**DEF**: Node: A point to which two or more components are connected.

**DEF**: Ground: Reference node to which all other nodes are compared with regard to voltage. Think of it as “sea level” for node voltages.

**DEF**: Node voltage: Potential difference between the node and ground.

**KVL**: Satisfied since KVL states that node voltages are path-independent.

**Note**: Node analysis works for *non*-planar circuits (unlike mesh eqns).

---

**PROCEDURE FOR WRITING NODE EQUATIONS:**

1. Select the *ground node*. Usually this is the node that has the most components connected to it. Often circuits are drawn so this node is at bottom; don’t count on it!

2. Define *node voltages* \( \{V_1, V_2 \ldots V_N\} \) at the other nodes.

3. Write **KCL** at each node: sum of currents leaving the node is zero. Do for each node except ground; Currents in terms of node voltages.

4. Each voltage source not connected to ground is regarded as a *supernode*: Write KCL for supernode, not the nodes voltage source connects.

5. **Dependent sources**: Express indpt variables in terms of node voltages.

6. Solve the linear system of equations for the unknown node voltages. Compute other voltages and currents of interest from node voltages.

---

**SIMPLE EXAMPLE**

- Define *ground* as the node at the bottom of the diagram above.
- Define *node* \( V \) as the node at upper right of the diagram above.
- Write KCL at node \( V \): Sum of currents *leaving* the node is zero: \( (V - 72)/3 + (V/6) + 9 = 0 \rightarrow V = 30 \).
- Compute other voltages and currents and check conservation of power:

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>VOLTAGE</th>
<th>CURRENT</th>
<th>POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>72 V</td>
<td>72 (source)</td>
<td>42/3 = 14</td>
<td>(72)(14) = 1008</td>
</tr>
<tr>
<td>3Ω</td>
<td>72 - 30 = 42</td>
<td>42/3 = 14</td>
<td>(42)(14) = 588</td>
</tr>
<tr>
<td>6Ω</td>
<td>30 (node)</td>
<td>30/6 = 5</td>
<td>(30)(05) = 150</td>
</tr>
<tr>
<td>9 A</td>
<td>30 (node)</td>
<td>9 (source)</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: supernodes; and dealing with dependent sources depending on voltage and current.

- Define *ground* as the node at the bottom of the diagram above.
- Define *node V* as the node at middle top of the diagram above.
- Write KCL at the supernode=dependent (on $4i_1$) voltage source:
  $$(V - 36)/3 + V/6 - 21 + (V + 4i_1)/4 + 2v_1 = 0$$
- Express indpt variables $v_1$ and $i_1$ in terms of node voltage $V$:
  $v_1 = V - 36; \quad i_1 = -(V + 4i_1)/4 \rightarrow i_1 = -V/8$
- Substitute these into the supernode equation for $V$:
  $$(V - 36)/3 + V/6 - 21 + (V - 4/8V)/4 + 2(V - 36) = 0$$
- Solve one equation in one unknown for $V$:
  $$V[(1/3) + (1/6) + (1/8) + 2] = 36/3 + 21 + 2(36) \rightarrow V = 40.$$  
- Compute indpt voltages and currents from $V = 40$:
  $$v_1 = V - 36 = 40 - 36 = 4; \quad i_1 = -V/8 = -40/8 = -5$$
- Compute current through dependent (on $4i_1$) voltage source:
  $$i_{4i_1} = 2v_1 - i_1 = 2(4) - (-5) = 13$$
- Compute other voltages and currents and check conservation of power:

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>VOLTAGE</th>
<th>CURRENT</th>
<th>POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 V</td>
<td>36 (source)</td>
<td>4/3 = 1.33</td>
<td>(36)(1.33) = 48</td>
</tr>
<tr>
<td>3Ω</td>
<td>40 − 36 = 4</td>
<td>4/3 = 1.33</td>
<td>(4)(1.33) = 5.33</td>
</tr>
<tr>
<td>6Ω</td>
<td>40 (node)</td>
<td>40/6 = 6.67</td>
<td>(40)(6.67) = 266.67</td>
</tr>
<tr>
<td>21 A</td>
<td>40 (node)</td>
<td>21 (source)</td>
<td>(40)(21) = 840</td>
</tr>
<tr>
<td>4i_1</td>
<td>4(−5) = −20</td>
<td>$i_{4i_1} = 13$</td>
<td>(20)(13) = 260</td>
</tr>
<tr>
<td>4Ω</td>
<td>−4(−5) = 20</td>
<td>$i_1 = −5$</td>
<td>(20)(5) = 100</td>
</tr>
<tr>
<td>2v_1</td>
<td>−4(−5) = 20</td>
<td>$2v_1 = 8$</td>
<td>(20)(8) = 160</td>
</tr>
</tbody>
</table>

- Power conserved: $840 = 48 + 5.33 + 266.67 + 260 + 100 + 160$ checks.
- Note that three out of the four sources *dissipate* power (unusual).