Topic 3

# Kirchhoff's laws:
# Kirchhoff's Voltage Law (KVL),
# Kirchhoff's Current Law (KCL)

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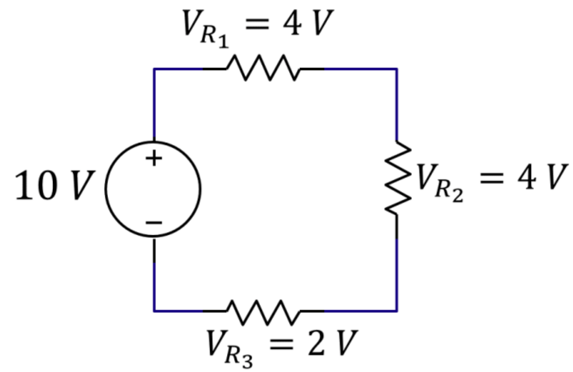
# Kirchhoff's Voltage Law (Mesh Law)

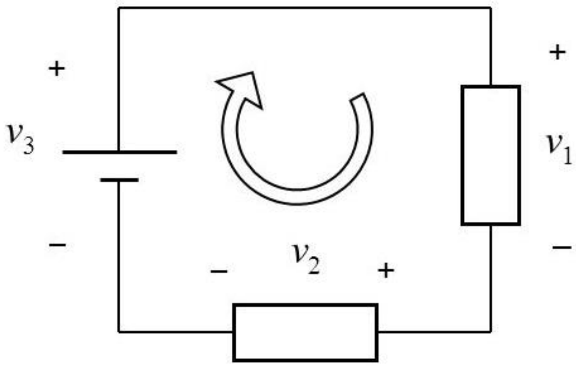
Around any complete (closed loop) circuit, the algebraic sum of the electromotive force equals the algebraic sum of the voltage drops.




$$\sum Voltage_{rise} = \sum Voltage_{drop}$$

$$10\ V = 4\ V + 4\ V + 2\ V$$

*"The algebraic sum of all voltages around any closed path in a circuit is zero" (positive for a voltage rise, negative for a voltage drop.*




$$+v_1 + v_2 - v_3 = 0$$

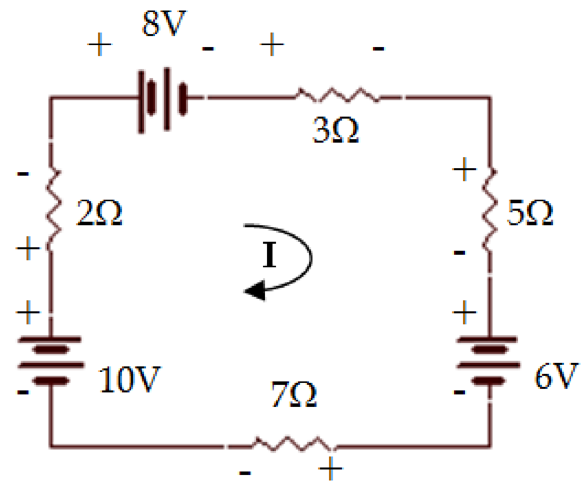
$$-v_1 - v_2 + v_3 = 0$$

$$v_1 + v_2 = v_3$$

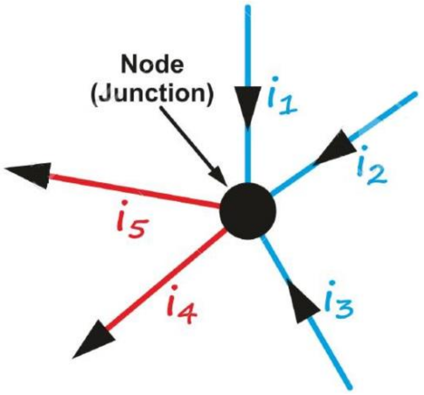
Example:

According to KVL,

$10V - 8V - 6V = 2I + 3I + 5I + 7I$
Or, $8V + 6V - 10V + 2I + 3I + 5I + 7I = 0$



# Kirchhoff's Current Law (Point Law)




In any electrical network, the algebraic sum of the currents meeting at a point or junction is zero. i.e $\sum$ I (incoming current) = $\sum$ I (leaving current).

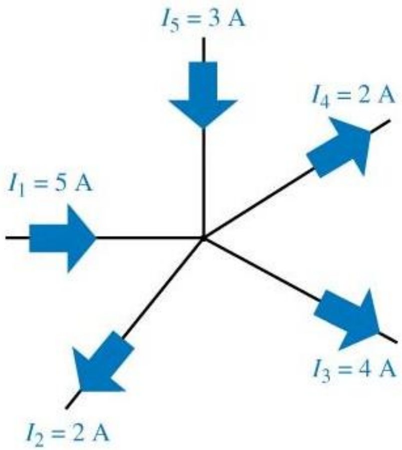
$$I_1 + I_2 + I_3 = I_4 + I_5$$

$$\text{or, } \Sigma I_{enter} = \Sigma I_{leave}$$

$$\text{or, } \Sigma I_{enter} - \Sigma I_{leave} = 0$$

The algebraic sum of the currents entering and leaving a node is equal to zero

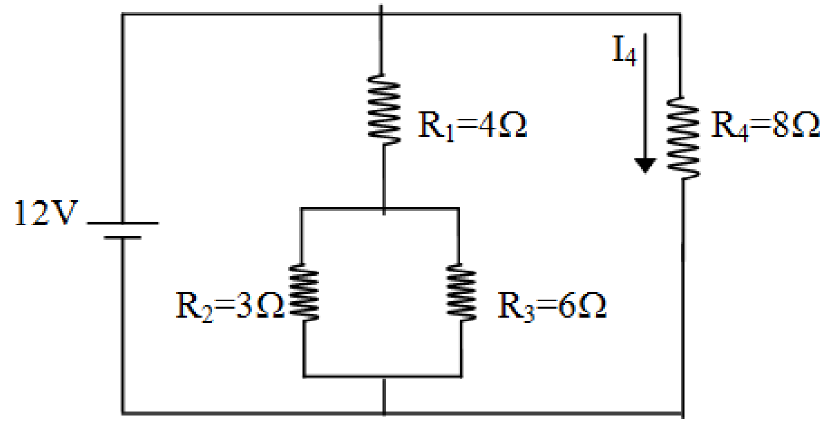
$$\sum I = 0$$




Currents entering a node are positive and those leaving a node are negative.

$$\sum_{n=1}^{N} I_n = I_1 + (-I_2) + (-I_3) + (-I_4) + I_5 = 0$$

**Problem-1)** Determine the current $I_4$ & the voltage $V_2$ for the network of the figure




Solution:

$R_T = \{R_1 + (R_2 \,||\, R_3)\} \,||\, R_4 = \{4 + (3\,||\,6)\}\,||\,8 = (4 + 2)\,||\,8 = 6\,||\,8 = 3.43\ \Omega$

$$I = \frac{E}{R_T} = \frac{12}{3.43} = 3.50A$$

$$I_4 = \frac{I \times R_{123}}{R_{123} + R_4} = \frac{3.5 \times 6}{6+8} = 1.5A$$

Alternative solution:

$$I_4 = \frac{E}{R_4} = \frac{12}{8} = 1.5A$$

Again, $I_1 = 2A$ through $R_1$ resistor. So,

$$I_2 = \frac{I_1 \times R_3}{R_2 + R_3} = \frac{2 \times 6}{3+6} = \frac{12}{9} = 1.33A$$

$$\therefore V_2 = I_2 \times R_2 = 1.33 \times 3 = 4V$$

Alternative solution:

$R_{23} = R_2 \,||\, R_3 = 3\,||\,6 = 2\Omega$

Applying voltage divider rule

$$V_2 = \frac{R_{23} \times E}{R_1 + R_{23}} = \frac{2 \times 12}{4+2} = 4V$$

**Problem-2)** Find the values of $V_1$ , $V_3$ , $V_{ab}$ & $I_S$ for the network.