Circuit Analysis

* Kirchhoff's Laws (KCL, KVL)

  Ohm's Law   } basic tools

* Equivalent Resistor

* Node Voltage Method

* Mesh Current Method   } more powerful methods

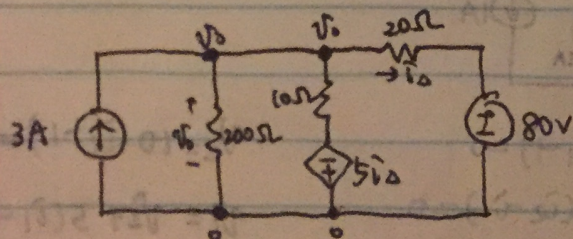## Node Voltage Method

- Find essential nodes

- Set reference node (ground)

- Node voltage = rise from ground

- State KCL at essential nodes

- A voltage source between 2 essential nodes
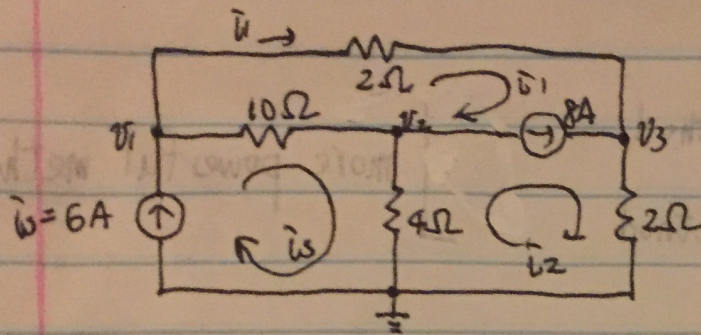 → supernode

Find V_0 and i_0

$$-3 + \frac{V_0}{200} + \frac{V_0 - (-5 i_0)}{10} + \frac{V_0 - 80}{20} = 0 \quad —①$$

$$V_0 = 80 + 20 i_0 \quad —②$$

$$\Rightarrow i_0 = -1.5 \, A, \quad V_0 = 50 \, V$$

Mesh Current Method

- Find meshes
- State KVL at each mesh
- Supermesh (current source)

Find $\bar{v}_1$.
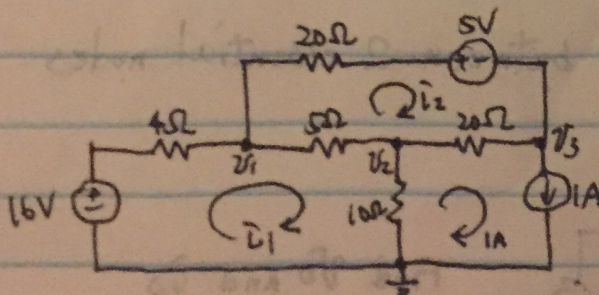
Then find V_1, V_2, and V_3

Supermesh:

$$2\bar{v}_1 + 2\bar{v}_2 + 4(\bar{i}_2-6) + 10(\bar{i}_1-6) = 0$$
$$-\bar{i}_1 - 8 + \bar{i}_2 = 0 \Rightarrow \bar{i}_2 = \bar{i}_1 + 8$$

$$\Rightarrow 18\bar{i}_1 = 36 \Rightarrow \bar{i}_1 = 2A$$
$$\bar{i}_2 = 10A$$

$$V_2 = (6-10)\cdot 4 = -16\,V$$

$$V_3 = 10\cdot 2 = 20\,V$$

$$V_1 = V_2 + (6-2)\cdot 10 = 24\,V$$

Find $\bar{i}_1$, $\bar{i}_2$, V_1, V_2, and V_3

$$\begin{cases} -16 + 4\bar{i}_1 + 5(\bar{i}_1 - \bar{i}_2) + 10(\bar{i}_1 - 1) = 0 \\ 20\bar{i}_2 + 5 + (\bar{i}_2 - 1)\cdot 20 + 5(\bar{i}_2 - \bar{i}_1) = 0 \end{cases}$$

$$\Rightarrow \begin{cases} 19\bar{i}_1 - 5\bar{i}_2 = 26 \\ 5\bar{i}_1 - 45\bar{i}_2 = -45 \end{cases} \Rightarrow \begin{cases} \bar{i}_1 = 1.5\,A \\ \bar{i}_2 = 0.5\,A \end{cases}$$

$$V_2 = 10(\bar{i}_1 - 1) = 5\,V$$

$$V_1 = V_2 + 5(\bar{i}_1 - \bar{i}_2) = 10\,V$$

$$V_3 = V_2 + 20(\bar{i}_2 - 1) = -5\,V$$