IQRA NATIONAL UNIVERSITY
PESHAWAR

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ID :- 16424

Semester :- 2nd

Subject :- LCA (Linear Circuit Analysis)

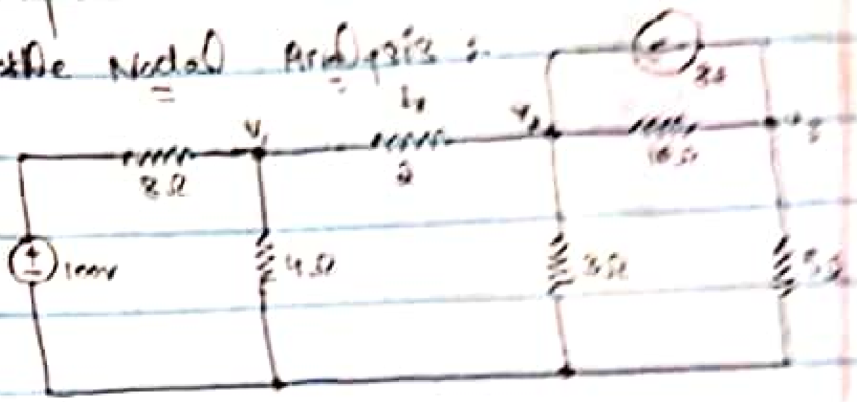
Teacher :- Dr. Sohail Imran.

Date :- 24.06-2020.

Question Number 1

Find the value of i_o for the circuit using.

(i)- Nodal Analysis:



Solution:-

Applying KCL on node 1:

$$\frac{V_1-100}{8} + \frac{V_1}{4} + \frac{V_1-V_2}{2} = 0$$

$$\frac{V_1 - 100 + 2V_1 + 4V_1 - 4V_2}{8} = 0$$

$$\frac{7V_1 - 4V_2 - 100}{8} = 0$$

Multiplying "8" on both sides.

$$8 \times \frac{7V_1 - 4V_2 - 100}{8} = 0 \times 8$$

$$7V_1 - 4V_2 - 100 = 0$$

$$7V_1 - 4V_2 - 100 = 0 \quad \text{—— (1)}$$

Now taking equation 1
we get.

$$7V_1 - 4V_2 = 100$$

$$V_1 = \frac{4V_2 + 100}{7} \quad \text{——— (a)}$$

Now taking equation 3

$$-V_2 + 3V_3 = -80$$

$$V_3 = \frac{V_2 - 80}{3} \quad \text{——— (b)}$$

Putting eq (a) and (b) in eq 2

$$-30(0.57V_2 + 14.28) + 53V_2 - 3(0.33V_2 - 26.67) = 480$$

$$-17.1V_2 - 428.4 + 53V_2 - 0.99V_2 + 80.01 = 480$$

$$34.91V_2 = 828.39$$

$$V_2 = \frac{828.39}{34.91}$$

$$V_2 = 20.31$$

Putting "V_2" in eq (a)

$$V_1 = \frac{4(20.31) + 100}{7}$$

$$V_1 = 25.89$$

$$i_x = \frac{V_1 - V_2}{2} = \frac{25.89 - 20.31}{2}$$

$$\boxed{i_x = 2.79 \text{ A}}$$

Now :-

Applying KCL on node 2n :-

$$\frac{V_2 - V_1}{2} + \frac{V_2}{3} + \frac{V_2 - V_3}{18} = 8$$

$$\frac{30V_2 - 30V_1 + 20V_2 + 3V_2 - 3V_3}{60} = 8$$

$$\frac{-30V_1 + 53V_2 - 3V_3}{60} = 8$$

Multiplying "60" o.b.s.

$$\cancel{60} \times \frac{-30V_1 + 53V_2 - 3V_3}{\cancel{60}} = 8 \times 60$$

$$-30V_1 + 53V_2 - 3V_3 = 480 \quad \text{——— (2)}$$

Now :-

Applying KCL on node 3n :-

$$\frac{V_3 - V_2}{10} + \frac{V_3}{5} = -8$$

$$\frac{V_3 - V_2 + 2V_3}{10} = -8$$

$$\frac{-V_2 + 3V_3}{10} = -8$$

Multiplying "10" on both sides.

$$\cancel{10} \times \frac{-V_2 + 3V_3}{\cancel{10}} = -8 \times 10$$

$$-V_2 + 3V_3 = -80 \quad \text{——— (3)}$$

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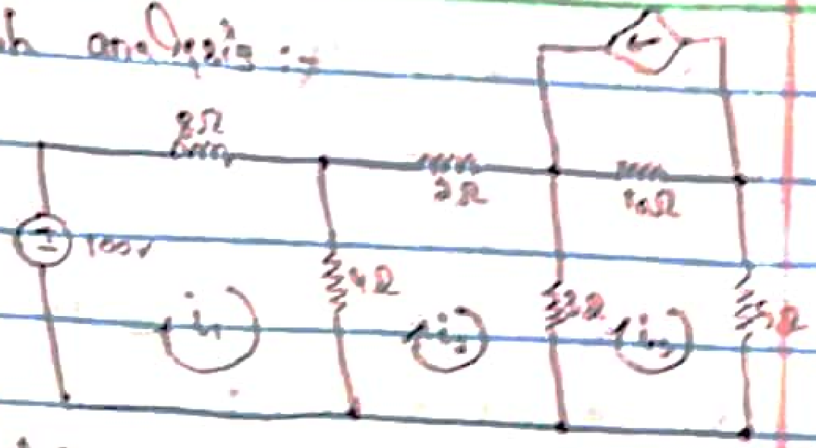
(ii) - Mesh analysis :-



Applying KVL on loop 1

$$8i_1 + 4(i_1 - i_2) = 100$$

$$8i_1 + 4i_1 - 4i_2 = 100$$

$$12i_1 - 4i_2 = 100 \quad \text{---- (1)}$$

Now:-

Applying KVL on loop 2

$$2i_2 + 4(i_2 - i_1) + 3(i_2 - i_3) = 0$$

$$2i_2 + 4i_2 - 4i_1 + 3i_2 - 3i_3 = 0$$

$$-4i_1 + 9i_2 - 3i_3 = 0$$

Again

Applying KVL on loop 3

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

$$3i_3 - 3i_2 + 10i_3 - 10i_x + 5i_3 = 0$$

As $i_x = 8$

$$-3i_2 + 18i_3 = -80 \quad \text{---- (3)}$$

Taking eq. in (1)

$$i_1 = \frac{4i_2 - 100}{12} \quad \text{---- (2)}$$

Date:

Taking equation (3)

$$-3i_2 + 18i_3 = -80$$

$$i_3 = \frac{-3i_2 + 80}{18} \quad \text{——— (b)}$$

Putting equation (a) and (b) in equation (2)

$$-4(0.33i_2 - 8.33) + 9i_2 - 3(0.16i_2 - 4.44) = 0$$

$$-1.32i_2 + 33.32 + 9i_2 - 0.48i_2 - 13.32 = 0$$

$$7.2i_2 = 20$$

$$i_2 = \frac{20}{7.2}$$

$$i_2 = 2.79\text{ A}$$

$$i_2 = I_x$$

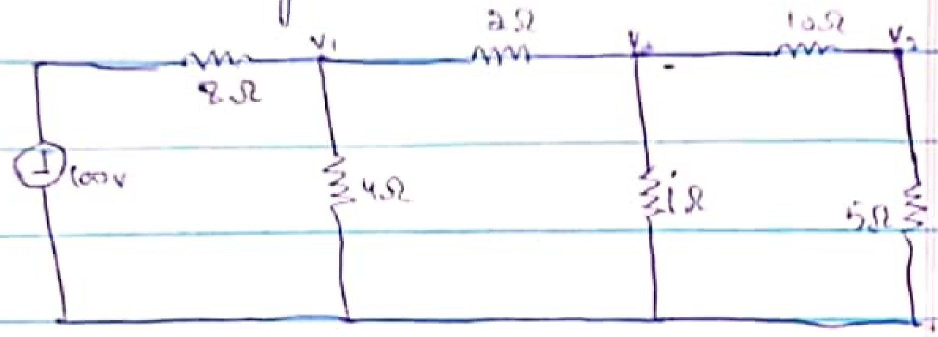
So,

$$\boxed{i_x = 2.79\text{ A}}$$

(iii)- Superposition Theorem:

First removing the current source i.e making it an open circuit

Re-drawing the circuit



Applying KCL on node 1n:

$$\frac{-100+V_1}{8} + \frac{V_1-V_2}{2} + \frac{V_1}{4} = 0$$

$$\frac{V_1 - 100 + 4V_1 - 4V_2 + 2V_1}{8} = 0$$

$$7V_1 - 4V_2 = 100 \quad \text{(1)}$$

Now:-

Applying KCL on node 2n:-

$$\frac{V_2-V_1}{2} + \frac{V_2}{3} + \frac{V_2-V_3}{10} = 0$$

So,

$$-30V_1 + 53V_2 - 3V_3 = 0 \quad \text{(2)}$$

CT

Again.

Applying KCL on node 3rd

$$\frac{V_3 - V_2}{10} + \frac{V_3}{5} = 0$$

$$\frac{V_3 - V_2 + V_3}{10} = 0$$

$$-V_2 + 2V_3 = 0 \quad \text{———} \quad (3)$$

Now taking eq (1)

$$7V_1 - 4V_2 = 100$$

$$7V_1 = 100 + 4V_2$$

Or

$$7V_1 = 4V_2 + 100$$

$$V_1 = \frac{4V_2 + 100}{7} \quad \text{———} \quad (a)$$

8

$$-V_2 + 3V_3 = 0$$

$$V_3 = \frac{1}{3}V_2 \quad \text{———} \quad (b)$$

By putting in eq (2)

$$-30(0.57V_2 + 14.28) - 4V_2 + 2(0.33V_2) = 0$$

$$-17.1V_2 - 428.4 - 4V_2 + 0.66V_2 = 0$$

$$20.44V_2 = 428.4$$

or

$$V_2 = \frac{428.4}{20.44}$$

$$\boxed{V_2 = 20.95}$$

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Put v_2 in eq ②

$v_1 = 2.31$

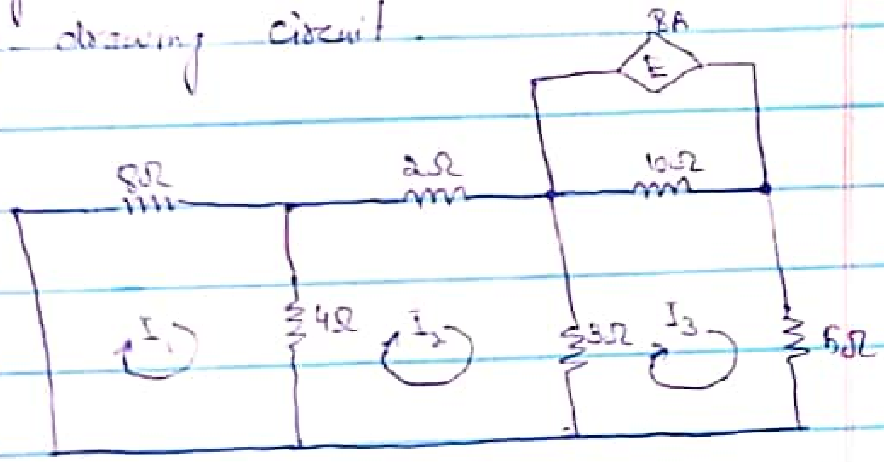
or $i_1 = \frac{2.31 + 20.95}{2}$

$i_1 = \frac{23.26}{2}$

$\boxed{i_1 = 11.63A}$.

Now removing voltage source & making it short circuit.

Re-drawing circuit.



$i_4 = 8A$.

Apply KVL on Loop 1

$8i_1 + 4(i_1 - i_2) = 0$

$8i_1 + 4i_1 - 4i_2 = 0$

$12i_1 - 4i_2 = 0$

$3i_1 - i_2 = 0$ ——— ①

Apply KVL on Loop 2.

$2i_2 + 3(i_2 - i_3) + 4(i_2 - i_1) = 0$.

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$2i_2 + 3i_2 - 3i_3 + 4i_2 - 4i_1 = 0$

$-4i_1 + 4i_2 - 3i_3 = 0$

$-4i_1 + 4i_2 - 3i_3 = 0$ ——— (3)

Now:

Applying KVL on Loop 3.

$10i_3 + 5i_3 + 3i_3 - 3i_2 + 8(10) = 0$

$-3i_2 + 18i_3 = -80$ ——— (3)

Taking equation (1)

$3i_1 - i_2 = 0$

$i_1 = 0.33\, i_2$ ——— (a)

Taking equation (3)

$-3i_2 + 18i_3 = -80$

$i_3 = \dfrac{3i_2 - 80}{18}$ ——— (b)

$-4(0.33 i_2) + 9i_2 - 3(0.16 i_2 - 4.44) = 0$

$1.32 i_2 + 9i_2 - 0.48 i_2 + 13.32 = 0$

$i_2 = 1.354$

Now:

$i_x = i_1 + i_2$

$i_x = 1.44 + 1.35$

$\boxed{i_x = 2.79\ A}$

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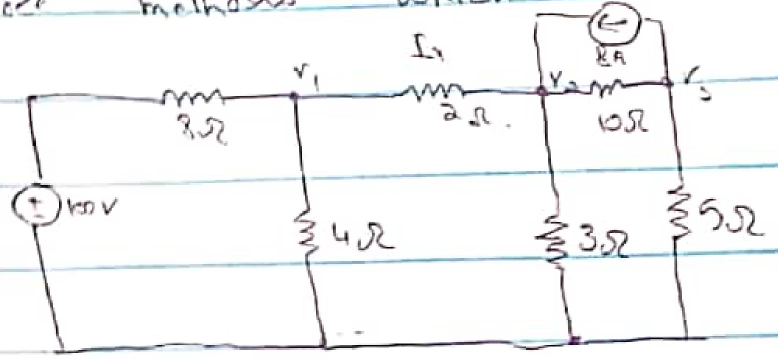
(iv) Compare the number of steps & degree of cosines of all the three methods which each other.



Applying KCL on node 1.

$$\frac{v_1 - 100}{3} + \frac{v_1}{4} + \frac{v_1 - v_2}{2} = 0$$

$$\frac{v_1 - 100 + 2v_1 + 4v_1 - 4v_2}{8} = 0$$

$$7v_1 - 4v_2 - 100 \quad \text{——} \quad (1)$$

now

Applying KCL node 2.

$$\frac{v_2 - v_1}{1} + \frac{v_2}{3} + \frac{v_2 - v_3}{18} = 8$$

$$\frac{30v_2 - 30v_1 + 20v_2 + 3v_2 - 3v_3}{60} = 8$$

Multiply "60" o.b.s

$$-30v_1 + 53v_2 - 3v_3 = 480 \quad \text{——} \quad (2)$$

Now:

Applying KCL on node 3.

$$\frac{V_3 - V_2}{10} + \frac{V_3}{5} = -8$$

$$\frac{V_3 - V_2 + 2V_3}{10} = -8$$

Multiplying "10" O.B.S

$$10 \times \frac{V_3 - V_2 + 2V_3}{10} = -8 \times 10$$

$$-V + 3V_2 = -80$$

Taking eq (1)

$$7V_1 - 4V_2 = 100$$

$$V_1 = \frac{4V_2 + 100}{7} \quad \text{—— (a)}$$

Taking eq (2)

$$-V_2 + 3V_3 = -80$$

$$V_3 = \frac{V_2 - 80}{3} \quad \text{—— (b)}$$

Putting (a) and (b) in eq (2)

$$-30(0.57V_2 + 14.28) + 53V_2 - 3(0.33V_2 - 26.67) = 480$$

$$-17.2V_2 - 428.4 + 53V_2 - 0.99V_2 - 80.01 = 48$$

$$34.91V_2 = 828.39$$

$$V_2 = \frac{828.39}{34.91}$$

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$V_2 = 20.31$

putting in eq (5)

$$V_2 = \frac{4(20.31) + 100}{7}$$

$V_2 = 25.84$

or

$$i_x = \frac{V_1 - V_2}{2}$$

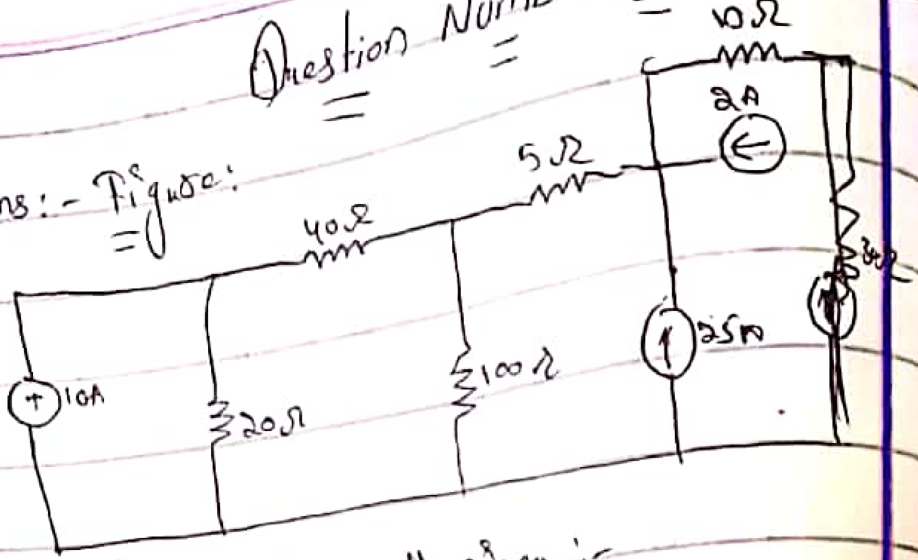
$$i_x = \frac{25.89 \quad 20.31}{2}$$

$$i_x = \frac{5.58}{2}$$

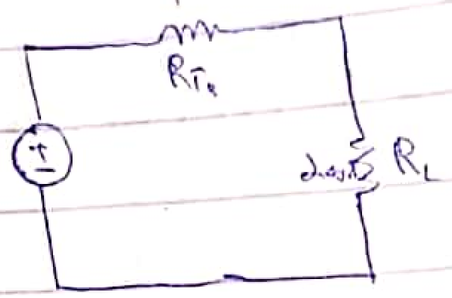
$$\boxed{i_x = 2.79 \quad \text{Ans}}$$

Question Number 2

Ans :- Figure:

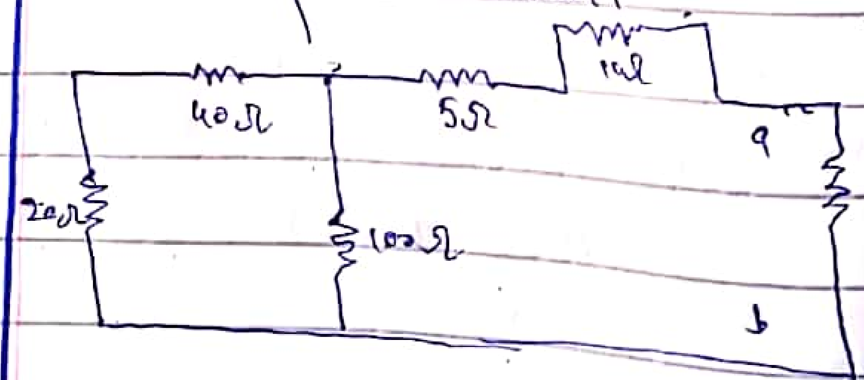


(1) Solving for thevinen :-



We will find R_{TH} for which we will remove all the current source by short circuit the load resistor.

Redrawing the circuit



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adding all resistor

$20 + 40 \parallel 100 + 5 + 10$

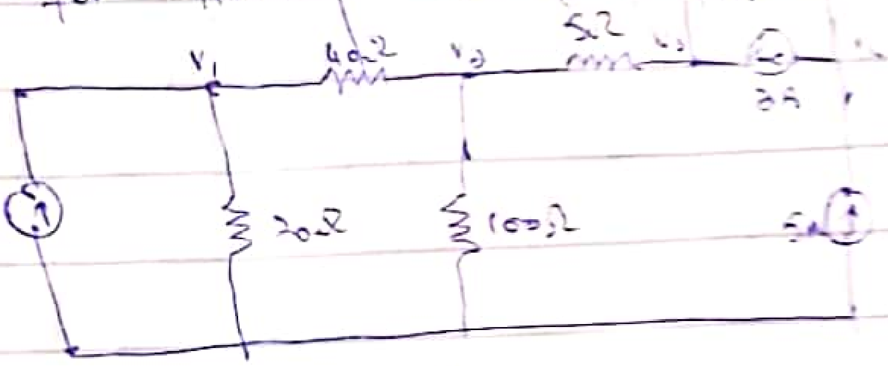
$60 \parallel 100 + 15$

$\frac{60 \times 100}{60 + 100} + 15$

$37.5 + 15$

$R_{TH} = 52.5$

For finding E_{TH} applying



applying KCL on V_1

$$\frac{V_1 - V_2}{40} + \frac{V_1}{20} = 10$$

$$\frac{V_1 - V_2 + 2V_1}{40} = 10$$

$$\frac{3V_1 - V_2}{40} = 10$$

$$3V_1 - V_2 = 400 \quad (1)$$

applying KCL on node 2.

$$\frac{V_2 - V_1}{40} + \frac{V_2}{100} + \frac{V_2 - V_3}{5}$$

$$\frac{50V_2 - 50V_1 + 20V_2 + 400V_2 - 400V_3}{2000}$$

$$-0.05 \quad \frac{-50V_1 + 70V_2 - 400V_3}{2000} = 0$$

$$-0.05V_1 + 0.035V_2 - 0.2V_3 = 0$$

Applying KCL on node (3)

$$\frac{V_3 - V_2}{5} + \frac{V_3 - V_4}{10} = 2.5 + 2$$

$$\frac{2V_3 - 2V_2 + V_3 - V_4}{10} = 4.5$$

$$-2V_2 + 3V_3 - V_4 = 45 \quad \text{--- (3)}$$

Applying KCL on node (4)

$$\frac{V_4 - V_3}{10} = 5 - 2.$$

$$V_4 - V_3 = 30 \quad \text{--- (4)}.$$

Solving them.

$V_1 = 275$

$V_2 = 124.9$

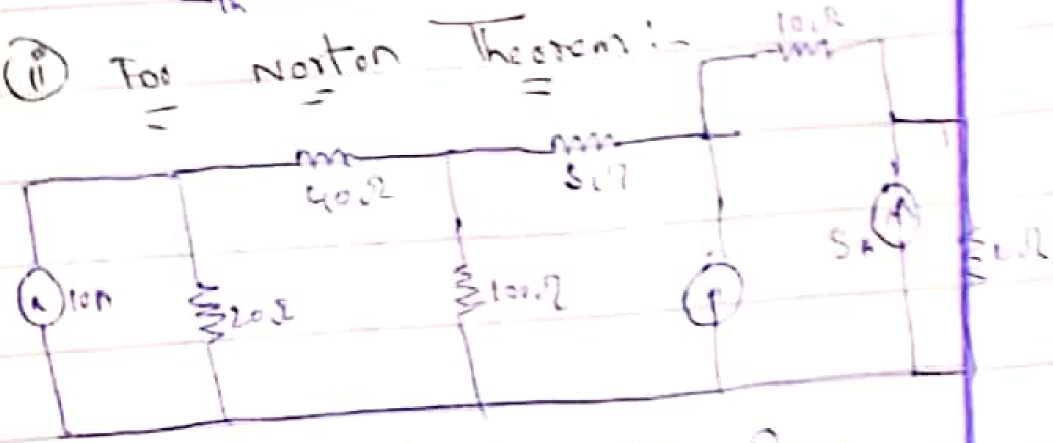
$V_3 = -87.5$

$V_4 = -57.5$

$$I_{Th} = \frac{5.1}{52.5+200}$$

$$I_{Th} = 0.02$$

(ii) For Norton Theorem :-



For R_N will be the same

$$R_N = R_{Th}$$

$$R_N = 52.5$$

find $I_n = \frac{V_{TH}}{R_N}$

$$I_n = 0.09.$$

As the circuit are same so, we find it directly.

(iii) Using thevin for finding power.

we know that

$$P = \left(\frac{V_{Th}}{R_{Th}+R_L}\right)^2 R_L$$

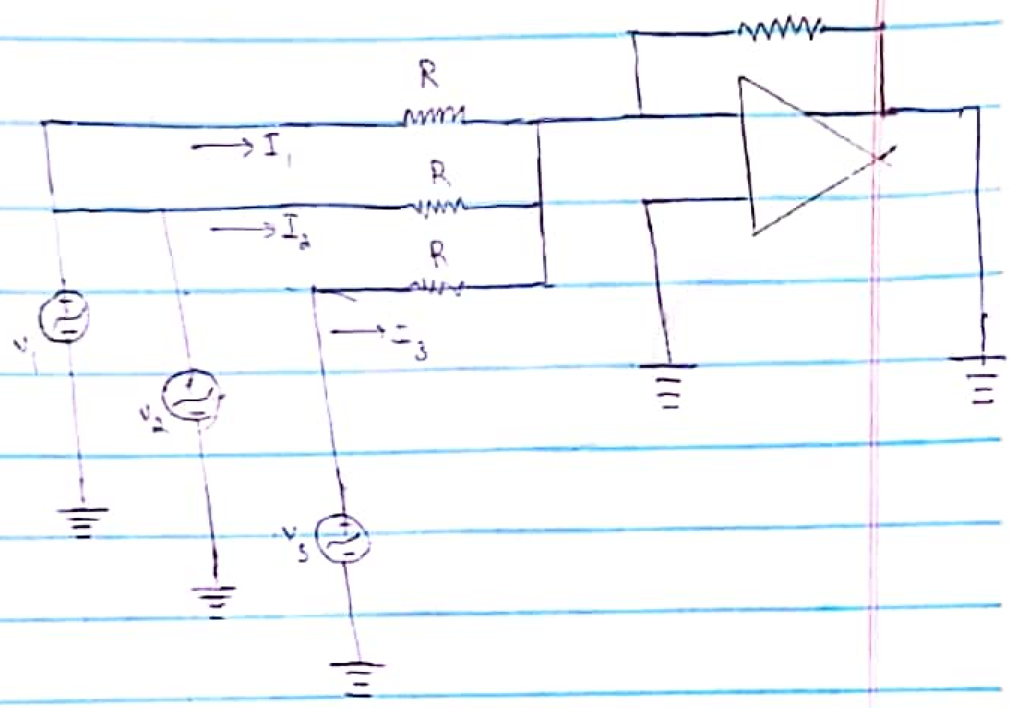
$$= \left(\frac{5.1}{52.5+200}\right)^2 200$$

$$\boxed{P = 0.08\,W}$$

Date:

Question Number 3

Obtain an expression for V_{out} in terms of v_1, v_2 and v_3 for amp circuit also known as a Summing amplifier.



Solution :-

The goal is the obtain an expression for V_{out} in terms of the inputs (v_1 : v_2 and v_3)

Since :-

No, current can flow into the inverting into terminal.

we can write

$$i = i_1 + i_2 + i_3$$

Therefore, we can write this following equation at the node labeled V_a

$$0 = \frac{V_a - V_{out}}{R_f} + \frac{V_a - V_1}{R} + \frac{V_a - V_2}{R} + \frac{V_a - V_3}{R}$$

As this equation contains both V_{out} and the input voltages but unfortunately it also contains the nodal voltage V_a

Now:-

we need to write an additional equation that related V_a to V_{out}, the initial voltages, R_f and R.

At this point we have not yet used ideal amp rule 2 and that we will almost certainly require the use of both rules when analyzing an op-amp circuit.

Thus,

Since $V_a = V_b = 0$

we can write following.

(17)

$$0 = \frac{V_{out}}{R_f} + \frac{V_1}{R} + \frac{V_2}{R} + \frac{V_3}{R}$$

by Re-arranging.

we obtain the following expression for V_{out}

$$V_{out} = -\frac{R_f}{R}(V_1 + V_2 + V_3)$$

In this Case, where $V_2 = V_3 = 0$

we see that our res.01 agrees, which was derived for essentially the same circuit.