Exercise 1.1

(a) $i = \frac{dq}{dt} = 20\pi \cos(4\pi t)$ mA

$p = vi = 100\pi \cos^2(4\pi t)$ mW

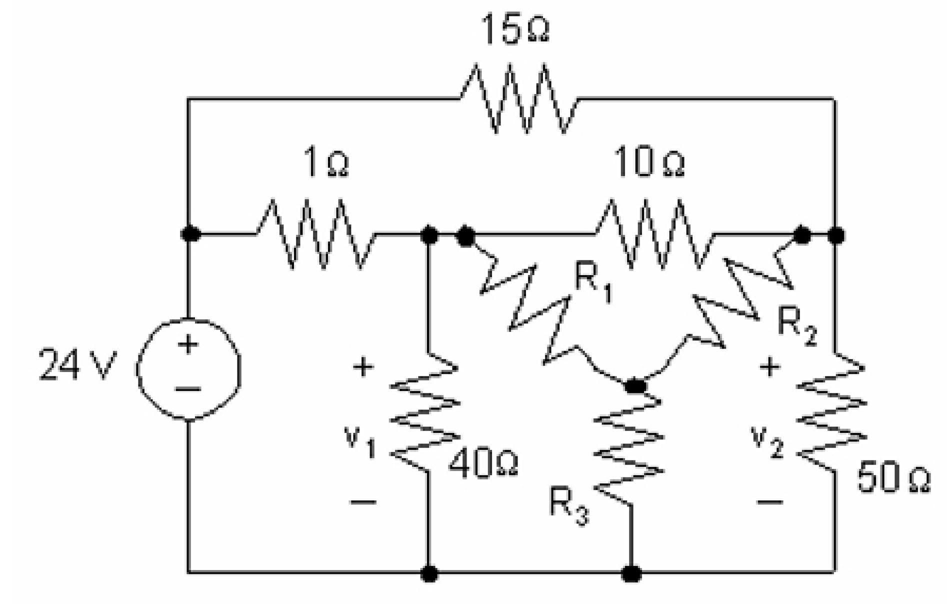
At $t = 0.3$ s, $p = 205.62$ mW

(b) $W = \int p\,dt = 100\pi \int_0^{0.6} \cos^2(4\pi t)\,dt = 97.92$ mJ

Exercise 1.2

Method 1

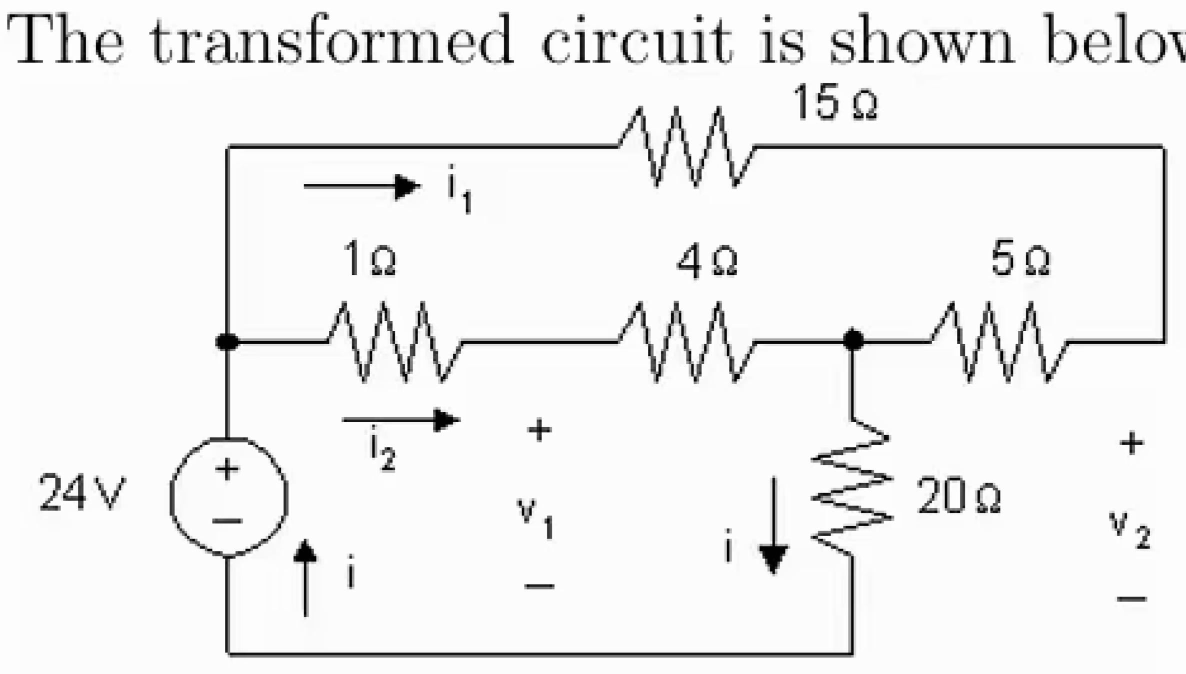
P 3.59 Begin by transforming the Δ-connected resistors ($10\,\Omega, 40\,\Omega, 50\,\Omega$) to Y-connected resistors. Both the Y-connected and Δ-connected resistors are shown below to assist in using Eqs. 3.44 – 3.46:



Now use Eqs. 3.44 – 3.46 to calculate the values of the Y-connected resistors:

$$R_1 = \frac{(40)(10)}{10+40+50} = 4\,\Omega; \quad R_2 = \frac{(10)(50)}{10+40+50} = 5\,\Omega; \quad R_3 = \frac{(40)(50)}{10+40+50} = 20\,\Omega$$

The transformed circuit is shown below:



The equivalent resistance seen by the 24 V source can be calculated by making series and parallel combinations of the resistors to the right of the 24 V source:

$$R_{eq} = (15+5)\|(1+4) + 20 = 20\|5 + 20 = 4 + 20 = 24\,\Omega$$

Therefore, the current i in the 24 V source is given by

$$i = \frac{24\text{ V}}{24\,\Omega} = 1\text{ A}$$

Use current division to calculate the currents i_1 and i_2. Note that the current i_1 flows in the branch containing the $15\,\Omega$ and $5\,\Omega$ series connected resistors, while the current i_2 flows in the parallel branch that contains the series connection of the $1\,\Omega$ and $4\,\Omega$ resistors:

$$i_1 = \frac{4}{15+5}(i) = \frac{4}{20}(1\text{ A}) = 0.2\text{ A}, \qquad \text{and} \qquad i_2 = 1\text{ A} - 0.2\text{ A} = 0.8\text{ A}$$

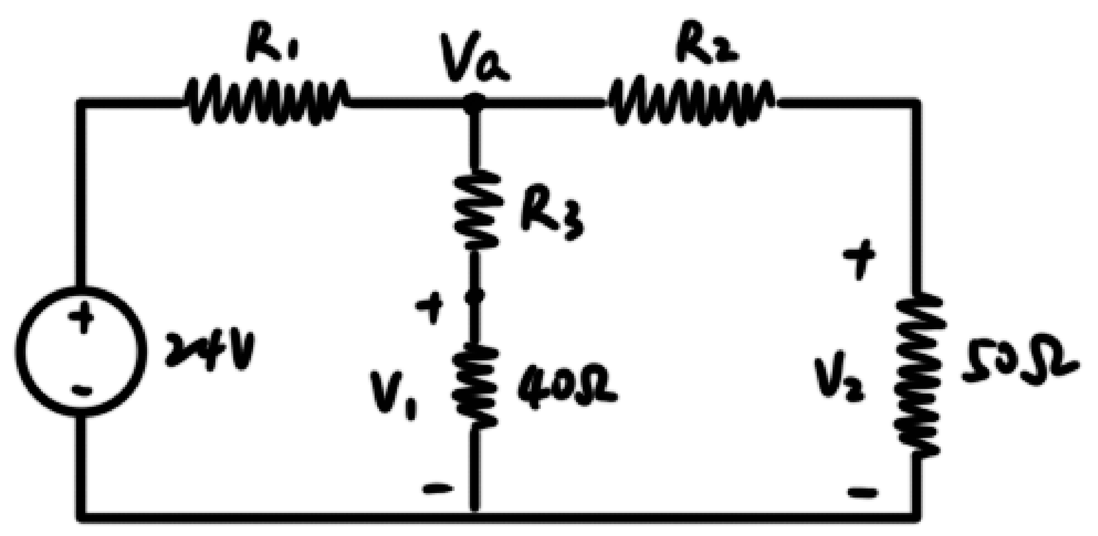
Now use KVL and Ohm's law to calculate v_1. Note that v_1 is the sum of the voltage drop across the $4\,\Omega$ resistor, $4i_2$, and the voltage drop across the $20\,\Omega$ resistor, $20i$:

$$v_1 = 4i_2 + 20i = 4(0.8\text{ A}) + 20(1\text{ A}) = 3.2 + 20 = 23.2\text{ V}$$

Finally, use KVL and Ohm's law to calculate v_2. Note that v_2 is the sum of the voltage drop across the $5\,\Omega$ resistor, $5i_1$, and the voltage drop across the $20\,\Omega$ resistor, $20i$:

$$v_2 = 5i_1 + 20i = 5(0.2\text{ A}) + 20(1\text{ A}) = 1 + 20 = 21\text{ V}$$

Method 2



$R_1 = \frac{15}{26}\,\Omega \quad R_2 = \frac{150}{26}\,\Omega \quad R_3 = \frac{10}{26}\,\Omega$

$R_{//} = \dfrac{1}{\frac{1}{R_2+50\Omega} + \frac{1}{R_3+40\Omega}} = \frac{609}{26}\,\Omega$

$Va = 24V \times \dfrac{R_{//}}{R_1 + R_{//}} = \frac{609}{26}\,V$

$V_1 = Va \times \dfrac{40\Omega}{R_3 + 40\Omega} = 23.2\,V$

$V_2 = Va \times \dfrac{50\Omega}{R_2 + 50\Omega} = 21\,V$

Exercise 1.3 (a) 9 branches. 5 nodes. 5 meshes

(b) $40i_2 + \dfrac{5}{40} + \dfrac{5}{10} = 0; \quad i_2 = -15.625 \text{ mA}$

$v_1 = 80i_2 = -1.25 \text{ V}$

$25i_1 + \dfrac{(-1.25)}{20} + (-0.015625) = 0; \quad i_1 = 3.125 \text{ mA}$

$v_g = 60i_1 + 260i_1 = 320i_1$

Therefore, $v_g = 1$ V.

Exercise 1.4 (a)

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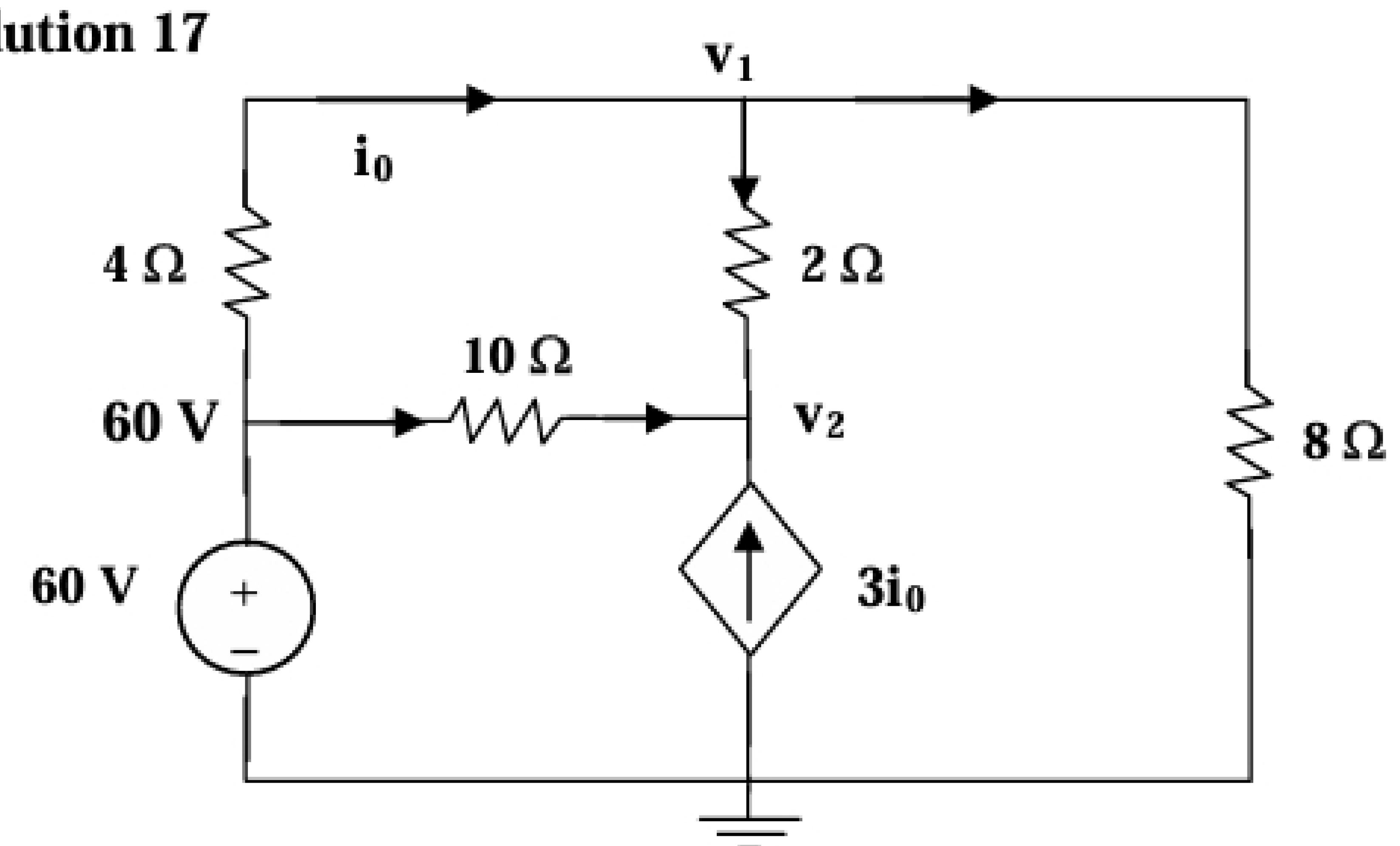


At node 1, $\dfrac{60 - v_1}{4} = \dfrac{v_1}{8} + \dfrac{v_1 - v_2}{2}$ $\qquad 120 = 7v_1 - 4v_2 \qquad (1)$

At node 2, $3i_0 + \dfrac{60 - v_2}{10} + \dfrac{v_1 - v_2}{2} = 0$

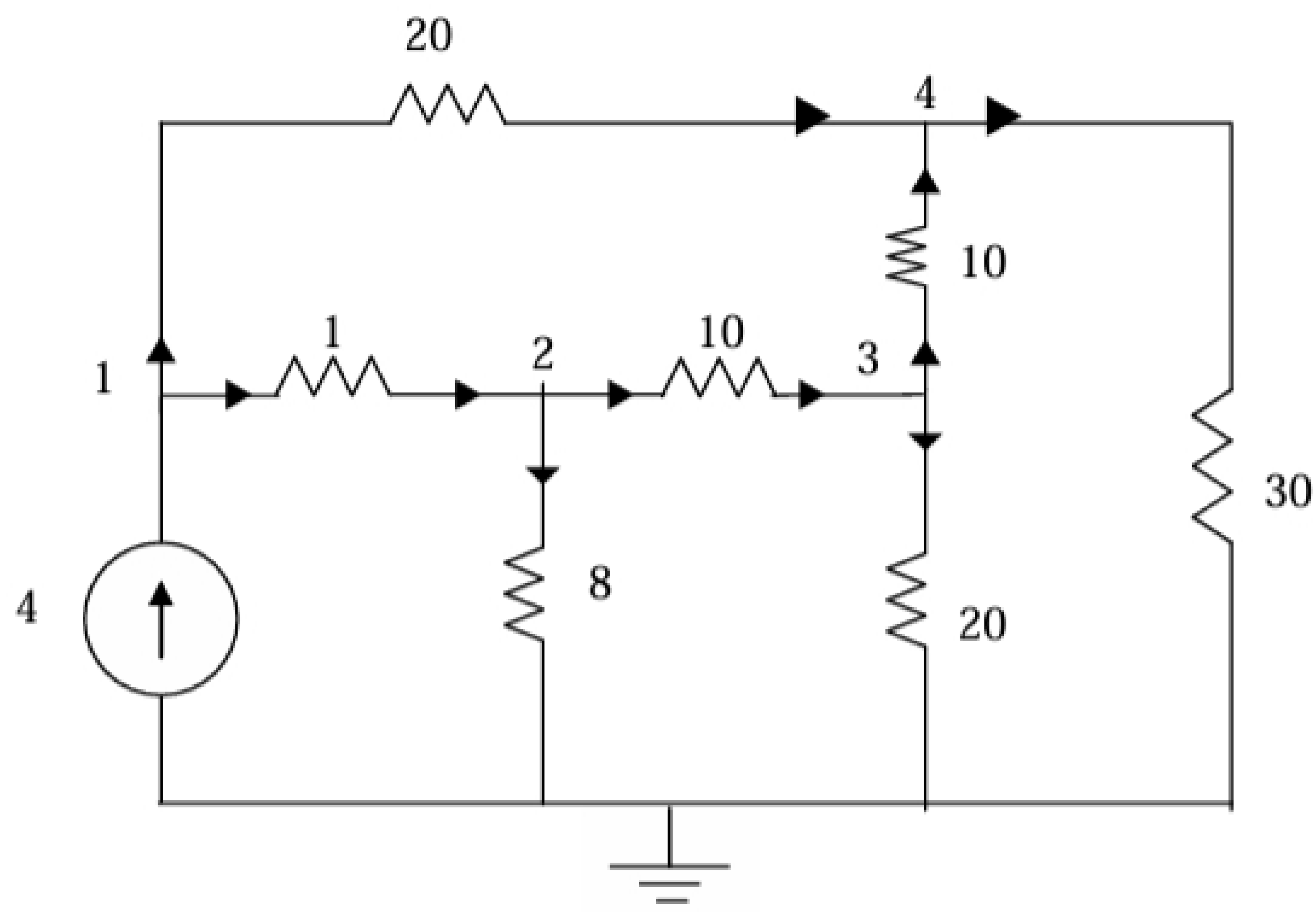
But $i_0 = \dfrac{60 - v_1}{4}$.

Hence

$$\frac{3(60 - v_1)}{4} + \frac{60 - v_2}{10} + \frac{v_1 - v_2}{2} = 0 \longrightarrow 1020 = 5v_1 + 12v_2 \qquad (2)$$

Solving (1) and (2) gives $v_1 = 53.08$ V. Hence $i_0 = \dfrac{60 - v_1}{4} = \mathbf{1.73\ A}$

(b) Consider the circuit shown below.



At node 1.

$$4 = \frac{V_1 - V_2}{1} + \frac{V_1 - V_4}{20} \longrightarrow 80 = 21V_1 - 20V_2 - V_4 \quad (1)$$

At node 2,

$$\frac{V_1 - V_2}{1} = \frac{V_2}{8} + \frac{V_2 - V_3}{10} \longrightarrow 0 = -80V_1 + 98V_2 - 8V_3 \quad (2)$$

At node 3,

$$\frac{V_2 - V_3}{10} = \frac{V_3}{20} + \frac{V_3 - V_4}{10} \longrightarrow 0 = -2V_2 + 5V_3 - 2V_4 \quad (3)$$

At node 4,

$$\frac{V_1 - V_4}{20} + \frac{V_3 - V_4}{10} = \frac{V_4}{30} \longrightarrow 0 = 3V_1 + 6V_3 - 11V_4 \quad (4)$$

Putting (1) to (4) in matrix form gives:

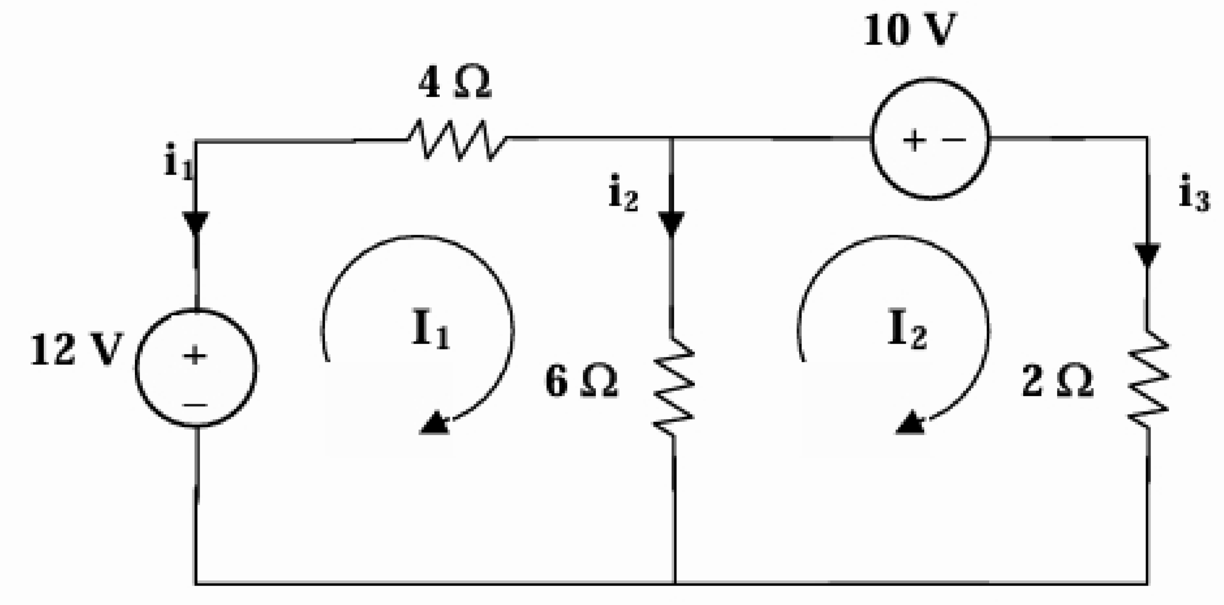
$$\begin{bmatrix} 80 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 21 & -20 & 0 & -1 \\ -80 & 98 & -8 & 0 \\ 0 & -2 & 5 & -2 \\ 3 & 0 & 6 & -11 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix}$$

$$B = A\ V \longrightarrow V = A^{-1} B$$

Using MATLAB leads to

$V_1 = \mathbf{25.52\ V}$, $V_2 = \mathbf{22.05\ V}$, $V_3 = \mathbf{14.842\ V}$, $V_4 = \mathbf{15.055\ V}$

Exercise 1.5 (a)



Applying mesh analysis gives,

$$10I_1 - 6I_2 = 12 \text{ and } -6I_1 + 8I_2 = -10$$

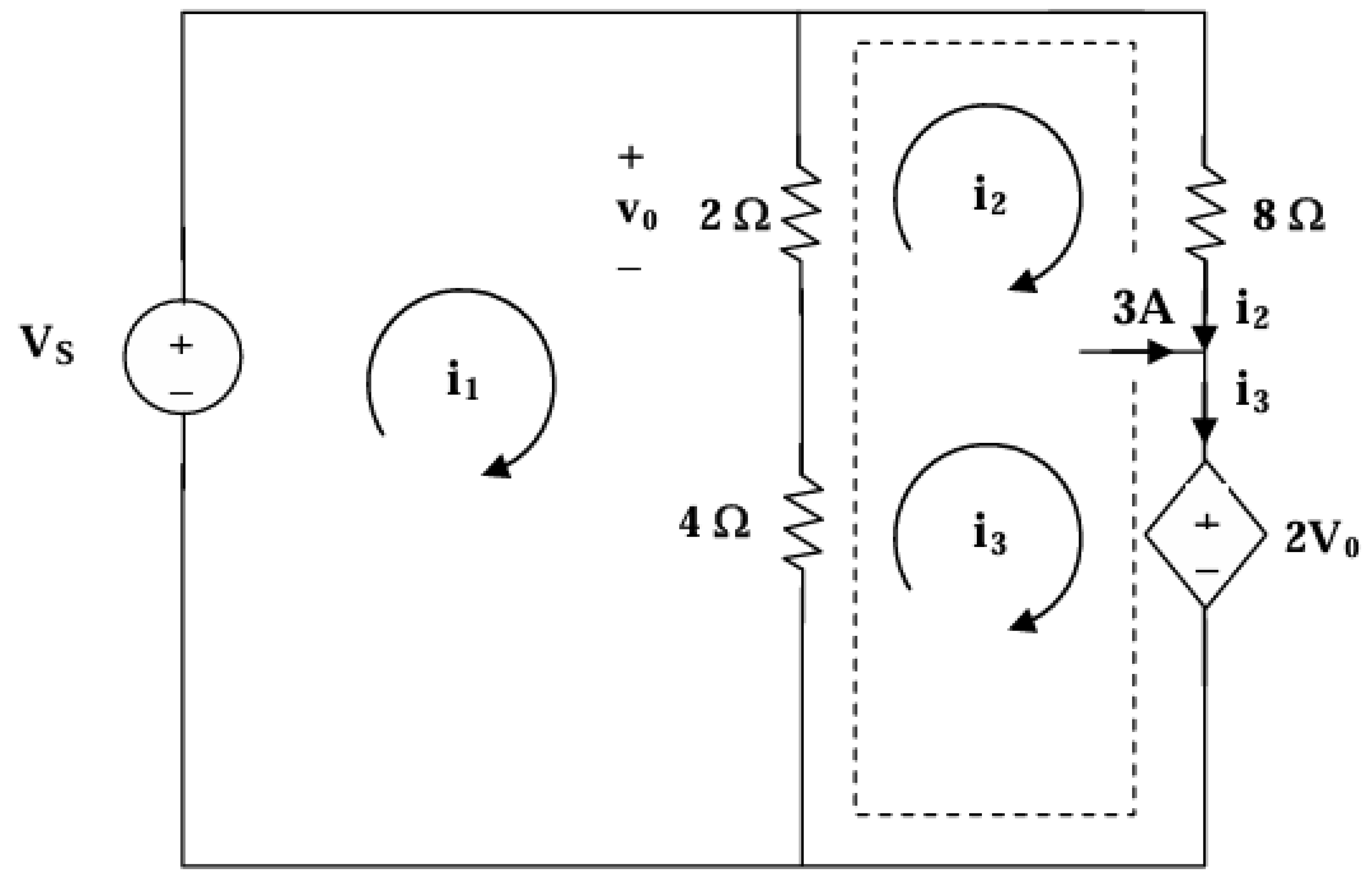
or

$$\begin{bmatrix} 6 \\ -5 \end{bmatrix} = \begin{bmatrix} 5 & -3 \\ -3 & 4 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 6 \\ -5 \end{bmatrix} \text{ or } \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \frac{\begin{bmatrix} 4 & 3 \\ 3 & 5 \end{bmatrix}}{11} \begin{bmatrix} 6 \\ -5 \end{bmatrix}$$

$I_1 = (24-15)/11 = 0.8182$ and $I_2 = (18-25)/11 = -0.6364$

$i_1 = -I_1 = \mathbf{-818.2\ mA}$; $i_2 = I_1 - I_2 = 0.8182+0.6364 = \mathbf{1.4546\ A}$; and $i_3 = I_2 = \mathbf{-636.4\ mA}$.

(b)



For mesh 1,

$$2(i_1 - i_2) + 4(i_1 - i_3) - 12 = 0 \text{ which leads to } 3i_1 - i_2 - 2i_3 = 6 \qquad (1)$$

For the supermesh, $2(i_2 - i_1) + 8i_2 + 2v_0 + 4(i_3 - i_1) = 0$

But $v_0 = 2(i_1 - i_2)$ which leads to $-i_1 + 3i_2 + 2i_3 = 0$
(2)

For the independent current source, $i_3 = 3 + i_2$ (3)

Solving (1), (2), and (3), we obtain,

i_1 = **3.5 A**, i_2 = **-0.5 A**, i_3 = **2.5 A**.