- Various techniques, all based upon Kirchhoff's law, are used for the circuit analysis

- The main techniques are :
  - Superposition Theorem
  - Thevenin's Theorem
  - Norton's Theorem
  - Maximum Power Transfer Theorem

- Each of these techniques have strengths aimed at solving particular types of circuit problem.

- Superposition Theorem :

→ It helps us to analyze a linear circuit with more than one independent sources.

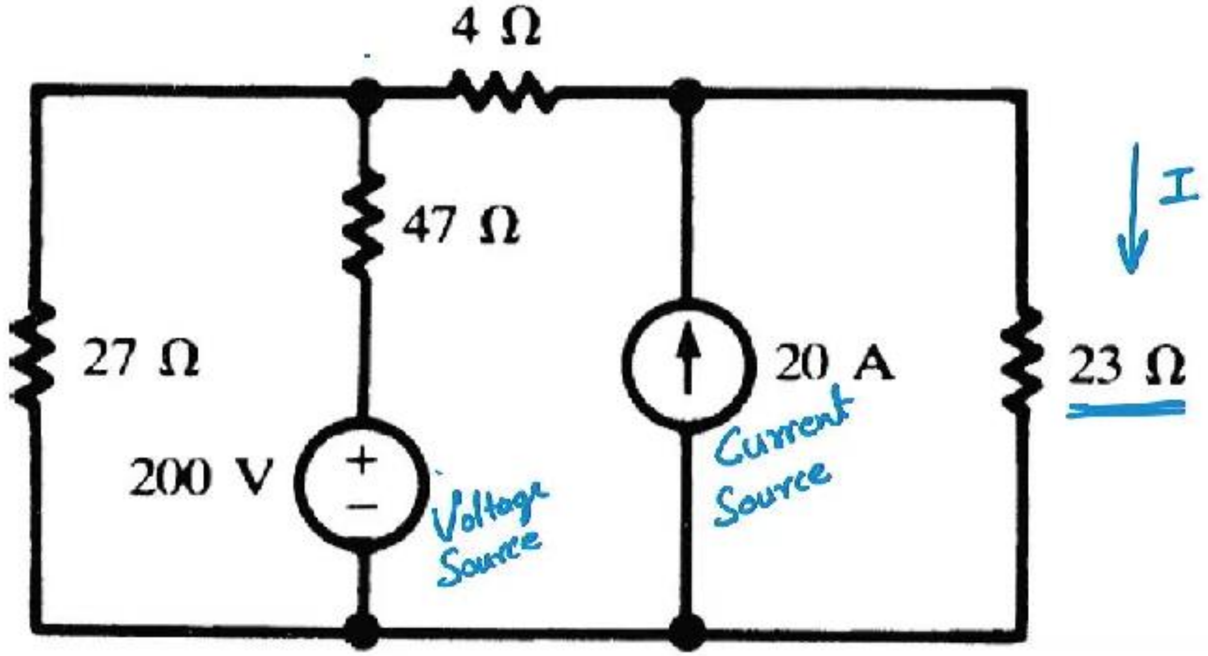
→ The output of a circuit is determined by summing the individual responses of each independent sources.

→ The idea of superposition rests on the linearity property.

→ It is the property of an element describing a linear relationship between cause and effect.

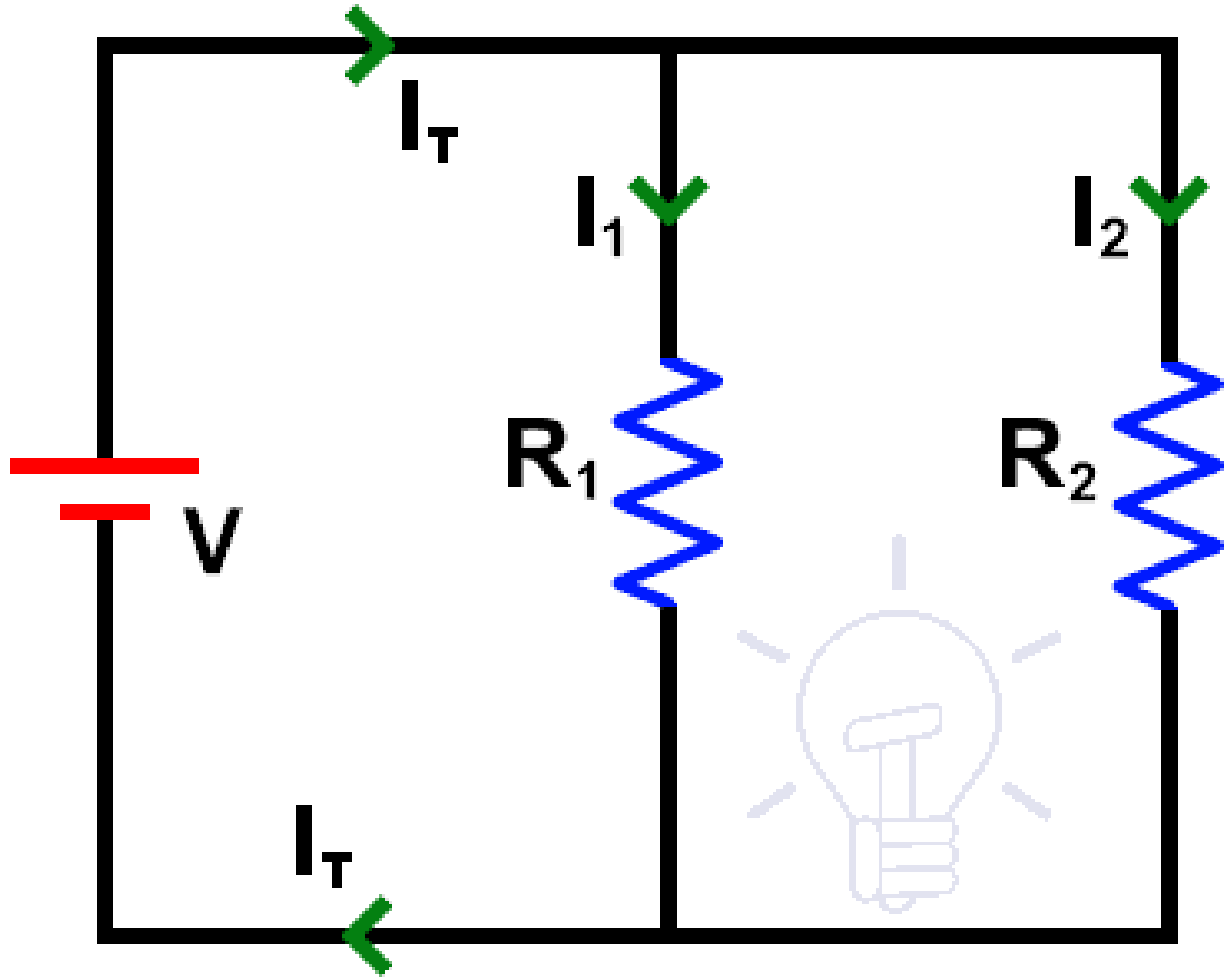
Example :

Calculate the current in 23 Ω resistor.



NPTEL

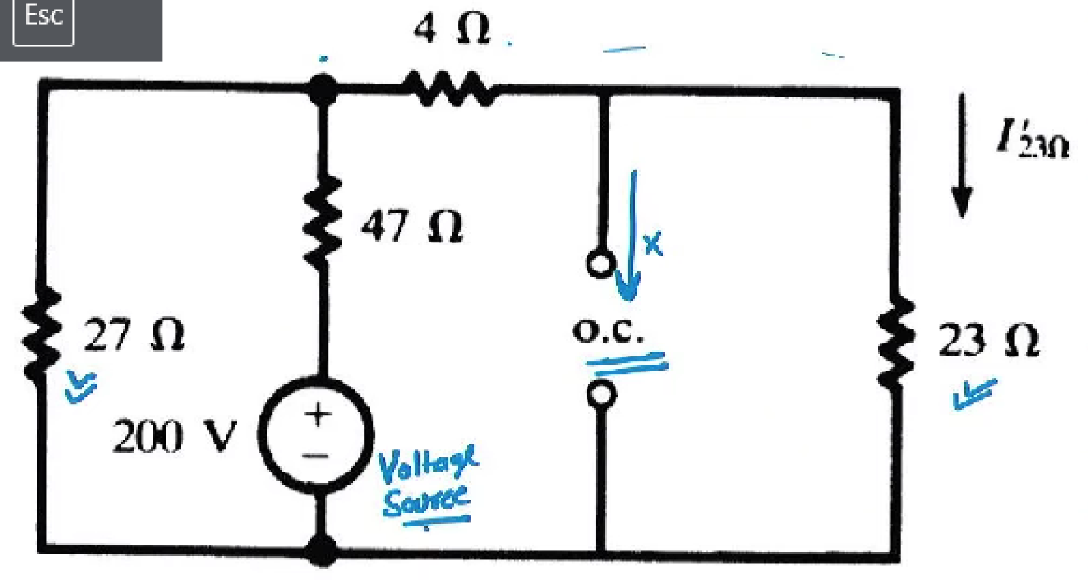
Current Divider Rule "CDR" Calculator



$$\boxed{I_1 = I_T \frac{R_2}{R_1 + R_2}}$$

$$\boxed{I_2 = I_T \frac{R_1}{R_1 + R_2}}$$

Step. 1 : Take Voltage source



$$R_{eq} = 47 + \frac{(27)(4+23)}{27+4+23} = 60.5\,\Omega$$

$$I_T = \frac{200}{60.5} = 3.31 \text{ Amp}$$

$$I'_{23\Omega} = \left(\frac{27}{54}\right) \times 3.31$$

$$= 1.65 \text{ Amp.}$$

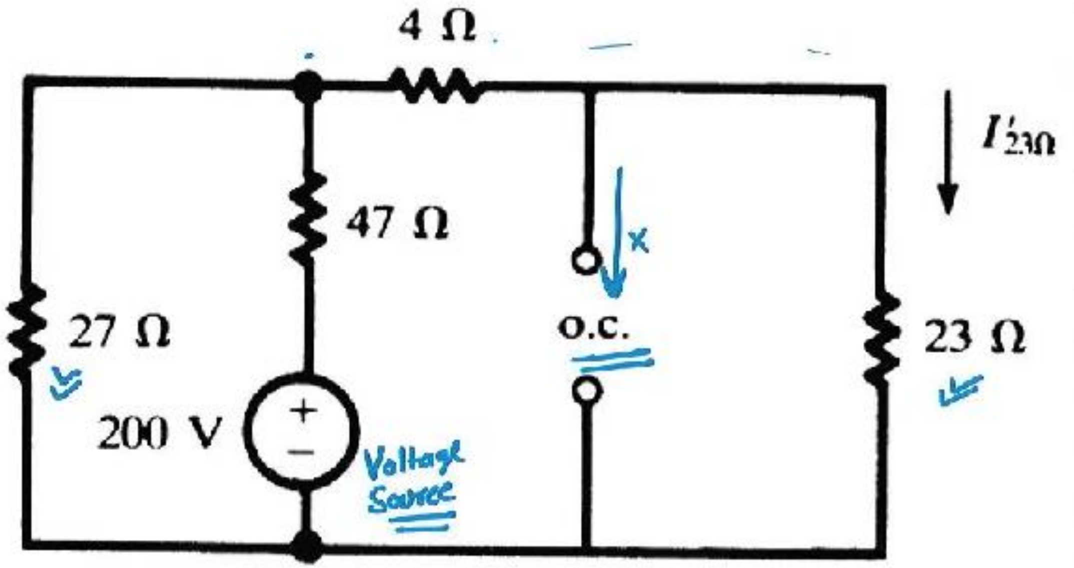
Step. 1 : Take Voltage source

$$R_{eq} = 47 + \frac{(27)(4+23)}{27+4+23} = 60.5\ \Omega$$

$$I_T = \frac{200}{60.5} = 3.31 \text{ Amp}$$

$$I'_{23\Omega} = \left(\frac{27}{54}\right) \times 3.31$$

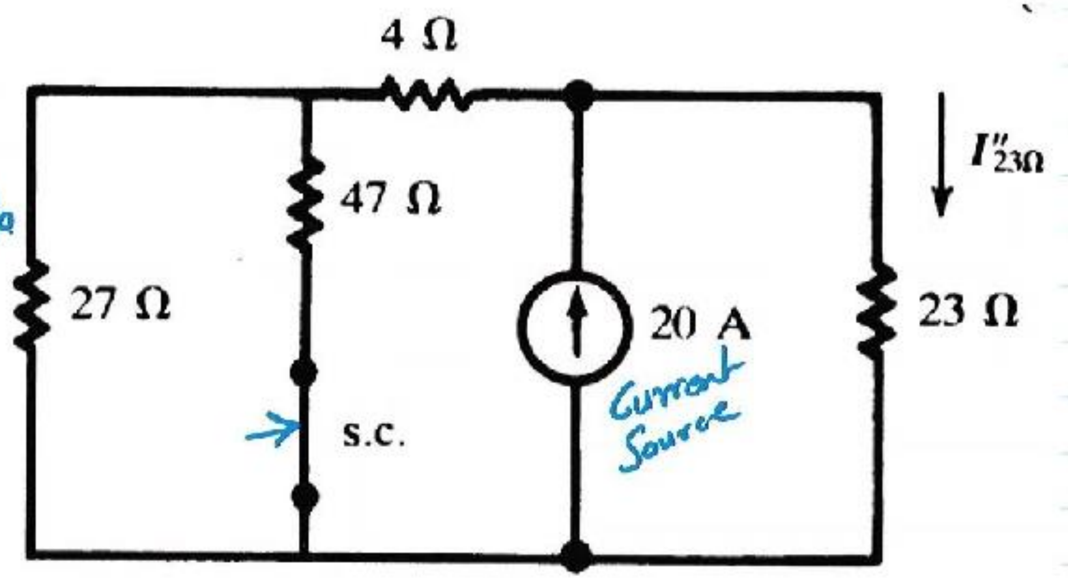
$$= 1.65 \text{ Amp.}$$



Step. 2 ; Take only current source :

$$R_{eq} = 4 + \frac{(27)(47)}{27+47} = 21.15\ \Omega$$

$$I''_{23\Omega} = \left(\frac{21.15}{21.15+23}\right)(20) = 9.58 \text{ Amp}$$



So, Total Current

$$I_{23\Omega} = 1.65 + 9.58$$

$$= 11.23 \text{ Amp.}$$

NPTEL

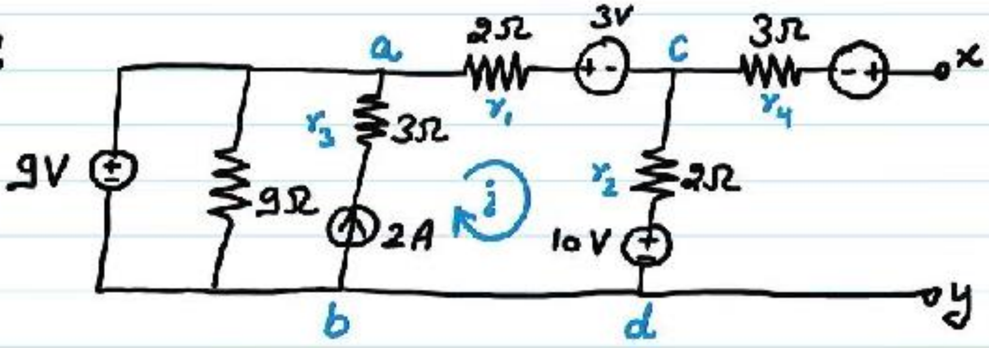
Thevenin's Theorem :

Thevenin theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source V_{TH} in series with a resistor R_{TH}, where V_{TH} is the open circuit voltage at the terminals and R_{TH} is the input or equivalent resistance at the terminals when the independent sources are turned off.

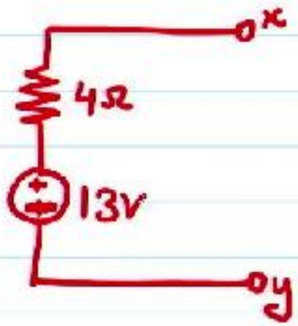
→ It is useful in the circuit analysis of power or battery systems where it will have effects on the adjoining part of the circuit.

NPTEL

Example :



$\Rightarrow$



Solution : Apply KVL at loop acdb

$$-V_{ab} + ir_1 + 3 + ir_2 + 10 = 0 \qquad [V_{a-b} = 9V]$$

$$-9 + 2i + 3 + 2i + 10 = 0$$

$$4i = -4 \Rightarrow i = -1\,A$$

Drop in $r_2 \Rightarrow 2 \times (-1) = -2V$

$$V_{c-d} = 10 - 2 = 8V$$

$$V_{OC} = V_{c-d} + 5 = 13\,V$$

To find R_{TH},

$$R_{TH} = 3 + \frac{2 \times 2}{2+2}$$

$$R_{TH} = 4\,\Omega$$

NPTEL

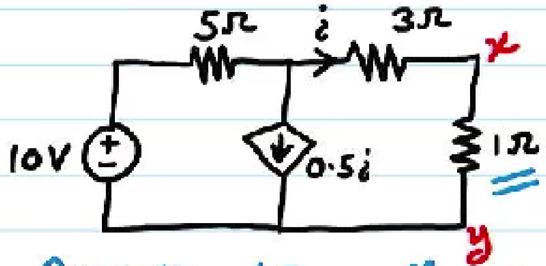
Norton's Theorem :

Norton theorem states that a linear two-terminal cicuit can be replaced by an equivalent circuit consisting of a current source I_N, in parallel with a resistor R_N,

where I_N is the short-circuit current through the terminals.

R_N is the input or equivalent resistance at the terminals when independent v sources are turned off.

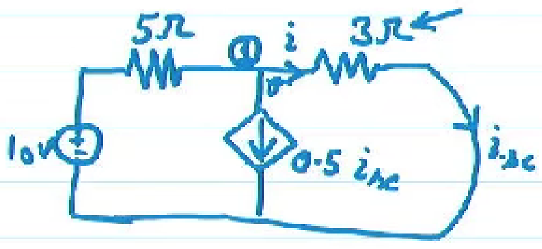
Example :



Find the current in 1Ω resistor.

Solution : Remove 1Ω , $v_{oc} = 10V$

Next, short circuit the output terminal.



$$\frac{v-10}{5} + 0.5\, i_{sc} + i_{sc} = 0$$

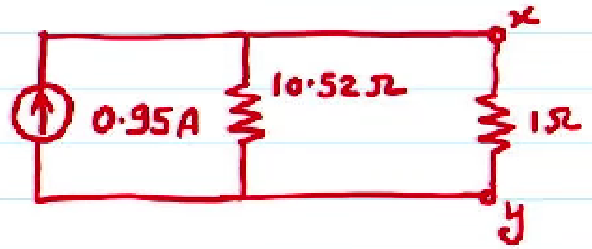
$$v = 3 \cdot i_{sc}$$

$$\frac{3 i_{sc} - 10}{5} + 1.5\, i_{sc} = 0$$

$$i_{sc} = 0.95 \text{ Amp.}$$

$$R_{int} = \frac{v_{oc}}{I_{sc}} = \frac{10}{0.95}$$

$$R_{int} = 10.52\ \Omega$$



NPTEL

Maximum Power Transfer Theorem :

Maximum Power is transferred to the load when the load resistance equals to the Thevenin's resistance as seen from the load.