Nodal analysis applies KCL to find unknown voltages in a given circuit, while mesh analysis applies KVL to find unknown currents.

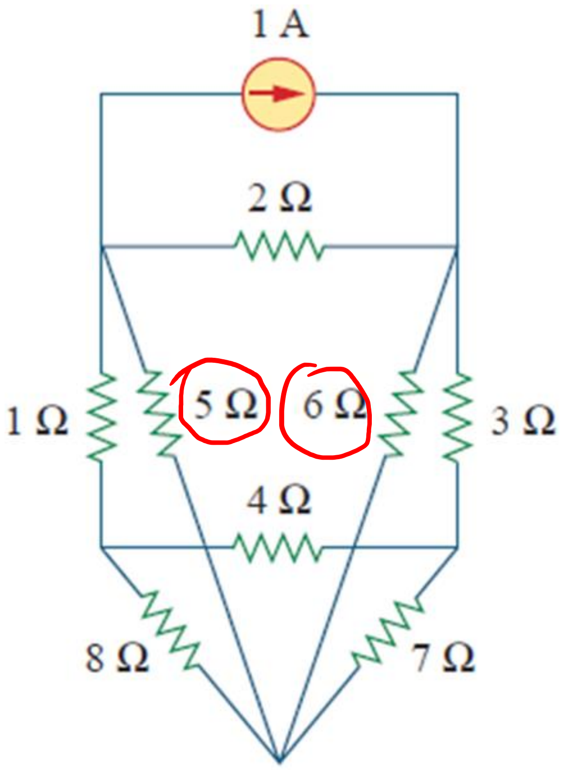
Mesh Analysis

Mesh analysis is also known as *loop analysis* or the *mesh-current method*.

- **Loop is a closed path with no node passed more than once OR**
  Loop is a path for which the first node and last node are same

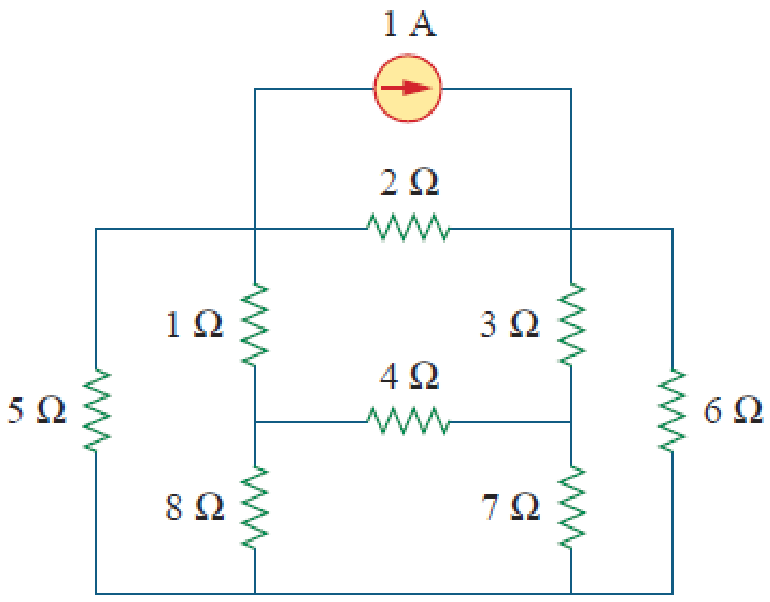
- **A mesh is a loop does not contain any other loop with in it**

- Planar Circuit : A circuit can be drawn on a flat surface without crossed wires
- For planar circuits, we use the Mesh Current Method and write the equations based on meshes.

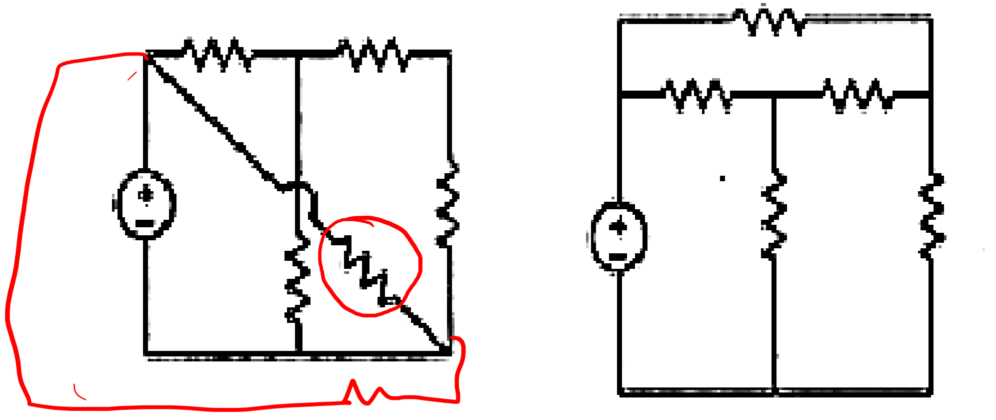


(a)

Planar

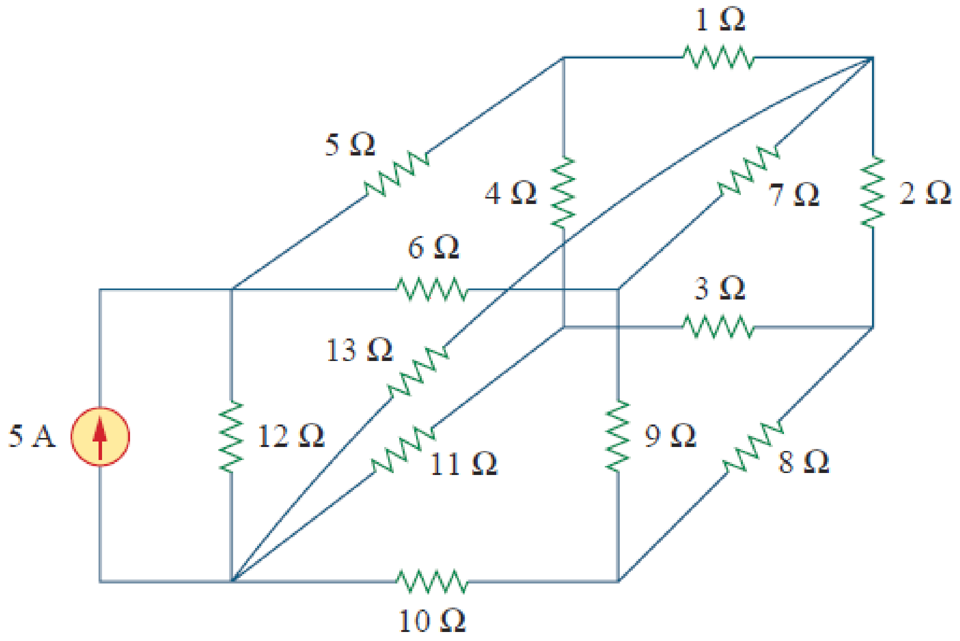


(b)

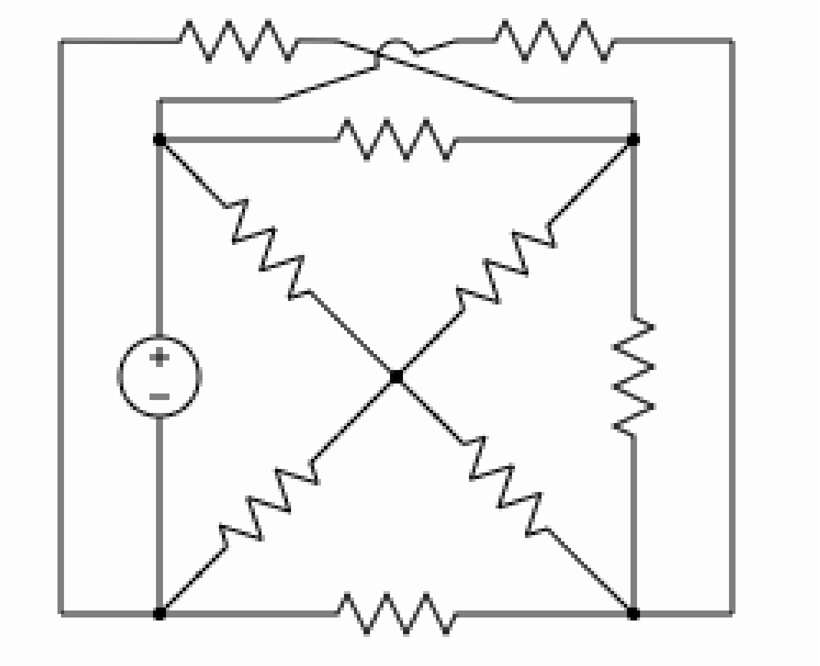


planar

- A non-planar circuit is one with at least one crossed wire
- Which cannot be drawn flat or no way to redraw the circuit to avoid a crossed wire

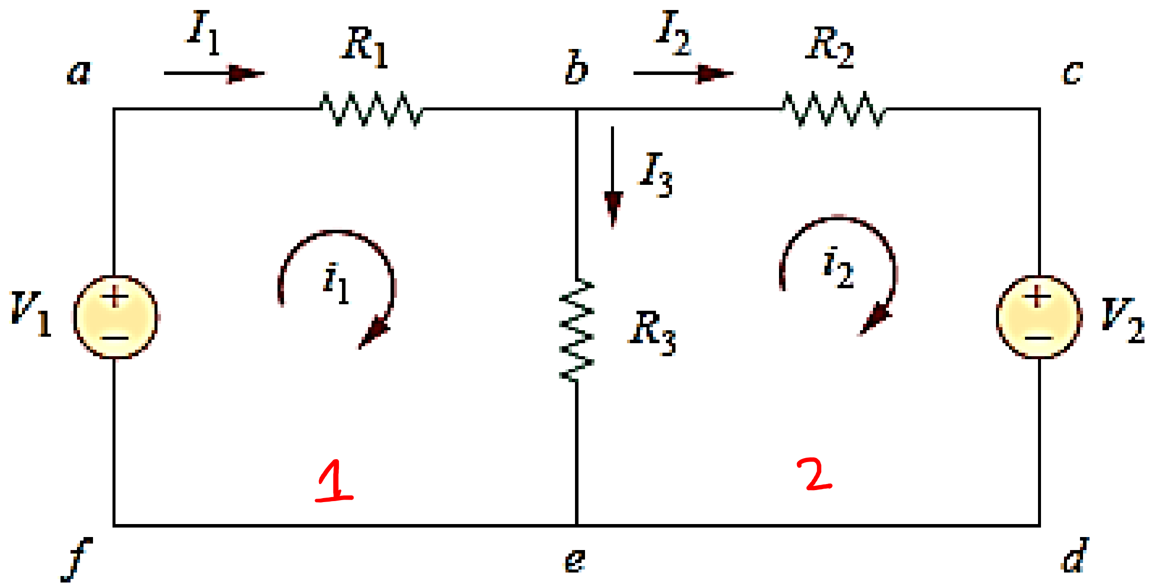


Non-planar



Non-planar

A mesh is a loop which does not contain any other loops within it.



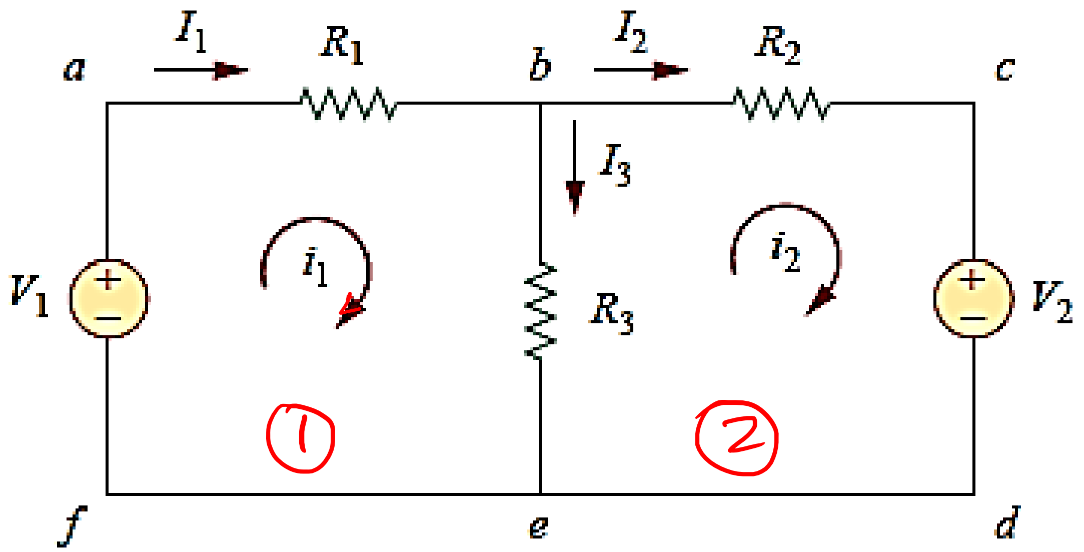
Steps to Determine Mesh Currents:

1. Assign mesh currents $i_1, i_2, \ldots, i_n$ to the n meshes.
2. Apply KVL to each of the n meshes. Use Ohm's law to express the voltages in terms of the mesh currents.
3. Solve the resulting n simultaneous equations to get the mesh currents.

1. Assign mesh currents i_1, i_2,

abefa — mesh 1

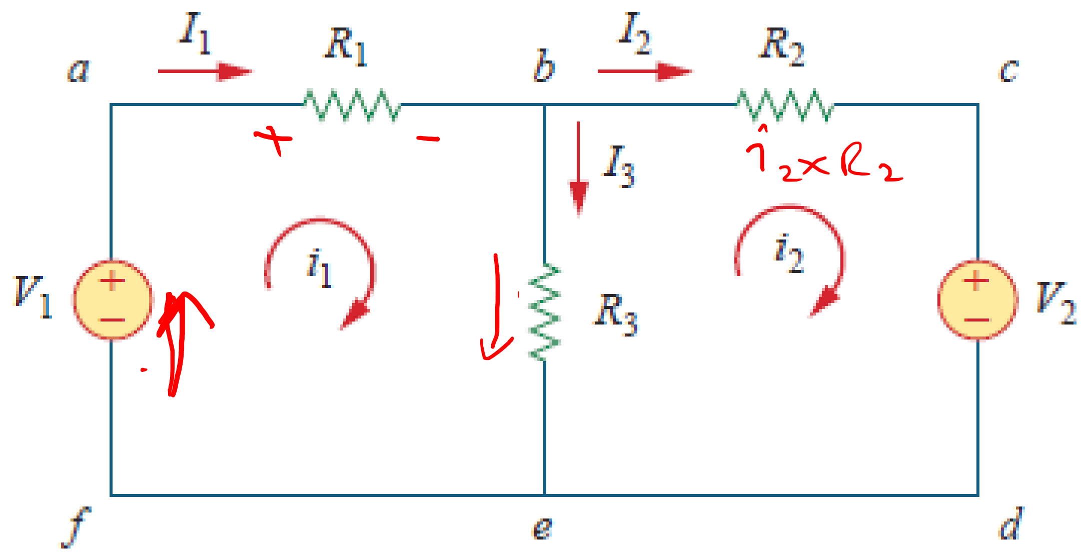
bcdeb → mesh 2



~~abcdefa~~

Outer loop cannot be considered as mesh because two loops are there within this loop

2. Apply KVL to each of the n meshes. Use Ohm's law to express the voltages in terms of the mesh currents.



No of equations require to solve an electrical network using mesh analysis is equal to number of meshes

to mesh 1, we obtain

$$-V_1 + R_1 i_1 + R_3(i_1 - i_2) = 0$$

or

$$(R_1 + R_3)i_1 - R_3 i_2 = V_1$$

For mesh 2, applying KVL gives

$$R_2 i_2 + V_2 + R_3(i_2 - i_1) = 0$$

or

$$-R_3 i_1 + (R_2 + R_3)i_2 = -V_2$$

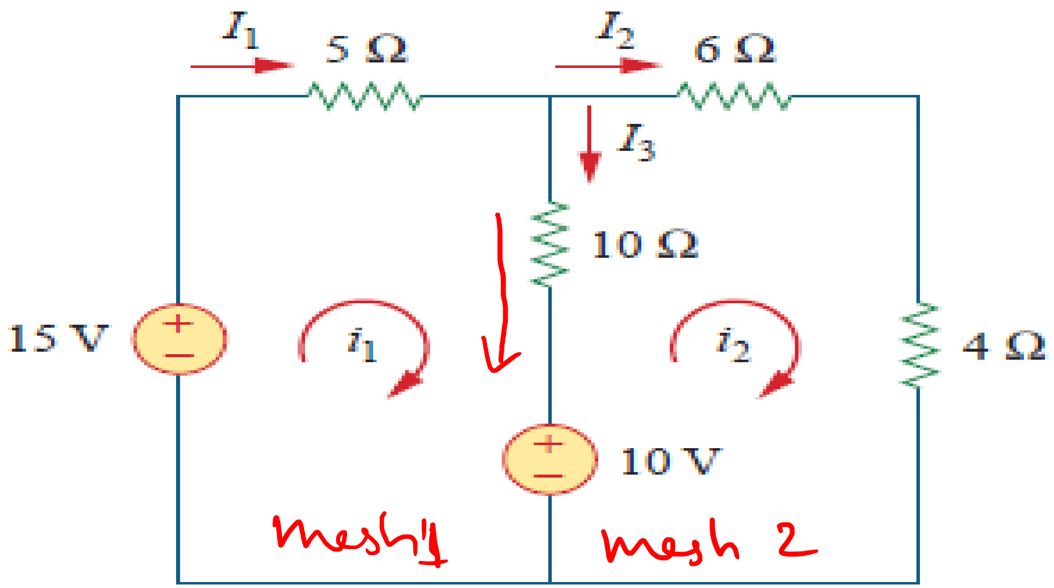
3. Solve the resulting n simultaneous equations to get the mesh currents.

$$(R_1 + R_3)i_1 - R_3 i_2 = V_1 \longrightarrow 1$$

$$-R_3 i_1 + (R_2 + R_3)i_2 = -V_2 \longrightarrow 2$$

$$\begin{bmatrix} R_1 + R_3 & -R_3 \\ -R_3 & R_2 + R_3 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} V_1 \\ -V_2 \end{bmatrix}$$

Example For the circuit in Fig. find the branch currents I_1, I_2, and I_3 using mesh analysis.



We first obtain the mesh currents using KVL. For mesh 1,

$$-15 + 5i_1 + 10(i_1 - i_2) + 10 = 0$$

$i_2 - i_1$

or

$$3i_1 - 2i_2 = 1 \quad (1)$$

For mesh 2,

$$6i_2 + 4i_2 + 10(i_2 - i_1) - 10 = 0$$

or

$$i_1 = 2i_2 - 1 \quad (2)$$

METHOD 1 Using the substitution method, we substitute Eq. (3.5.2) into Eq. (3.5.1), and write

$$6i_2 - 3 - 2i_2 = 1 \qquad \Rightarrow \qquad i_2 = 1\text{ A}$$

From Eq. (3.5.2), $i_1 = 2i_2 - 1 = 2 - 1 = 1$ A. Thus,

$$I_1 = i_1 = 1\text{ A}, \qquad I_2 = i_2 = 1\text{ A}, \qquad I_3 = i_1 - i_2 = 0$$

METHOD 2 To use Cramer's rule,

$$\begin{bmatrix} 3 & -2 \\ -1 & 2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

We obtain the determinants

$$\Delta = \begin{vmatrix} 3 & -2 \\ -1 & 2 \end{vmatrix} = 6 - 2 = 4$$

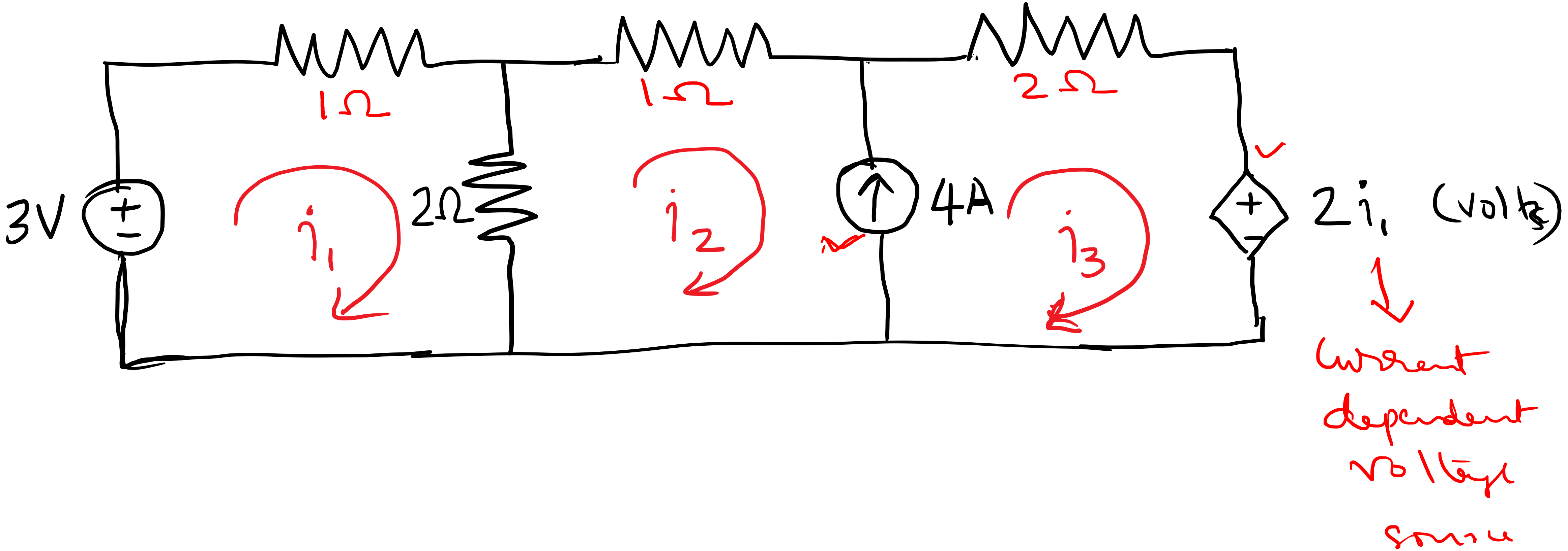
$$\Delta_1 = \begin{vmatrix} 1 & -2 \\ 1 & 2 \end{vmatrix} = 2 + 2 = 4, \qquad \Delta_2 = \begin{vmatrix} 3 & 1 \\ -1 & 1 \end{vmatrix} = 3 + 1 = 4$$

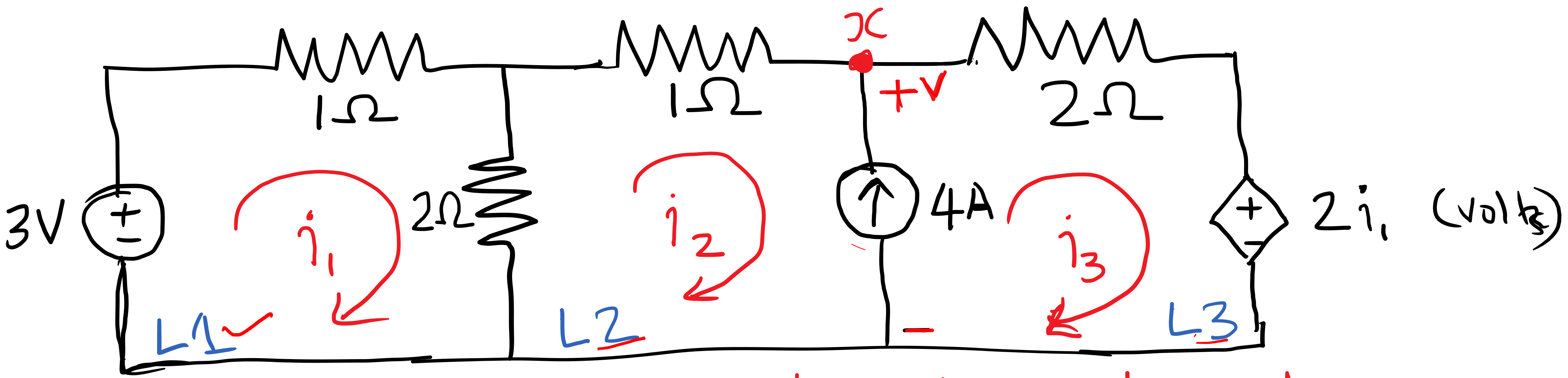
Thus,

$$i_1 = \frac{\Delta_1}{\Delta} = 1 \text{ A}, \qquad i_2 = \frac{\Delta_2}{\Delta} = 1 \text{ A}$$

as before.

Find the loop currents i_1, i_2 and i_3 in the network (use mesh analysis)





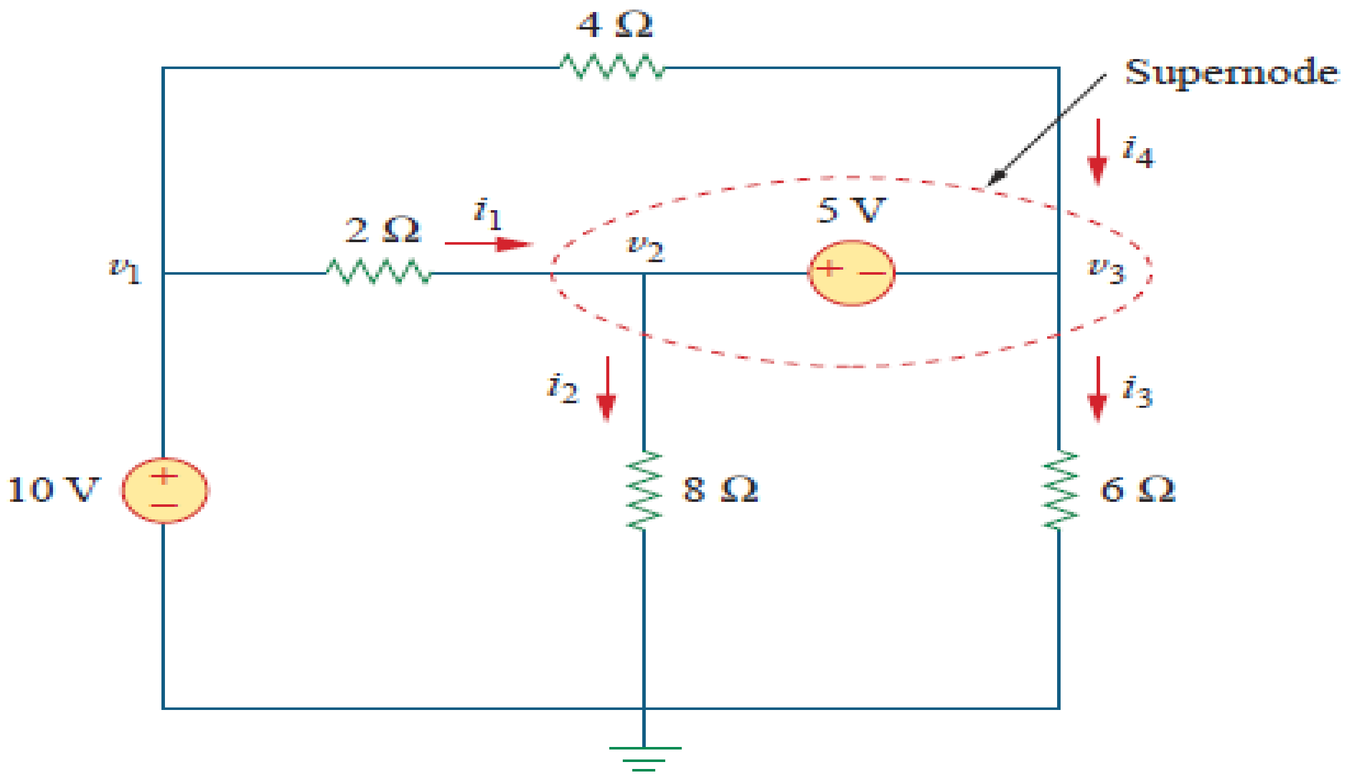
V is the assumed voltage at node x

KVL in L1	KVL in L2	KVL in L3
$i_1 \times 1 + (i_1 - i_2) \times 2 - 3 = 0$	$(i_2 - i_1) 2 \times i_2 \times 1 + V = 0$	$-V + 2i_3 + 2i_1 = 0$
$3i_1 - 2i_2 = 3 \rightarrow (1)$	$3i_2 - i_1 + V = 0 \rightarrow (2)$	$2i_3 + 2i_1 = V \rightarrow (3)$

Use (3) in (2) and solve $\Rightarrow$ $i_1 = -1/17$ A ; $i_2 = -27/17$ A ; $\frac{41}{17}$ A

Mesh Analysis with Current Sources

Nodal Analysis with Voltage Sources



DA1
Q1

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.