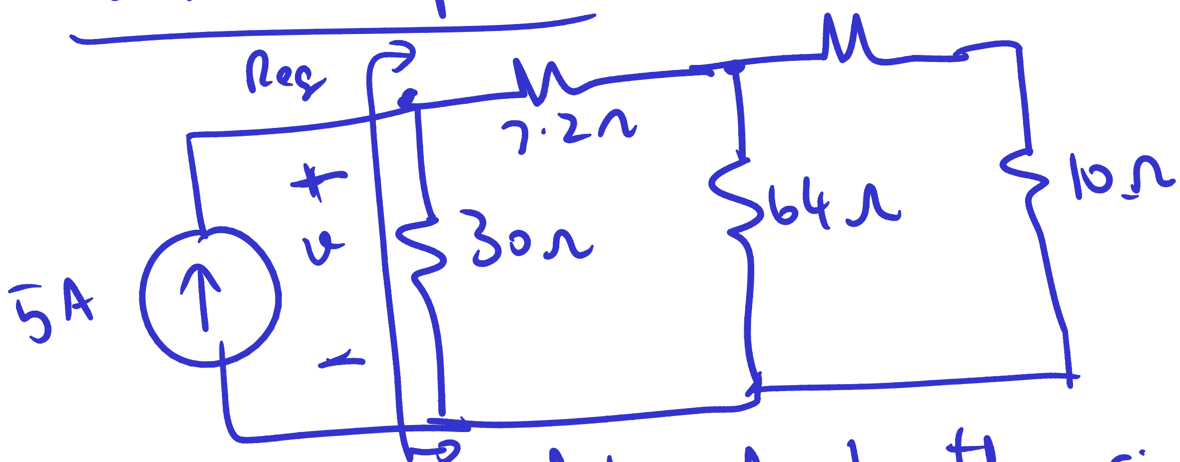
EE100Su08 Lecture #4 (June 30th 2008)

- Outline
  - **Questions?**
  - **Lab notes:**
    - **Finish lab 1, will shorten lab 2 and others**
  - **Dependent Sources Example**
  - Node-Voltage Analysis
    - Concept
    - Examples
    - Node voltage method with dependent sources

Review

(1) DP3.1 on p.62



(Q:) Find v, power delivered to the circuit by the source & power dissipated in the 10Ω resistor.

Sol: Combine resistors into one equivalent resistance across the 5A source ⇒ we can find v.

$$R_{eq} = \left[\left\{(6+10) \parallel 64\right\} + 7.2\right] \parallel 30 = \left[(16 \parallel 64) + 7.2\right] \parallel 30$$

DP 3.1 (contd.)

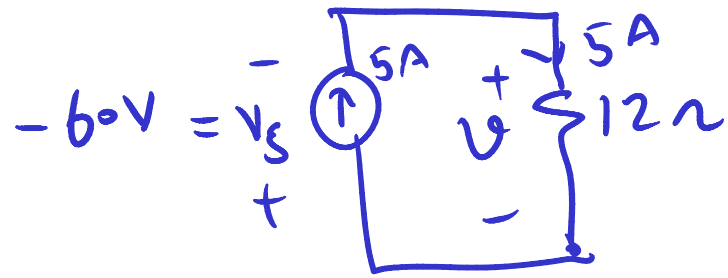
$\therefore$ KVL: $-V_s - V = 0$

$\Rightarrow V_s = -V$

$$= \left[\left(\frac{16.64}{80}\right) + 7.2\right] \| 30$$

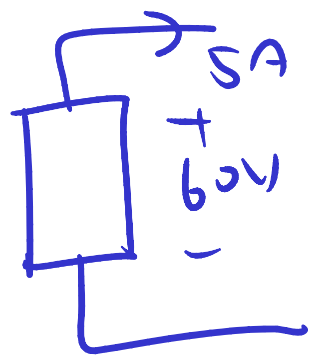
$$= (12.8 + 7.2) \| 30$$

$$= 20 \| 30 = \frac{20 \cdot 30}{50} = 12\,\Omega$$



$\therefore v = (5\,A)(12\,\Omega)$

$= 60\,V$

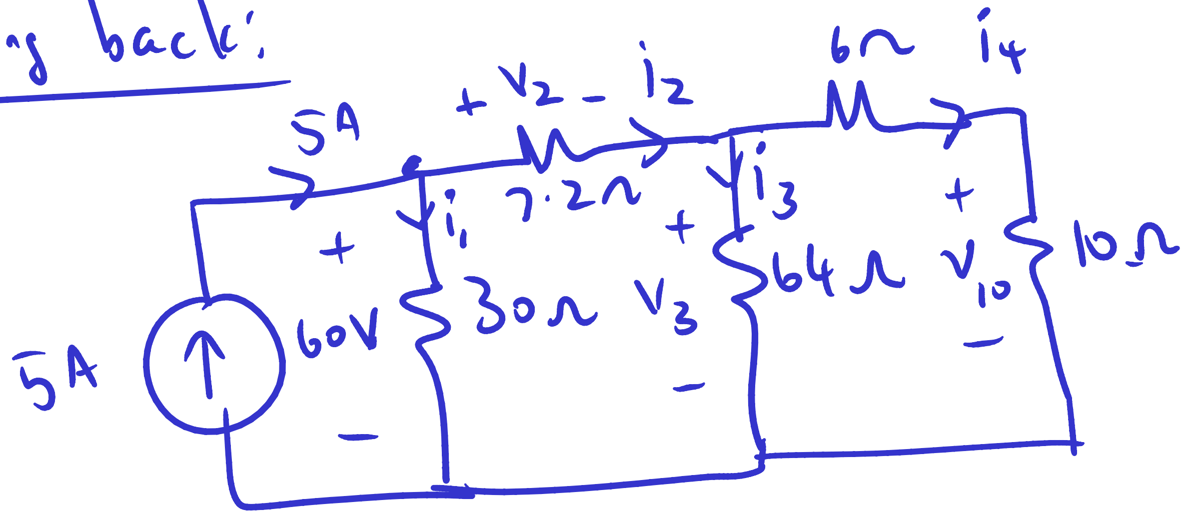


$$P_{5A} = -vi = -(60)(5) = -300\,W$$

$\therefore$ Power delivered by the 5A source = 300 W

DP 3-1 (contd.)

Going back:



$$i_1 = \frac{60V}{30\Omega} = 2A \quad \therefore i_2 = 3A \text{ (by KCL)}$$

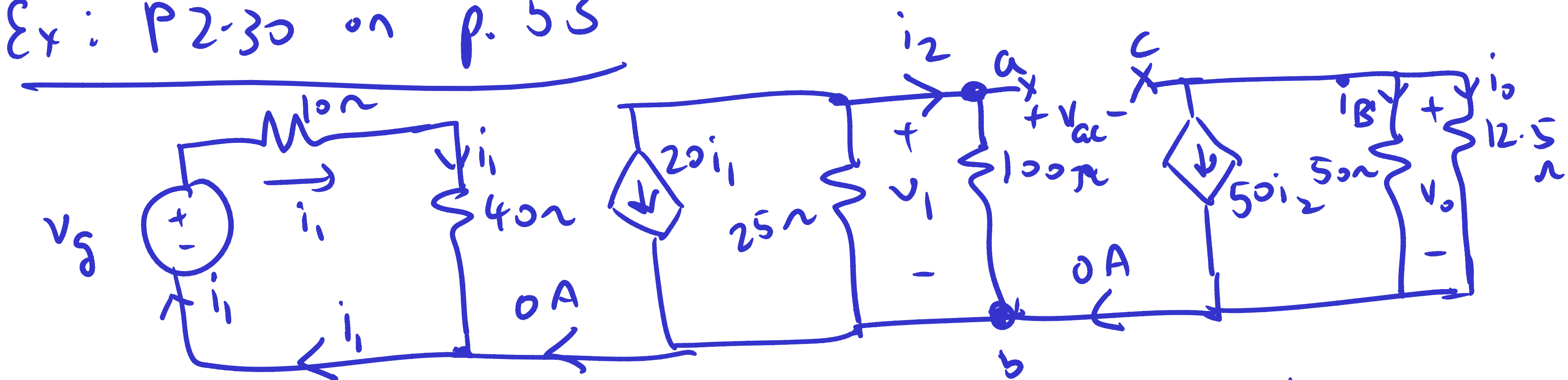
$$v_2 = (3)(7.2) = 21.6\,V \Rightarrow v_3 = 60 - 21.6 \text{ (KVL)}$$
$$= 38.4\,V$$

$$\therefore i_3 = \frac{38.4}{64} = 0.6\,A \Rightarrow i_4 = 2.4\,A \text{ (by KCL)} \Rightarrow P_{10\Omega} = v_{10} i_4$$

DP3.1 (contd.)

$\therefore P_{10\Omega} = vi = i^2R = (2.4)^2(10) = (5.76)(10) = 57.6\,W$

Ex: P2-30 on p. 53



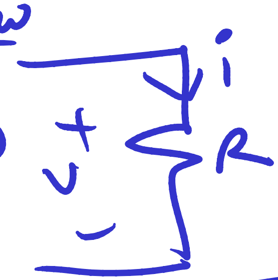
(Q:) Find v_1 & v_g if $v_o = 250\,mV = 0.25\,V = \frac{1}{4}\,V$

Notice: $V_{ac} = V_1 - V_o$

Also: $i_o = \frac{V_o}{12.5} = \frac{0.25}{12.5} = 20\,mA$

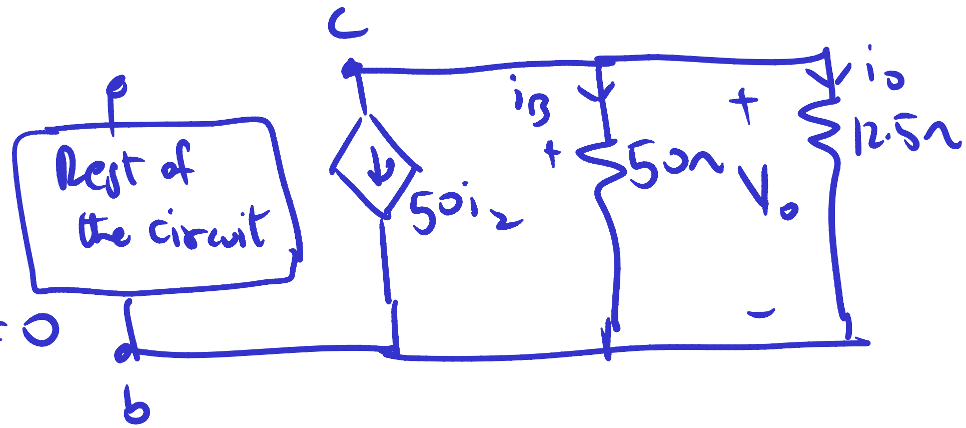
Ohm's law

$v = iR \Leftrightarrow$



P 2.30 (contd.)

$$i_B = \frac{V_o}{50} = \frac{0.25}{50} = 5\,mA$$

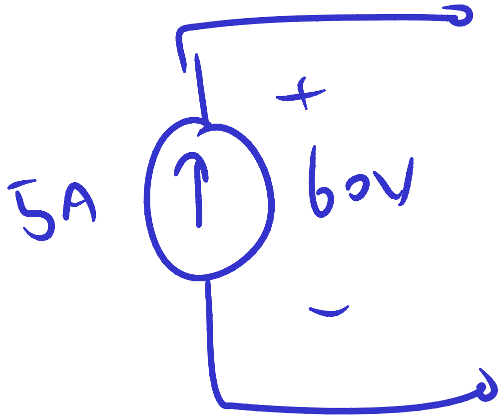


KCL @ node "c": $50i_2 + i_B + i_o = 0$

$$\Rightarrow \quad 50i_2 = -25\,mA$$

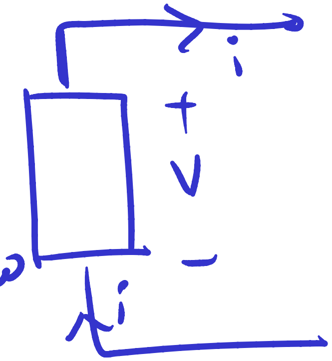
$$\Rightarrow \quad i_2 = -\frac{1}{2}\,mA$$ ⇒ use same strategy to find i_1 & consequently V_g.

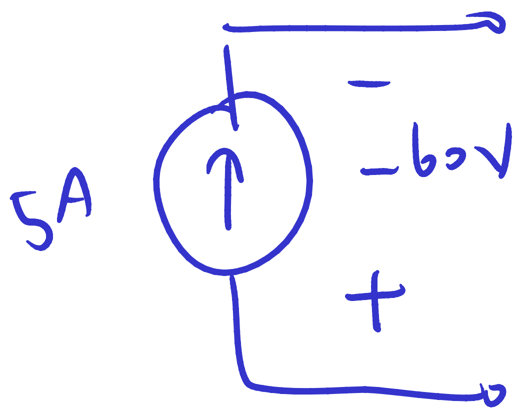
Note on sign conventions



$$P_{5A} = -vi$$

$$= -(60)(5) = -300W$$

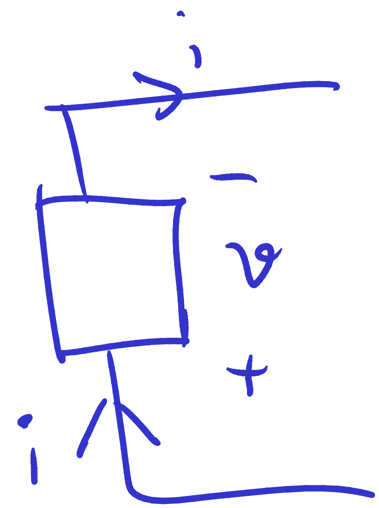




$$P_{5A} = +vi$$

$$= +(-60)(5)$$

$$= -300W$$



Node-Voltage Circuit Analysis Method

(1) Sections 4.1 thro' 4.4

(2) Book has a good intuitive explanation of why nodal analysis works ⇒ uses concept of essential nodes.

(3) I will use a different approach to explain nodal analysis.

Node-Voltage Circuit Analysis Method

1. **Choose a reference node** ("ground")

   Look for the one with the most connections!

2. **Define unknown node voltages**

   those which are not fixed by voltage sources

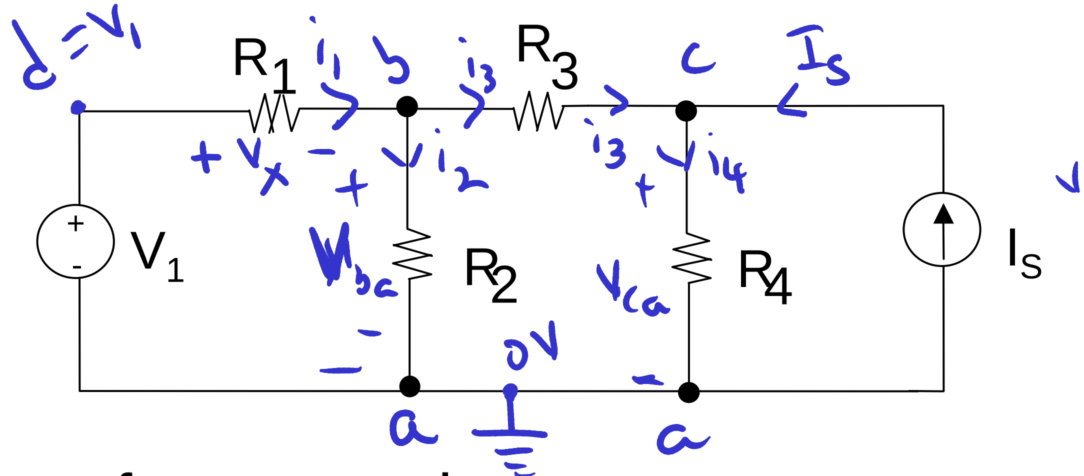
3. **Write KCL at each unknown node**, expressing current in terms of the node voltages (using the *I-V* relationships of branch elements)

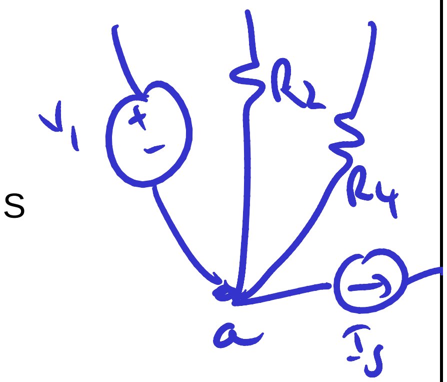
   Special cases: floating voltage sources

4. **Solve the set of independent equations**

   N equations for *N* unknown node voltages

Nodal Analysis: Example #1





1. Choose a reference node.

2. Define the node voltages (except reference node and the one set by the voltage source).

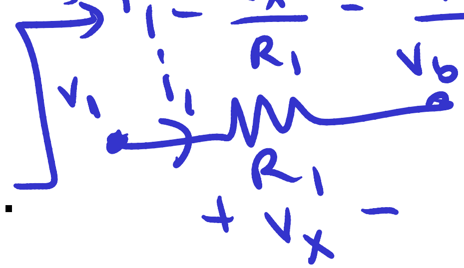
3. Apply KCL at the nodes with unknown voltage.

KCL @ node "b" : $i_1 = i_2 + i_3$

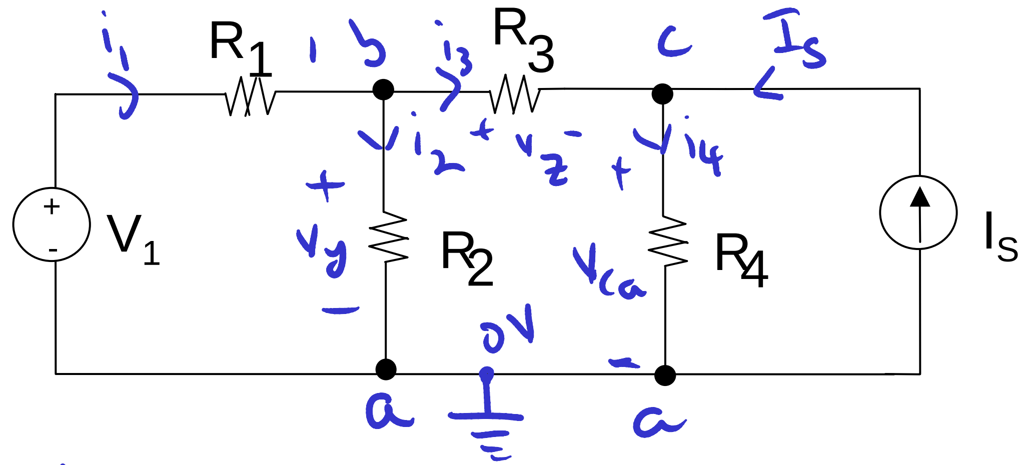
KCL @ node "c" : $i_3 + I_s = i_4$

4. Solve for unknown node voltages.

4(a) $i_1 = \frac{V_x}{R_1} = \frac{V_1 - V_b}{R_1}$



Nodal Analysis: Example #1



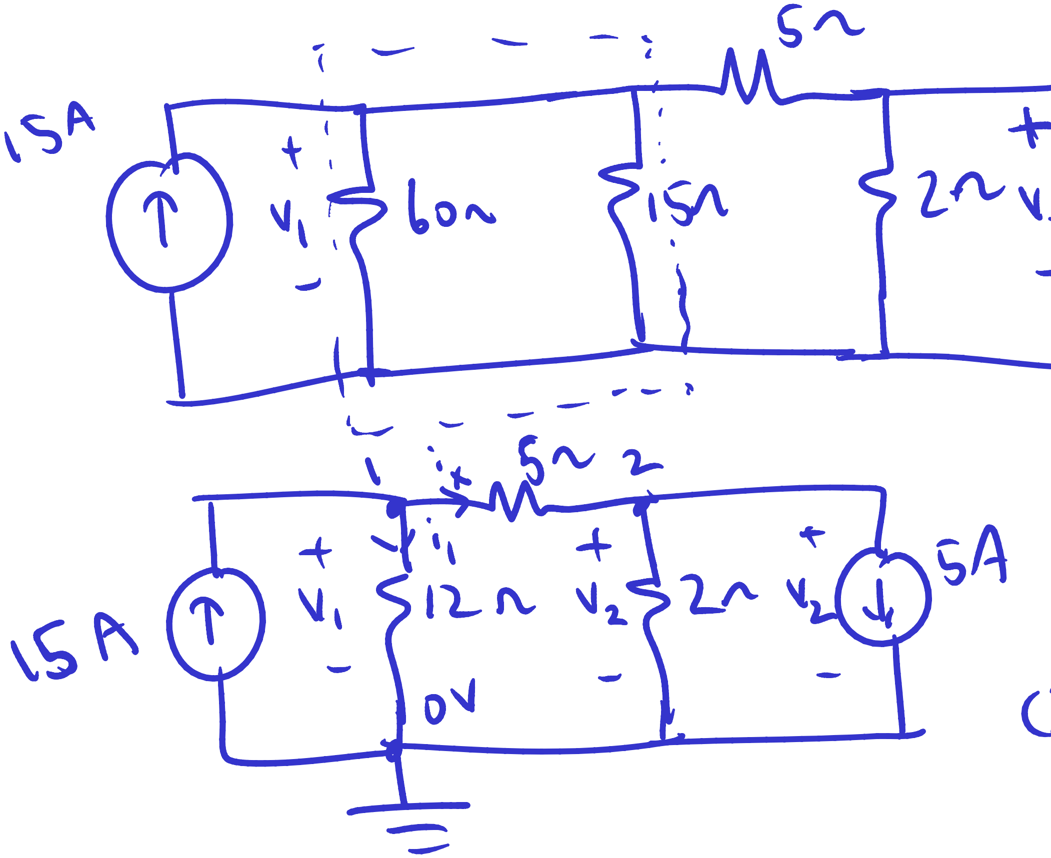
$$i_2 = \frac{V_y}{R_2} = \frac{V_b}{R_2}, \quad i_3 = \frac{V_z}{R_3} = \frac{V_b - V_c}{R_3}$$

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

Step (4) b: $i_1 = i_2 + i_3 \Rightarrow \frac{V_1 - V_b}{R_1} = \frac{V_b}{R_2} + \frac{V_b - V_c}{R_3}$

$$i_3 + I_s = i_4 \Rightarrow \frac{V_b - V_c}{R_3} + I_s = V_c / R_4$$

Node analysis example: DP4.1 on p. 99



(Q.) Use node-voltage method to find v_1 & v_2.

Nodal analysis:

(1) Assign ground

(2) Nodal analysis @ ①:

$$15 = \frac{V_1}{12} + \frac{V_1 - V_2}{5} \quad -①$$

Nodal analysis @ ②:

$$\frac{V_1 - V_2}{5} = \frac{V_2}{2} + 5 \quad -②$$

DP4.1 on p.99 (contd.)

(1) $\times 60 \Rightarrow 900 = 5v_1 + 12(v_1 - v_2)$

(2) $\times 10 \Rightarrow 2(v_1 - v_2) = 5v_2 + 50.$

$$\Rightarrow 900 = 17v_1 - 12v_2$$

$$50 = 2v_1 - 7v_2$$

solve $\Rightarrow$ $\boxed{v_1 = 60\,V, \quad v_2 = 10\,V}$

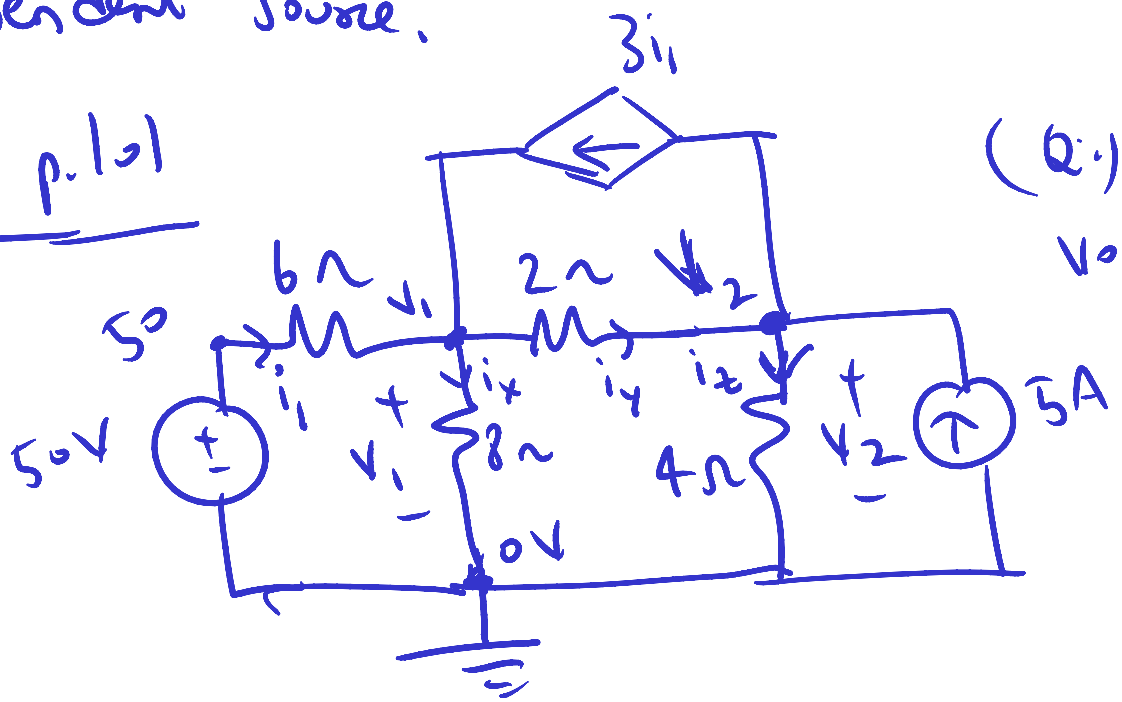
Check: $17 \cdot 60 - 12 \cdot 10 = 1020 - 120 = 900$ ✓

$2 \cdot 60 - 7 \cdot 10 = 120 - 70 = 50$ ✓

Section 4.3: Node-voltage method & Dependent sources

Nothing special, just need a "constraint equation" for the dependent source.

DP4.3 on p.161



(Q:) Use node voltage to find the power associated with each source.

constraint eqn.

Nodal analysis: @ v_1: $i_1 + 3i_1 = i_x + i_y$, $i_1 = \frac{50 - v_1}{6}$

$i_x = \frac{v_1}{8}$, $i_y = \frac{v_1 - v_2}{2}$, @ v_2: $i_y + 5 = i_z + 3i_1$, $i_z = v_2/4$