DEF: Mesh: A loop which does not contain any other loops inside it. 
A circuit often looks like a multi-paned window; each pane is a mesh.

DEF: Mesh current: defined to flow around the perimeter of a mesh.
KCL: Automatically satisfied; mesh currents flow into and out of nodes.
Note: Mesh analysis only works for planar circuits (unlike node eqns).
Note: Mesh analysis is “...probably used more often than it should be; other methods are often simpler” (Hayt and Kemmerly, 4th ed., p. 67).

PROCEDURE FOR WRITING MESH EQUATIONS:
1. Define mesh currents \{I_1, I_2 \ldots I_N\} flowing clockwise in each mesh. 
   Each circuit “windowpane” should have an associated mesh current.
2. KVL around each mesh: sum of voltage drops around mesh is zero.
3. Each current source not on perimeter is enclosed by a supermesh: 
   Write KVL around exterior of the two meshes that share current source. 
   Difference of the two mesh currents is given by the current source.
   Still define mesh currents for each mesh; just don’t write KVL for each.
4. Dependent sources: Express indpt variables in terms of mesh currents.
5. Solve the linear system of equations for the unknown mesh currents.
   Compute other voltages and currents of interest from mesh currents.

SIMPLE EXAMPLE

\[
\begin{align*}
&+ \quad 72 \text{ V} \quad 3\Omega \quad 6\Omega \quad 9 \text{ A} \quad - \\
&\begin{array}{c}
\downarrow \\
\end{array}
\end{align*}
\]

- Define mesh current \(I_1\) around the left mesh; \(I_2\) around right.
- Write KVL around left mesh: \[72 - 3I_1 - 6(I_1 - I_2) = 0.\]
- Current source on perimeter in right mesh: \(I_2 = 9\). Get \(I_1 = 14\).
- Compute other voltages and currents and check conservation of power:

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>CURRENT</th>
<th>VOLTAGE</th>
<th>POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>72 V :</td>
<td>(I_1 = 14)</td>
<td>72 (source)</td>
<td>(72)(14) = 1008</td>
</tr>
<tr>
<td>3\Omega :</td>
<td>(I_1 = 14)</td>
<td>(14)(3) = 42</td>
<td>(42)(14) = 588</td>
</tr>
<tr>
<td>6\Omega :</td>
<td>(I_1 - I_2 = 5)</td>
<td>(5)(6) = 30</td>
<td>(30)(05) = 150</td>
</tr>
<tr>
<td>9 A :</td>
<td>(I_2 = 9)</td>
<td>(5)(6) = 30</td>
<td>(30)(09) = 270</td>
</tr>
</tbody>
</table>

- Power conserved: 1008 = 588 + 150 + 270 checks.
- Note that the 9 A current source dissipates power (not unusual).
Note: This example contains all four types of sources. Shows: supermeshes; and dealing with dependent sources depending on voltage and current.

- Define *mesh currents* $I_1, I_2, I_3, I_4$ around meshes left to right.
- Write KVL around left mesh: $36 - 3I_1 - 6(I_1 - I_2) = 0$.
- Write KVL around supermesh consisting of middle two meshes. Supermesh encloses 21 A current source: $6(I_1 - I_2) + 4i_1 - 4(I_3 - I_4) = 0$.
- Within the supermesh, current source $\rightarrow I_3 - I_2 = 21$.
- Express indpt variables $v_1$ and $i_1$ in terms of mesh currents: $v_1 = -3I_1; \ i_1 = I_4 - I_3; \ 2v_1 = I_4 \rightarrow I_4 = -6I_1$.
- Substitute the second of these into the supermesh equation: $6(I_1 - I_2) + 4(I_4 - I_3) - 4(I_3 - I_4) = 0$ entirely in terms of mesh currents.
- Solve four equations in four unknowns $I_1, I_2, I_3, I_4$:

\[
\begin{align*}
9I_1 &- 6I_2 = 36 \quad I_1 = -\frac{4}{3} \\
6I_1 &- 6I_2 - 8I_3 + 8I_4 = 00 \quad I_2 = -8 \\
-6I_2 &+ I_3 = 21 \quad I_3 = 13 \\
6I_1 &+ I_4 = 00 \quad I_4 = 08
\end{align*}
\]

- Compute indpt voltages and currents from mesh currents: $v_1 = -3I_1 = 4; \ i_1 = I_4 - I_3 = 8 - 13 = -5$.
- Compute other voltages and currents and check conservation of power:

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>CURRENT</th>
<th>VOLTAGE</th>
<th>POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 V</td>
<td>$-I_1 = 4/3$</td>
<td>36 <em>(source)</em></td>
<td>$(36)(4/3) = 48$</td>
</tr>
<tr>
<td>3Ω</td>
<td>$-I_1 = 4/3$</td>
<td>$(4/3)(3) = 4$</td>
<td>$(4)(4/3) = 16/3$</td>
</tr>
<tr>
<td>6Ω</td>
<td>$I_1 - I_2 = 20/3$</td>
<td>$(20/3)(6) = 40$</td>
<td>$(40)(20/3) = 800/3$</td>
</tr>
<tr>
<td>21 A</td>
<td>21 <em>(source)</em></td>
<td>$(20/3)(6) = 40$</td>
<td>$(40)(21) = 840$</td>
</tr>
<tr>
<td>4i₁</td>
<td>$-I_3 = -13$</td>
<td>$4(-5) = -20$</td>
<td>$(-20)(-13) = 260$</td>
</tr>
<tr>
<td>4Ω</td>
<td>$I_3 - I_4 = 5$</td>
<td>$(4)(5) = 20$</td>
<td>$(20)(5) = 100$</td>
</tr>
<tr>
<td>2v₁</td>
<td>$I_4 = 8$</td>
<td>$(4)(5) = 20$</td>
<td>$(20)(8) = 160$</td>
</tr>
</tbody>
</table>

- Power conserved: $840 = 48 + 16/3 + 800/3 + 260 + 100 + 160$ checks.
- Note that three out of the four sources *dissipate* power (unusual).