

# **Electrical Circuit (1)**

**Introduction (week1 class2)**

**Dr. Akram Al-Mahrouk**

**Philadelphia University**

## Chapter 2 Basic Laws 29

2.1	Introduction	30
2.2	Ohm's Law	30
2.3	†Nodes, Branches, and Loops	35
2.4	Kirchhoff's Laws	37
2.5	Series Resistors and Voltage Division	43
2.6	Parallel Resistors and Current Division	45
2.7	†Wye-Delta Transformations	52
	Delta to Wye Conversion	
	Wye to Delta Conversion	
2.8	†Applications	58
	2.8.1 Lighting Systems	
	2.8.2 Design of DC Meters	
2.9	Summary	64
	Review Questions	66
	Problems	67
	Comprehensive Problems	78

# Ohm's Law

$$v \propto i$$

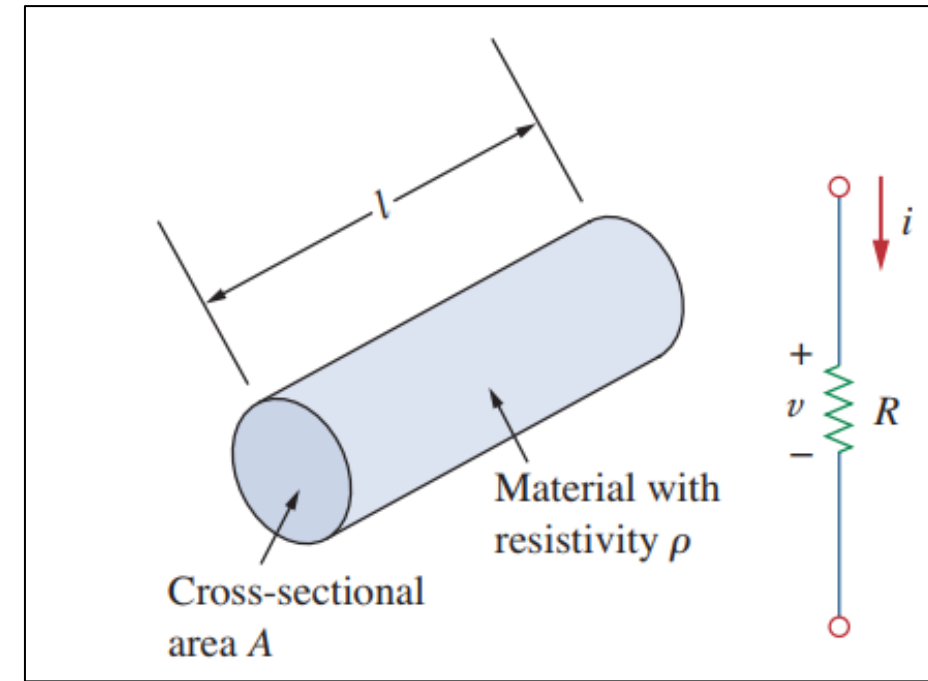
$$v = iR$$

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

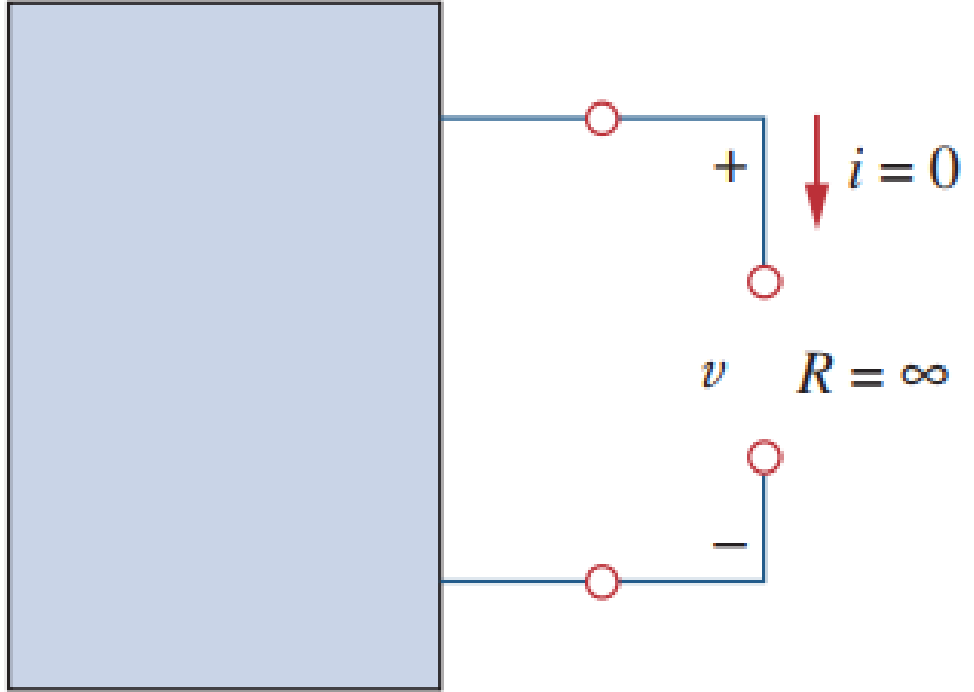
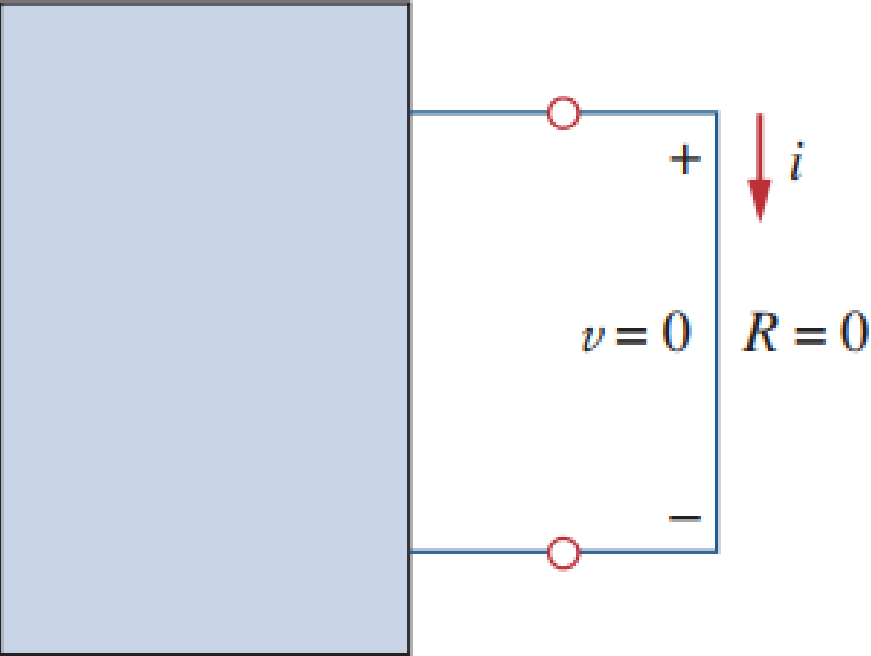
**TABLE 2.1**

Resistivities of common materials.

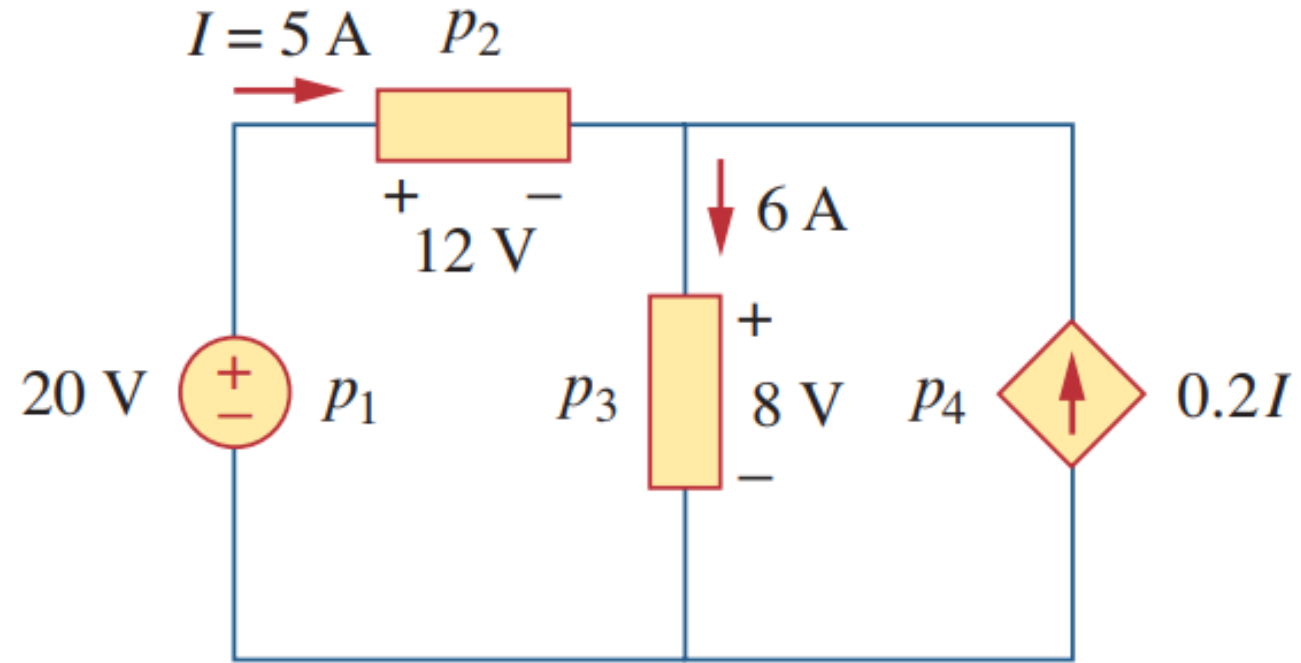
Material	Resistivity ( $\Omega \cdot \text{m}$ )	Usage
Silver	$1.64 \times 10^{-8}$	Conductor
Copper	$1.72 \times 10^{-8}$	Conductor
Aluminum	$2.8 \times 10^{-8}$	Conductor
Gold	$2.45 \times 10^{-8}$	Conductor
Carbon	$4 \times 10^{-5}$	Semiconductor
Germanium	$47 \times 10^{-2}$	Semiconductor
Silicon	$6.4 \times 10^2$	Semiconductor
Paper	$10^{10}$	Insulator
Mica	$5 \times 10^{11}$	Insulator
Glass	$10^{12}$	Insulator
Teflon	$3 \times 10^{12}$	Insulator



# Ohm's Law



## Power and Energy



$$P_1 = 20\text{V} * (-5\text{A}) = -100 \text{ watt}$$

$$P_2 = 12\text{V} * (5\text{A}) = 60 \text{ watt}$$

$$P_3 = 8\text{V} * (6\text{A}) = 48 \text{ watt}$$

$$P_4 = 8\text{V} * (-0.2 * 5\text{A}) = -8 \text{ watt}$$

# Power and Energy

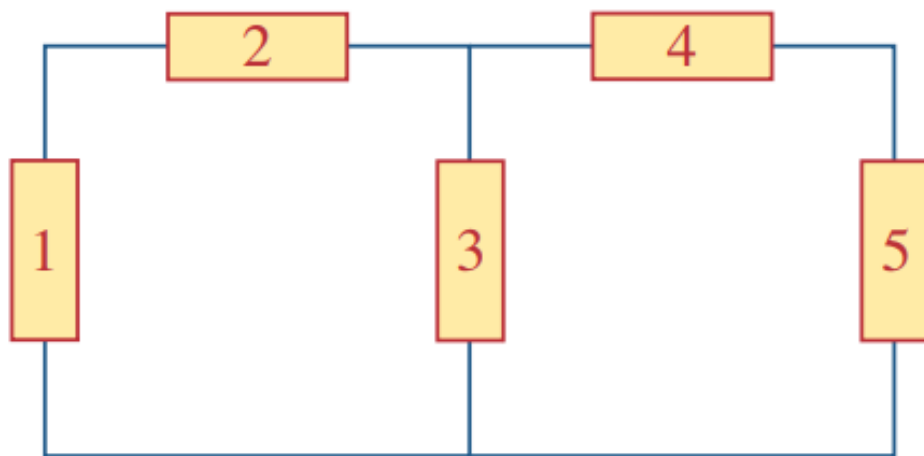
**TABLE 1.3**

Typical average monthly consumption of household appliances.

<b>Appliance</b>	<b>kWh consumed</b>	<b>Appliance</b>	<b>kWh consumed</b>
Water heater	500	Washing machine	120
Freezer	100	Stove	100
Lighting	100	Dryer	80
Dishwasher	35	Microwave oven	25
Electric iron	15	Personal computer	12
TV	10	Radio	8
Toaster	4	Clock	2

## Power and Energy

**1.17** Figure 1.28 shows a circuit with five elements. If  $p_1 = -205 \text{ W}$ ,  $p_2 = 60 \text{ W}$ ,  $p_4 = 45 \text{ W}$ ,  $p_5 = 30 \text{ W}$ , calculate the power  $p_3$  received or delivered by element 3.



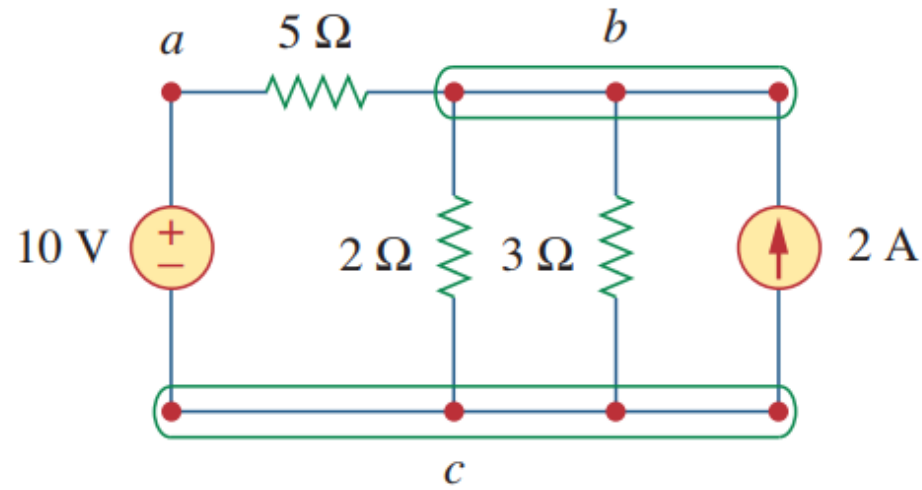
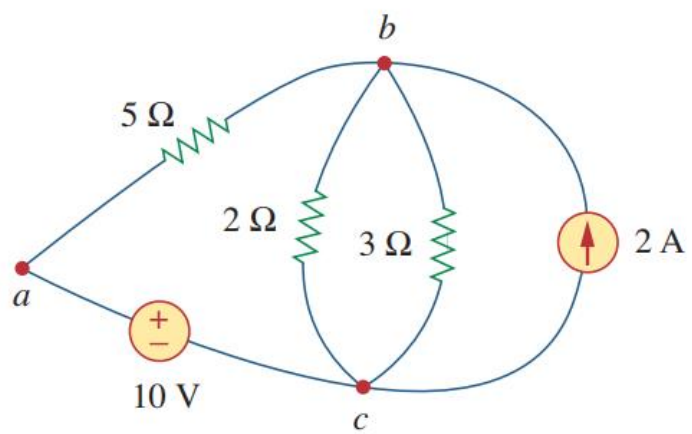
# † Nodes, Branches, and Loops

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.

$$b = l + n - 1$$



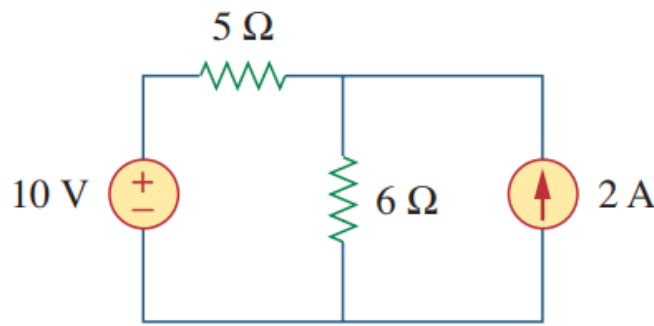
**Figure 2.11**  
The three-node circuit of Fig. 2.10 is redrawn.

# † Nodes, Branches, and Loops

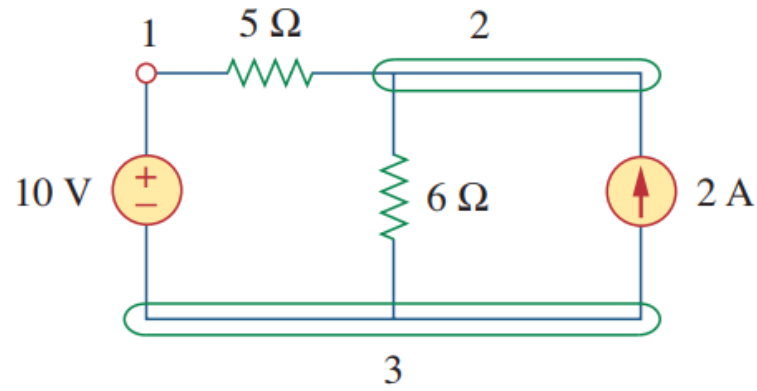
Nodes

Branches

Loops

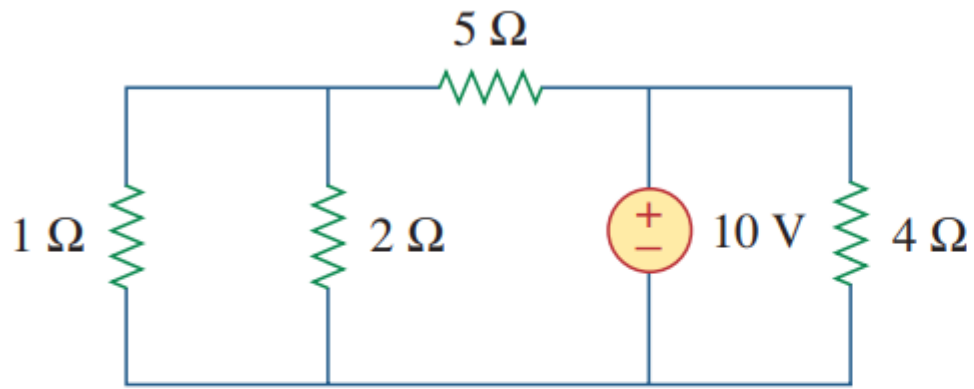


**Figure 2.12**  
For Example 2.4.

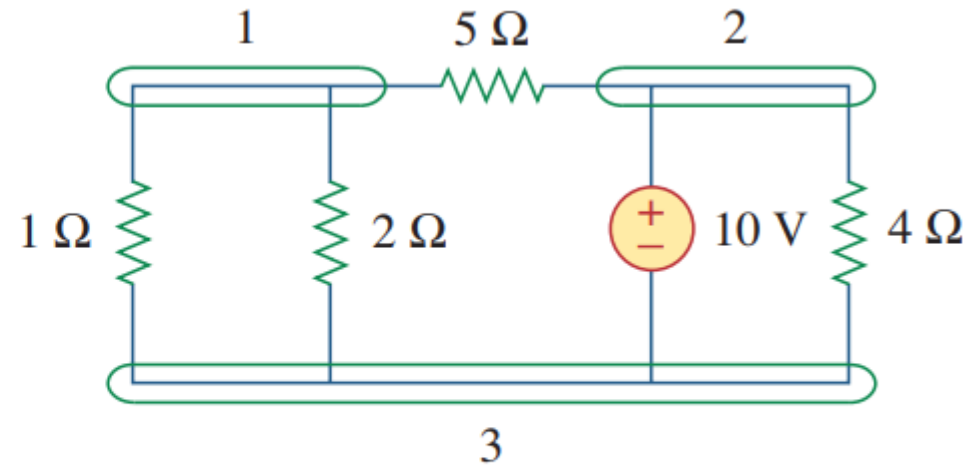


**Figure 2.13**  
The three nodes in the circuit of Fig. 2.12.

# † Nodes, Branches, and Loops



**Figure 2.14**  
For Practice Prob. 2.4.



**Figure 2.15**  
Answer for Practice Prob. 2.4.

Nodes

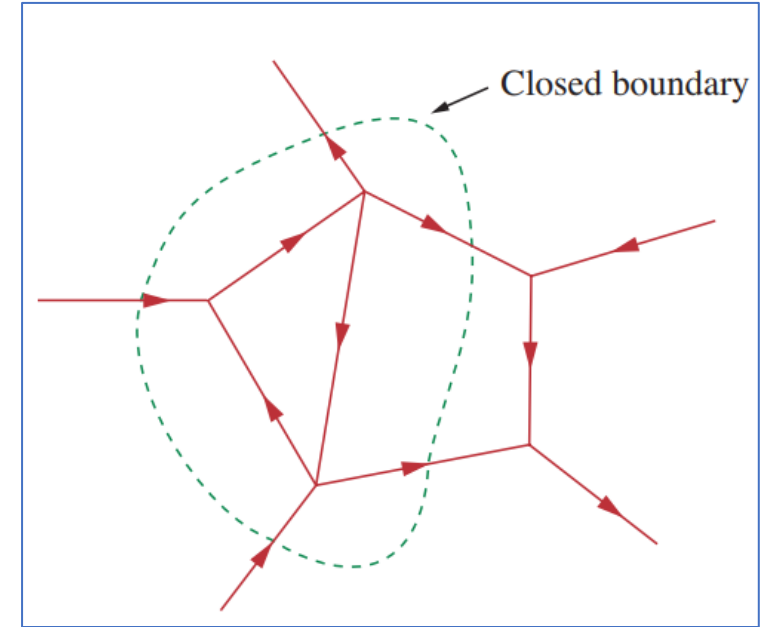
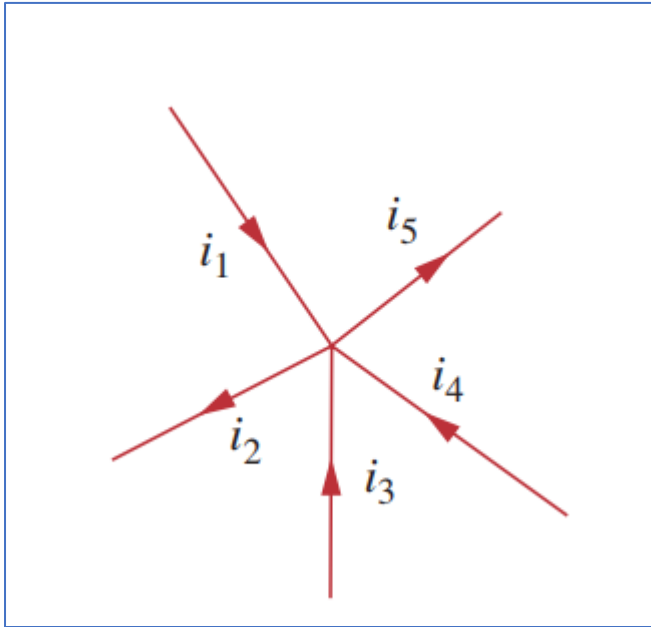
Branches

Loops

# Kirchhoff's Laws

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

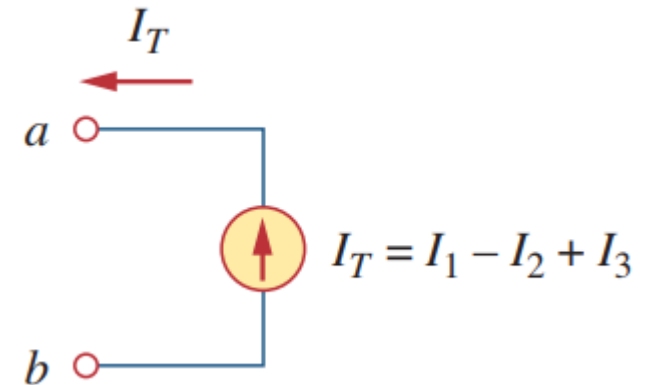
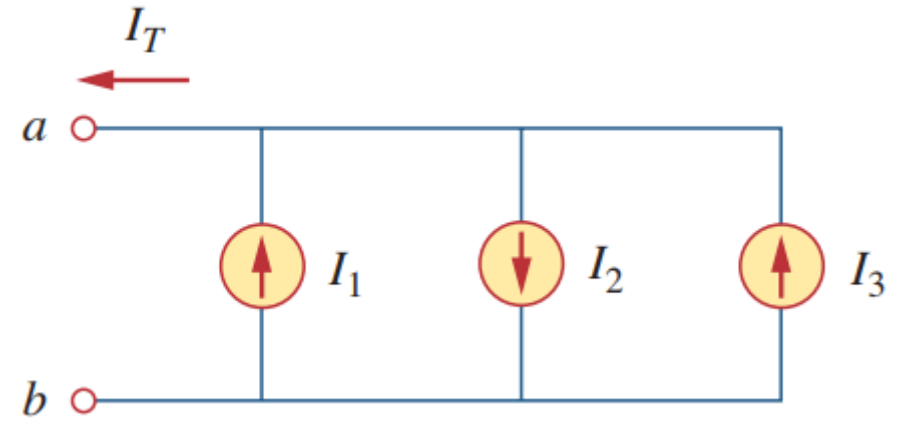
$$\sum_{n=1}^N i_n = 0$$



# Kirchhoff's Laws

$$I_T + I_2 = I_1 + I_3$$

$$I_T = I_1 - I_2 + I_3$$



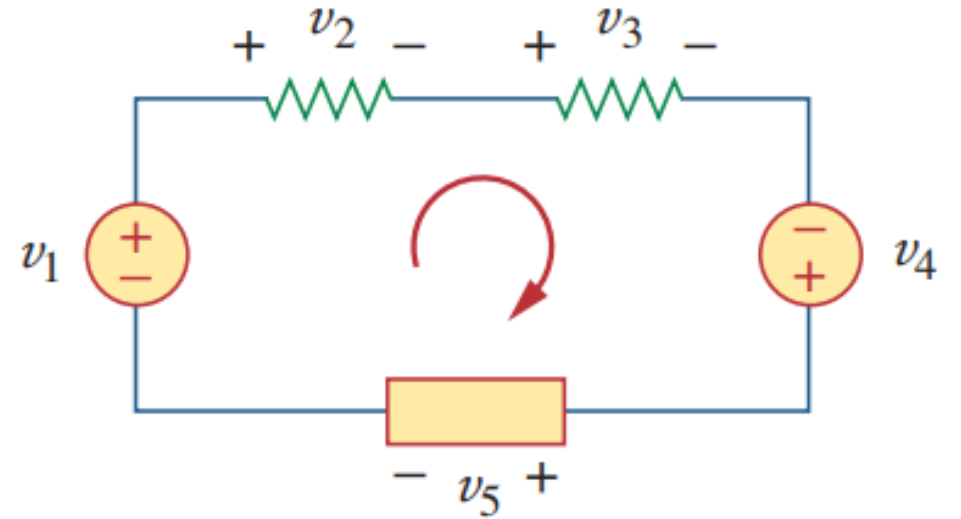
# Kirchhoff's Laws

Kirchhoff's voltage law (KVL) states that the algebraic sum of all voltages around a closed path (or loop) is zero.

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

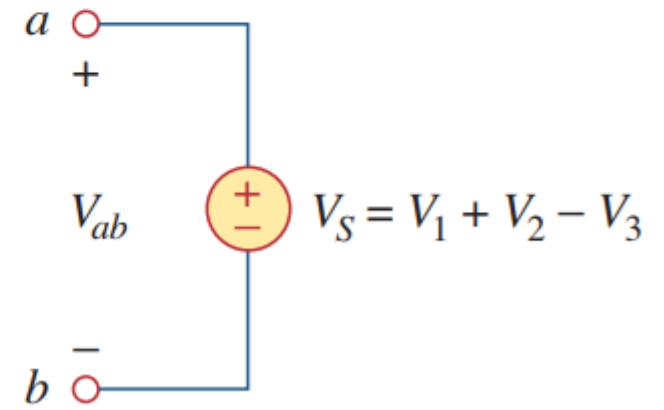
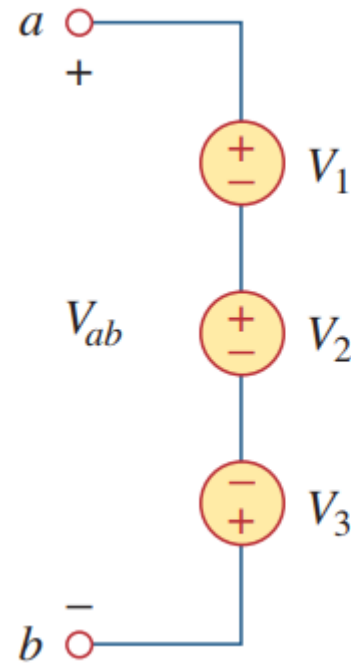
$$-v_1 + v_2 + v_3 - v_4 + v_5 = 0$$

$$v_2 + v_3 + v_5 = v_1 + v_4$$

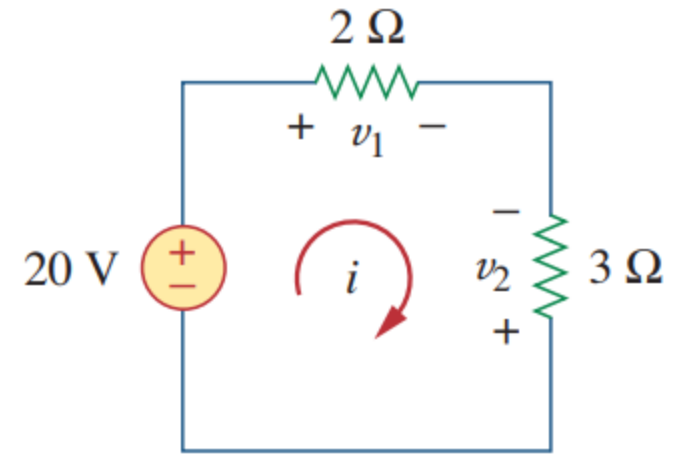
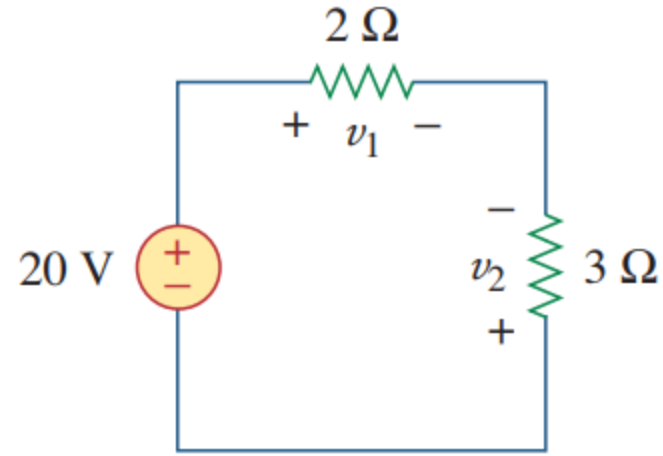


# Kirchhoff's Laws

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



# Kirchhoff's Laws



From Ohm's law,

$$v_1 = 2i, \quad v_2 = -3i \quad (2.5.1)$$

Applying KVL around the loop gives

$$-20 + v_1 - v_2 = 0 \quad (2.5.2)$$

Substituting Eq. (2.5.1) into Eq. (2.5.2), we obtain

$$-20 + 2i + 3i = 0 \quad \text{or} \quad 5i = 20 \quad \Rightarrow \quad i = 4 \text{ A}$$

Substituting  $i$  in Eq. (2.5.1) finally gives

$$v_1 = 8 \text{ V}, \quad v_2 = -12 \text{ V}$$

