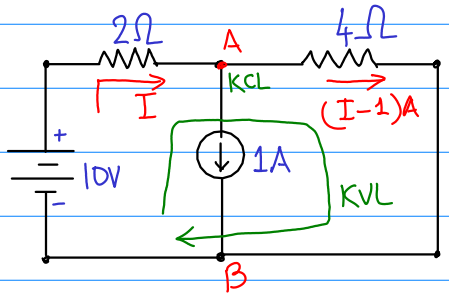
29.12.2021

Circuit Theorems

Recap: A simple ckt. with both voltage and current sources.



KCL, KVL

$10V = 2I + 4(I-1)$

Solve to get I.

$I = \frac{7}{3} A \; ; \; \frac{4}{3} A$

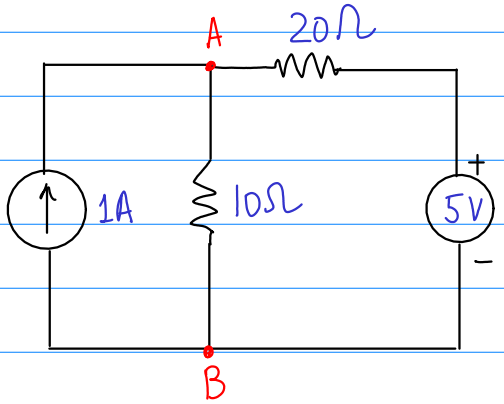
Suppose we have more number of sources in the ckt., and we would like to determine the effect of all the sources to a given ckt. element (eg. resistor).

Superposition Theorem: The voltage across (or the current through) an element in a given linear ckt. is the algebraic sum of the voltages across (or current through) that element due to each sources acting alone.

⇒ This means that while determining voltage (or current) due to one source, we need to zero the other sources

To make the sources zero, we need

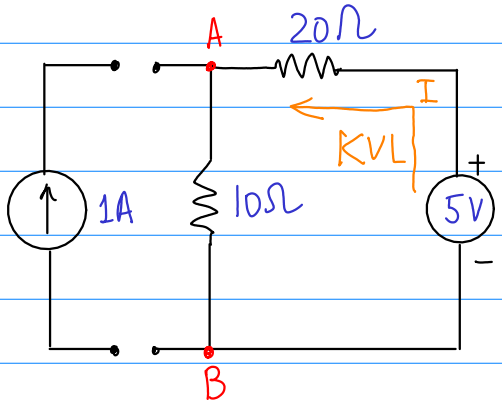
Open :	all other current sources
Short :	all other voltage sources



Use superposition theorem to determine voltage across AB (ie, V_{AB})

(i) Effect of the voltage source acting alone.

⇒ We need to zero the current source



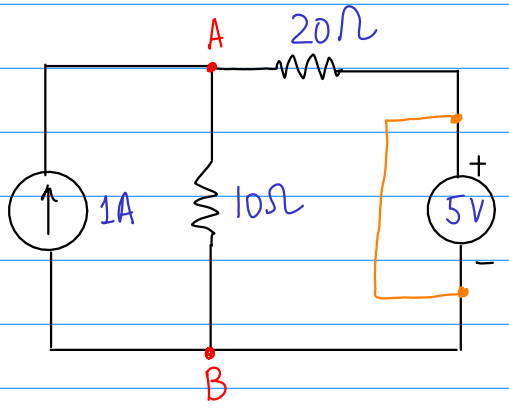
$$I = \frac{5V}{20\Omega + 10\Omega} = \frac{1}{6} A$$

$$V_{AB1} = \frac{10}{6} = \frac{5}{3} V$$

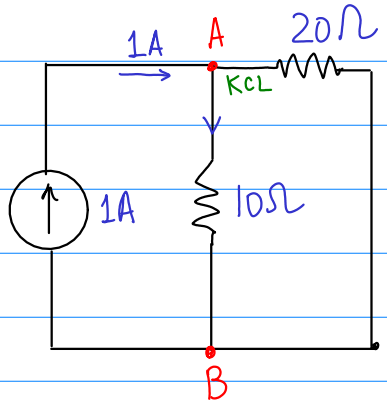
$$\boxed{V_{AB1} = \frac{5}{3} V}$$

(ii) effect of current source acting alone.

⇒ We need to zero the voltage source.



shorting the voltage source



⇒ Current divider ckt.

Current through 10Ω resistor

$$= \left(\frac{20\Omega}{10\Omega + 20\Omega}\right) 1A$$

$$= \frac{2}{3} A$$

$$V_{AB(2)} = \frac{2}{3} A \cdot 10\Omega$$

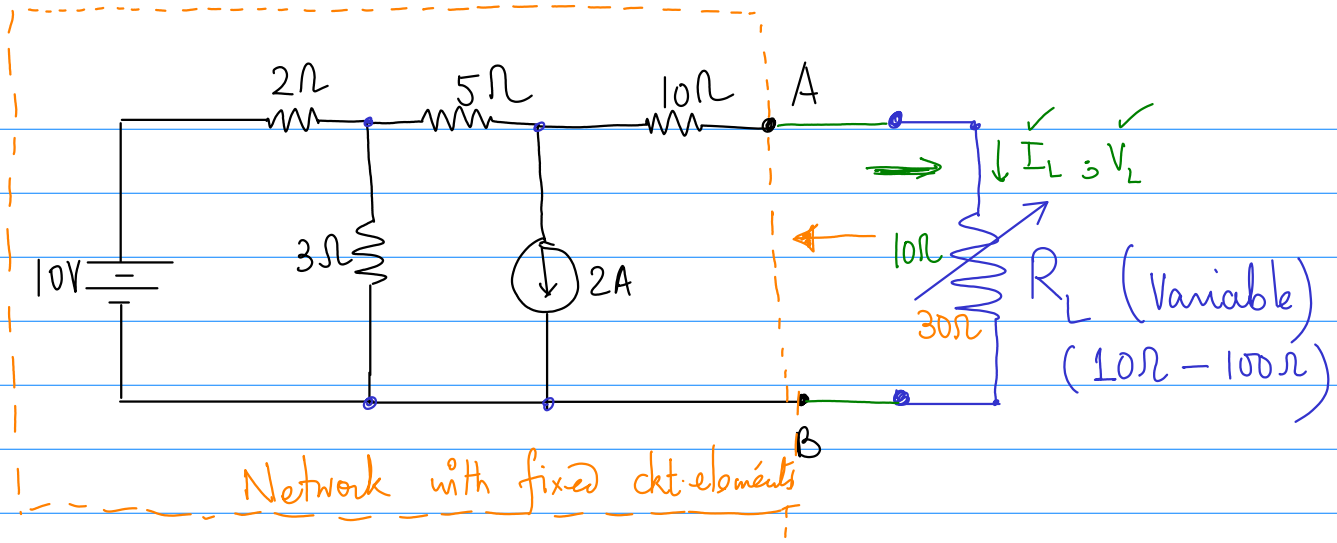
$$= \frac{20}{3} V$$

Therefore, according to superposition theorem:

$$V_{AB} = V_{AB(1)} + V_{AB(2)} = \frac{5}{3} V + \frac{20}{3} V$$

$$= \frac{25}{3} V$$

$$\boxed{V_{AB} = \frac{25}{3} V}$$



The value of load current (or load voltage) for a given network with fixed elements depends on the value of load resistance.

That is, each time value of R_L changes, you need re-calculate all the current/voltage to determine the value I_L & V_L.

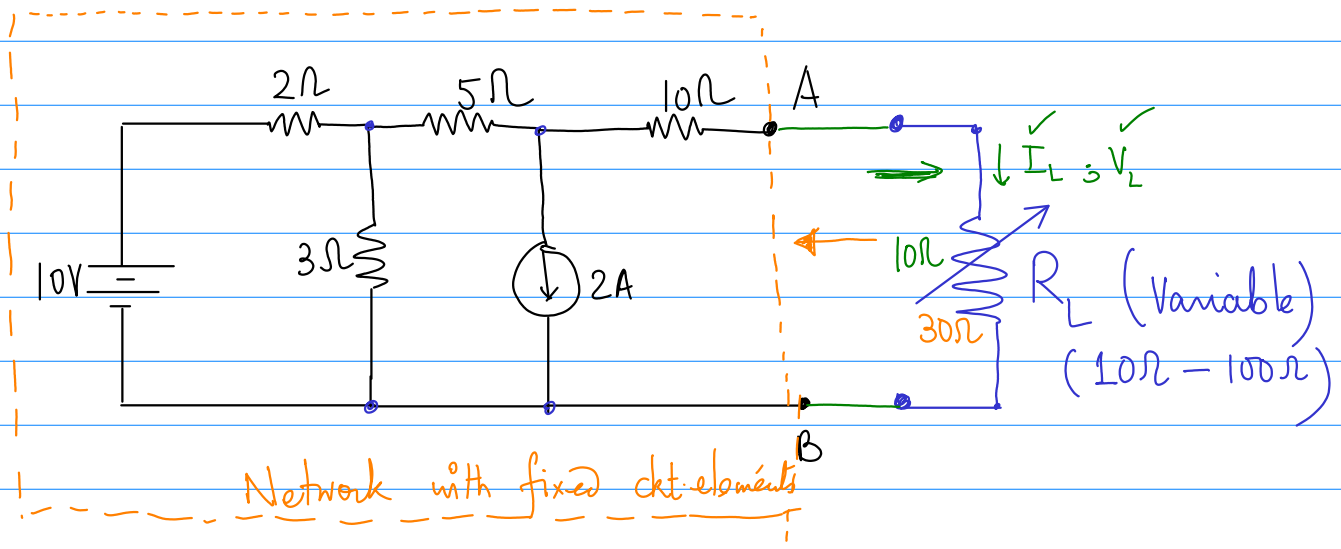
To overcome this difficulty of ckt. analysis, we have a ckt. theorem.

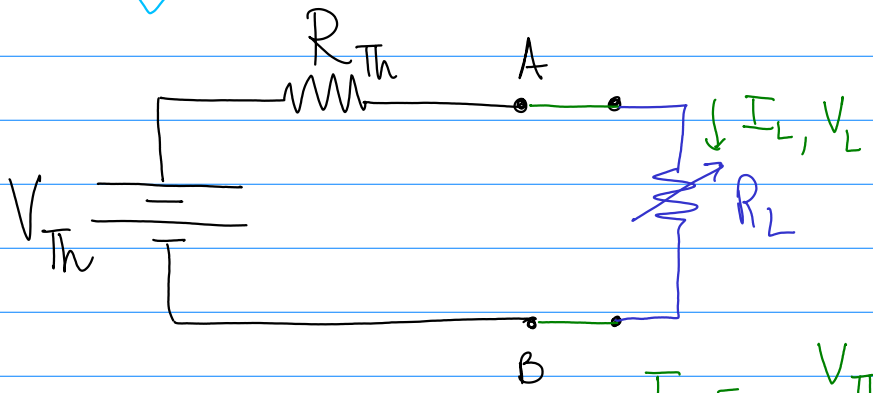
Ckt. theorem given by a French Engineer Leon Charles Thevenin.

Thevenin's Theorem:

A linear network with fixed values of ckt. elements

Can be replaced by an equivalent network consisting of a single voltage source and a series resistance.





$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

$$V_L = I_L R_L$$

Ques: How do we determine V_{Th} & R_{Th} for a given network.

V_{Th} = Open ckt. voltage across the load terminals (here AB)

$\Rightarrow$ Remove the load across AB & measure the open ckt. V_{AB} (open ckt.)

R_{Th} = Equivalent resistance of the given network across the load terminal (here AB) making all the sources zero.