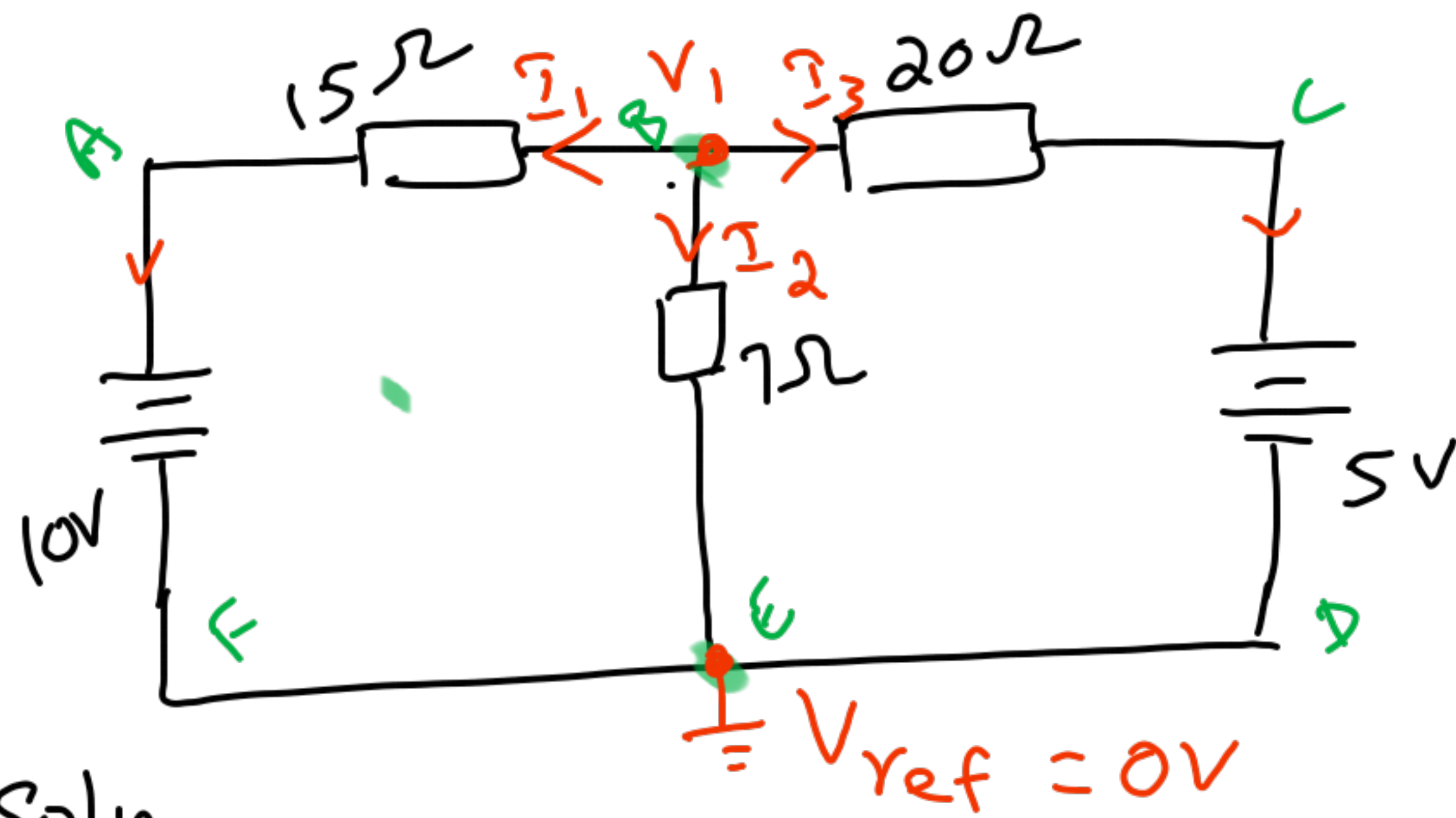


Nodal Analysis

- 1) Draw the circuit
- 2) Identify the Junction / Essential Node
- 3) Mark the current direction in the first Junction, assuming all the current flow away from the junction.
- 4) Based on the current direction from step 3, mark the remaining current direction.
- 5) Apply KCL at each Junction / Essential node.

- 6) Assume one of the node/Junction as reference node, $V_{ref} = 0V$ (Ground)
- 7) Apply Ohm's law in each branch in terms of current $\left[\hat{I} = \frac{V}{R}\right]$
- 8) Substitute the equation obtained from step(7) in the equation obtained by KCL.
- 9) Solve the equation.

1) Determine the Voltage across 7Ω resistor using nodal analysis



Soln.

Apply KCL at V_1

$$0 = \bar{I}_1 + \bar{I}_2 + \bar{I}_3 \quad \text{--- ①}$$

Apply ohm's law in BAFE

$$\bar{I}_1 = \frac{V_1 - 10 - V_{ref}}{15} = \frac{V_1 - 10 - 0}{15} = \frac{V_1 - 10}{15}$$

Apply ohm's law in BE

$$\bar{I}_2 = \frac{V_1 - V_{ref}}{7} = \frac{V_1}{7}$$

Apply ohm's law in BCDE

$$\bar{I}_3 = \frac{V_1 - 5 - V_{ref}}{20} = \frac{V_1 - 5}{20}$$

Sub. I_1 , I_2 and I_3 in eq ①

$$\textcircled{1} \Rightarrow I_1 + I_2 + I_3 = 0$$

$$\frac{V_1 - 10}{15} + \frac{V_1}{7} + \frac{V_1 - 5}{20} = 0$$

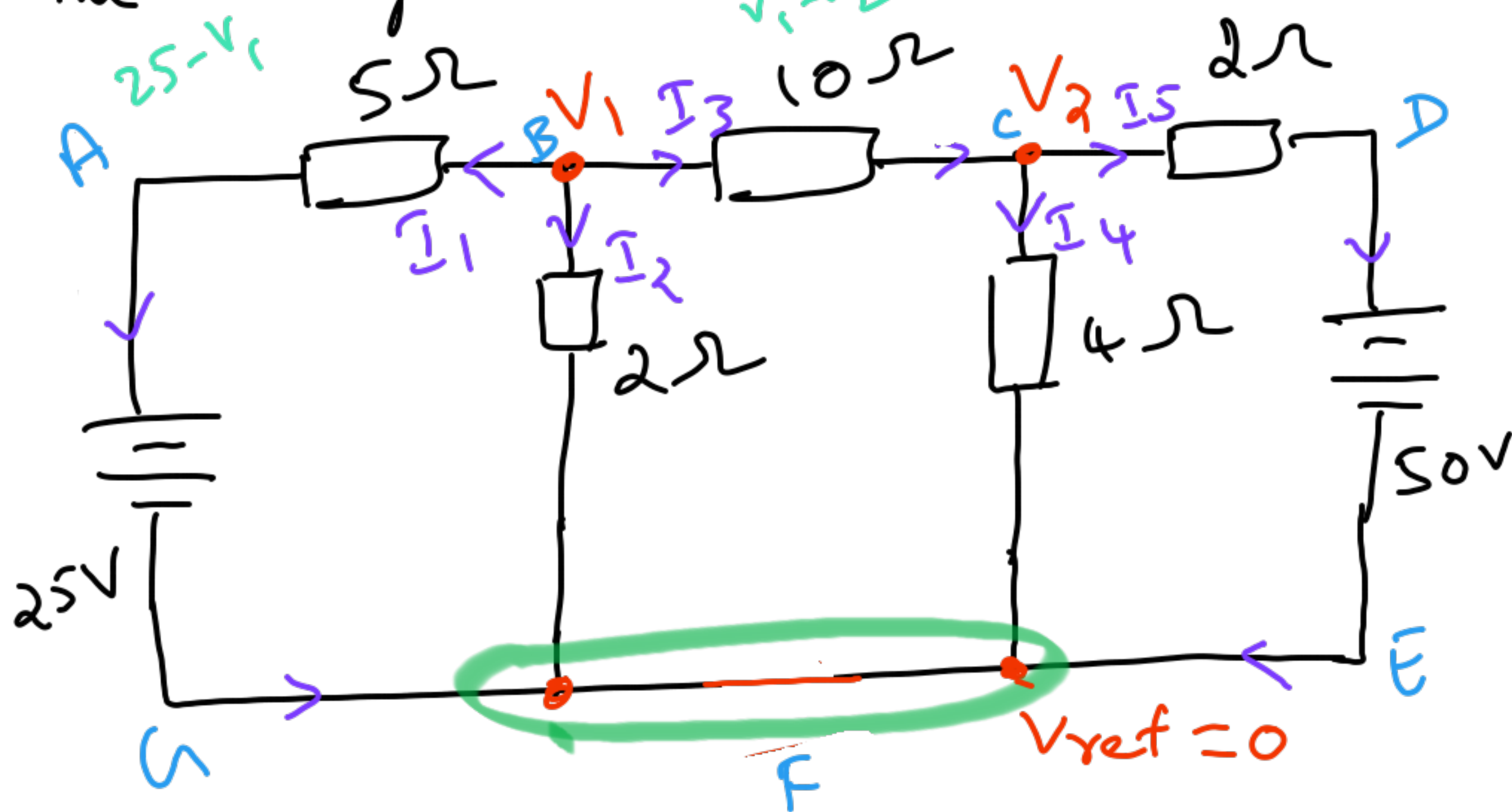
$$0.067(V_1 - 10) + 0.14V_1 + 0.05(V_1 - 5) = 0$$

$$0.067V_1 - 0.67 + 0.14V_1 + 0.05V_1 - 0.25 = 0$$

$$0.26V_1 = 0.92$$

$$V_1 = \frac{0.92}{0.26} = 3.54V$$

2) Apply nodal analysis and determine the voltage at each Junction.



Apply KCL at v_1

$$0 = \vec{I}_1 + \vec{I}_2 + \vec{I}_3 \quad \text{--- (1)}$$

Apply KCL at V_2

$$\hat{I}_3 = \hat{I}_4 + \hat{I}_5$$

$$\hat{I}_4 + \hat{I}_5 - \hat{I}_3 = 0 \quad \text{--- (2)}$$

Apply Ohm's law in BAG F

$$I_1 = \frac{V_1 - 25 - 0}{5} = \frac{V_1 - 25}{5}$$

Apply Ohm's law in BF

$$I_2 = \frac{V_1}{2}$$

Apply Ohm's law in BC

$$\bar{I}_3 = \frac{V_1 - V_2}{10}$$

Apply Ohm's law in CF

$$\bar{I}_4 = \frac{V_2}{4}$$

Apply Ohm's law in CDEF

$$\bar{I}_5 = \frac{V_2 - 50}{2}$$

Sub. $\bar{I}_1$, $\bar{I}_2$, $\bar{I}_3$ and $\bar{I}_4$ in eq ① & ②

$$\text{①} \Rightarrow \bar{I}_1 + \bar{I}_2 + \bar{I}_3 = 0$$

$$\frac{V_1 - 25}{5} + \frac{V_1}{2} + \frac{V_1 - V_2}{10} = 0$$

$$0.2(V_1 - 25) + 0.5V_1 + 0.1(V_1 - V_2) = 0$$

$$0.2V_1 - 5 + 0.5V_1 + 0.1V_1 - 0.1V_2 = 0$$

$$0.8V_1 - 0.1V_2 = 5 \quad \text{--- ③}$$

eq ② $\Rightarrow$

$$\bar{I}_4 + \bar{I}_5 - \bar{I}_3 = 0$$

$$\frac{V_2}{4} + \frac{V_2 - 50}{2} - \left(\frac{V_1 - V_2}{10} \right) = 0$$

$$0.25 V_2 + 0.5(V_2 - 50) - 0.1(V_1 - V_2) = 0$$

$$0.25 V_2 + 0.5 V_2 - 25 - 0.1 V_1 + 0.1 V_2 = 0$$

$$-0.1 V_1 + 0.85 V_2 = 25 \quad (4)$$

$$\text{eq (3)} \Rightarrow 0.8 V_1 - 0.1 V_2 = 5 \quad +$$

$$\text{eq (4)} \times 8 \Rightarrow -0.8 V_1 + 6.8 V_2 = 200$$

$$6.7 V_2 = 205$$

$$V_2 = \frac{205}{6.7}$$

$$V_2 = 30.6 \text{ V}$$

Sub. V_2 in eq (3)

$$0.8 V_1 - 0.1(30.6) = 5$$

$$0.8 V_1 - 3.06 = 5$$

$$0.8 V_1 = 5 + 3.06$$

$$0.8 V_1 = 8.06$$

$$V_1 = \frac{8.06}{0.8}$$

$$V_1 = 10.08 \text{ V}$$

