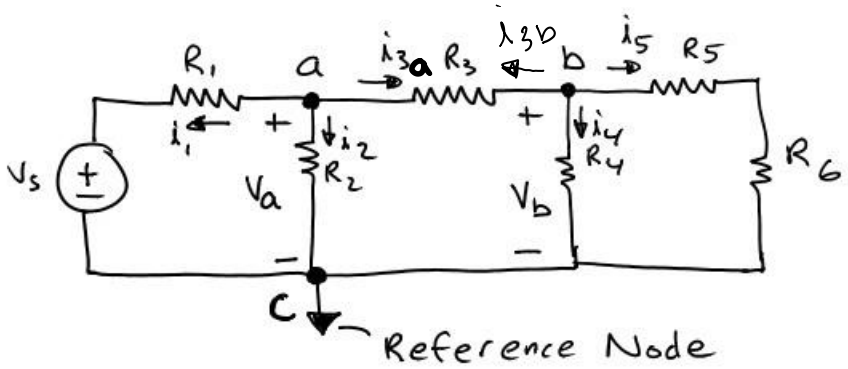
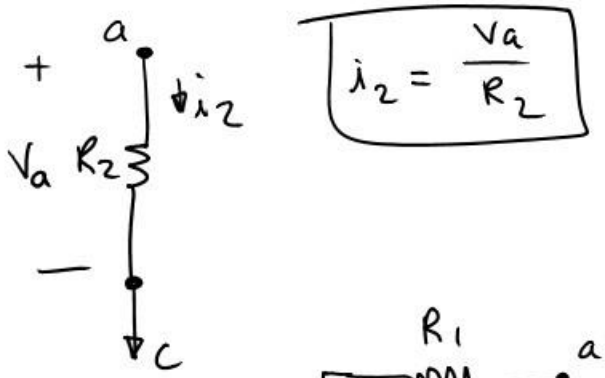
ENGR 2219 – Linear Circuits I
Advanced Circuit Techniques – The Node Voltage Method

Essential Node
- Connects three or more circuit elements

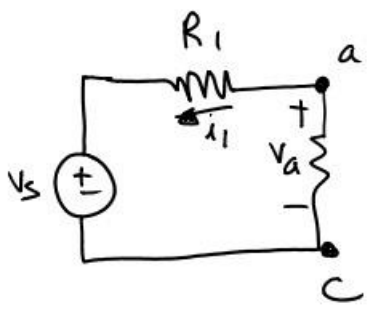
Essential Branch
- Connects two essential nodes

Node Voltage Method
- Define the essential nodes
- One of the essential nodes is selected as the reference node (Typically the reference node connects the most essential branches)
- Define the node voltages
    - Voltage between the reference node and each of the other essential nodes
    - The reference node has the negative polarity
- KCL at each reference node
    - Determine each current in terms of the node voltages using Ohm's Law





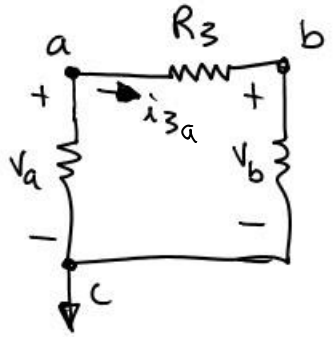
$$i_2 = \frac{V_a}{R_2}$$



KVL (CCW)

$$i_1 R_1 + V_s - V_a = 0$$

$$i_1 = \frac{V_a - V_s}{R_1}$$

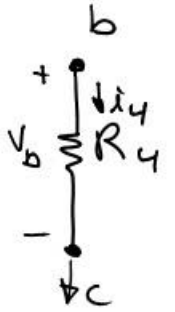


KVL (cw)

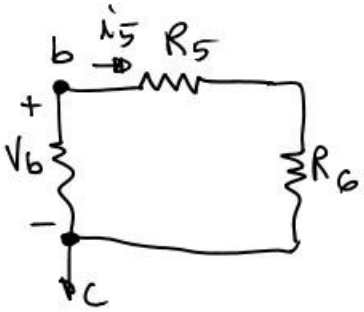
$$i_{3a}R_3 + V_b - V_a = 0$$

$$i_{3a} = \frac{V_a - V_b}{R_3}$$

$$i_{3b} = -i_{3a} = \frac{V_b - V_a}{R_3}$$



$$i_4 = \frac{V_b}{R_4}$$



$$i_5 = \frac{V_b}{R_5 + R_6}$$

KCL

a

$$i_1 + i_2 + i_{3a} = 0$$

$$\frac{V_a - V_s}{R_1} + \frac{V_a}{R_2} + \frac{V_a - V_b}{R_3} = 0$$

b

$$i_{3b} + i_4 + i_5 = 0$$

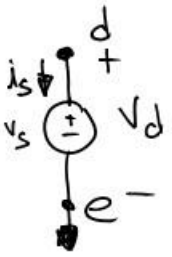
$$\frac{V_b - V_a}{R_3} + \frac{V_b}{R_4} + \frac{V_b}{R_5 + R_6} = 0$$

Special Cases

- Current Source

$i = i_s$

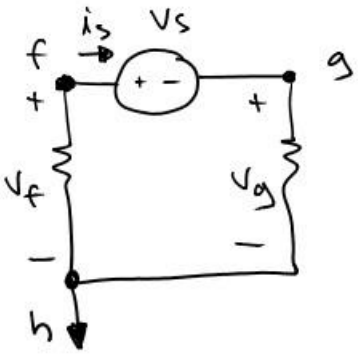
- Voltage Source



- Node voltage is known

$V_d = V_s$

- i_s can't be solved for in terms of the node voltages
  => includes i_s as an unknown



- i_s is added as an unknown
- Add a constraint equation (KVL)

KVL (CW)

$-V_f + V_s + V_g = 0$

OR

Create a Supernode

Combine nodes f & g into a supernode

KCL at the supernode

=> Eliminate i_s

=> Add a constraint equation