

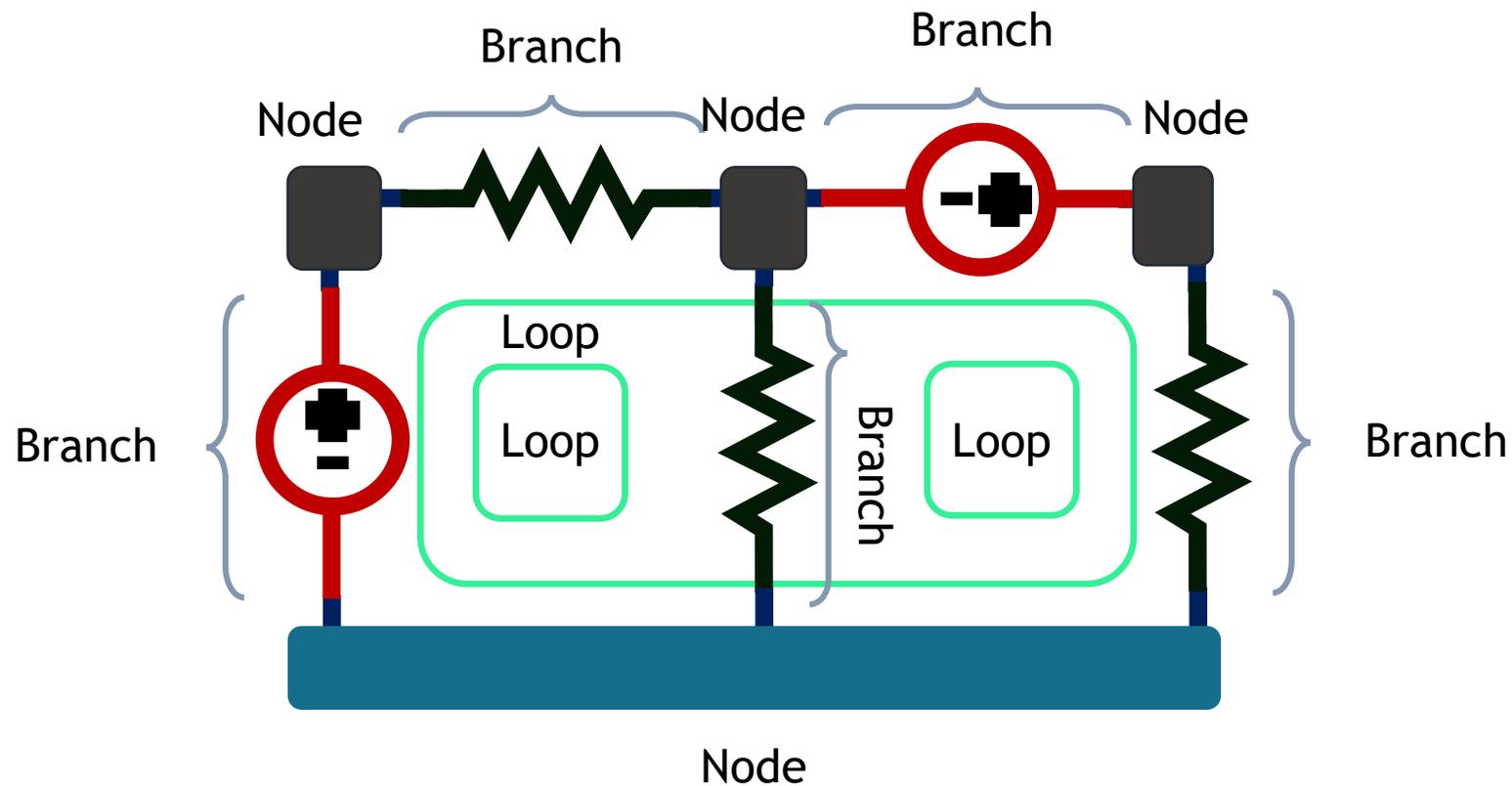
# **NODAL ANALYSIS**

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- Nodal Analysis
- Node Analysis with voltage source.
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# What is Nodal Analysis

Nodal analysis is a process that uses KCL to determine node voltages.

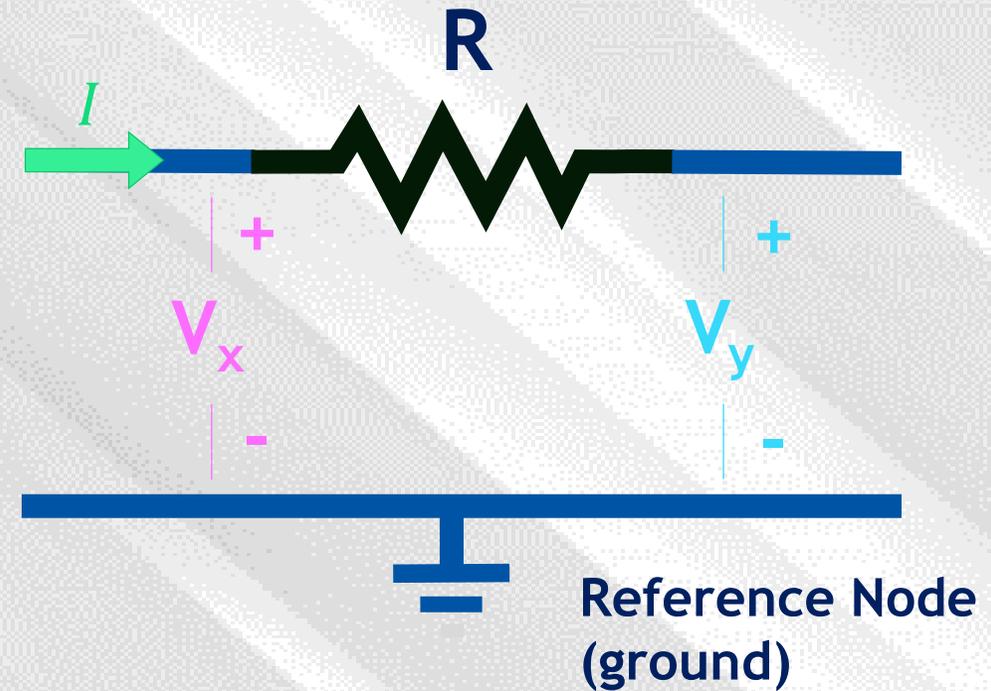


# Steps in Nodal Analysis

In nodal analysis, we are interested in finding the node voltages.

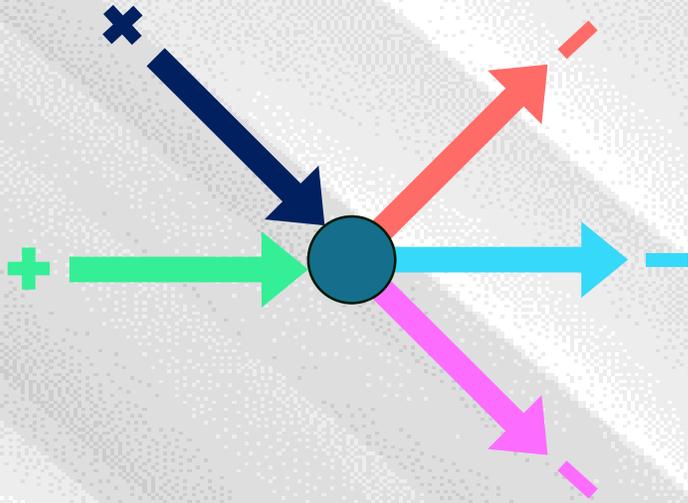
Given a circuit with  $n$  nodes without voltage sources, the nodal analysis of the circuit involves taking the following three steps.

- Select a node as the reference node. Assign voltages to the remaining nodes. These voltages are referenced with respect to the reference node.



# Steps in Nodal Analysis

- Apply KCL to each of the nonreference nodes. Use Ohm's law to express the branch currents in terms of node voltages.



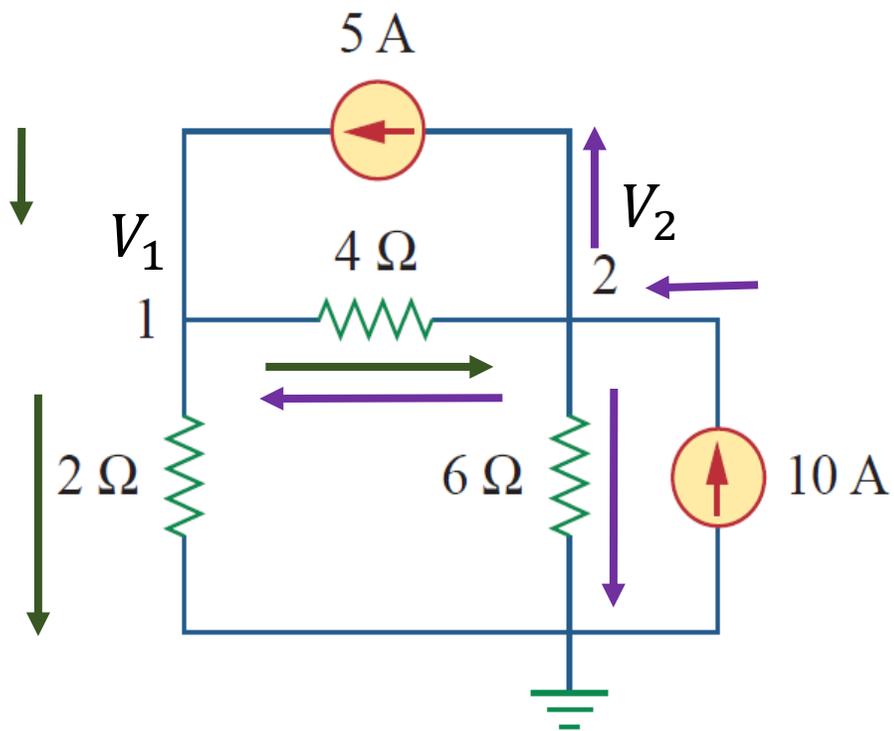
Current Entering & Exiting a Node



- Solve the resulting simultaneous equations to obtain the unknown node voltages.

# Mathematical Problem-1

Calculate the node voltages in the circuit shown



$$\frac{V_1 - V_2}{4} + \frac{V_1}{2} - 5 = 0 \qquad \frac{3V_1}{4} - \frac{V_2}{4} = 5$$

$$3V_1 - V_2 = 20$$

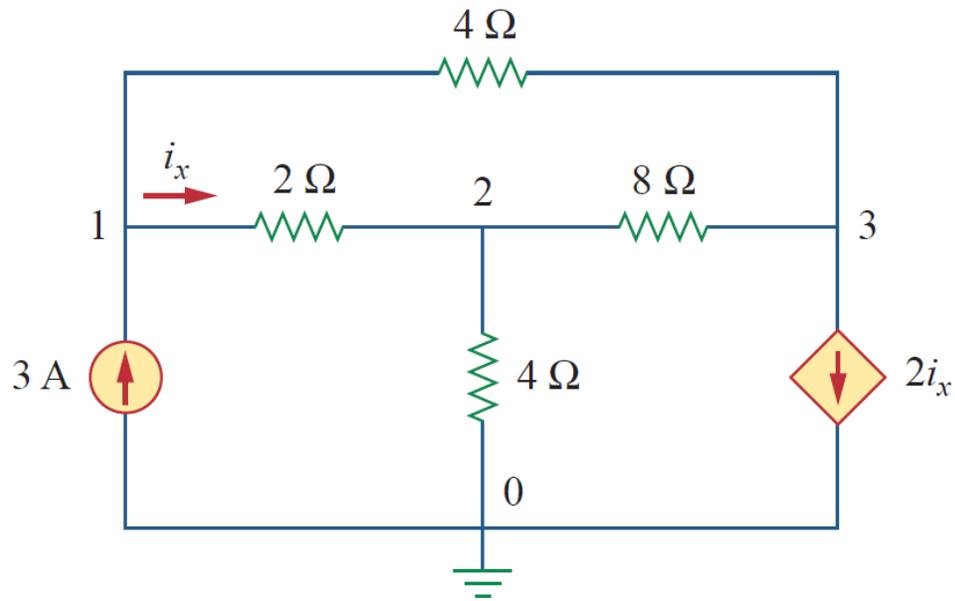
$$\frac{V_2 - V_1}{4} + \frac{V_2}{6} + 5 - 10 = 0 \qquad \frac{5V_2}{12} - \frac{V_1}{4} = 5$$

$$5V_2 - 3V_1 = 60$$

$$V_1 = \frac{40}{3} V \qquad V_2 = 20 V$$

# Mathematical Problem-2

Determine the voltages at the nodes in Fig.



$$i_x = \frac{V_1 - V_2}{2}$$

$$\frac{V_1 - V_2}{2} + \frac{V_1 - V_3}{4} - 3 = 0$$

$$3V_1 - 2V_2 - V_3 = 12$$

$$\frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{8} + \frac{V_2}{4} = 0$$

$$7V_2 - 4V_1 - V_3 = 0$$

$$\frac{V_3 - V_1}{4} + \frac{V_3 - V_2}{8} + 2i_x = 0$$

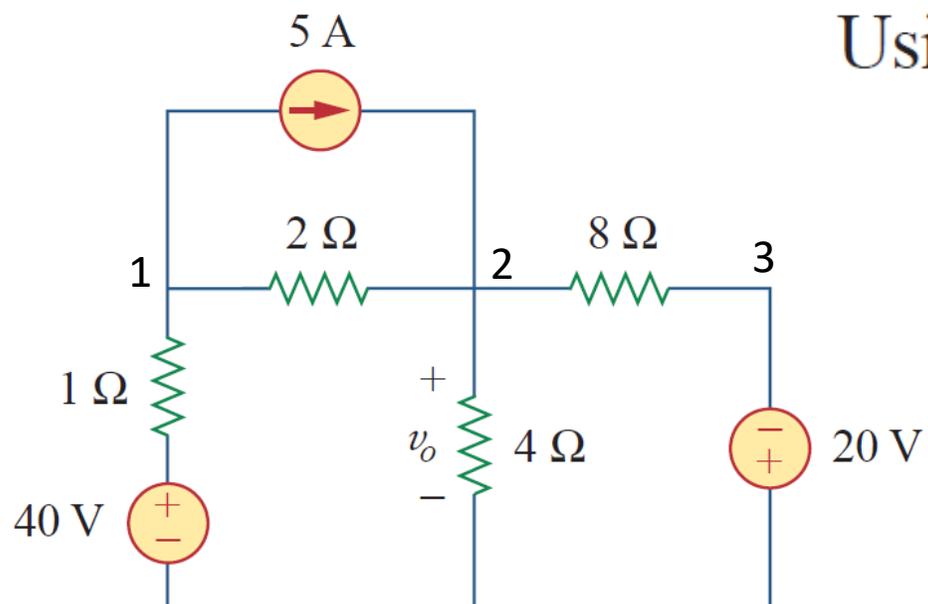
$$\frac{V_3 - V_1}{4} + \frac{V_3 - V_2}{8} + 2 \times \frac{V_1 - V_2}{2} = 0$$

$$3V_3 + 6V_1 - 9V_2 = 0$$

$$V_1 = 4.8 \text{ V} \quad V_2 = 2.4 \text{ V} \quad V_3 = -2.4 \text{ V}$$

# Mathematical Problem-3

Using nodal analysis, find  $v_o$  in the circuit of Fig.



$$\frac{V_1 - V_2}{2} + \frac{V_1 - 40}{1} + 5 = 0$$

$$3V_1 - V_2 = 70$$

$$\frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{8} + \frac{V_2}{4} - 5 = 0$$

$$7V_2 - 4V_1 - V_3 = 40$$

$$V_3 = -20 \text{ V}$$

$$V_1 = 30 \text{ V}$$

$$V_2 = 20 \text{ V}$$

$$V_0 = V_2 = 20 \text{ V}$$

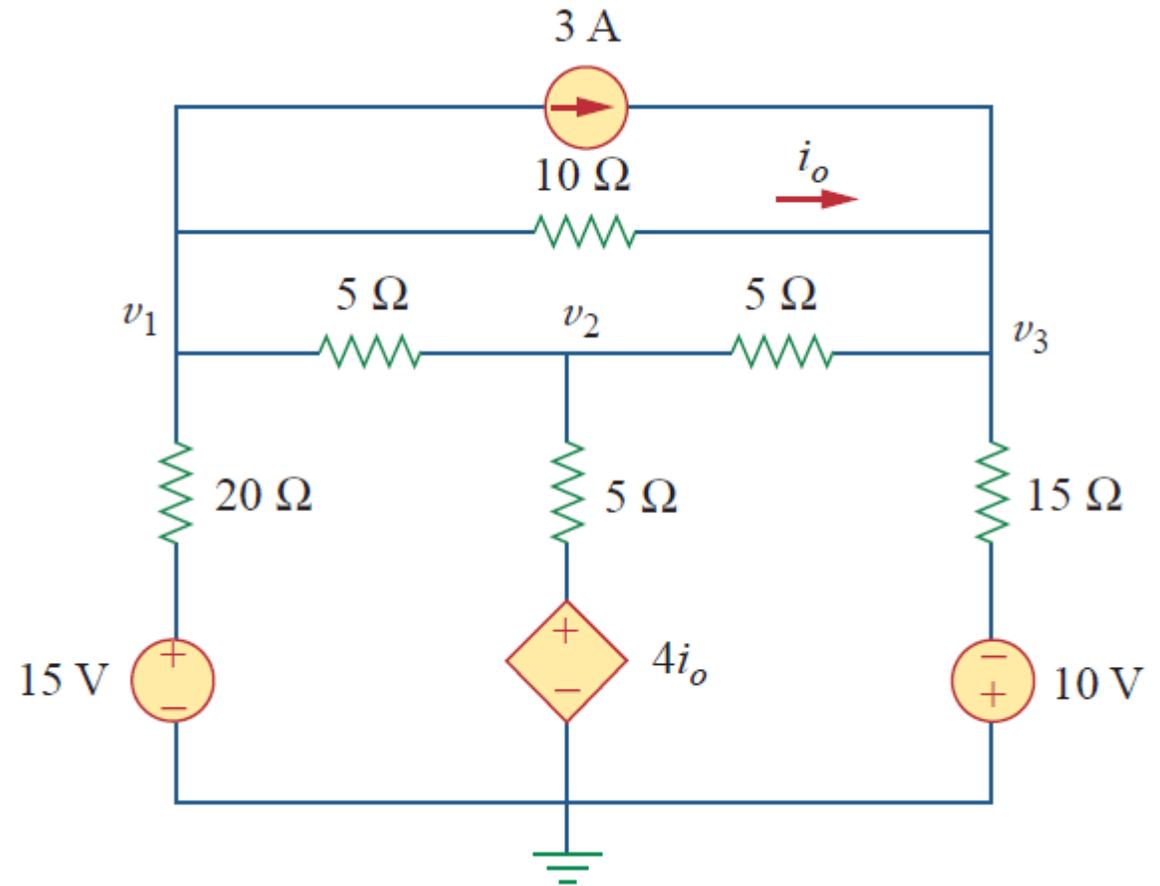
$$V_0 = 4 \times \frac{V_2 - V_g}{4}$$

$$V_0 = V_2 - V_g$$

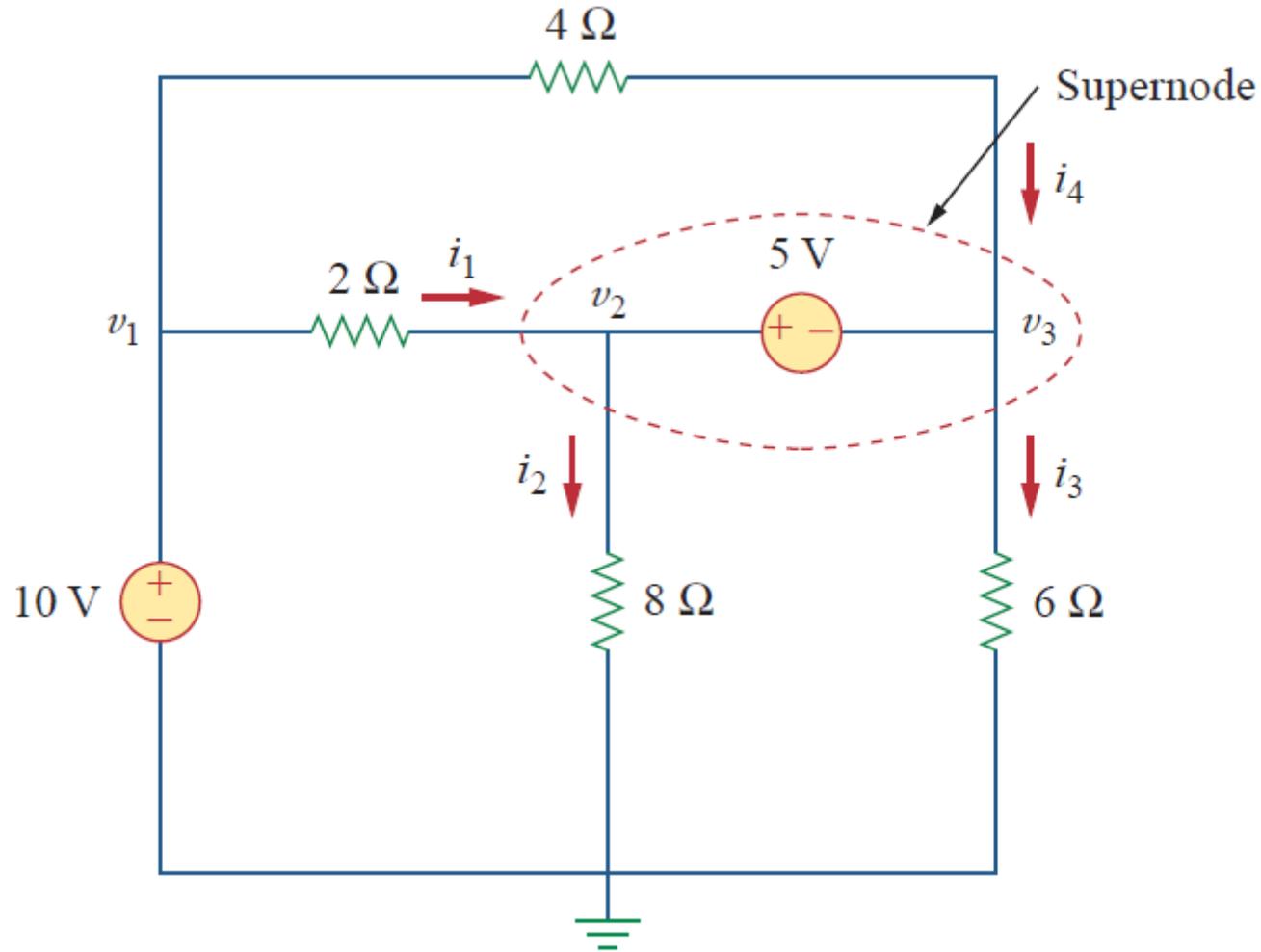
$$V_0 = V_2$$

# Assignment

Calculate the node voltages  $v_1$ ,  $v_2$ , and  $v_3$  in the circuit of Fig.



# Nodal Analysis with Voltage Sources



A **supernode** is formed by enclosing a (dependent or independent) voltage source connected between two nonreference nodes and any elements connected in parallel with it.

$$i_1 + i_4 = i_2 + i_3$$

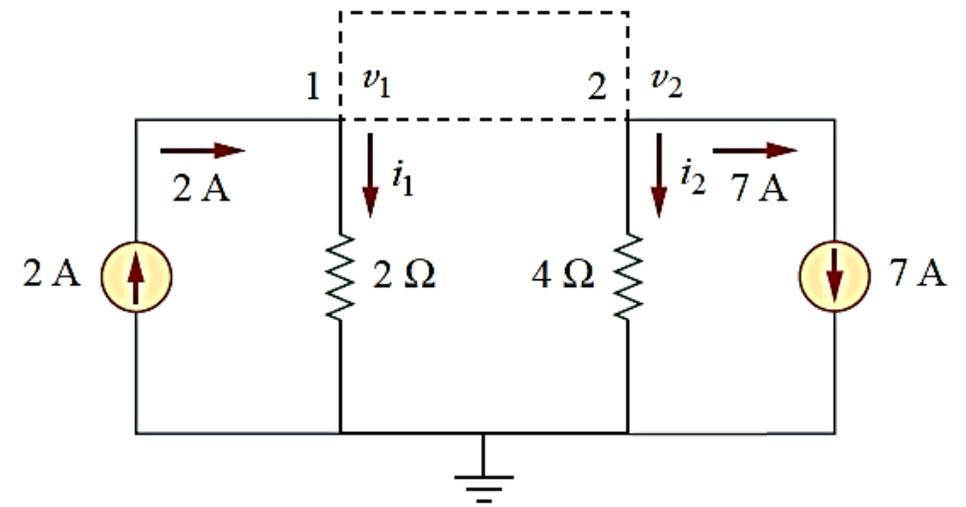
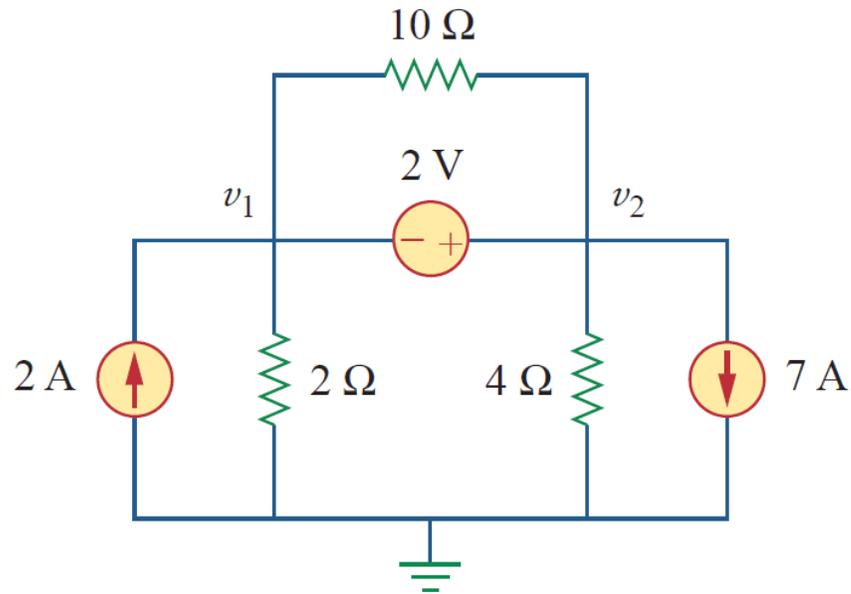
$$\frac{v_1 - v_2}{2} + \frac{v_1 - v_3}{4} = \frac{v_2 - 0}{8} + \frac{v_3 - 0}{6}$$

$$\frac{V_2 - V_1}{2} + \frac{V_2}{8} + \frac{V_3 - V_1}{4} + \frac{V_3}{6} = 0$$

$$V_2 - V_3 = 5 \quad V_1 = 10$$

# Nodal Analysis with Voltage Sources

For the circuit shown in Fig. 3.9, find the node voltages.



$$\frac{V_1}{2} + \frac{V_2}{4} + 7 - 2 = 0$$

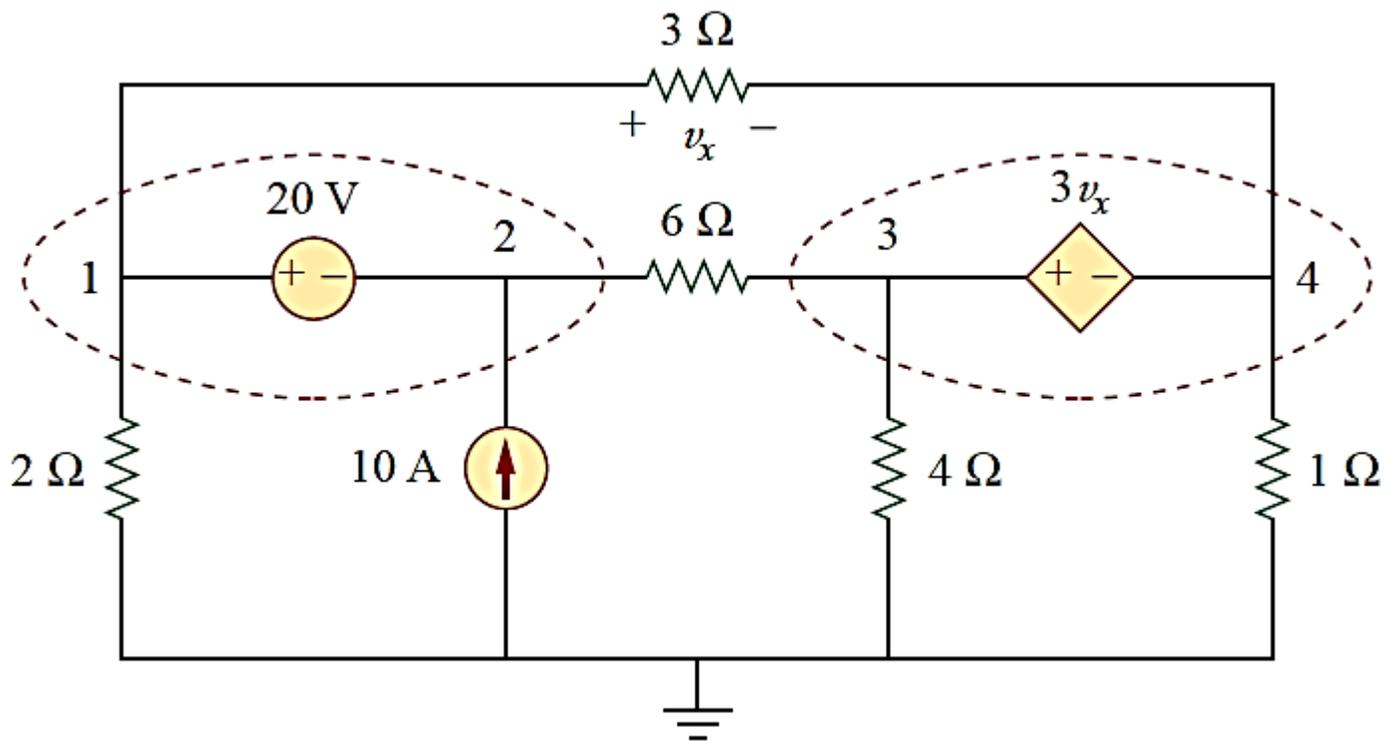
$$2V_1 + V_2 = -20$$

$$V_2 - V_1 = 2$$

$$V_1 = -7.33 \text{ V} \ \& \ V_2 = -5.33 \text{ V}$$

# Mathematical Problem-4

Find the node voltages in the circuit of Fig. 3.12.



$$V_1 = 26.67 \text{ V}$$

$$V_2 = 6.67 \text{ V}$$

$$V_3 = 173.33 \text{ V}$$

$$V_4 = -46.67 \text{ V}$$

$$V_1 - V_2 = 20$$

$$V_3 - V_4 = 3V_x = 3(V_1 - V_4)$$

$$3V_1 - V_3 - 2V_4 = 0$$

$$\frac{V_1 - V_4}{3} + \frac{V_1}{2} + \frac{V_2 - V_3}{6} - 10 = 0$$

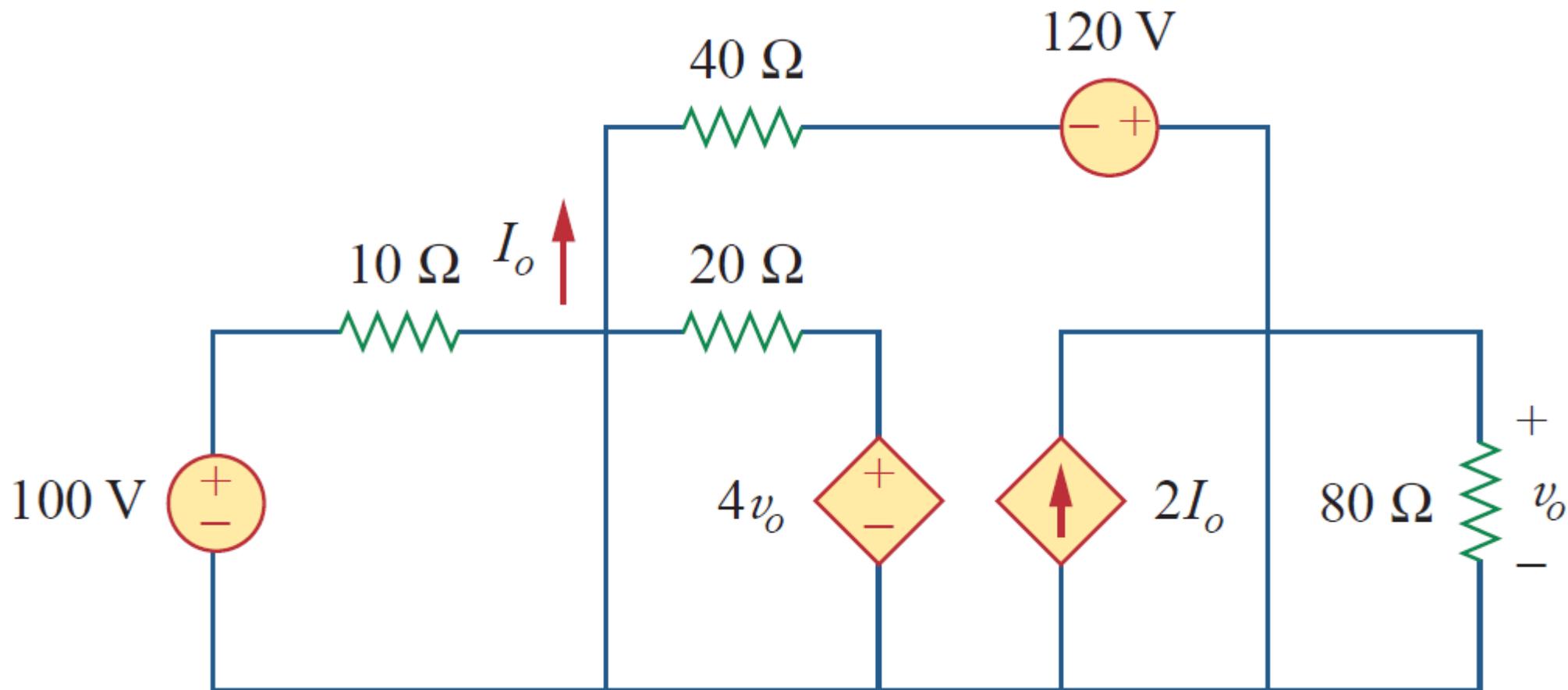
$$5V_1 + V_2 - V_3 - 2V_4 = 60$$

$$\frac{V_3}{4} + \frac{V_4}{1} + \frac{V_4 - V_1}{3} + \frac{V_3 - V_2}{6} = 0$$

$$5V_3 + 16V_4 - 4V_1 - 2V_2 = 0$$

# Assignment

Using nodal analysis, find  $v_o$  and  $I_o$  in the circuit





THANK YOU