Basic Electrical Engineering (TEE 101)

Lecture 13: Numerical on Theorems

Content

This lecture covers Numerical on :

- Superposition Theorem
- Thevenin’s Theorem
- Norton’s Theorem

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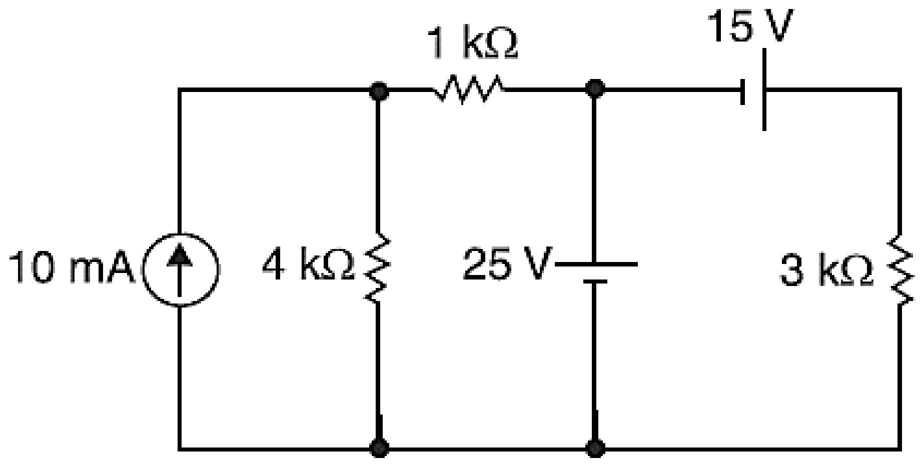
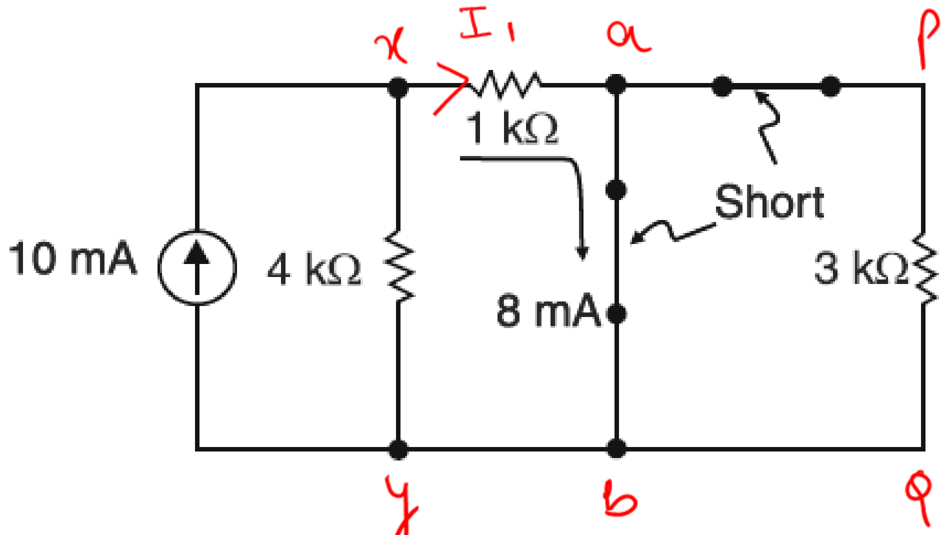
Lecture 13(a): Numerical on Superposition theorem

Using the superposition theorem, find the current through 1k Ω resistor in Figure shown below. Assume the sources to be ideal.





Step 1: The current through 1kΩ resistor due to **current source**

The current through 1kΩ resistor due to **current source acting alone** is found by replacing 25-V and 15-V sources by short circuit

Let the current through 1kΩ resistor due to **current source acting alone** is I_1

Apply current division rule at J^n x we get

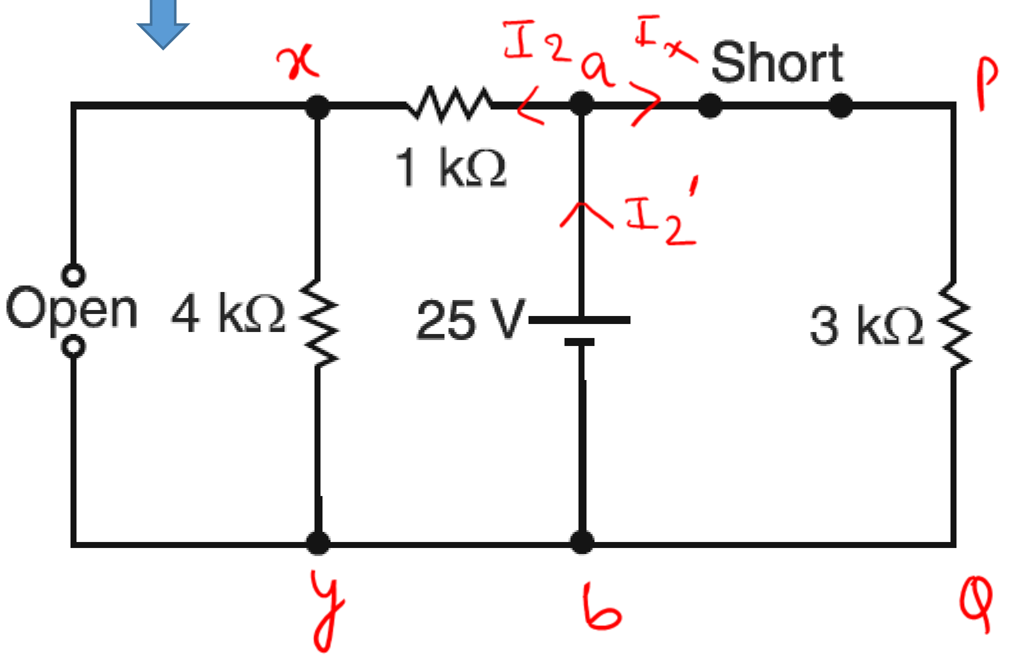
$$I_1 = \frac{10\,mA \times 4k\Omega}{4k\Omega + 1k\Omega} = 8 \times 10^{-3} A$$

$I_1 = 8mA$ [from x → a]

Step 2: The current through 1kΩ resistor due to **25 V source**

The current through 1kΩ resistor due to due to **25 V source acting alone** is found by replacing the 10 mA current source by an open circuit and 15 V source by a short circuit

Let the current through 1kΩ resistor due to 25V **voltage source acting alone** is I_2



Let the net current by 25 V source is I_2'.

apply current division rule at Jn "a"

$$I_2 = \frac{I_2' \times 3k\Omega}{4k\Omega + 1k\Omega + 3k\Omega} = \frac{3I_2'}{8}$$

Now, we have to calculate I_2'

$$I_2' = \frac{25V}{R_{eq}}$$

$$R_{eq} = (4k\Omega + 1k\Omega) \| 3k\Omega$$

$$R_{eq} = 5k\Omega \| 3k\Omega$$

$$R_{eq} = \frac{15}{8} k\Omega$$

hence I_2' is

$$I_2' = \frac{25}{15} \times 8 \times 10^{-3} A$$

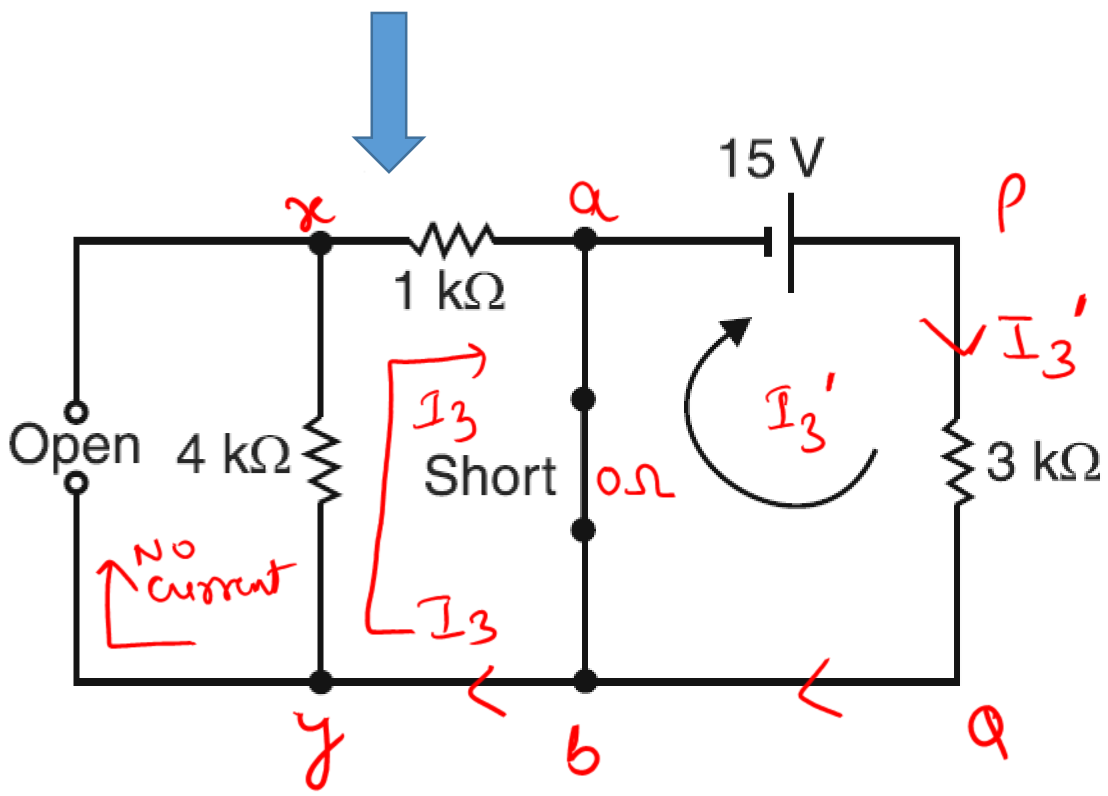
$$I_2' = \frac{40}{3} mA$$

So; the value of I_2 is 5mA (from $a \to x$)

Step 3: The current through 1kΩ resistor due to **15 V source**

The current through 1kΩ resistor due to due to **15 V source acting alone** is found by replacing the 10 mA current source by an open circuit and 25 V source by a short circuit

Let the current through 1kΩ resistor due to 15V **voltage source acting alone** is I_3



In this case the current (I_3) through 1KΩ resistor can be calculated as:
apply C.D.R at J^n "b" we get

$$I_3 = \frac{I_3' \times 0}{4K\Omega + 1K\Omega + 0} = 0$$

i.e $I_3 = 0$, hence the current will not flow through 1KΩ resistor.

So, as per the Superposition theorem the net current through 1KΩ R is

$= 8mA - 5mA + 0$

$= 3mA$ Answer

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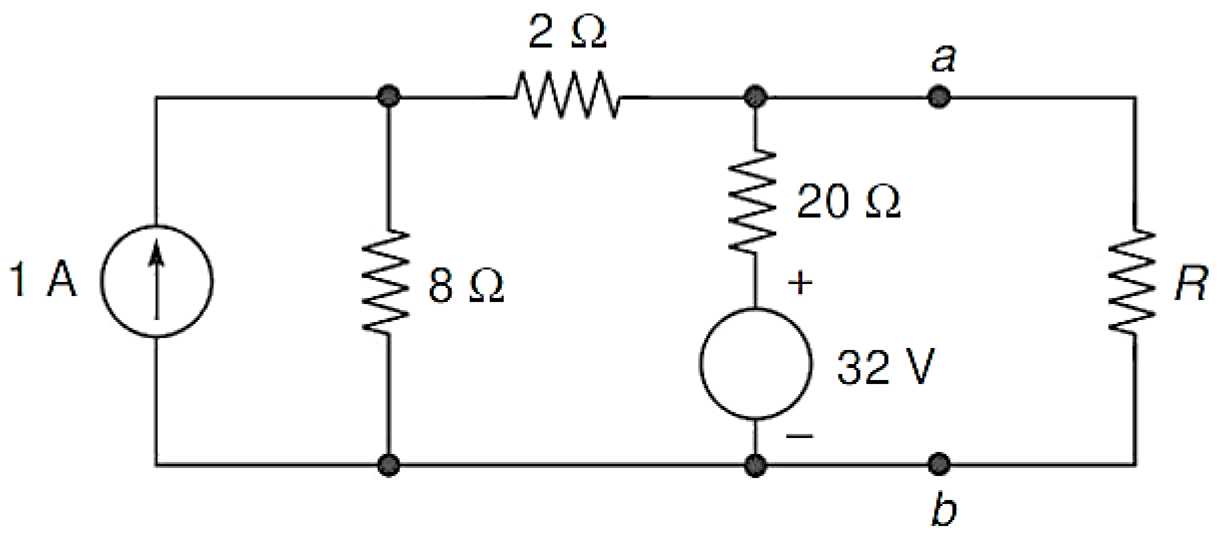
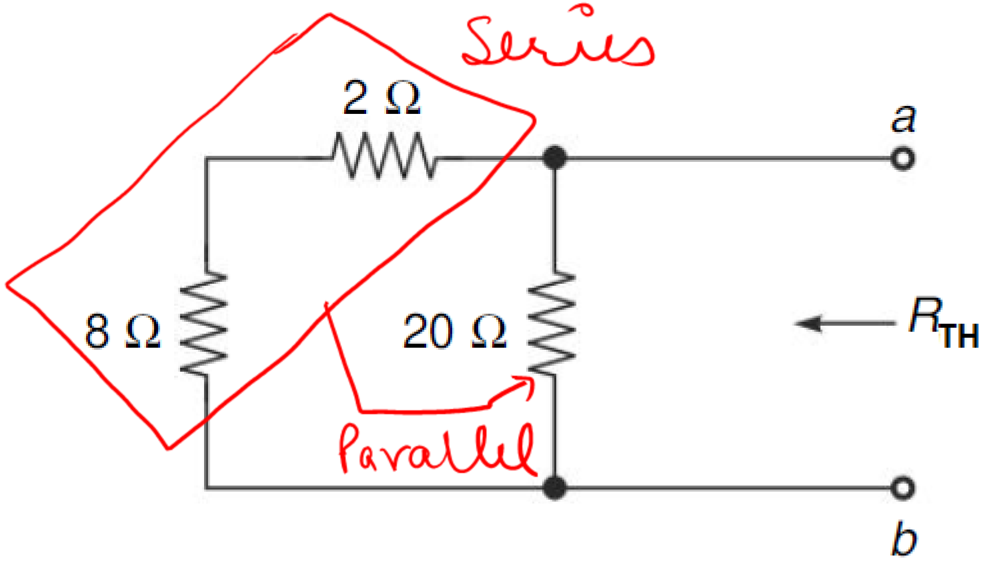
Lecture 13(b): Numerical on Thevenin's Theorem

Find the Thevenin's equivalents of the circuit of Figure shown below, as seen at terminal ab, and hence calculate the load current (I_L) **(Assume R = 10 Ω)**



(1) Calculate the Thevenin's Resistance (R_{TH})

(a) Thevenin's Resistance (R_{TH}) can be calculated by replacing the 1A current source with open path and 32V source with short path.



(b) R_{Th} is calculated by removing the load and making the load terminals open.

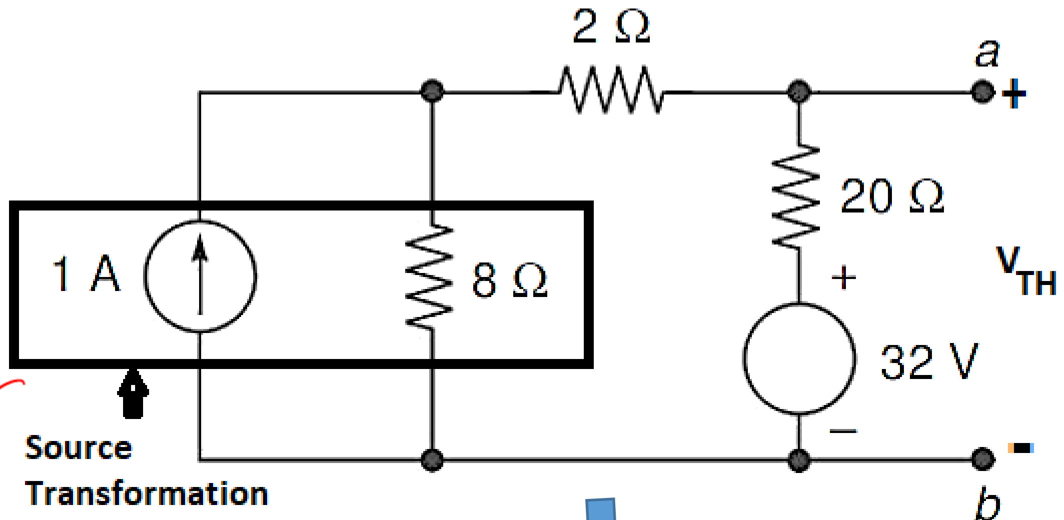
$$R_{Th} = (8\Omega + 2\Omega) \| 20\Omega$$
$$= 10\Omega \| 20\Omega = \frac{200}{30}\Omega$$

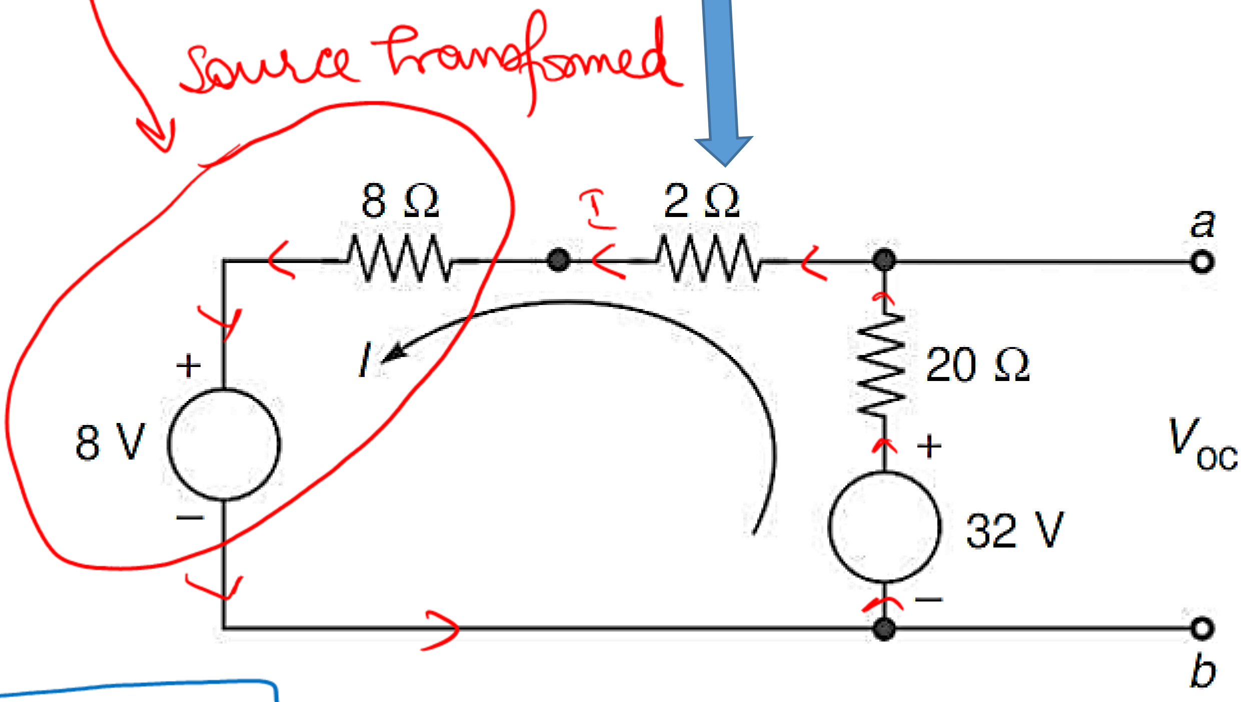
$$\boxed{R_{Th} = \frac{20}{3}\Omega}$$

(2) Calculate the Thevenin's Voltage (V_{TH})

Remove load resistance R causing open-circuit at ab.

Replace 1A source and 8X resistance in parallel with it by its equivalent voltage source.





$V_{oc} = V_a - V_b$, or

$V_{oc} = V_x - V_y$

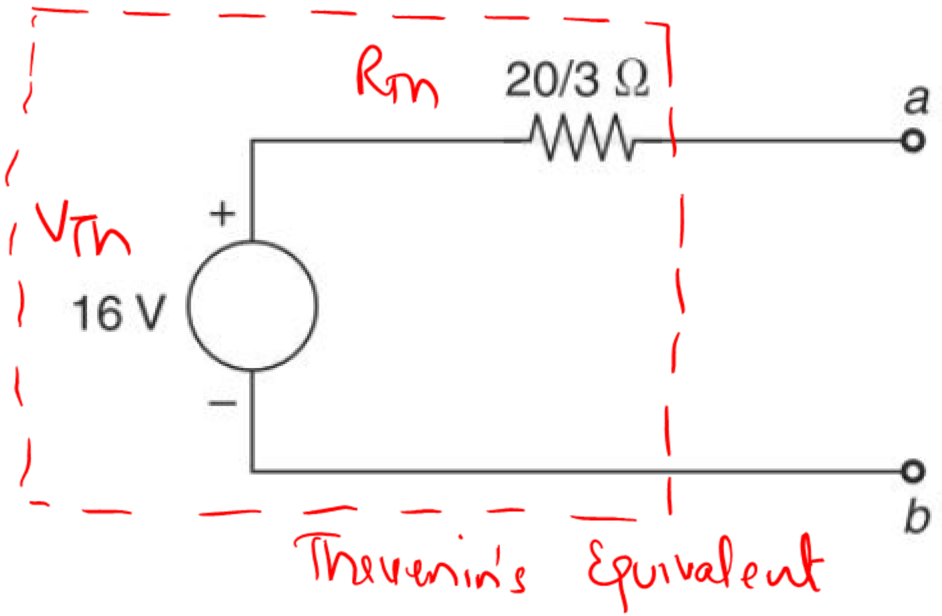
$V_x - V_y = 32 - 20I$ —— ①

$I = \dfrac{32-8}{8+2+20} = \dfrac{24}{30} = 0.8\,A$

$V_x - V_y = 32 - 20 \times (0.8) = 32 - 16$

$V_x - V_y = 16V$ or $\boxed{V_{oc} = 16\,V}$

(3) Draw the Thevenin's Equivalent



Load current, I_L is calculated as :→

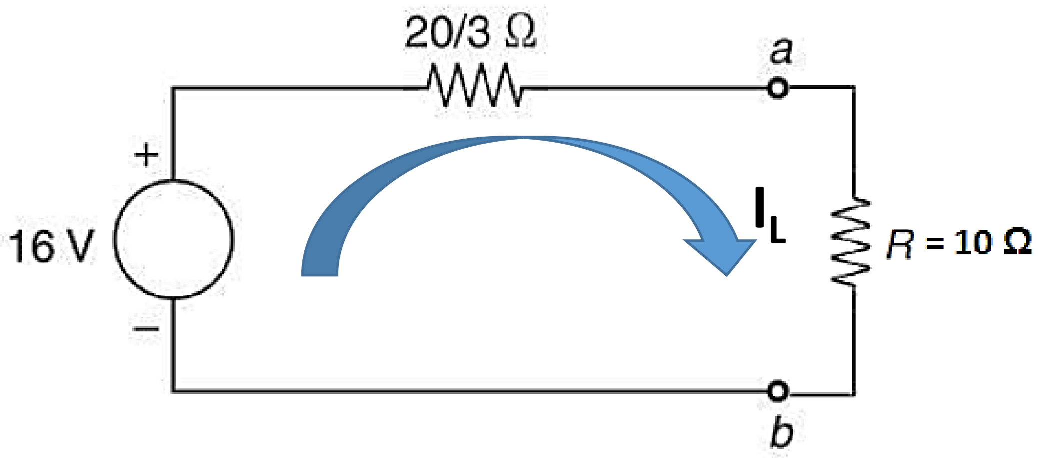
$$I_L = \frac{V_{Th} \text{ (or } V_{oc})}{R_{Th} + R_L}$$

$$= \frac{16}{\frac{20}{3} + 10} = \frac{16 \times 3}{20 + 30}$$

$$\boxed{I_L = \frac{48}{50} \text{ A}}$$

Answer

(4) Calculate the load current (I_L)



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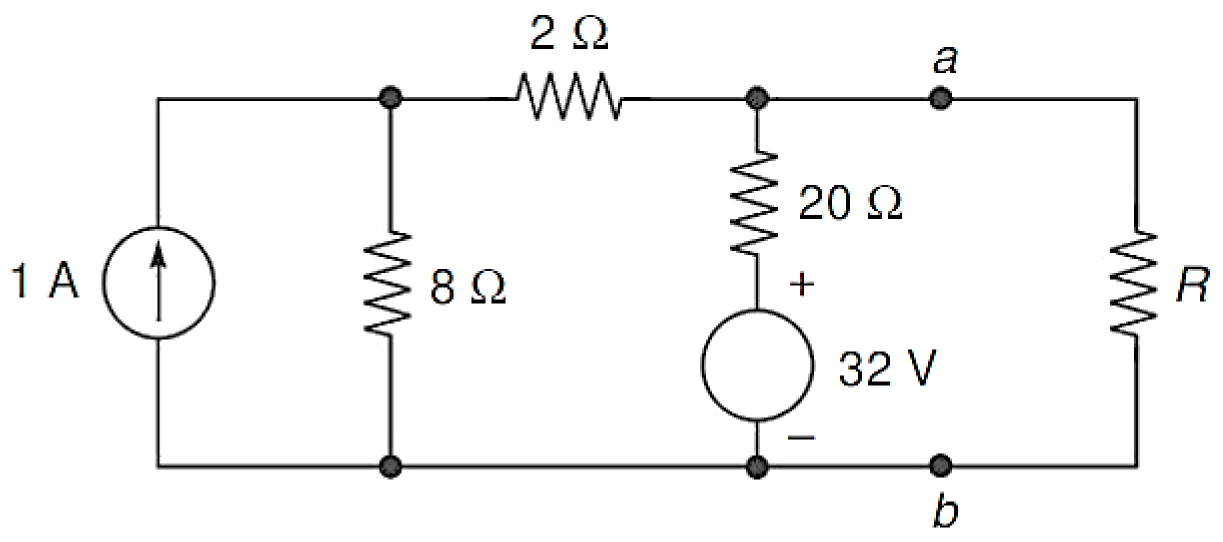
Lecture 13(c): Numerical on Norton's Theorem

Find the Norton's equivalents of the circuit of Figure shown below, as seen at terminal ab, and hence calculate the load current (I_L) **(Assume R = 10 ohm)**



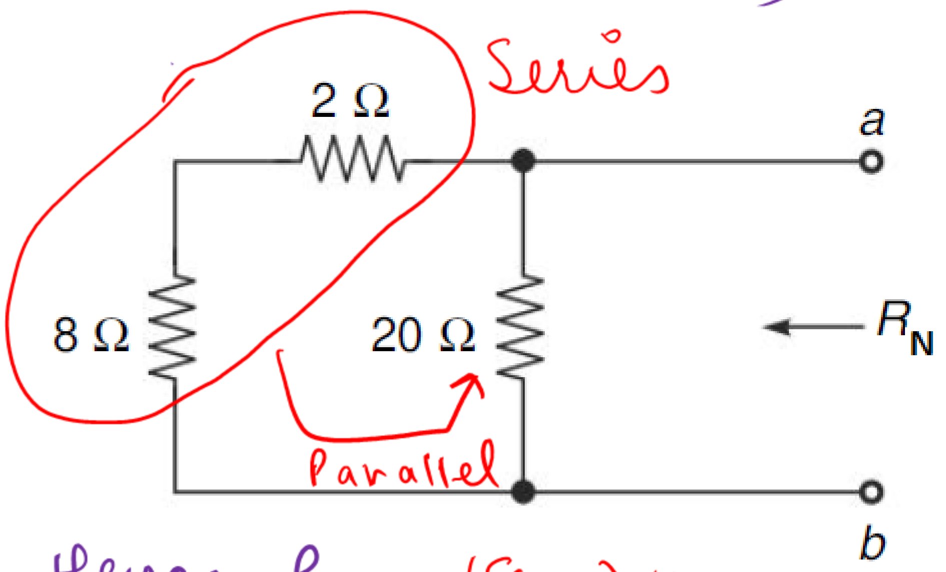
To obtain the Norton's Equivalent of the given network we need:

⇒ Norton's Resistance (R_N), and

⇒ Norton's Current (I_N)

(1) Calculate the Norton's Resistance (R_N)

Norton's Resistance (R_N) can be calculated by replacing the 1A current source with open path and 32V source with short path.



R_N is calculated in the similar manner as R_{th} is calculated.

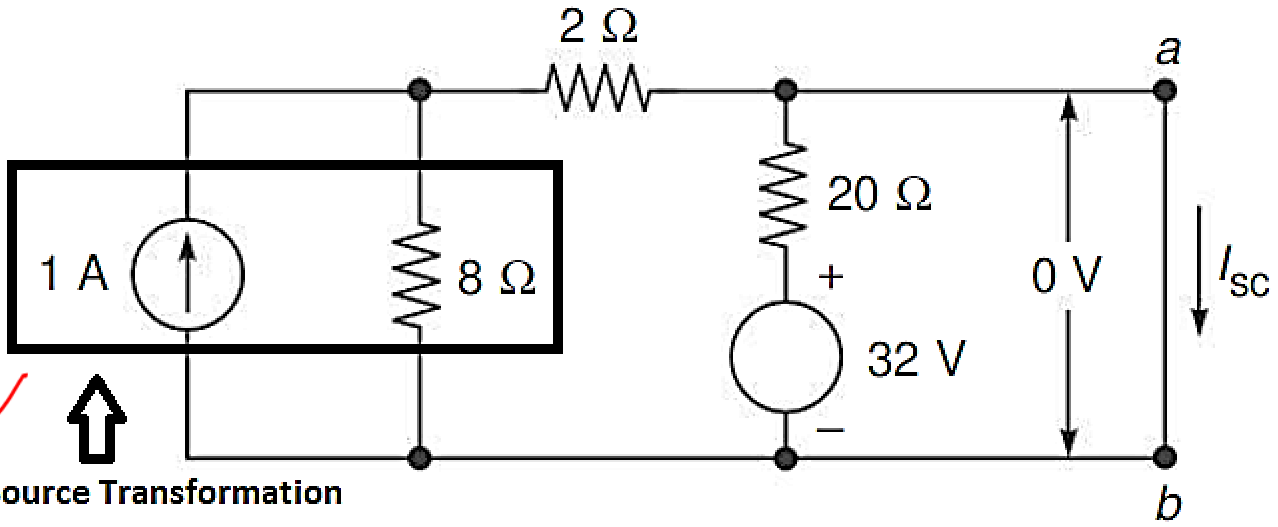
Hence, $R_N = (8+2) \| 20$

$R_N = 10 \| 20 = \frac{200}{30} = \frac{20}{3}\ \Omega$

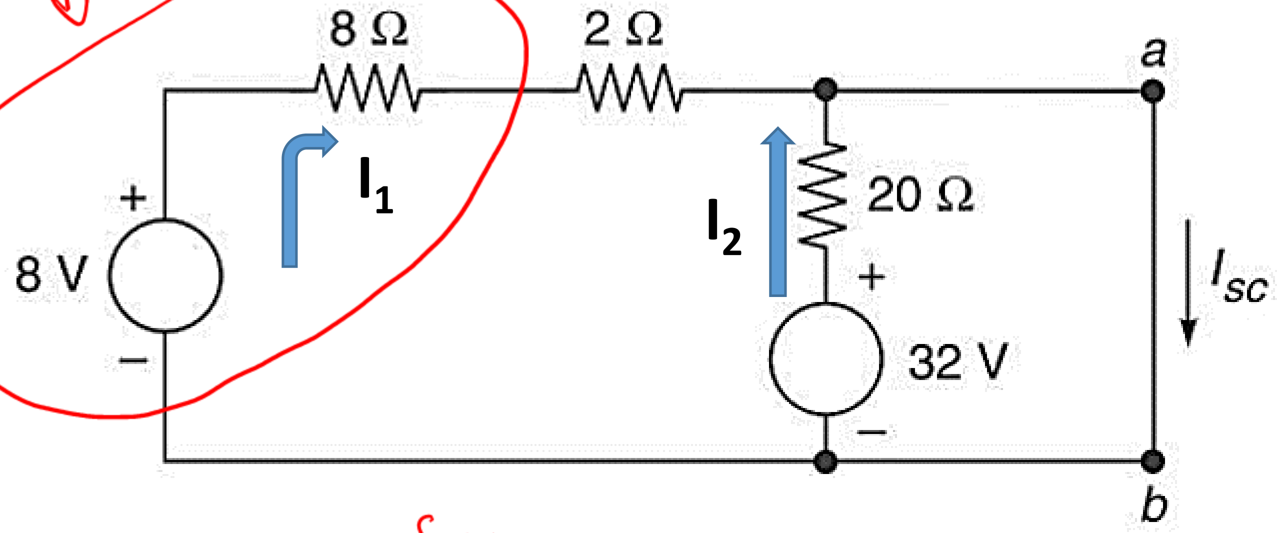
(2) Calculate the Norton's Current (I_N)

Remove load resistance R causing open-circuit at ab.

Replace 1A source and 8X resistance in parallel with it by its equivalent voltage source.



Source transformed



I_{sc} ⇒ short circuit current (also known as Norton's current I_N)

I_1 is current due to 8V source

I_2 " " " " 32V "

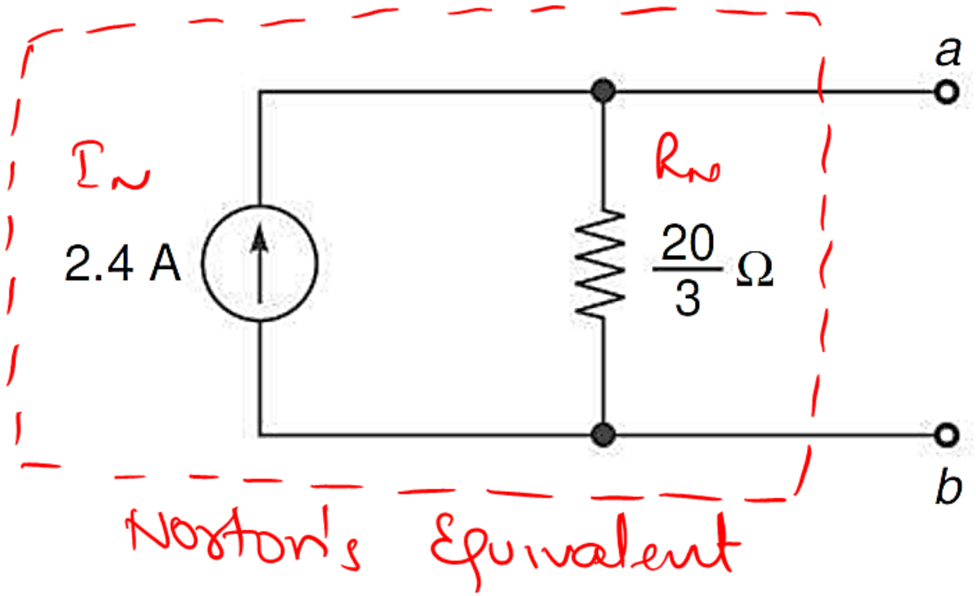
Both currents will flow in path a-b as I_{sc} because this branch has ZERO Resistance. Hence

$I_{sc} = I_1 + I_2$; $I_1 = \frac{8}{10} = 0.8\ A$; $I_2 = \frac{32}{20} = 1.6\ A$

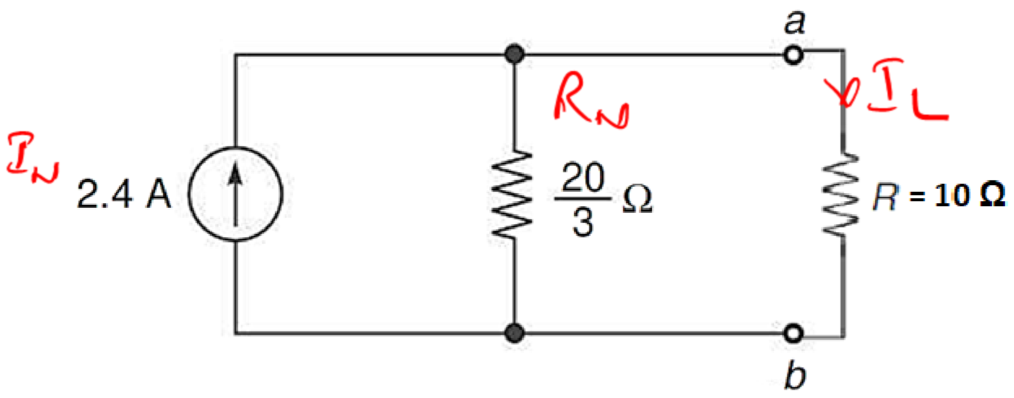
So; $I_{sc} = 0.8 + 1.6$

$I_{sc} = 2.4\ A$

(3) Draw the Norton's Equivalent



(4) Calculate the load current (I_L)



Load current, I_L is

$$I_L = \frac{I_N \times R_N}{R_N + R_L}$$

$$I_L = \frac{2.4 \times \frac{20}{3}}{\frac{20}{3} + 10} = \frac{(48/3)}{(50/3)}$$

$$\boxed{I_L = \frac{48}{50}\ \text{A}}$$ Answer.

Thank You