BASIC LAWS

Engineers must be able to design and conduct experiments, as well as analyze and interpret.

--- Accreditation Board for Engineering and Technology

Ohm’s Law

Ohm's law states that the current through a conductor between two points is directly proportional to the potential difference across the two points…

$$v \infty \ i$$

$$v = i R$$

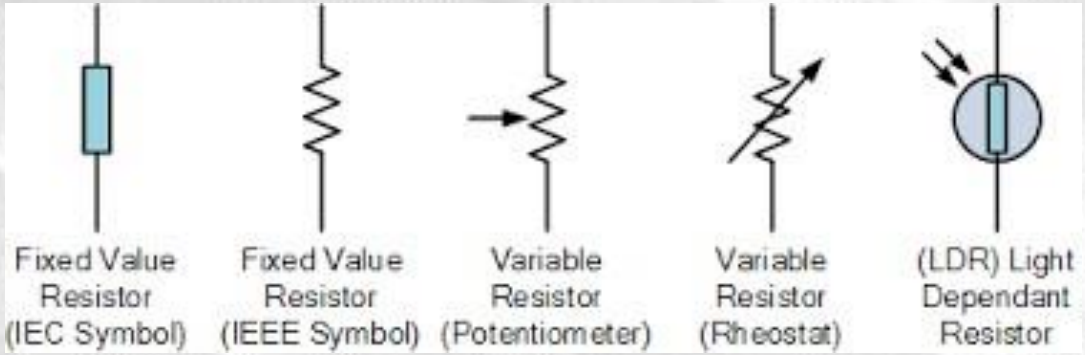
The resistance R of an element denotes its ability to resist the flow of electric current; it is measured in ohms (Ω).

$$R = \ \rho \ \frac{L}{A}$$

Ohm's Law

This implies that current flows from a higher potential to a lower potential in order for V=iR. If current flows from a lower potential to a higher potential, V = -iR.

$$I = \frac{V_A - V_B}{R}$$



A short circuit is a circuit element with resistance approaching zero. An open circuit is a circuit element with resistance approaching infinity.

Ohm's Law

Conductance is the ability of an element to conduct electric current; it is measured in mhos or siemens (S).

$$R = \frac{1}{G} \qquad i = Gv \qquad p = vi = i^2R = \frac{v^2}{R} \qquad p = vi = v^2G = \frac{i^2}{G}$$

The power dissipated in a resistor is a nonlinear function of either current or voltage.

Since R and G are positive quantities, the power dissipated in a resistor is always positive. Thus, a resistor always absorbs power from the circuit. This confirms the idea that a resistor is a passive element, incapable of generating energy.

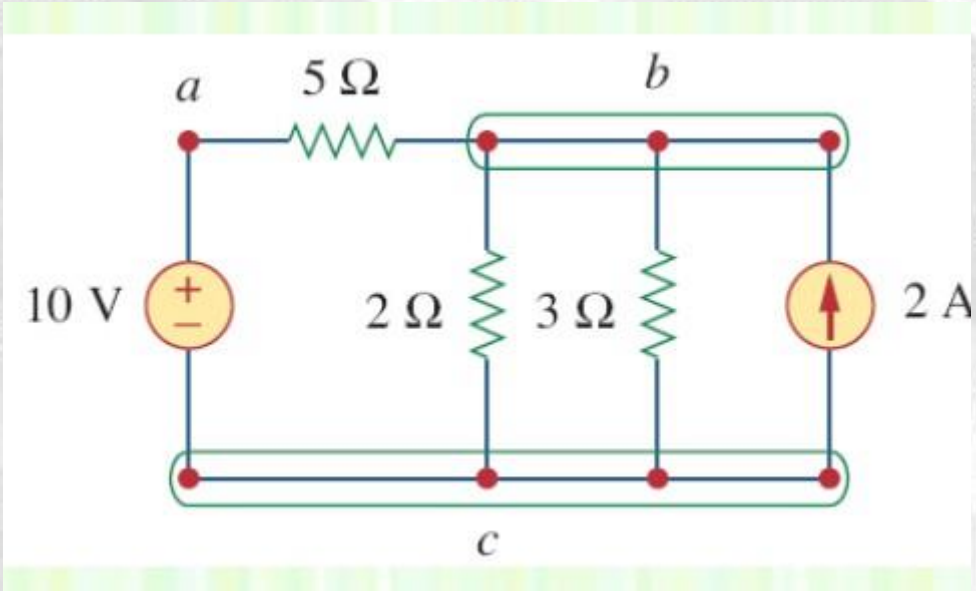
Nodes, Branches, and Loops

A branch represents a single element such as a voltage source or a resistor.

A node is the point of connection between two or more branches

A loop is any closed path in a circuit.

A loop is said to be independent if it contains at least one branch which is not a part of any other independent loop. Independent loops or paths result in independent sets of equations.

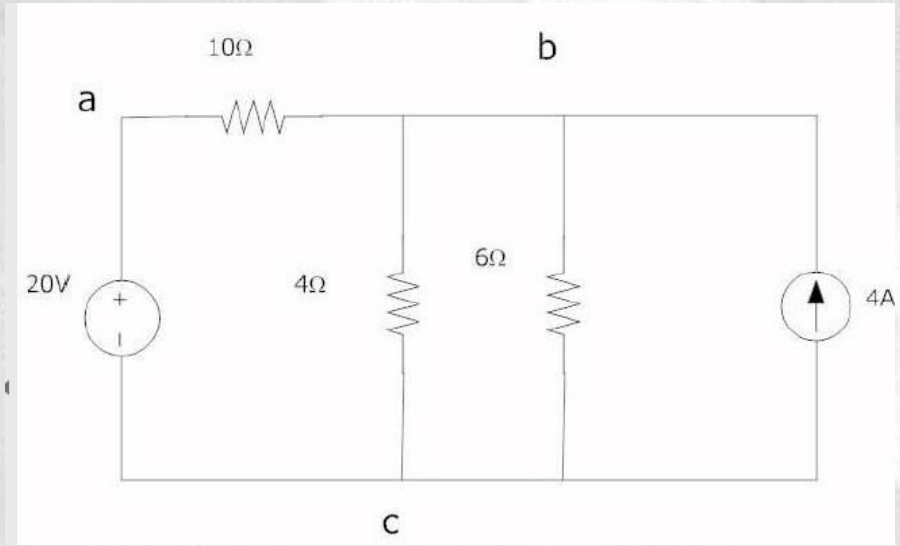


Nodes, Branches, and Loops

- A network with b branches, n nodes, and l independent loops will satisfy the fundamental theorem of network topology.
- Two or more elements are in series if they exclusively share a single node and consequently carry the same current.
- Two or more elements are in parallel if they are connected to the same two nodes and consequently have the same voltage across them.

$$b = l + n - 1$$

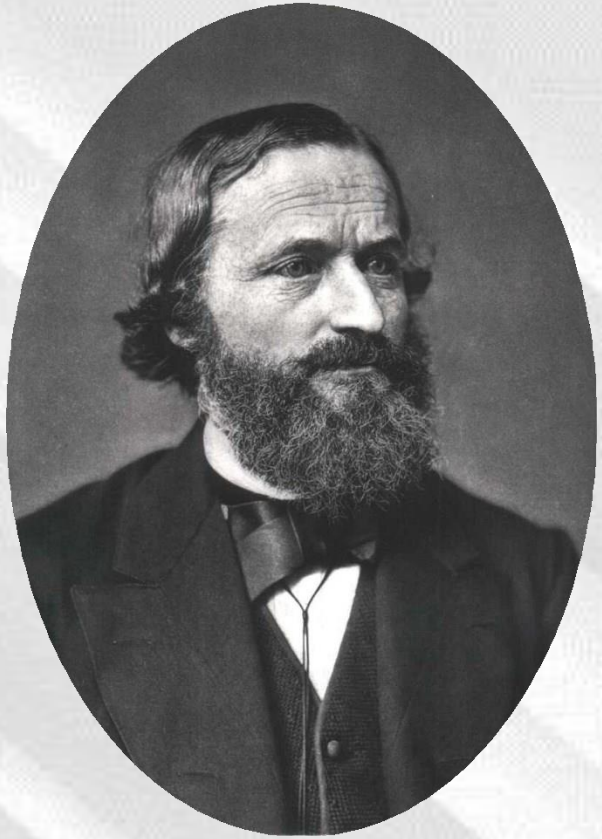
$$b = 5 ; n = 3 ; l = 3$$



Kirchhoff's Laws

- Kirchhoff's laws were first introduced in 1847 by the German physicist Gustav Robert Kirchhoff (1824 –1887)

- These laws are formally known as Kirchhoff's current law (KCL) and Kirchhoff's voltage law (KVL).



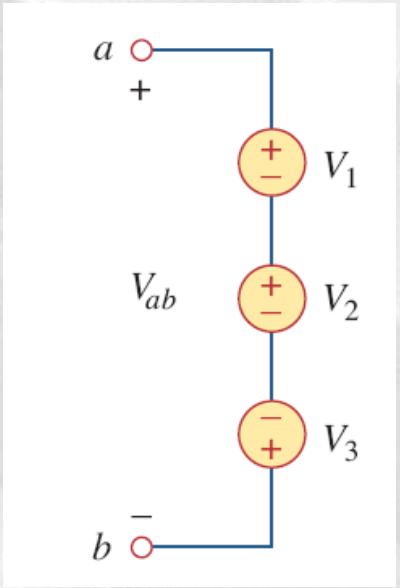
Gustav Robert Kirchhoff 1824-1887

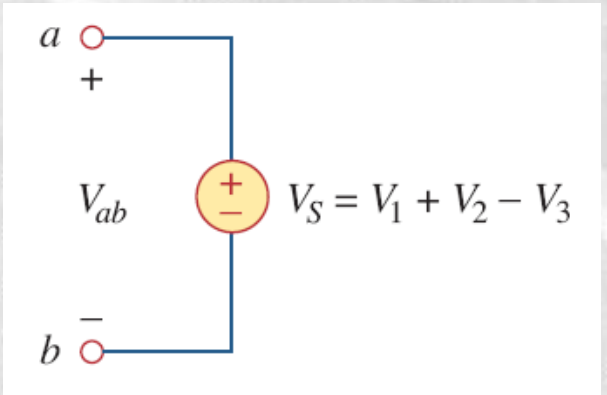
Kirchhoff's Voltage Law

- Kirchhoff's first law is based on the law of conservation of charge, which requires that the algebraic sum of charges within a system cannot change.

- Kirchhoff's voltage law (KVL) states that the algebraic sum of all voltages around a closed path (or loop) is zero. So, the Sum of voltage drops=Sum of voltage rises

$$\sum_{m=1}^{M} v_m = 0$$





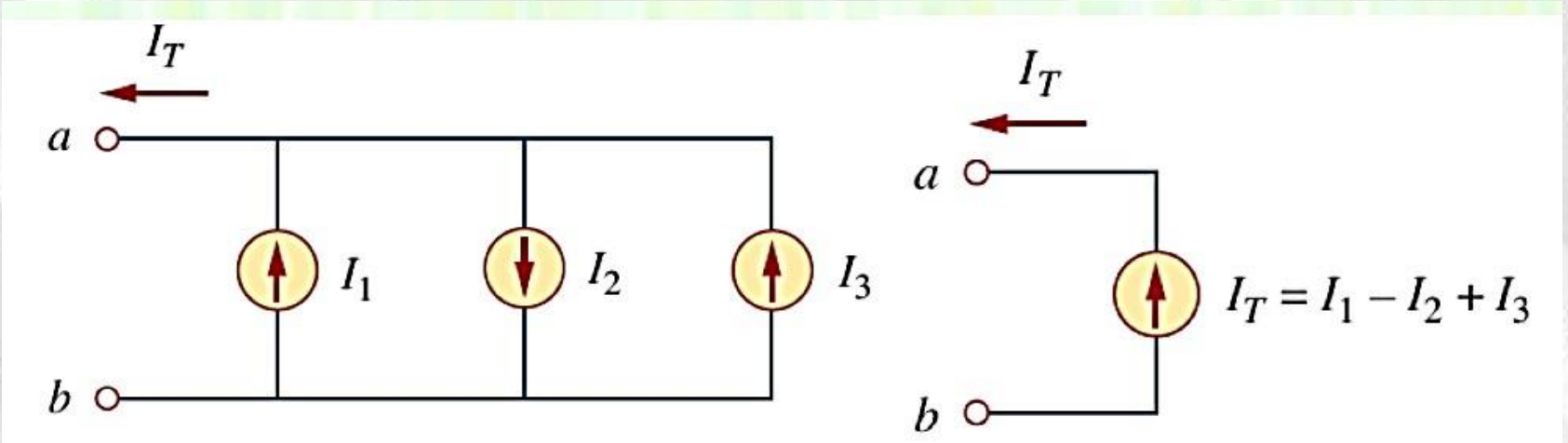
$$V_{AB} = V_s$$

Kirchhoff's Current Law

- Kirchhoff's current law (KCL) states that the algebraic sum of currents entering a node (or a closed boundary) is zero.
- Kirchhoff's current law (KCL) Note that KCL also applies to a closed boundary.

$$\sum_{n=1}^{N} i_n = 0$$

$$-I_T + i_1 + i_2 - i_3 = 0$$



Circuit Solve

Example 2.7

Find current i_o and voltage v_o in the circuit shown in Fig. 2.25.

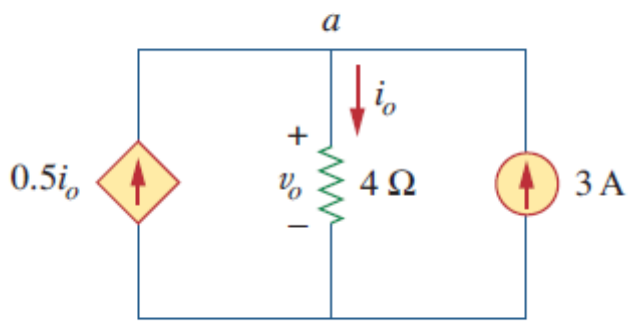


Figure 2.25
For Example 2.7.

Solution:

Applying KCL to node a, we obtain

$$3 + 0.5i_o = i_o \quad \Rightarrow \quad i_o = 6\ \text{A}$$

$$\sum_{n=1}^{N} i_n = 0$$

For the 4-Ω resistor, Ohm's law gives

$$v_o = 4i_o = 24\ \text{V}$$

$$v = \text{i R}$$

Circuit Solve

Practice Problem 2.7

Find v_o and i_o in the circuit

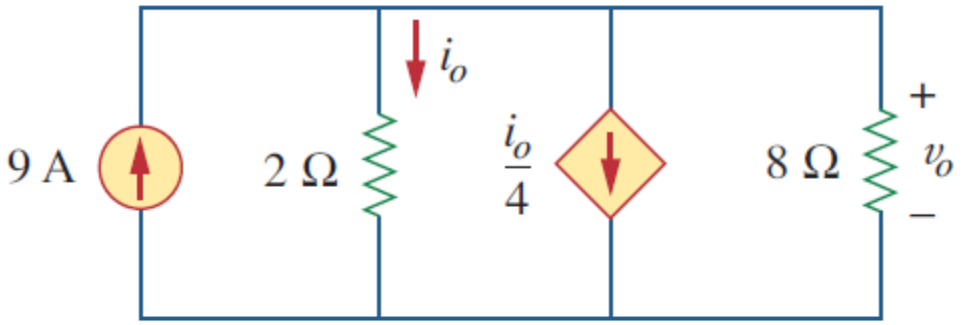


Figure 2.26
For Practice Prob. 2.7.

Try Yourself

Answer : 12 V, 6 A.

Circuit Solve

Practice Problem 2.7

Find v_o and i_o in the circuit

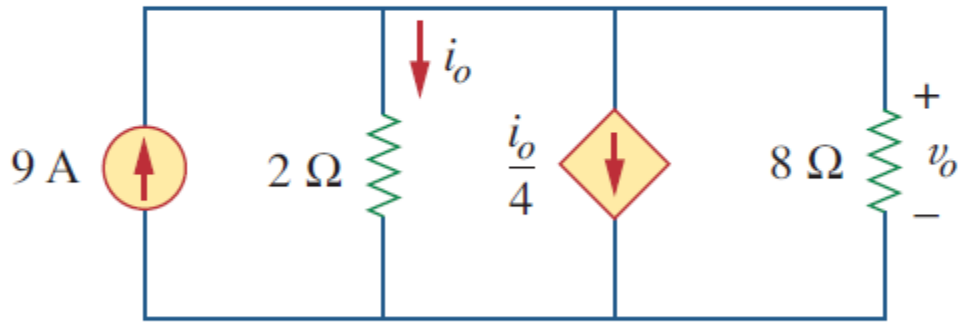


Figure 2.26
For Practice Prob. 2.7.

$$V_0 = 2i_0$$

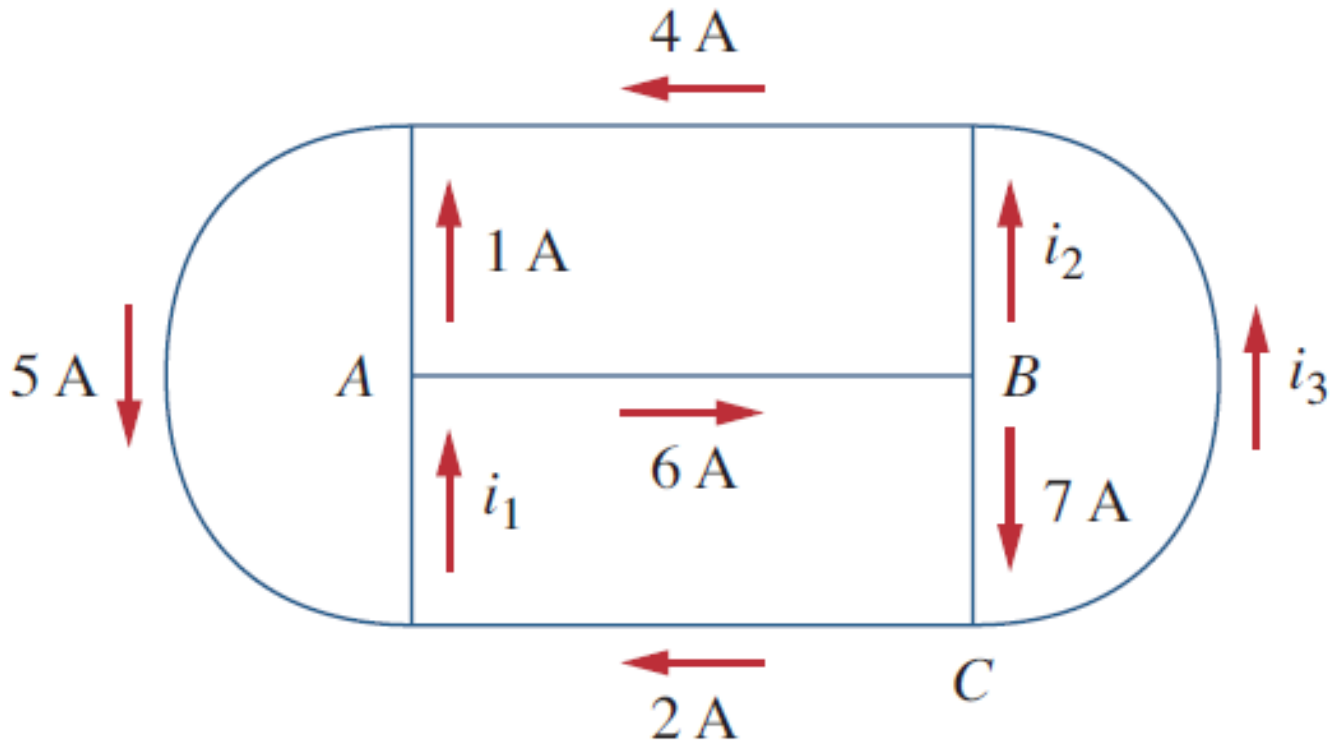
$$9 - i_0 - \frac{i_0}{4} - \frac{V_0}{8} = 0$$

$$\frac{5i_0}{4} + \frac{V_0}{8} = 9$$

Answer : 12 V, 6 A.

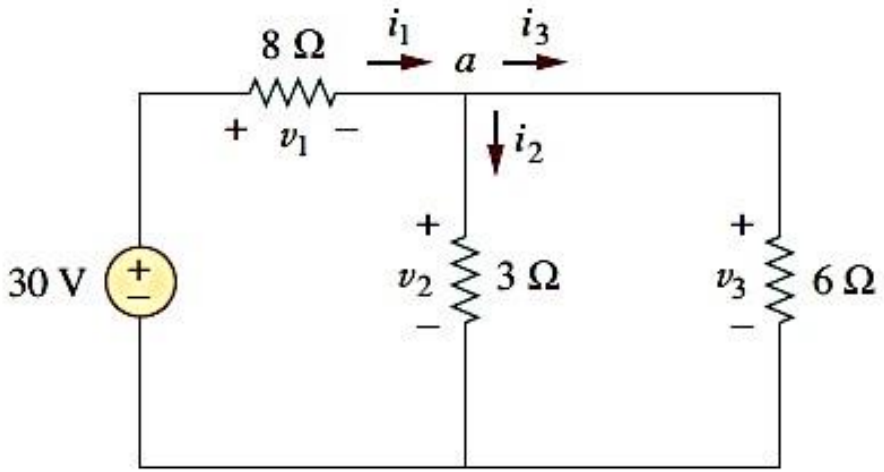
Circuit Solve - Assignment

Find i_1, i_2, and i_3

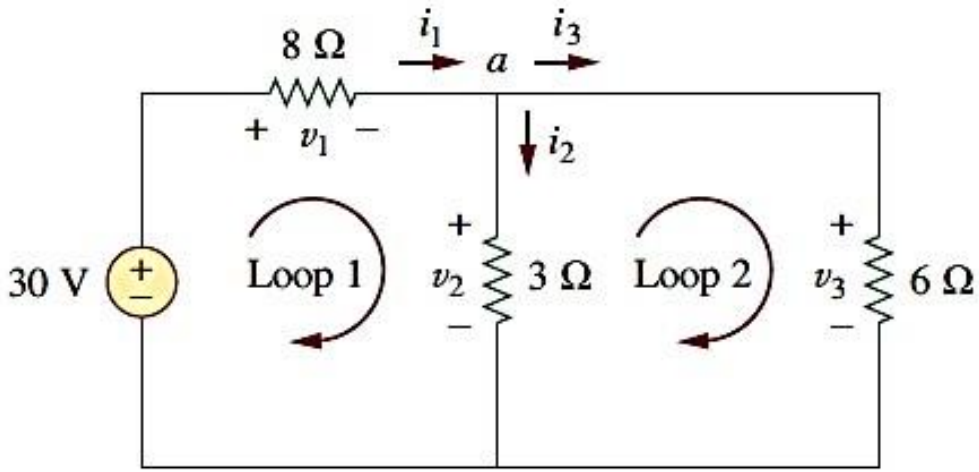


Circuit Solve

Example 2.8 Find currents and voltages in the circuit shown in Fig. 2.27(a).



(a)



(b)

Circuit Solve

We apply Ohm's law and Kirchhoff's laws. By Ohm's law,

$$v_1 = 8i_1, \qquad v_2 = 3i_2, \qquad v_3 = 6i_3$$

Applying KCL at node a :

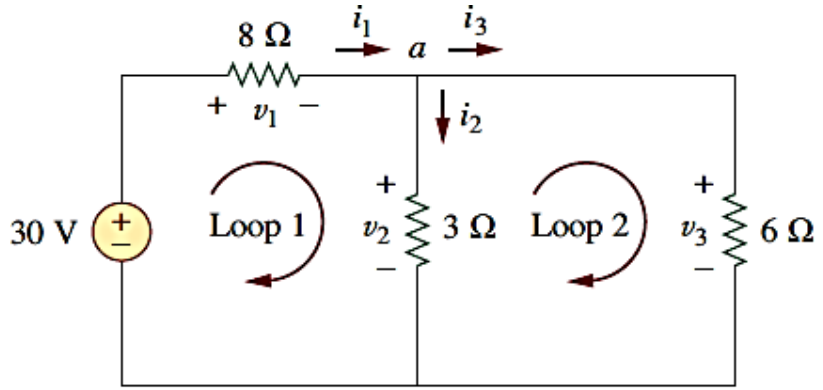
$$i_1 - i_2 - i_3 = 0$$

Applying KVL at loop 1 :

$$-30 + v_1 + v_2 = 0$$

$$-30 + 8i_1 + 3i_2 = 0$$

$$i_1 = \frac{(30 - 3i_2)}{8}$$



(b)

Applying KVL at loop 2 :

$$-v_2 + v_3 = 0 \quad \Rightarrow \quad v_3 = v_2$$

$$6i_3 = 3i_2 \quad \Rightarrow \quad i_3 = \frac{i_2}{2}$$

$$\frac{30 - 3i_2}{8} - i_2 - \frac{i_2}{2} = 0$$

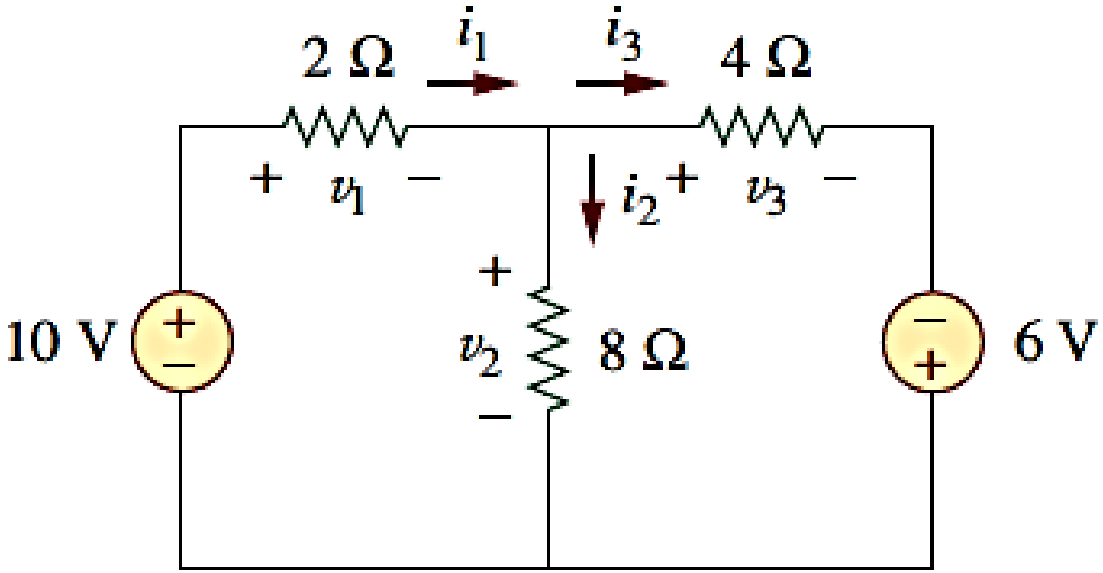
$$i_2 = 2 \text{ A}.$$

$$i_1 = 3 \text{ A}, \qquad i_3 = 1 \text{ A},$$

$$v_1 = 24 \text{ V}, \qquad v_2 = 6 \text{ V}, \qquad v_3 = 6 \text{ V}$$

Circuit Solve-Assignment

Find the currents and voltages in the circuit shown



Thank you