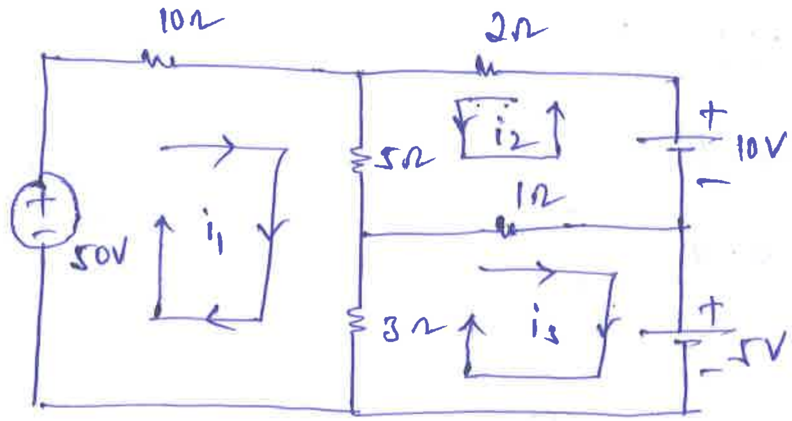
Branch : EEE

Date : 27/06/2025

Exam : I B.Tech, II SEM

Faculty : Dr. M. Krishna.

(1)



Determine the mesh current I_1.

Apply KVL to loop ①

$$-50 + 10i_1 + (i_1+i_2)5 + (i_1-i_3)3 = 0$$

$$18i_1 + 5i_2 - 3i_3 = 50 \quad \text{—— ①}$$

Apply KVL to loop ②

$$5(i_2+i_1) + 2i_2 - 10 + 1(i_2+i_3) = 0$$

$$5i_1 + 8i_2 + i_3 = 10 \quad \text{—— ②}$$

Apply KVL to loop ③

$$3(i_3-i_1) + (i_3+i_2)1 + 5 = 0$$

$$-3i_1 + i_2 + 4i_3 = -5 \quad \text{—— ③}$$

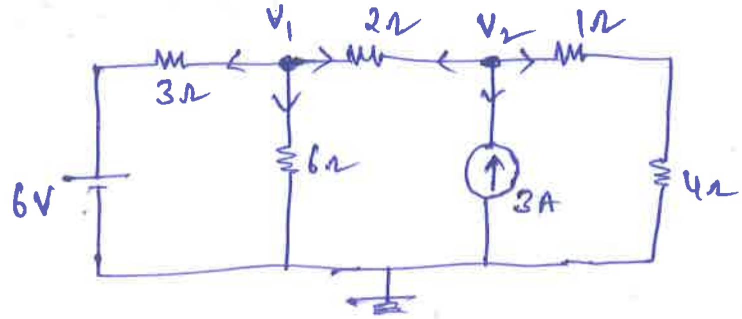
Solve eq ①, ② & ③

$$\boxed{I_1 = 3.3\,A}$$

$$i_2 = -0.99\,A$$

$$i_3 = 1.474\,A$$

1 (b) Find the voltage across the 4 Ω resistor



Apply KCL to node (1)

$$\frac{V_1 - 6}{3} + \frac{V_1}{6} + \frac{V_1 - V_2}{2} = 0$$

$$V_1 - 0.5V_2 = 2 \quad \text{---} (1)$$

Apply KCL to node (2)

$$\frac{V_2 - V_1}{2} - 3 + \frac{V_2}{5} = 0$$

$$-0.5V_1 + 0.7V_2 = 3 \quad \text{---} (2)$$

Solve eq (1) & (2)

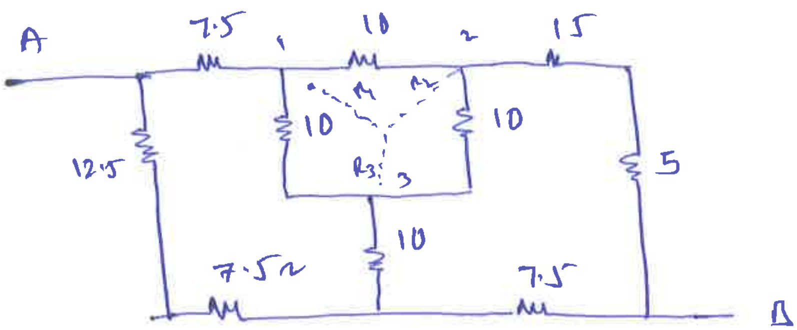
$$V_1 = 6.44\,V, \quad V_2 = 8.889\,V.$$

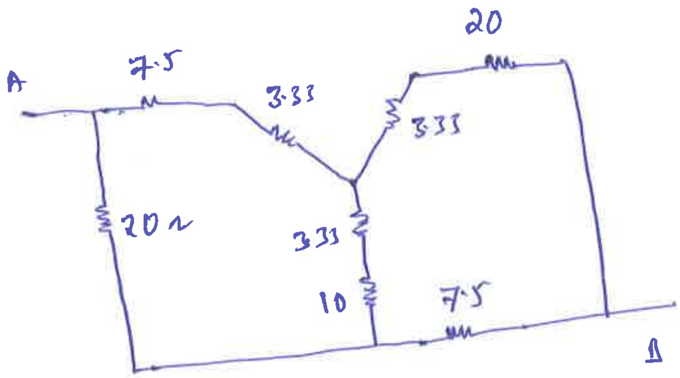
Voltage across 4Ω resistor

$$V_{4\Omega} = \frac{V_2}{5} \times 4 = \frac{8.889}{5} \times 4$$

$$\boxed{V_{4\Omega} = 7.11\,V}$$

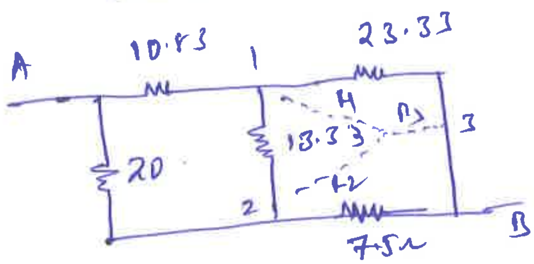
2 (a) Find the equivalent resistance b/w Terminal A & B





$$R_1 = R_2 = R_3 = \frac{10 \times 10}{10+10+10}$$

$$= 3.33\ \Omega$$



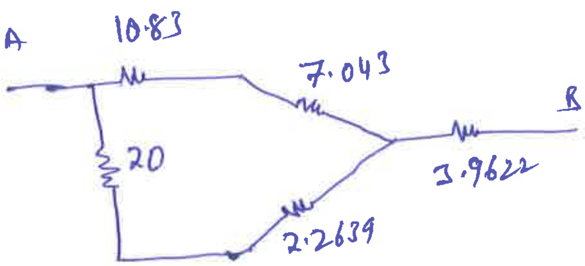
$$R_1 = \frac{23.33 \times 13.33}{23.33 + 13.33 + 7.5}$$

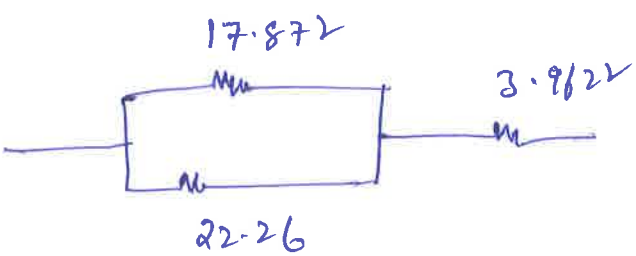
$$= 7.042\ \Omega$$

$$R_2 = \frac{13.33 \times 7.5}{23.33 + 13.33 + 7.5}$$

$$= 2.2639\ \Omega$$

$$R_3 = \frac{23.33 \times 7.5}{44.16} = 3.9622$$

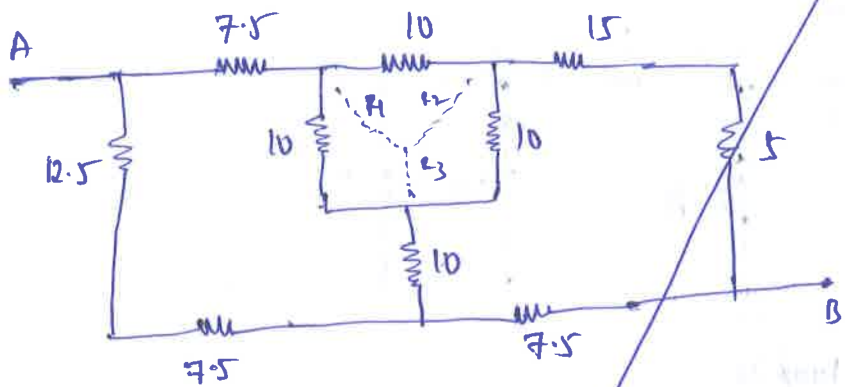




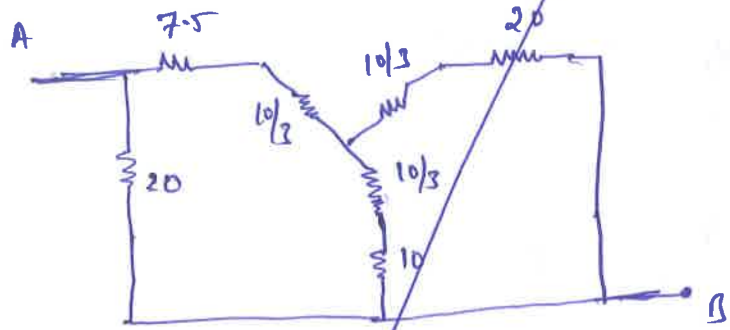
$$R = \frac{17.872 \times 22.26}{17.872 + 22.26}$$

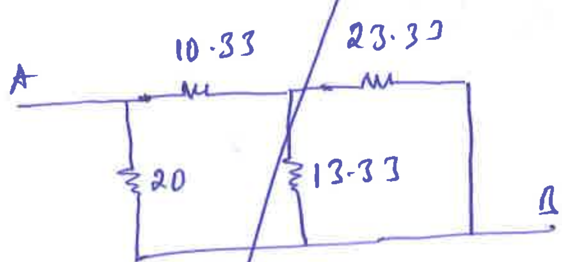
$$\therefore \boxed{R_{eq} = 13.87\ \Omega}$$

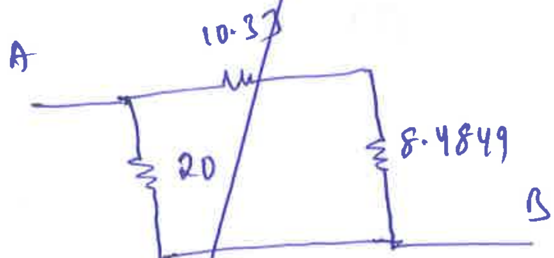
2 (a) Find the equivalent resistance b/w terminal A & B

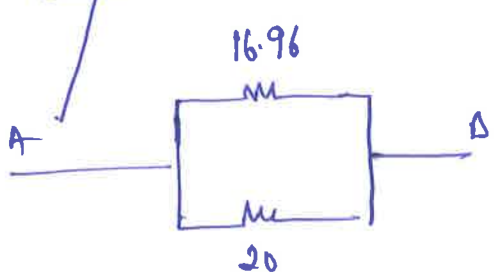


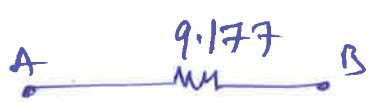
$$R_1 = R_2 = R_3 = \frac{10 \times 10}{10+10+10} = 10/3$$





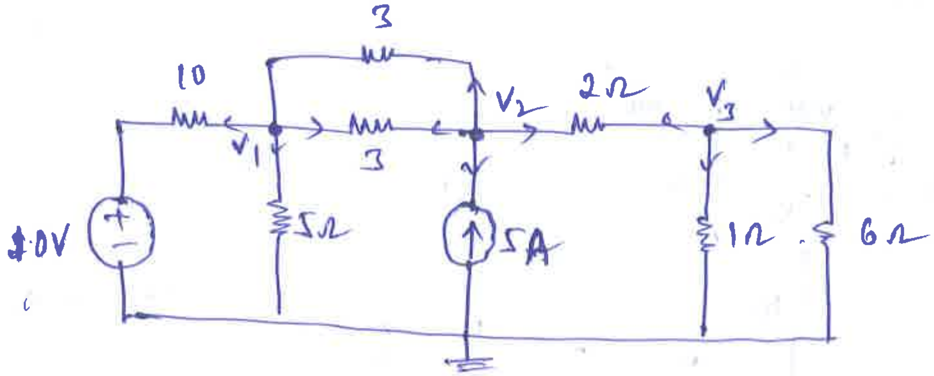






$R_{eq} = 9.177\,\Omega$

Determine the voltages at each node.



Apply KCL to Node ①

$$\frac{V_1-10}{10}+\frac{V_1}{5}+\frac{V_1-V_2}{3}+\frac{V_1-V_2}{3}=0$$

$$0.966V_1-0.666V_2=1 \quad —— ①$$

Apply KCL to Node ②:

$$\frac{V_2-V_1}{3}+\frac{V_2-V_1}{3}-5+\frac{V_2-V_3}{2}=0$$

$$-0.666V_1+1.166V_2-0.5V_3=5 \quad —— ②$$

Apply KCL to Node ③

$$\frac{V_3-V_2}{2}+\frac{V_3}{1}+\frac{V_3}{6}=0$$

$$-0.5V_2+1.666V_3=0 \quad —— ③$$

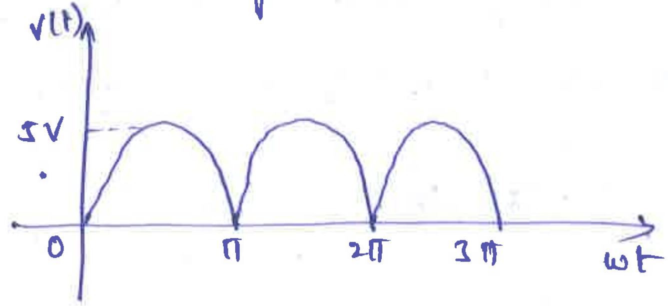
Solve eq ①, ② & ③

$$V_1=8.063V$$

$$V_2=10.201V$$

$$V_3=3.061V$$

3 (a) Find the Average & RMS value



$V(t) = 5\sin\omega t \quad 0 < \omega t < \pi$

Time periode $(T) = \pi - 0$

$= \pi$ rad

$$V_{avg} = \frac{\int_0^T v(t)\, d\omega t}{T}$$

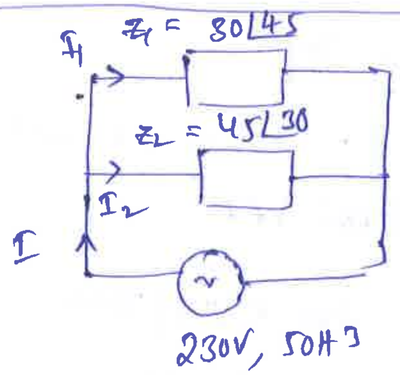
$$= \frac{1}{\pi}\int_0^{\pi}(5\sin\omega t)\, d\omega t$$

$$= \frac{5}{\pi}\left[-\cos\omega t\right]_0^{\pi} = \frac{10}{\pi}$$

$$V_{RMS} = \sqrt{\frac{\int_0^T v^2(t)\, d\omega t}{T}}$$

$$= \sqrt{\frac{1}{\pi}\int_0^{\pi}(5\sin\omega t)^2 d\omega t} = \frac{5}{\sqrt{2}}$$

3 (b)



a) $I_1 = \frac{V}{Z_1} = \frac{230}{30\angle 45} = 7.66\angle -45$

$I_2 = \frac{V}{Z_2} = \frac{230}{45\angle 30} = 5.11\angle -30$

(b) $I = I_1 + I_2 = 12.66\angle -39.005$

(c) P.F = cos (phase Angle diff b/w V & I)

$= \cos(0 - (-39.005)) = 0.777$

4 (a) Average value: The average value is the arithmetic mean of all instantaneous values of the waveform over one complete cycle.

$$V_{avg} = \frac{\int_0^T v(t)\, dt}{T} = \frac{2V_m}{\pi}$$

RMS value: The RMS value represents the effective value of an AC signal. It is the DC equivalent of AC signal that would produce the same amount heat in a resistor.

$$V_{R.MS} = \sqrt{\frac{\int_0^T v^2(t)\, dt}{T}} = \frac{V_m}{\sqrt{2}}$$

Form Factor: (FF) $= \dfrac{\text{RMS Value}}{\text{Average Value}} = 1.11$

Peak factor (PF) $= \dfrac{\text{Peak value}}{\text{RMS Value}} = \sqrt{2}$

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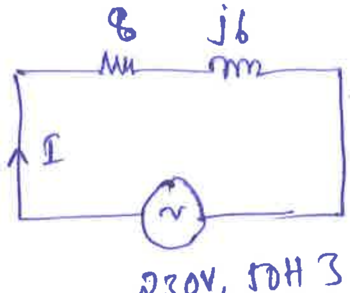
4 (b)



(i) $I = \dfrac{V}{Z} = \dfrac{230}{8+j6} = 23\angle -36.86$

(ii) $p.f = \cos[0 - (-36.86)]$

$p.f = 0.8$ lag

(iii) $Q = VI\sin\phi = 230 \times 23 \times \sin(36.86)$

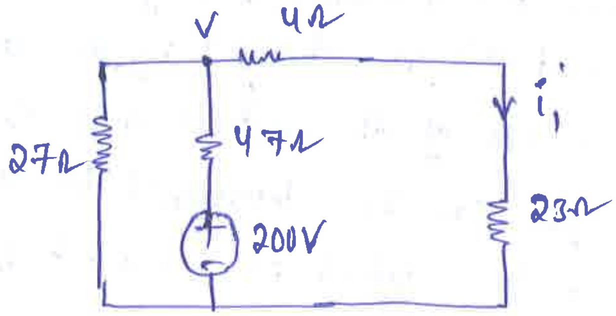
$= 3173.2688$ VAR

(iv) $S = VI^* = 230 \times 23\angle 36.86$

$= 5290\angle 36.86$

5 (a) Find the current in 23Ω resistor using Superposition theorem

<u>Case (i)</u> 200V source active & 20A current source inactive



Apply KCL to the Node

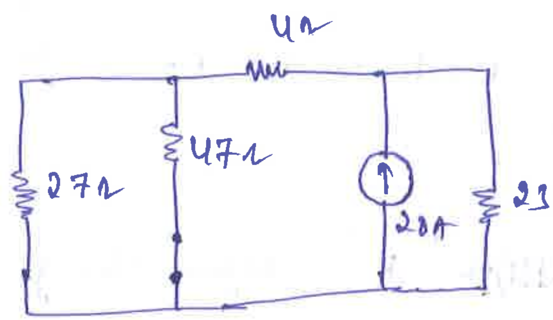
$$\frac{V}{27} + \frac{V-200}{47} + \frac{V}{27} = 0$$

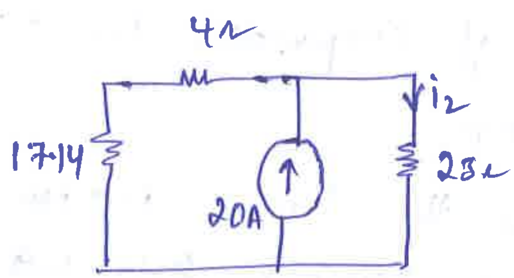
$$0.09535V = 4.255$$

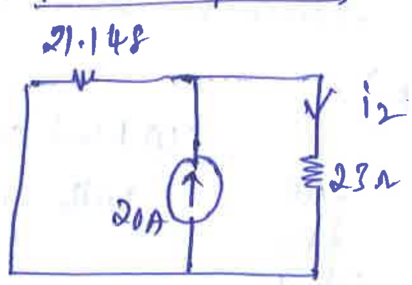
$$V = 44.624$$

$$i_1 = \frac{V}{23+4} = 1.6527\,A$$

Case (ii) 20A current source active & 200V source inactive.







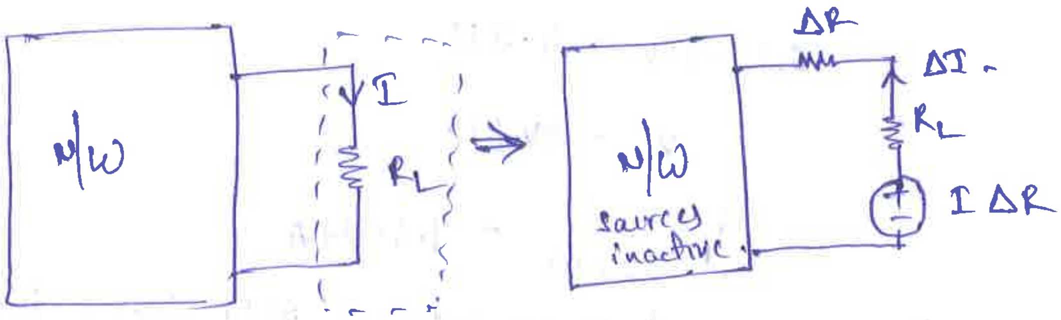
$$\Rightarrow i_2 = \frac{20 \times 21.148}{21.148 + 23}$$

$= \cancel{10.419}\,A \quad 9.58\,A$

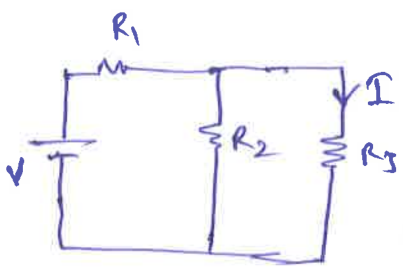
$i_{23} = i_1 + i_2 = 11.232\,A$

5 (b) Compensation Theorem

The compensation theorem says that in a linear time invariant network, when the resistance (R) of an uncoupled branch carrying a current (I) is changed by an amount ΔR, The current in all branches of the network will change accordingly. These changes can be determined by assuming an ideal voltage source V_c, which is connected with $R + \Delta R$, such that $V_c = I \cdot \Delta R$, In this case, all other sources in the network are replaced by their internal resistance.



Ex:



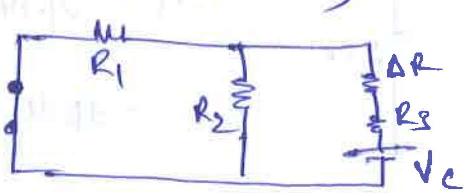
Resistance in R_3 is increased by ΔR

(1) Find the current (I) in "R_3" before change

(2) Find the value of compensation source.

$$V_c = I \Delta R.$$

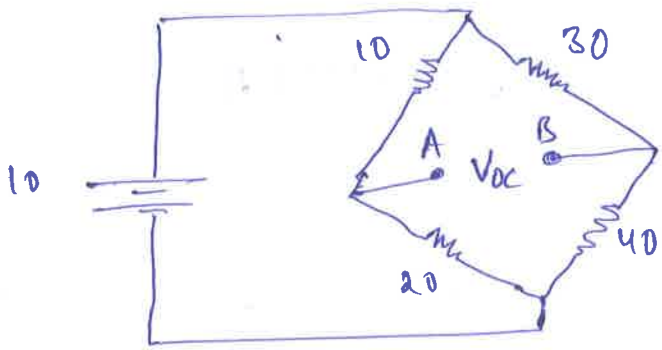
(3) make the all the sources inactive & connect compensation voltage source in series with modified resistance ($R_3 + \Delta R$)



(4) Find current change with modified circuit

Find current through 50Ω resistor using thevenin's theorem

V_{Th} calculation: Replace the load with open circuit



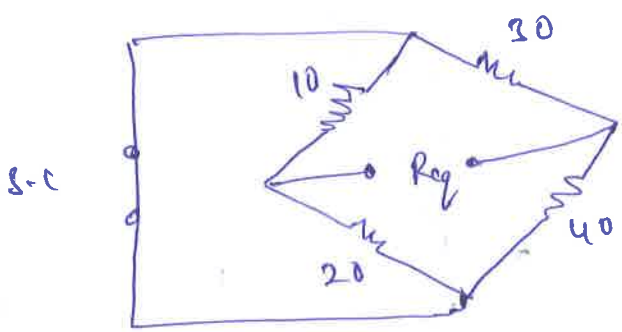
$\therefore V_{OC} = V_{Th} = V_A - V_B$

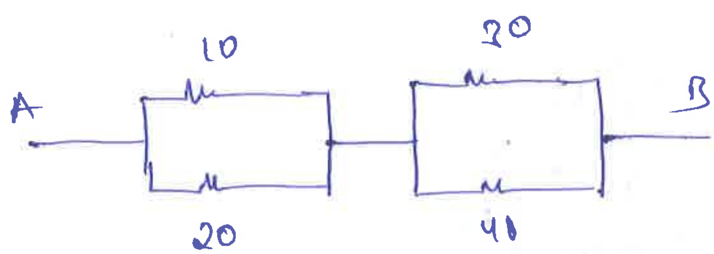
$$V_A = \frac{10 \times 20}{10+20} = 6.667$$

$$V_B = \frac{10 \times 40}{30+40} = 5.7142$$

$\therefore V_{Th} = V_A - V_B = 0.9527V$

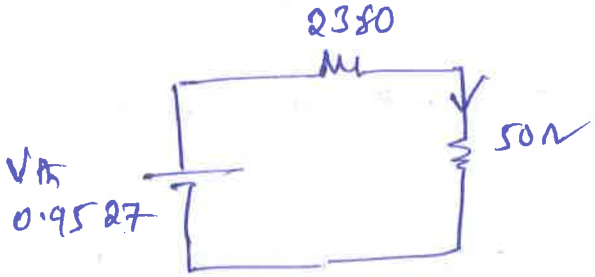
R_{Th} calculation: Make all sources inactive & find equivalent Resistance b/w open circuit terminals.





$R_{Th} = 23.80\,\Omega$

Thevenin's equivalent



$$I_{50\Omega} = \frac{V_{Th}}{R_{Th}+R_L}$$

$$= 0.0129\ A$$

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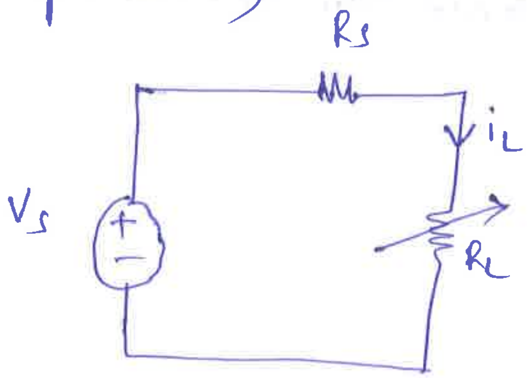
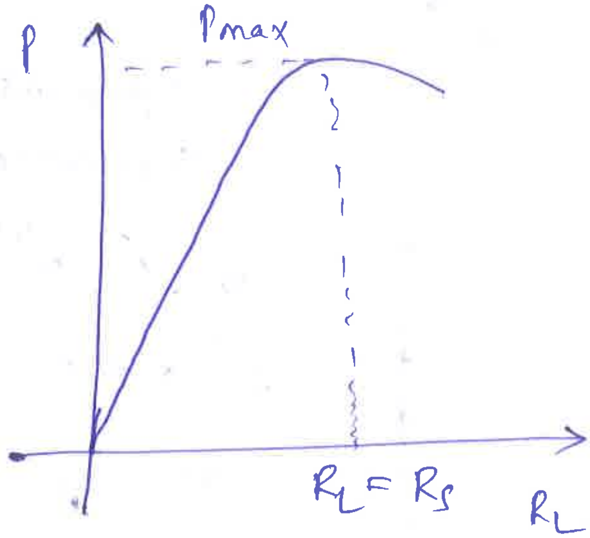
6 (b) <u>Maximum Power transfer Theorem</u>: In any linear circuit, The source will deliver maximum power to the load when the load resistance is equal to the source ristance. in DC Circuits. (In case of AC circuits, when load impedance is complex conjugate of the source impedance.)





$$i_L = \frac{V_s}{R_s+R_L}$$

$\therefore$ Load power $= I_L^2 R_L$

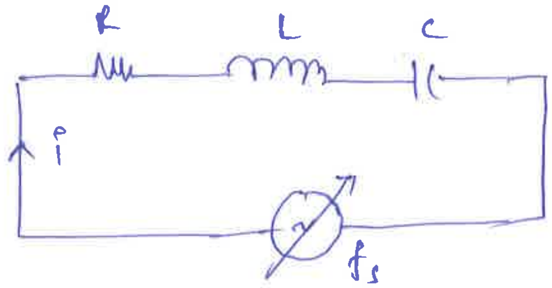
$$P_L = \left[\frac{V_s}{R_s+R_L}\right]^2 R_L$$

condition for maximum power transfer, when R_L variable

$$\frac{dP_L}{dR_L} = 0$$

$$\boxed{\therefore\ R_L = R_{Th}}$$

7 (a) RLC Series Resonance Circuit



At resonance, net reactive power delivered by the source / observed by the circuit is zero.

$\therefore$ Capacitive Reactive power = Inductive reactive power

$$\cancel{i^2} X_C = \cancel{i^2} X_L$$

$$\therefore X_L = X_C$$

at $f = f_r$

$$2\pi f_r L = \frac{1}{2\pi f_r C}$$

Resonance frequency. $\boxed{\therefore f_r = \frac{1}{2\pi\sqrt{LC}}}$

at resonance, $X_L = X_C$

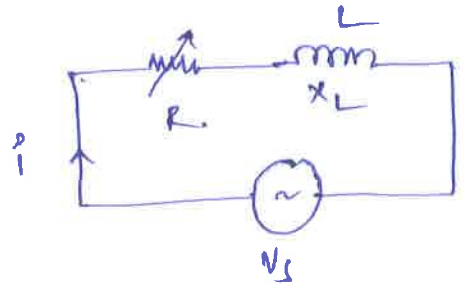
$$Z = R + jX_L - jX_C$$

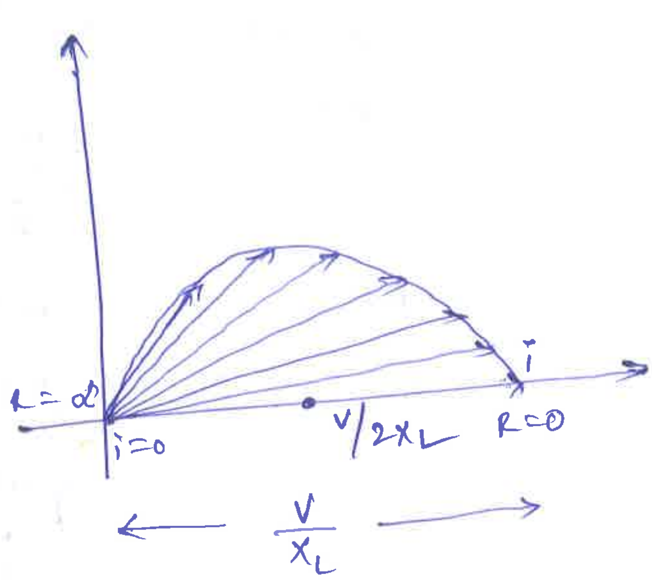
$$\boxed{\therefore Z = Z_{min} = R}$$

As impedance is minimum, current at resonance is maximum.

$$\boxed{I_{max} = \frac{V}{Z_{min}} = \frac{V}{R}}$$

4 (e) Current locus of RL series circuit





$$i = \frac{V_s}{R+jX_L}$$

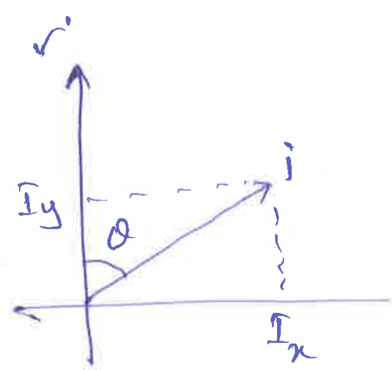
$$i = \frac{V}{\sqrt{R^2+X_L^2}} \angle -\tan^{-1}\left(\frac{X_L}{R}\right)$$

at $R=0$

$$i = \frac{V}{X_L} \angle -90$$

at $R=\alpha$

$$i = 0 \angle 0$$



Circle equation :

$I_x = i \sin\theta$; $I_y = i\cos\theta$

$= \frac{V}{Z}\sin\theta$; $I_y = \frac{V}{Z}\cos\theta$

$= \frac{V}{Z}\,\frac{X}{Z}$; $I_y = \frac{V}{Z}\,\frac{R}{Z}$

$\boxed{I_x = V\cdot\frac{X}{Z^2}}$; $\boxed{I_y = \frac{V\,R}{Z^2}}$

Resultant current

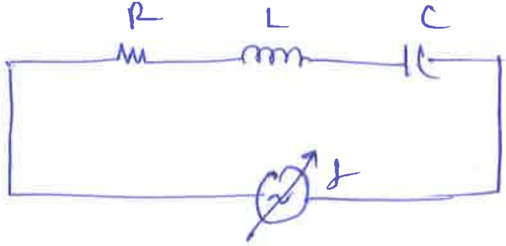
$$I_x^2 + I_y^2 = \frac{V^2}{R^2+X^2} \Rightarrow I_x^2 + I_y^2 = V\,\frac{X}{I_x}$$

$$\therefore\ I_x^2 + I_x^2 - \frac{V\,X}{I_x} = 0$$

Add $\left(\frac{V}{2X_L}\right)^2$ to both sides

$$\boxed{\therefore \text{ Equation of circle is } \left(I_x - \frac{V}{2X_L}\right)^2 + I_y^2 = \left(\frac{V}{2X_L}\right)^2}$$

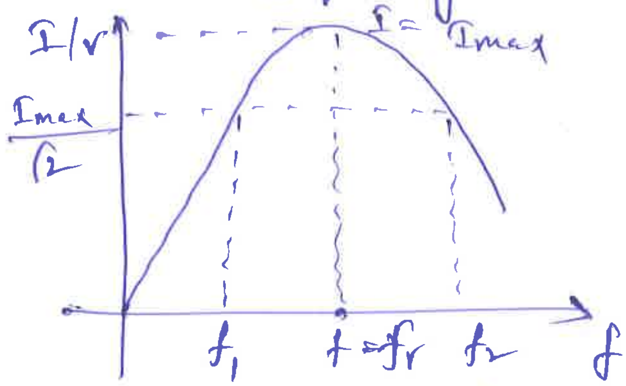
5 (a)



(1) Resonance frequency (fr): The frequency at which the net reactance of the circuit is zero (or) Net reactive power delivered to the circuit is zero

$$\therefore \boxed{f_r = \frac{1}{2\pi\sqrt{LC}}} \text{ Hz}$$

(2) Bandwidth: The range of frequencies for which the current (or) o/p voltage is equal to 70.7% of its value at the resonance frequency is called Bandwidth



$$\therefore \boxed{B.W = f_2 - f_1}$$

(3) Quality factor (Q): It is the ration of energy stored in the capacitor (or) Inductor to the energy dissipated per cycle.

$$Q = 2\pi \times \frac{\text{Energy stored}}{\text{Energy dissipated}}$$

$$= \frac{I^2 X_L}{I^2 R} = \frac{X_L}{R} = \frac{\omega L}{R}$$

$$\therefore Q = \frac{\omega L}{\ }$$

$\therefore$ Band width (BW) $= \dfrac{R}{2\pi L}$

Quality factor (Q) $= \dfrac{wL}{R}$

$\therefore \cancel{\dfrac{BW}{Q}} \cancel{\neq} \cancel{\dfrac{R/2\pi L}{2\pi f L/R}}$

$(B.W.) \times Q = \dfrac{\cancel{R}}{2\pi \cancel{L}} \cdot \dfrac{2\pi f_r \cancel{L}}{\cancel{R}}$

$$\boxed{\therefore f_r = (B.W.) \times Q}$$

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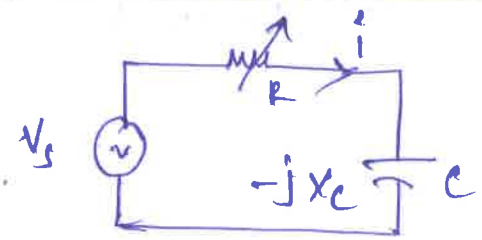
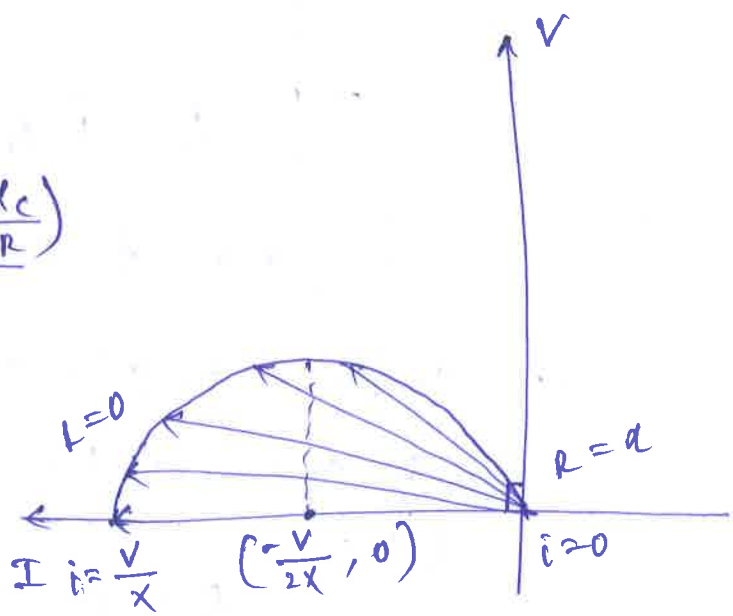
8 (b) <u>current locus of RC circuit</u>



$i = \dfrac{V}{R - jX_c}$

$\therefore i = \dfrac{V}{\sqrt{R^2 + X_c^2}} \angle \tan^{-1}\left(\dfrac{X_c}{R}\right)$



$\therefore$ <u>at R = 0</u>

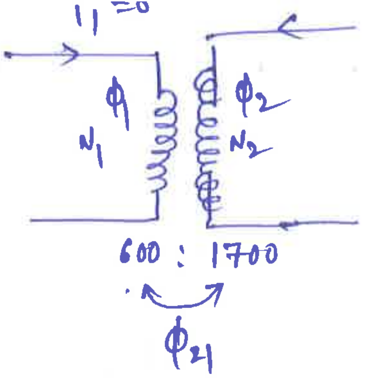
$i = \dfrac{V}{X_c} \angle 90$

<u>at R = α</u>

$i = \dfrac{V}{\alpha} \angle \tan^{-1}\left(\dfrac{X_c}{\alpha}\right)$

$i = 0 \angle 0$

(4) (a)



$i_2 = 6A$

$\phi_2 = 0.8 \, mwb$

$\phi_{21} = 0.5 \, mwb$

Self inductance of coils

$$L_2 i_2 = N_2 \phi_2$$

$$\therefore \quad L_2 = \frac{N_2 \phi_2}{i_2} = \frac{1700 \times 0.8 \times 10^{-3}}{6}$$

$$\boxed{L_2 = 0.2266 \text{ H}}$$

$$\frac{L_1}{L_2} = \left(\frac{N_1}{N_2}\right)^2 \Rightarrow L_1 = L_2 \cdot \left(\frac{N_1}{N_2}\right)^2$$

$$\boxed{L_1 = 0.028 \text{ H}}$$

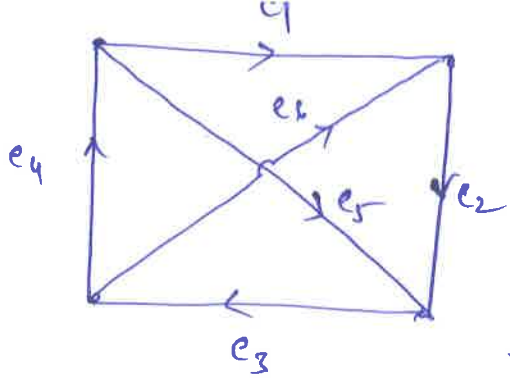
coefficient of coupling (K) $= \dfrac{\phi_{21}}{\phi_2} = \dfrac{0.5m}{0.8m}$

$$\boxed{K = 0.625}$$

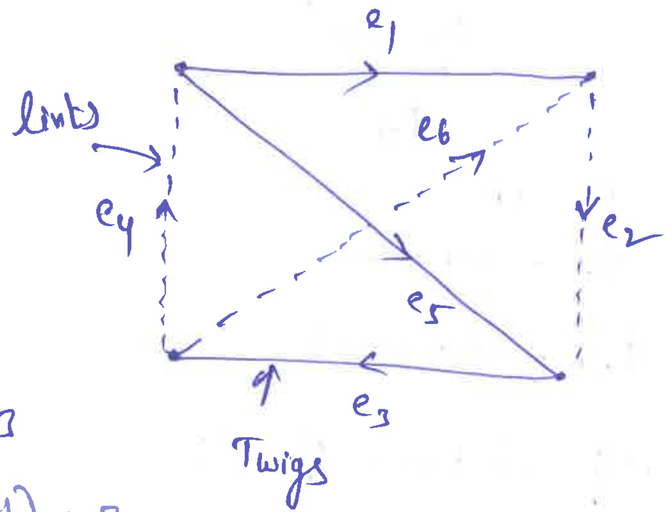
Mutual Inductance (M) $= K \sqrt{L_1 L_2}$

$$\boxed{M = 0.0497 \text{ H}}$$

9 (b)



Tree branches e_1, e_3, e_5



No. of nodes (n) $= 4$

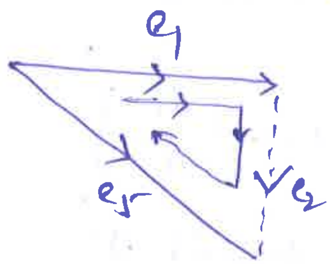
No. of branches (b) $= 6$

No. of twigs $= (n-1) = 3$

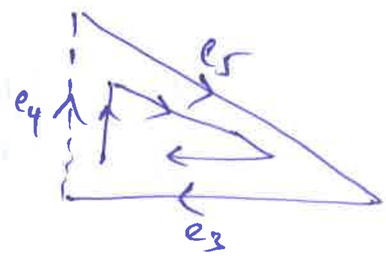
No. of links $= b-(n-1) = 3$

fundamental loops

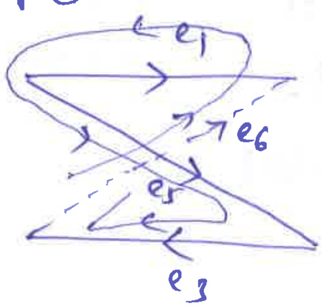
loop ① with link e_2 ;



loop ② with link e_4



loop ③ with link e_6

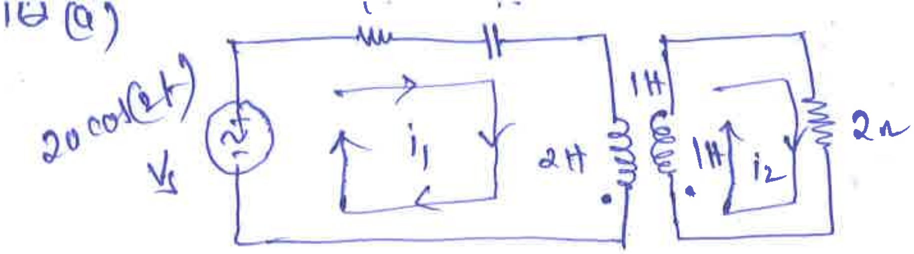


Tie-set matrix

Braches

	e_1	e_2	e_3	e_4	e_5	e_6
loop ①	1	1	0	0	-1	0
loop ②	0	0	1	1	1	0
loop ③	-1	0	1	0	1	1

10 (a)



Coefficient of coupling (K) $= \dfrac{M}{\sqrt{L_1 L_2}}$

$= \dfrac{1}{\sqrt{2 \times 1}} = 0.707$

KVL to loop ① :

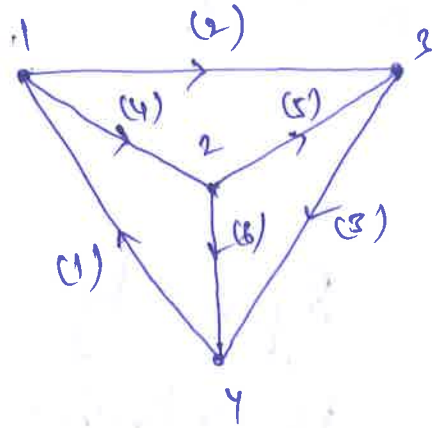
$$-V_s + i_1 4 + \frac{1}{1/8}\int i\,dt + 2\frac{di_1}{dt} + 1\frac{di_2}{dt} = 0$$

KVL to loop ② :

$$1\frac{di_2}{dt} + 2i_2 - 1\frac{di_1}{dt} = 0$$

---

10 (b)



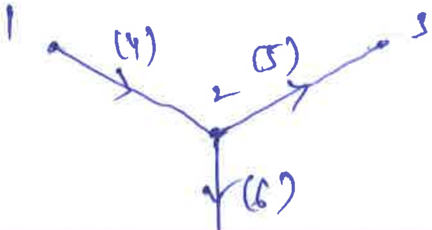
No. of Nodes = 4

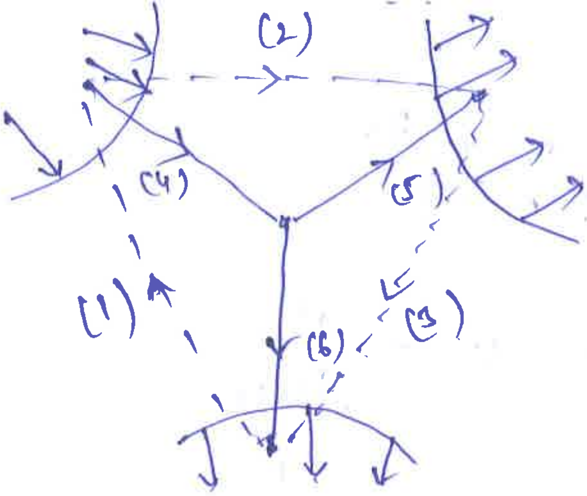
No. of branches (b) = 6

No. of Twigs = n-1 = 3

No. of links = b-(n-1) = 3

given tree : (4), (5), & (6)





cut set: 3

cut set matrix

		Branches					
		(1)	(2)	(3)	(4)	(5)	(6)
cut sets	cut 1	-1	1	0	1	0	0
	cut 2	0	1	-1	0	1	0
	cut 3	-1	0	1	0	0	1

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