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SUBJECT : LCA
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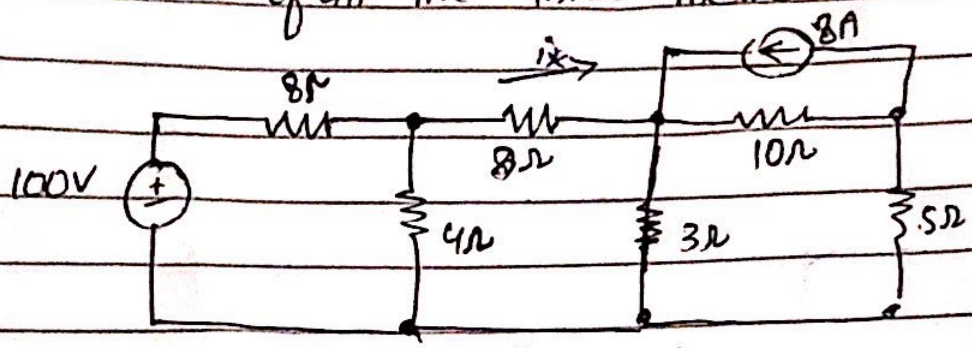
2ND Semester (final paper)

QUESTION #01

find the value of ix for the circuit using
i) Nodal Analysis
ii) Mesh Analysis
iii) superposition theorem
iv) Compare the number of steps and degree of easiness of all the three methods with each other.



Solution:- (i) Nodel analysis:

Apply KCL on node 1

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

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

$$7v_1-4v_2=100 \quad \text{— (1)}$$

Apply KCL on Node 2:

$$\frac{v_2-v_1}{2}+\frac{v_2}{3}+\frac{v_2-v_3}{18}=8$$

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

$-30V_1 + 53V_2 - 3V_3 = 480$ — (2)

Apply KCL on node 3

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

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

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

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

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

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

$$34.91V_1 = 828.39$$

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

$$\boxed{V_2 = 20.31}$$

putting in eq (a)

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

$$V_2 = 25.89$$

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

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

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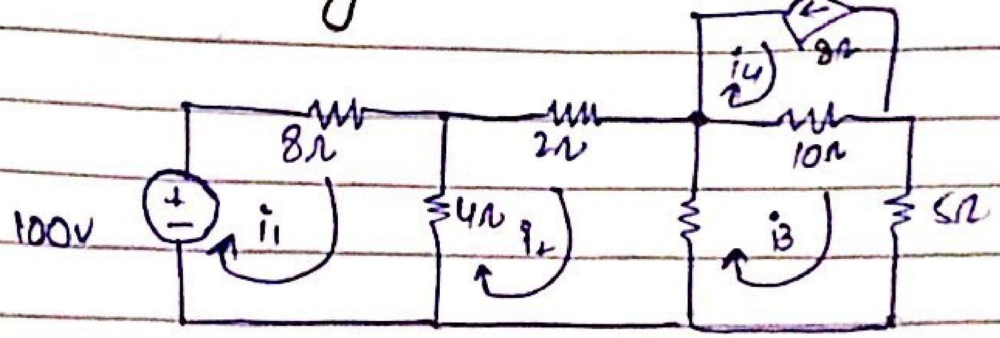
Mesh analysis:



Apply KVL on loop 1

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

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

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

Applying KVL on loop 2

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

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

$$-4i_1 + 9i_2 - 3i_3 = 0 \quad \text{—— (2)}$$

Apply KVL on loop 3

$$3(i_3 - i_2) + 10(i_3 - i_4) + 5i_3 = 0$$

$3i_3 - 3i_2 + 10i_3 - 10i_4 + 5i_3 = 0$

As $i_4 = 8$

$-3i_2 + 18i_3 = -80$ — (3)

Taking eq (1)

$i_1 = \frac{4i_2 - 100}{12}$ — (a)

Taking eq (3)

$-3i_2 + 18i_3 = -80$

$i_3 = \frac{-3i_2 + 80}{18}$ — (b)

putting eq (a) and (b) on eq (2)

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

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

$7.2i_2 = +20$

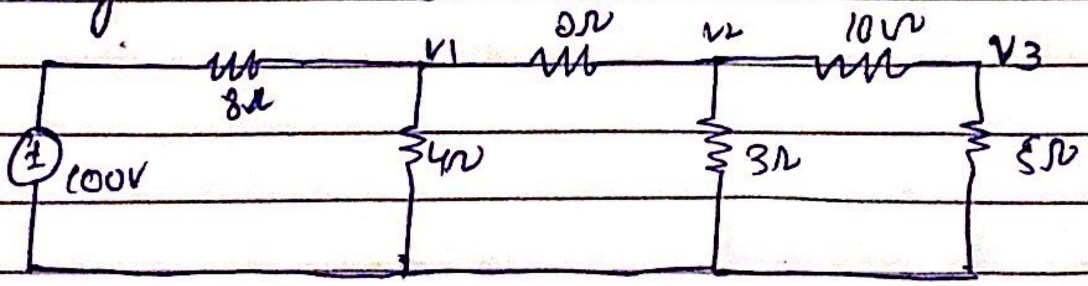
$\Rightarrow i_2 = 20/7.2$

$\Rightarrow i_2 = i_x$

$\Rightarrow i_2 = 2.79A$

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

iii) Superposition Theorem:-
First we remove the current source and then making it an open circuit Re drawing the circuit.



Apply KCL on node 1

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

$$\frac{V_1-100+4V_1-4V_1+2V_3}{8} = 0$$

$$7V_1 - 4V_2 + 100 \longrightarrow ①$$

Apply KCL on node 2:

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

$$-30V_1 + 53V_2 - 3V_3 = 0$$

Apply kcl on node 3

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

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

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

Now Taking eq (1) and (3)

$$7V_1 - 4V_2 = 100$$

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

Now $-V_2 + 3V_3 = 0$

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

putting on eq (2)

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

$$-17.1V_2 - 428.4 - 4V_2 + 0.00V_2 = 0$$

$$V_2 = -20.95$$

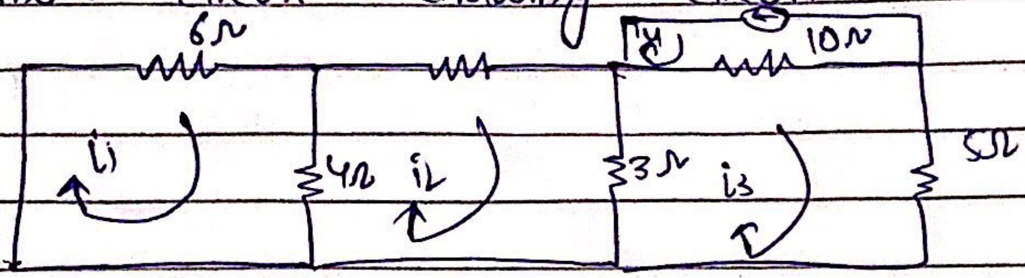
putting in eq (a)

$$v_2 = 2.31$$

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

$$i_1 = 11.63$$

Now removing voltage source and making it short circuit Re-drawing circuit.



$i_4 = 8A \Rightarrow$ Apply KVL on loop 1

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

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

$$12i_1 - 4i_2 = 0$$

$$3i_1 - i_2 = 0 \quad \text{---} \quad (1)$$

Apply KVL on loop 2

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

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

$$-4i_1 + i_2 - 3i_3 = 0 \quad \text{---} \quad (2)$$

Apply KVL on loop 3

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

$$-3i_2 + 18i_3 = -80 \longleftarrow (3)$$

Taking eq (1)

$3i_1 - i_2 = 0$

$i_1 = 0.33 i_2$ — (a)

Taking eq (3)

$-3i_2 + 18i_3 = -80$

$i_3 = \frac{3i_2 - 80}{18}$ — (b)

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

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

$i_2 = 1.354$

Now $i_x = i_1 + i_2$

$i_x = 1.44 + 1.35$

$i_x = 2.79A$

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

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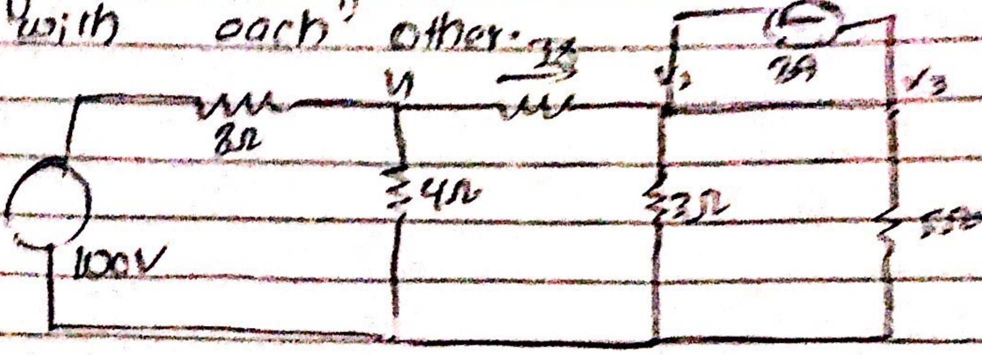
compare the number of steps and degree of easiness of all the three methods with each other:



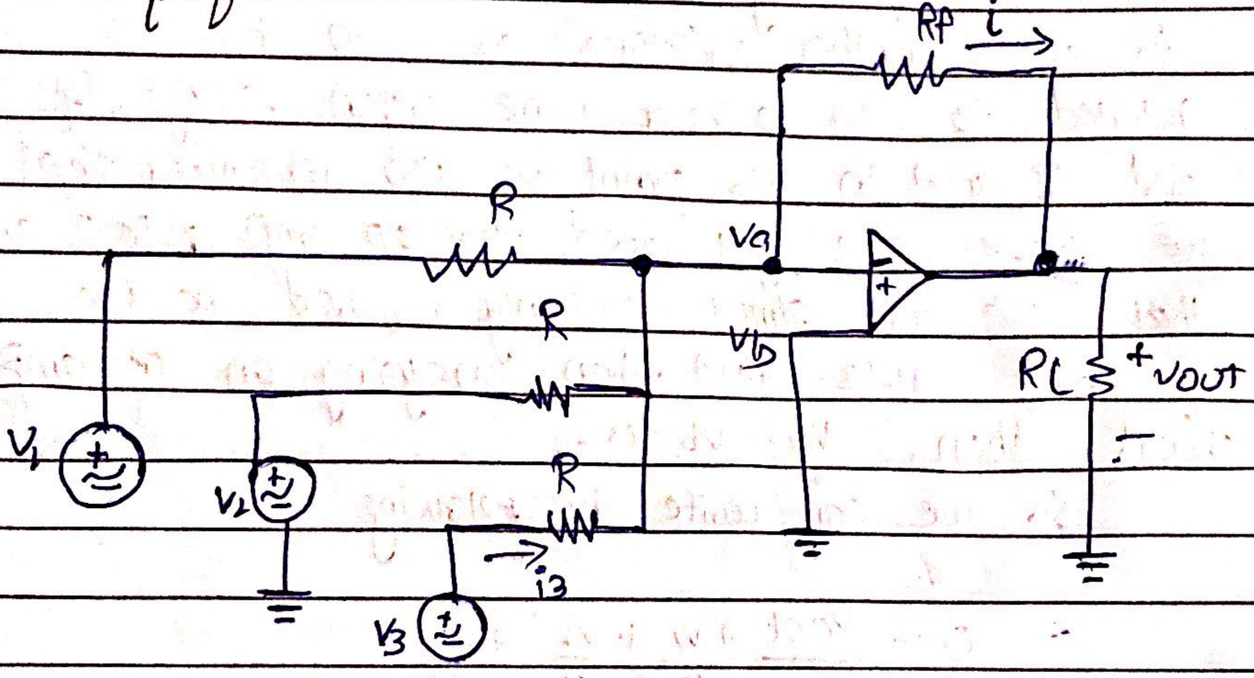
The number of steps in nodal and mesh analysis are almost equal ~~but~~ in superposition the number of mesh and nodal analysis.

Degreee of easinesn:

According to opinion mesh analysis is easyer then nodel analysis and superposition theorem.

Question #03

Obtain an expression for Vout in terms of V_1, V_2 and V_3 for the op amp circuit in figure, also known as a summing amplifier.



In this simple summing amplifier circuit, the output voltage (Vout) now becomes proportional to the sum of input voltages V_1, V_2, V_3 etc.

Now,

$$i = i_1 + i_2 + i_3$$

so we can write the following equation at the node labeled Va:

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

This all equation contains both input voltages and Vout voltage. ~~but~~ also contain another voltage that is nodal voltage Va. To remove this unknown quantity from our expression, we need to write another additional equation that is related to Va to Vout & the input voltage, Rf and R and In this point we also remember that we have not yet used ideal op amp rule 2, and that we will almost certainly required the use of both rules. And when analyzing an op amp circuit then. $V_a = V_b = 0$.

So we can write the following

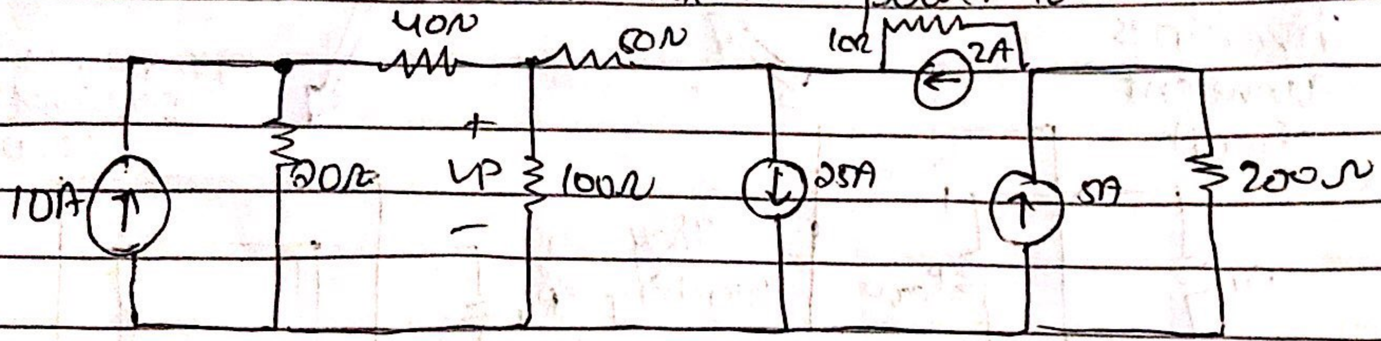
$$0 = \frac{V_{out}}{R_f} + \frac{V_1}{R} + \frac{V_2}{R} + \frac{V_3}{R}$$

from Rearranging, we obtain the following expression for Vout:

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

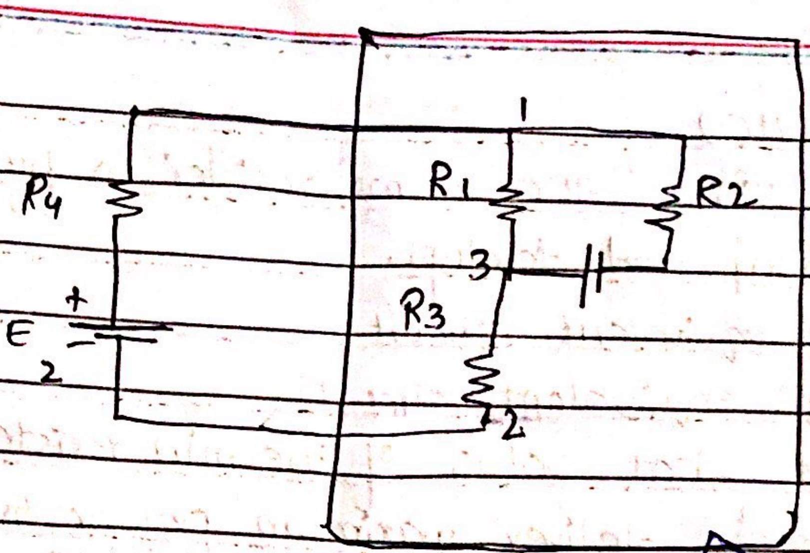
In this special case $V_2 = V_3 = 0$ we see that this equation was derived essentially the sam circuit.

Question #02
consider the 200 ohms resister in figure as load resistor and develop.
i) Thevinin equivalent circuit
ii) Norton equivalent circuit
iii) find out what value of thevinin resistance should be used deliver maximum power to the load.



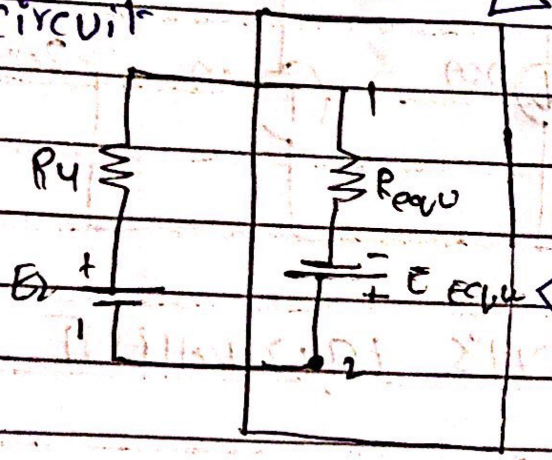
THEVENIN'S AND NORTON'S EQUIVALENT TUTORIAL:

Thevenin's theorm states that we can replace entire network by an equilalent circuit is an independent current source in parallel with an impedance (resistor).
Therefore, the Norton equivalent circuit is a source transformation of the thevenin equivalent circuit.



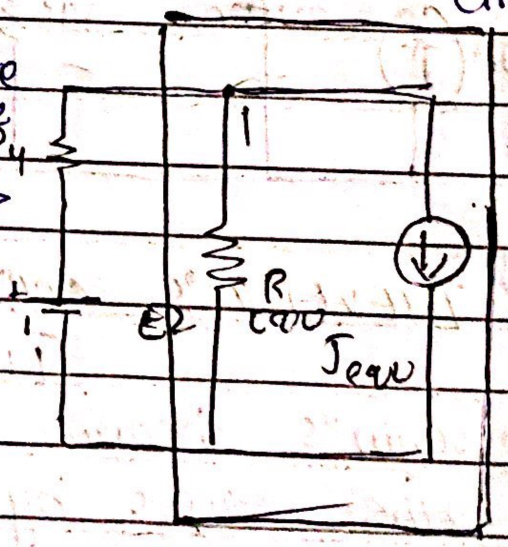
Orignal circuit

Thevenin's equivalent circuit



They are Interchangeable

Norton's equivalent circuit.



How to find Thevenin's equivalent circuit.

If the circuit contains	you should do
Resistors and independent sources.	1) connect an open circuit b/w a and b. 2) find the voltage across the open circuit which is $V_{oc} = V_{th}$. 3) Deactivate the independent sources voltage source → open circuit. current source → short circuit.
Resistors and dependent sources or independent shores.	1) connect an open circuit b/w a and b 2) find the voltage across the open circuit which Voc. $V_{oc} = V_{th}$. If there are both dependent and independent sources. 3) connect a short circuit b/w a and b. 4) Determine the current b/w a and b. 5) $R_{th} = V_{oc} / I_{ab}$
	If there only dependent sources. 2) connect 1 Ampere current source flowing from terminal b to a. $I_t = 1[A]$ 4) Then $R_{th} = V_{oc} / I_t = V_{oc} / I$