Basic Electrical Technology

Class 9 – 24 November 2021

- Network Theorems 2

Why Thevenin's Theorem

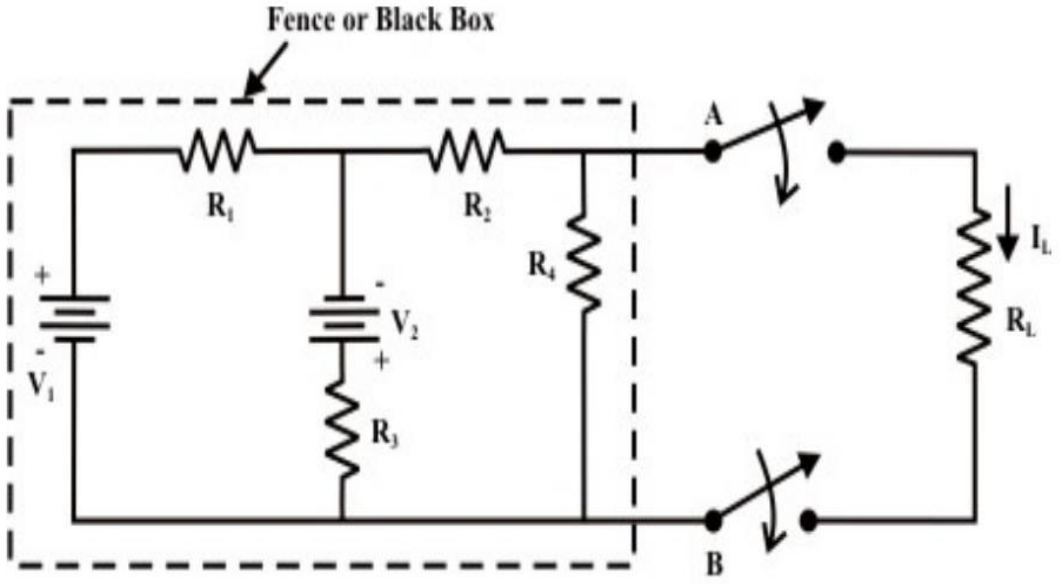
In many applications, a network may contain a variable component or element while other elements in the circuit are kept constant.

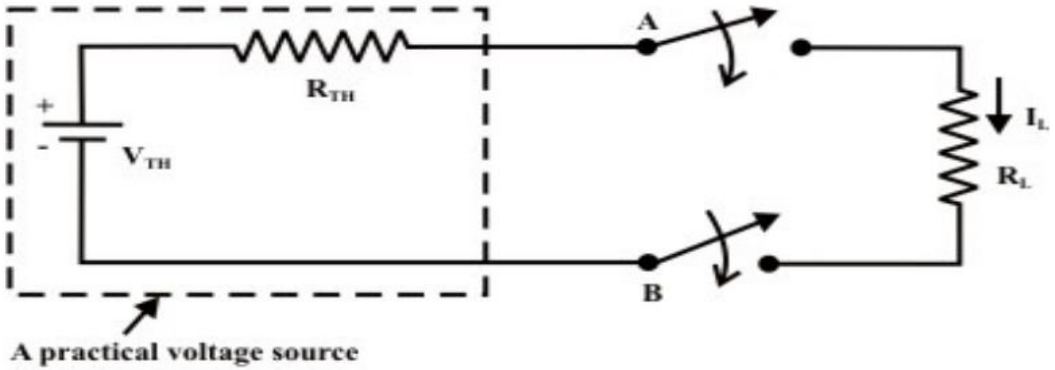
If the solution for current or voltage or power in any component of network is desired, in such cases the whole circuit need to be analyzed each time with the change in component value

For the circuit shown,

- Find
  - Mesh current method needs 3 equations to be solved
  - Node voltage method requires 2 equations to be solved

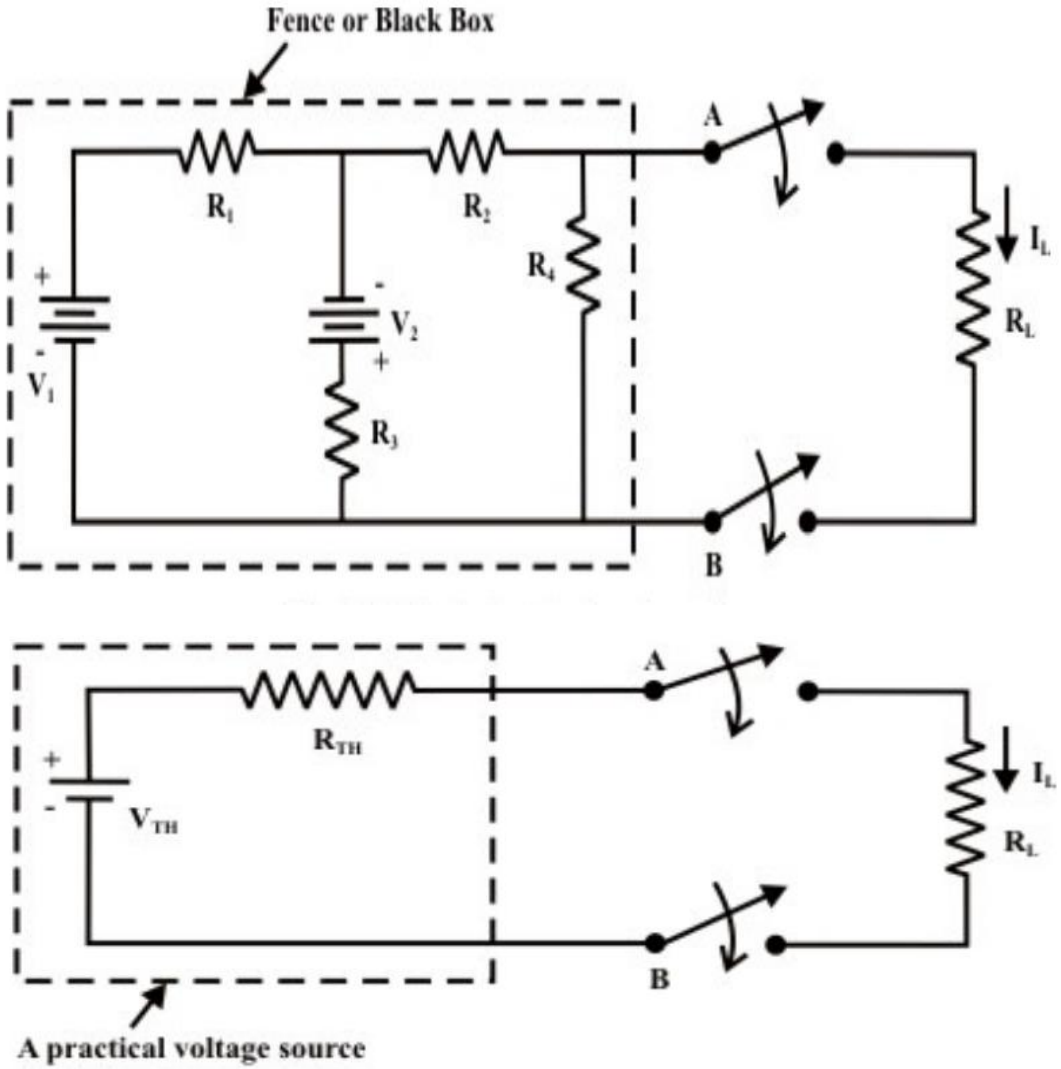
In order to avoid such repeated computation, it is desirable to introduce a method that will not have to be repeated for each value of variable component.





Definition of Thevenin's Theorem

- Any **linear, bilateral** network may be replaced by a single voltage source (called Thevenin's equivalent voltage, $\mathbf{V_{Th}}$) in series with one resistance (called Thevenin's equivalent resistance, $\mathbf{R_{Th}}$) across the load terminals.
- Thevenin's equivalent voltage, $\mathbf{V_{Th}}$, is the open circuit voltage at the load terminals.
- Thevenin's equivalent resistance, $\mathbf{R_{Th}}$, is the equivalent resistance at the load terminals, after replacing the sources by their internal resistances.

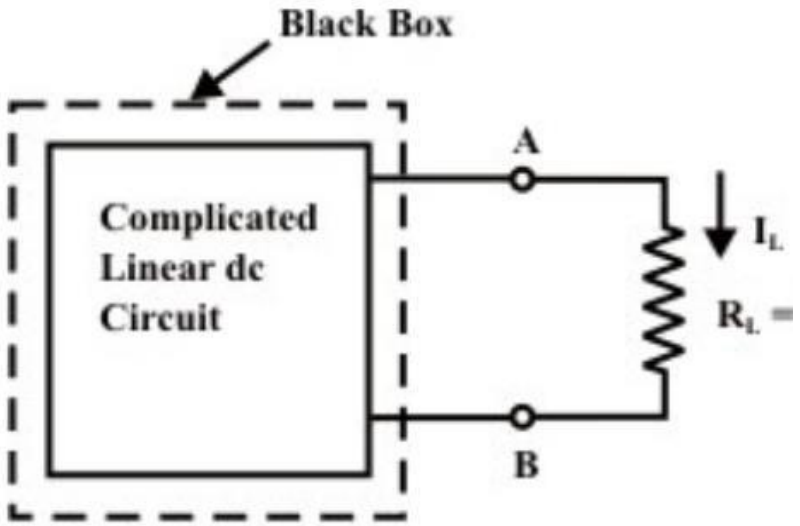


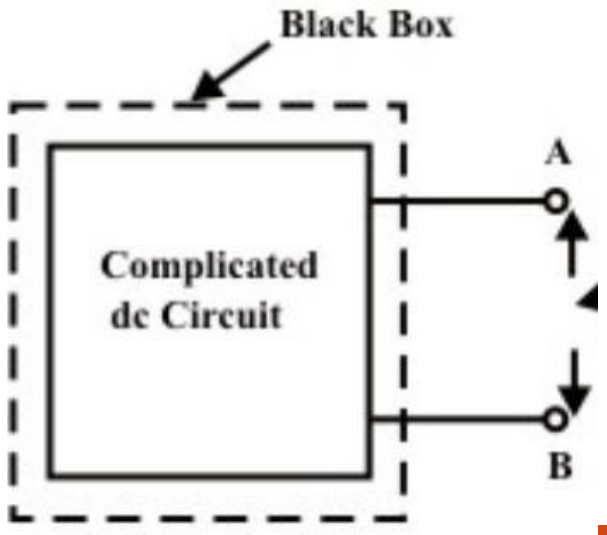
Procedure of Thevenin's Theorem

Suppose: Find I_L through R_L .

Step-1: Disconnect R_L

- Remove the load
- Keep the terminals open circuited as shown in 2nd figure below.

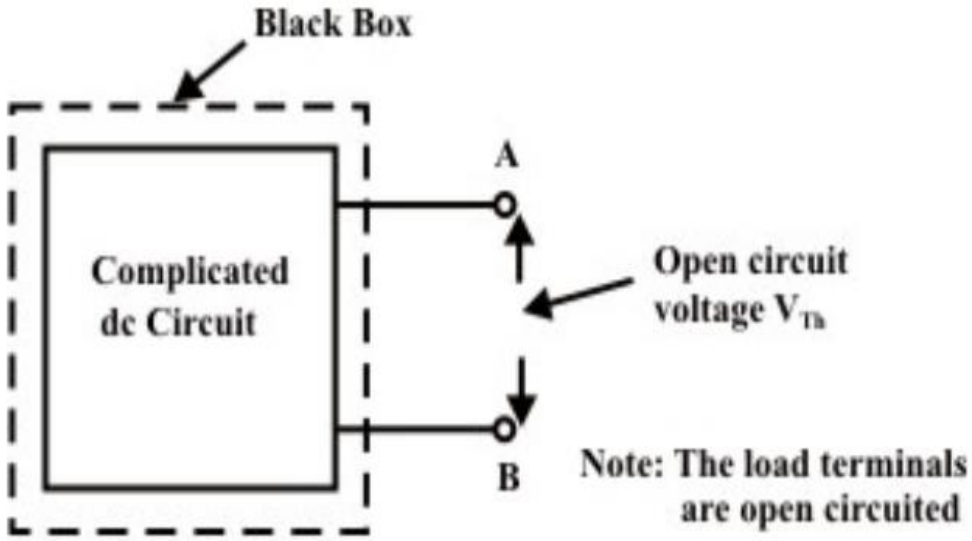




Procedure of Thevenin's Theorem

➢ **Step-2: Find V_{Th}**

- Apply mesh current / node voltage method
- Find the voltage across the open circuited terminals.

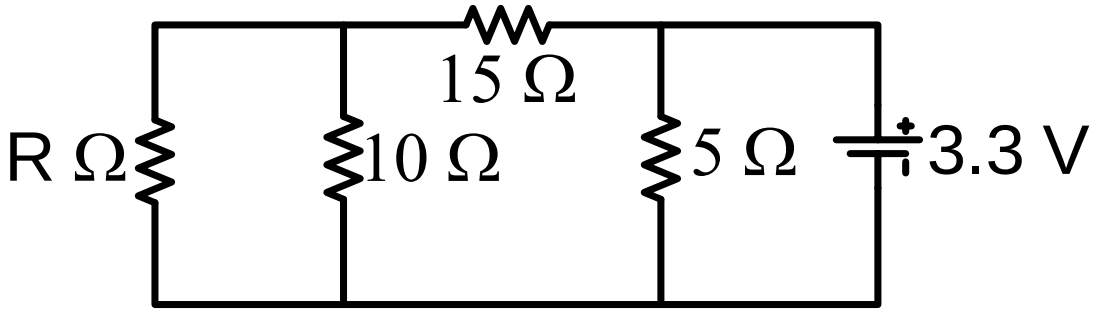


➢ **Step-3: To find R_{Th}**

- Keep the load terminals open.
- Replace all the sources by their internal resistances.
  - **Voltage sources** should be **short-circuited (just remove them and replace with plain wire)**
  - **Current sources** should be **open-circuited (just remove them)**
- Find the equivalent resistance with respect to open circuited load terminals.

Illustration 4

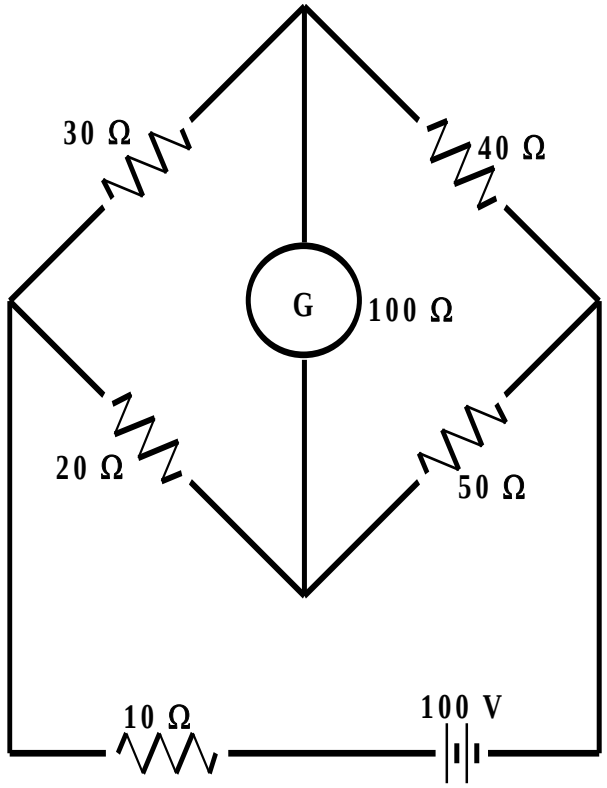
Using Thevenin's theorem, find the value of **R** such that the current through it is 120 mA



Ans: 5 Ω

Illustration 3

Determine the current through the galvanometer using Thevenin's Theorem



Answer : Current is I_{BA} = 84.249mA

Maximum Power Transfer Theorem

Definition:

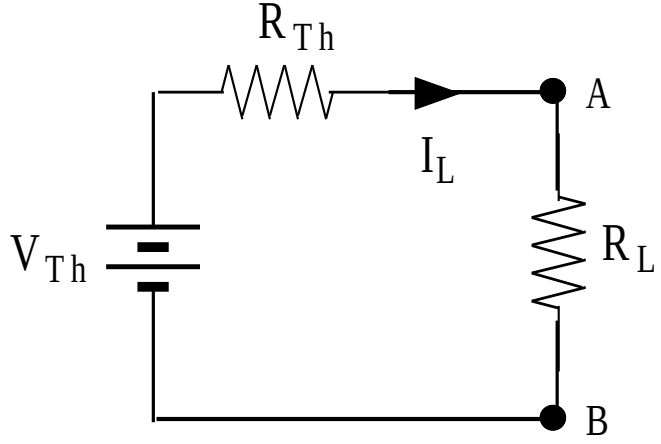
In **any linear, bi-lateral network**, maximum power will be transferred to the load from the network when the load resistance is equal to the internal resistance of the network.

Proof

Consider the Thevenin's equivalent circuit of a network

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

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



$$For P_L \text{ to be maximum}, \frac{dP_L}{dR_L} = 0$$

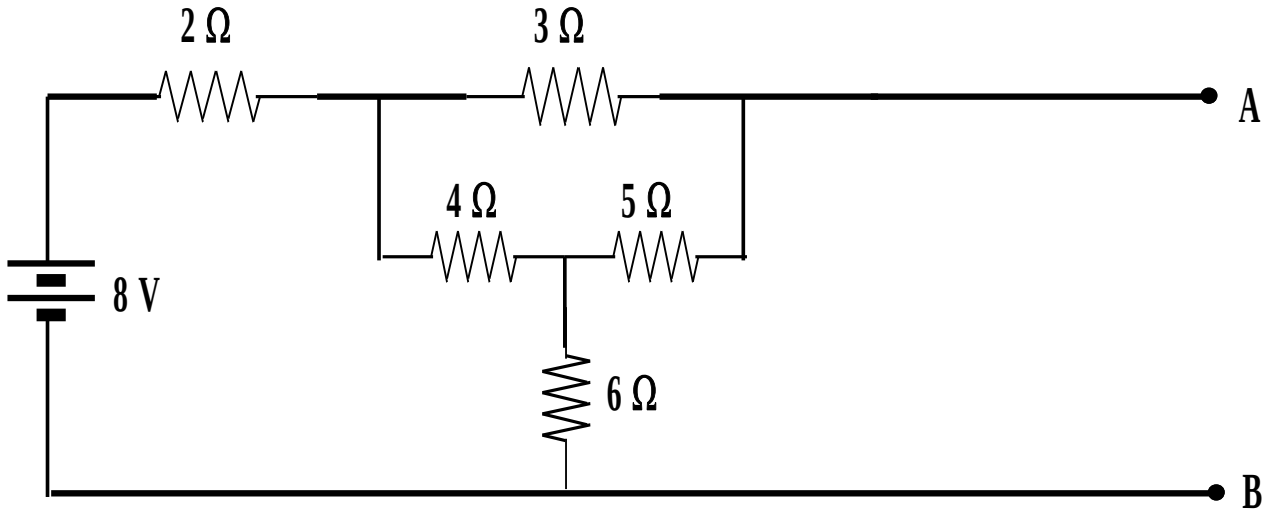
$$\text{which yields}, \boldsymbol{R_L = R_{Th}}$$

$$\text{Maximum Power},$$

$$P_{L-max} = \left(\frac{V_{Th}}{R_{Th}+R_{Th}}\right)^2 R_{Th} = \frac{V_{Th}^2}{4R_{Th}}$$

Illustration 5

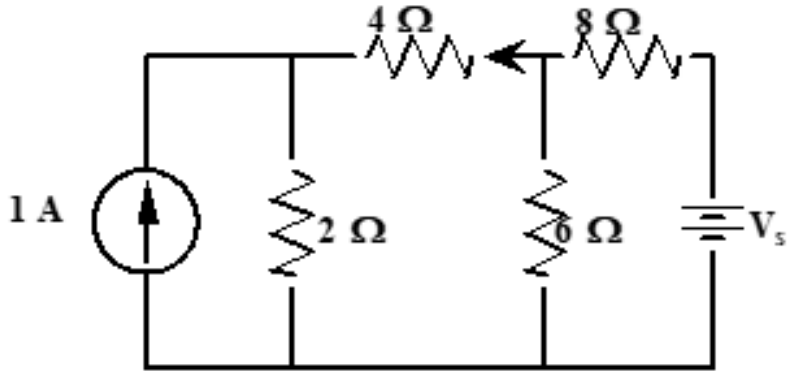
Determine the value of resistor to be connected across the terminals A & B such that maximum power is transferred to the that resistor. Also, find the value of maximum power.



Ans: 3.41 Ω, 2.43 W

Question 1

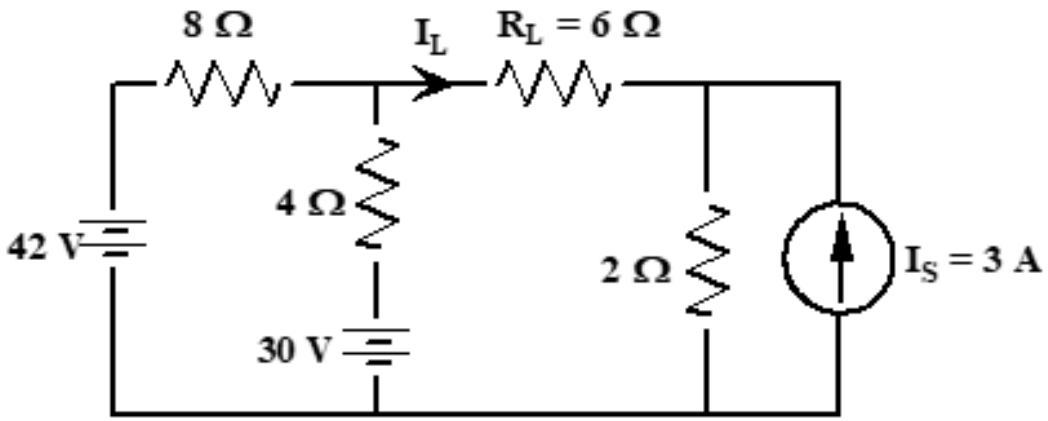
Using Superposition theorem, find the value of Vs if the current in 4 Ω is 0.515 A and the direction is as shown in the diagram below.



Ans: 16 V

Question 2

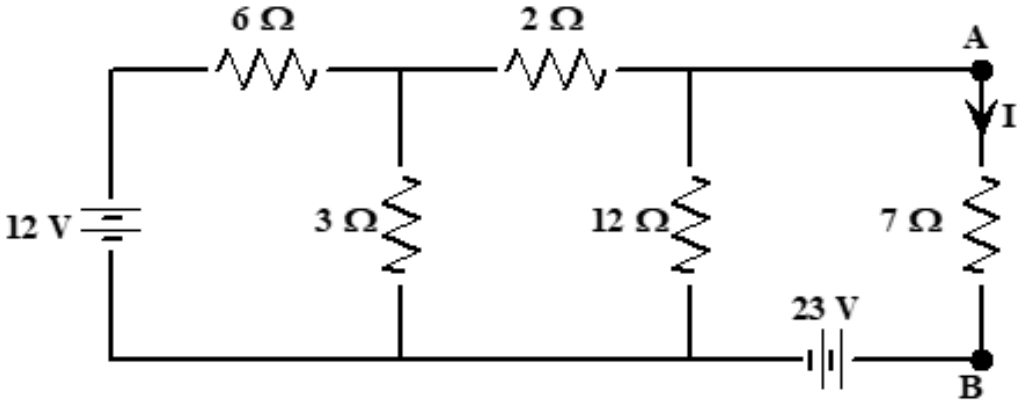
For the circuit shown find the current I_L through 6 Ω resistor using Thevenin's theorem



Ans: $I_L = 2.625$ A

Question 3

In the figure shown below replace the network to the left of terminals A & B by its Thevenin equivalent circuit. Hence, determine I



Answer:

R_{th} = 3 Ω,

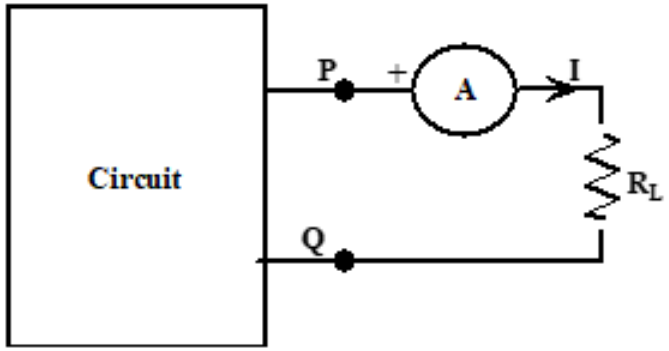
V_{th} = 20 V

I = -2 A

Question 4

The box shown in the adjacent figure consists of independent dc sources and resistances. Measurements are taken by connecting an ammeter in series with the resistor R_L and the results are shown in the table below. Find the value of R_L for which the current is 0.6 A

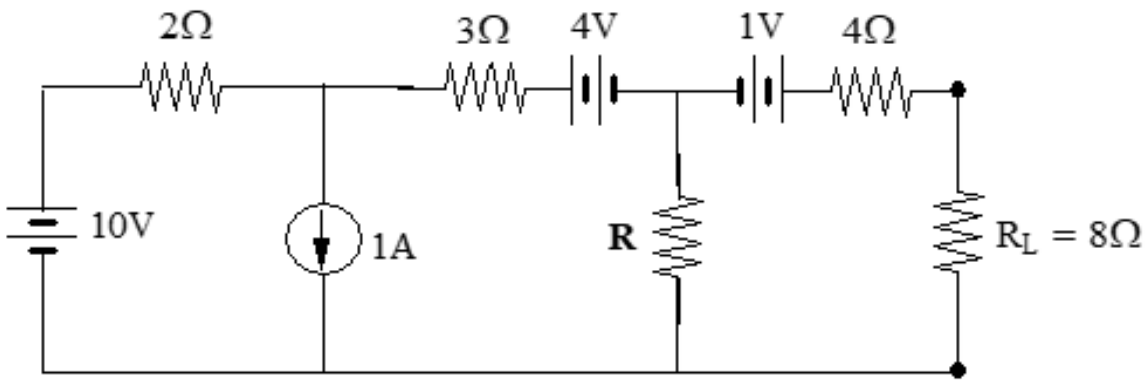
R_L	I
10 Ω	2.0 A
20 Ω	1.5 A
?	0.6 A



Ans: R_L = 80 Ω

Question 5

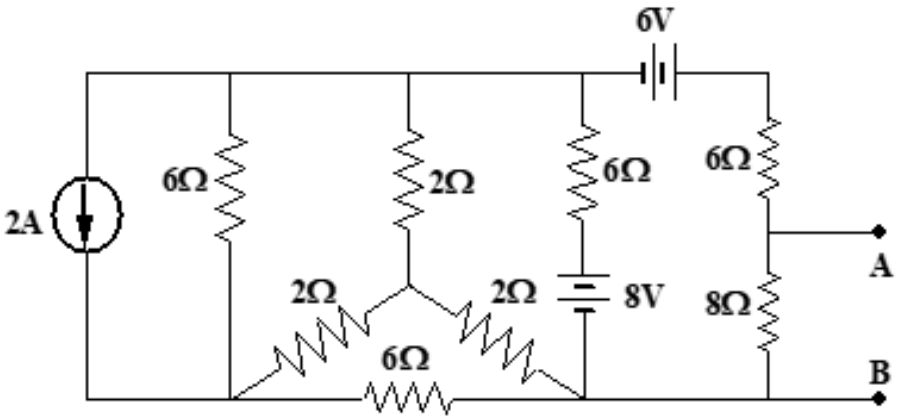
Find the value of **R** such that maximum power is transferred to **8 Ω** resistor.



Ans: 20 Ω

Question 06

Determine the value of load resistance to be connected across the terminals A & B such that maximum power is transferred to the load.



Ans: 4 Ω