Mesh Current Method

The mesh current method is the companion of the node voltage method. The mesh current method, like the node voltage method, provides a systematic means to specify the equations needed to solve a circuit. Why do we have two of these systematic methods? Because for a particular circuit, one of the two methods might be easier to use, might give the desired result directly, might involve writing and solving fewer equations, or might just appeal to you more than the other method. With two methods you have a choice, and you should think through the steps of each method before deciding which one to use. Remember that once you have used one method to solve the circuit, you can use the other method to check your solution, instead of or in addition to using a power balance.

The mesh current method uses the **meshes** in a circuit. Remember that a mesh is a loop in the circuit that does not contain any other loops. The mesh current method uses **KVL** equations that are written for each of the meshes in the circuit. Remember that KVL states the the sum of all of the voltage drops around a loop is zero.

The mesh current method can be broken into the following steps:

1. Identify all of the meshes in the circuit. To do this we draw a curved arrow to identify the direction of the current flowing in the mesh.

2. Assign a variable name to the current in each mesh. Place the variable name next to the curved arrow that identifies the current and its direction. Use variable names like i_1, i_a, i_β, and so on.

3. Write a KVL equation around each of the meshes in the direction of the current arrow. We will use the same clockwise direction for each current arrow and thus will always sum the voltages in a clockwise direction.

4. Write any supplemental equations that are needed. Supplemental equations will be needed when there are dependent sources in the circuit and when there are current sources in the circuit.

5. Transform all of the equations into standard form. The standard form will enable you to solve the equations on a calculator, to solve them using a matrix method like Cramer's rule, or to solve them using a computer tool like MATLAB.

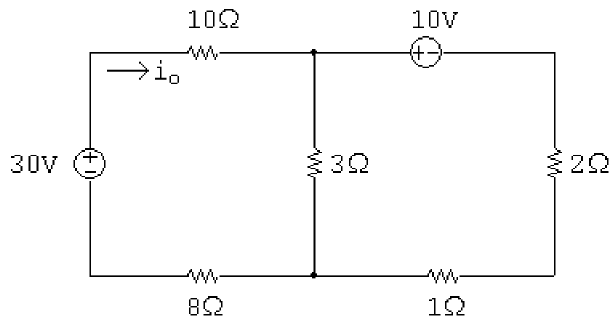

Figure 1: The circuit for Mesh Current Example 1

6. Solve the equations and check your solution using a power balance. If the power balances, use the solution to calculate the desired output value for the circuit.

First we present an example that contains only resistors and independent voltage sources. Once you have mastered these types of circuits we move on to circuits containing dependent voltage sources, and then to circuits containing current sources.

Mesh Current Example 1

Using the mesh current method, find i_o for the circuit in Fig. 1

Solution

1. Identify all of the meshes in the circuit by drawing curved arrows in the center of the mesh in the direction of the current flow. The direction of the current flow is arbitrary, but to be consistent we will always define the direction of current flow as clockwise. The current arrows are shown in Fig. 2.

2. Assign a variable name for each mesh current and label the current arrow in each mesh. The chosen variable names are also shown in Fig. 2. Remember that the mesh currents are the currents that exist on the perimeter of each mesh. When a component belongs to only one mesh, its current is the same as the mesh current. When a component belongs to two meshes, its current is the sum of the mesh currents, where the sum must take the mesh current directions into account.

3. Write a KVL equation around each of the meshes in the direction of the current arrow. It is a good idea to put a little "x" at the point on the mesh where you start. In the left mesh, we will start just below

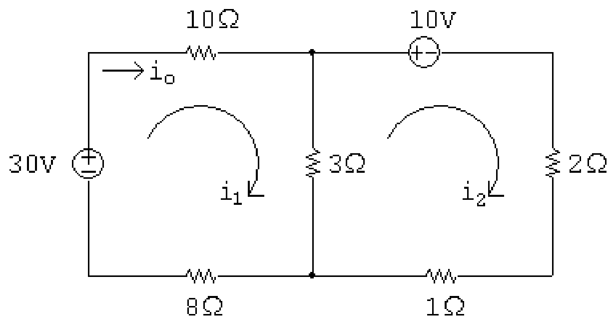

Figure 2: The circuit for Mesh Current Example 1, with the mesh currents defined

the 30V source, and in the right mesh, we will start to the left of the 18V source.

$$\begin{array}{lrcl} \text{left mesh:} & -30 + 10i_1 + 3(i_1 - i_2) + 8i_2 & = & 0 \\ \text{right mesh:} & -18 + 2i_2 + 1i_2 + 3(i_2 - i_1) & = & 0 \end{array}$$

Note that there are two unknowns, the two mesh currents i_1 and i_2, and two equations in terms of those unknowns.

4. Write any supplemental equations. In this example there are no supplemental equations, since there are no dependent sources or current sources in the circuit. Also, we have already written a sufficient number of equations to solve for all of the unknowns.

5. Place the equations in standard form. The form we use collects all of the terms involving each of the unknowns on the left-hand side of each equation, and collects the constants on the right-hand side of the equation. The standard form for the mesh current equations is shown below:

$$\begin{array}{lcccccc} \text{left mesh:} & i_1(10+3+8) & + & i_2(-3) & = & 30 \\ \text{right mesh:} & i_1(-3) & + & i_2(2+1+3) & = & 0 \end{array}$$

Note that there are two terms on the left-hand side of each equation, one for each of the two unknown mesh currents, and each mesh current variable appears in the same position in each equation. Be sure to check your standard form equations against your original mesh current equations to make sure you have not made an errors.

6. Solve the equations and check your solution. When these equations are input into a calculator, the solution is

$$i_1 = 2 \text{ A}; \qquad i_2 = 4 \text{ A}$$

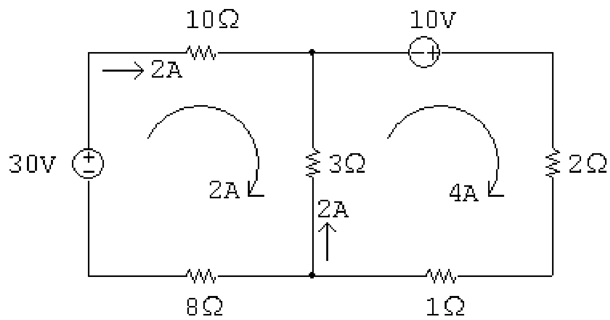

Figure 3: The circuit for Mesh Current Example 1, solved

The circuit is repeated in Fig. 3 with the values of all the currents through every component labeled. Using the values in Fig. 3 we can calculate the power for each component:

$$\begin{aligned}
p_{30\text{V}} &= -vi = -(30)(2) = -60 \text{ W};\\
p_{18\text{V}} &= -vi = -(18)(4) = -72 \text{ W};\\
p_{10\Omega} &= i^2R = 2^2(10) = 40 \text{ W};\\
p_{3\Omega} &= i^2R = 2^2(3) = 12 \text{ W};\\
p_{8\Omega} &= i^2R = 2^2(8) = 32 \text{ W};\\
p_{2\Omega} &= i^2R = 4^2(2) = 32 \text{ W};\\
p_{1\Omega} &= i^2R = 4^2(1) = 16 \text{ W};
\end{aligned}$$

Thus,

$$\sum p = -60 - 72 + 40 + 12 + 32 + 32 + 16 = 0 \text{ W} \qquad \text{checks}$$

The power balance verifies that we have the correct solution, so $i_o = i_1 = 2$ A.

Now try using the mesh current method for each of the practice problems below.

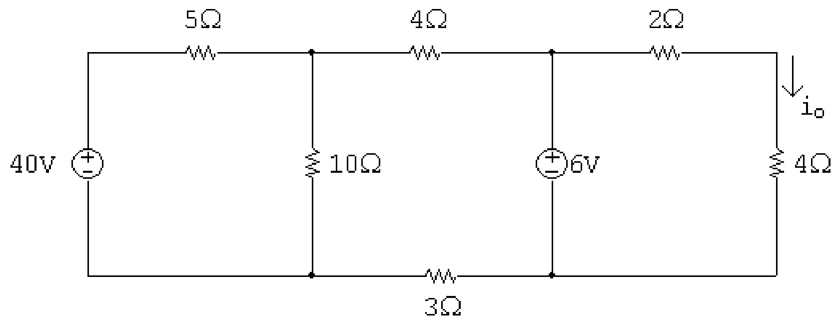

Figure 4: The circuit for Mesh Current Practice Problem 1.

Mesh Current Practice Problem 1

Find i_o for the circuit in Fig. 4.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 4 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 4.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate i_o.

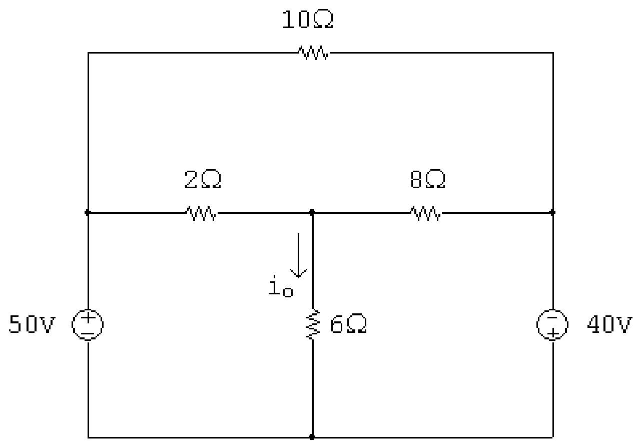

Figure 5: The circuit for Mesh Current Practice Problem 2.

Mesh Current Practice Problem 2

Find i_o for the circuit in Fig. 5.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 5 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 5.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate i_o.

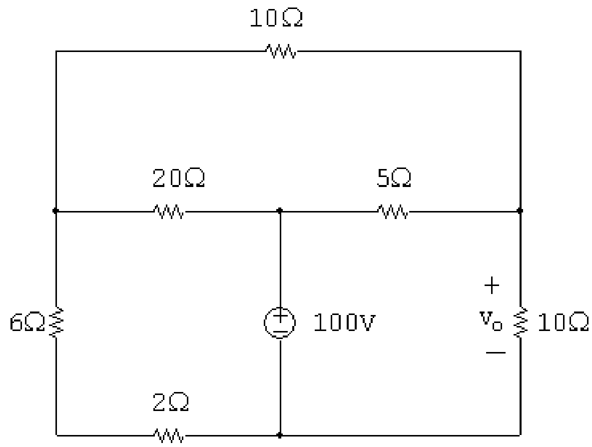

Figure 6: The circuit for Mesh Current Practice Problem 3.

Mesh Current Practice Problem 3

Find v_o for the circuit in Fig. 6.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 6 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 6.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate v_o.

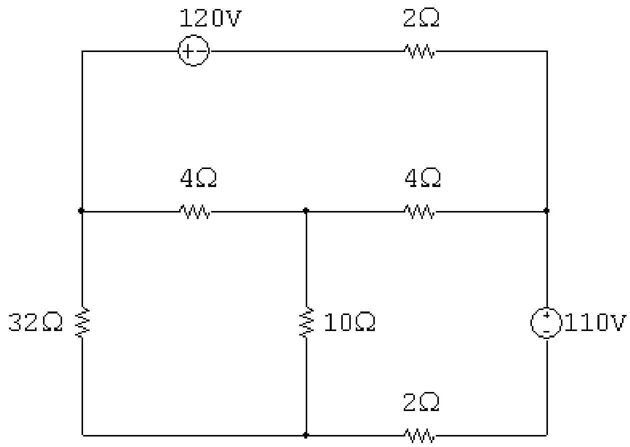

Figure 7: The circuit for Mesh Current Practice Problem 4.

Mesh Current Practice Problem 4

Find the power dissipated in the 32Ω resistor for the circuit in Fig. 7.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 7 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 7.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate $p_{32\Omega}$.

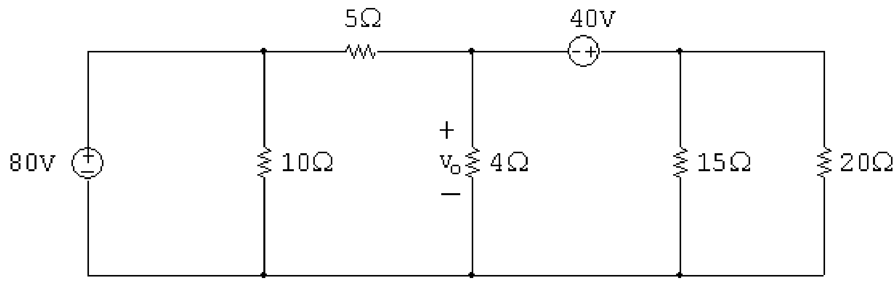

Figure 8: The circuit for Mesh Current Practice Problem 5.

Mesh Current Practice Problem 5

Find v_o for the circuit in Fig. 8.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 8 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 8.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate v_o.

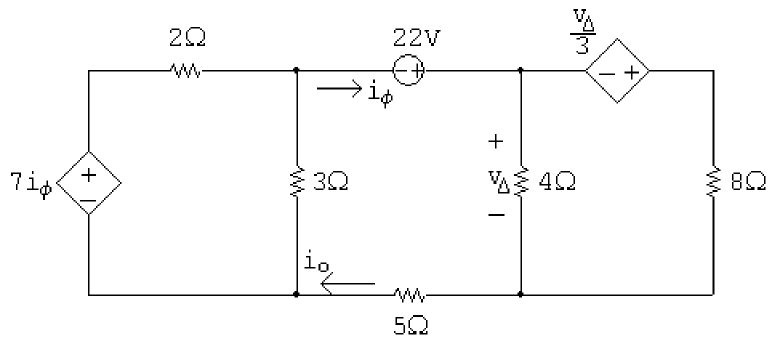

Figure 9: The circuit for Mesh Current Example 2

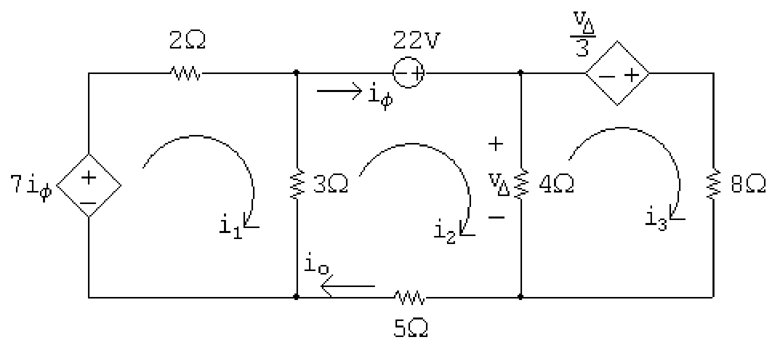

Figure 10: The circuit for Mesh Current Example 2, with the mesh currents defined

Mesh Current Example 2

Using the mesh current method, find i_o for the circuit in Fig. 1

Solution

1. Identify all of the meshes in the circuit by drawing curved arrows in the center of the mesh in the direction of the current flow. As usual, we define the direction of current flow as clockwise. The current arrows are shown in Fig. 10.

2. Assign a variable name for each mesh current and label the current arrow in each mesh. The chosen variable names are also shown in Fig. 10.

3. Write a KVL equation around each of the meshes in the direction of the current arrow. In the left mesh, we will start just below the dependent source, in the center mesh we start just to the left of the 22V source,

and in the right mesh we will start to the left of the dependent source.

$$\begin{aligned} \text{left mesh:} \quad & -7i_\phi + 2i_1 + 3(i_1 - i_2) &= 0 \\ \text{center mesh:} \quad & -22 + 4(i_2 - i_3) + 5i_2 + 3(i_2 - i_1) &= 0 \\ \text{right mesh:} \quad & -\frac{v_\Delta}{3} + 8i_3 + 4(i_3 - i_2) &= 0 \end{aligned}$$

Note that there are five unknowns, the three mesh currents i_1, i_2, and i_3, the current i_ϕ that controls one dependent source and the voltage v_Δ that controls the other dependent source. Yet there are only three KVL equations. This means we have to specify two more equations.

4. Write any supplemental equations. This is where the remaining two equations will be developed. Whenever there are dependent sources in the circuit, we will need to write a supplemental equation for each dependent source that defines the current or voltage used to control each source in terms of the mesh currents in our circuit. These supplemental equations are also called **constraint equations** because they constrain the relationship between two or more unknowns in our circuit. Thus, one of the unknowns is no longer an independent variable byt rather is dependent on the other independent variables in the circuit.

   Now turn to the circuit in Fig. 10. Notice that the controlling current i_ϕ is the same as the mesh current i_2. Thus, our first constraint equation is

$$i_\phi = i_2$$

   From the circuit we see that the controlling voltage v_Δ is the voltage drop across the 4Ω resistor. We use Ohm's Law to define that voltage drop in terms of the current flowing through the resistor. The current flowing through the resistor in the direction of the voltage drop must be defined in terms of the mesh currents, so is equal to $i_2 - i_3$. Thus, our second constraint equation is

$$v_\Delta = 4(i_2 - i_3)$$

   The three KVL equations and the two constraint equations now provide the five equations needed to solve for the five unknowns in the circuit.

5. Place the equations in standard form. This is shown below:

$$\begin{array}{lcccccccccccc} \text{left mesh:} & i_1(2+3) & + & i_2(-3) & + & i_3(0) & + & i_\phi(-7) & + & v_\Delta(0) & = & 0 \\ \text{center mesh:} & i_1(-3) & + & i_2(3+4+5) & + & i_3(-4) & + & i_\phi(0) & + & v_\Delta(0) & = & 22 \\ \text{right mesh:} & i_1(0) & + & i_2(-4) & + & i_3(4+8) & + & i_\phi(0) & + & v_\Delta(-1/3) & = & 0 \\ \text{constraint:} & i_1(0) & + & i_2(1) & + & i_3(0) & + & i_\phi(-1) & + & v_\Delta(0) & = & 0 \\ \text{constraint:} & i_1(0) & + & i_2(-4) & + & i_3(4) & + & i_\phi(0) & + & v_\Delta(1) & = & 0 \end{array}$$

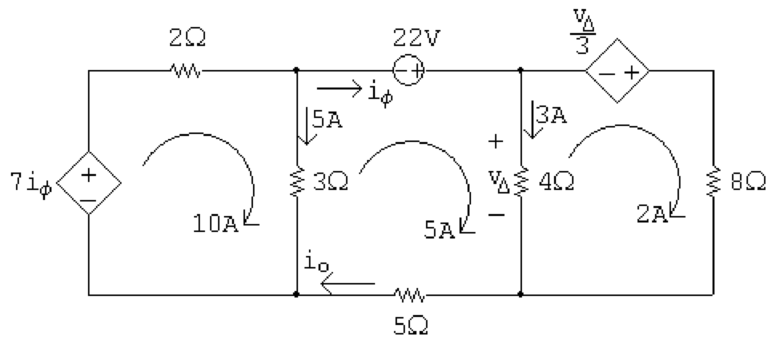

Figure 11: The circuit for Mesh Current Example 2, solved

6. Solve the equations and check your solution. When these equations are input into a calculator, the solution is

$$i_1 = 10 \text{ A}; \qquad i_2 = 5 \text{ A}; \qquad i_3 = 2 \text{ A}; \qquad i_\phi = 5 \text{ A}; \qquad v_\Delta = 12 \text{ V}$$

The circuit is repeated in Fig. 11 with the values of all the currents through every component labeled. Using the values in Fig. 11 we can calculate the power for each component:

$$\begin{aligned}
p_{7i_\phi} &= -vi = -[7(5)](10) = -350 \text{ W};\\
p_{22\text{V}} &= -vi = -(22)(5) = -110 \text{ W};\\
p_{v_\Delta/3} &= -vi = -[12/3](2) = -8 \text{ W};\\
p_{2\Omega} &= i^2R = 10^2(2) = 200 \text{ W};\\
p_{3\Omega} &= i^2R = 5^2(3) = 75 \text{ W};\\
p_{5\Omega} &= i^2R = 5^2(5) = 125 \text{ W};\\
p_{4\Omega} &= i^2R = 3^2(4) = 36 \text{ W};\\
p_{8\Omega} &= i^2R = 2^2(8) = 32 \text{ W};
\end{aligned}$$

Thus,

$$\sum p = -350 - 110 - 8 + 200 + 75 + 125 + 36 + 32 = 0 \text{ W} \qquad \text{checks}$$

The power balance verifies that we have the correct solution, so $i_o = i_2 = 5$ A.

Now try using the mesh current method for each of the practice problems below.

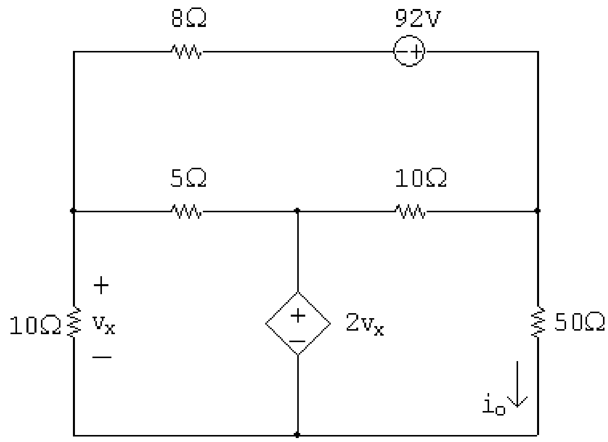

Figure 12: The circuit for Mesh Current Practice Problem 6.

Mesh Current Practice Problem 6

Find i_o for the circuit in Fig. 12.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 12 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 12.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate i_o.

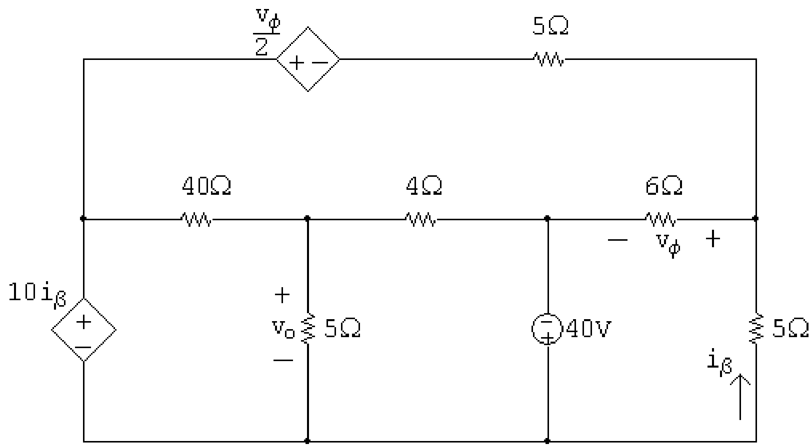

Figure 13: The circuit for Mesh Current Practice Problem 7.

Mesh Current Practice Problem 7

Find v_o for the circuit in Fig. 13.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 13 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 13.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate v_o.

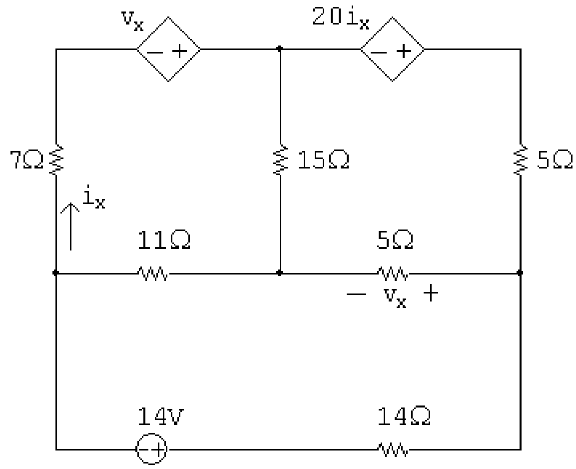

Figure 14: The circuit for Mesh Current Practice Problem 8.

Mesh Current Practice Problem 8

Find the power delivered in the circuit in Fig. 14.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 14 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 14.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate $p_{\text{delivered}}$.

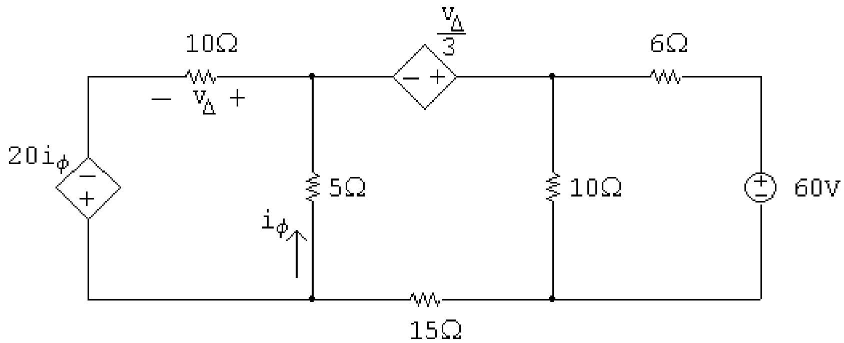

Figure 15: The circuit for Mesh Current Practice Problem 9.

Mesh Current Practice Problem 9

Find the power for the 15Ω resistor in the circuit in Fig. 15.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 15 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 15.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate $p_{15\Omega}$.

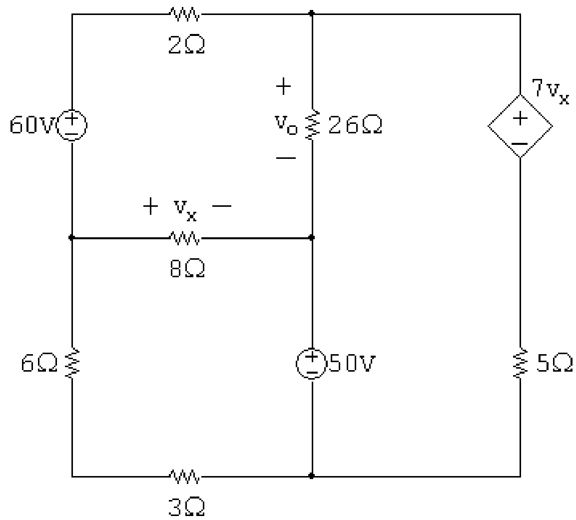

Figure 16: The circuit for Mesh Current Practice Problem 10.

Mesh Current Practice Problem 10

Find v_o in the circuit in Fig. 16.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 16 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 16.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate v_o.

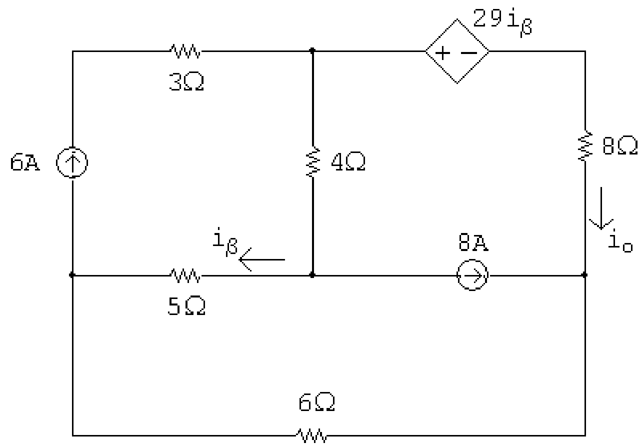

Figure 17: The circuit for Mesh Current Example 3

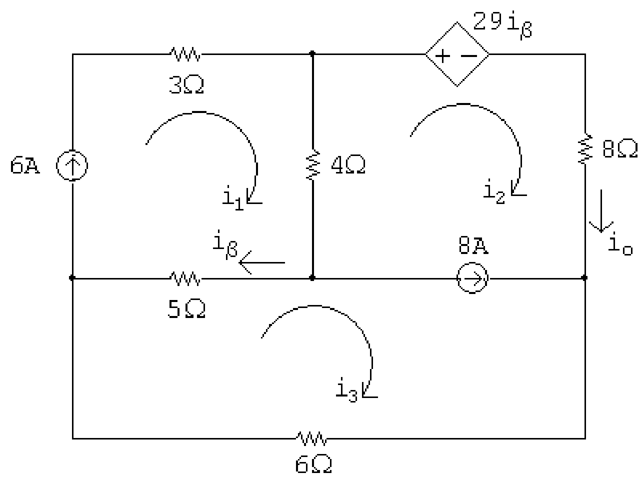

Figure 18: The circuit for Mesh Current Example 3, with the mesh currents defined.

Mesh Current Example 3

Using the mesh current method, find i_o for the circuit in Fig. 17

Solution

1. Identify all of the meshes in the circuit by drawing curved arrows in the center of the mesh in the direction of the current flow. As usual, we define the direction of current flow as clockwise. The current arrows are shown in Fig. 18.

2. Assign a variable name for each mesh current and label the current arrow in each mesh. The chosen variable names are also shown in

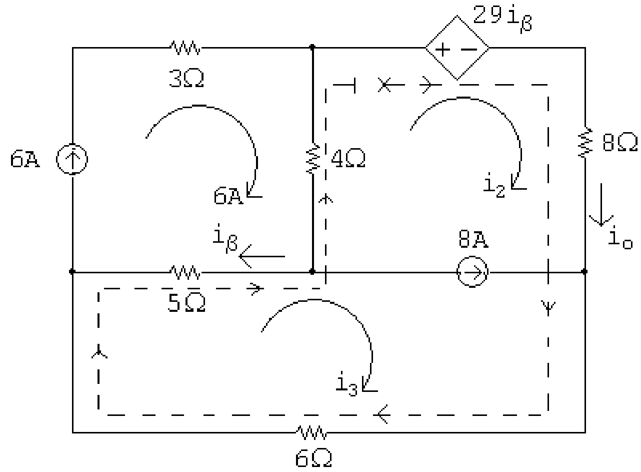

Figure 19: The circuit for Mesh Current Example 3, with a known mesh current and a supermesh.

Fig. 18.

3. Write a KVL equation around each of the meshes in the direction of the current arrow. We modify this step whenever the circuit contains current sources. The circuit in Fig. 18 has two current sources. Consider first the 6A current source. This current source is on the perimeter of a mesh, meaning that the current source establishes the value of the mesh current in this mesh. Thus, $i_1 = 6$A, so there is no need to write a KVL equation for this mesh.

   Now consider the 8A current source. This source is shared between two meshes, rather than being on the perimeter of a single mesh. Any time a current source is shared between two meshes, the two meshes should be combined to form a **supermesh**. Whenever a supermesh is present in a circuit we will write one single KVL equation for the supermesh and one constraint equation defining the relationship between the two mesh currents that form the supermesh. Figure 19 shows the known value of the current in the top left mesh and identifies the path of the supermesh with a dashed line.

   Thus, in this step we write a KVL equation for each single mesh where the current is not known and for each supermesh. For the circuit in Fig. 19 we need only write the single KVL equation for the supermesh, because the remaining mesh current is known. We start just to the left of the dependent voltage source:

$$\text{supermesh:} \quad 29i_\beta + 8i_2 + 6i_3 + 5(i_3 - 6A) + 4(i_2 - 6A) \quad = \quad 0$$

4. Write any supplemental equations. Since there is a dependent source in the circuit, we know we will need at least one supplemental equation. This equation defines the quantity used to control the dependent source, i_β, in terms of the labeled mesh currents. Thus, the equation is

$$i_\beta = 6A - i_3$$

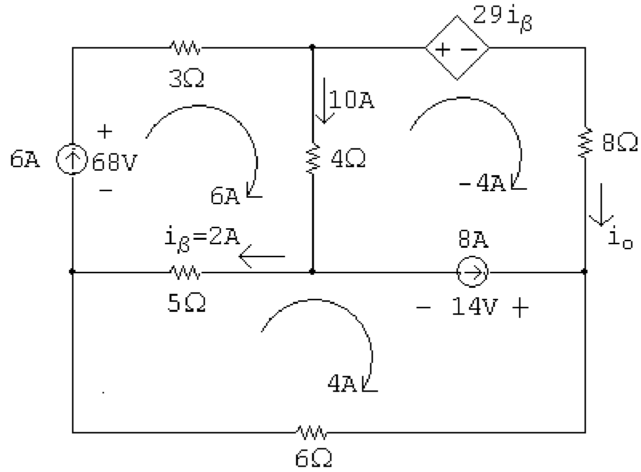

Figure 20: The circuit for Mesh Current Example 3, solved

But there is a second supplemental, or constraint, equation due to the presence of the supermesh. Remember that the current source shared between the two meshes constrains the difference between these mesh currents. The second constraint equation is thus

$$i_3 - i_2 = 8 \text{ A}$$

The single KVL equation and the two supplemental equations provide the three equations needed to solve for the three unknowns — i_2, i_3, and i_β. Remember that $i_1 = 6$A because of the current source on the perimeter of the top left mesh.

5. Solve the equations and check your solution. When these equations are input into a calculator, the solution is

$$i_2 = -4 \text{ A}; \qquad i_3 = 4 \text{ A}; \qquad i_\beta = 2 \text{ A}$$

The circuit is repeated in Fig. 20 with the values of all the currents through every component labeled. In addition, we have labeled the voltage drop across each current source. The voltage drops were calculated by writing a KVL equation for a mesh containing the current source and treating the voltage drop across the current source as an unknown. For example, to calculate the voltage drop across the 6A current source, define the voltage drop as $v_{6\text{A}}$ (positive at the top) and write a KVL equation for the top left mesh, starting just below the 6A source and going clockwise:

$$-v_{6\text{A}} + (3\Omega)(6A) + (4\Omega)(10A) + (5\Omega)(2A) = 0$$

Solving, we see that $v_{6\text{A}} = 68$V, as indicated in Fig. 20. Using the values in Fig. 20 we can calculate the power for each component:

$$\begin{array}{lcccccl}
p_{6\text{A}} & = & -vi & = & -(68)(6) & = & -408 \text{ W;} \\
p_{8\text{A}} & = & -vi & = & -(14)(8) & = & -112 \text{ W;} \\
p_{29i_\beta} & = & vi & = & [29(2)](-4) & = & -232 \text{ W;} \\
p_{3\Omega} & = & i^2R & = & 6^2(3) & = & 108 \text{ W;} \\
p_{4\Omega} & = & i^2R & = & 10^2(4) & = & 400 \text{ W;} \\
p_{5\Omega} & = & i^2R & = & 2^2(5) & = & 20 \text{ W;} \\
p_{6\Omega} & = & i^2R & = & 4^2(6) & = & 96 \text{ W;} \\
p_{8\Omega} & = & i^2R & = & 4^2(8) & = & 128 \text{ W;}
\end{array}$$

Thus,

$$\sum p = -408 - 112 - 232 + 108 + 400 + 20 + 96 + 128 = 0 \text{ W} \qquad \text{checks}$$

The power balance verifies that we have the correct solution, so $i_o = i_2 = -4$ A.

Now try using the mesh current method for each of the practice problems below.

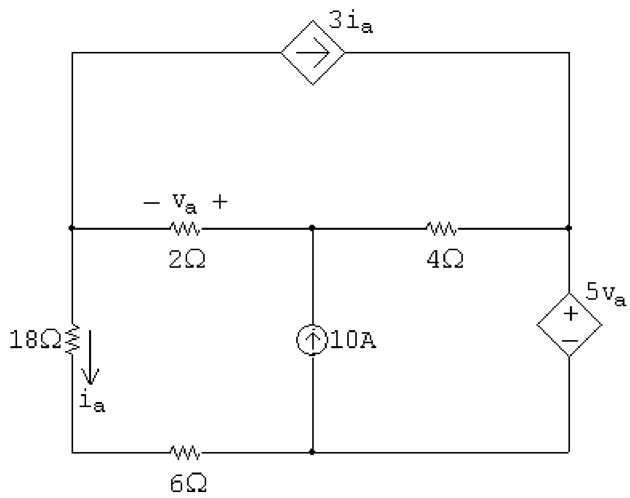

Figure 21: The circuit for Mesh Current Practice Problem 11.

Mesh Current Practice Problem 11

Find the power delivered to the 18Ω resistor in the circuit in Fig. 21.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 21 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 21.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate $p_{18\Omega}$.

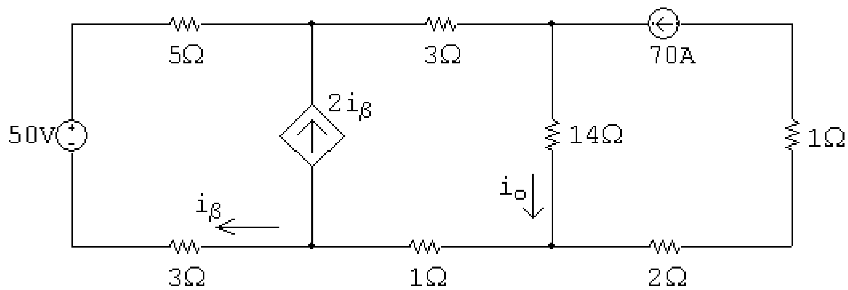

Figure 22: The circuit for Mesh Current Practice Problem 12.

Mesh Current Practice Problem 12

Find i_o for the circuit in Fig. 22.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 22 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 22.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate i_o.

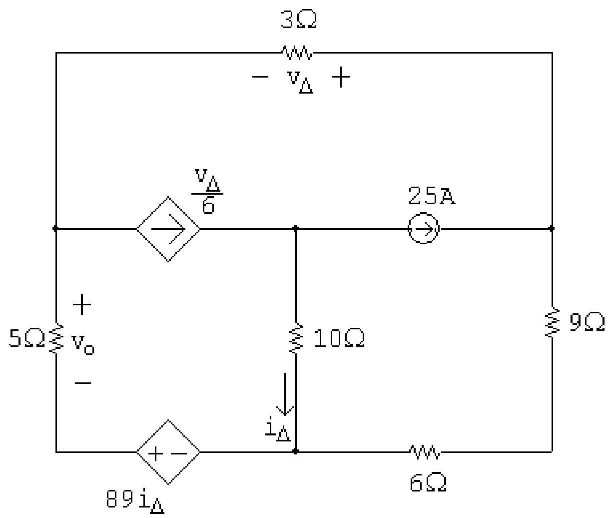

Figure 23: The circuit for Mesh Current Practice Problem 13.

Mesh Current Practice Problem 13

Find v_o for the circuit in Fig. 23.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 23 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 23.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate v_o.

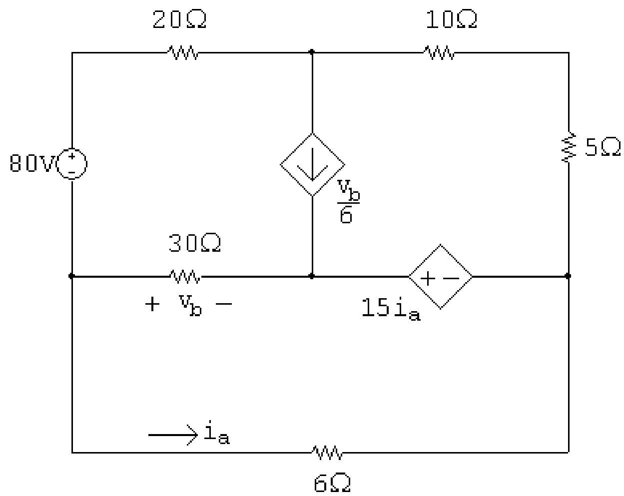

Figure 24: The circuit for Mesh Current Practice Problem 14.

Mesh Current Practice Problem 14

Find the power for the 80V source in the circuit in Fig. 24.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 24 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 24.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate $p_{80\text{V}}$.

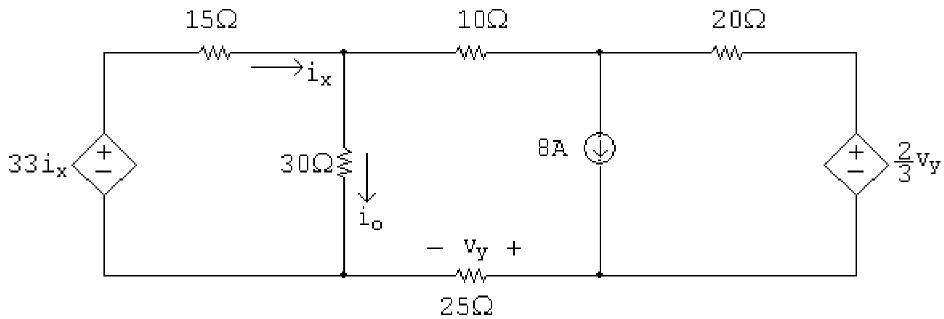

Figure 25: The circuit for Mesh Current Practice Problem 15.

Mesh Current Practice Problem 15

Find i_o for the circuit in Fig. 25.

1. Identify all of the meshes in the circuit by drawing a curved arrow in the center of each mesh in Fig. 25 to represent the direction of the current in that mesh.

2. Assign variable names to all of the mesh currents by labeling the mesh current arrows in Fig. 25.

3. Write a KVL equation around each of the meshes in the direction of the current arrow.

4. Are any supplemental equations required? If not, why not? If so, write them in the space below.

5. Express all of the equations in standard form.

6. Solve the equations, using a calculator, a computer tool, or Cramer's method.

   Check your solution by calculating the power for each element and summing the power for all elements.

   Calculate i_o.

Reading

- in *Introductory Circuits for Electrical and Computer Engineering*:
  - Section 3.1 — terminology and definitions
  - Section 3.5 — introduction to mesh current method
  - Section 3.6 — mesh current method with circuits containing dependent sources
  - Section 3.7 — supermeshes
- in *Electric Circuits*, sixth edition:
  - Section 4.1 — terminology and definitions
  - Section 4.5 — introduction to mesh current method
  - Section 4.6 — mesh current method with circuits containing dependent sources
  - Section 4.7 — supermeshes
- Workbook section — Power Balancing in DC Circuits

Additional Problems

- in *Introductory Circuits for Electrical and Computer Engineering*:
  - 3.26
  - 3.29 — 3.41
- in *Electric Circuits*, sixth edition:
  - 4.27
  - 4.30 — 4.42

Solutions

- Mesh Current Practice Problem 1 — the clockwise mesh currents are 4A, 2A, and 1A and $i_o = 1$A.
- Mesh Current Practice Problem 2 — the clockwise mesh currents are 16A, 6A, and 11A and $i_o = 5$A.
- Mesh Current Practice Problem 3 — the clockwise mesh currents are -5A, -2A, and 6A and $v_o = 60$V.
- Mesh Current Practice Problem 4 — the clockwise mesh currents are -5A, -20A, and -15A and $p_{32\Omega} = 800$W.

- Mesh Current Practice Problem 5 — the clockwise mesh currents are 20A, 12A, 7A, and 3A and $v_o = 100$V.
- Mesh Current Practice Problem 6 — the clockwise mesh currents are -4A, 4A, and 2A and $i_o = 2$A.
- Mesh Current Practice Problem 7 — the clockwise mesh currents are 4A, 8A, -2A, and 3A and $v_o = 80$V.
- Mesh Current Practice Problem 8 — the clockwise mesh currents are 4A, 6A, and 2A and $p_{\text{delivered}} = 560$W.
- Mesh Current Practice Problem 9 — the clockwise mesh currents are -6A, -2A, and -5A and $p_{15\Omega} = 60$W.
- Mesh Current Practice Problem 10 — the clockwise mesh currents are -15A, -10A and -20A and $v_o = 130$V.
- Mesh Current Practice Problem 11 — the clockwise mesh currents are -5A, 15A, and 5A and $p_{18\Omega} = 450$W.
- Mesh Current Practice Problem 12 — the clockwise mesh currents are -15A, -45A, and -70A and $i_o = 25$A.
- Mesh Current Practice Problem 13 — the clockwise mesh currents are -20A, -40A, and -15A and $v_o = 100$V.
- Mesh Current Practice Problem 14 — the clockwise mesh currents are 7A, -8A, and 10A and $p_{80\text{V}} = 560$W (delivered).
- Mesh Current Practice Problem 15 — the clockwise mesh currents are 15A, 6A, and -2A and $i_o = 9$A.