

Nodal Analysis

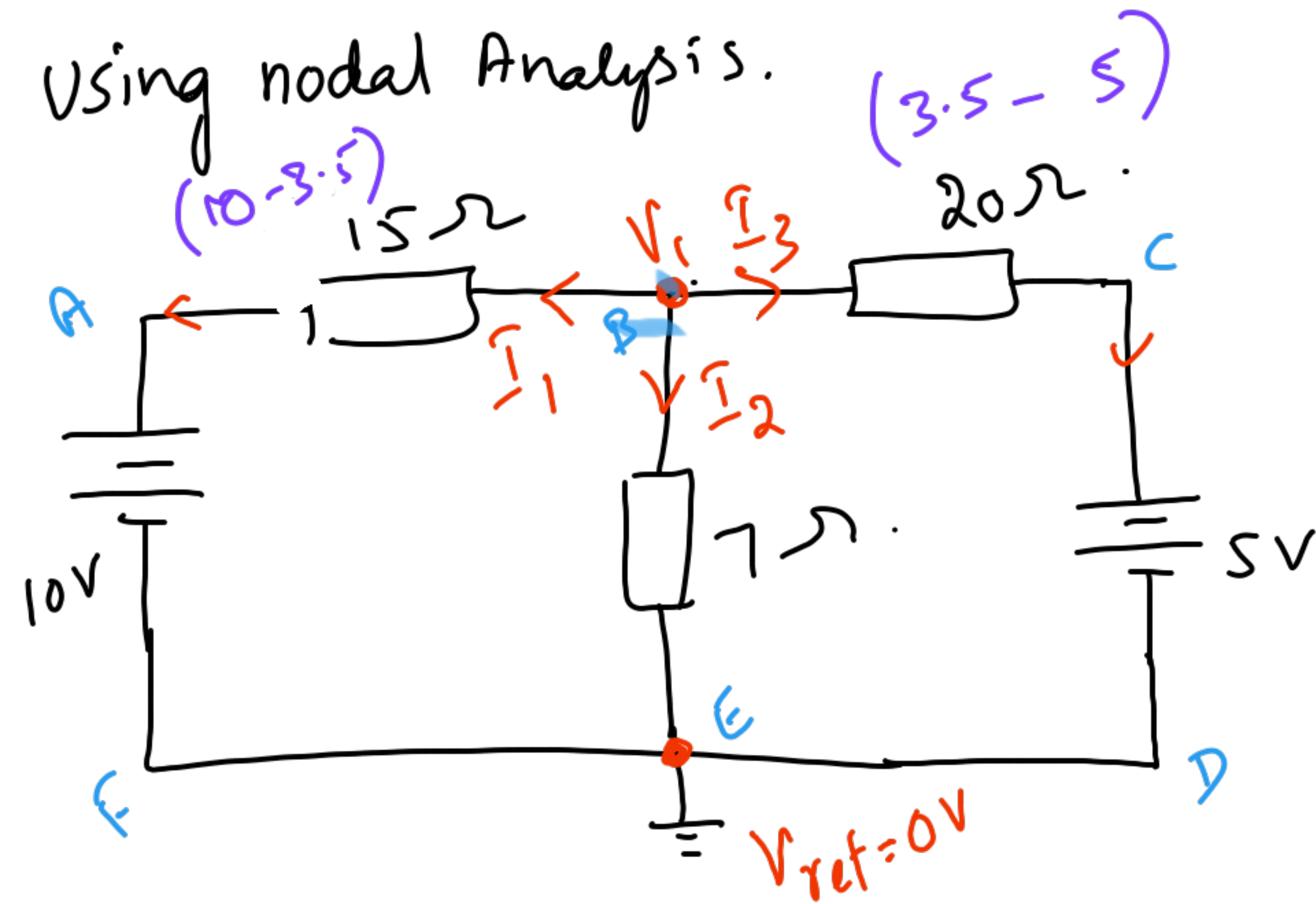
- Identify the Junction / node - V?
- Mark the current direction. from the first Junction.
Assuming the current is flowing away from the node.
- Mark the current direction in Rest of the branches.
- Apply KCL in each node.
- $V_{ref} = 0V / \text{Ground}$

→ Apply Ohm's law in each branch, in terms of current $\left[\hat{I} = \frac{V}{R} \right]$

→ Substitute the above equation in the equation obtained from KCL.

→ Solve the equation.

1) Determine the Voltage across 7Ω resistor using nodal Analysis.



Essential nodes.

Apply KCL in V_1

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

Apply Ohm's law in BAFE

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

$$\left[\hat{I} = \frac{V}{R} \right]$$

$$\hat{I}_1 = \frac{V_1 - 10}{15}$$

$$\left[\because V_{ref} = 0 \right]$$

Apply Ohm's law in BE

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

Apply Ohm's law in BCDE

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

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

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

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

$$\left[\frac{V_1 - 10}{15} + \frac{V_1}{7} + \frac{V_1 - 5}{20} = 0 \right]$$

$$0.067(V_1 - 10) + 0.14V_1 + 0.05(V_1 - 5) = 0$$
$$0.067V_1 - 0.67 + 0.14V_1 + 0.05V_1 - 0.25 = 0$$

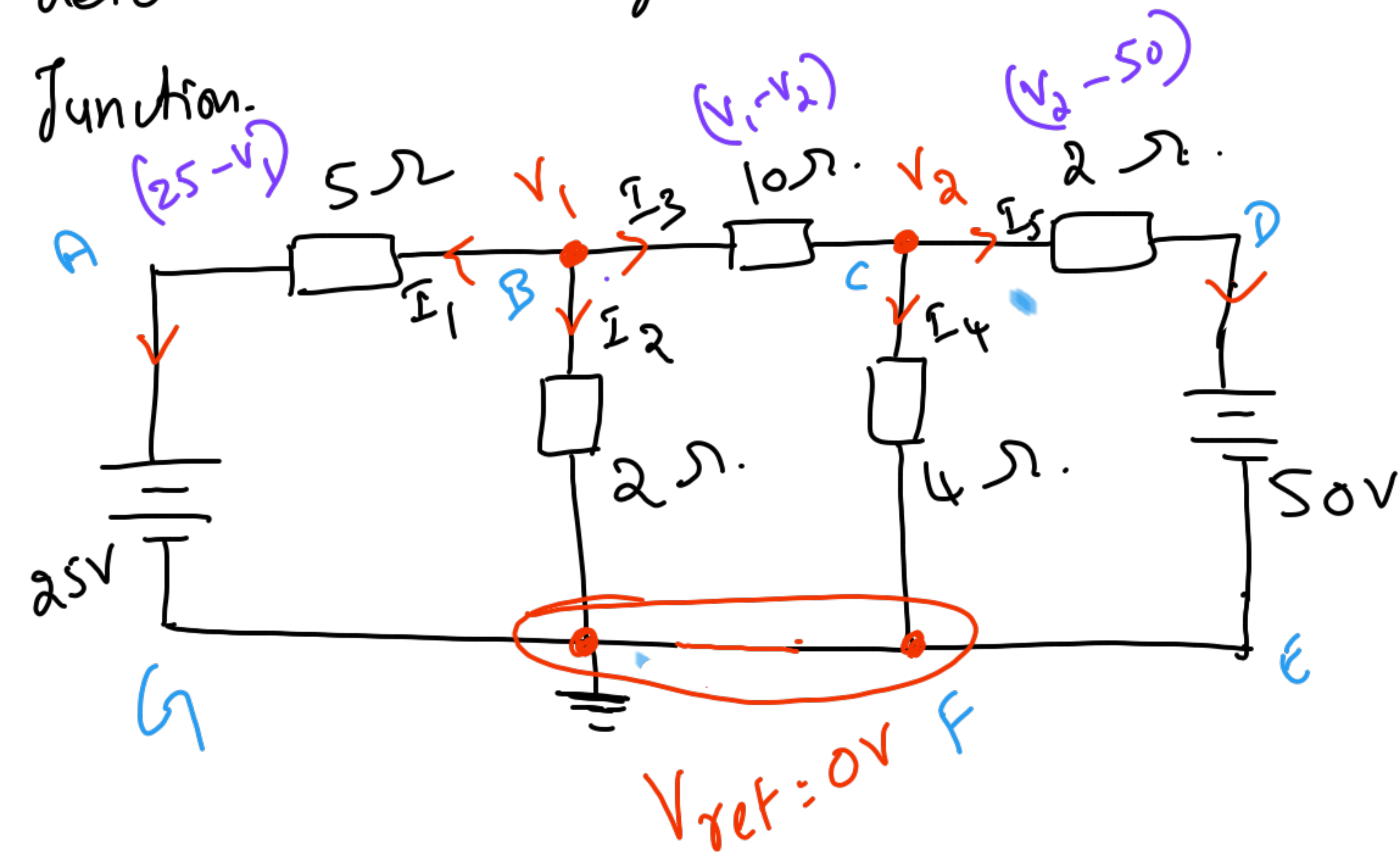
$$0.26V_1 = 0.92$$

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

$$\underline{\underline{V_1 = 3.53V}}$$

$$\frac{1}{15}(V_1 - 10) + \frac{1}{7}(V_1) + \frac{1}{20}(V_1 - 5)$$

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



Apply KCL in V_1

$$0 = I_1 + I_2 + I_3 \quad \text{--- ①}$$

Apply KCL in V_2

$$I_4 + I_5 = I_3$$

$$I_4 + I_5 - I_3 = 0 \quad \text{--- ②}$$

Apply Ohm's law in BAGF

$$I_1 = \frac{V_1 - 25 - V_{ret}}{5}$$

$$\hat{I}_1 = \frac{V_1 - 25}{5}$$

Apply Ohm's law in BF

$$\hat{I}_2 = \frac{V_1 - V_{ref}}{2} = \frac{V_1}{2}$$

$$\hat{I}_2 = \frac{V_1}{2}$$

Apply Ohm's law in BC

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

Apply Ohm's law in CF

$$\hat{I}_4 = \frac{V_2 - V_{ref}}{4} = \frac{V_2}{4}$$

Apply Ohm's law in CDEF

$$\hat{I}_5 = \frac{V_2 - 50 - V_{ref}}{2}$$

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

Sub. the values of $\hat{I}$ in eq ①.

$$\textcircled{1} \Rightarrow \hat{I}_1 + \hat{I}_2 + \hat{I}_3 = 0$$

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

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

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

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

$$\textcircled{2} \Rightarrow \bar{I}_4 + \bar{I}_5 - \bar{I}_3 = 0$$

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

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

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

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

Solve equation (3) and (4).

$$\textcircled{3} \Rightarrow 0.8V_1 - 0.1V_2 = 5$$

$$\textcircled{4} \Rightarrow -0.1V_1 + 0.85V_2 = 25$$

$$0.1 \times \textcircled{3} \quad 0.08V_1 - 0.01V_2 = 0.5 \quad +$$

$$0.8 \times \textcircled{4} \quad -0.08V_1 + 0.68V_2 = 20$$

$$+ 0.67V_2 = 20.5$$

$$V_2 = \frac{20.5}{0.67}$$

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

Sub v_2 in eq ③

$$\text{eq ③} \Rightarrow 0.8v_1 - 0.1(30.6) = 5$$

$$0.8v_1 - 3.06 = 5$$

$$0.8v_1 = 5 + 3.06$$

$$0.8v_1 = 8.06$$

$$v_1 = \frac{8.06}{0.8}$$

$$v_1 = 10.08 \text{ V}$$

$$0.08v_1 - 0.01v_2 + (-0.08v_1 + 0.068v_2) = 0.5 + 20$$

$$\cancel{0.08v_1} - 0.01v_2 - \cancel{0.08v_1} + 0.068v_2 = 20.5$$