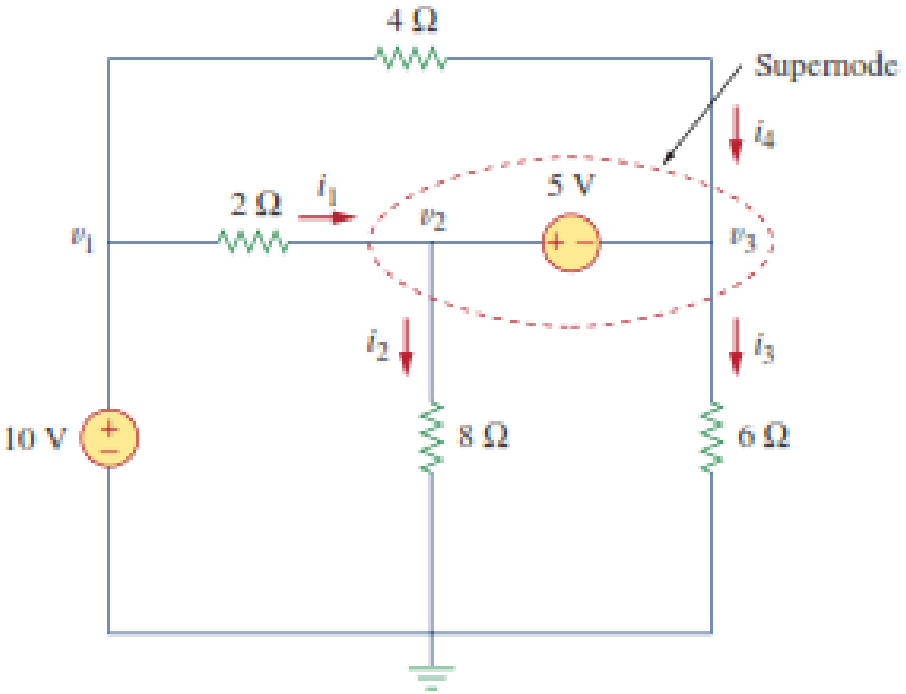
Electrical Circuits for Engineers (EC1000)

Lecture-3 (B)
Super Node and Super Mesh
(Ch.3.3)

Super Node
(Nodal Analysis with Voltage Sources)

- We now consider how voltage sources affect nodal analysis.
- We use the circuit below for illustration.



Consider the following two possibilities

1. If a voltage source is connected between the reference node and a non-reference node, we simply set the voltage at the non-reference node equal to the voltage of the voltage source. *See Fig,* $V_1 = 10$ V

2. If the voltage source (dependent or independent) is connected between two non-reference nodes, the two non-reference nodes form a generalized node or ***supernode***;

we apply both KCL and KVL to determine the node voltages.

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

Super Node
(Nodal Analysis with Voltage Sources)

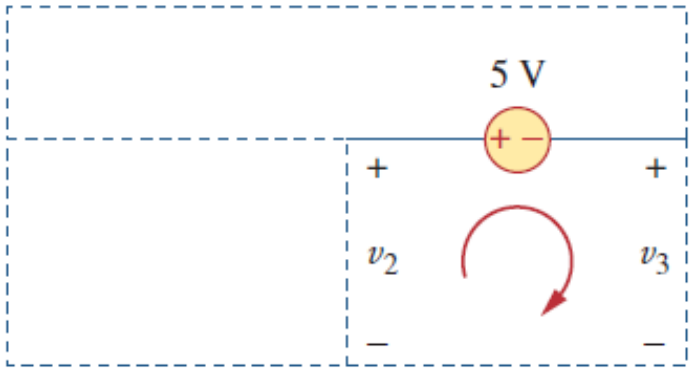
KCL must be satisfied at a supernode like any other node. Hence, at the supernode in Figure,

$$i_1 + i_4 = i_2 + i_3$$

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

To apply KVL to the supernode in Figure, we redraw the circuit as shown in Figure (see right side). Going around the loop in the clockwise direction gives

$$-v_2 + 5 + v_3 = 0 \quad \Rightarrow \quad v_2 - v_3 = 5$$

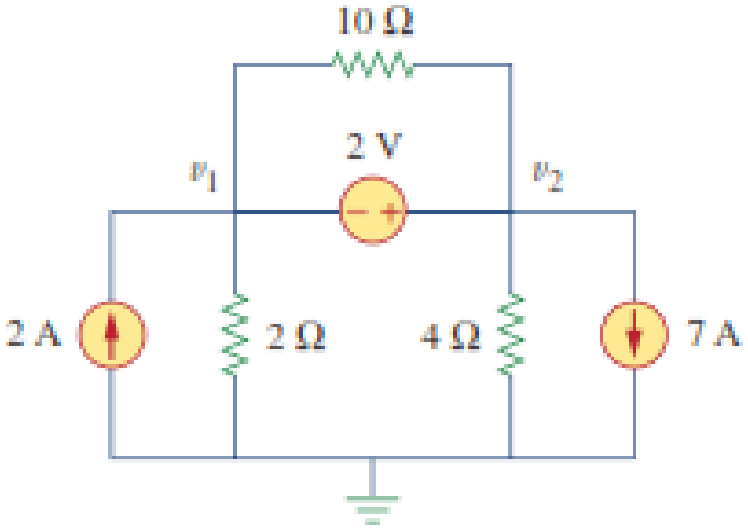


we obtain the node voltages

- The voltage source inside the supernode provides a constraint equation needed to solve for the node voltages.
- A supernode has no voltage of its own.
- A supernode requires the application of both KCL and KVL.

Super Node

For the circuit shown in Figure, find the node voltages.



Applying KCL to the supernode

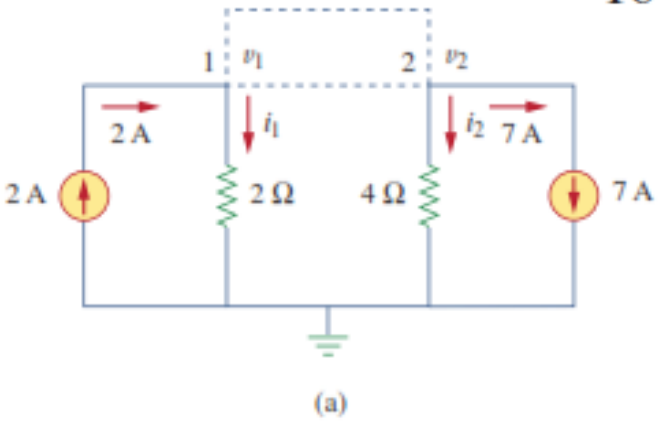
$$2 = i_1 + i_2 + 7$$

Expressing i_1 and i_2 in terms of the node voltages

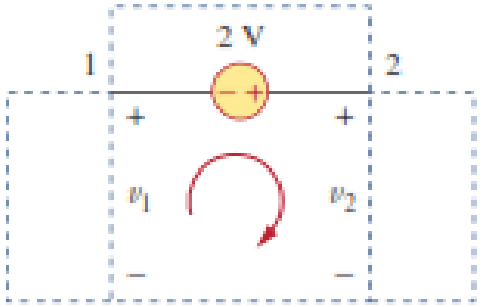
$$2 = \frac{v_1 - 0}{2} + \frac{v_2 - 0}{4} + 7 \qquad \Rightarrow 8 = 2v_1 + v_2 + 28$$

$$v_2 = -20 - 2v_1$$

To get the relationship between v_1 and v_2, we apply KVL to the circuit



(a)



(b)

$$-v_1 - 2 + v_2 = 0 \qquad \Rightarrow \qquad v_2 = v_1 + 2$$

$$v_2 = v_1 + 2 = -20 - 2v_1$$

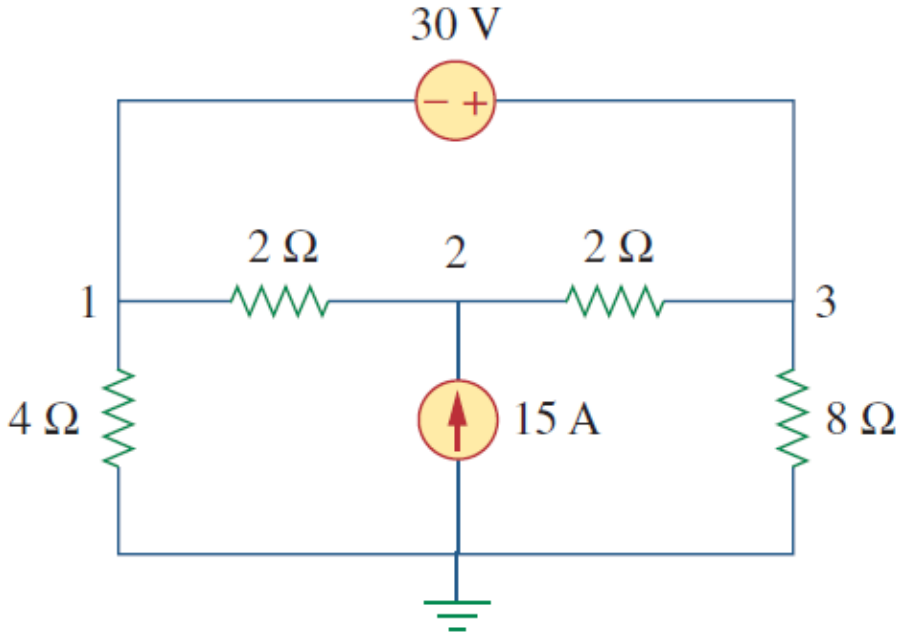
$$3v_1 = -22 \qquad \Rightarrow \qquad v_1 = -7.333 \text{ V}$$

(a) KCL to the supernode, (b) KVL to the loop.

and $v_2 = v_1 + 2 = -5.333$ V. Note that the 10-Ω resistor does not make any difference because it is connected across the supernode.

Problems

1. Apply nodal analysis to find node voltages

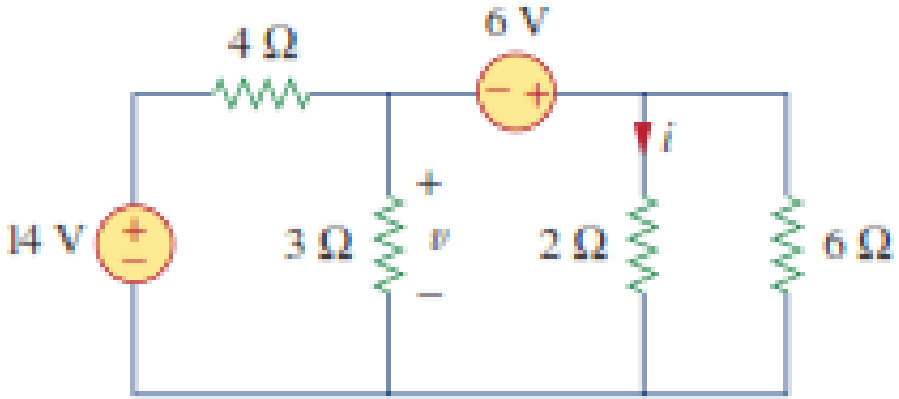


Ans:

$v_1 = 30$ V

$v_2 = v_2 = 60$ V

2. Find *v and i in the circuit of Figure.*



Ans: **2.8 A, -**400 mV,

Thank You