**Example:** Consider the circuit shown in Figure 1. Find the value of the current source current, $I_a$.

![Figure 1](image1.png)

**Figure 1** The circuit considered in this example.

**Solution:** Figure 2 shows the circuit from Figure 1 after replacing the voltmeter by an equivalent open circuit and labeling the voltage measured by the voltmeter. This circuit can be analyzed using mesh equations or using node equations. We will do both.

First, consider analyzing the circuit in Figure 2 using mesh equations. Figure 3 shows the circuit after labeling the mesh currents, $i_1$ and $i_2$.

The mesh current $i_2$ is equal to the current in the 4 Ω resistor. The voltmeter measured to voltage across that 4 Ω resistor to be 9 V. Using Ohm’s Law, the mesh current is given by

$$i_2 = \frac{9}{4} = 2.25 \text{ A}$$

![Figure 2](image2.png)

**Figure 2** The circuit from Figure 1 after replacing the voltmeter by an open circuit.

![Figure 3](image3.png)

**Figure 3** The circuit from Figure 2 after labeling the meshes.
The mesh current $i_1$ flows through the current source. The reference direction of $i_1$ agrees with the reference direction of the current source current, so $I_a = i_1$. Apply KVL to the right mesh to get

$$6 + 9 + 20i_2 - 16(i_1 - i_2) = 0 \implies 15 + 20(2.25) - 16(I_a - 2.25) = 0 \implies I_a = 6 \, \text{A}$$

Next, consider analyzing the circuit in Figure 2 using node equations. Figure 4 shows the circuit after selecting a reference node and numbering the other nodes. Let $v_1$, $v_2$ and $v_3$ denote the node voltages at nodes 1, 2 and 3, respectively.

Apply KCL at node 3 to get

$$\frac{v_2 - v_3}{4} = \frac{v_3}{20} \quad (1)$$

The voltage measured by the voltmeter is expressed in terms of the node voltages as

$$v_2 - v_3 = 9 \, \text{V} \quad (2)$$

Substituting this expression into Equation 1 gives

$$\frac{9}{4} = \frac{v_3}{20} \implies v_3 = 45 \, \text{V}$$

Substituting this expression into Equation 2 gives

$$v_2 = 54 \, \text{V}$$

The voltage of the voltage source can be expressed in terms of the node voltages as

$$6 = v_1 - v_2 \implies 6 = v_1 - 54 \implies v_1 = 60 \, \text{V}$$

Apply KCL to the supernode to get

$$I_a = \frac{v_1}{16} + \frac{v_2 - v_3}{4} = \frac{60}{16} + \frac{9}{4} = 6 \, \text{A}$$

As expected, this value of current source current agrees with the value calculated using mesh equations.

![Figure 4](Image)

**Figure 4** The circuit from Figure 2 after labeling the nodes. (The encircled numbers are node numbers.)