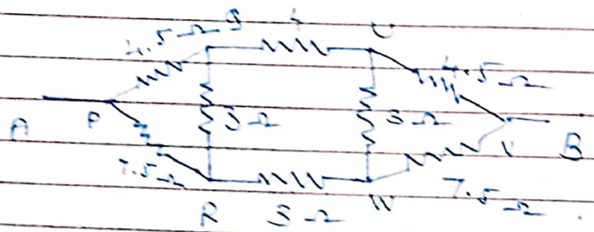


A linear network containing more than one source of emf resultant current in any branch algebraic sum of the currents that would have been produced by each source of emf taken separately (with all other sources of emf being replaced by their respective internal resistance)

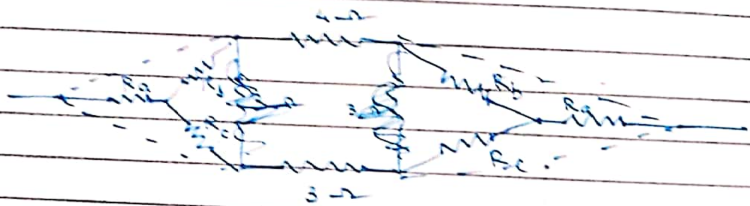
* Thevenin's Theorem :-

Any two terminals of network can be replaced by an equivalent voltage source and equivalent series resistance. A voltage source is voltage across two terminals with load removed. Series resistance is the resistance of network mesured between two terminals with load removed and constant voltage sources being replaced by that internal resistance.

Q.1 Find an equivalent resistance betⁿ A & B



Convert ΔPQR & ΔUVW in star

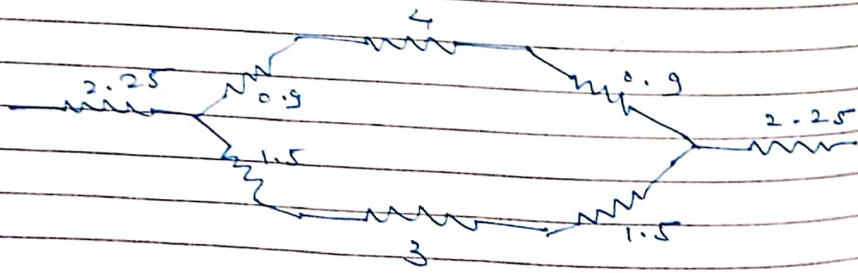


$R_a = \frac{4.5 \times 7.5}{4.5+7.5+3} = \frac{4.5 \times 7.5}{15}$

$= 2.25\ \Omega$

$R_b = \frac{4.5 \times 3}{15} = 0.9\ \Omega$

$R_c = \frac{7.5 \times 3}{15} = 1.5\ \Omega$



$0.9 + 4 + 0.9 = 5.8$

$1.5 + 3 + 1.5 = 6$

$6 \parallel 4$

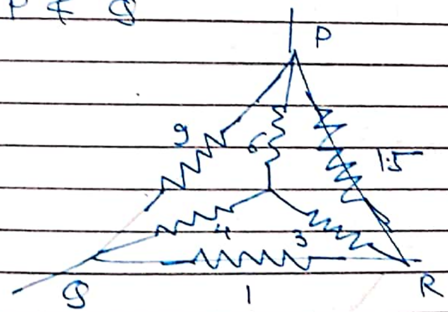
$\therefore \frac{1}{4} + \frac{1}{6}$

$\frac{10}{24} = 2.4$

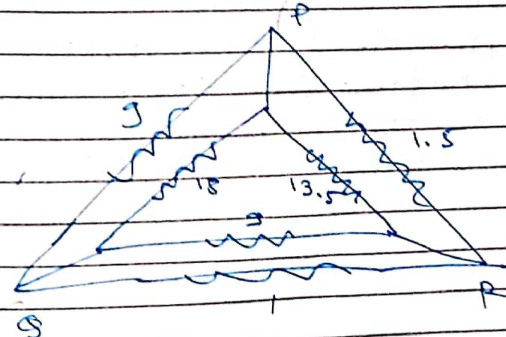
$2.25 + 2.25 + 2.4$

$= 6.9$

Q.2] Find equivalent resistance betⁿ P & Q



→



$\frac{1}{18} + \frac{2}{18}$

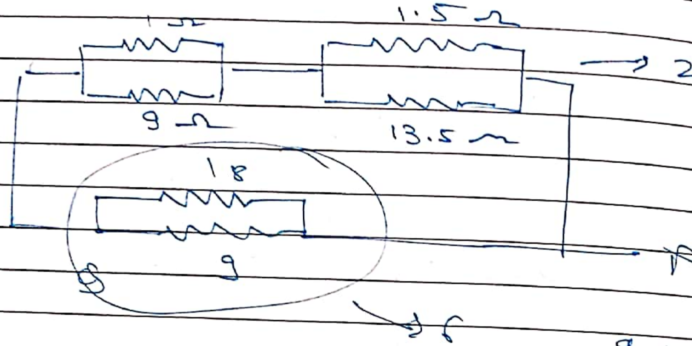
$2.5 \parallel 22.5$

2

2.25

Ans = 1.63

it is similar to



→ 2.25

$\frac{1}{1.5} + \frac{1}{13.5}$

$\frac{9}{9} + \frac{1}{9}$

$\frac{9}{10}$

$0.9 + 1.35$

2.25

~~= 8.25 Ω~~

$= \frac{1}{6} + \frac{1}{2.25}$

$= 1.6363$

* Magnetic circuits :-

i) Magnetic flux (ϕ)
ii) magn. flux density (B)
iii) magn. field strength (H)
iv) magnetomotive force (mmf)
v) Absolute permeability (μ)
vi) Reluctance (S)

* ~~Magne~~

· ~~Electric ckt~~

1) Magnetic flux = imaginary lines indicate direction of magnetic field is called magnetic flux, unit (wb)

2) Magnetic flux passing through unit cross sectional area of magnetic ckt which is ⊥ to area $B = \phi/A$

3) It is defined as mmf required to circulate flux through unit length (AT/m) $\frac{NI}{l}$, $H = mmf/l$

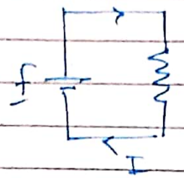
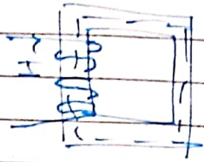
4) It is force which circulates magnetic flux in the magnetic ckt (A.Turns)
$I \cdot N$

5) It is ratio of magnetic flux density to magn. field strength
$\mu = \frac{B}{H}$, $\mu = \mu_0 \mu_r$

6) It is opposition of magnetic ckt to passage of magn. flux through it.
(A.T/wb) $\frac{B}{H}$

$S = \frac{mmf}{\phi}$

Similarities

Elec ckt	Magn. ckt
1)  $E = IR$	 $F = I.N$, mmf $= \phi . S$
2) Emf in volt	2) mmf in AT
3) Resis in Ω	3) Reluctance in AT/wb
4) $R = \frac{\rho l}{A} = \frac{E}{I}$	4) $S = \frac{l}{\mu A} = \frac{mmf}{\phi}$
5) current +ve to -ve	5) Flux = N pole to S. pole

Differce

* Heat, power & energy.

Relation betn elec. & mech. energy.

$1 KWh = 1000 W \times 3600 sec$

$= 3.6$ M joules

Relation betn thermal & mech energy

$$\text{Heat (cal)} = \frac{\text{mech energy}}{\text{mech equivalent of heat (J)}}$$

1 cal = 4.187 Joul of mech. work

Relation betn electric & thermal energy

$J = 4.187$ joules/cal

$1 KWh = 3.6 \times 10^6$ joules

$= \frac{3.6 \times 10^6}{c}$ Kal

$1 KWh = 860 \times 10^3$ cal

Heat $= m s \Delta\theta$

1 cal $= 4.187$ Joul

elec. power $= I^2 R = \frac{V^2}{R}$

elec energy $= VIt = I^2 R t = \frac{V^2}{R} t$

* An electric heater consist of 4 lit of water with initial temp of 15°c Now 0.25 KWh heat is supplied to water by heater assuming no loses calculate final temp of water

→ $Q = m s \Delta\theta$

$\therefore 0.25 = \rho \times V \times s \times (T_2 - 15)$

$\therefore 0.25 = 1000 \times 4 \times 10^{-3} \times 1 \times (T_2 - 15)$

$\therefore 0.25 = 4 (T_2 - 15)$ Kcal

$1 Kwh = 860 \times 10^3$ cal

$\therefore 0.25 \times 860 = 215$ Kcal

$\therefore 215 = 4 (T_2 - 15)$

$T_2 = 68.75°c$

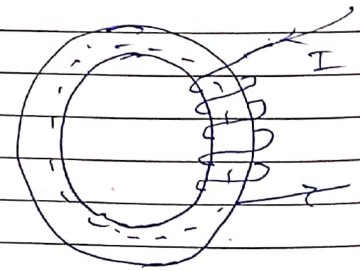
* A heater takes 1 hour to heat 50 kg of H_2O from 20°c to Boiling point calculate elect. energy in KWh & power rating

→ $Q = ms\Delta\theta$
$= 50 \times 1 \times (100-20)$
$Q = 4000$ K cal
$Q = \frac{4000 \text{ K cal}}{860 \times 10^3 \text{ cal}}$
$Q = 4.65$ KWh (Elec. energy)

power rating $= \frac{E}{t} = \frac{4.65 \text{ KWh}}{1 \text{ hr}} = 4.65$ KW

*

$mmf = IN$
$S = \frac{mmf}{\phi} = \frac{l}{\mu A}$

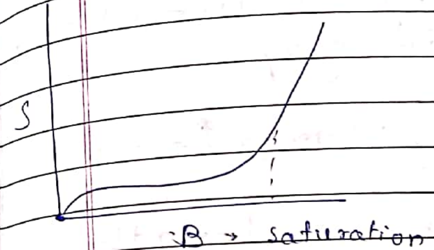


$H = \frac{NI}{l}$
$B = \mu_0 \mu_r H$
$B = \mu_0 \mu_r \frac{NI}{l}$

$\phi = BA = \frac{\mu_0 \mu_r NI A}{l} = \frac{NI}{(l/\mu_0 \mu_r A)}$
$= \frac{NI}{S} = \frac{mmf}{S}$

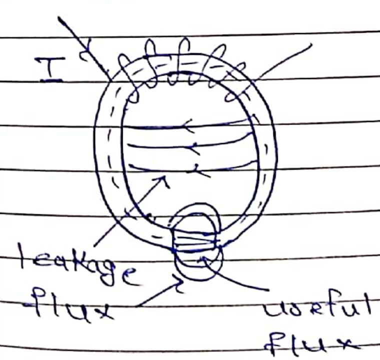
* Magnetic saturation :-

– mmf ↑ = B ↑



– limit for increase in B in magnetic ~~field~~ core
– Higher reluctance for iron.
– Beyond limit, no good conductor of flux.
– so more mmf to develope flux in core

* Magnetic leakage flux :-

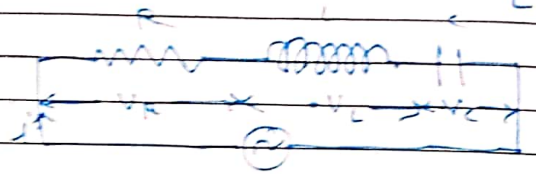


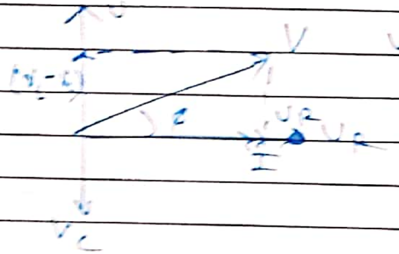
– Follows a path not intended for it
– The passage of magn. flux outside the path along which it can do useful work useful flux.

$\text{Leakage flux} = \frac{\text{Total (leak + useful) flux}}{\text{Useful flux}}$

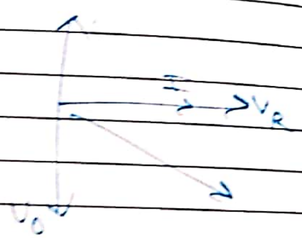
R-L-C Series

i) $V_L > V_C$
ii) $V_L < V_C$
iii) $V_L = V_C$

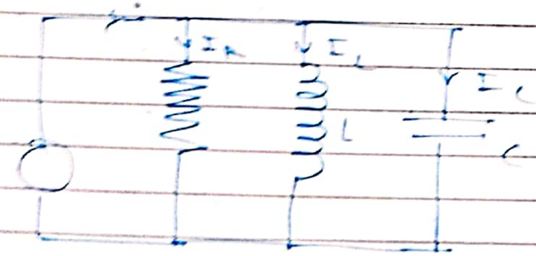




$V_L > V_C$

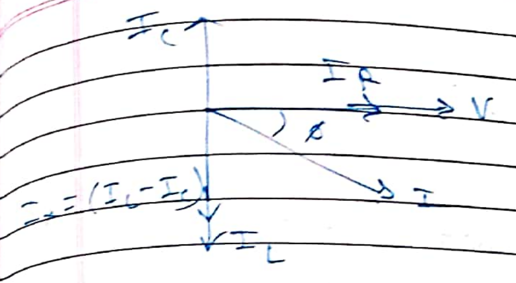


* Parallel RLC ckt



$I_R = \frac{V}{R}$, $I_L = \frac{V}{X_L}$, $I_C = \frac{V}{X_C}$

$V_R = V_L = V_C = V$ (supply voltage)



$$\bar{I}_x = \bar{I}_L - \bar{I}_C$$
$$= \frac{V}{X_L} - \frac{V}{X_C}$$
$$= V\left(\frac{1}{X_L} - \frac{1}{X_C}\right) = \frac{V}{X}$$

$$I = I_R + j(|I_L - I_C|)$$

where $|I_L - I_C| = I_x$

$$I = \sqrt{I_R^2 + I_x^2} = \sqrt{\frac{V^2}{R^2} + \frac{V^2}{X^2}} = \frac{V}{Z}$$

1) Two sinusoidal currents are given as $I_1 = 10\sqrt{2}\sin\omega t$ & $I_2 = 20\sqrt{2}\sin(\omega t + 60)$ Find expression for sum of these currents

→ $I_{m_1} = 10\sqrt{2}$, $I_{m_2} = 20\sqrt{2}$ A

Rms value of $i_1 = I_{rms_1} = 10$ at $\angle 0°$
Rms value of $i_2 = I_{rms_2} = 20$ at $\angle 60°$

$$I = (10\angle 0) + (20\angle 60°)$$
$$= (10 + j(0)) + (10 + j(17.32))$$
$$= 20 + (17.32)j$$
$$= (26.457), \theta = 40.8°)$$

$I_m = I_{rms} \times \sqrt{2}$

$= 26.457 \times \sqrt{2}$

$I_m = 37.41$

$I = 37.41 \sin(\omega t + 40.8°)$

	Polar	Rectangular
1)	$5 + 10j$	$r = 11.18$, $\theta = 63.43$
2)	$22\angle 36.86°$	$x = 17.6$, $y = 13.19$ $17.6 + 13.19j$
3)	pol(5, 10)	$\cancel{=}$ $70.17\angle 85.9$

Multiplication in polar form

$A = (10\angle 20)$, $B = (30\angle 80)$

$A \times B = (10 \times 30)\angle(20 + 80)$

$A / B = \left(\frac{10}{30}\angle 20 - 80\right)$

Q 4) $v = 20\sin(100\pi t)$ V $2\pi f = 100\pi$

$I = 7\sin(100\pi t + 60°)$ A

Find i) Avg Value of vtg & current
ii) Rms of vtg & current
iii) Impedence
iv) Power factor
v) Active power
vi) freq

$V_{avg} = \frac{2V_m}{\pi} = \frac{40}{\pi} = 12.73$ V

$I_{avg} = \frac{2I_m}{\pi} = \frac{2 \times 7}{\pi} = 4.456$ V

$V_{rms} = \frac{V_m}{\sqrt{2}} = \cancel{28.28} \; 14.14$

$I_{rms} = \frac{I_m}{\sqrt{2}} = 4.9504$

$|Impedence| = \frac{V_m}{I_m} = \frac{20}{7} = 2.85714\ \Omega$

Power factor $= \cos\phi = \cos 60$

$= 0.5$ (lead)

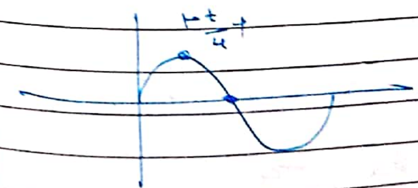
freq $= \cancel{2\pi} n = 50$

Active power $= V_{rms} \times I_{rms} \cos\phi$

$= 69.998 \times \frac{1}{2}$

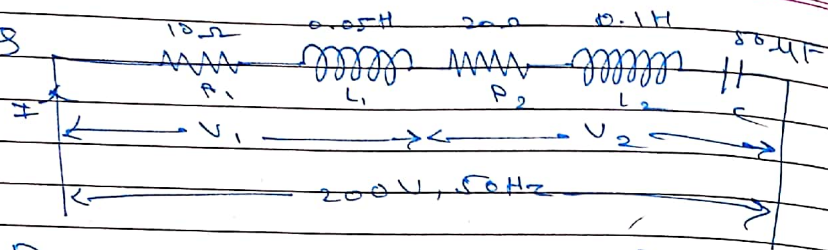
$= 34.99$ W

* Time taken betn max value & next zero value



$t = \frac{1}{50}$

$\frac{t}{4} = \frac{1}{200} = 0.005$

Q.2) Q 

Draw vector diagram for ckt shown indicating terminal vtg V_1, V_2 & current also calculate current through ckt V_1 & V_2 & power factor

→ $X_L = 2\pi n L$

$X_{L_1} = 2\pi \times 50 \times 0.05$

$X_{L_1} = 15.7\ \Omega$

$X_{L_2} = 31.4\ \Omega$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

$X_C = 63.69\ \Omega$

$R_1 = 10\ \Omega$, $R_2 = 20\ \Omega$

$Z = \frac{V}{I}$ $\therefore I = \frac{V}{Z}$

For this ckt

$Z = R_1 + R_2 + jX_{L_1} + jX_{L_2} - jX_C$

$Z = 30 + j(-16.59)$

$Z = 30 - j(16.59)$

$I = \frac{V}{Z} = \frac{200\angle 0}{34.28\angle -28.9}$

$= 5.834\angle(+28.9^\circ)$ A

$Z_1 = R_1 + jX_{L_1}$

$V_1 = I Z_1 = I(R_1 + jX_{L_1})$

$= 5.834\angle 28.9^\circ (10 + j(15.71))$

$= 5.834\angle 28.9^\circ \times 18.62\angle 57.52$

$= 108.629\angle 86.42$

$Z_2 = R_2 + j(X_{L_2} - X_C)$

$= 20 + j(-32.29)$

$= 20 - 32.29j$

$V_2 = I Z_2$

$= 5.834\angle 28.9^\circ \times (20 - 32.29j)$

$= 5.834\angle 28.9^\circ \times 37.98\angle -58.2$

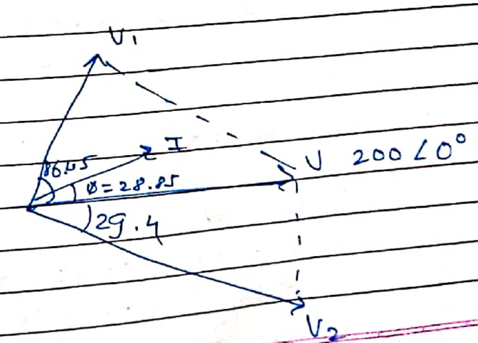
$= 221.57\angle -29.3$

Power factor $= \cos\phi$

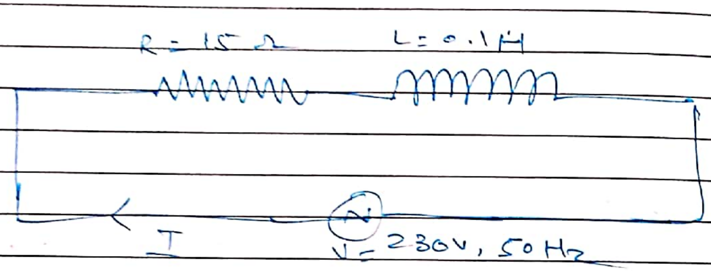
$= \cos(28.9)$

$= 0.875$ W current is leading

Vector diagram



Q.3 A reactor having negligible resistance, inductance of 0.1 H is connected in series with resistor of 15 ohm. The circuit is connected across 230V, 50Hz single phase AC supply calculate i) current in ckt ii) power factor iii) vtg a/c resistor & reactor



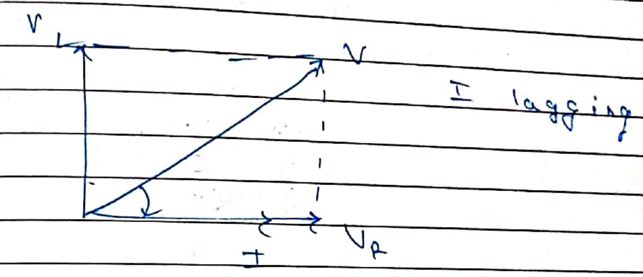
$X_L = 2\pi f L$
$= 2\pi \times 50 \times 0.1$
$= 31.4$
$R = 15\,\Omega$
$Z = 15 + 31.4j$
$V = 230V \angle 0^\circ$
$I = \frac{V}{Z} = \frac{230 \angle 0^\circ}{34.79 \angle 64.4}$
$I = 6.611 \angle -64.4$
$-ve$ = lagging

Power factor $= \cos(64.4)$
$= 0.4320$

$V_L = I \times X_L$
$= 6.611 \angle -64.4 \times (0 + j(X_L))$
$= 6.611 \angle -64.4 \times (31.4j)$
$= (6.611 \angle -64.4) \times (31.4 \angle 90^\circ)$

$V_L = 207.58 \angle 25.6$

$V_R = I \times R$
$= (6.611 \angle -64.4) \times (15 \angle 0)$
$= 99.165 \angle -64.4$



H.W A capacitive reactance of 4 Ω is connected in series with resistor of 5 Ω. ~~A seri~~ this series ckt connected a/c 230V, 50 Hz calculate
i) capacitance, impedance, supply current, vtg drop a/c capacitor, resistor, power factor, reactive, active & apparent factor.

* phase values

1) voltage generated in each phase winding is called phase voltage
Ex. V_R, V_B

2) Current supplied by each phase is phase current. Ex. I_B

* Line value

1) line vtg = voltg available betn any two lines of system Ex. V_{BR}

2) line current = current passing through line Ex. I_B

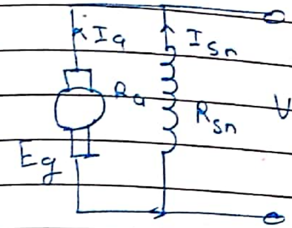
* In star connection
$I_{phase} = I_{line}$
$V_{line} = \sqrt{3}\, V_{phase}$

* In Delta connection
$V_{phase} = V_{line}$
$I_{line} = \sqrt{3}\, I_{phase}$

* $E_g = \dfrac{\phi Z N P}{60 A}$ E_b (generator)

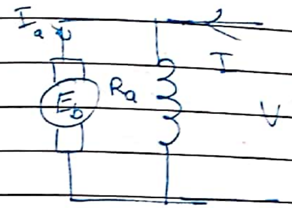
$E_b \propto \dfrac{N}{\phi}$

shunt gen.



$E_g = V + I_a R_a$ (Gen)

shunt motor



$E_b = V - I_a R_a$ (motor)
back emf

Q.1) A lap wound 4 poled DC shunt generateor having 80 slots with 10 conduc. per slot Generates at low load an emf of 400V when running at 1000 rpm. At what speed could it be rotated to generate voltage of 220V on open ckt.

→ Lap : $A = P$ (Pole) $E_g = 400$ V
wave : $A = 2$ $N = 1000$ rpm
$Z = 80 \times 10 = 800$
(no of conduc)

$E_{g_1} = \dfrac{\phi Z N \cancel{P}}{60 \cancel{A}}$ $(A = P)$

$400 = \dfrac{\phi \times 800 \times 1000}{60}$

$\boxed{\phi = 0.03 \text{ Wb}}$

E_{g_2} at 220 V

$E_{g_2} = 220\,V$

$E_{g_2} = \frac{\phi N_2 Z}{60}$

$N_2 = \frac{E_{g_2} \times 60}{\phi Z}$

$= \frac{60 \times 220}{0.03 \times 200}$

$N_2 = 550$ rpm

Q.2] A 200 volt DC shunt motor runs at 1000 rpm when armature current is 25 A. Armature resistance of motor is 0.5 Ω calculate speed of the motor at 10 A of armature current

→ $E_b = V - I_a R_a$

In shunt motor $E_b \propto \frac{N}{\phi}$

but ϕ is const.

$E_{b_1} = 200 - 25 \times 0.5$

$E_{b_1} = 187.5$ V

$E_{b_2} = 200 - 10 \times 0.5$

$E_{b_2} = 195$ V

$\frac{E_{b_1}}{E_{b_2}} = \frac{N_1}{N_2}$ $\therefore \frac{187.5}{195} = \frac{1000}{N_2}$

$\boxed{N_2 = 1040 \text{ rpm}}$

Transformer

A single phase 50 V transformer has 350 secondary turns & primary 30. Net cross sectional area is 250 cm². If primary winding is connected to 230 V, 50 Hz supply calculate

1. Peak value of flux density in core
2. Voltage induced in secondary winding
3. The primary current when secondary current is 100 A

→ $E_1 = 4.44 f B_m A N_1$

$f = 50$ Hz

$N_1 = 30$, $N_2 = 350$

$A = 250 \times 10^{-4}$ m²

$E_1 = 230$ V

$I_2 = 100$ A

(1) $B_m = \frac{E_1}{4.44 f A N_1}$

$= \frac{230}{4.44 \times 50 \times 250 \times 10^{-4} \times 30}$

$=$

(2) $\frac{E_1}{E_2} = \frac{N_1}{N_2}$

$\therefore E_2 = \frac{230 \times 350}{30}$

(3) $\frac{i_1}{i_2} = \frac{N_2}{N_1}$

$i_1 = \frac{30}{350} \times 100$

2] 200 KVA, 11KV/415V 50 Hz transformer has 80 turns in secondary. Calculate
(i) primary turns
(ii) Full load secondary current
(iii) Approx value of primary current. Consider transformer to be ideal

→ $V_1 = 11 KV$
$V_2 = 415 V$
$f = 50 Hz$
$N_2 = 80$
$P = 200 KVA$

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$N_1 = \frac{11 \times 10^3}{415} \times 80$$

$$\boxed{N_1 = 2120}$$

$$P = V_2 I_2$$

$$200 \times 10^3 = 415 I$$

$$\boxed{I_2 = 481.92 A}$$

$$P = V_1 I_1$$

$$200 \times 10^3 = 11 \times 10^3 \times I$$

$$\boxed{I_1 = 18.1818 A}$$

$$\eta = \frac{x KVA \cos\phi}{x KVA \cos\phi + P_i + x^2 P_{cu}} \times 100 \%$$

* Efficiency of X'mer

$$\% \eta = \frac{(x KVA \cos\phi)}{(x KVA \cos\phi) + x^2 P_i + P_{cu}} \times 100$$

$$= \frac{\frac{1}{x} \times (KVA\ rating) \times \cos\phi}{\left(\frac{1}{x} \times (KVA\ ratting) \times \cos\phi\right) + P_i + \frac{1}{x^2} P_{cu}}$$

(at full load)

x = % of load

$P_i \rightarrow V \rightarrow$ const. loss
$P_{cu} \rightarrow I \rightarrow$ variable loss

current is varriable so P_{cu} are variable as resistance changes

i] In 25KVA, 2000/200 V transformer The iron losses are 350 watt whereas cu losses are 400 watt at full load and calculate efficiency of p.transformer at unity power factor (1) full load (2) half load.

→ $V_1 = 2000$, $V_2 = 200$, $\cos\phi = 1$
$P = VI = 25 KVA$

(i) Full load, $x = 1$

$$\eta_{full} = \frac{KVA}{KVA + P_i + P_{cu}} = \frac{25 \times 10^3}{25000 + 350 + 400}$$

$$= 0.97087 \times 100$$

$$= 97.08$$

(2) half, $x = 0.5$

$$\eta = \frac{2 \times KVA}{2 KVA + P_i + 4P_{cu}}$$

$$= \frac{2 \times 25 \times 10^3}{2 \times 25 \times 10^3 + 250 + 4 \times 400}$$

$= 0.9624 \times 100$

2) A single phase transformer work at unity power factor has efficiency of 90% at both half load of full load of 500 watt. Determine the eff. at 75% of full load.

$KVA = 500$

→ $\frac{90}{100} = \frac{1 \times KVA \times 1}{KVA + P_i + P_{cu}}$

$$0.9 = \frac{KVA}{KVA + P_i + P_{cu}} \quad \text{— (1)}$$

$$0.9 = \frac{2 KVA}{2KVA + P_i + 4P_c}$$

$0.9(2KVA + P_i + 4P_c) = 2KVA$

$\eta_{FL} = 90\%$

output (FL) = 500W

Iron losses at X_{mer} = x W

copper losses at FL = y W

Total losses at FL = $x + y$

at FL

$$90 = \frac{500}{500 + x + y} \times 100$$

$0.9x + 0.9y = 50$ — (1)

at HL

Cu loss at Half load changes
Iron loss = const

$\therefore$ cu loss $= \left(\frac{1}{2}\right)^2 \times y = \frac{y}{4}$

η at HL = 90%.

o/p of X_{mer} at HL $= \frac{1}{2} 500 = 250$

=

$$\therefore 0.9 = \frac{250}{250 + x + \frac{y}{4}}$$

wrong

$\boxed{0.9x + 0.225y = 25}$ — (2)

$\frac{x}{2} < \frac{x}{2}$

$x/2$

$x = 2$

$$\eta_{75\%} = \frac{0.75 \times 500}{0.75 \times 500 \cos\phi +}$$

$$\boxed{\eta_{75\%} = 90.5\%}$$

3) A 10 KVA, 50 Hz 2300/230 V transformer has iron loss of 82.2 W at full load & copper loss of 150 watt at full load. It is supplying load having power factor of 0.8 lagging and rated voltage of 230 V. Find η of Xmer i) at full load ii) 60% of full load

→

$$\eta_{FL} = \frac{x\, KVA \cos\phi}{x KVA \cos\phi + P_i + x^2 P_{cu}}$$

@ 10 KVA = 10×10^3 VA = 10^4 watt

$$= \frac{1 \times 10^4 \times 0.8}{1 \times 10^4 \times 0.8 + 82.2 + 1 \times 150} \times 100$$

η_{FL} = 97.17 %

$$\eta_{60\%} = \frac{0.6 \times 10^4 \times 0.8}{0.6 \times 10^4 \times 0.8 + 82.2 + (0.6)^2 150}$$

= 97.24 %

4) A 400 KVA distribution Xmer has full load iron losses of 2.5 Kwatt & copper loss of 3.5 KW during day & night its load cycle for 24 hrs is as follow

6 Hrs :- 300 KW at 0.8 (lag)
10 Hrs :- 200 KW at 0.7 (lead)
4 Hrs :- 100 KW at 0.9 (lag)

Determine all day efficiency

→ Iron losses will be const through out the day

Energy spent due to iron losses for 24 hrs $= E_i = 2.5 \times 24$ KWh $= 60$ KWh

Energy o/p $= (300 \times 6) + (200 \times 10) + (100 \times 4)$
$= 4200$ KWhr

Energy spent due to Cu-loss
@ load 1 :- 300 KW at 0.8 pf lag

KVA supplied $= \frac{300}{0.8} = 375$ KVA

% x (loading) $= \frac{375}{400} \times 100 = 93.75\%$

$\therefore$ Cu loss for load 1 $= (0.9375)^2 \times 3.50 = 3.076$ KW

Energy spent on Cu loss for load 1 = 3.076×...
= 18.46 kWh

(b) load 2 : 200 kW, 0.7 pf load

$KVA = \frac{200}{0.7} = 285.71\ KVA$

17.85

$\%\ x = \frac{285.71}{400} \times 100 = 71.42\ \%$

Cu loss for load $= (0.7142)^2 \times 3.5$

$= 1.785$

Energy spent $= 1.785 \times 10 = 17.85$ kWh

(c) load 3 : 100 kW, 0.9 pf load

$KVA = \frac{100}{0.9} = 111.11$

$\%\ x = \frac{111.11}{400} \times 100 = 27.77$

Cu loss $= (0.2777)^2 \times 3.5$

$= 0.2700$

Energy $= 0.2700 \times 4 = 1.08$

* Total energy spent for copper loss $= 18.46 + 17.85 + 1.08$

(E_{cu}) 37.4 kWh

$E_{iron} = 60$ kWh

$\} \rightarrow 97.4$ kWh

E o/p = 4200 kWh

$\therefore \eta = \frac{4200}{4200 + 97.4} \times 100$

$= 97.7\ \%$