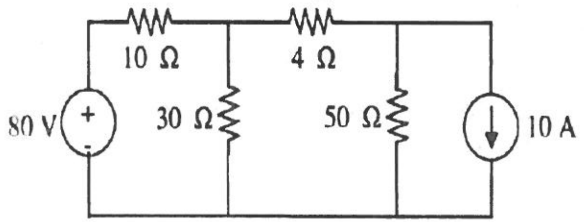
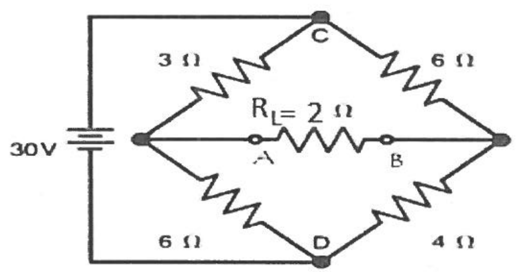
		obtain relation between bandwidth, resonant frequency and Q-factor.			
	b)	A series RLC circuit has R=10Ω, L=0.2H and C=40μF. The applied voltage is 100V. Find (i) Resonant frequency (ii) Quality factor of a coil (iii) Bandwidth (iv) Upper and Lower half power frequencies.	L4	CO4	6 M
		OR			
9		Interpret the procedure to draw the locus diagram of R-C series circuit when C is varying.	L3	CO3	10 M
		UNIT-V			
10	a)	State and explain Superposition theorem.	L2	CO1	4 M
	b)	Verify Superposition theorem for 4Ω resistor for the following circuit. 	L4	CO4	6 M
		OR			
11	a)	State and explain Thevenin's theorem.	L2	CO1	4 M
	b)	Find the Thevenin's equivalent circuit across A&B terminals. Also draw the Norton's equivalent circuit. 	L4	CO4	6 M

PVP 23

Code: 23EE3201

I B.Tech - II Semester – Regular / Supplementary Examinations MAY 2025

ELECTRICAL CIRCUIT ANALYSIS-I
(ELECTRICAL & ELECTRONICS ENGINEERING)

Duration: 3 hours Max. Marks: 70

Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

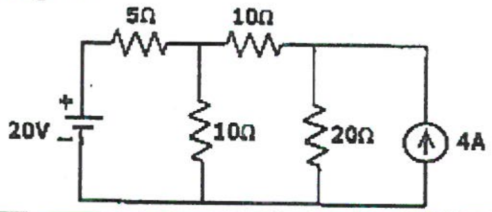
BL – Blooms Level CO – Course Outcome

PART – A

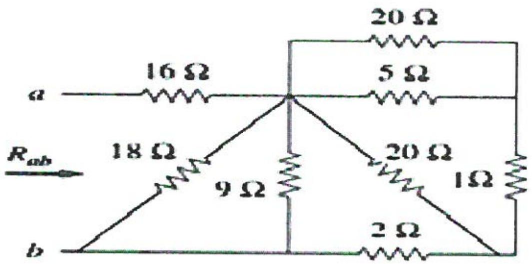
		BL	CO
1.a)	Illustrate Kirchhoff's Voltage Law with an example.	L3	CO2
1.b)	An electric iron is rated 1000W, 240V. Find the current drawn & resistance of the heating element.	L3	CO2
1.c)	Define Magnetic flux and Flux density.	L2	CO1
1.d)	State Faraday's law of Electromagnetic Induction.	L3	CO2
1.e)	Define Peak Factor and Form Factor.	L2	CO1
1.f)	An alternating current is given by i=70.71 sin (100πt), find R.M.S value and Average value.	L4	CO4
1.g)	Define resonance?	L2	CO1
1.h)	Draw the current locus for Series RL circuit with varying Resistance R.	L3	CO3
1.i)	State Millman's Theorem.	L2	CO1
1.j)	Give the condition to transfer maximum power to load impedance.	L2	CO1

PART – B

			BL	CO	Max. Marks
		UNIT-I			
2	a)	Discuss in detail the classification of network elements.	L3	CO2	4 M
	b)	Find the value of current flowing through 20 Ohms resistor by using source transformation and network reduction techniques.	L4	CO4	6 M

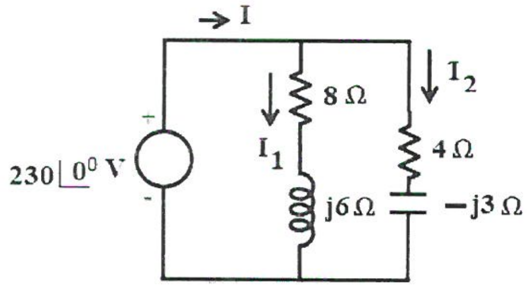


			BL	CO	Max. Marks
		OR			
3	a)	Derive the equivalent DELTA expressions for given STAR.	L3	CO2	6 M
	b)	Find the equivalent resistance R_{ab} in the circuit given below.	L4	CO4	4 M



			BL	CO	Max. Marks
		UNIT-II			
4	a)	Give the differences between magnetic and electric circuits.	L3	CO2	5 M
	b)	An iron ring of mean circumference 30cm	L4	CO4	5 M

		with area of cross section of 1.5 cm^2 has 240 turns of wire wound uniformly on it through which a current of 2A Passes. The flux on iron is found to be 0.75mwb in the iron. Find the relative permeability of iron.			
		OR			
5	a)	Explain about dot convention in mutually coupled circuits.	L3	CO2	5 M
	b)	Derive the expression for equivalent inductance when the two coupled inductors are connected in Series aiding and series opposition.	L3	CO2	5 M
		UNIT-III			
6	a)	Interpret Average and RMS values.	L3	CO3	4 M
	b)	Calculate the form factor and peak factor for the following waveforms i) sinusoidal waveform ii) Full wave rectified sine wave.	L3	CO3	6 M
		OR			
7	a)	Find **I, I_1, I_2,** Total Active, Reactive and Apparent Powers of the circuit shown below	L4	CO4	5 M



	b)	Interpret the steady state analysis of R-C series circuit and draw the phasor diagram.	L3	CO3	5 M
		UNIT-IV			
8	a)	Derive the equation for resonance frequency of a series RLC circuit. Also	L3	CO3	4 M

II B.Tech - II semester - Regular/supplementary Examinations
May 2025

Electrical circuit Analysis - I
(Electrical & Electronics Engineering).

PART - A

1. a) KVL —— 2M

b) current calculation - 1M
Resistance calculation - 1M

c) Flux definition — 1M
Flux Density definition — 1M

d) Any one statement of Faraday's law of EMI — 2M.

e) peak factor Definition — 1M
form factor Definition — 1M.

f) RMS value calculation — 1M
Avg. value calculation — 1M

g) Resonance Definition — 2M

h) current locus dig. — 2M

i) Millman's Theorem statement — 2M

j) Condition for MPT —— 2M.

PART - B

2. a) N/w elements classification —— 4M

b) Finding current through 20Ω resistor — 6M
(Any correct procedure allot full marks).

3. a) Derivation — 6M

b) finding Req — 4M.

4. a) Any 5 differences — 5M

b) Finding μ_r — 5M

(Any correct procedure allot full marks).

5. a) Dot convention explanation — 5M

b) Equivalent inductance derivation — 5M.

6. a) Avg. value — 2M

RMS value — 2M

b) Calculation of FF and PF of

i) Sinusoidal wave form — 3M

ii) Full wave rectified wave form — 3M

7. a) formulas — 2M

calculation — 4M.

b) phasor dia — 2M

steady state Analysis — 3M.

9. a) Locus diagram — 6M

procedure — 4M

8. a) f_0 Derivation — 2M

Relation btw f_0, B.W, Q — 2M.

b) formulas — 2M

calculations — 4M.

10. a) Superposition Theorem — 4M

b) Verification of Theorem — 6M.

(for solving ckts, any correct procedure allot full marks)

11. a) Thevenin's Theorem — 4M.

b) V_{Th} & R_{Th} calculations — 3M

Eq Thevenin's & Norton's ckt's — 3M.

Code: 23EE3201

PVP23.

I B.Tech - II sem - Regular / supplementary Examinations
May 2025

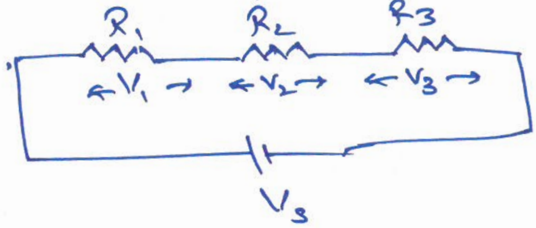
Electrical circuit Analysis - I
(Electrical & Electronics Engineering)

Max. Marks : 70.

PART - A

1. a) KVL states that algebraic sum of voltages ~~any~~ around any closed path is always Zero.

$V_s = V_1 + V_2 + V_3$



b) $P = 1000\,W$.
$V = 240\,V$

$I = \frac{P}{V} = \frac{1000}{240} = 4.167\,A$.

$P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P} = 57.6\,\Omega$ (or) $P = I^2 R \Rightarrow R = \frac{P}{I^2}$
$= 57.6\,\Omega$

c) Magnetic flux (ϕ):

Magnetic flux (ϕ) is the total amount of magnetic field lines passing through a surface.

Flux Density (B):

Flux Density is the amount of magnetic flux per Unit Area.

d) Faraday's law of Electromagnetic Induction:

i) I Law: whenever a magnetic flux linking the coil changes an emf is induced.

ii) II Law: The magnitude of the induced emf is proportional to the time rate of change of flux linkages.

e) peak factor:

It is the ratio of peak value to the RMS val

$$\text{peak factor} = \frac{\text{peak value}}{\text{RMS Value}}$$

form factor:

It is the ratio of RMS value to the avg. value

$$\text{Form Factor} = \frac{\text{RMS Value}}{\text{Avg. value}}$$

f) $i = 70.71 \sin(100\pi t)$

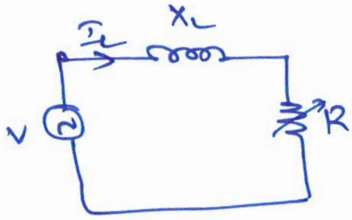
$$i_{rms} = \frac{I_m}{\sqrt{2}} = \frac{70.71}{\sqrt{2}} = 50 \text{ A}.$$

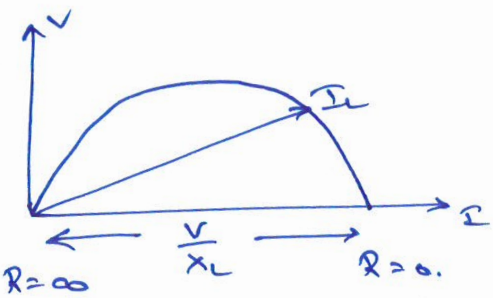
$$i_{avg} = \frac{2I_m}{\pi} = \frac{2 \times 70.71}{\pi} = 45 \text{ A}$$

g) Resonance:

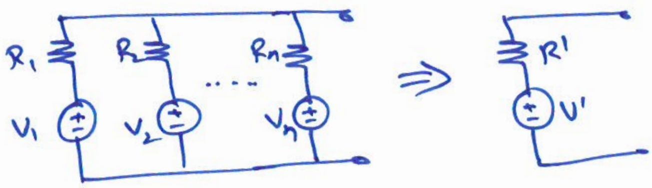
The circuit containing reactance is said to be in resonance if the voltage across the ckt is in phase with the current through it.

h)





i) Millman's Theorem states that in any N/w, if the voltage sources $V_1, V_2 \ldots V_n$ in series with internal resistances $R_1, R_2 \ldots R_n$ respectively are in parallel, then these sources may be replaced by a single voltage source V' in series with R'.



j) Maximum power Transfer occurs when the load Impedance is complex conjugate of source Impedance.

$$Z_L = Z_S^*$$

PART - B

2. a) Network elements are classified as

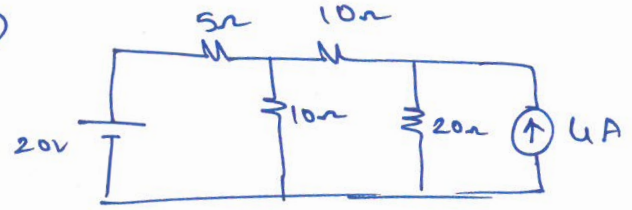
i) Active and passive elements

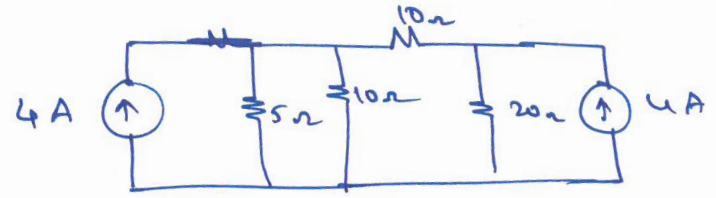
ii) linear and Non-linear elements

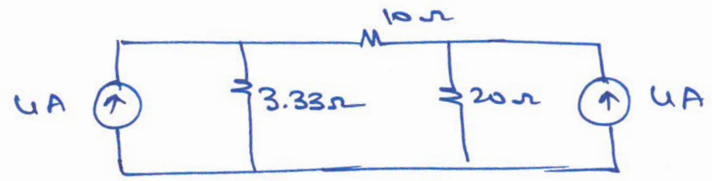
iii) Unilateral and Bilateral elements

iv) Lumped and Distributed elements.

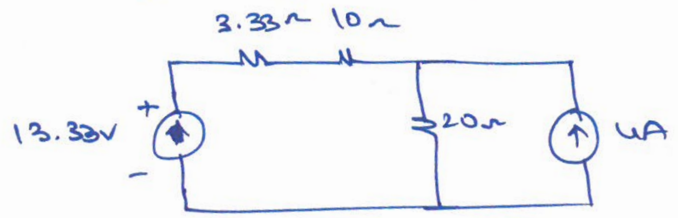
2. b)

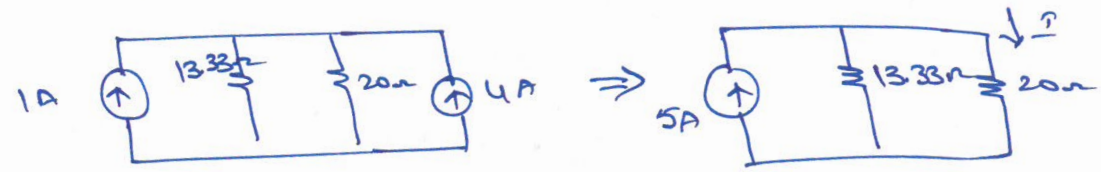






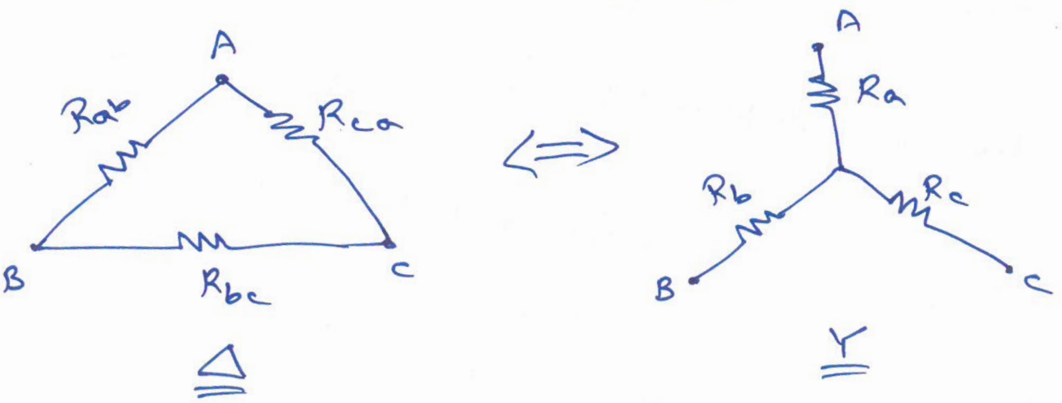
for Any correct procedure allot full marks.





$$I = 5 \times \frac{13.33}{20+13.33} \Rightarrow \boxed{I = 2A}$$

3) a) STAR - DELTA Transformation:



Δ $\qquad\qquad$ Y

$$R_{AB} = \frac{(R_{ab})(R_{bc}+R_{ca})}{R_{ab}+R_{bc}+R_{ca}} \longrightarrow (1) \qquad R_{AB} = R_a + R_b \longrightarrow (4)$$

$$R_{BC} = \frac{(R_{bc})(R_{ab}+R_{ca})}{R_{ab}+R_{bc}+R_{ca}} \longrightarrow (2) \qquad R_{BC} = R_b + R_c \longrightarrow (5)$$

$$R_{CA} = \frac{(R_{ca})(R_{ab}+R_{bc})}{R_{ab}+R_{bc}+R_{ca}} \longrightarrow (3) \qquad R_{CA} = R_c + R_a \longrightarrow (6)$$

By solving above equations.

$$R_a = \frac{R_{ab}R_{ca}}{R_{ab}+R_{bc}+R_{ca}}, \quad R_b = \frac{R_{bc}R_{ab}}{R_{ab}+R_{bc}+R_{ca}}, \quad R_c = \frac{R_{ca}R_{bc}}{R_{ab}+R_{bc}+R_{ca}} \longrightarrow (7)$$

From above equations

$$R_aR_b = \frac{R_{ab}^2 R_{bc} R_{ca}}{(R_{ab}+R_{bc}+R_{ca})^2} \text{ ——— } (8)$$

$$R_bR_c = \frac{R_{ab} R_{bc}^2 R_{ca}}{(R_{ab}+R_{bc}+R_{ca})^2} \text{ ——— } (9)$$

$$R_cR_a = \frac{R_{ab} R_{bc} R_{ca}^2}{(R_{ab}+R_{bc}+R_{ca})^2} \text{ ——— } (10)$$

$$R_{ab}R_b + R_bR_c + R_cR_a = \frac{R_{ab}R_{bc}R_{ca}}{R_{ab}+R_{bc}+R_{ca}} \text{ ——— } (11)$$

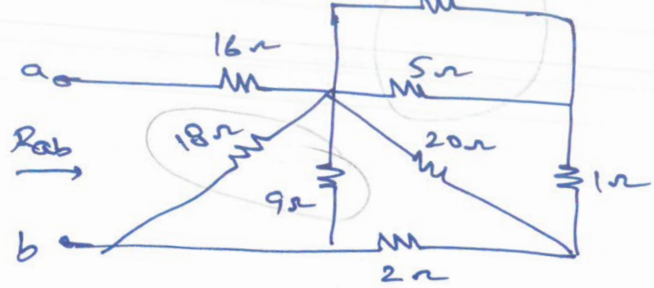
∴ Divide (11) by R_c

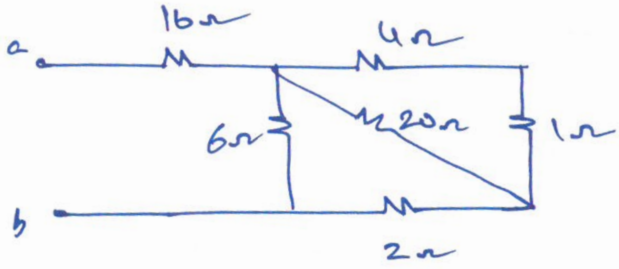
$$R_{ab} = \frac{R_aR_b + R_bR_c + R_cR_a}{R_c}$$

$$R_{bc} = \frac{R_aR_b + R_bR_c + R_cR_a}{R_a}$$

$$R_{ca} = \frac{R_aR_b + R_bR_c + R_cR_a}{R_b}$$

3.b)





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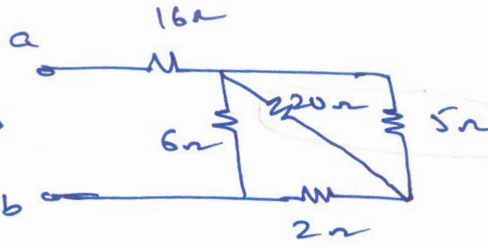

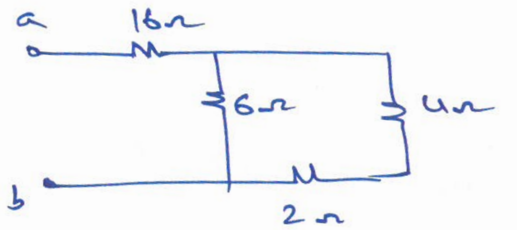

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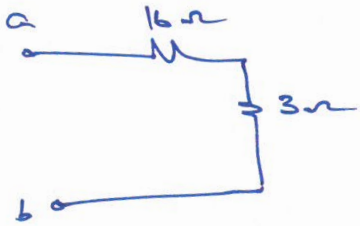


$\therefore$ $R_{ab} = 16 + 3 = 19\,\Omega$

4) a)

magnetic ckt	Electric ckt
i) closed path for magnetic flux ~~ckt~~ is called magnetic ckt.	i) closed path for electric current is called electric ckt.
ii) $\text{flux} = \dfrac{\text{MMF}}{\text{Reluctance}}$	ii) $\text{current} = \dfrac{\text{EMF}}{\text{Resistance}}$
iii) Flux Density $B = \dfrac{\Phi}{A}$	iii) current Density, $J = \dfrac{I}{A}$
iv) Reluctance, $S = \dfrac{l}{\mu_0 \mu_r A}$	iv) Resistance, $R = \rho \dfrac{l}{A}$.
v) Truely speaking magnetic flux doesn't flow.	v) Electric current flows in electric ckt.
vi) There is no magnetic insulator	vi) There is no of electric insulators.
vii) Residual flux permits after removal of mmf	vii) The current is reduced to zero after removal of emf.
viii) The value of μ_r is not const.	viii) The value of resistivity varies very slightly with temp.
ix) No Energy is expended in ~~mag.~~ magnetic ckt.	ix) when ~~a~~ i flows ~~the~~ in ckt, energy is expended so long as i fl

4.b) $l = 30\,cm$

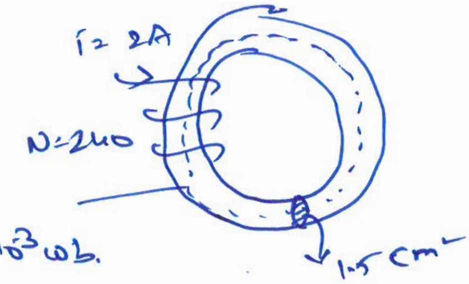
$= 30\times10^{-2}\,m.$

$a = 1.5\,cm^2$

$= 1.5\times10^{-4}\,m^2$

$N = 240.$, $i = 2A$, $\phi = 0.75\times10^{-3}\,wb.$

$\mu_r = ?$



$$H = \frac{NI}{l} = \frac{240\times2}{30\times10^{-2}} = 1600\ AT/m.$$

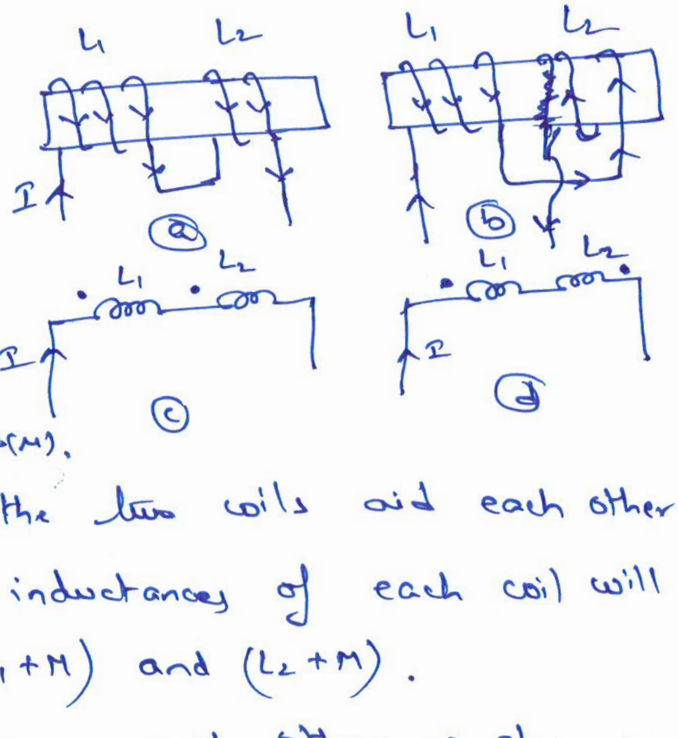
$$B = \frac{\phi}{A} = \frac{0.75\times10^{-3}}{1.5\times10^{-4}} = 5\ wb/m^2$$

$B = \mu H$

$$B = \mu_0\mu_r H \Rightarrow \mu_r = \frac{B}{\mu_0 H} = \frac{5}{4\pi\times10^{-7}\times1600}$$

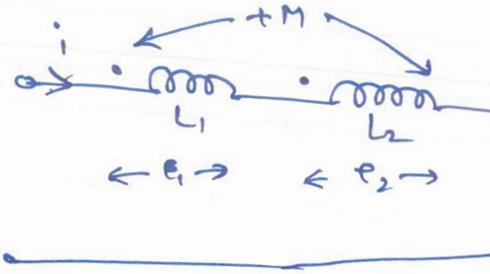
$$\therefore \boxed{\mu_r = 2486.79}.$$

5.a) Dot convention:



- consider two coils of inductances L_1 and L_2 are connected in series.
- Each coil will contribute same mutual flux and hence, same mutual inductance(M).
- If the mutual fluxes of the two coils aid each other as shown in fig.(a), the inductances of each coil will be increased by M. ie, (L_1+M) and (L_2+M).
- If the mutual fluxes oppose each other as shown in fig.(b), the inductances of coils will become (L_1-M) & (L_2-M).
- whether the two coil mutual fluxes aid each other or oppose will depend upon the way coils are wound
- The method described above is very inconvenient. There is another simple method of defining the directions of currents in the coils. This is known as a dot convention.

Series aiding :



The magnetic fluxes of the two coils oppose each other.

Total induced emf will be

$$e = L_1 \frac{di}{dt} + M\frac{di}{dt} + L_2 \frac{di}{dt} - M\frac{di}{dt}$$

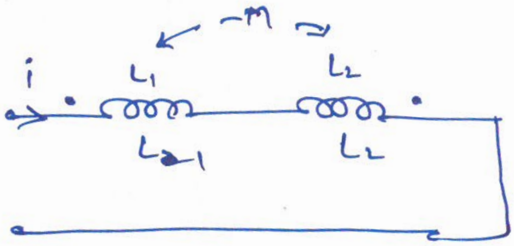
$$e = (L_1 + L_2 + 2M)\frac{di}{dt}$$

If L_T is the total Inductance of the ckt,

$$e = L_T \frac{di}{dt}$$

$$\therefore \boxed{L_T = L_1 + L_2 + 2M}$$

Series - opposing :



The magnetic fluxes of the two coils oppose each other.

$$e = L_1 \frac{di}{dt} - M\frac{di}{dt} + L_2\frac{di}{dt} - M\frac{di}{dt}$$

$$e = (L_1 + L_2 - 2M)\frac{di}{dt}.$$

If L_T is the total inductance of the ckt,

$$e = L_T \frac{di}{dt}$$

$$\therefore \boxed{L_T = L_1 + L_2 - 2M}$$

6. a) **Average values :**

The average value of an AC waveform is the arithmetic mean of all instantaneous values over one complete cycle.

$$V_{avg} = \frac{1}{T}\int_0^T v(t)\, dt$$

6. a) RMS value:

The RMS value of an alternating current (or) Voltage is the equivalent DC value that would produce the same heating effect in a resistor.

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v(t)^2\, dt}.$$

6. b) i) Sinusoidal waveform:

$$V_{avg} = \frac{2V_m}{\pi}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}}.$$

$$\text{form factor} = \frac{\text{RMS value}}{\text{avg. value}}$$

$$= \frac{V_m/\sqrt{2}}{2V_m/\pi} = \frac{\pi}{2\sqrt{2}}$$

$\therefore$ Form factor $= 1.11.$

$$\text{peak factor} = \frac{\text{max. value}}{\text{RMS value}}$$

$$= \frac{V_m}{V_m/\sqrt{2}} = \sqrt{2} = 1.414$$

ii) Full wave rectified sine wave:

$$V_{avg} = \frac{2V_m}{\pi}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

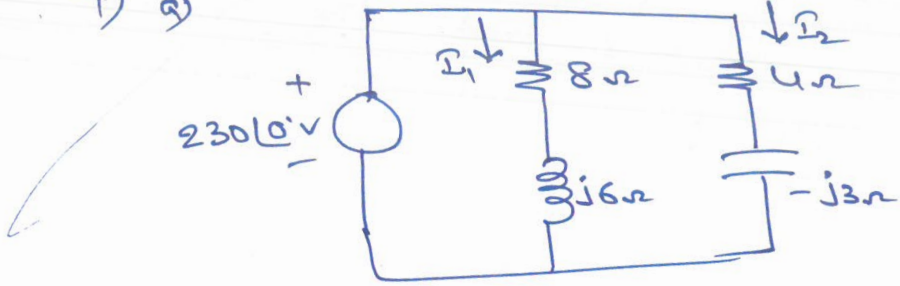
$$\text{Form factor (FF)} = \frac{\text{RMS value}}{\text{Avg. value}}$$

$$= \frac{V_m/\sqrt{2}}{2V_m/\pi} = \frac{\pi}{2\sqrt{2}} = 1.11$$

$$\text{peak factor} = \frac{\text{max. value}}{\text{RMS value}}$$

$$= V_m / V_m/\sqrt{2} = \sqrt{2} = 1.414$$

1) a)



$$I_1 = \frac{230}{8+j6} = 23\angle -36.87^\circ \text{ A}$$

$$I_2 = \frac{230}{4-j3} = 46\angle 36.87^\circ \text{ A}$$

$$I = I_1 + I_2 = 56.9\angle 14.04^\circ \text{ A.}$$

$$P = VI\cos\phi = 230 \times 56.9 \times \cos 14.04$$
$$= 12696 \text{ W.}$$

$$Q = VI\sin\phi = 230 \times 56.9 \times \sin 14.04$$
$$= 3174.9 \text{ VAR.}$$

$$S = VI = 230 \times 56.9 = 13087 \text{ VA}$$

---

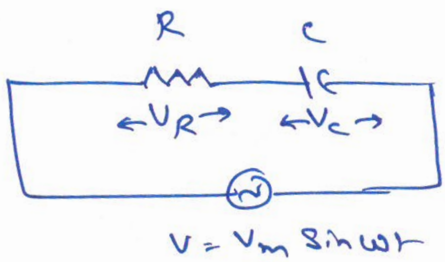
7. b) **Series RC ckt:**

Let Applied voltage

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

in phasor form

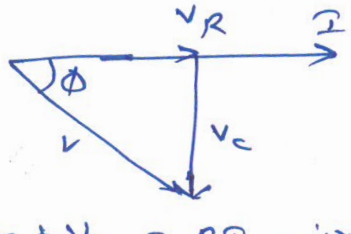
$V = V_m \angle 0^\circ$ V.



$\therefore$ $V_R = RI$ ⟶ V_R is inphase with I

$V_c = -jX_c I$. ⟶ V_c lags behind the current I. by 90°.

phasor diagram:



Impedance:

$$V = V_R + V_c = RI - jX_c I = (R - jX_c)\, I$$

$$Z = \frac{V}{I} = (R - jX_c). \quad |Z| = \sqrt{R^2 + X_c^2}$$

$$= |Z|\angle\phi \qquad \phi = \tan^{-1}\left(\frac{X_c}{R}\right)$$

Current:

From phasor dia, The current I leads the applied voltage V by an angle ϕ.

If $V = V_m \sin \omega t$

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

where $I_m = \frac{V_m}{Z}$, $\phi = \tan^{-1}\left(\frac{X_c}{R}\right)$.

---

8. a) for Resonant Frequency (f_0):

for a series RLC ckt,

at resonance, $X_L = X_C$

$$\omega_0 L = \frac{1}{\omega_0 C}$$

$$\omega_0^2 = \frac{1}{LC}.$$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$\boxed{f_0 = \frac{1}{2\pi\sqrt{LC}}}$$

Relation b/n B.W, Q, and f_0:

$$B.W = f_2 - f_1 = \frac{R}{2\pi L} \quad \text{--- (1)}$$

$$Q = \frac{\omega_0 L}{R} = \frac{2\pi f_0 L}{R} \quad \text{--- (2)}$$

(1) ⇒ $$\frac{B.W}{f_0} = \frac{R}{2\pi L}$$

$$\frac{B.W}{f_0} = \frac{1}{Q}.$$

$$\therefore \boxed{Q = \frac{f_0}{B.W}}$$

(or)

$$\boxed{B.W = \frac{f_0}{Q}}$$

$R = 10\Omega$, $L = 0.2H$ and $C = 40\mu F$.

i) $f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.2\times40\times10^{-6}}} = 56.27$ Hz

ii) $Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{10}\sqrt{\frac{0.2}{40\times10^{-6}}} = 7.07$.

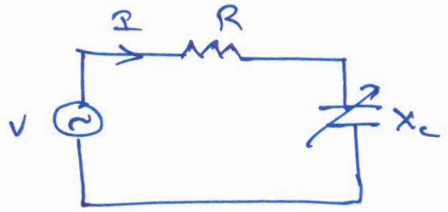
iii) $B.W = \frac{R}{2\pi L} = \frac{10}{2\pi\times0.2} = 7.96$ Hz

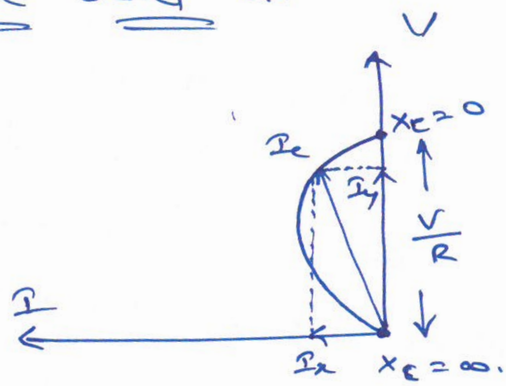
iv) $f_1 = f_0 - \frac{R}{4\pi L} = 52.29$ Hz

$f_2 = f_0 + \frac{R}{4\pi L} = 60.25$ Hz

9) **Locus diagram of RC series ckt:**

C varying:





- Consider a series RC ckt with constant R and variable X_c.

Impedance, $Z = \frac{V}{\sqrt{R^2+X_c^2}}$.

- when $X_c = 0$

$I_c = \frac{V}{R}$ and is max. value

and $\theta = 0$.

The p.f of the ckt is unity.

- As the value X_c is increased from zero, I_c is reduced and finally when X_c is ∞, current becomes zero and θ will be lagging behind the voltage by 90°.

- when $X_c = \infty$

$I = 0$ and is min value

and

$\theta = 90°$

- The current vector describes a semi circle with diameter $\frac{V}{R}$ and lies in the ~~right~~ left-side of the voltage vector OV.

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10. a) <u>Superposition Theorem:</u>

Superposition theorem states that, If a no. of voltage & current sources are acting simultaneously in a linear network, the resultant voltage across (or current through) an element is the algebric sum of the ~~currents~~ voltages across (& current through) that element due to each independent source acting alone. while the other independent sources are replaced by their internal resistances.

ie, ~~the~~ other Ideal voltage sources and current sources in the network are replaced by short circuit and open circuit across their terminals.

while applying superposition theorem, we consider one independent source at a time while all other independent sources are turned off. This implies that we replace every voltage source by a short ckt and every current source by open circuit

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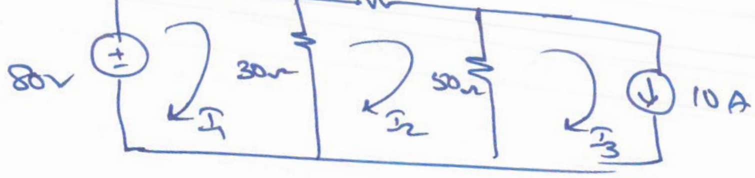


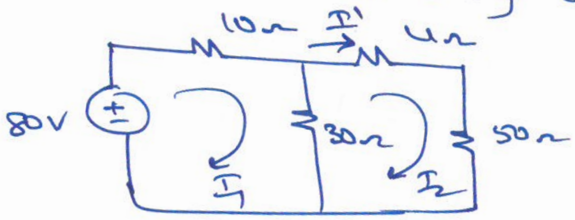
$$40 I_1 - 30 I_2 = 80 \quad \text{——— ①}$$
$$-30 I_1 + 84 I_2 - 50 I_3 = 0 \quad \text{——— ②}$$
$$I_3 = 10 \quad \text{——— ③}$$

By solving ①…
$I_1 = 8.829$
$I_2 = 9.106$
$I_3 = 10$ A.

$\therefore$ $\boxed{I = 9.106 \text{ A}}$

Case (i):

80 V V.S acting alone.



$$40 I_1 - 30 I_2 = 80$$
$$-30 I_1 + 84 I_2 = 0$$

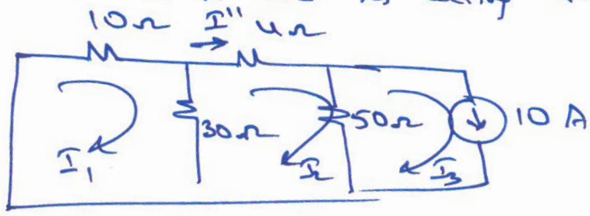
By solving ④ & ⑤

$I_1 = 2.732$ A $\quad I_2 = 0.976$ A

$\therefore$ $\boxed{I' = 0.976 \text{ A.}}$

Case (ii):

10 A C.S is acting alone.



$$40 I_1 - 30 I_2 = 0 \longrightarrow ⑥$$
$$-30 I_1 + 84 I_2 - 50 I_3 = 0 \longrightarrow ⑦$$
$$I_3 = 10 \longrightarrow ⑧$$

By solving ⑥, ⑦ & ⑧

$I_1 = 6.097$ A

$I_2 = 8.13$ A

$I_3 = 10$ A.

$\therefore$ $\boxed{I'' = 8.13 \text{ A}}$

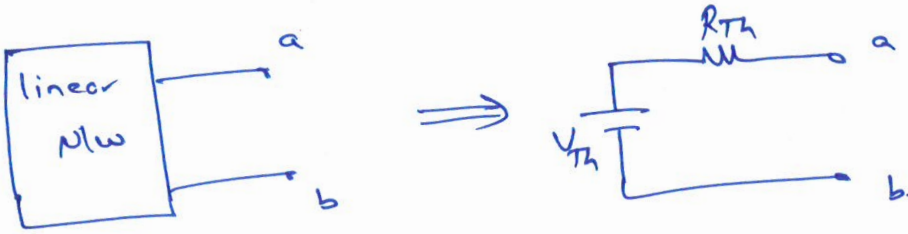
$\therefore$ $I = I' + I'' = 0.976 + 8.13$

$\boxed{I = 9.106 \text{ A}}$

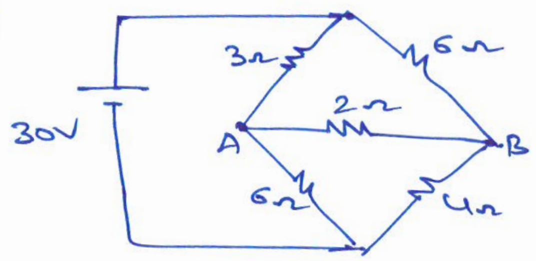
Hence superposition theorem is verified.

11. a) Thevenin's Theorem:

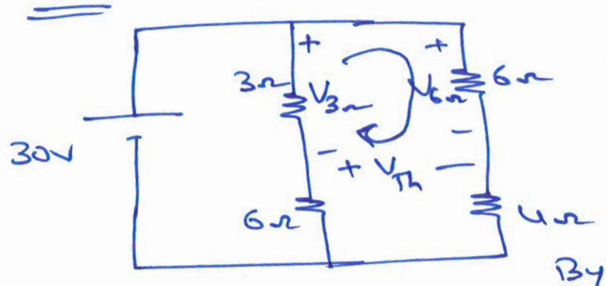
Thevenin's Theorem states that any two terminal li[illegible] N/w having a no. of voltage, current sources and resistances can be replaced by a simple equivalent c[illegible] consisting of a single voltage source in series [illegible] a resistance, when the value of the voltage source is equal to the open circuit voltage across the two terminals of the N/w, and the resistance is equal to the equivalent resistance measured btn the terminals with all the energy sources are replaced by their internal resistances.



11. b)



V_{Th}:



$$V_{3Ω} = 30 \times \frac{3}{3+6} = 10V$$

$$V_{6Ω} = 30 \times \frac{6}{6+4} = 18V$$

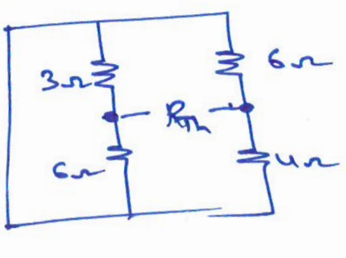
By applying KVL

$$-V_{3Ω} + V_{6Ω} - V_{Th} = 0.$$

$$V_{Th} = 18 - 10 = 8V$$

$$\boxed{V_{Th} = 8V}$$

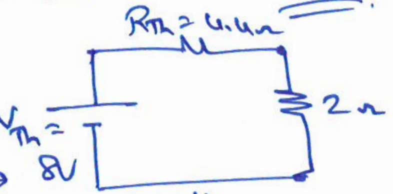
R_{Th}:



$$R_{Th} = \frac{3 \times 6}{3+6} + \frac{6 \times 4}{6+4}$$

$$\boxed{R_{Th} = 4.4Ω}$$

Thevenin's ckt



Norton ckt