

**Nodal analysis**

Nodal Analysis is a circuit analysis technique which allows circuit analysis with significantly fewer equations than the big gun technique. Nodal Analysis is a general analysis technique which can be used to analyze any circuit

The first step in nodal analysis is to choose one node as the *reference node*.

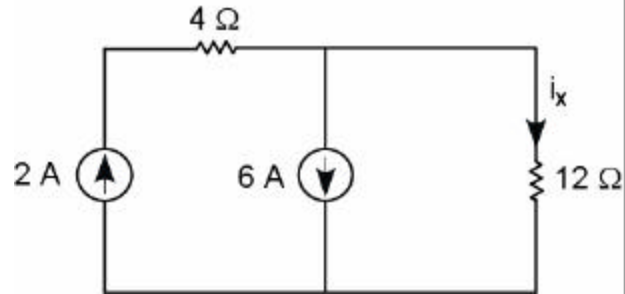
For each remaining node, we assign a *node voltage* which has its positive sign at the respective node and the negative sign at the reference node.

The clever thing about this choice of variable is that KVL is automatically satisfied. This allows analysis to focus on KCL and element relations.

To repeat, nodal analysis is based on KCL and element relations.

**Example**

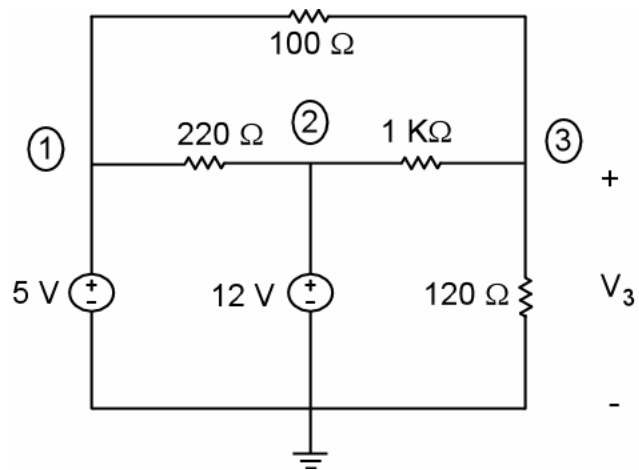
Use nodal analysis to find  $i_x$ .



check your work:  $i_x = -4 \text{ A}$

**Example**

Notice there was no voltage sources in the first example.



check your work:  $V_1 = 5 \text{ V}$ ,  $V_2 = 12 \text{ V}$ ,  $V_3 = 3.207 \text{ V}$

### Procedure for nodal analysis

1. Choose a reference node
2. Label node voltages
3. Express control variables in terms of node voltages.
4. Circle all voltage sources by supernodes
5. Write KCL equations for all nodes or supernodes not associated with the reference node.
6. Write element relations for voltage sources in terms of node voltages.

The result should be a sufficient set of independent equations. That is, the number of equations should equal the number of variable (node voltages).

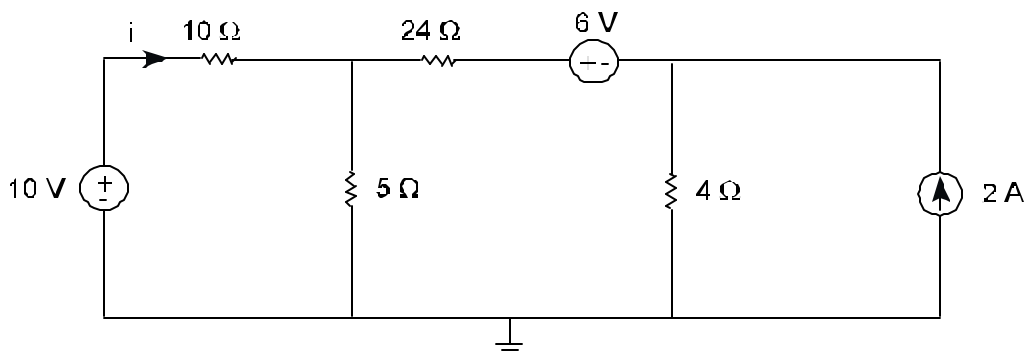
In nodal analysis the number of equations is equal to the number of node voltages. That is, the number of nodes minus one. There will be one equation for each voltage source, the remaining equations come from KCL.

### Example

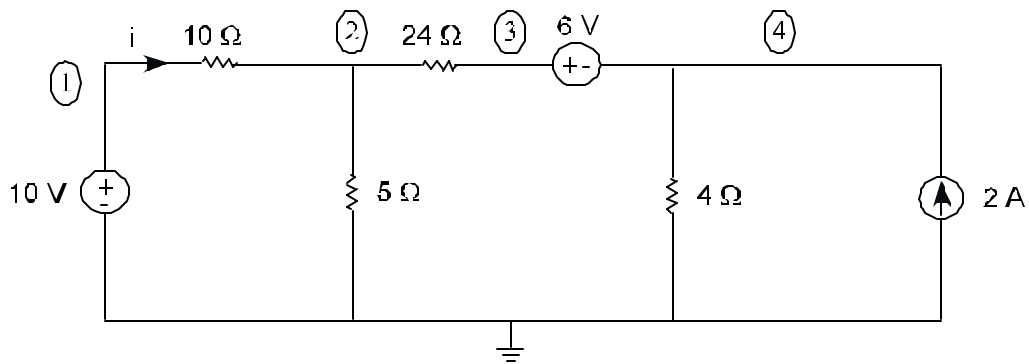
5-node circuit, 2 voltage sources.

What equations are needed in nodal analysis? Four equations in  $V_1 - V_4$  are required. They come from KCL and voltage sources.

Perform nodal analysis on this circuit:



same circuit, labeled as shown



Find  $i$  and the power delivered by the 10V source.

*check your work:*

$$V_1 = 10V, \quad V_2 = 4.47V, \quad V_3 = 12.64V, \quad V_4 = 6.64V$$

$$i = (10 - V_2)/10 = 0.553A \quad P_{del-10V} = 10V(i) = 5.53W$$

All these node voltages are positive. Is it possible for node voltages to be negative? Zero?

### Discuss

Compare nodal analysis with the big gun technique for this last circuit. How many variables would have been required? How many equations? Is nodal analysis more efficient? Is nodal analysis worth the trouble of learning?