BASIC ELECTRICAL ENGINEERING

Course Code: EE100

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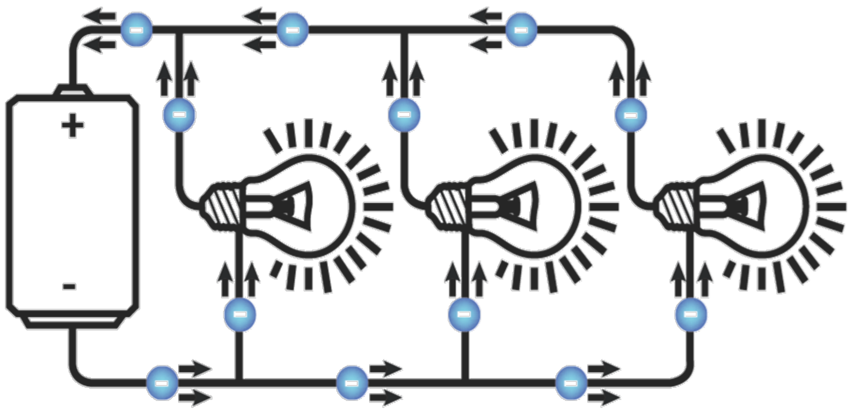
Module 1: DC Circuits

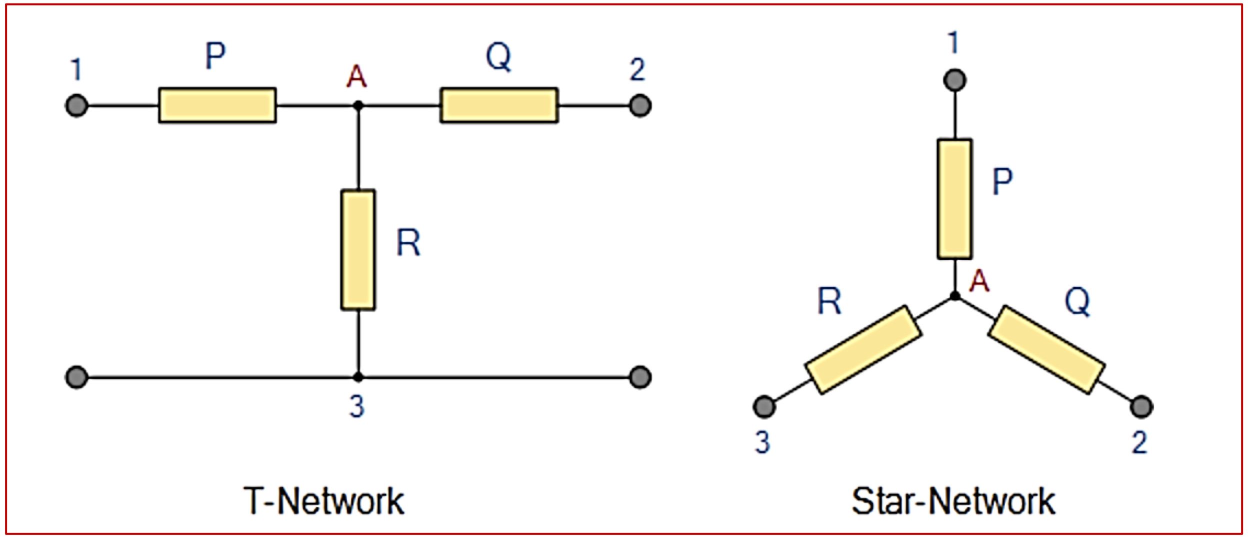
- ❖Star-Delta Conversion
- ❖KCL and KVL
- ❖Series and Parallel Circuits
- ❖Nodes, Branch, Loops and Mesh
- ❖Voltage Source – Current Source Conversion



Star-Delta Conversion

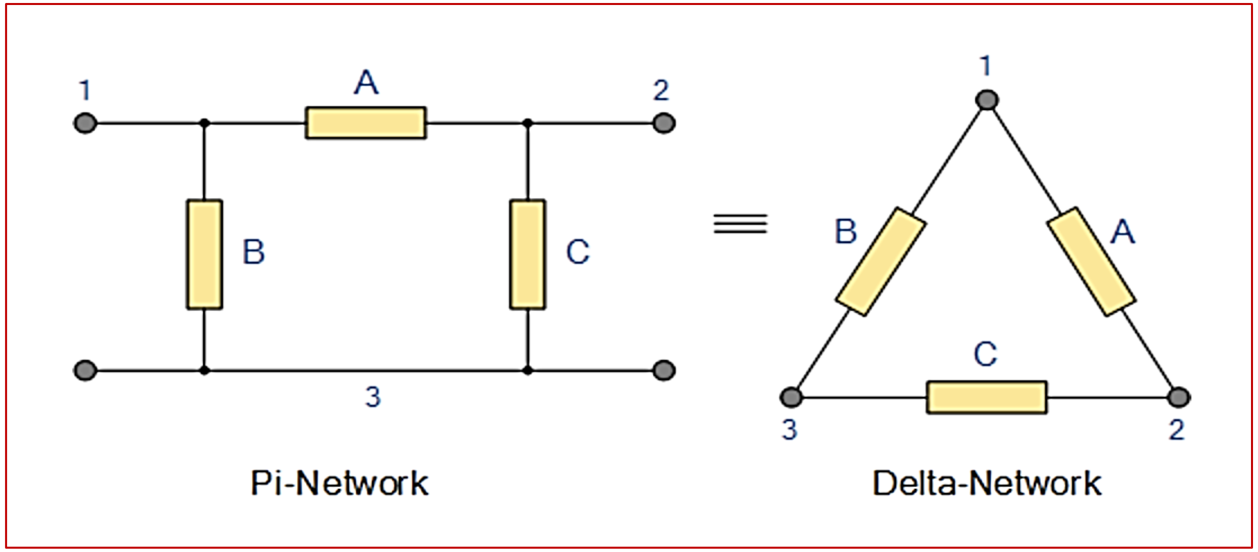
T-connected and Equivalent Star Network

We can redraw the T resistor network above to produce an electrically equivalent **Star** or Y type network

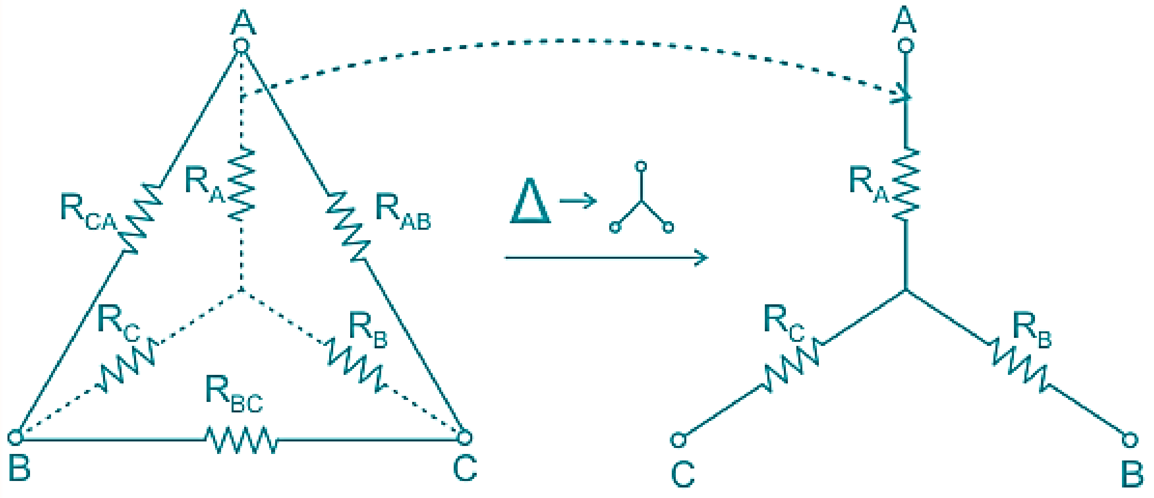


Δ-connected and Equivalent Delta Network

We can also convert a Pi or π type resistor network into an electrically equivalent **Delta** or Δ type network as shown



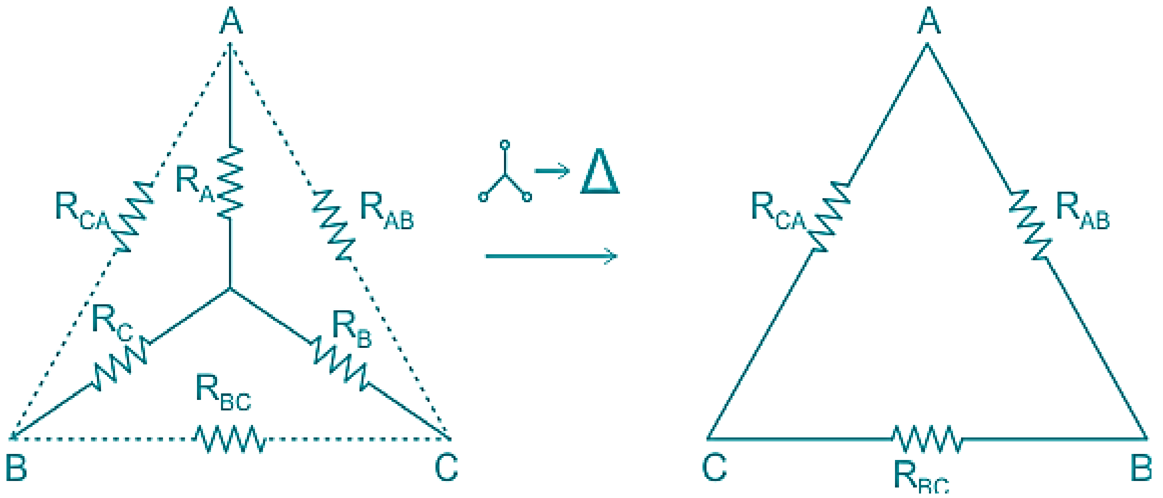
Delta- Star Conversion & Vice-Versa



$$R_A = \frac{R_{AB} \cdot R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$$

$$R_B = \frac{R_{AB} \cdot R_{BC}}{R_{AB} + R_{BC} + R_{CA}}$$

$$R_C = \frac{R_{BC} \cdot R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$$



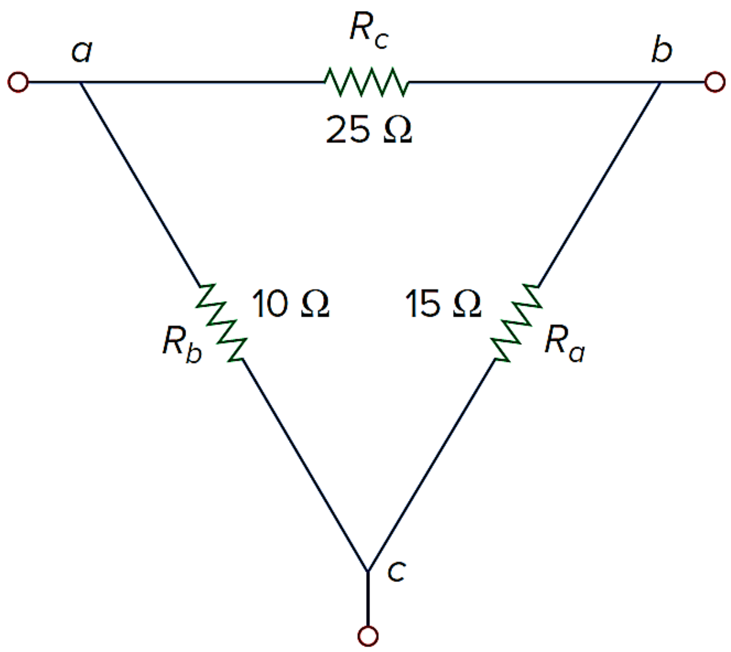
$$R_{AB} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C}$$

$$R_{BC} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A}$$

$$R_{CA} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_B}$$

Numericals:

Q1: **Convert the Δ network in Fig. below to an equivalent Y network**



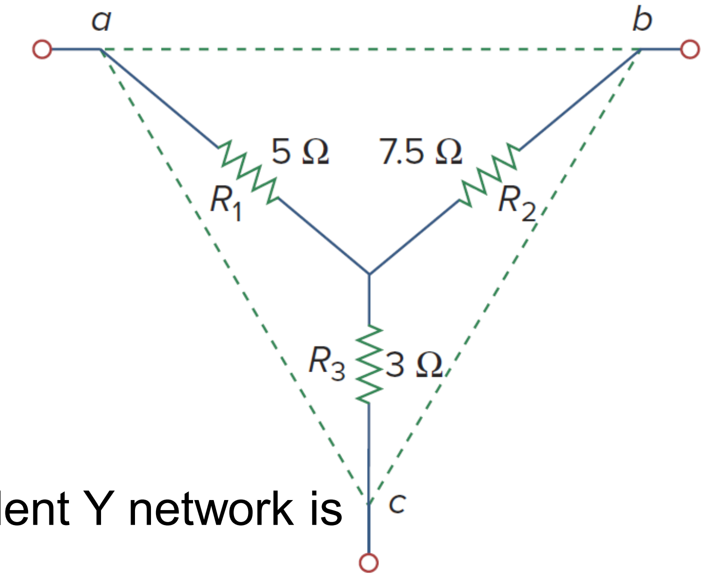
Solution:

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c} = \frac{10 \times 25}{15 + 10 + 25} = \frac{250}{50} = 5\ \Omega$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c} = \frac{25 \times 15}{50} = 7.5\ \Omega$$

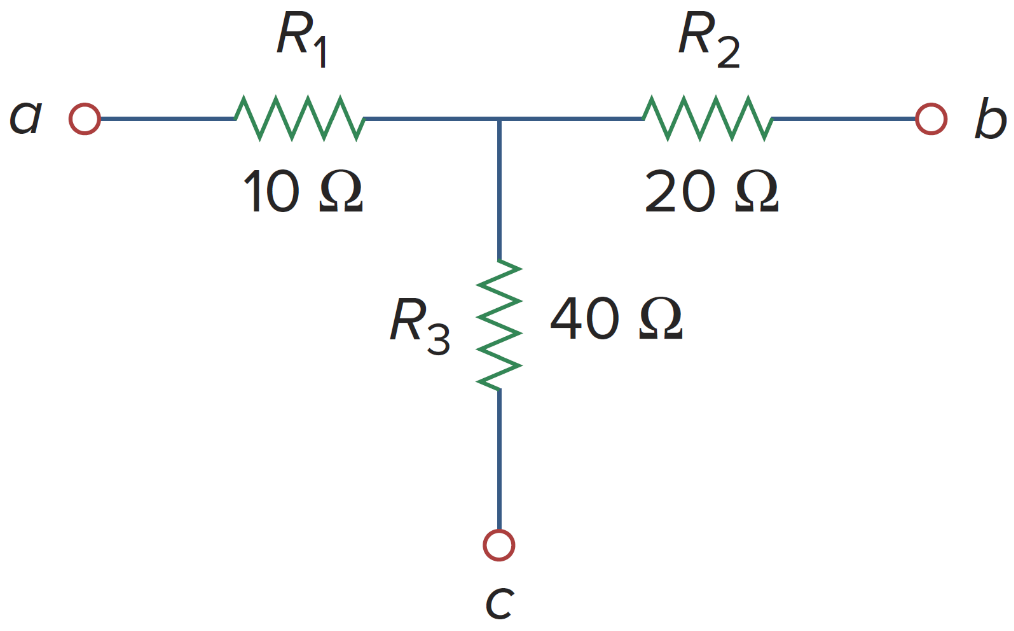
$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c} = \frac{15 \times 10}{50} = 3\ \Omega$$

The equivalent Y network is



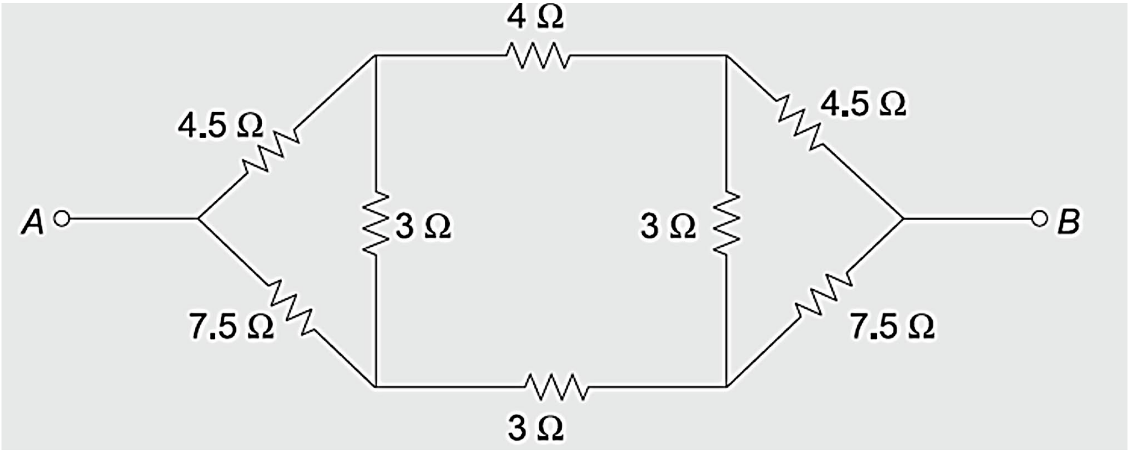
Numericals:

Q2: Convert the Y network in Fig. below to an equivalent Δ network

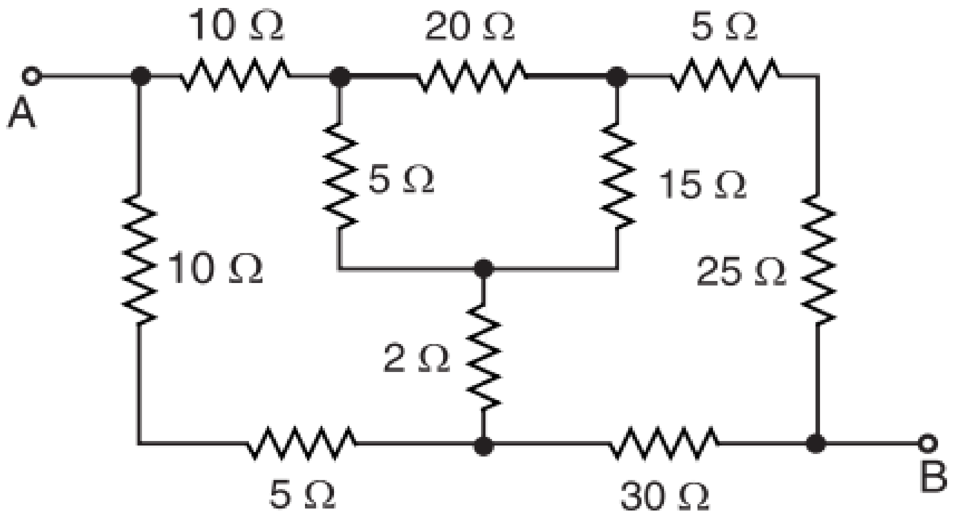


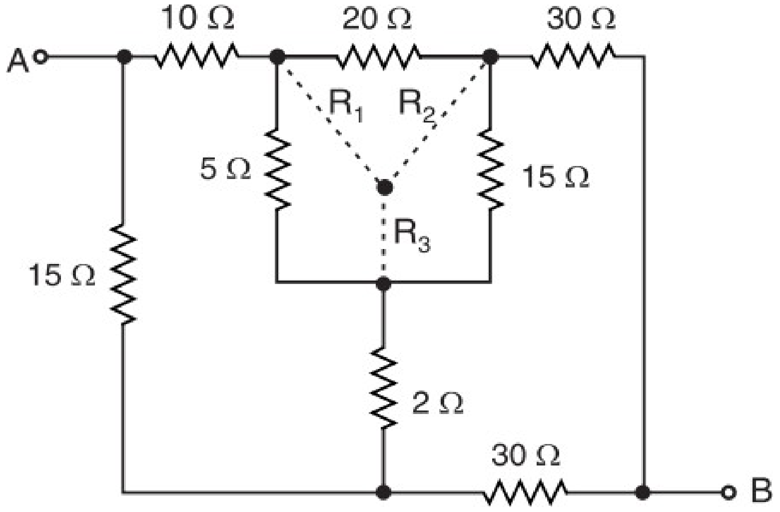
Answer: *Ra* = 140 Ω, *Rb* = 70 Ω, *Rc* = 35 Ω.

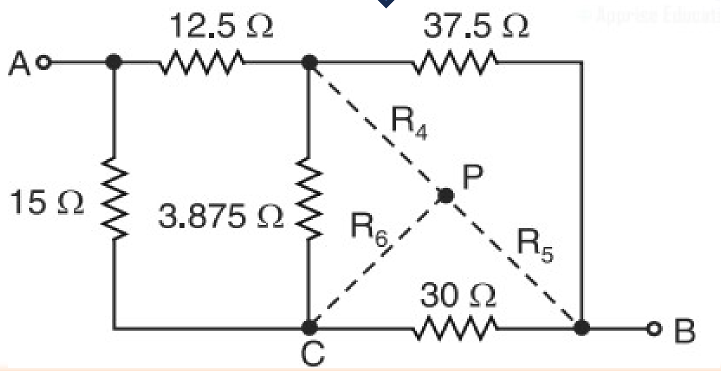
Q3: Find the equivalent resistance between A & B

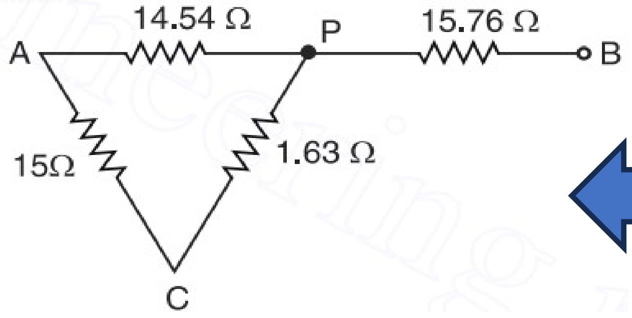


Q4: Find the equivalent resistance between A & B





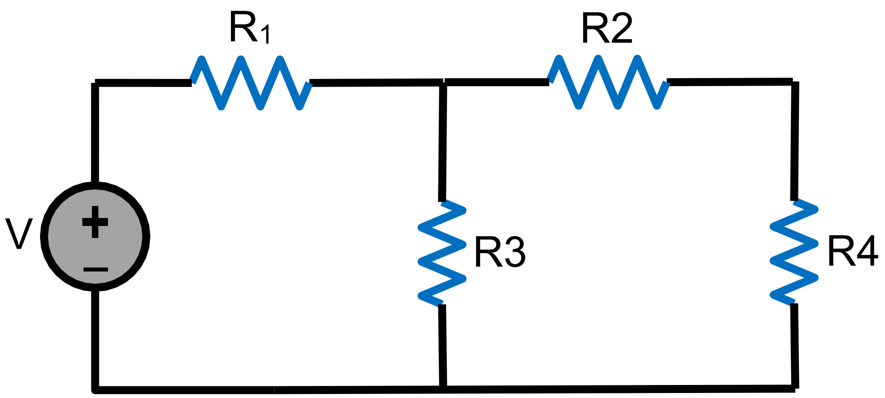




$$R_{AB} = 15.76 + [14.54 \parallel (15 + 1.63)] = 15.76 + \frac{14.54 \times 16.63}{31.17} = 23{\cdot}5\ \Omega$$

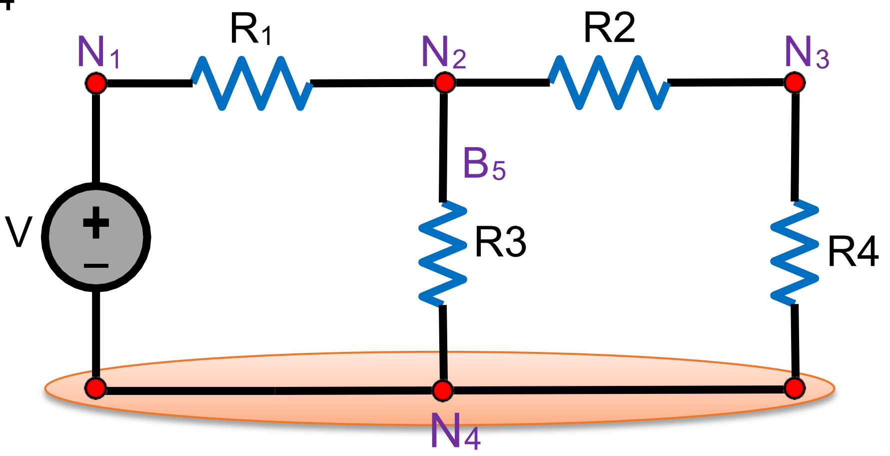
Node, Branch, Loop & Mesh:

Circuit Topology



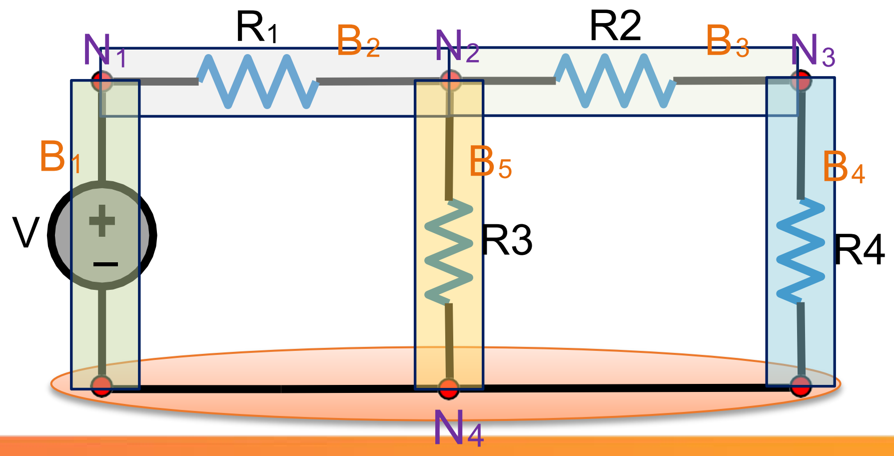
Node

A point or junction where two or more circuit's elements meet is called Node.



Branch

That part or section of a circuit which locate between two junctions is called the branch.

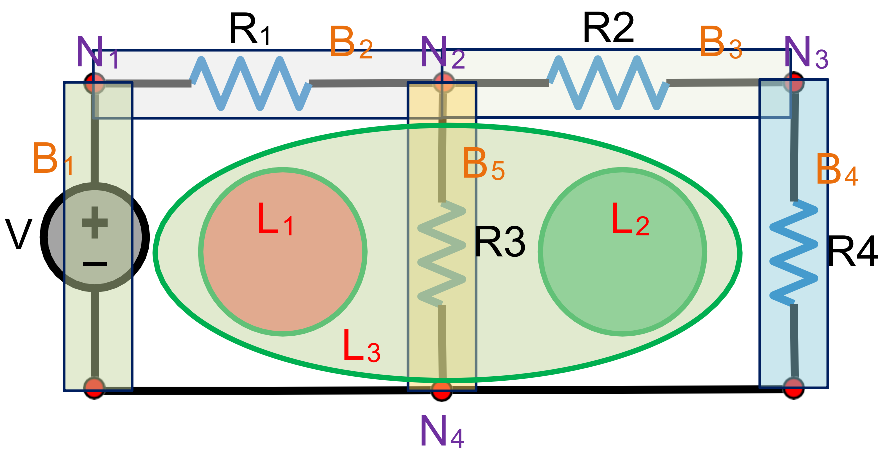


Node, Branch, Loop & Mesh:

Circuit Topology

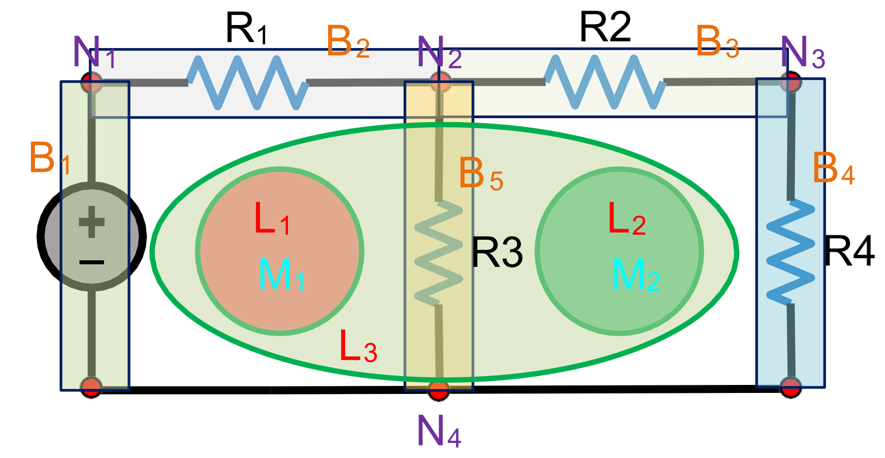
Loop

A closed path in a circuit is called as Loop.



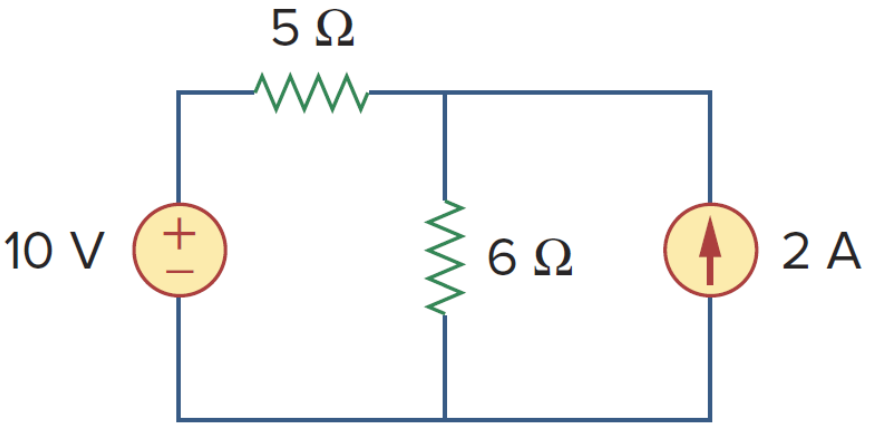
Mesh

A closed loop which contains no other loop within it or a path which does not contain on other paths is called Mesh

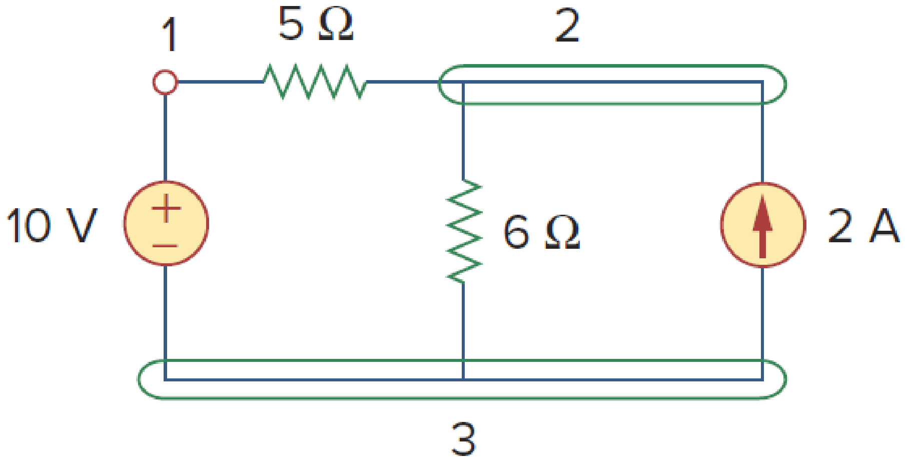


Numericals:

Q1: Determine the number of branches and nodes in the circuit shown in Fig. Identify which elements are in series and which are in parallel.

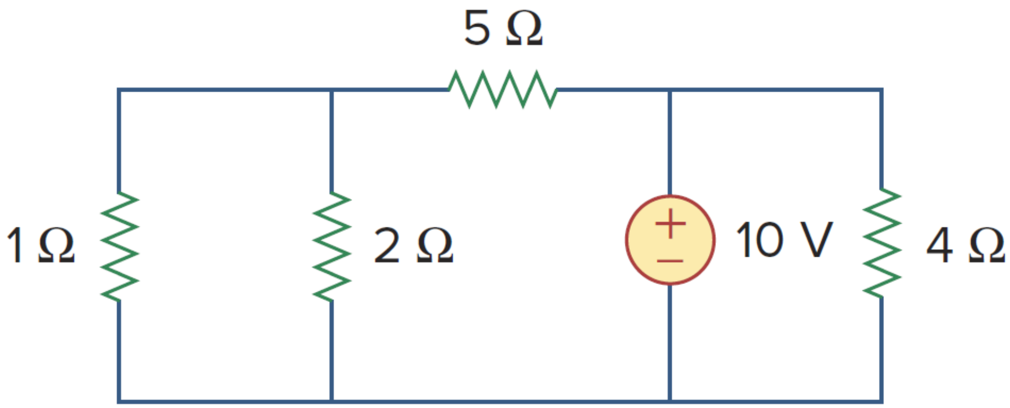


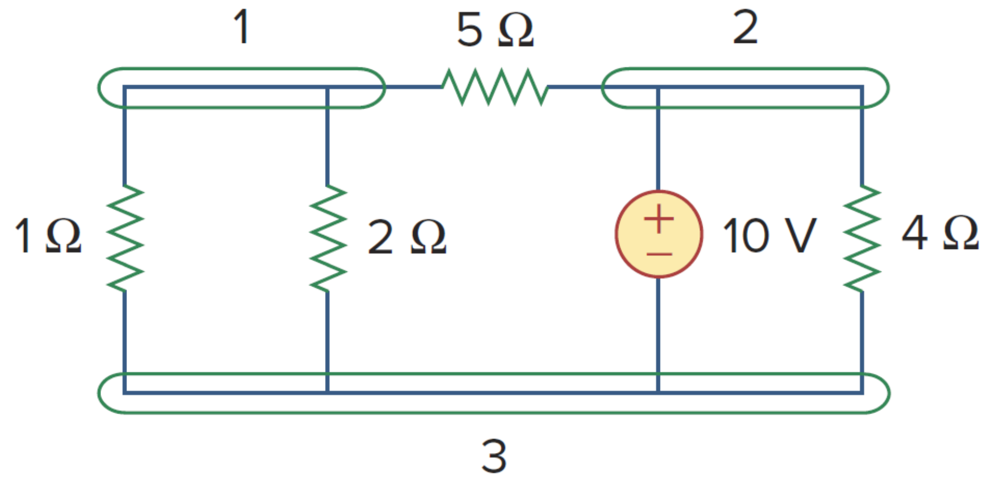
Since there are four elements in the circuit, the circuit has four branches: 10 V, 5 Ω, 6 Ω, and 2 A.



Ans: 4 Branches, 3 Nodes

Q2: Determine the number of branches and nodes in the circuit shown in Fig. Identify which elements are in series and which are in parallel.

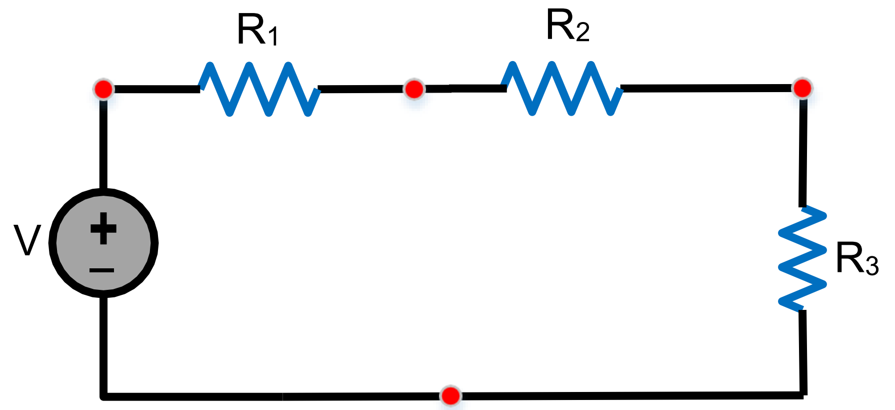




Circuit Topology

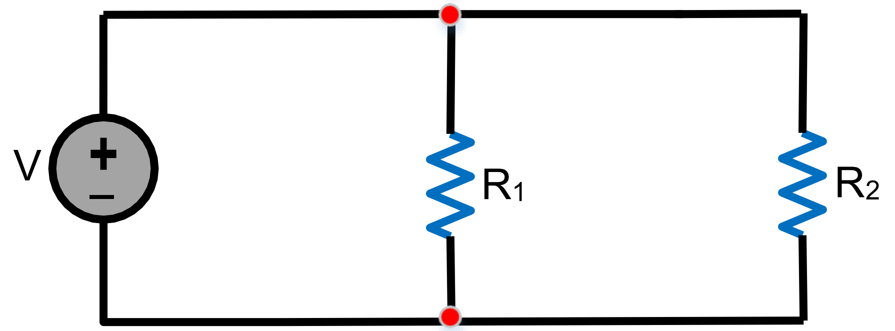
Series

Two or more elements are in series if they are cascaded or connected sequentially and consequently carry the same current.



Parallel

Two or more elements are in parallel if they are connected to the same two nodes and consequently have the same voltage across them.



Kirchhoff's Law

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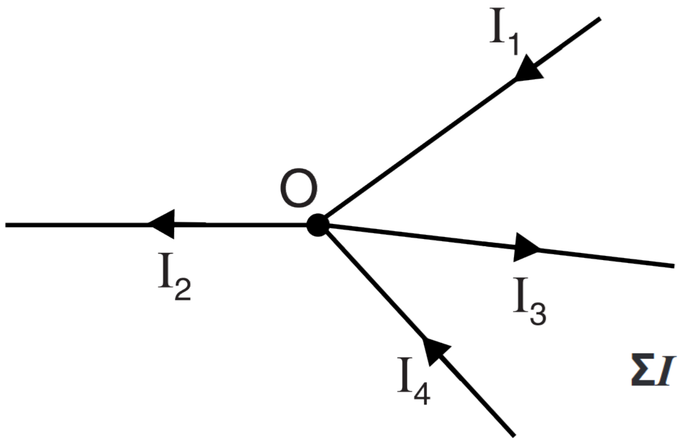
- Kirchhoff's Current Law (KCL)
- Kirchhoff's Voltage Law (KVL)

Kirchhoff's Current Law (KCL)

The algebraic sum of the currents meeting at a junction in an electrical circuit is zero.



$$(I_1) + (I_4) + (-I_2) + (-I_3) = 0$$

$$I_1 + I_4 = I_2 + I_3$$

ΣI Entering = ΣI Leaving

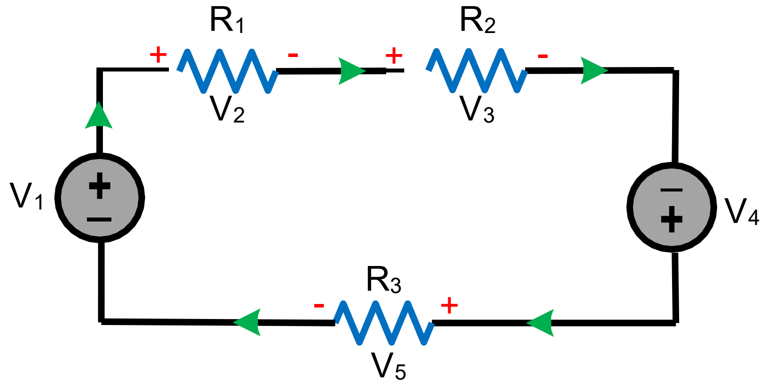
Sum of incoming currents = Sum of outgoing currents

Kirchhoff's Law

Kirchhoff's Voltage Law (KVL)

In any closed electrical circuit or mesh, the algebraic sum of all the electromotive forces (e.m.fs) and voltage drops in resistors is equal to zero.

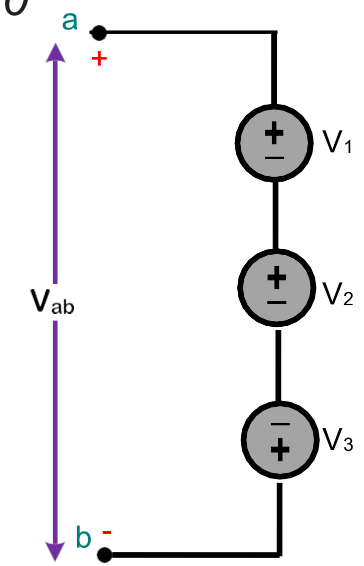
In any closed circuit or mesh, *Algebraic sum of e.m.fs + Algebraic sum of voltage drops = 0*



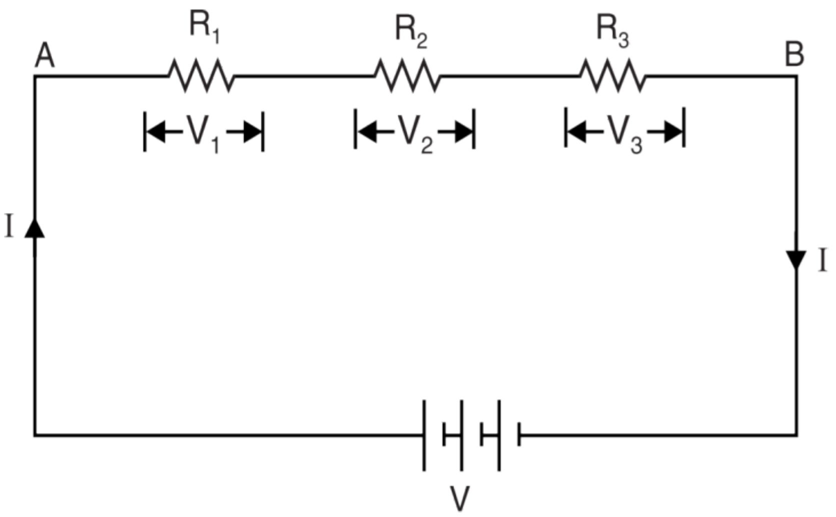
$$+V1 - V2 - V3 + V4 - V5 = 0$$

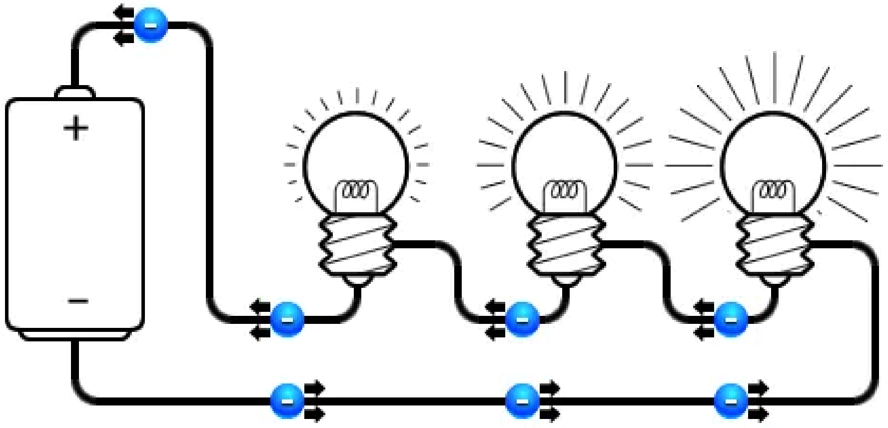
$$V_2 + V_3 + V_5 = V_1 + V_4$$

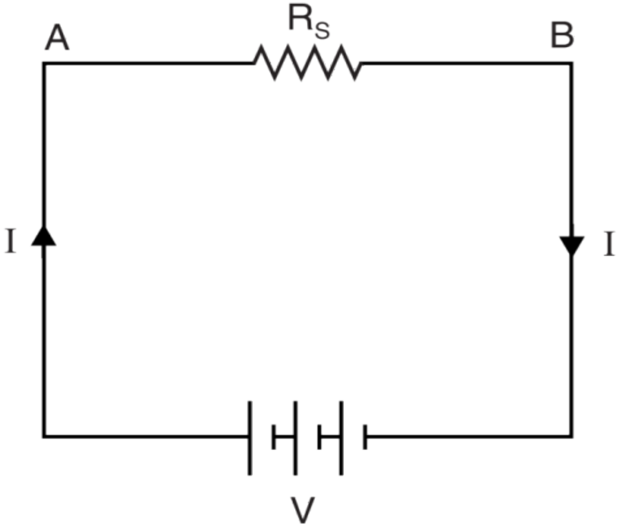
$$V_{ab} = V_1 + V_2 - V_3$$



Series connection







By Ohm's law, voltage across the various resistances is

$$V_1 = IR_1; V_2 = IR_2; V_3 = IR_3$$

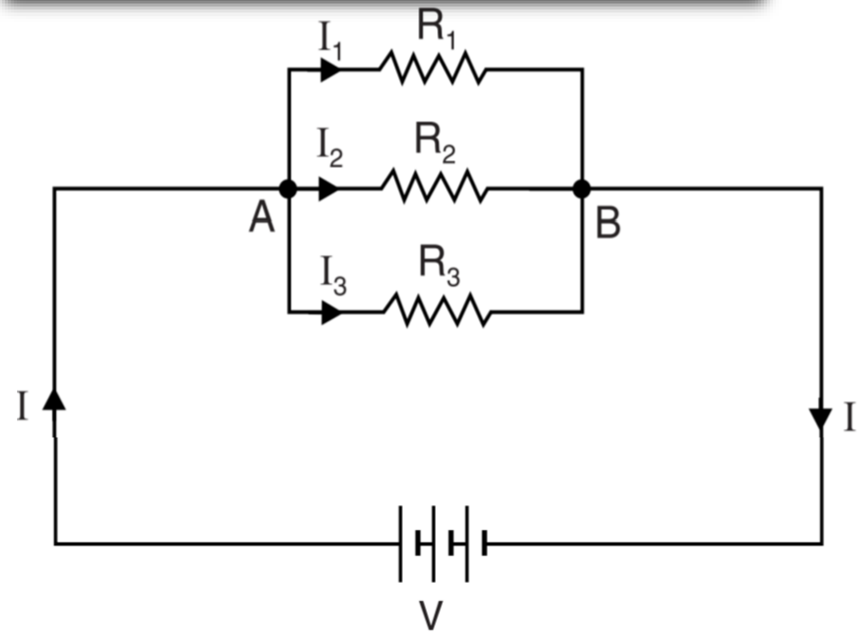
$$V = V_1 + V_2 + V_3$$

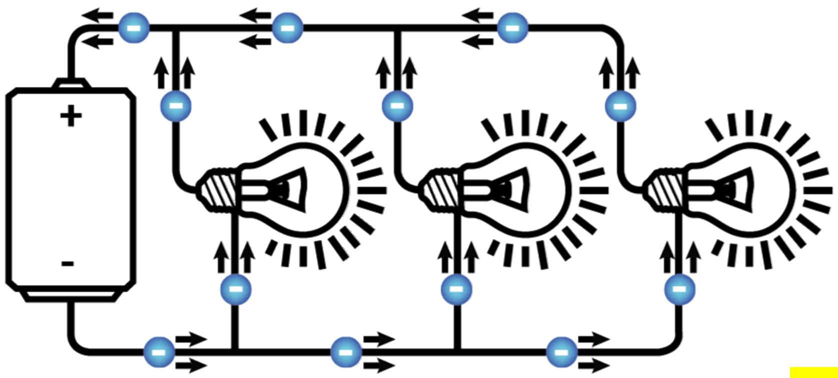
$$V = IR_1 + IR_2 + IR_3$$
$$V = I[R_1 + R_2 + R_3]$$

$$R_S = R_1 + R_2 + R_3$$

Hence when a number of resistances are connected in series, the total resistance is equal to the sum of the individual resistances

Parallel connection





$$I_1 = \frac{V}{R_1}; I_2 = \frac{V}{R_2}; I_3 = \frac{V}{R_3}$$

$$I = I_1 + I_2 + I_3$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

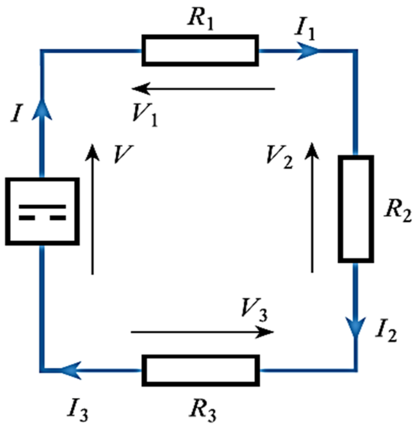
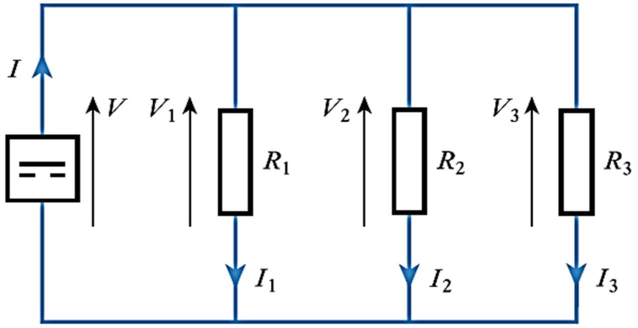
$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Two Resistances in Parallel

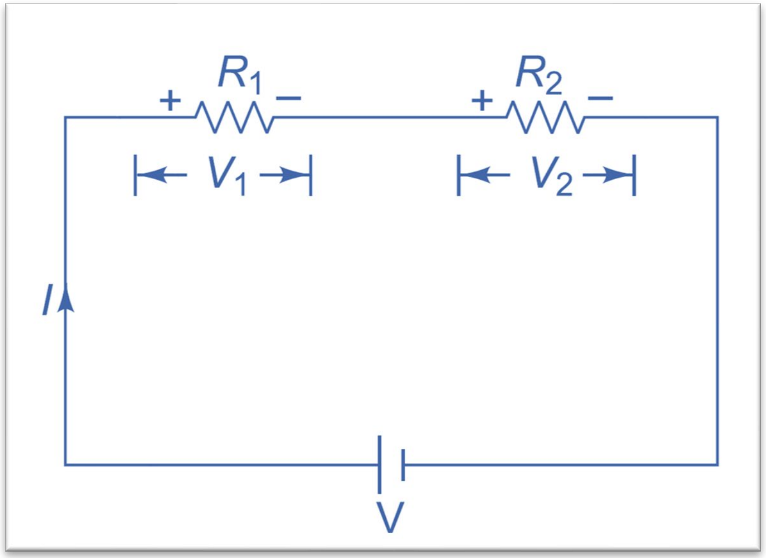
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_{\text{eq}} = \frac{R_1 R_2}{R_1 + R_2}$$

Hence when a number of resistances are connected in parallel, the reciprocal of total resistance is equal to the sum of the reciprocals of the individual resistances

	Series circuit	Parallel network
		
Current	The current is the same in all parts of the circuit	The total current supplied to the network equals the sum of the currents in the various branches
	$I = I_1 = I_2 = I_3$	$I = I_1 + I_2 + I_3$
Voltage	The total voltage equals the sum of the voltages across the different parts of the circuit	The voltage across a parallel combination is the same as the voltage across each branch
	$V = V_1 + V_2 + V_3$	$V = V_1 = V_2 = V_3$
Resistance	The total resistance equals the sum of the separate resistances	The reciprocal of the equivalent resistance equals the sum of the reciprocals of the branch resistances
	$R = R_1 + R_2 + R_3$	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Voltage Division Rule



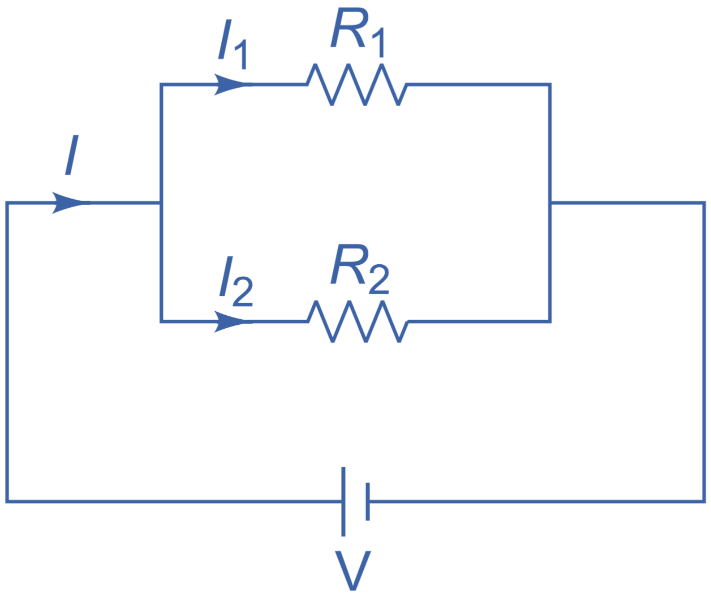
Voltage Division in a Series Circuit

$$I = \frac{V}{R_1 + R_2}$$

Hence, voltage across $R_1 = V_1 = R_1 I = R_1 \frac{V}{R_1 + R_2} = \frac{R_1}{R_1 + R_2} V$

Similarly, voltage across $R_2 = V_2 = R_2 I = R_2 \frac{V}{R_1 + R_2} = \frac{R_2}{R_1 + R_2} V$

Current Division Rule



Current Division in a Parallel Circuit

Case (i) When two resistances are connected in parallel,

$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

Also, $V = R_T I = R_1 I_1 = R_2 I_2$

Hence, current through $R_1 = I_1 = \frac{V}{R_1} = \frac{R_T I}{R_1} = \frac{R_2}{R_1 + R_2} I$

Similarly, current flowing through $R_2 = I_2 = \frac{V}{R_2} = \frac{R_T I}{R_2} = \frac{R_1}{R_1 + R_2} I$

Source Transformation

- A voltage source with a series resistor can be converted into an equivalent current source with a parallel resistor.
- Conversely, a current source with a parallel resistor can be converted into a voltage source with a series resistor.