Chapter Three:

Nodal and Loop Analysis Techniques

3.1 Find I_o in the circuit in Fig. P3.1 using nodal analysis. **CS**

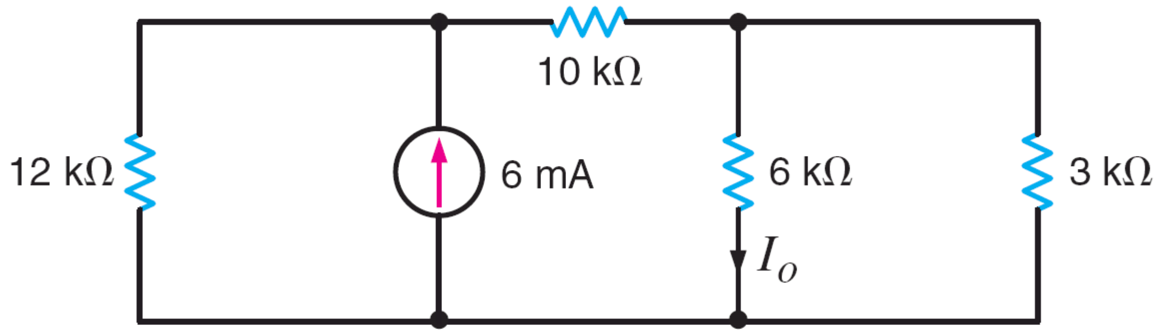
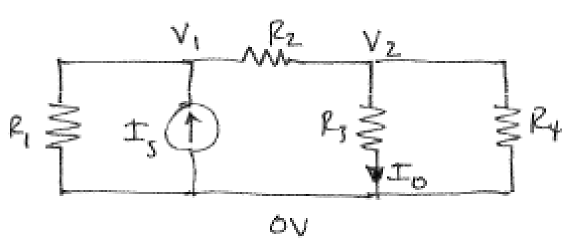


Figure P3.1

SOLUTION:

3.1 I_o via nodal.



$R_1 = 12\,k\Omega$ $R_2 = 10\,k\Omega$ $R_3 = 6\,k\Omega$

$R_4 = 3\,k\Omega$ $I_S = 6\,mA$

@ V_1: $$\frac{V_1}{R_1} - I_S + \frac{V_1 - V_2}{R_2} = 0$$

@ V_2: $$\frac{V_2 - V_1}{R_2} + \frac{V_2}{R_3} + \frac{V_2}{R_4} = 0$$

$: $I_o = V_2 / R_3$

$$\boxed{I_o = 1\,mA}$$

3.2 Use nodal analysis to find V_1 in the circuit in Fig. P3.2.

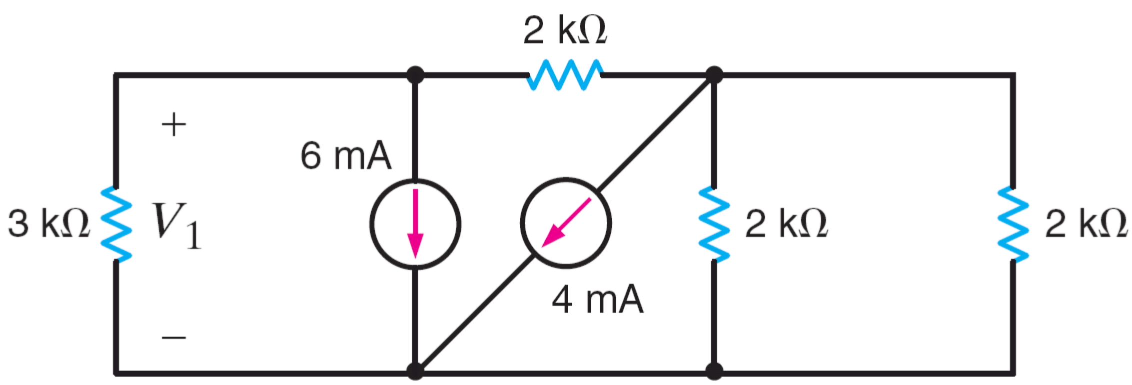
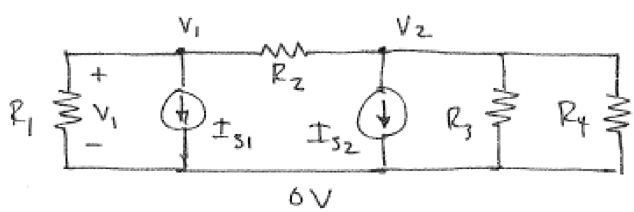


Figure P3.2

SOLUTION:

3.2 Find V_1 via nodal.



$R_1 = 3k\Omega \quad R_2 = R_3 = R_4 = 2k\Omega$

$I_{S1} = 6mA \quad I_{S2} = 4mA$

@ V_1: $\frac{V_1}{R_1} + I_{S1} + \frac{V_1 - V_2}{R_2} = 0$

@ V_2: $\frac{V_2 - V_1}{R_2} + \frac{V_2}{R_3} + \frac{V_2}{R_4} + I_{S2} = 0$

$\boxed{V_1 = -11V}$

3.3 Use nodal analysis to find both V_1 and V_o in the circuit in Fig. P3.3. **PSV**

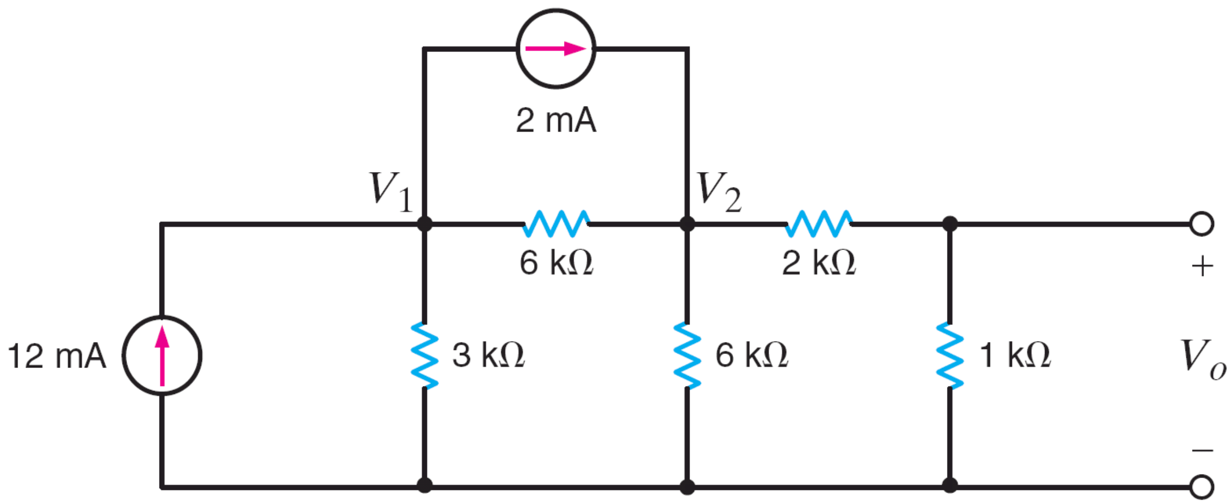
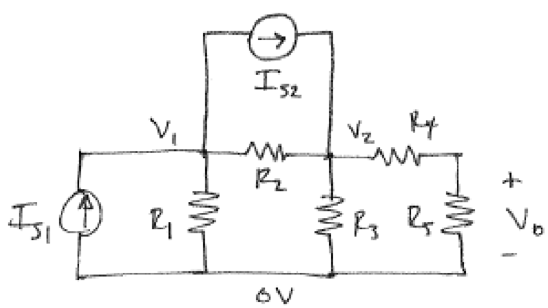


Figure P3.3

SOLUTION:

3.3 Find V_o & V_1 by nodal.



$R_1 = 3k\Omega \quad R_2 = R_3 = 6k\Omega \quad R_4 = 2k\Omega$

$R_5 = 1k\Omega \quad I_{S1} = 12mA \quad I_{S2} = 2mA$

@ V_1: $I_{S2} - I_{S1} + \frac{V_1}{R_1} + \frac{V_1 - V_2}{R_2} = 0$

@ V_2: $-I_{S2} + \frac{V_2 - V_1}{R_2} + \frac{V_2}{R_3} + \frac{V_2 - V_o}{R_4} = 0$

@ V_o: $\frac{V_2 - V_o}{R_4} = \frac{V_o}{R_5}$

$V_o = 2.91V \qquad V_1 = 22.9V$

3.4 Find V_1 and V_2 in the circuit in Fig. P3.4 using nodal analysis. Then solve the problem using MATLAB and compare your answers.

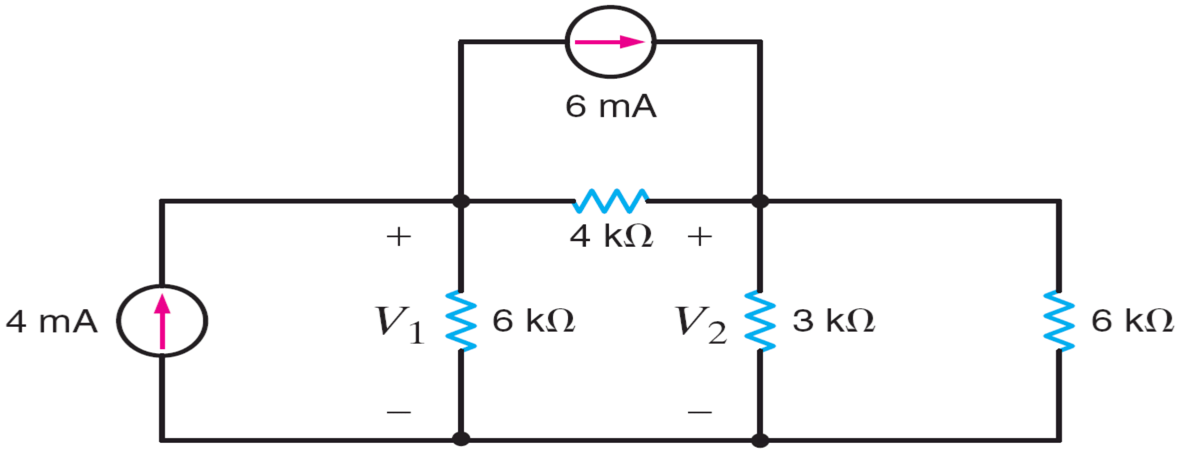
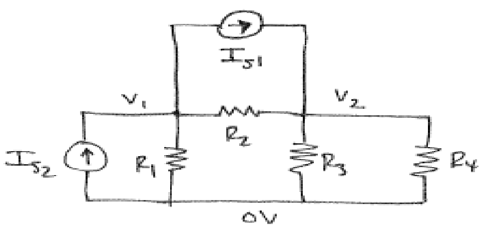


Figure P3.4

SOLUTION:

3.4 Find V_1 & V_2 by nodal



@ V_1: $I_{S1} - I_{S2} + \frac{V_1}{R_1} + \frac{V_1 - V_2}{R_2} = 0$

@ V_2: $-I_{S1} + \frac{V_2 - V_1}{R_2} + \frac{V_2}{R_3} + \frac{V_2}{R_4} = 0$

$R_1 = R_4 = 6k\Omega \quad R_2 = 4k\Omega \quad R_3 = 3k\Omega$

$I_{S1} = 6mA \quad I_{S2} = 4mA$

$\boxed{V_1 = 0V \qquad V_2 = 8V}$

Matrix Format

$$\begin{bmatrix} \frac{1}{R_1} + \frac{1}{R_2} & -\frac{1}{R_2} \\ -\frac{1}{R_2} & \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} I_{S2} - I_{S1} \\ I_{S1} \end{bmatrix}$$

Continued on the next page.

3_4.txt

MATLAB WORK

Factor 1/24000 out of conductance matrix.

```
EDU» g=[12,-6;-6,18]

g =

    12    -6
    -6    18

EDU» i=[-0.002;0.006]

i =

   -0.0020
    0.0060

EDU» 24000*inv(g)*i

ans =

     0
     8
```

3.5 Find I_o in the circuit in Fig. P3.5 using nodal analysis. CS

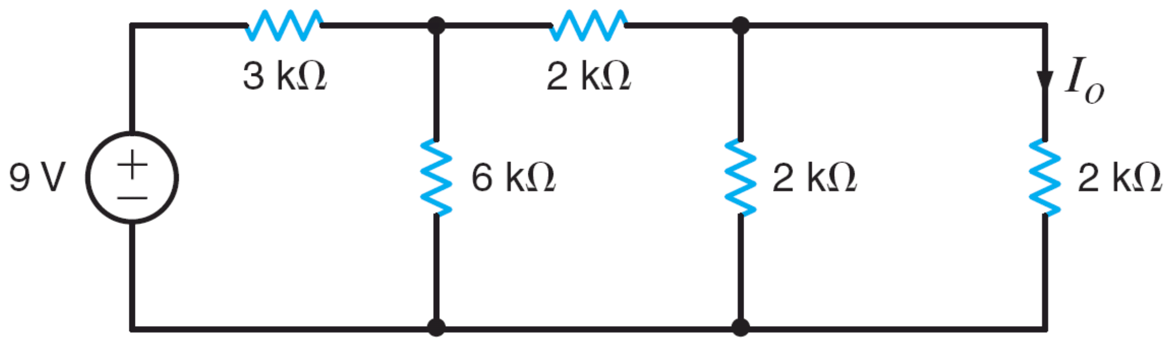
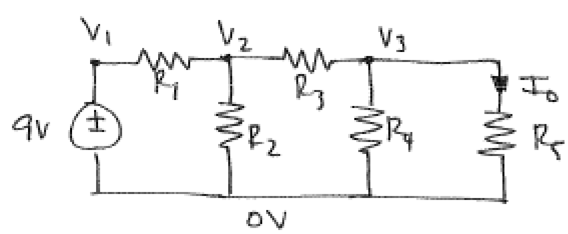


Figure P3.5

SOLUTION:

3.5 Find I_o by nodal.



$R_1 = 3k\Omega \quad R_2 = 6k\Omega \quad R_3 = R_4 = R_5 = 2k\Omega$

@ V_1: $V_1 = 9V$

@ V_2: $\frac{V_2 - V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - V_3}{R_3} = 0$

@ V_3: $\frac{V_3 - V_2}{R_3} + \frac{V_3}{R_4} + \frac{V_3}{R_5} = 0$

and $I_o = V_3 / R_5$

$\boxed{I_o = 0.6 mA}$

3.6 Find I_o in the network in Fig. P3.6 using nodal analysis.

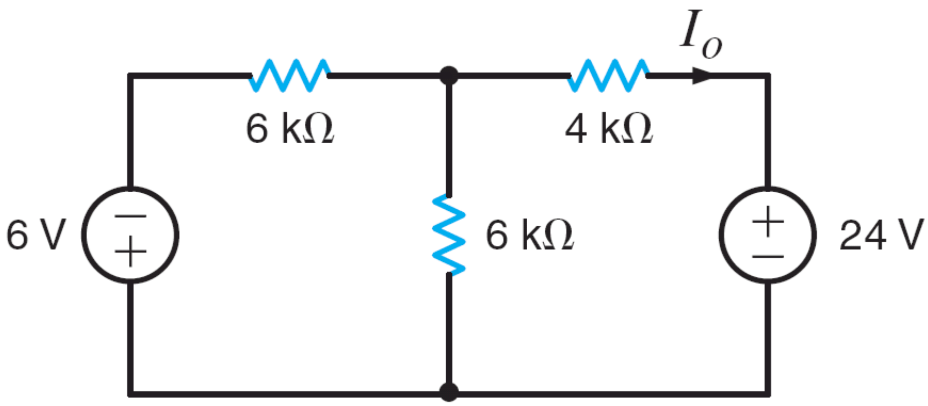
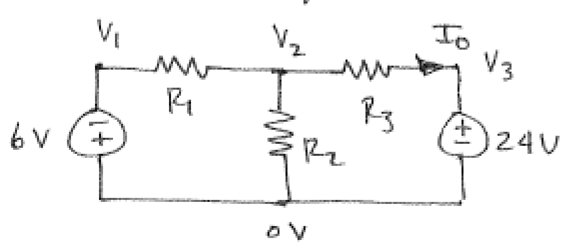


Figure P3.6

SOLUTION:

3.6 Find I_o by nodal.



$R_1 = R_2 = 6\,k\Omega \quad R_3 = 4\,k\Omega$

@ V_1: $V_1 = -6V$

@ V_2: $\frac{V_2 - V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - V_3}{R_3} = 0$

@ V_3: $V_3 = 24V$

and $I_o = (V_2 - V_3)/R_3$

$V_2 = 8.57\ V$

$$\boxed{I_o = -3.86\,mA}$$

3.7 Find V_o in the network in Fig. P3.7 using nodal analysis.
CS

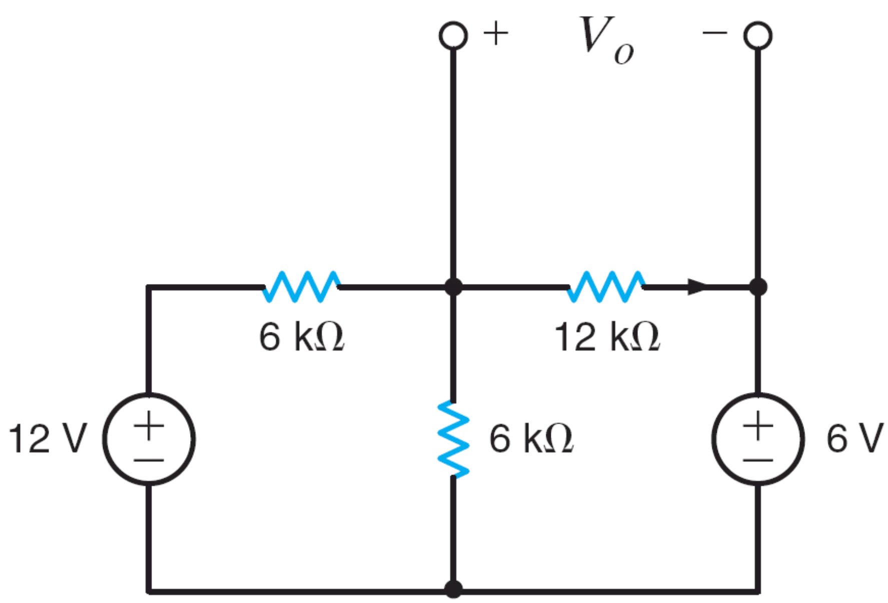
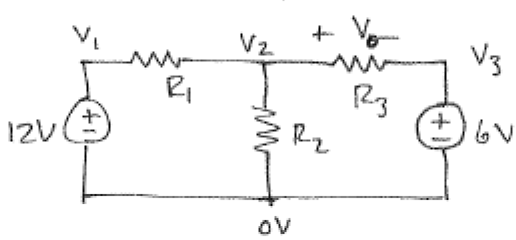


Figure P3.7

SOLUTION:

3.7 Find V_o by nodal.



$R_1 = R_2 = 6k\Omega$

$R_3 = 12k\Omega$

@ V_1: $V_1 = 12V$

@ V_2: $\frac{V_2 - V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - V_3}{R_3} = 0$

@ V_3: $V_3 = 6V$

and $V_o = V_2 - V_3$

$V_2 = 6V$

$\boxed{V_o = 0V}$

3.8 Find V_o in the circuit in Fig. P3.8 using nodal analysis.
PSV

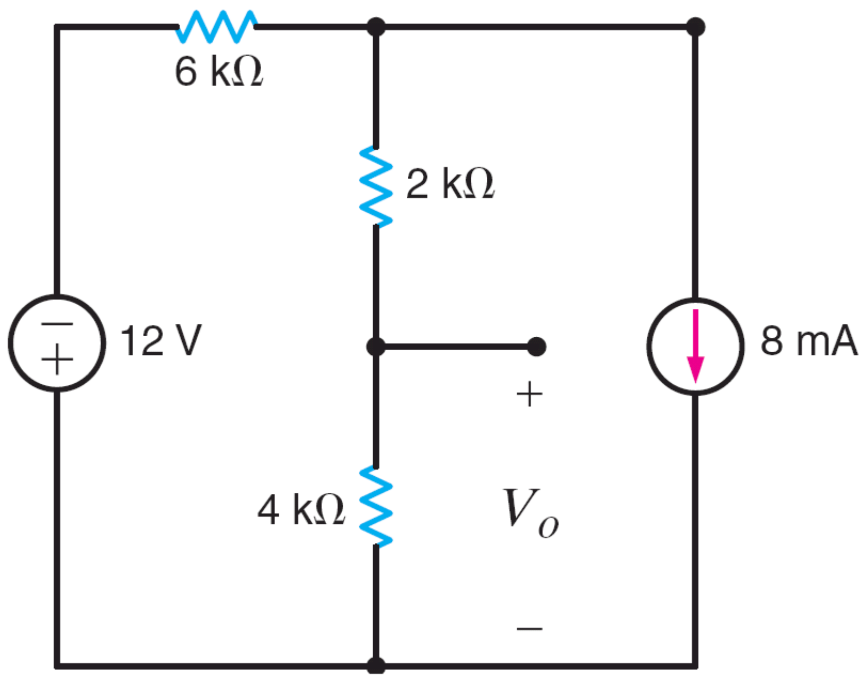
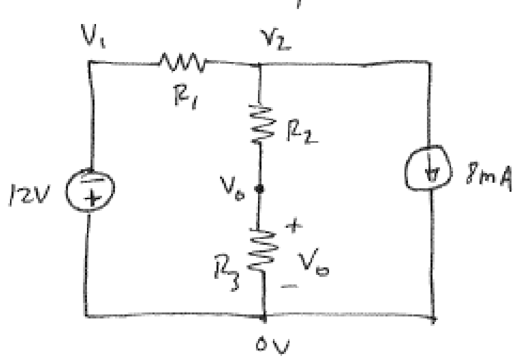


Figure P3.8

SOLUTION:

3.8 Find V_o by nodal.



$R_1 = 6k\Omega \quad R_2 = 2k\Omega \quad R_3 = 4k\Omega$

$V_1 = -12V$

@ V_2: $\frac{V_2 - V_1}{R_1} + \frac{V_2 - V_o}{R_2} + 8\times 10^{-3} = 0$

@ V_o: $\frac{V_2 - V_o}{R_2} = \frac{V_o}{R_3}$

$\boxed{V_o = -20V}$

3.9 Use nodal analysis to find V_o in the circuit in Fig. P3.9.

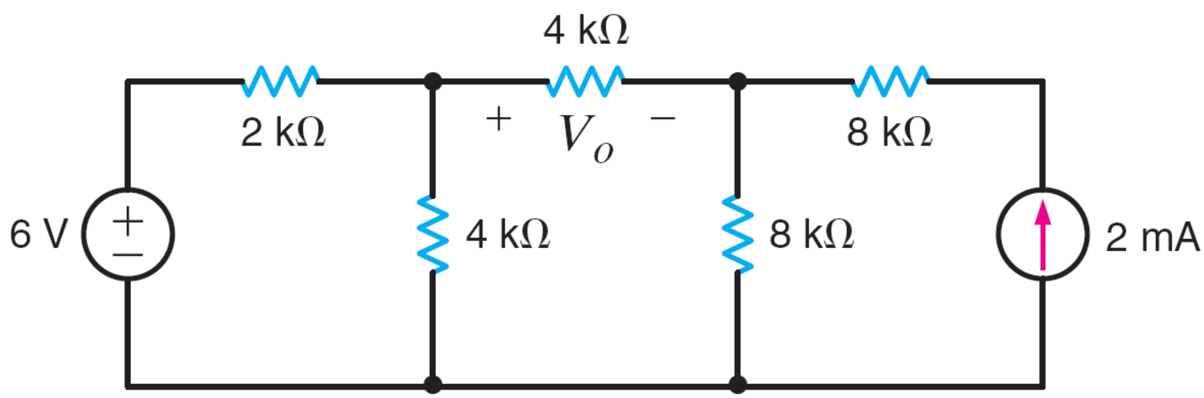
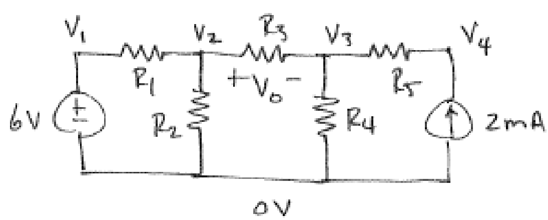


Figure P3.9

SOLUTION:

3.9 Find V_o by nodal.



$R_1 = 2k\Omega \quad R_2 = R_3 = 4k\Omega$

$R_4 = R_5 = 8k\Omega$

$V_1 = 6V$

@ V_2: $\frac{V_2 - V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - V_3}{R_3} = 0$

@ V_3: $\frac{V_3 - V_2}{R_3} + \frac{V_3}{R_4} + \frac{V_3 - V_4}{R_5} = 0$

@ V_4: $\frac{V_4 - V_3}{R_5} = 2\times10^{-3}$

and $V_o = V_2 - V_3$

$V_2 = 5.2V, \quad V_3 = 8.8V$ $\boxed{V_o = -3.6V}$

3.10 Find I_o in the circuit in Fig. P3.10 using nodal analysis.

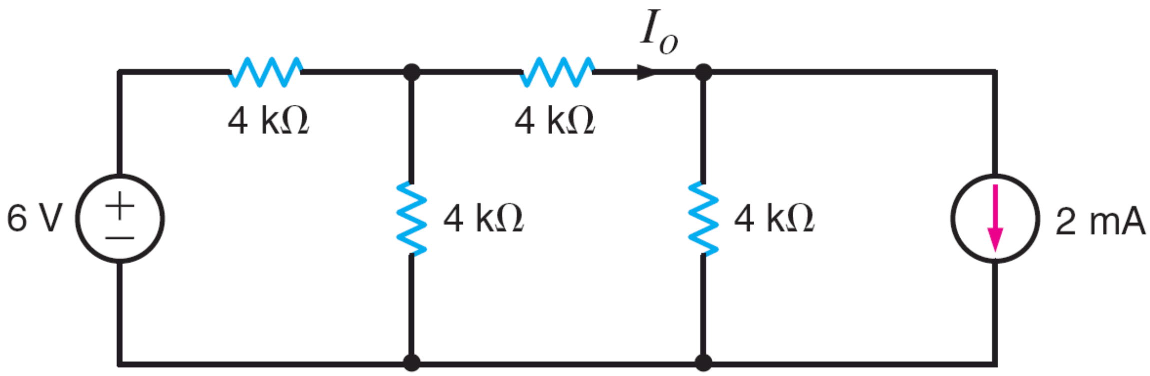
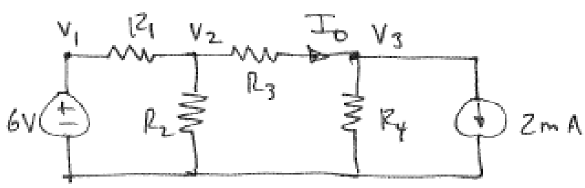


Figure P3.10

SOLUTION:

3.10 Find I_o by nodal.



all $R = 4\,k\Omega$

$V_1 = 6V$

@ V_2: $$\frac{V_2 - V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - V_3}{R_3} = 0$$

@ V_3: $$\frac{V_3 - V_2}{R_3} + \frac{V_3}{R_4} + 2\times10^{-3} = 0$$

and $$I_o = \frac{V_2 - V_3}{R_3}$$

$V_2 = 0.8V$ $V_3 = -3.6V$ $\boxed{I_o = 1.1\,mA}$

3.11 Use nodal analysis to find V_o in the network in Fig. P3.11. Then solve the problem using MATLAB and compare your answers.

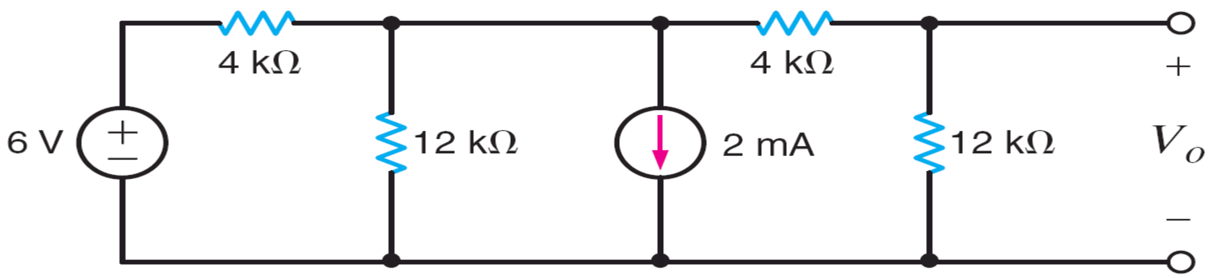
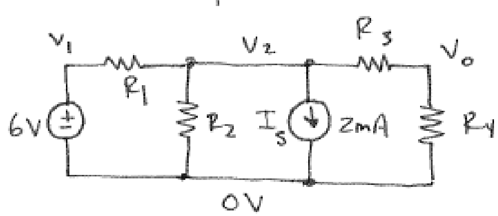


Figure P3.11

SOLUTION:

3.11 Find V_o by nodal & MATLAB



$V_1 = 6V$

@ V_2: $\frac{V_2 - V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - V_o}{R_3} + I_S = 0$

@ V_o: $\frac{V_o - V_2}{R_3} + \frac{V_o}{R_4} = 0$

$R_1 = 4k\Omega \quad R_2 = 12k\Omega \quad R_3 = 4k\Omega$

$R_4 = 12k\Omega$

$\boxed{V_o = -0.95V}$

In matrix form:

$$\begin{bmatrix} 1 & 0 & 0 \\ -\frac{1}{R_1} & \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} & -\frac{1}{R_3} \\ 0 & -1/R_3 & \frac{1}{R_3} + \frac{1}{R_4} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_o \end{bmatrix} = \begin{bmatrix} 6 \\ -2\times10^{-3} \\ 0 \end{bmatrix}$$

Continued on the next page.

3_11.txt

```
MATLAB WORK

Factor out 1/12000 from the conductance matrix


EDU» g=[12000,0,0;-3,7,-3;0,-3,4]

g =

       12000           0           0
          -3           7          -3
           0          -3           4

EDU» i=[6;-0.002;0]

i =

    6.0000
   -0.0020
         0


EDU» v=12000*inv(g)*i

v =

    6.0000
   -1.2632
   -0.9474
```

3.12 Use nodal analysis to find V_o in the circuit in Fig. P3.12.

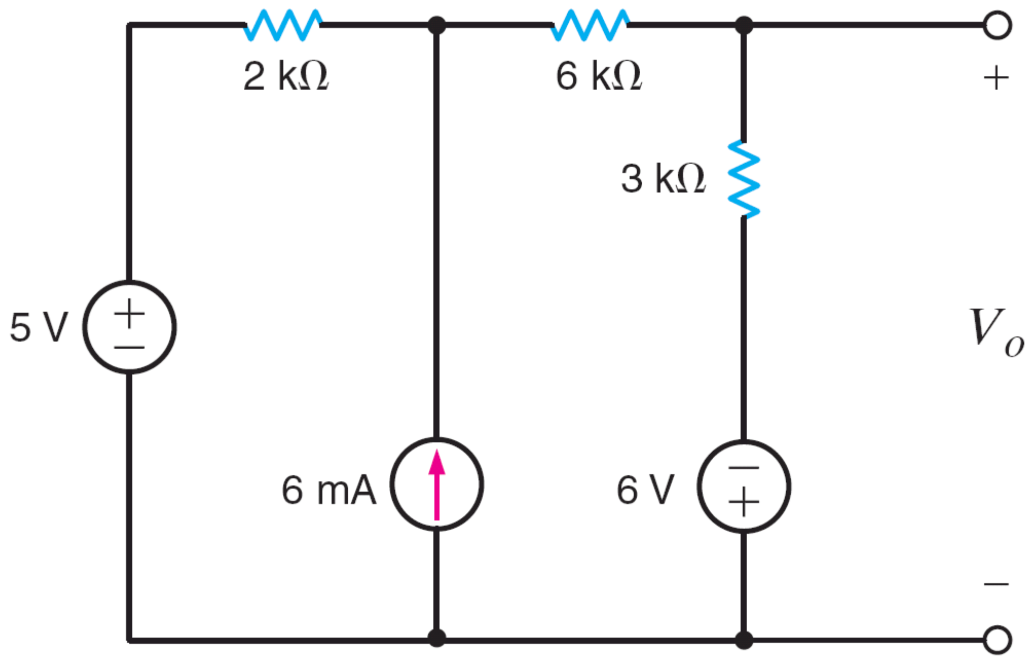
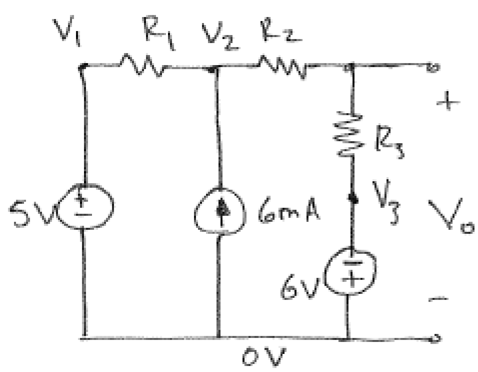


Figure P3.12

SOLUTION:

3.12 V_o by nodal.



$R_1 = 2k\Omega$ $R_2 = 6k\Omega$ $R_3 = 3k\Omega$

$V_1 = 5V$ & $V_3 = -6V$

@ V_2: $\dfrac{V_2 - V_1}{R_1} + \dfrac{V_2 - V_o}{R_2} - 6\times10^{-3} = 0$

@ V_o: $\dfrac{V_o - V_2}{R_2} + \dfrac{V_o - V_3}{R_3} = 0$

$\boxed{V_o = 0.27\ V}$

3.13 Use nodal analysis to find V_o in the circuit in Fig. P3.13.

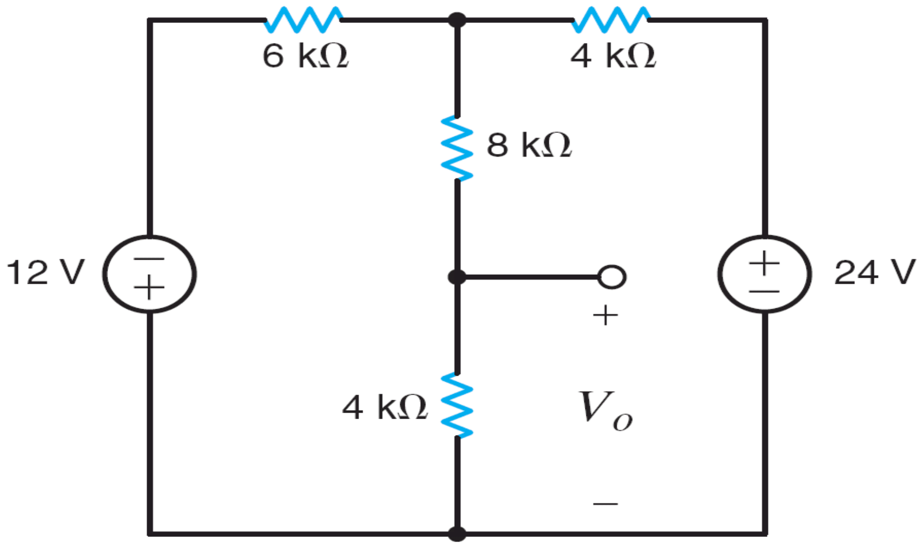
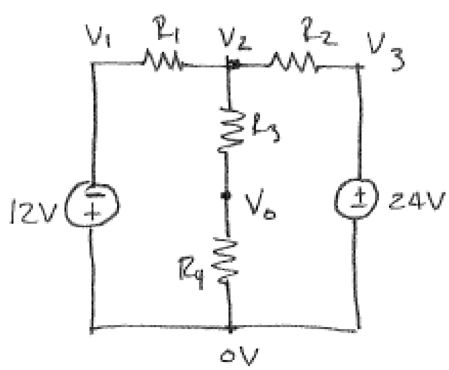


Figure P3.13

SOLUTION:

3.13 Find V_o by nodal.



$R_1 = 6k\Omega \quad R_2 = R_4 = 4\,k\Omega$

$R_3 = 8\,k\Omega$

$V_1 = -12V \qquad V_3 = 24V$

@ V_2: $\frac{V_2 - V_1}{R_1} + \frac{V_2 - V_3}{R_2} + \frac{V_2 - V_o}{R_3} = 0$

@ V_o: $\frac{V_o - V_2}{R_3} + \frac{V_o}{R_4} = 0$

$V_o = 2.67V$

3.14 Find I_o in the network in Fig. P3.14. CS

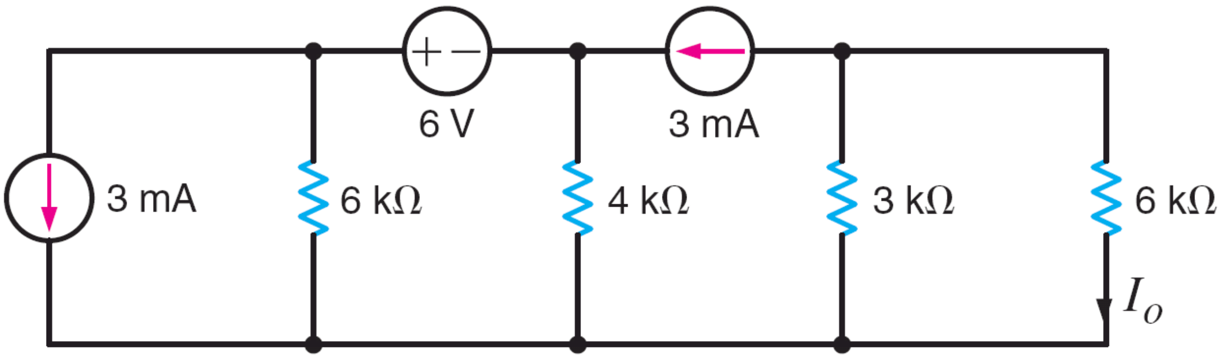
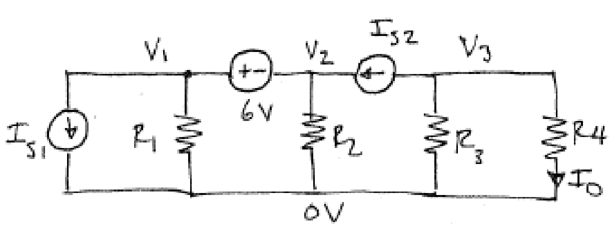


Figure P3.14

SOLUTION:

3.14 Find I_o.



$R_1 = R_4 = 6k\Omega$ $R_2 = 4k\Omega$ $R_3 = 3k\Omega$

$I_{s1} = 3mA$ $I_{s2} = 3mA$

$V_1 - V_2 = 6V$

@ V_3: $I_{s2} + \frac{V_3}{R_3} + \frac{V_3}{R_4} = 0$

@ ref: $I_{s1} + \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \frac{V_3}{R_4} = 0$

also, $I_o = V_3 / R_4$

$$\boxed{I_o = -1mA}$$

3.15 Find I_1 in the network in Fig. P3.15. **CS**

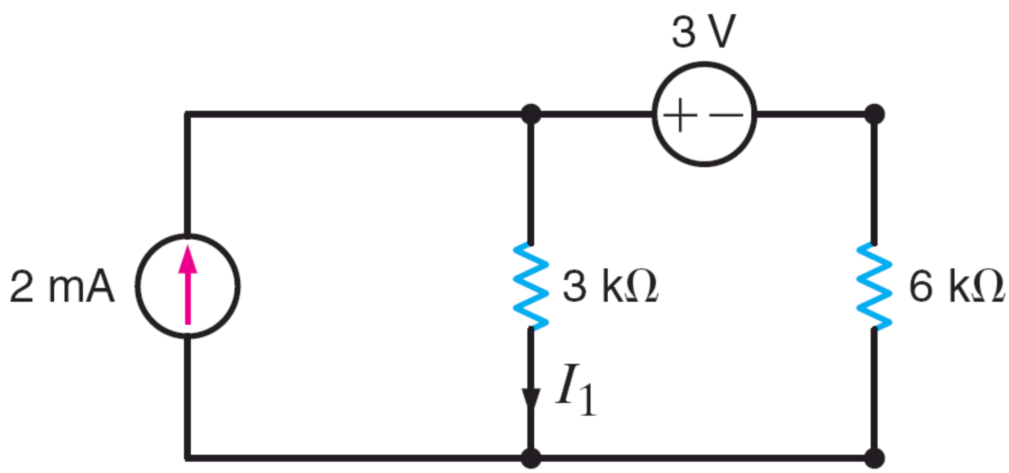
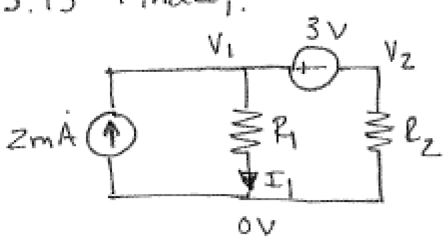


Figure P3.15

SOLUTION:

3.15 Find I_1.



$R_1 = 3k\Omega$ $R_2 = 6k\Omega$

$V_1 - V_2 = 3V$

@ ref: $\frac{V_1}{R_1} + \frac{V_2}{R_2} - 2\times10^{-3} = 0$

and, $I_1 = V_1/R_1$

$\boxed{I_1 = 1.67 \text{ mA}}$

3.16 Find I_o in the network in Fig. P3.16.

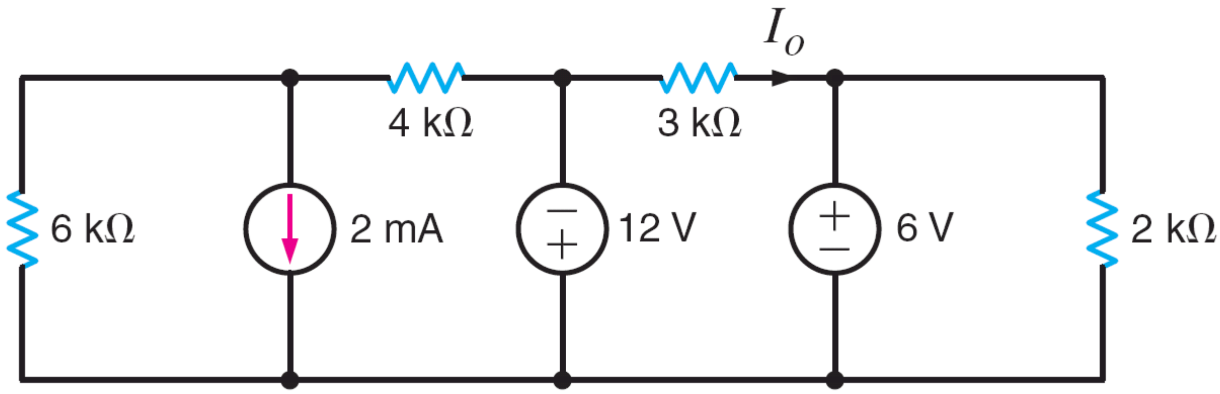
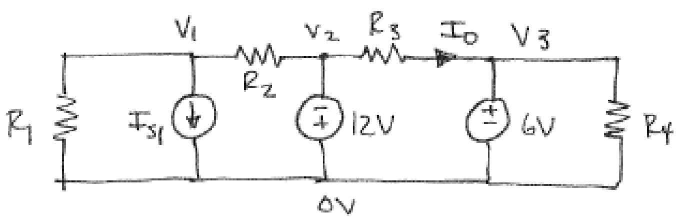


Figure P3.16

SOLUTION:

3.16 Find I_o.



$R_1 = 6k\Omega \quad R_2 = 4k\Omega \quad R_3 = 3k\Omega \quad R_4 = 2k\Omega$

$I_{s1} = 2mA$

$V_2 = -12V \quad V_3 = 6V$

@ V_1: $\frac{V_1}{R_1} + \frac{V_1 - V_2}{R_2} + I_{s1} = 0$

and $I_o = \frac{V_2 - V_3}{R_3}$

$\boxed{I_o = -6mA}$

3.17 Use nodal analysis to find V_x and V_y in the circuit in Fig. P3.17.

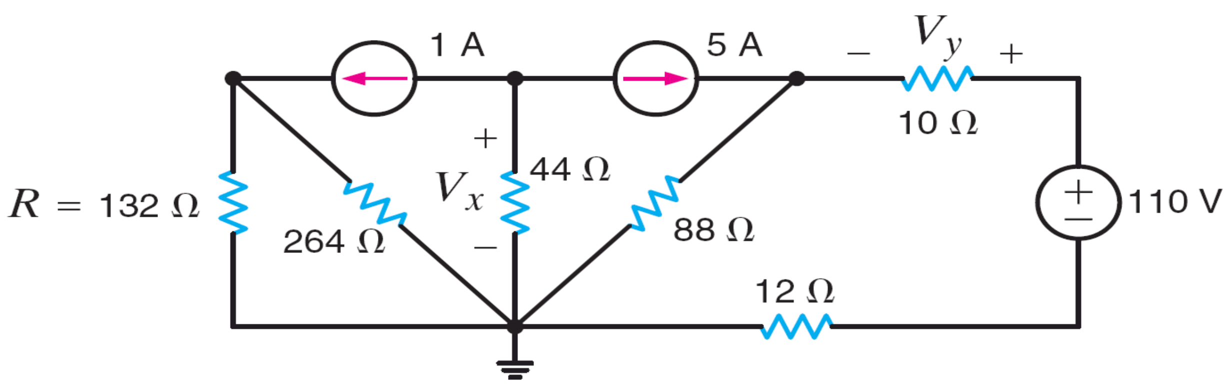
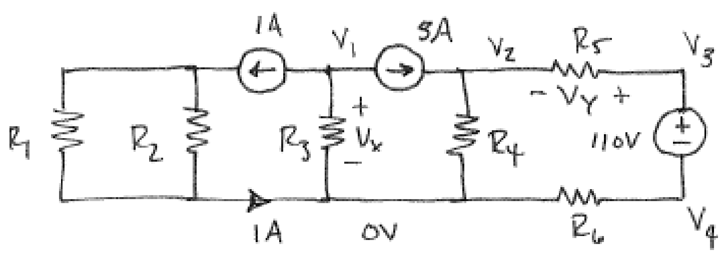


Figure P3.17

SOLUTION:

3.17 Find V_x and V_y by nodal.



$R_1 = 132\Omega$ $R_2 = 264\Omega$

$R_3 = 44\Omega$ $R_4 = 88\Omega$

$R_5 = 10\Omega$ $R_6 = 12\Omega$

@ V_1: $1 + 5 + \frac{V_x}{R_3} = 0 \Rightarrow$ $\boxed{V_x = -264V}$

@ V_2: $5 = \frac{V_2}{R_4} + \frac{V_2 - V_3}{R_5}$

@ ref: $1 + \frac{V_1}{R_3} + \frac{V_2}{R_4} + \frac{V_4}{R_6}$

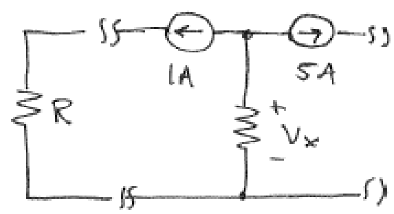
$V_3 - V_4 = 110V$

$V_y = V_3 - V_2$ $\boxed{V_y = 30V}$

3.18 For the network in Fig P3.17, explain why the resistor *R* plays no role in determining V_x and V_y.

SOLUTION:

3.18 As shown in the simple circuit here the 1-A current source fixes the current in its branch, independent of the value of R.



Since V_x & V_y depend only on the branch's current, the value of R does not impact V_x or V_y.

3.19 Use nodal analysis to find V_o in the network in Fig P3.19.

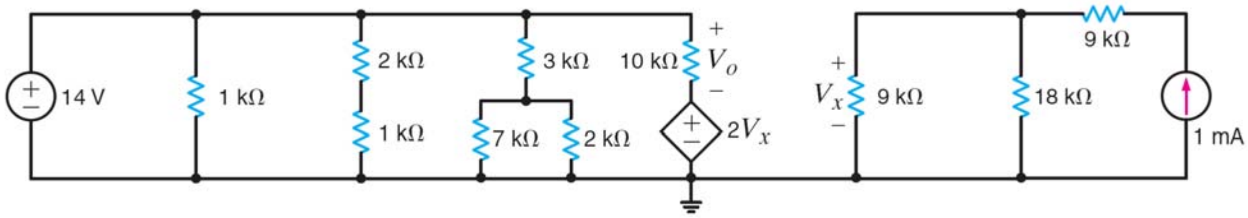
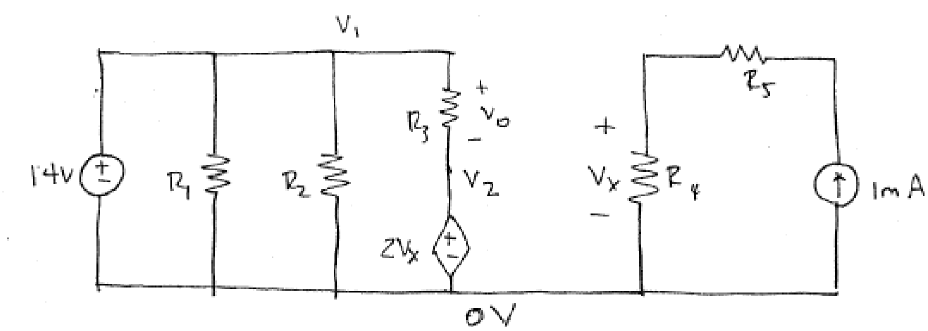


Figure P3.19

SOLUTION:

3.19 Find V_o by nodal



$R_1 = 1000 // (2000 + 1000) = 750\Omega$ $\quad R_3 = 10k\Omega$ $\quad R_5 = 9k\Omega$

$R_4 = 9000 // 18000 = 6k\Omega$ $\quad R_2 = 3000 + (7000 // 2000) = 4.55k\Omega$

$V_1 = 14V$ $\quad V_2 = 2V_x$ $\quad V_x = 1\times10^{-3}(R_4) = 6V$

$V_o = V_1 - V_2$ $\quad \boxed{V_o = 2V}$

3.20 Use nodal analysis to find V_A and V_B in the network in Fig. P3.20. Simplify the analysis by making an insightful choice for the reference node.

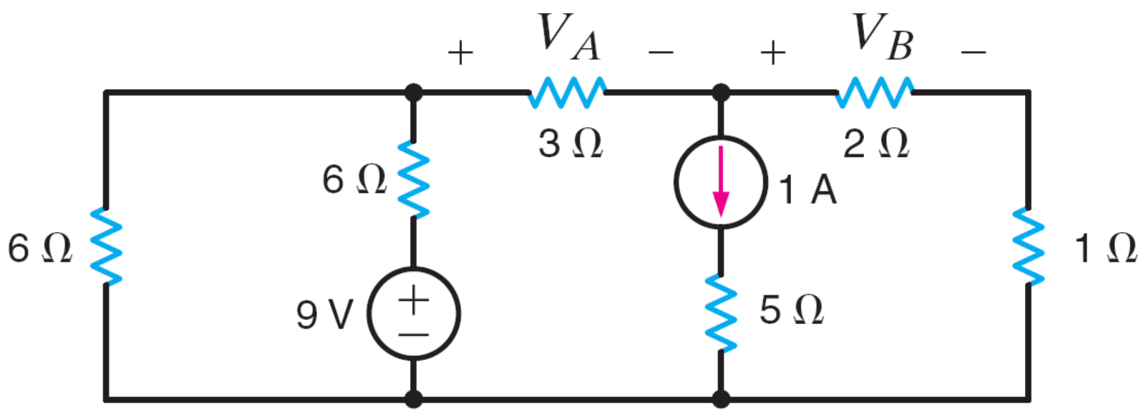
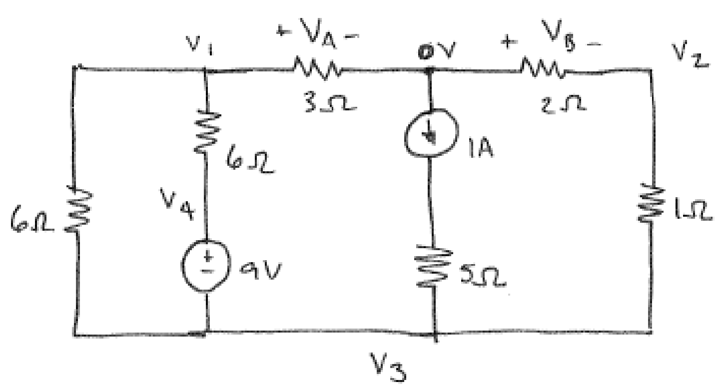


Figure P3.20

SOLUTION:

3.20 Find V_A & V_B by nodal



$$V_4 - V_3 = 9$$

$$\frac{V_1 - V_4}{6} + \frac{V_1}{3} + \frac{V_1 - V_3}{6} = 0$$

$$\frac{V_1}{3} + \frac{V_2}{2} = 1$$

$$\frac{V_2}{2} + \frac{V_2 - V_3}{1} = 0$$

$V_A = V_1$

$V_B = -V_2$

$V_A = 2.5\text{V}$
$V_B = -0.33\text{V}$

3.21 Find I_o in the circuit in Fig. P3.21.

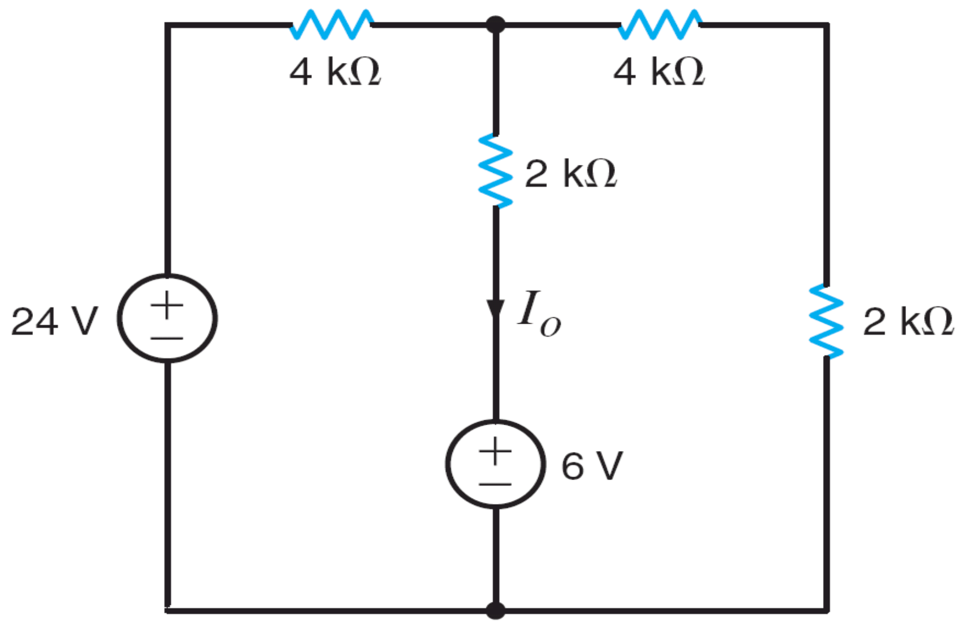
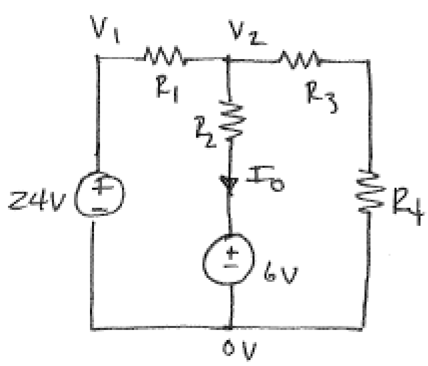


Figure P3.21

SOLUTION:

3.21 Find I_o.



$V_1 = 24V$

$$\frac{V_2 - V_1}{R_1} + \frac{V_2 - 6}{R_2} + \frac{V_2}{R_3 + R_4} = 0$$

$$I_o = \frac{V_2 - 6}{R_2}$$

$\boxed{I_o = 1.91 \text{ mA}}$

$R_1 = R_3 = 4k\Omega$

$R_2 = R_4 = 2k\Omega$

3.22 Use nodal analysis to find I_o and I_S in the circuit in Fig. P3.22.

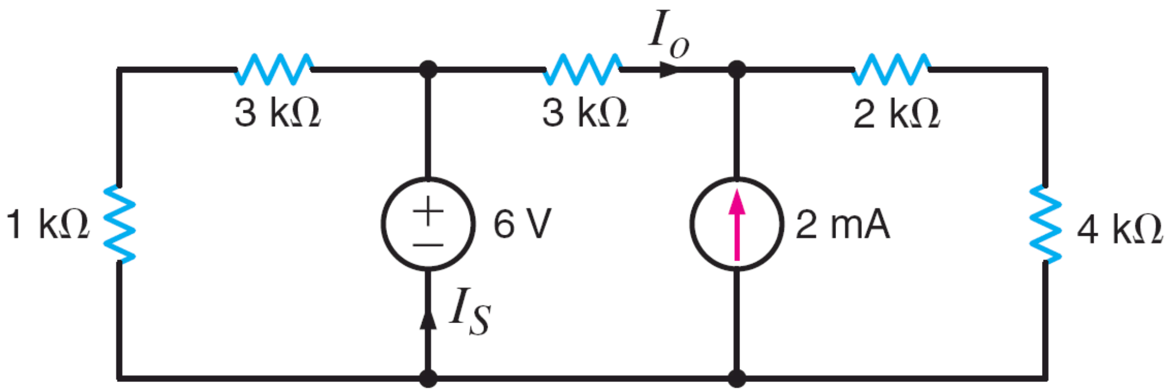
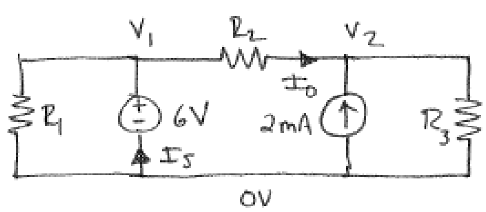


Figure P3.22

SOLUTION:

3.22 Find I_o and I_s by nodal.



$R_1 = 1000 + 3000 = 4000\,\Omega$

$R_3 = 2000 + 4000 = 6\,k\Omega$

$V_1 = 6\,V$

$\dfrac{V_1 - V_2}{R_2} + 2\times10^{-3} = V_2/R_3$

$I_o = (V_1 - V_2)/R_2$

$\boxed{I_o = -0.67\,mA}$

$I_s = \dfrac{V_1}{R_1} + I_o \Rightarrow \boxed{I_s = 0.83\,mA}$

3.23 Use nodal analysis to find V_o in the network in Fig. P3.23.

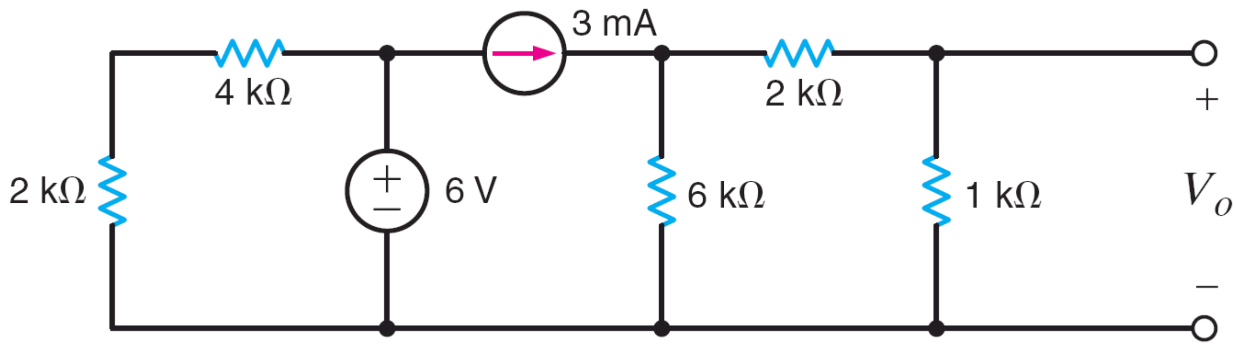
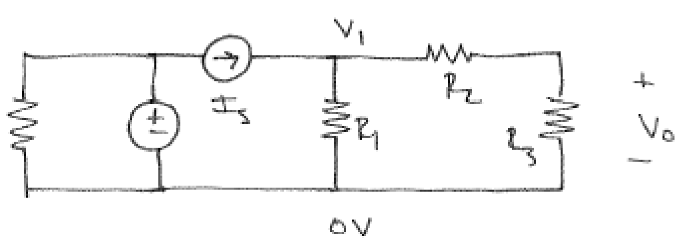


Figure P3.23

SOLUTION:

3.23 Find V_o by nodal.



$R_1 = 6\,k\Omega$ $R_2 = 2\,k\Omega$ $R_3 = 1\,k\Omega$

$I_s = 3\,mA$

$$I_s = \frac{V_1}{R_1} + \frac{V_1}{R_2 + R_3}$$

$$V_o = V_1 \left(\frac{R_3}{R_2 + R_3} \right)$$

$$\boxed{V_o = 2\,V}$$

3.24 Use nodal analysis to find I_o in the circuit in Fig. P3.24.

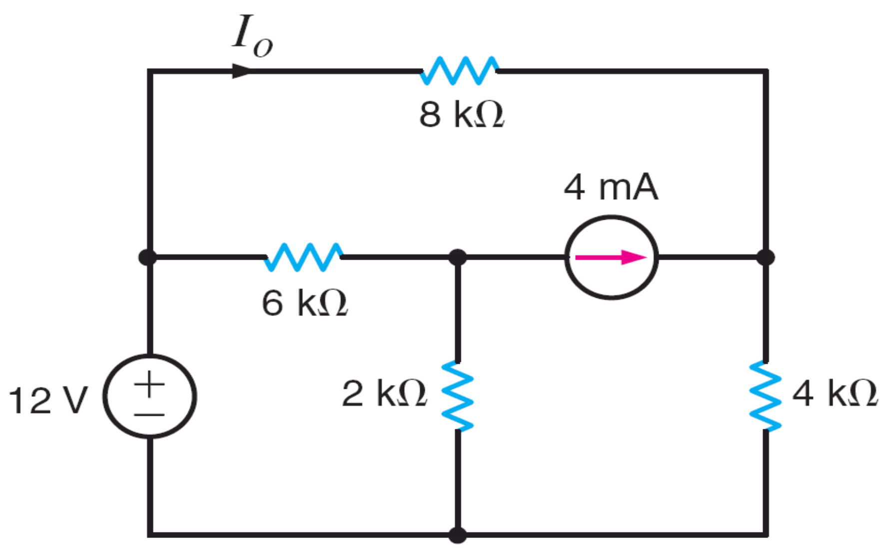
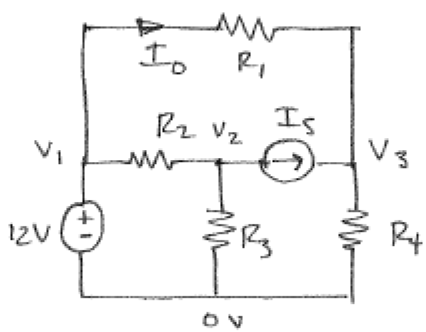


Figure P3.24

SOLUTION:

3.24 Find I_o by nodal.



$R_1 = 8k\Omega \quad R_2 = 6k\Omega$

$R_3 = 2k\Omega \quad R_4 = 4k\Omega$

$I_s = 4mA$

$V_1 = 12V$

$$\frac{V_2 - V_1}{R_2} + \frac{V_2}{R_3} + I_s = 0$$

$$\frac{V_3 - V_1}{R_1} + \frac{V_3}{R_4} = I_s$$

and, $I_o = \dfrac{V_1 - V_3}{R_1}$

$$\boxed{I_o = -0.33mA}$$

3.25 Find I_o in the network in Fig. P3.25 using nodal analysis.

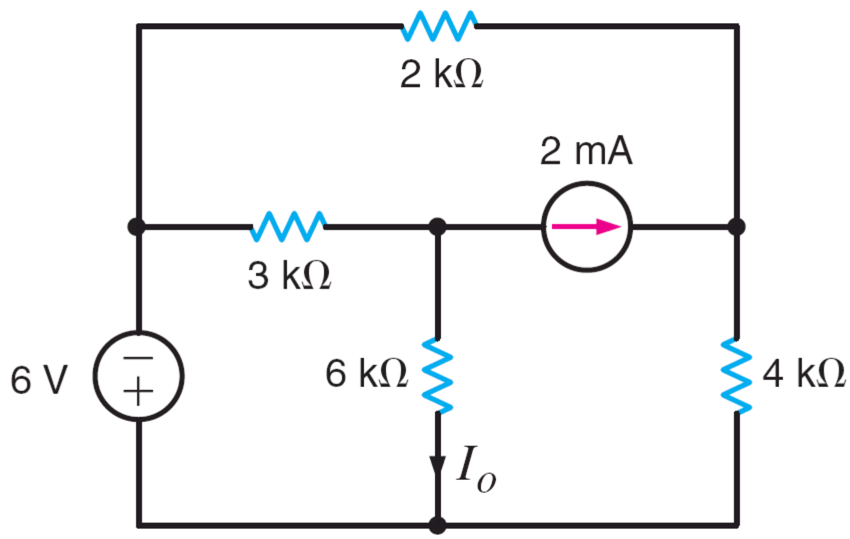
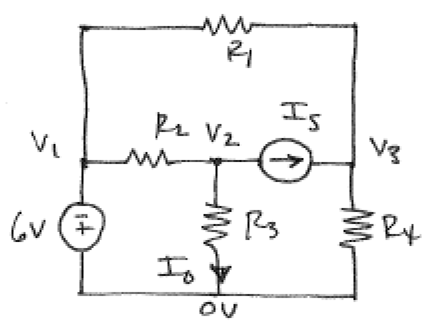


Figure P3.25

SOLUTION:

3.25 Find I_o by nodal.



$V_1 = -6V$

$$\frac{V_2 - V_1}{R_2} + \frac{V_2}{R_3} + I_S = 0$$

$$I_o = V_2 / R_3$$

$R_1 = 2k\Omega \quad R_2 = 3k\Omega$

$R_3 = 6k\Omega \quad R_4 = 4k\Omega$

$I_S = 2mA$

$$\boxed{I_o = 0\ A}$$

3.26 Use nodal analysis to find I_o in the network in Fig. P3.26.

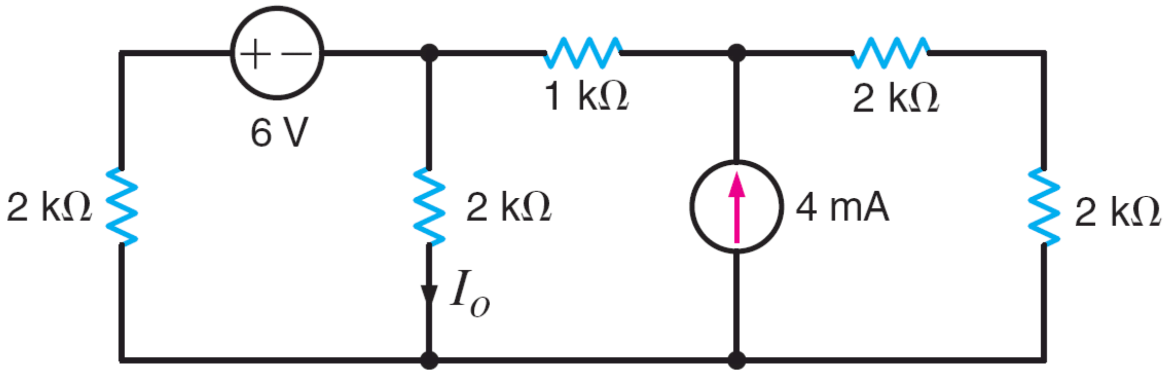
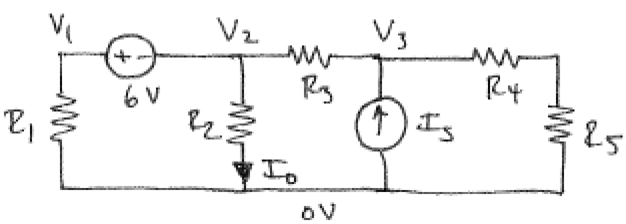


Figure P3.26

SOLUTION:

3.26 Find I_o by nodal.



$R_1 = R_2 = R_4 = R_5 = 2k\Omega$

$R_3 = 1k\Omega \quad I_s = 4mA$

$V_1 - V_2 = 6V$

@ V_3: $\dfrac{V_3 - V_2}{R_3} + \dfrac{V_3}{R_4 + R_5} = I_s$

@ ref: $\dfrac{V_1}{R_1} + \dfrac{V_2}{R_2} + \dfrac{V_3}{R_4 + R_5} = I_s$

and $I_o = V_2 / R_2$

$\boxed{I_o = 83.3 \mu A}$

3.27 Use nodal analysis to find V_o in the network in Fig. P3.27. Then solve this problem using MATLAB and compare your answers. **cs**

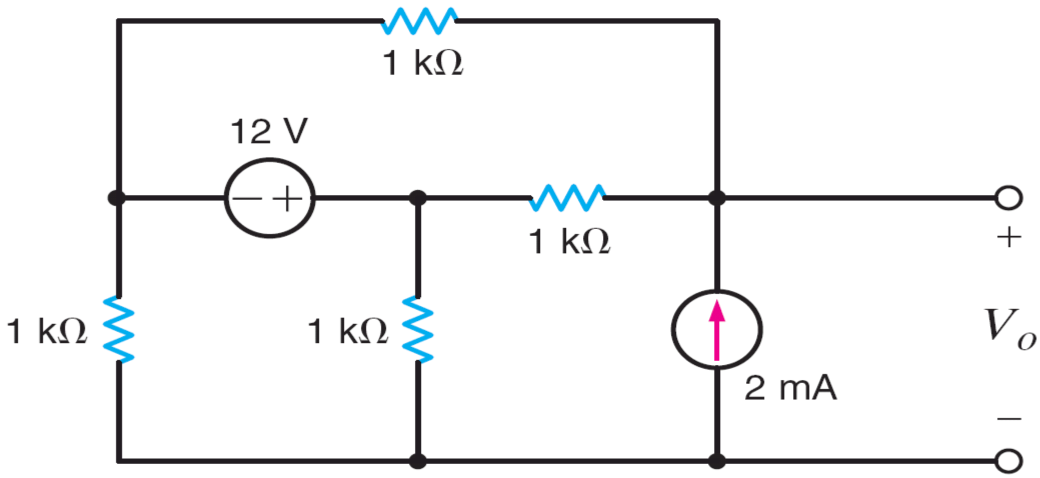
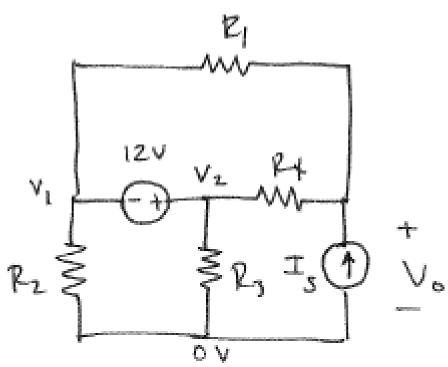


Figure P3.27

SOLUTION:

3.27 Find V_o by nodal and MATLAB.



$V_2 - V_1 = 12V$

at V_o: $\frac{V_o - V_2}{R_4} + \frac{V_o - V_1}{R_1} = I_s$

@ ref: $\frac{V_1}{R_2} + \frac{V_2}{R_3} = I_s$

$R_1 = R_2 = R_3 = R_4 = 1k\Omega$

$I_s = 2mA$

$\boxed{V_o = 2V}$

3.28 Find V_o in the circuit in Fig. P3.28 using nodal analysis.
PSV

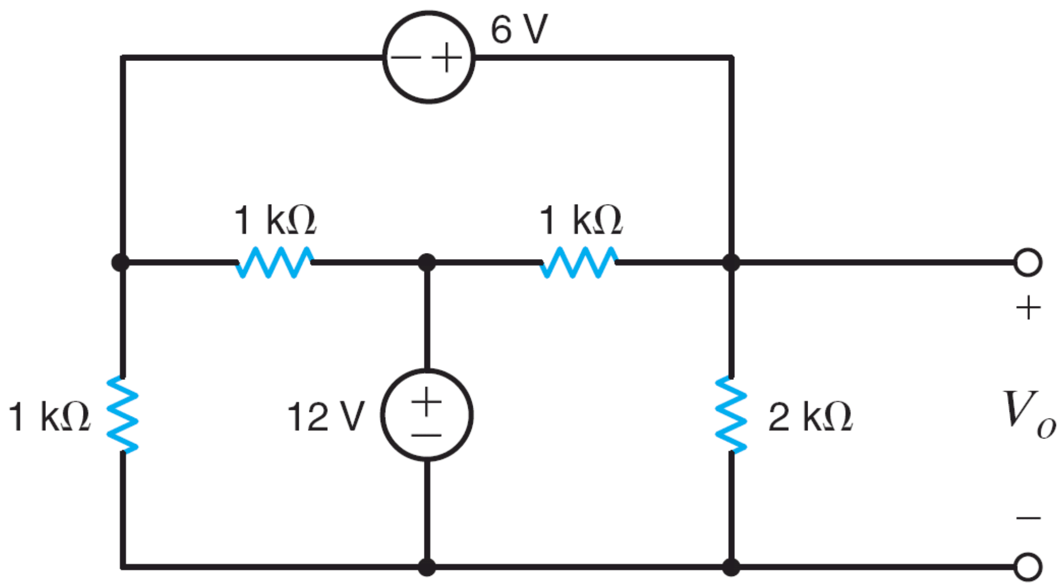
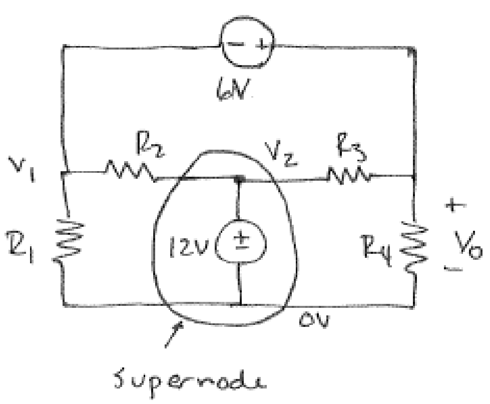


Figure P3.28

SOLUTION:

3.28 Find V_o by nodal.



$R_1 = R_2 = R_3 = 1k\Omega \quad R_4 = 2k\Omega$

$V_o - V_1 = 6V \qquad V_2 = 12V$

at supernode,

$$\frac{V_1 - V_2}{R_2} + \frac{V_1}{R_1} + \frac{V_o - V_2}{R_3} + \frac{V_o}{R_4} = 0$$

$V_o = 10.3V$

3.29 Use nodal analysis to find V_o in the circuit in Fig. P3.29.
CS

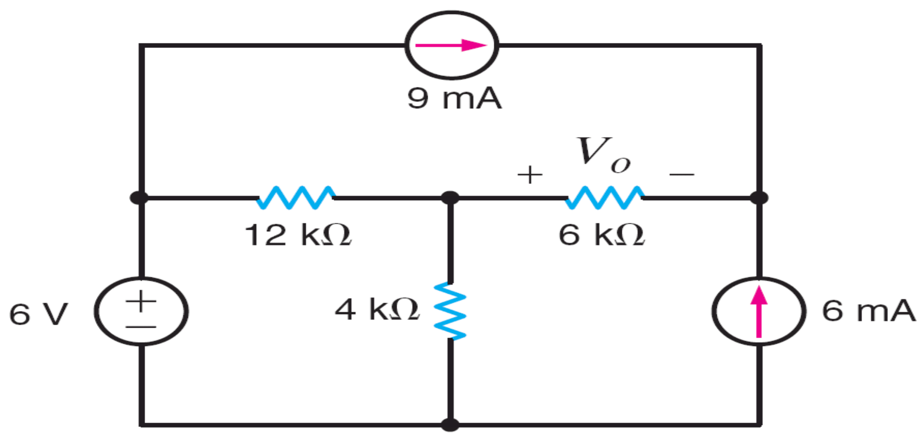
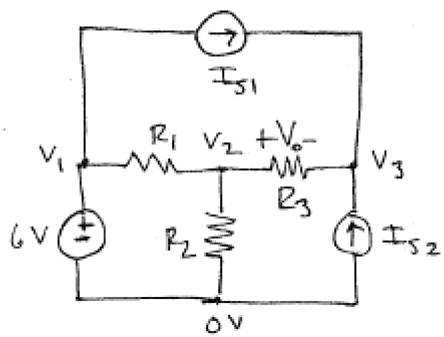


Figure P3.29

SOLUTION:

3.29 Find V_o by nodal



$R_1 = 12k\Omega \quad R_2 = 4k\Omega$

$R_3 = 6k\Omega \quad I_{S1} = 9mA$

$I_{S2} = 6mA$

$V_1 = 6V$

@ V_2: $$\frac{V_2 - V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - V_3}{R_3} = 0$$

@ V_3: $$\frac{V_3 - V_2}{R_3} = I_{S1} + I_{S2}$$

and $V_o = V_2 - V_3$

$$\boxed{V_o = -90V}$$

3.30 Use nodal analysis to find V_o in the circuit in Fig. P3.30.

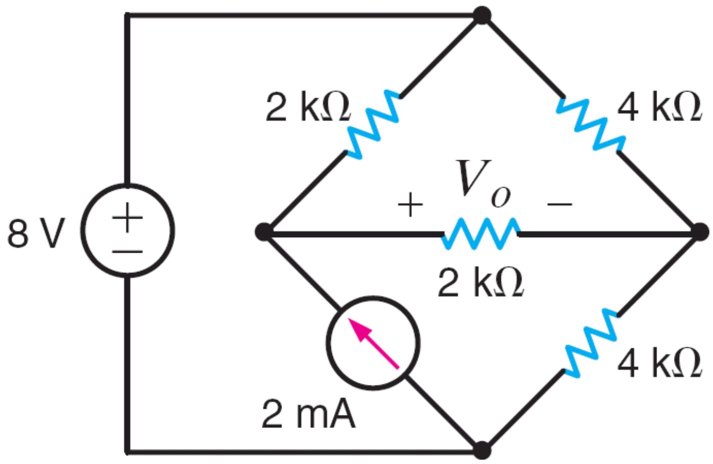
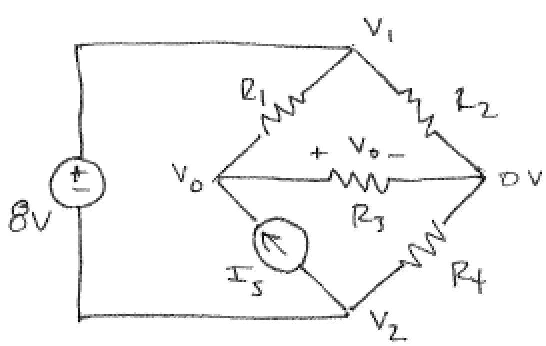


Figure P3.30

SOLUTION:

3.30 Find V_o by nodal



$R_1 = 2k\Omega$ $R_2 = 4k\Omega$ $R_3 = 2k\Omega$

$R_4 = 4k\Omega$ $I_S = 2mA$

$V_1 - V_2 = 8V$

@ V_o: $\frac{V_o - V_1}{R_1} + \frac{V_o}{R_3} = I_S$

@ ref: $\frac{V_1}{R_2} + \frac{V_o}{R_3} + \frac{V_2}{R_4} = 0$

$\boxed{V_o = 2.67V}$

3.31 Use nodal analysis to find V_o in the circuit in Fig. P3.31.

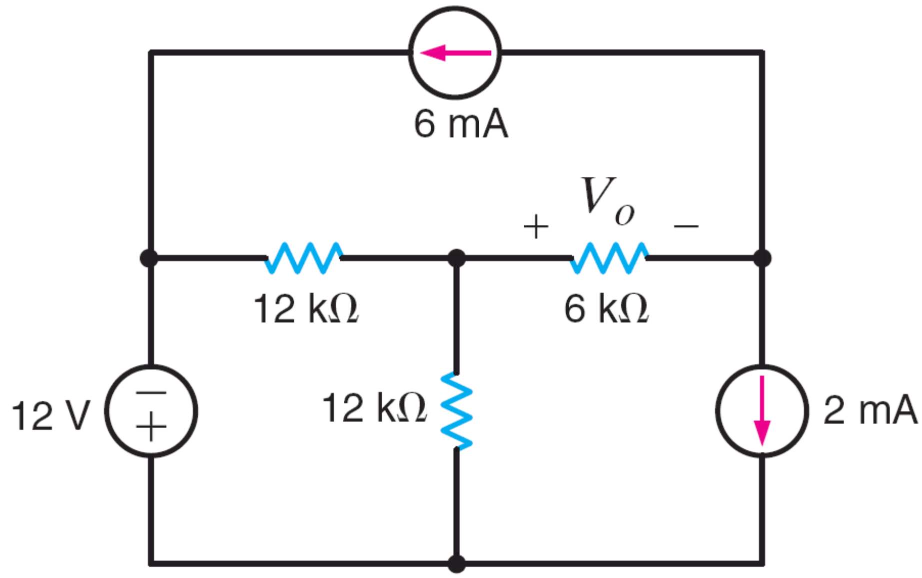
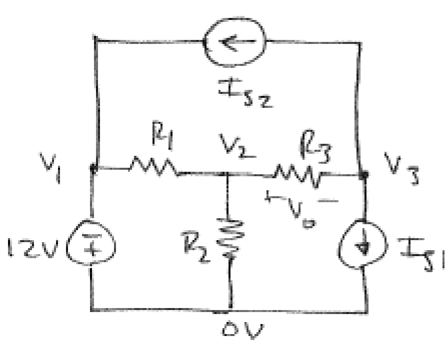


Figure P3.31

SOLUTION:

3.31 Find V_o by nodal.



$R_1 = R_2 = 12k\Omega \quad R_3 = 6k\Omega$

$I_{S1} = 2mA \quad I_{S2} = 6mA$

$V_1 = -12V$

@ V_2: $\frac{V_2 - V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - V_3}{R_3} = 0$

@ V_3: $\frac{V_3 - V_2}{R_3} + I_{S1} + I_{S2} = 0$

$V_o = V_2 - V_3$

$V_o = 48V$

3.32 Find V_o in the network in Fig. P3.32 using nodal analysis.
CS

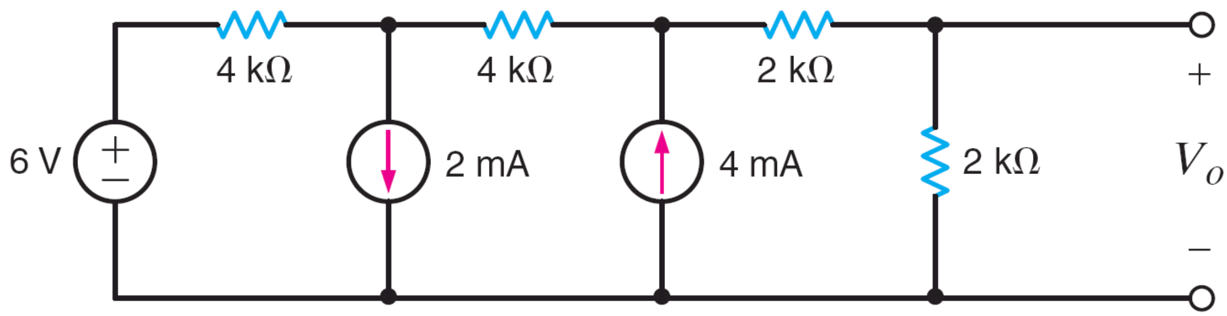
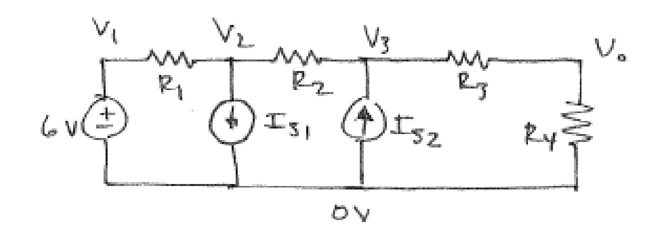


Figure P3.32

SOLUTION:

3.32 Find V_o by nodal.



$R_1 = R_2 = 4\,k\Omega \quad R_3 = R_4 = 2\,k\Omega$

$I_{S1} = 2\,mA \quad I_{S2} = 4\,mA$

$V_1 = 6V$

@ V_2: $\frac{V_2 - V_1}{R_1} + \frac{V_2 - V_3}{R_2} + I_{S1} = 0$

@ V_3: $\frac{V_3 - V_2}{R_2} + \frac{V_3 - V_o}{R_3} = I_{S2}$

@ V_o: $\frac{V_o - V_3}{R_3} + \frac{V_o}{R_4} = 0$

$\boxed{V_o = 5V}$

3.33 Use nodal analysis to find V_o in the network in Fig. P3.33.

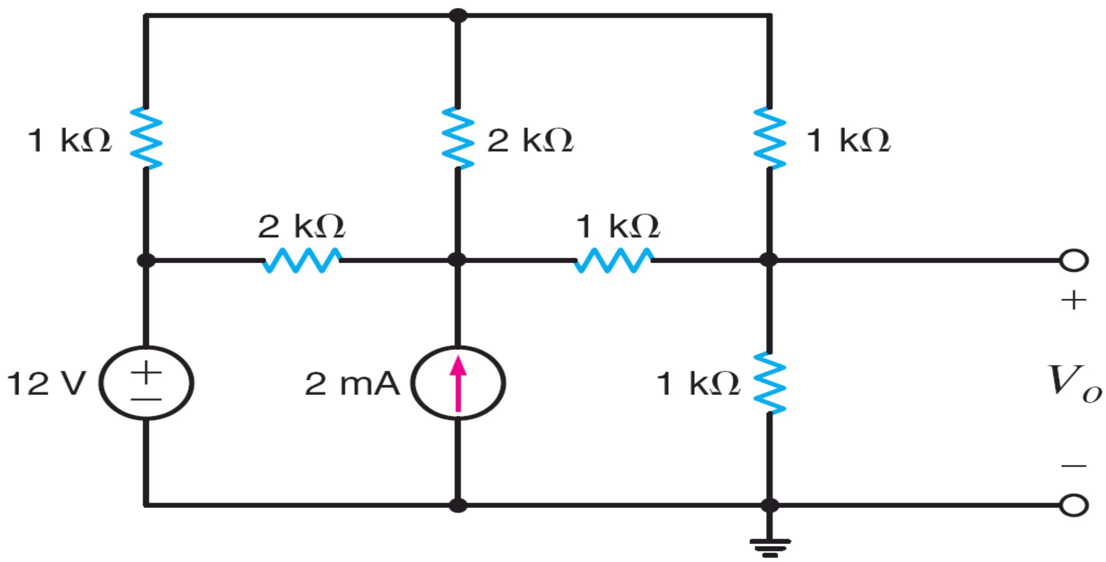
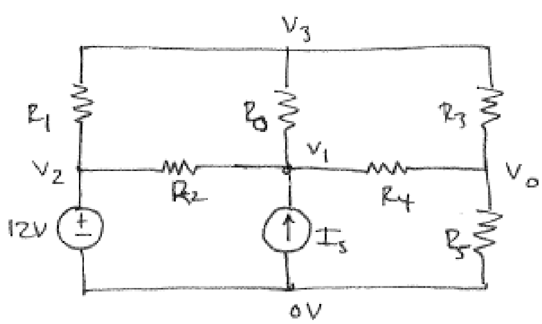


Figure P3.33

SOLUTION:

3.33 Find V_o by nodal.



$R_1 = R_3 = R_4 = R_5 = 1k\Omega \quad R_2 = R_0 = 2k\Omega$

$I_s = 2mA$

$V_2 = 12V$

$$@ V_3: \quad \frac{V_3 - V_2}{R_1} + \frac{V_3 - V_1}{R_0} + \frac{V_3 - V_o}{R_3} = 0$$

$$@ V_1: \quad I_s = \frac{V_1 - V_3}{R_0} + \frac{V_1 - V_o}{R_4} + \frac{V_1 - V_2}{R_2}$$

$$@ V_o: \quad \frac{V_o - V_1}{R_4} + \frac{V_o}{R_5} + \frac{V_o - V_3}{R_3} = 0$$

$$\boxed{V_o = 6.17V}$$

3.34 Find V_o in the circuit in Fig. P3.34 using nodal analysis.

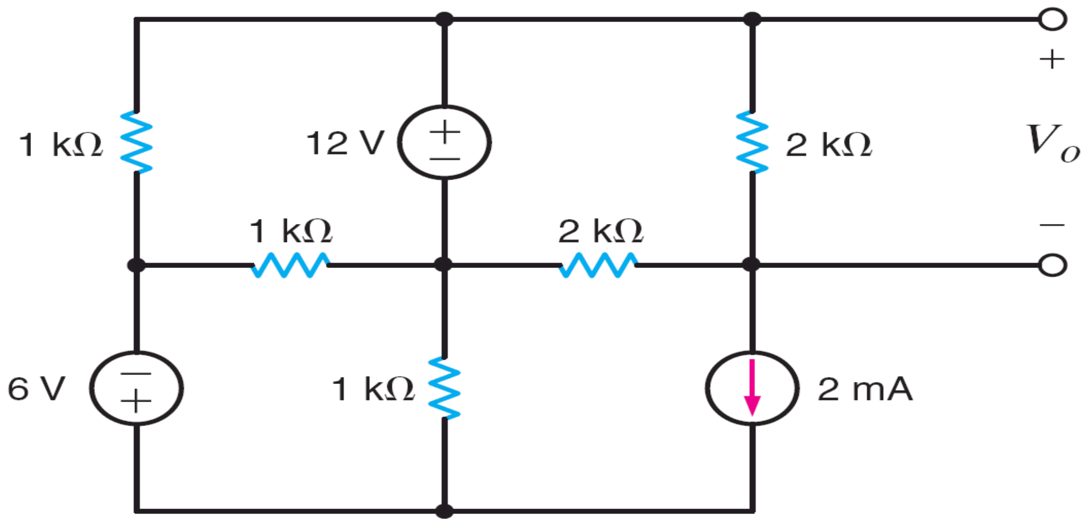
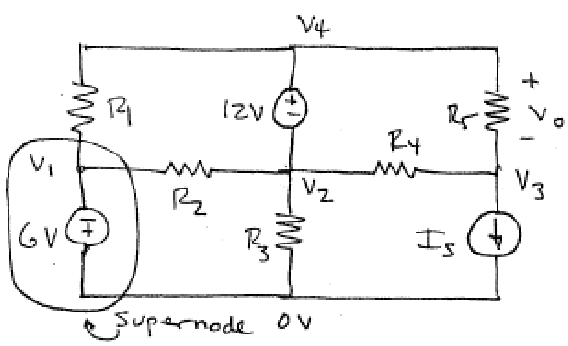


Figure P3.34

SOLUTION:

3.34 Find V_o by nodal.



$R_1 = R_2 = R_3 = 1k\Omega \quad I_s = 2mA$

$R_4 = R_5 = 2k\Omega$

$V_1 = -6\,V \qquad V_4 - V_2 = 12\,V$

@ V_3: $\dfrac{V_3 - V_2}{R_4} + \dfrac{V_3 - V_4}{R_5} + I_s = 0$

@ supernode:

$$\frac{V_4 - V_1}{R_1} + \frac{V_2 - V_1}{R_2} + \frac{V_2}{R_3} + I_s = 0$$

$V_o = V_4 - V_3$

$\boxed{V_o = 8V}$

3.35 Use nodal analysis to find V_o in the network in Fig. P3.35.

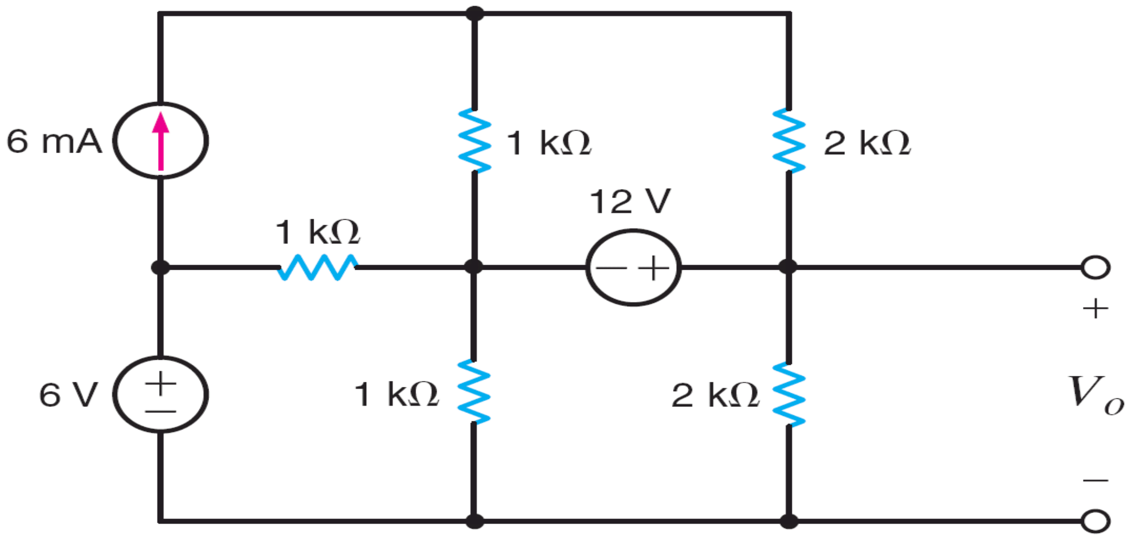
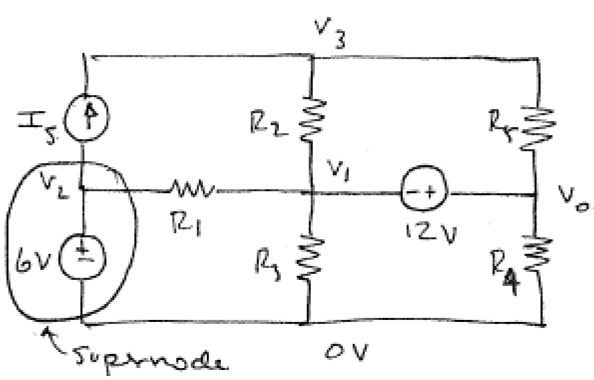


Figure P3.35

SOLUTION:

3.35 Use nodal to find V_o



$R_1 = R_2 = R_3 = 1\,k\Omega \qquad I_S = 6\,mA$

$R_4 = R_5 = 2\,k\Omega$

$V_2 = 6\,V \qquad V_o - V_1 = 12\,V$

$@\ V_3: \quad I_S = \frac{V_3 - V_1}{R_2} + \frac{V_3 - V_o}{R_5}$

@ supernode:

$$\frac{V_1 - V_2}{R_1} + \frac{V_1}{R_3} + \frac{V_o}{R_4} = I_S$$

$$\boxed{V_o = 14.4\ V}$$

3.36 Use MATLAB to find the node voltages in the network in Fig. P3.36. CS

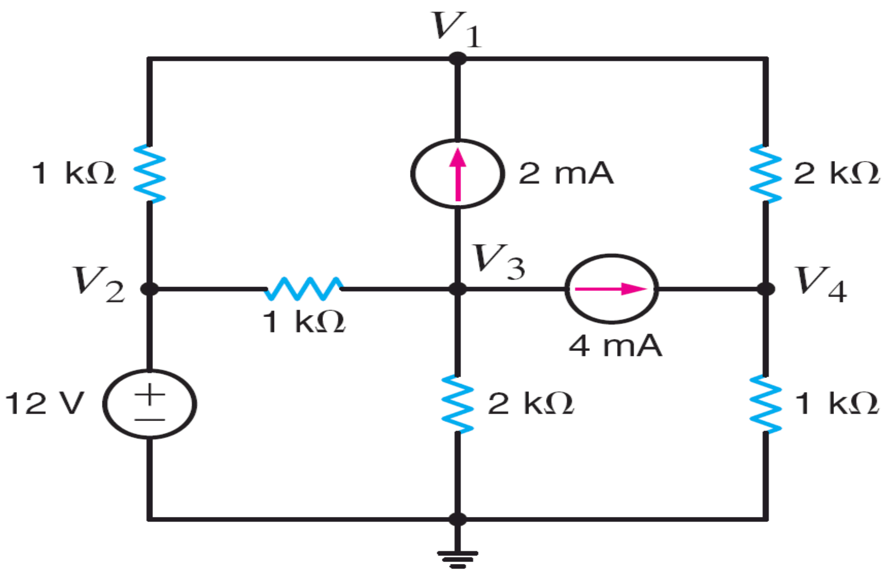
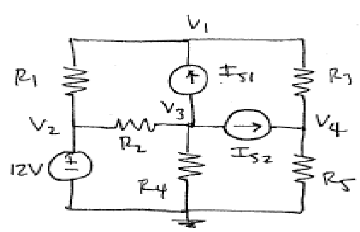


Figure P3.36

SOLUTION:

3.36 Use MATLAB to find node voltages.



$V_2 = 12\text{V}$

@ V_1: $\frac{V_1 - V_2}{R_1} + \frac{V_1 - V_4}{R_3} = I_{S1}$

@ V_3: $\frac{V_3 - V_2}{R_2} + \frac{V_3}{R_4} + I_{S1} + I_{S2} = 0$

@ V_4: $\frac{V_4 - V_1}{R_3} + \frac{V_4}{R_5} = I_{S2}$

$R_1 = R_2 = R_5 = 1\text{k}\Omega$

$R_4 = R_3 = 2\text{k}\Omega$

$I_{S1} = 2\text{mA} \quad I_{S2} = 4\text{mA}$

matrix form:

$$\begin{bmatrix} 0 & 1 & 0 & 0 \\ \frac{1}{R_1} + \frac{1}{R_3} & -\frac{1}{R_1} & 0 & -\frac{1}{R_3} \\ 0 & -\frac{1}{R_2} & \frac{1}{R_2} + \frac{1}{R_4} & 0 \\ -\frac{1}{R_3} & 0 & 0 & \frac{1}{R_3} + \frac{1}{R_5} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} 12 \\ I_{S1} \\ -I_{S1} - I_{S2} \\ I_{S2} \end{bmatrix}$$

MATLAB:

Continued on the next page.

MATLAB WORK

Factor 1/1000 out of the conductance matrix.

```
EDU» g=[0,1000,0,0;1.5,-1,0,-0.5;0,-1,1.5,0;-0.5,0,0,1.5]

g =

  1.0e+003 *

         0    1.0000         0         0
    0.0015   -0.0010         0   -0.0005
         0   -0.0010    0.0015         0
   -0.0005         0         0    0.0015

EDU» i=[12;0.002;-0.006;0.004]

i =

   12.0000
    0.0020
   -0.0060
    0.0040

EDU» v=1000*inv(g)*i

v =

   11.5000
   12.0000
    4.0000
    6.5000
```

3.37 Determine V_o in the network in Fig. P3.37 using nodal analysis.

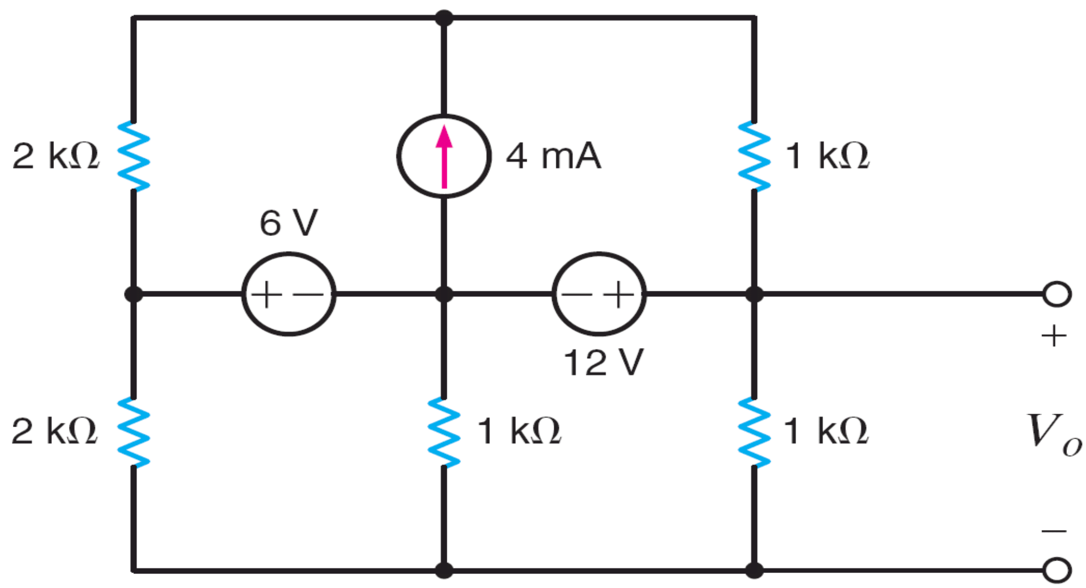
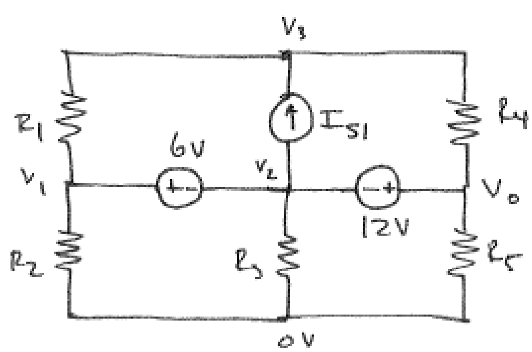


Figure P3.37

SOLUTION:

3.37 Find V_o by nodal.



$V_1 - V_2 = 6V \qquad V_o - V_2 = 12V$

@ V_3: $\frac{V_3 - V_1}{R_1} + \frac{V_3 - V_o}{R_4} = I_{S1}$

@ ref: $\frac{V_1}{R_2} + \frac{V_2}{R_3} + \frac{V_o}{R_5} = 0$

$R_1 = R_2 = 2k\Omega \quad I_{S1} = 4mA$

$R_3 = R_4 = R_5 = 1k\Omega$

$\boxed{V_o = 6V}$

3.38 Find V_o in the circuit in Fig. P3.38.

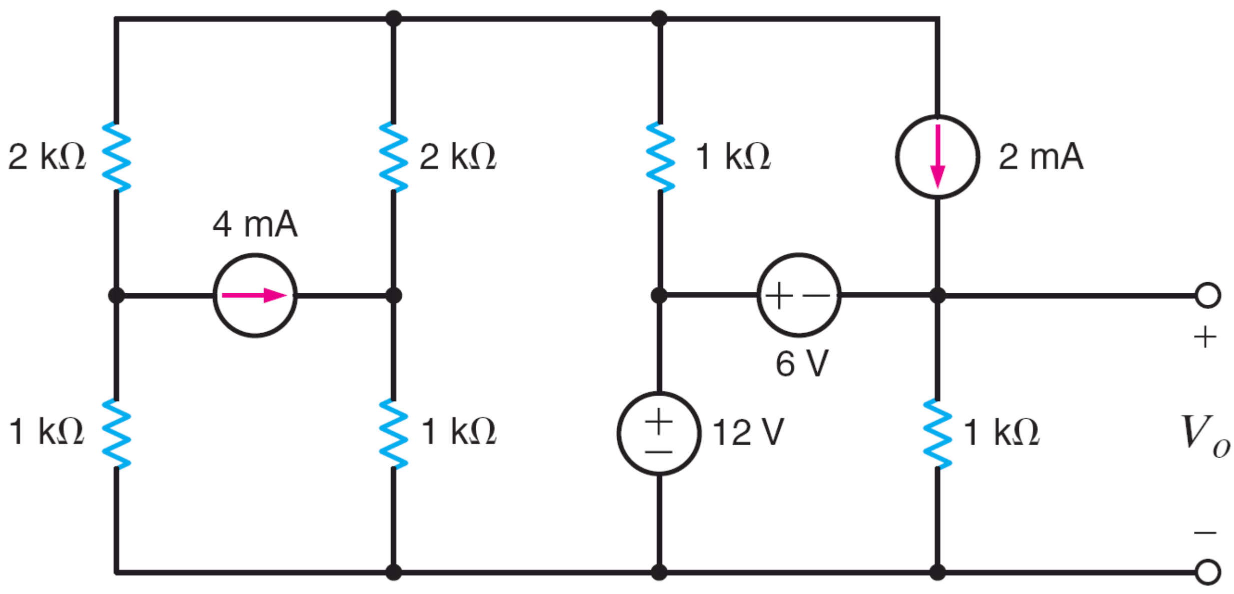
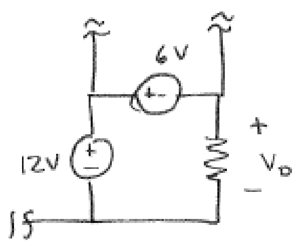


Figure P3.38

SOLUTION:

3.38 Find V_o



Rest of circuit is of no consequence to V_o

$V_o = 12 - 6$ $\boxed{V_o = 6V}$

3.39 Find V_o in the network in Fig. P3.39.

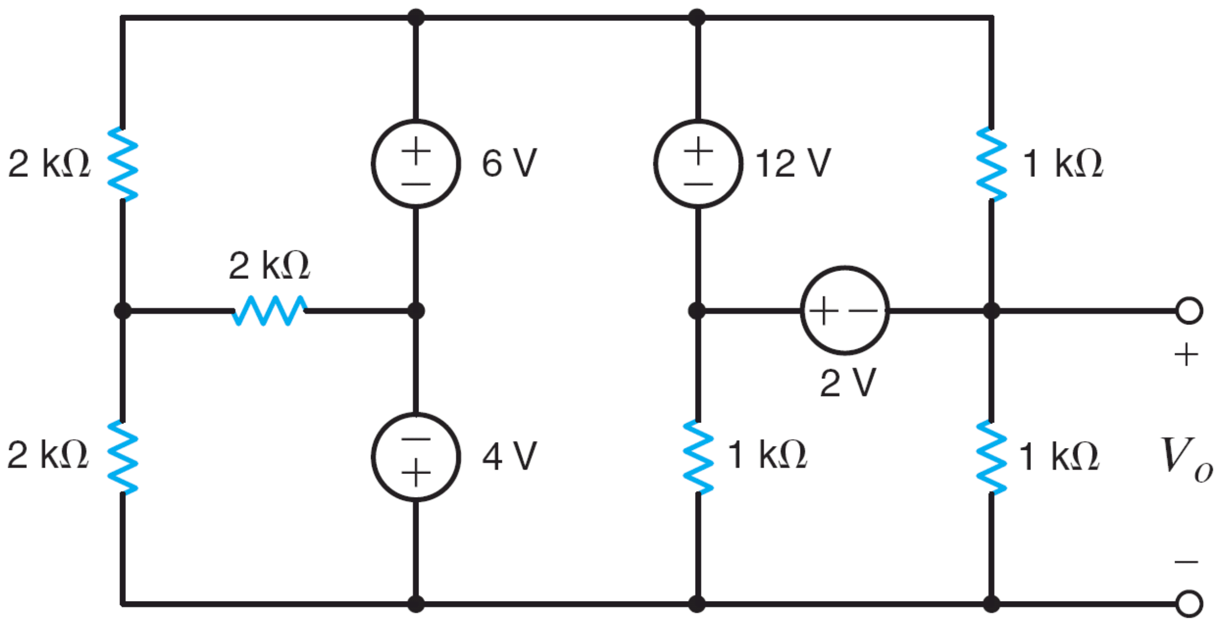
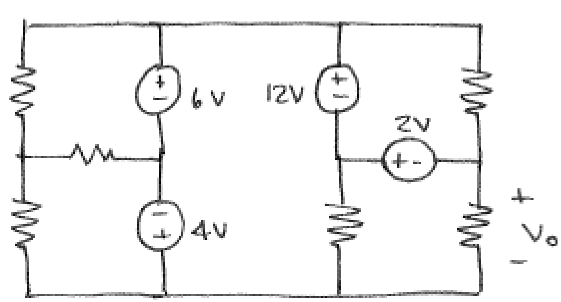


Figure P3.39

SOLUTION:

3.39 Find V_o



By KVL:

$$4 - 6 + 12 + 2 + V_o = 0$$

$$\boxed{V_o = -12}$$

3.40 Use nodal analysis to find V_o in the circuit in Fig. P3.40.

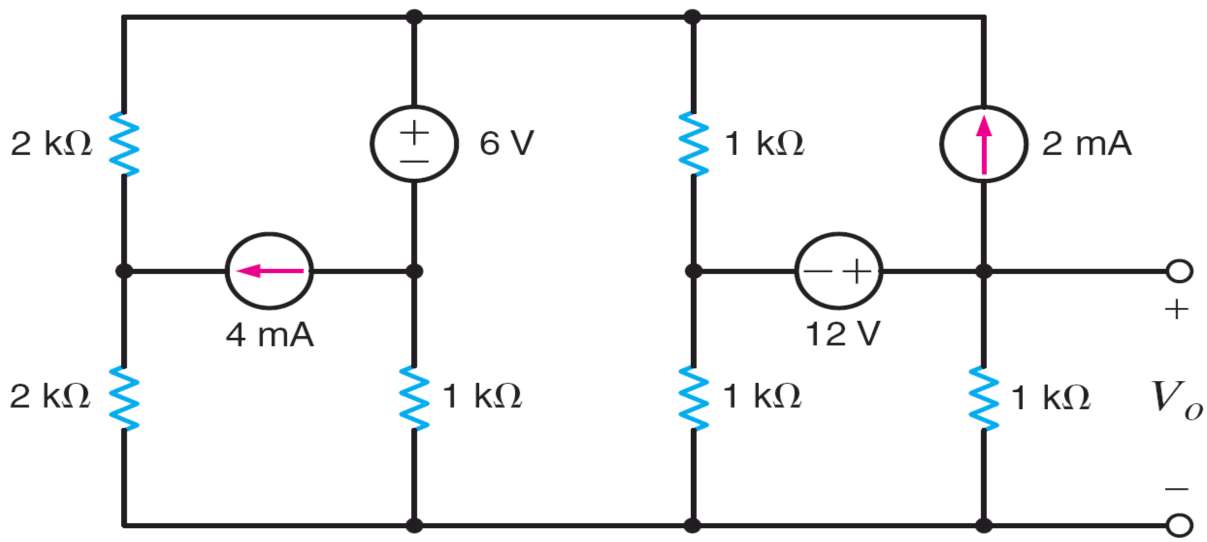
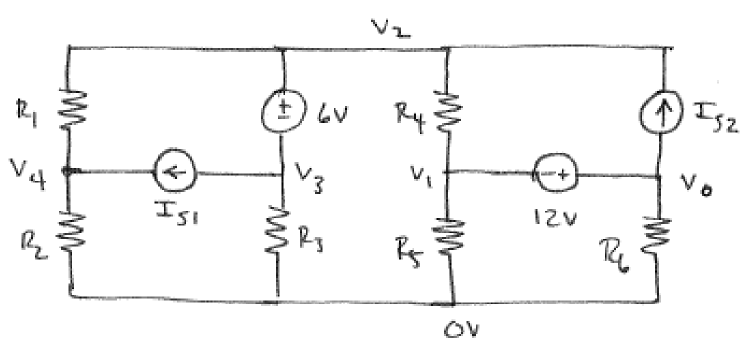


Figure P3.40

SOLUTION:

3.40 Find V_o by nodal.



$R_1 = R_2 = 2k\Omega$

$R_3 = R_4 = R_5 = R_6 = 1k\Omega$

$I_{S1} = 4mA$

$I_{S2} = 2mA$

$V_2 - V_3 = 6V \qquad V_o - V_1 = 12V$

@ V_4: $\dfrac{V_4 - V_2}{R_1} + \dfrac{V_4}{R_2} = I_{S1}$

$\boxed{V_o = 7.57\,V}$

@ ref: $\dfrac{V_4}{R_2} + \dfrac{V_3}{R_3} + \dfrac{V_1}{R_5} + \dfrac{V_o}{R_6} = 0$

3.41 Determine V_o in the network in Fig. P3.41.

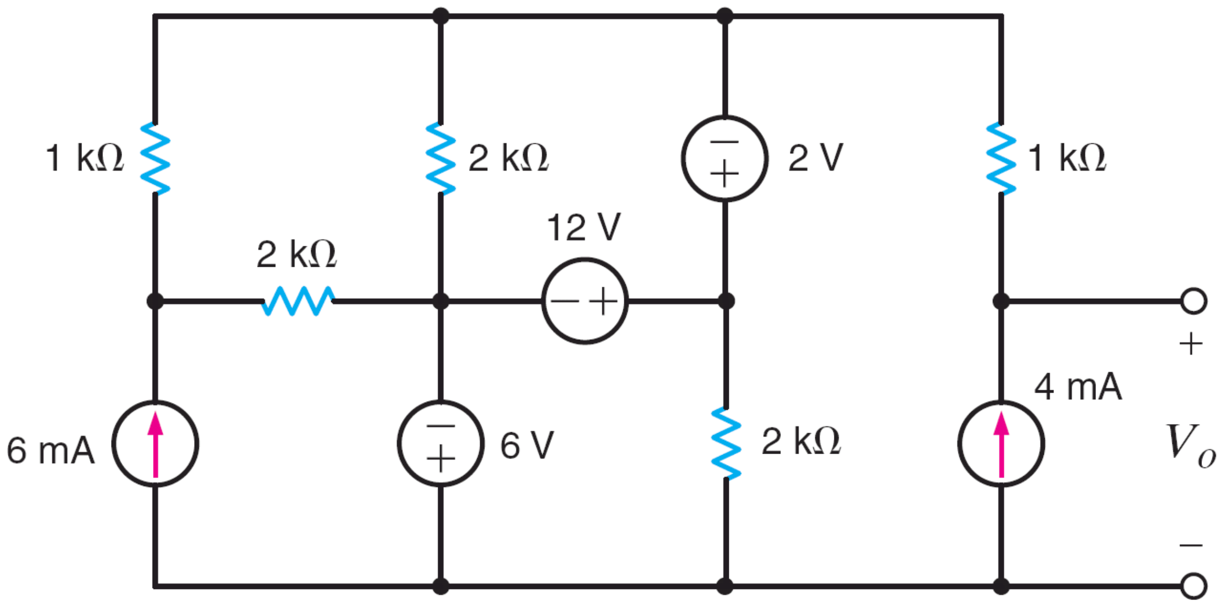
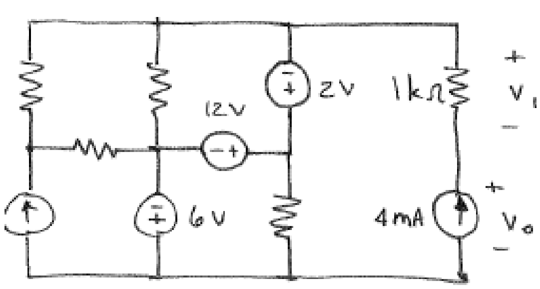


Figure P3.41

SOLUTION:

3.41 Find V_o



KVL: $6 - 12 + 2 + V_1 + V_o = 0$

$V_1 = (-4 \times 10^{-3})(10^3) = -4V$

$\boxed{V_o = 8V}$

3.42 Find V_o in the circuit in Fig. P3.42.

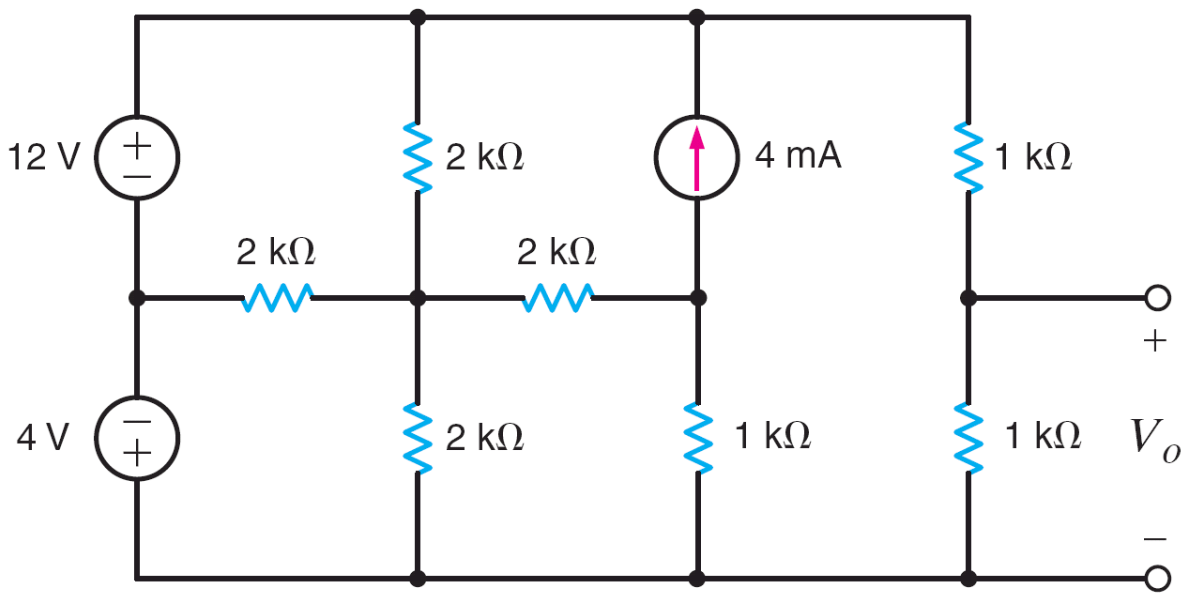
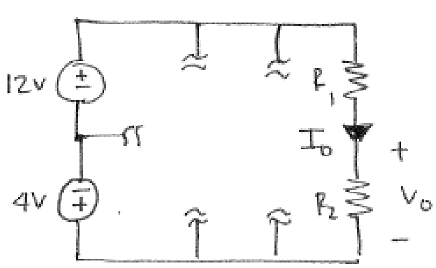


Figure P3.42

SOLUTION:

3.42 Find V_o



$R_1 = R_2 = 1k\Omega$

Rest of circuit has no effect on V_o!

KVL: $4 - 12 + I_oR_1 + I_oR_2 = 0$

$I_o = 4mA$

$V_o = R_2 I_o$ $\quad$ $\boxed{V_o = 4V}$

3.43 Find I_o in the circuit in Fig. P3.43 using nodal analysis.

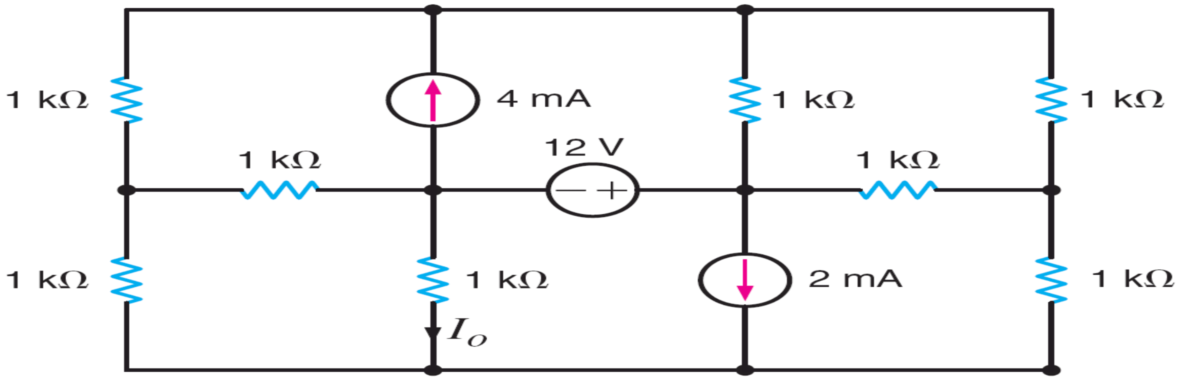
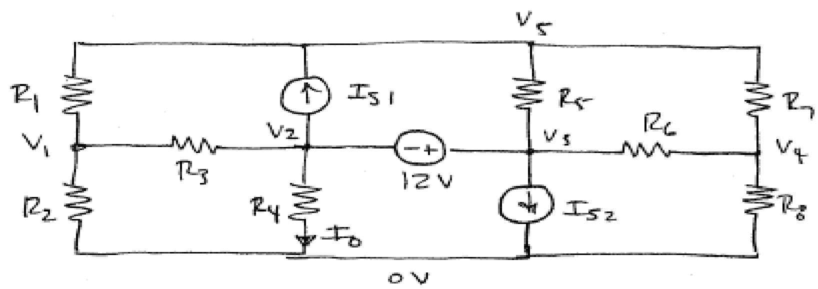


Figure P3.43

SOLUTION:

3.43 Find I_o by nodal.



all $R = 1k\Omega$

$I_{s1} = 4mA$

$I_{s2} = 2mA$

$V_3 - V_2 = 12$

@ V_1: $\frac{V_1 - V_5}{R_1} + \frac{V_1}{R_2} + \frac{V_1 - V_2}{R_3} = 0$

@ V_4: $\frac{V_4 - V_3}{R_6} + \frac{V_4 - V_5}{R_7} + \frac{V_4}{R_8} = 0$

@ V_5: $\frac{V_5 - V_1}{R_1} + \frac{V_5 - V_3}{R_5} + \frac{V_5 - V_4}{R_7} = I_{s1}$

@ ref: $\frac{V_1}{R_2} + \frac{V_2}{R_4} + \frac{V_4}{R_8} + I_{s2} = 0$

$I_o = V_2 / R_4$

$I_o = -5.47mA$

3.44 Use nodal analysis to find V_o in Fig. P3.44.

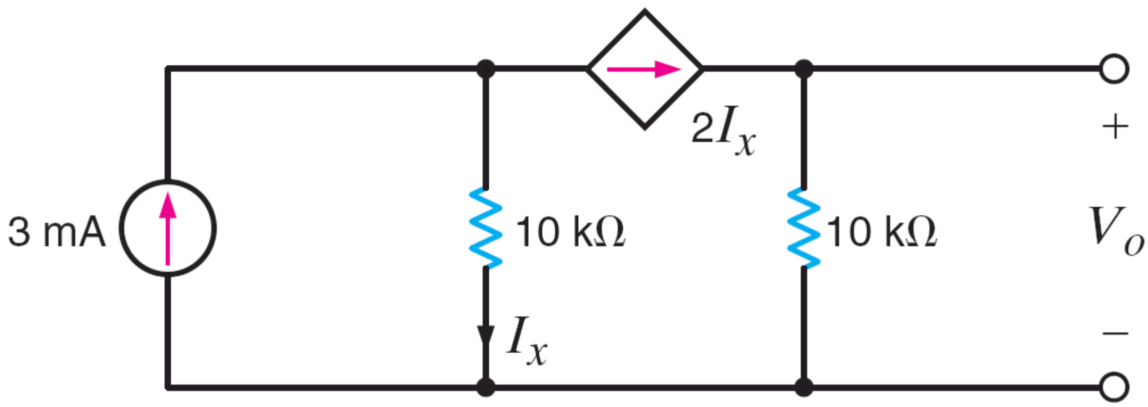
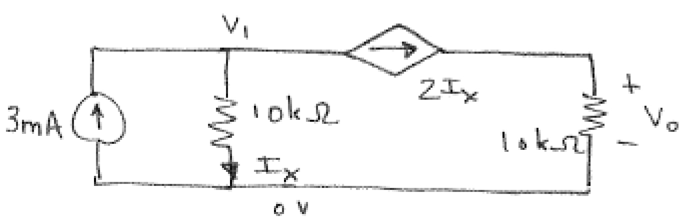


Figure P3.44

SOLUTION:

3.44 Find V_o by nodal.



@V_1: $3\times10^{-3} = \frac{V_1}{10^4} + 2I_x$ $\qquad I_x = \frac{V_1}{10^4}$

@V_o: $2I_x = \frac{V_o}{10^4}$ $\qquad \boxed{V_o = 20\text{V}}$

3.45 Find V_o in the circuit in Fig. P3.45 using nodal analysis.

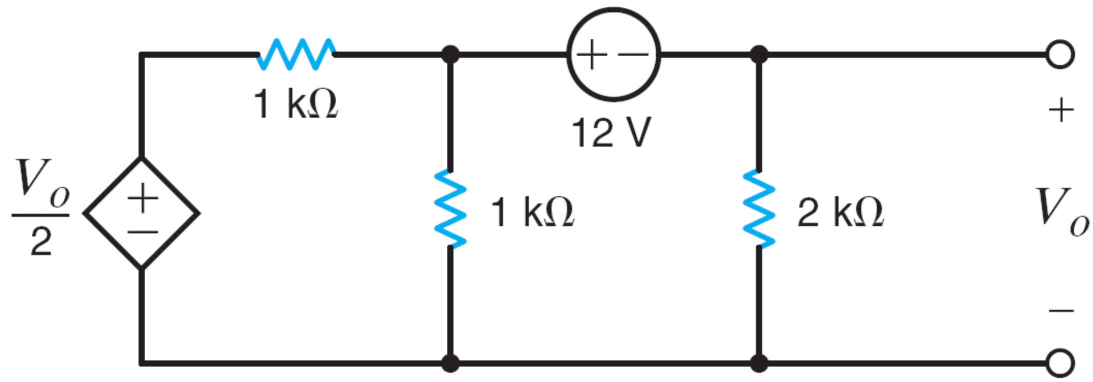
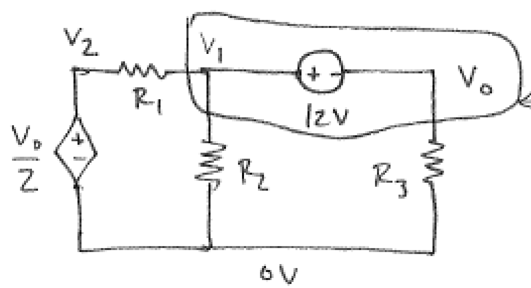


Figure P3.45

SOLUTION:

3.45 Find V_o by nodal.

$V_1 - V_0 = 12V$ $\qquad$ $V_2 = V_o/2$



supernode: $\frac{V_1 - V_2}{R_1} + \frac{V_1}{R_2} + \frac{V_o}{R_3} = 0$

$R_1 = 1\ k\Omega \quad R_2 = 1k\Omega \quad R_3 = 2k\Omega$

$\boxed{V_0 = -12V}$

3.46 Find V_o in the circuit in Fig. P3.46 using nodal analysis. Then solve the problem using MATLAB and compare your answers. CS

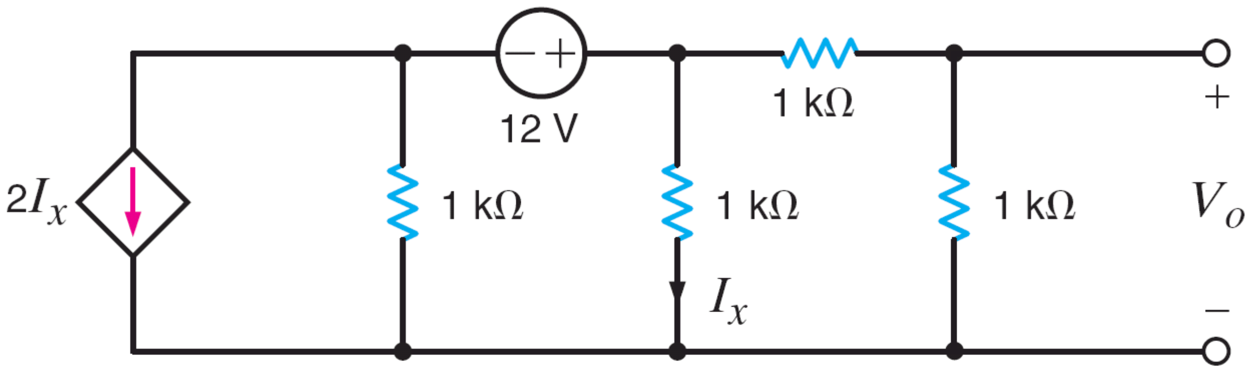
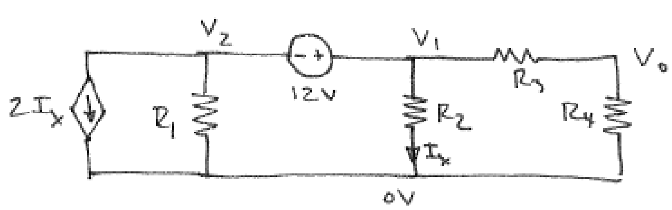


Figure P3.46

SOLUTION:

3.46 Find V_o by nodal & MATLAB



All R = 1kΩ

$$V_1 - V_2 = 12$$

@ V_o: $$\frac{V_o - V_1}{R_3} + \frac{V_o}{R_4} = 0$$

@ ref: $$2I_x + \frac{V_2}{R_1} + \frac{V_1}{R_2} + \frac{V_o}{R_4} = 0$$

$$I_x = V_1 / R_2$$

$$\boxed{V_o = 1.33V}$$

3.47 Find I_o in the network in Fig. P3.47. **PSV**

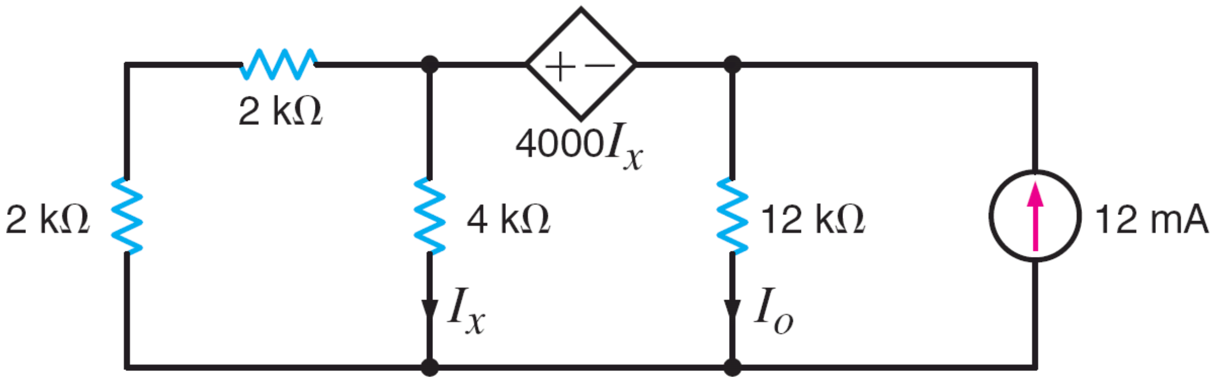
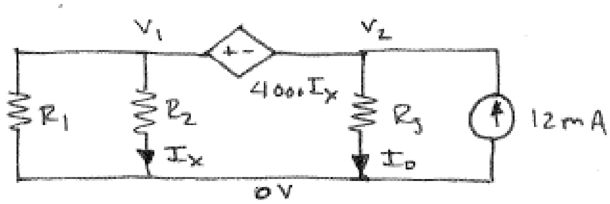


Figure P3.47

SOLUTION:

3.47 Find I_o.



$R_1 = R_2 = 4k\Omega \quad R_3 = 12k\Omega$

$V_1 - V_2 = 4000 I_x$

$I_x = V_1 / R_2$

$\frac{V_1}{R_1} + \frac{V_1}{R_2} + \frac{V_2}{R_3} = 12 \times 10^{-3}$

$I_o = V_2 / R_3$

$\boxed{I_o = 0A}$

3.48 Find I_o in the circuit in Fig. P3.48 using nodal analysis.

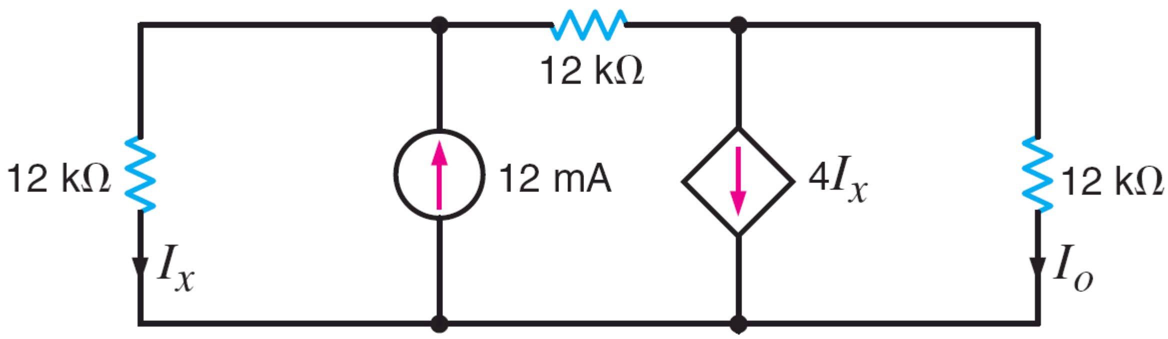
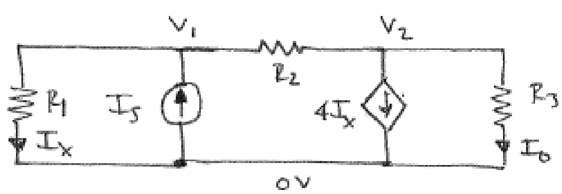


Figure P3.48

SOLUTION:

3.48 Find I_o by nodal.



All R = 12kΩ I_s = 12mA

@ V_1: $I_s = \frac{V_1}{R_1} + \frac{V_1 - V_2}{R_2}$

@ V_2: $\frac{V_2 - V_1}{R_2} + \frac{V_2}{R_3} + 4I_x = 0$

$I_x = V_1 / R_1$

$I_o = V_2 / R_3$

$\boxed{I_o = 5.14\text{mA}}$

3.49 Find V_o in the network in Fig. P3.49 using nodal analysis.

CS

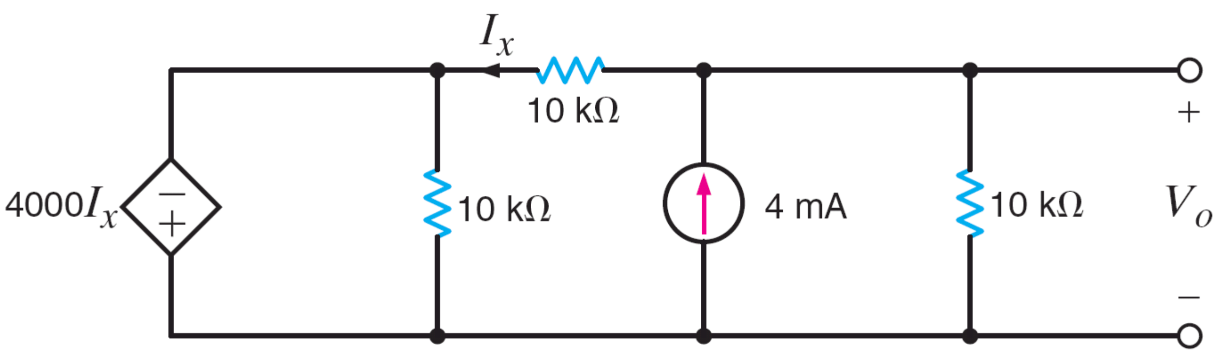
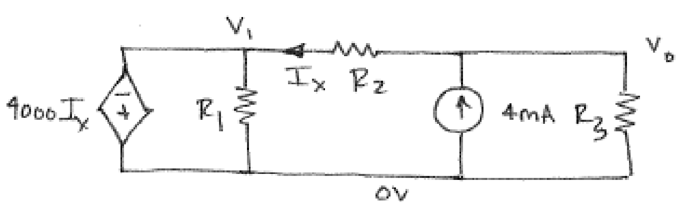


Figure P3.49

SOLUTION:

3.49 Find V_o by nodal.



$R_1 = R_2 = R_3 = 10k\Omega$

$V_1 = -4000 I_x$

$I_x = (V_o - V_1)/R_2$

@ V_o: $\dfrac{V_o}{R_3} + \dfrac{V_o - V_1}{R_2} = 4\times10^{-3}$

$V_o = 15V$

3.50 Find V_o in the circuit in Fig. P3.50. **PSV**

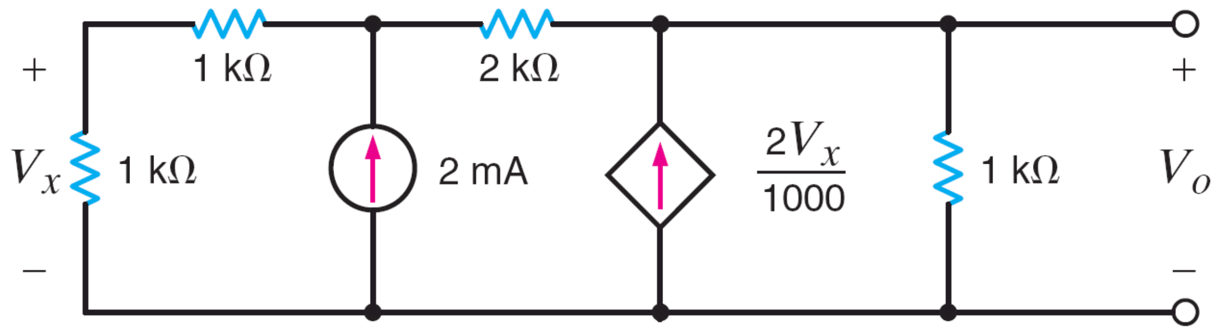
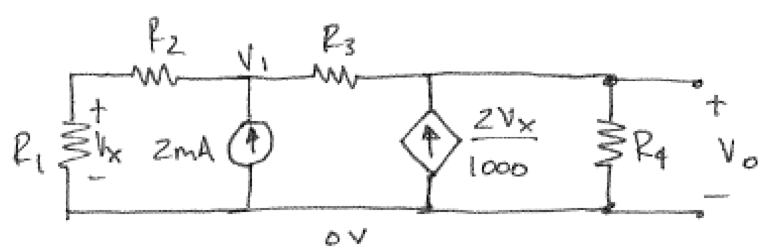


Figure P3.50

SOLUTION:

3.50 Find V_o



$R_1 = R_2 = R_4 = 1k\Omega$

$R_3 = 2k\Omega$

Nodal Analysis:

$$2\times10^{-3} = \frac{V_1 - V_o}{R_3} + \frac{V_1}{R_1+R_2}$$

$$\frac{2V_x}{1000} = \frac{V_o - V_1}{R_3} + \frac{V_o}{R_4}$$

Voltage Division

$$V_x = V_1\left[\frac{R_1}{R_1+R_2}\right]$$

$$V_x = V_1/2$$

$$\boxed{V_o = 4V}$$

3.51 Use nodal analysis to find V_o in the circuit in Fig. P3.51. In addition, find all branch currents and check your answers using KCL at every node.

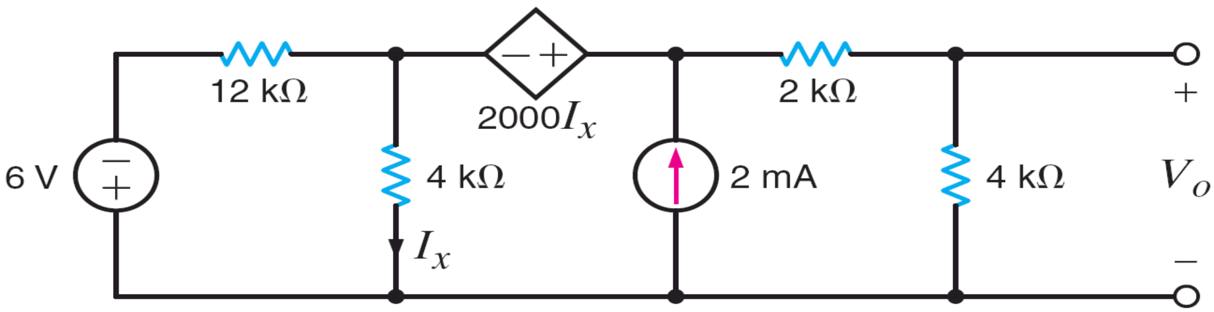
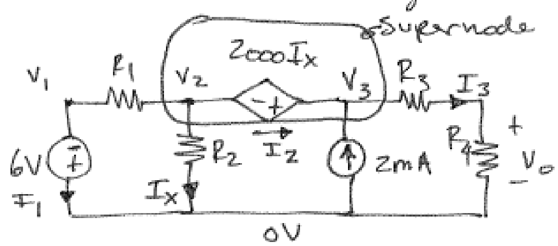


Figure P3.51

SOLUTION:

3.51 Use nodal analysis to find V_o & check via KCL.



$R_1 = 12k\Omega$ $\quad R_2 = 4k\Omega$

$R_3 = 2k\Omega$ $\quad R_4 = 4k\Omega$

$V_1 = -6V \qquad V_2 - V_3 = -2000 I_x \qquad I_x = V_2/R_2$

$$\frac{V_3 - V_o}{R_3} = \frac{V_o}{R_4} \qquad \frac{V_2 - V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3 - V_o}{R_3} = 2\times10^{-3}$$

Solve for V_o : $\boxed{V_o = 2.57V}$

$I_1 = 714\mu A \qquad I_x = 643\mu A \qquad I_2 = -1357\mu A \qquad I_3 = 643\mu A$

@ V_2 $\qquad I_1 + I_2 + I_x = 0$? $\qquad 714 + 643 - 1357 = 0$ ✓

@ V_3 $\qquad I_2 + 2\times10^{-3} = I_3 \qquad -1357 + 2000 = 643$ ✓

@ ref: $\qquad I_1 + I_x + I_3 = 2\times10^{-3} \qquad 714 + 643 + 643 - 2000 = 0$ ✓

3.52 Find the power supplied by the 2-A current source in the network in Fig. P3.52 using nodal analysis.

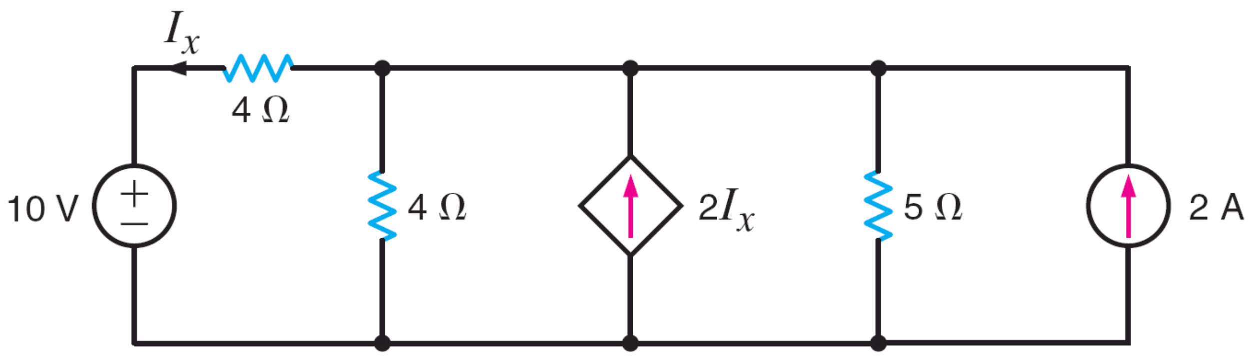
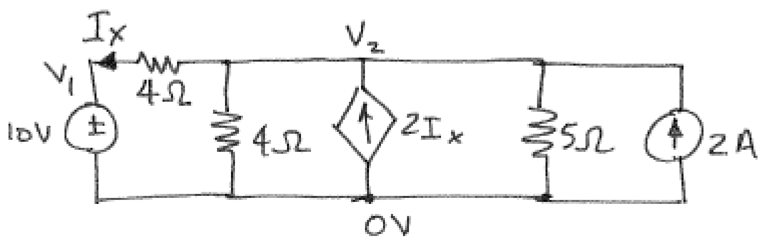


Figure P3.52

SOLUTION:

3.52 Find P_{2A} by nodal analysis.



$V_1 = 10V$

$I_x = \frac{V_2 - V_1}{4}$

$$2 + 2I_x = \frac{V_2}{4} + \frac{V_2}{5} + \frac{V_2 - V_1}{4} \Rightarrow \quad V_2 =$$

$P_{2A} = (2)(V_2) = -5$ W supplied

2A-source absorbs 5W

3.53 Use nodal equations for the circuit in Fig. P3.53 to determine V_o .

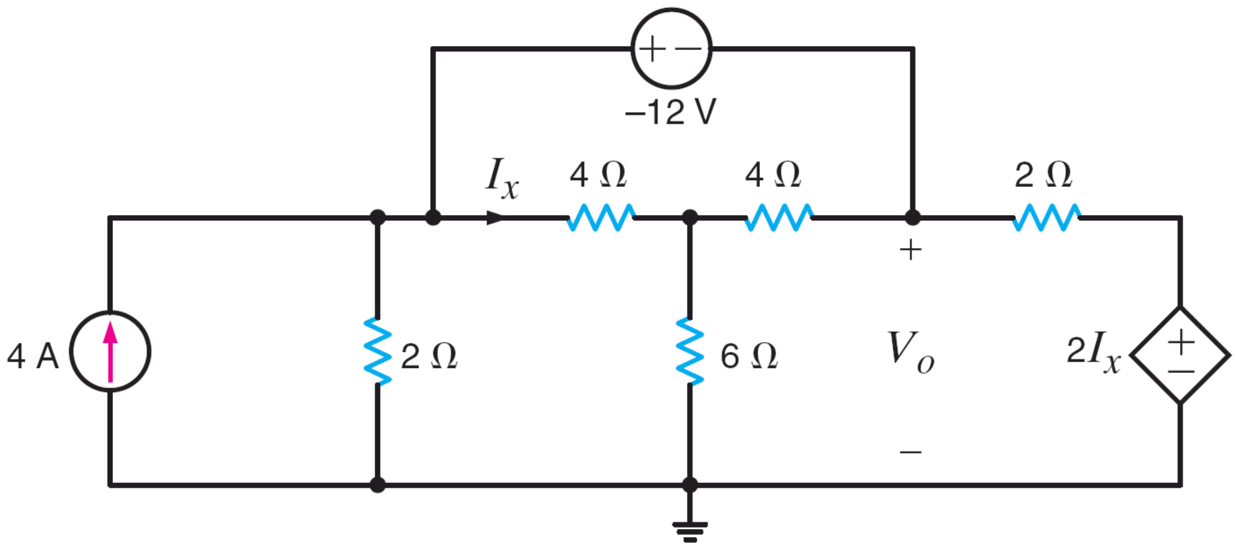
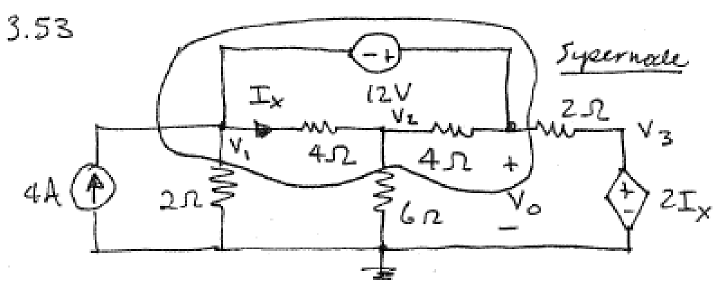


Figure P3.53

SOLUTION:

3.53



Find V_o by nodal analysis.

$12 = V_o - V_1$

$2I_x = V_3$

$I_x = (V_1 - V_2)/4$

at V_2: $\frac{V_1 - V_2}{4} + \frac{V_o - V_2}{4} = \frac{V_2}{6}$

at supernode: $4 = \frac{V_1}{2} + \frac{V_2}{6} + \frac{V_o - V_3}{2}$

Solve for V_o: $\boxed{V_o = 8.35\text{ V}}$

3.54 Determine V_o in the network in Fig. P3.54 using nodal analysis.

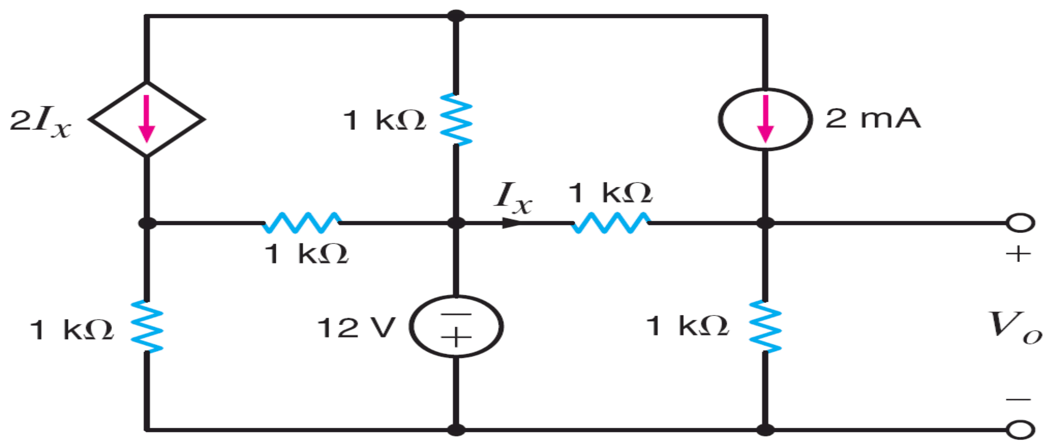
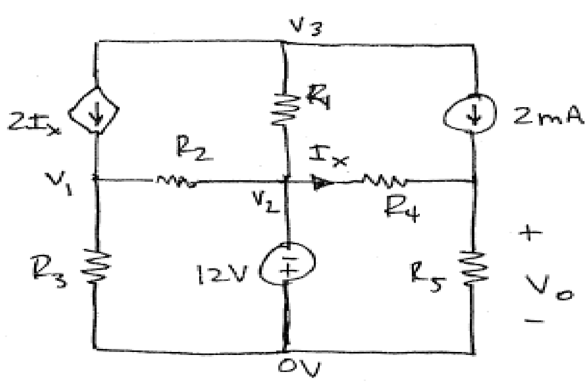


Figure P3.54

SOLUTION:

3.54 Find V_o by nodal analysis.



All R's = 1kΩ

$V_2 = -12$

$I_x = \frac{V_2 - V_o}{R_4}$

at V_3: $2I_x + 2\times10^{-3} + \frac{V_3 - V_2}{R_1} = 0$

at V_1: $2I_x + \frac{V_2 - V_1}{R_2} = \frac{V_1}{R_3}$

at V_o: $2\times10^{-3} + \frac{V_2 - V_o}{R_4} = \frac{V_o}{R_5}$

Solve for V_o: $\boxed{V_o = -5V}$

3.55 Calculate V_o in the circuit in Fig. P3.55 using nodal analysis.

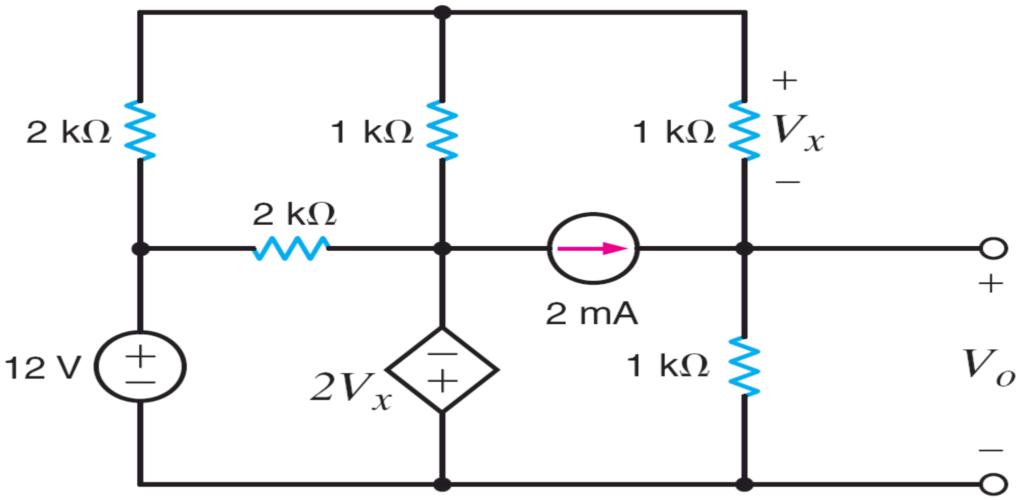
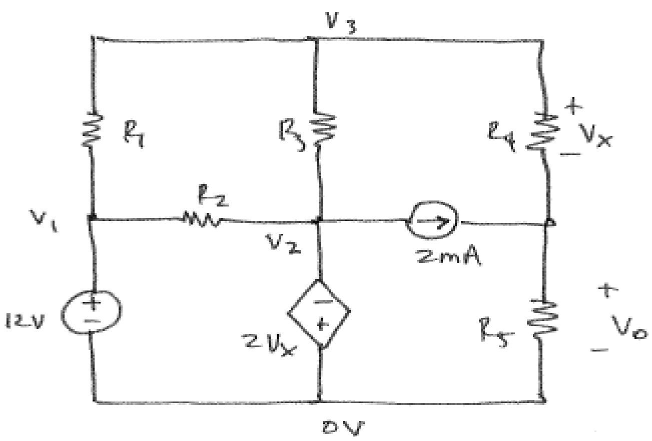


Figure P3.55

SOLUTION:

3.55 Find V_o by nodal analysis.



$R_1 = R_2 = 2\text{k}\Omega$

$R_3 = R_4 = R_5 = 1\text{k}\Omega$

$V_x = V_3 - V_o$

$V_1 = 12\text{V}$

$V_2 = -2V_x$

at V_3: $$\frac{V_3 - V_1}{R_1} + \frac{V_3 - V_2}{R_3} + \frac{V_3 - V_o}{R_4} = 0$$

at V_o: $$\frac{V_3 - V_o}{R_4} + 2\times10^{-3} = \frac{V_o}{R_5}$$

Solve for V_o: $\boxed{V_o = 2.5\text{V}}$

3.56 Using nodal analysis, find V_o in the network in Fig. P3.56.

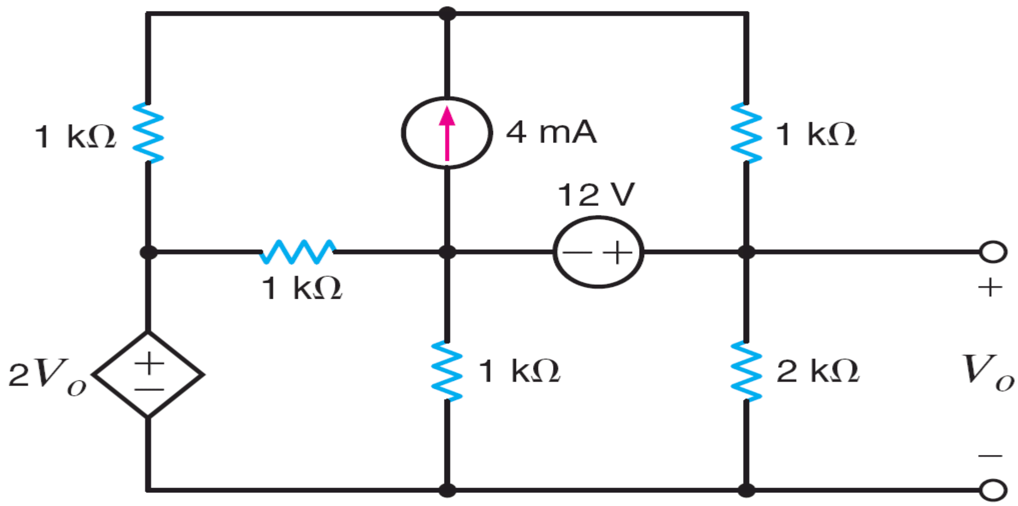
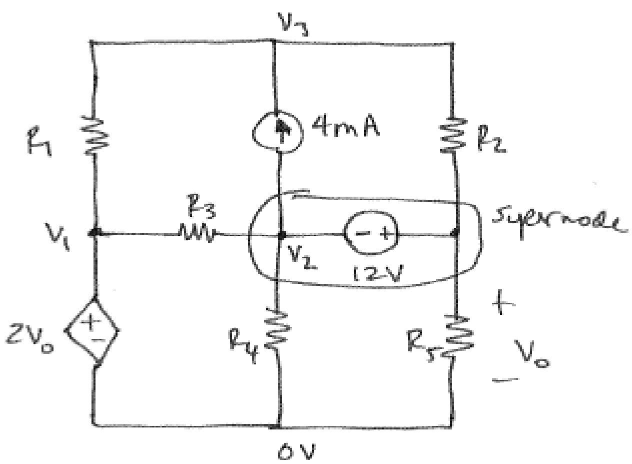


Figure P3.56

SOLUTION:

3.56 Find V_o by nodal analysis.



$R_1 = R_2 = R_3 = R_4 = 1k\Omega$

$R_5 = 2k\Omega$

$V_1 = 2V_o$

$V_o - V_2 = 12V$

at V_3:

$$4\times10^{-3} = \frac{V_3 - V_1}{R_1} + \frac{V_3 - V_o}{R_2}$$

at supernode:

$$\frac{V_o}{R_5} + \frac{V_2}{R_4} + \frac{V_o - V_3}{R_2} + \frac{V_2 - V_1}{R_3} + 4\times10^{-3} = 0$$

Solve for V_o:

$$\boxed{V_o = \infty\ V}$$

3.57 Use nodal analysis to find V_o in the circuit in Fig. P3.57.

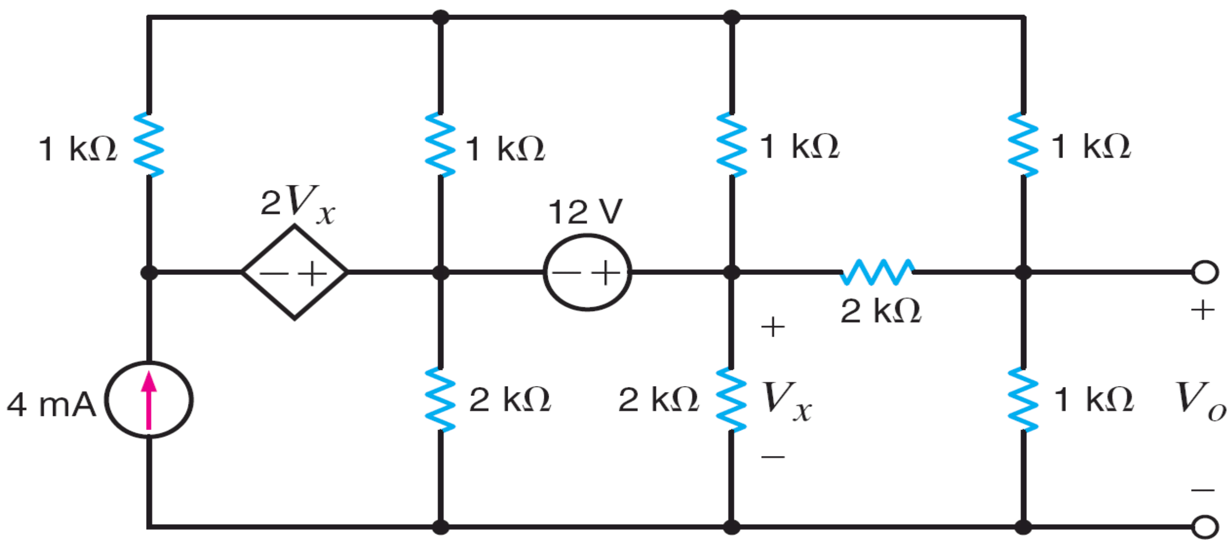
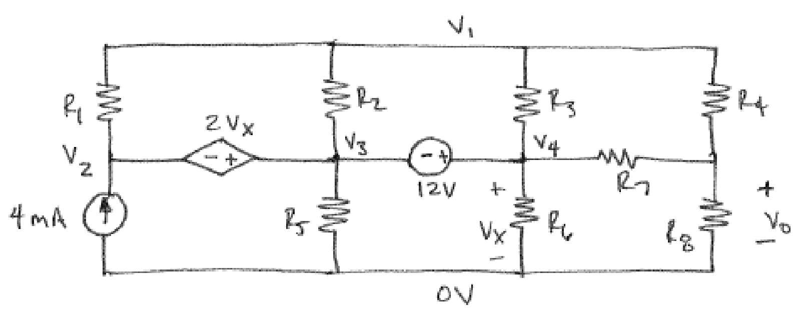


Figure P3.57

SOLUTION:

3.57 Find V_o by nodal analysis.



$R_1 = R_2 = R_3 = R_4 = R_8 = 1k\Omega$

$R_5 = R_6 = R_7 = 2k\Omega$

$V_4 - V_3 = 12$

$V_3 - V_2 = 2V_x$

$V_x = V_4$

at V_1
$$\frac{V_1 - V_2}{R_1} + \frac{V_1 - V_3}{R_2} + \frac{V_1 - V_4}{R_3} + \frac{V_1 - V_o}{R_4} = 0$$

at ref
$$\frac{V_3}{R_5} + \frac{V_4}{R_6} + \frac{V_o}{R_8} = 4\times10^{-3}$$

Solve for V_o: $\boxed{V_o = 0.5V}$

3.58 Use nodal analysis to determine I_o in the circuit in Fig. P3.58.

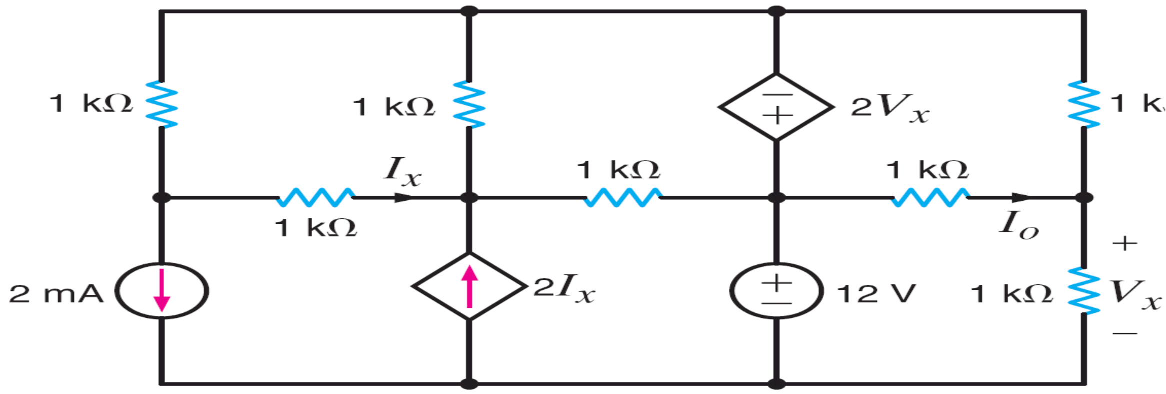
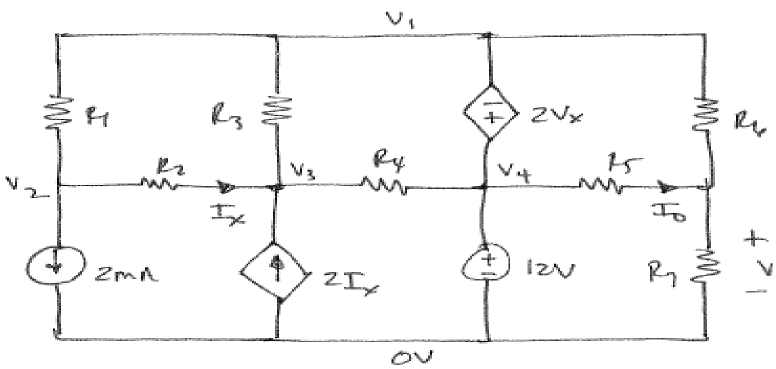


Figure P3.58

SOLUTION:

3.58 Use nodal to find I_o



All R's = 1kΩ

$V_4 - V_1 = 2V_x$

$V_4 = 12V$

$I_x = (V_2 - V_3)/R_2$

at V_2: $\dfrac{V_2 - V_1}{R_1} + \dfrac{V_2 - V_3}{R_2} + 2\times10^{-3} = 0$

at V_3: $\dfrac{V_3 - V_2}{R_2} + \dfrac{V_3 - V_1}{R_3} + \dfrac{V_3 - V_4}{R_4} = 2I_x$

at V_x: $\dfrac{V_x}{R_7} + \dfrac{V_x - V_4}{R_5} + \dfrac{V_x - V_1}{R_6} = 0$

Finally, $I_o = (V_4 - V_x)/R_5$

$V_4 = 12V$ $\qquad V_x = 4.8V$ $\qquad \boxed{I_o = 7.2\,mA}$

3.59 Find I_o in the network in Fig. P3.59 using nodal analysis.

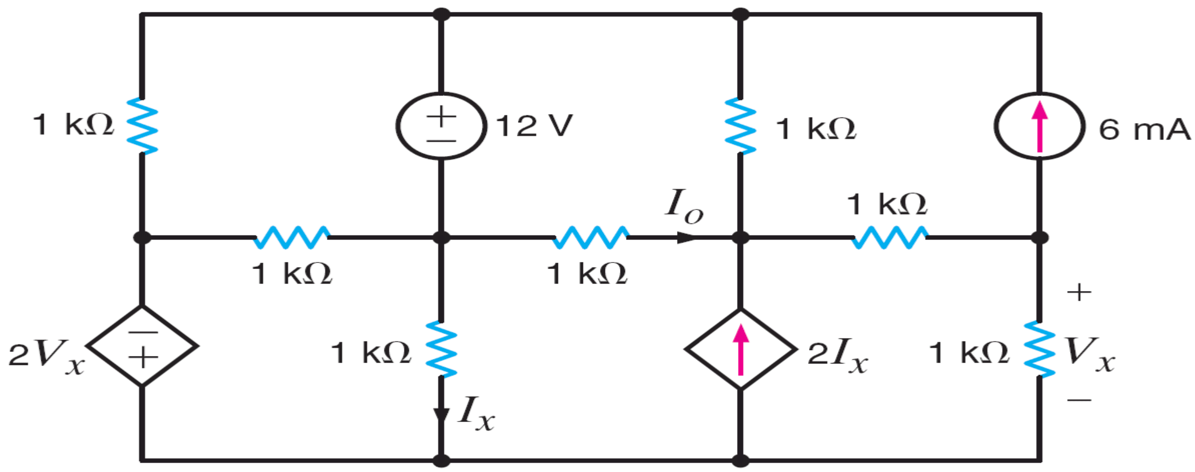
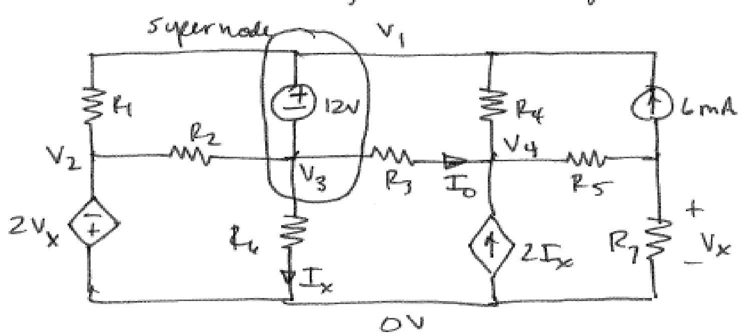


Figure P3.59

SOLUTION:

3.59 Find I_o by nodal analysis



All R's = 1kΩ

$12 = V_1 - V_3$

$2V_x + V_2 = 0$

$I_x = V_3 / R_6$

At V_4: $$\frac{V_4 - V_1}{R_4} + \frac{V_4 - V_x}{R_5} + \frac{V_4 - V_3}{R_3} = 2I_x$$

At supernode: $$\frac{V_1 - V_2}{R_1} + \frac{V_1 - V_4}{R_4} - 6\times10^{-3} + \frac{V_3 - V_2}{R_2} + \frac{V_3 - V_4}{R_3} + \frac{V_3}{R_6} = 0$$

And $$I_o = \frac{V_3 - V_4}{R_3}$$

$V_3 = -1.2V$ $\quad$ $V_4 = 1.68V$ $\quad$ $\boxed{I_o = 2.88mA}$

3.60 Given the network in Fig. P3.60, we wish to determine the power dissipated in the resistor R_3.

(a) Is mesh or nodal analysis the most efficient approach? Why?

(b) For a nodal analysis, comment on the advantages of selecting node 1 as the reference node. Repeat for nodes 2, 3, and 4.

(c) Based on your results in (b), write the node equations.

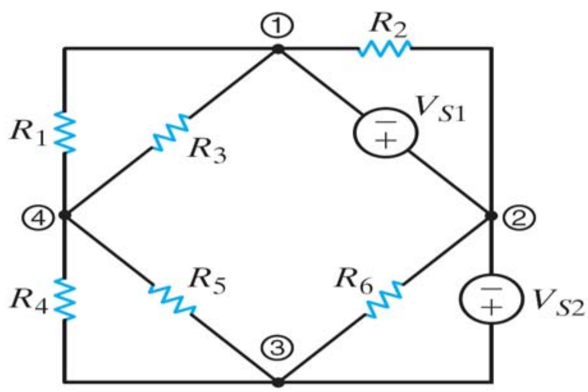


Figure P3.60

SOLUTION:

3.60 Find power absorbed by R_3.

a) Mesh or nodal?

5 mesh vs. 3 non-ref nodes ⇒ nodal.

b) Justify ref node choice

Node 1 - Great choice. V_{R_3} will be V_4.

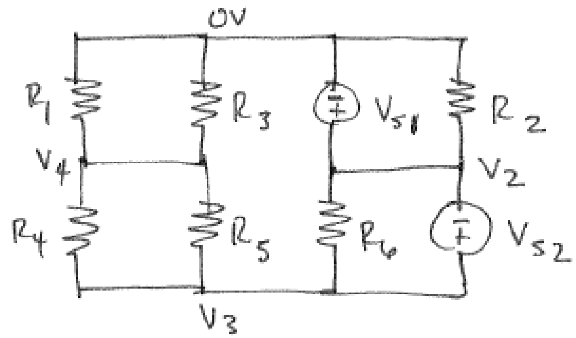
Node 4 - Just as good as choosing node 1. V_{R_3} will be V_1.

Node 2 - Poor choice. $V_{R_3} = V_1 - V_4$ requiring 2 calculations. But V_{S1} & V_{S2} will be simple to write in terms of node voltages

Node 3 - Worst choice of all.

Continued on the next page.

c) Choose V_1 as reference.



$$V_{S1} = V_2$$

$$V_{S2} = V_3 - V_2$$

$$\frac{V_4}{R_1} + \frac{V_4}{R_3} + \frac{V_4 - V_3}{R_4} + \frac{V_4 - V_3}{R_5} = 0$$

3.61 In the circuit in Fig. P3.61, use Gaussian elimination to determine V_o.

(a) Would mesh or nodal analysis be the most efficient approach? Why?

(b) If mesh analysis is used, are any supermeshes required? Write the mesh equations. If nodal analysis is used, are any supernodes required? If so, how many? What is the best location for the reference node and why? Write the node equations.

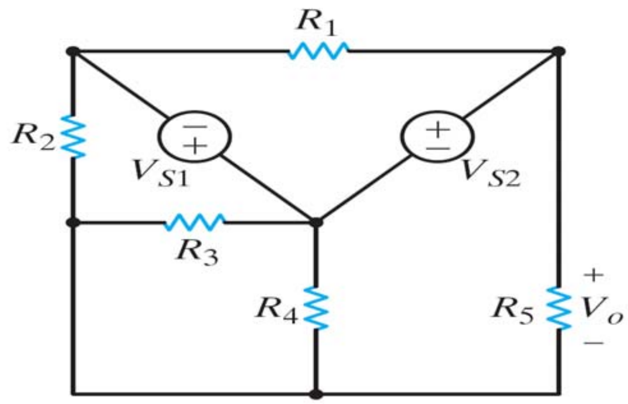


Figure P3.61

SOLUTION:

3.61 Find V_o

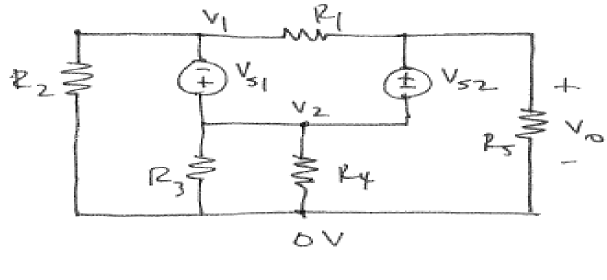
a) Mesh or nodal?

4 meshes, 3 non-ref. nodes, 2 voltage sources ⇒ Nodal

b) No supermeshes required because there are no current sources

No supernodes are needed because the 2 voltage sources connect at only 3 of the nodes, leaving the 4th node free for application of KCL.

Best location for ref node is at bottom of schematic.



$$V_1 - V_2 = -V_{S1}$$

$$V_o - V_2 = V_{S2}$$

$$\frac{V_1}{R_2} + \frac{V_2}{R_3} + \frac{V_2}{R_4} + \frac{V_o}{R_5} = 0$$

3.62 Use mesh equations to find V_o in the circuit in Fig. P3.62.

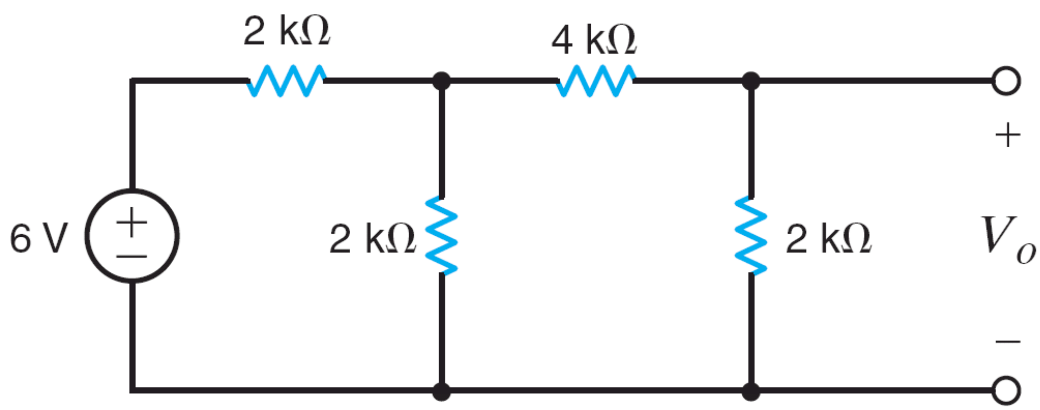
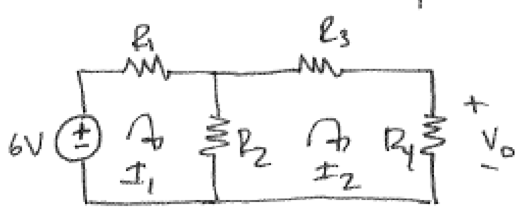


Figure P3.62

SOLUTION:

3.62 Use mesh analysis to find V_o.



$R_1 = R_2 = R_4 = 2k\Omega \quad R_3 = 4k\Omega$

$6 = I_1 R_1 + (I_1 - I_2) R_2$

$0 = -R_2 I_1 + I_2 (R_2 + R_3 + R_4)$

$V_o = I_2 R_4$

$I_2 = 429 \mu A$ $\boxed{V_o = 858 mV}$

3.63 Find V_o in the network in Fig. P3.63 using mesh equations. **PSV**

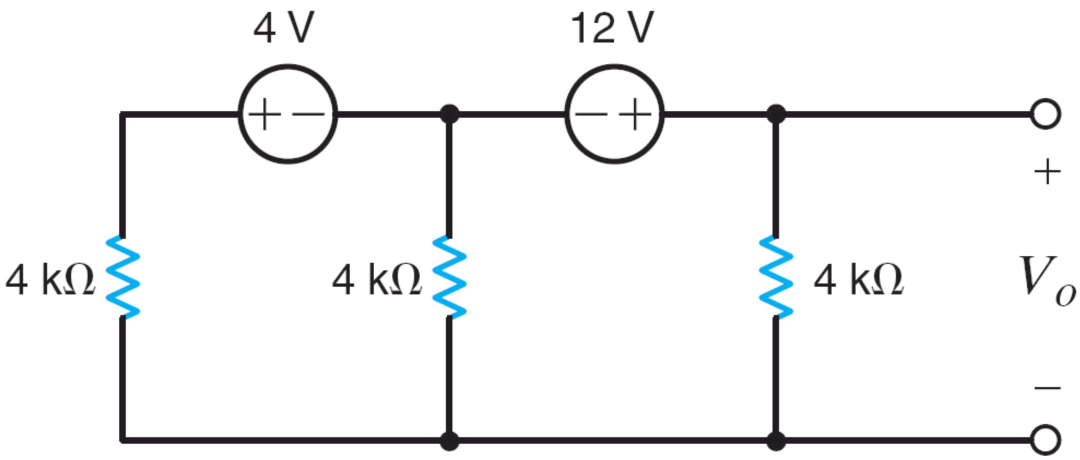
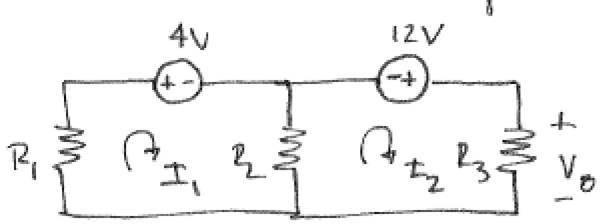


Figure P3.63

SOLUTION:

3.63 Use mesh analysis to find V_o.



all R's = 4kΩ

$$I_1R_1 + (I_1 - I_2)R_2 + 4 = 0$$

$$I_2R_3 + (I_2 - I_1)R_2 = 12$$

$$V_o = I_2R_3$$

$I_2 = 1.67$ mA

$$\boxed{V_o = 6.67V}$$

3.64 Use mesh analysis to find V_o in the circuit in Fig. P3.64.

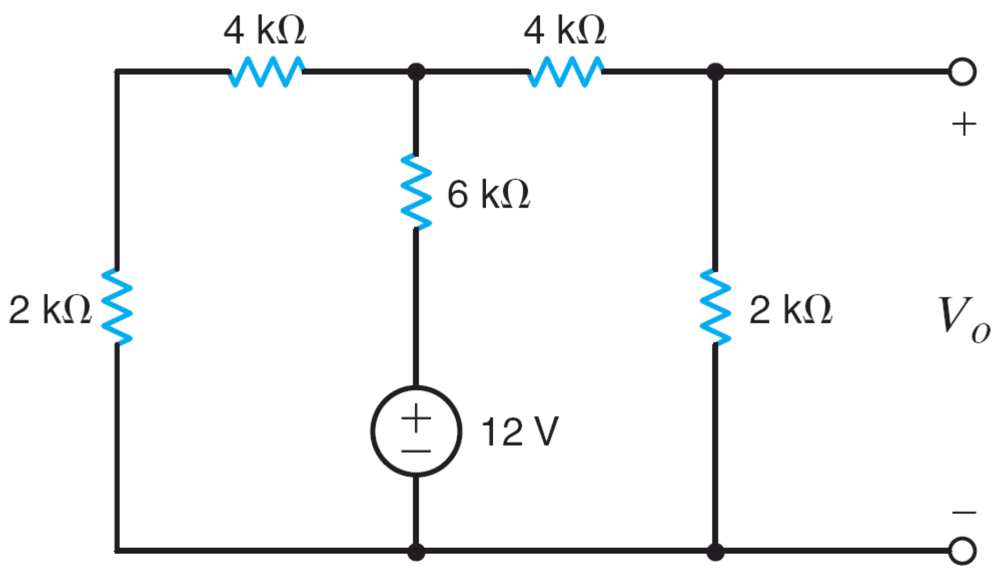
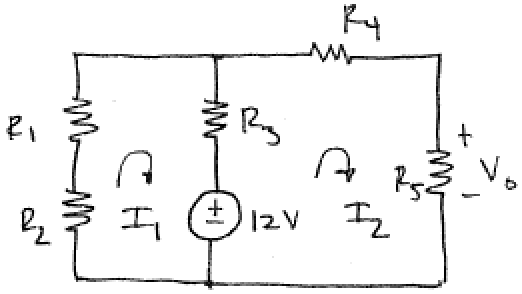


Figure P3.64

SOLUTION:

3.64 Use mesh to find V_o



$R_1 = 4k\Omega \quad R_2 = 2k\Omega \quad R_3 = 6k\Omega$

$R_4 = 4k\Omega \quad R_5 = 2k\Omega$

$V_o = I_2 R_5$

$$I_1 R_1 + I_1 R_2 + (I_1 - I_2) R_3 + 12 = 0$$

$$I_2 R_4 + I_2 R_5 + (I_2 - I_1) R_3 = 12$$

$I_2 = 0.67\ mA$ $\boxed{V_o = 1.33V}$

3.65 Use mesh analysis to find V_o in the circuit in Fig. P3.65.

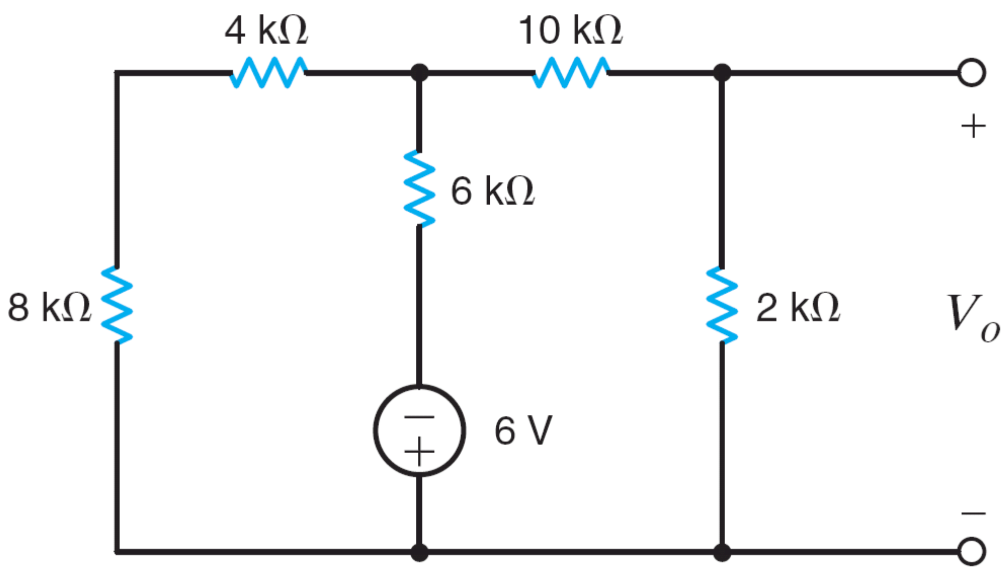
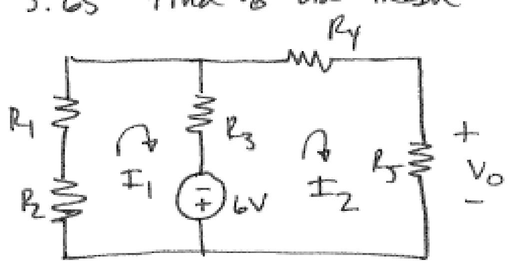


Figure P3.65

SOLUTION:

3.65 find V_o via mesh



$R_1 = 4k\Omega \quad R_2 = 8k\Omega \quad R_3 = 6k\Omega$

$R_4 = 10k\Omega \quad R_5 = 2k\Omega$

$V_o = I_2 R_5$

$$I_1 R_1 + I_1 R_2 + (I_1 - I_2) R_3 = 6$$

$$I_2 R_4 + I_2 R_5 + (I_2 - I_1) R_3 = -6$$

$I_2 = -250 \mu A$ $\boxed{V_o = -0.5 V}$

3.66 Use mesh analysis to find V_o in the network in Fig. P3.66. CS

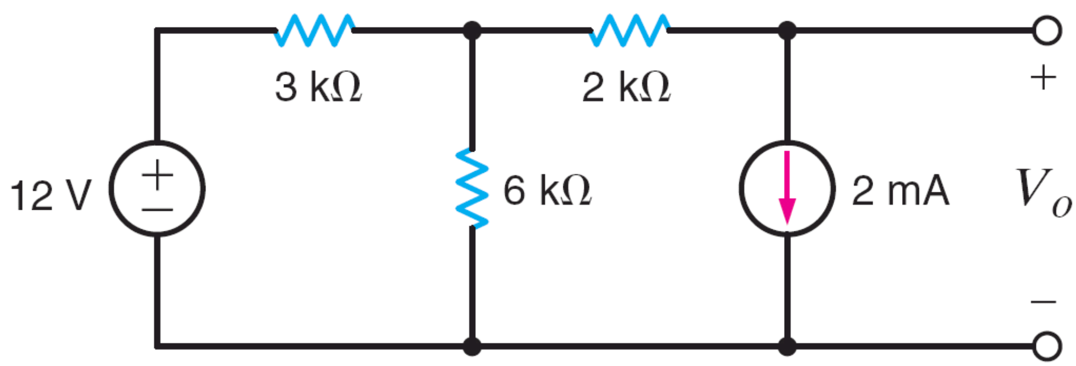
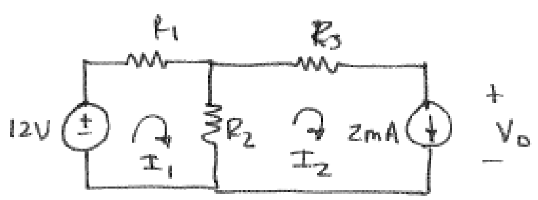


Figure P3.66

SOLUTION:

3.66 Find V_o using mesh analysis.



$R_1 = 3k\Omega \quad R_2 = 6k\Omega \quad R_3 = 2k\Omega$

$I_2 = 2mA$

$12 = I_1 R_1 + (I_1 - I_2) R_2$

$V_o = 12 - I_1 R_1 - I_2 R_3$

$I_1 = 2.67\ mA$

$\boxed{V_o = 0V}$

3.67 Use loop analysis to find V_o in the circuit in Fig. P3.67.

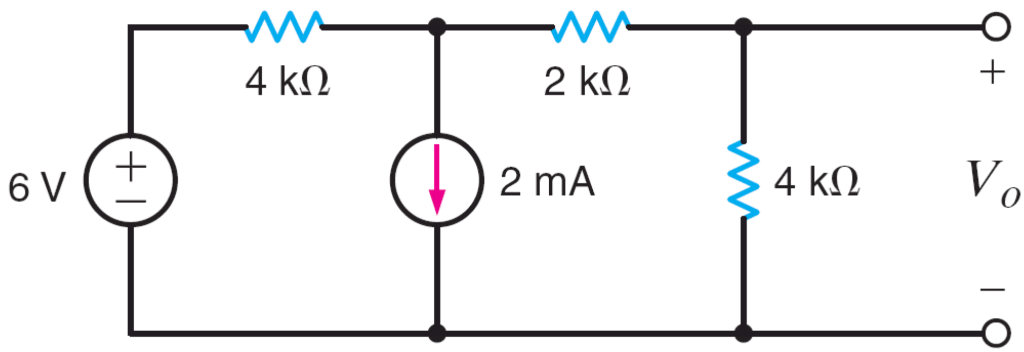
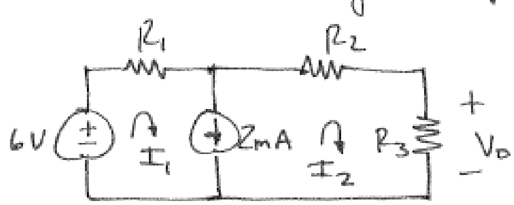


Figure P3.67

SOLUTION:

3.67 Find V_o using loop analysis.



$R_1 = 4k\Omega \quad R_2 = 2k\Omega \quad R_3 = 4k\Omega$

$2mA = I_1 - I_2$

$6 = I_1 R_1 + I_2 R_2 + I_2 R_3$

$V_o = I_2 R_3$

$I_2 = -200\,\mu A$

$\boxed{V_o = -0.8V}$

3.68 Use loop analysis to find V_o in the network in Fig. P3.68.
PSV

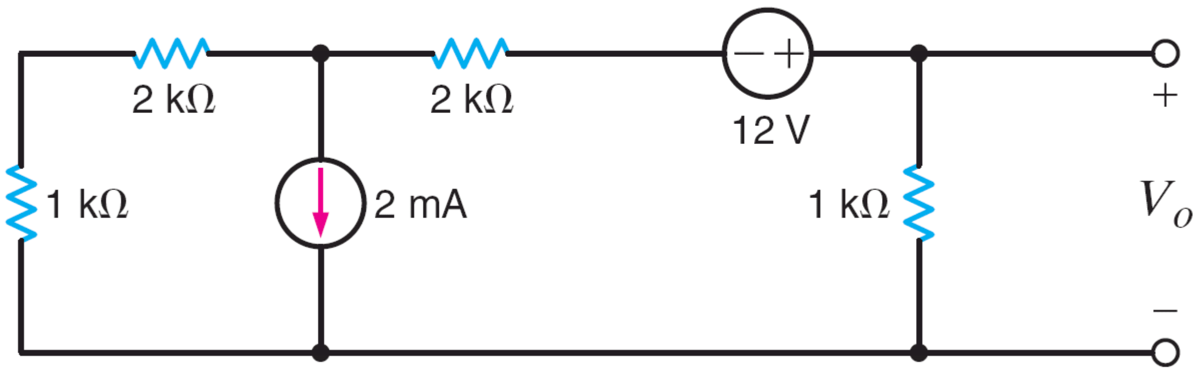
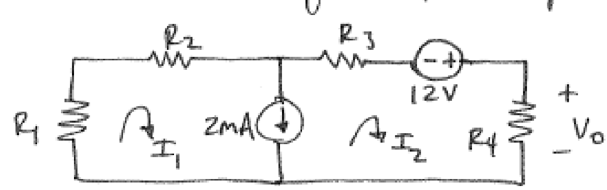


Figure P3.68

SOLUTION:

3.68 Find V_o using loop analysis.



$R_1 = R_4 = 1k\Omega \qquad R_2 = R_3 = 2k\Omega$

$V_o = I_2 R_4$

$I_1 - I_2 = 2mA \qquad I_1 R_1 + I_1 R_2 + I_2 R_3 + I_2 R_4 = 12$

$I_2 = 1mA \qquad \boxed{V_o = 1V}$

3.69 Find I_o in the network in Fig. P3.69 using mesh analysis.
cs

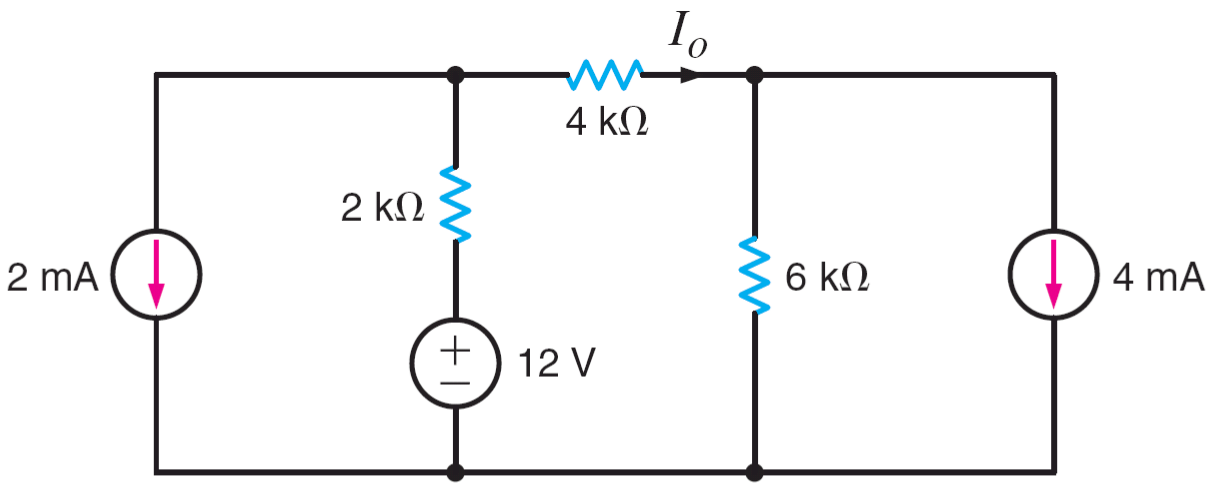
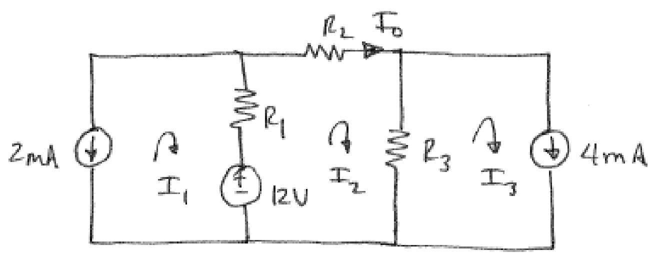


Figure P3.69

SOLUTION:

3.69 Use mesh analysis to find I_o.



$R_1 = 2k\Omega \quad R_2 = 4k\Omega \quad R_3 = 6k\Omega$

$I_o = I_2$

$I_1 = -2mA$

$I_3 = 4mA$

$12 = (I_2 - I_1)R_1 + I_2 R_2 + (I_2 - I_3)R_3 \Rightarrow I_2 = 2.67mA$

$\boxed{I_o = 2.67mA}$

3.70 Use both nodal analysis and mesh analysis to find I_o in the circuit in Fig. P3.70.

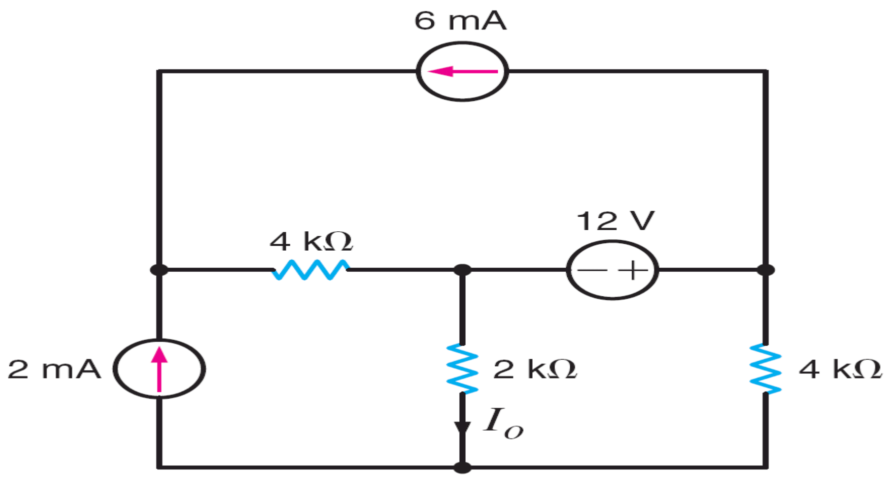
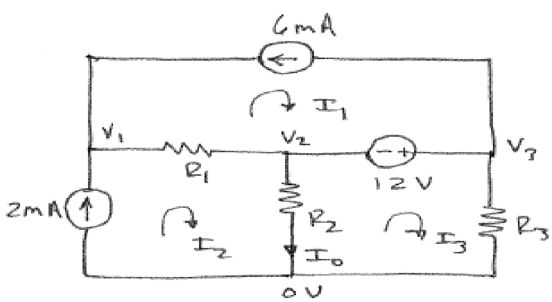


Figure P3.70

SOLUTION:

3.70 Use nodal & mesh to find I_o.



$R_1 = 4k\Omega$ $R_2 = 2k\Omega$ $R_3 = 4k\Omega$

Mesh

$I_1 = -6mA$

$I_2 = 2mA$

$12 = I_3 R_3 + (I_3 - I_2) R_2$

$I_o = I_2 - I_3$

$I_2 = 2mA$

$I_3 = 2.67mA$

$\boxed{I_o = -0.67mA}$

Nodal

$V_3 - V_2 = 12$

$6 \times 10^{-3} + 2 \times 10^{-3} + \frac{V_2 - V_1}{R_1} = 0$

$V_2/R_2 + V_3/R_3 = 2 \times 10^{-3}$

$I_o = V_2/R_2$

$V_2 = -1.33V$

$\boxed{I_o = -0.67mA}$

3.71 Find I_o in the network in Fig. P3.71 using loop analysis. Then solve the problem using MATLAB and compare your answers. CS

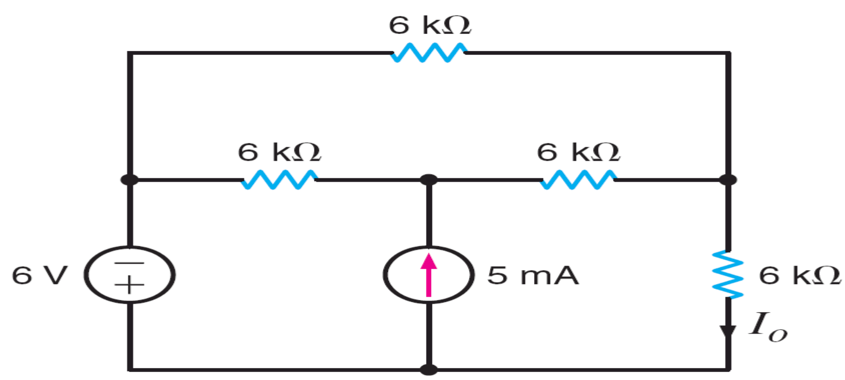
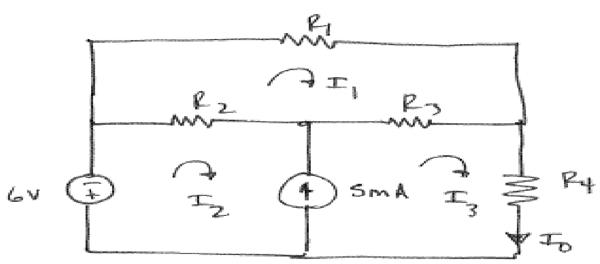


Figure P3.71

SOLUTION:

3.71 Find I_o using loop analysis. Verify with MATLAB.



All R's = $6k\Omega$

$I_3 - I_2 = 5mA$

$I_o = I_3$

$$I_1R_1 + (I_1 - I_3)R_3 + (I_1 - I_2)R_2 = 0$$

$$6 + (I_2 - I_1)R_2 + (I_3 - I_1)R_3 + I_3R_4 = 0$$

$I_3 = 0.4mA$ $\boxed{I_o = 0.4mA}$

Format for MATLAB

$$I_1(R_1 + R_2 + R_3) - R_2I_2 - R_3I_3 = 0$$

$$-I_1(R_2 + R_3) + R_2I_2 + I_3(R_3 + R_4) = -6$$

$$-I_2 + I_3 = 5\times10^{-3}$$

$$\begin{bmatrix} 18\times10^3 & -6\times10^3 & -6\times10^3 \\ -12\times10^3 & +6\times10^3 & 12\times10^3 \\ 0 & -1 & 1 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 0 \\ -6 \\ 5\times10^{-3} \end{bmatrix}$$

Continued on the next page.

3_71.txt

```
MATLAB WORK

Factor 1000 out of the resistance matrix.


EDU» r=[18,-6,-6;-12,6,12;0,-0.001,0.001]

r =

   18.0000   -6.0000   -6.0000
  -12.0000    6.0000   12.0000
         0   -0.0010    0.0010

EDU» v=[0;-6;0.005]

v =

         0
   -6.0000
    0.0050


EDU» 0.001*inv(r)*v

ans =

   -0.0014
   -0.0046
    0.0004
```

3.72 Find V_o in the network in Fig. P3.72 using both mesh and nodal analysis. **PSV**

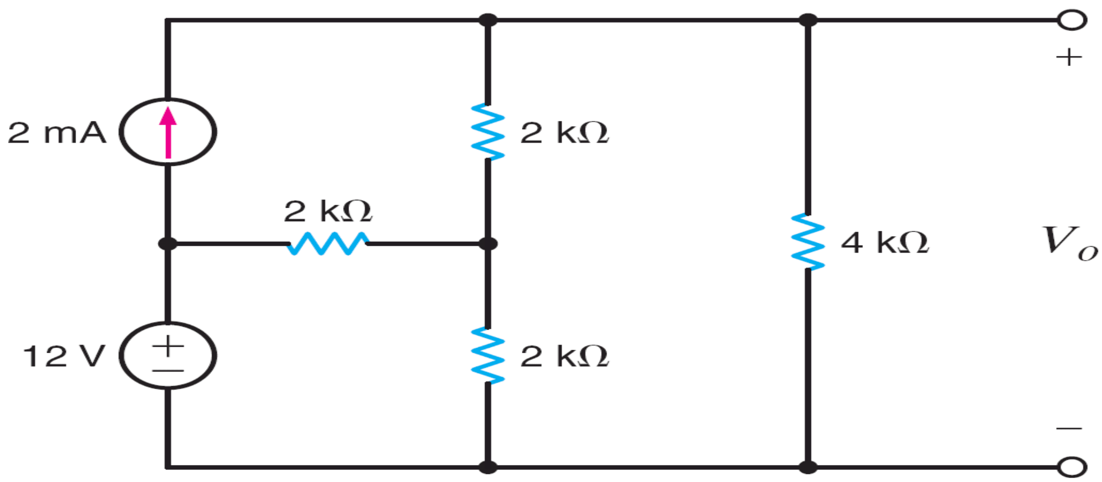
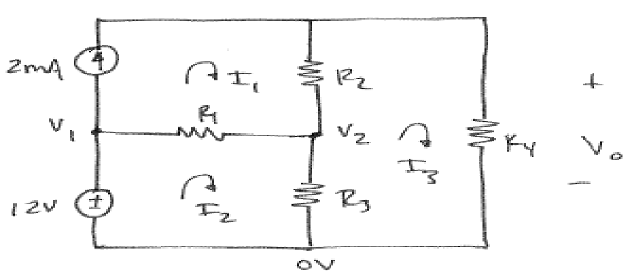


Figure P3.72

SOLUTION:

3.72 Find V_o using mesh & nodal.



$R_1 = R_2 = R_3 = 2\,k\Omega$

$R_4 = 4\,k\Omega$

Mesh

$I_1 = 2mA$

$12 = (I_2 - I_1)R_1 + (I_2 - I_3)R_3$

$0 = (I_3 - I_2)R_3 + (I_3 - I_1)R_2 + I_3 R_4$

$V_o = R_4 I_3$

$I_3 = 1.71\ mA$

$\boxed{V_o = 6.86\ V}$

Nodal

$V_1 = 12V$

$2\times10^{-3} = \frac{V_o - V_2}{R_2} + \frac{V_o}{R_4}$

$\frac{V_o - V_2}{R_2} + \frac{V_1 - V_2}{R_1} + \frac{0 - V_2}{R_3} = 0$

$\boxed{V_o = 6.86\ V}$

3.73 Use loop analysis to find I_o in the network in Fig. P3.73.
CS

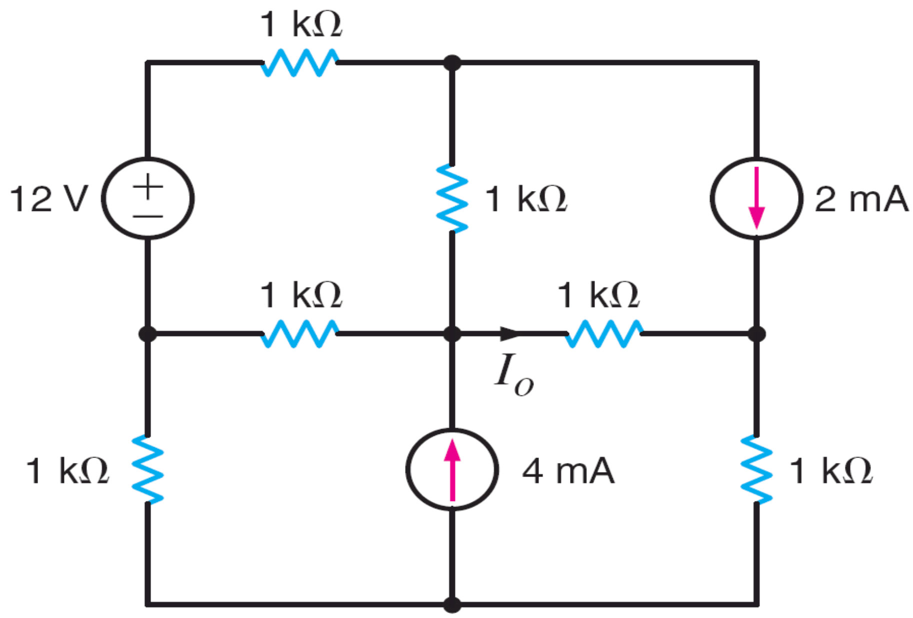
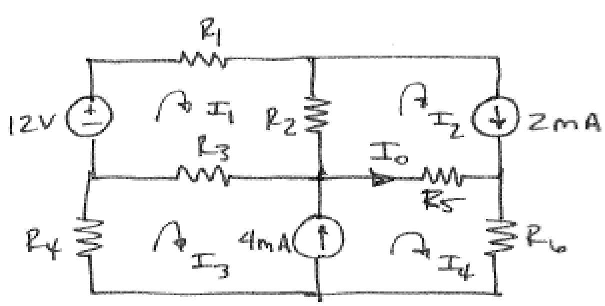


Figure P3.73

SOLUTION:

3.73 Use loop to find I_o.



all R's = 1kΩ

$I_2 = 2mA$

$I_4 - I_3 = 4mA$

$I_o = I_4 - I_2$

$12 = I_1 R_1 + R_2(I_1 - I_2) + R_3(I_1 - I_3)$

$0 = I_3 R_4 + R_3(I_3 - I_1) + R_5(I_4 - I_2) + I_4 R_6$

$I_4 = 3.64mA$

$\boxed{I_o = 1.64mA}$

3.74 Find I_o in the circuit in Fig. P3.74. **CS**

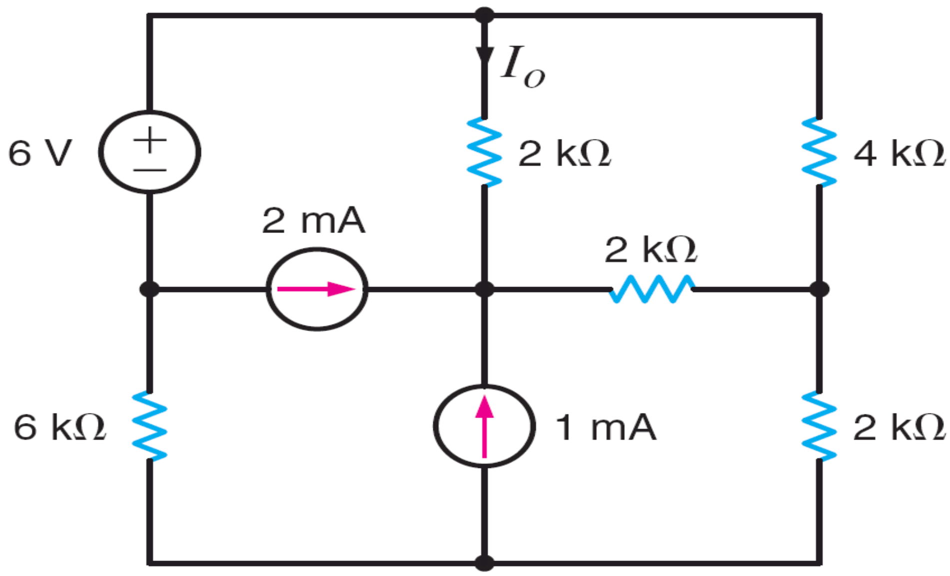
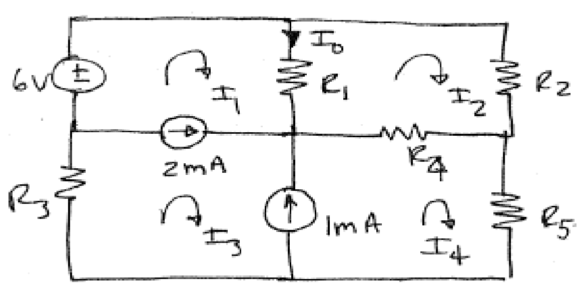


Figure P3.74

SOLUTION:

3.74 Find I_o



$R_1 = R_5 = R_4 = 2k\Omega$

$R_2 = 4k\Omega \quad R_3 = 6k\Omega$

$I_3 - I_1 = 2mA$

$I_4 - I_3 = 1mA$

$I_2 R_2 + (I_2 - I_4) R_4 + (I_2 - I_1) R_1 = 0$

$6 = I_2 R_2 + I_4 R_5 + I_3 R_3$

$I_o = I_1 - I_2$

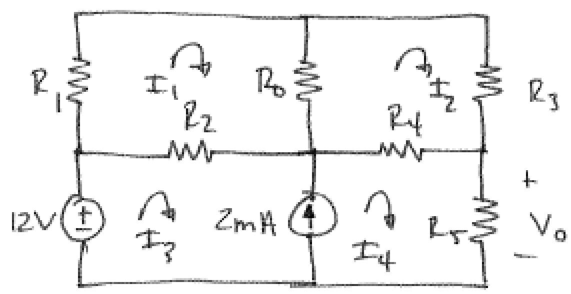
$I_1 = -1.5mA \qquad I_2 = 0A$

$\boxed{I_o = -1.5mA}$

3.75 Solve Problem 3.33 using loop analysis.

SOLUTION:

3.75 Find V_o by loop analysis.



$R_1 = R_3 = R_4 = R_5 = 1k\Omega$

$R_2 = R_o = 2k\Omega$

$V_o = I_4 R_5$

$I_4 - I_3 = 2mA$

$I_1 R_1 + (I_1 - I_2) R_o + (I_1 - I_3) R_2 = 0$

$I_2 R_3 + (I_2 - I_4) R_4 + (I_2 - I_1) R_o = 0$

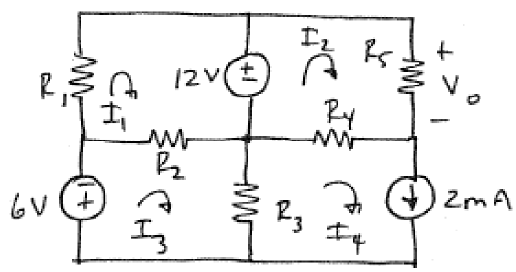
$12 = (I_3 - I_1) R_2 + (I_4 - I_2) R_4 + I_4 R_5$

$I_4 = 6.17 mA$ $\boxed{V_o = 6.17 V}$

3.76 Solve Problem 3.34 using loop analysis.

SOLUTION:

3.76 Find V_o by loop analysis.



$R_1 = R_2 = R_3 = 1k\Omega \qquad R_4 = R_5 = 2k\Omega$

$I_4 = 2mA \qquad V_o = I_2 R_5$

$$6 + (I_3 - I_1) R_2 + (I_3 - I_4) R_3 = 0$$

$$I_1 R_1 + (I_1 - I_3) R_2 + 12 = 0$$

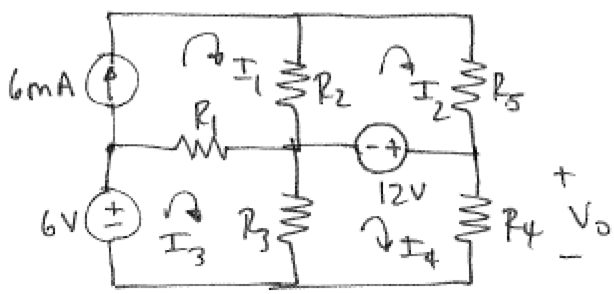
$$I_2 R_5 + (I_2 - I_4) R_4 = 12$$

$I_2 = 4mA \qquad \boxed{V_o = 8V}$

3.77 Solve Problem 3.35 using loop analysis.

SOLUTION:

3.77 Find V_o using loop analysis.



$R_1 = R_2 = R_3 = 1k\Omega$

$R_4 = R_5 = 2k\Omega$

$I_1 = 6mA$

$I_4 R_4 = V_o$

$6 = (I_3 - I_1)R_1 + (I_3 - I_4)R_3$

$-12 = (I_2 - I_1)R_2 + I_2 R_5$

$12 = I_4 R_4 + (I_4 - I_3)R_3$

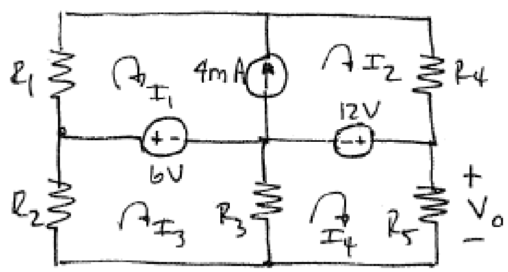
$I_4 = 7.2mA$

$\boxed{V_o = 14.4V}$

3.78 Solve Problem 3.37 using loop analysis.

SOLUTION:

3.78 Find V_o by loop analysis.



$R_1 = R_2 = 2k\Omega \qquad R_3 = R_4 = R_5 = 1k\Omega$

$V_o = I_4 R_5$

$I_2 - I_1 = 4\,mA$

$-6 = R_3(I_3 - I_4) + R_2(I_3)$

$6 = I_1 R_1 + I_2 R_4 + 12$

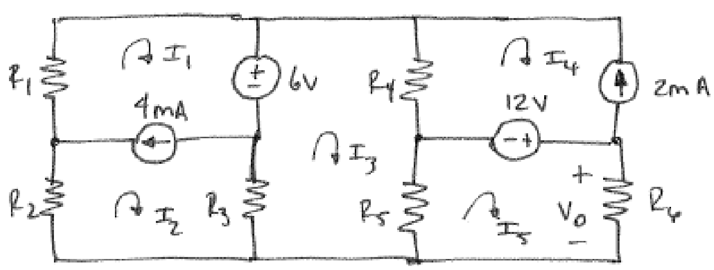
$12 = I_4 R_5 + (I_4 - I_3) R_3$

$I_4 = 6mA$ $\qquad$ $\boxed{V_o = 6V}$

3.79 Solve Problem 3.40 using loop analysis.

SOLUTION:

3.79 Find V_o by loop analysis.



$R_1 = R_2 = 2k\Omega$

$R_3 = R_4 = R_5 = R_6 = 1k\Omega$

$I_4 = -2mA$

$I_1 - I_2 = 4mA$

$$-6 = R_3(I_2 - I_3) + I_2R_2 + I_1R_1$$

$$6 = R_4(I_3 - I_4) + R_5(I_3 - I_5) + R_3(I_3 - I_2)$$

$$12 = R_6I_5 + R_5(I_5 - I_3)$$

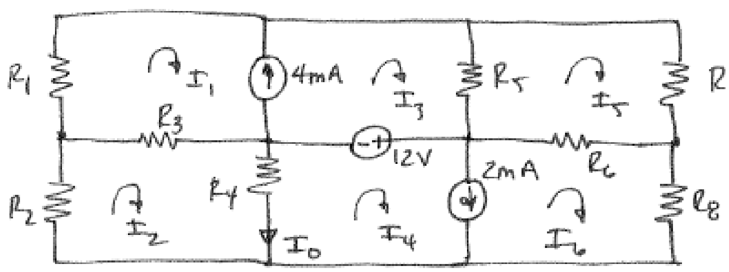
$$V_o = I_5R_6$$

$I_5 = 7.57\ mA$ $\boxed{V_o = 7.57V}$

3.80 Solve Problem 3.43 using loop analysis.

SOLUTION:

3.80 find I_o using loop analysis.



all R's = 1kΩ

$I_3 - I_1 = 4mA$

$I_4 - I_6 = 2mA$

$I_o = I_2 - I_4$

$$0 = I_2R_2 + (I_2 - I_1)R_3 + (I_2 - I_4)R_4$$

$$0 = I_5R_7 + (I_5 - I_6)R_6 + (I_5 - I_3)R_5$$

$$-12 = I_1R_1 + (I_3 - I_5)R_5 + (I_1 - I_2)R_3$$

$$12 = (I_6 - I_5)R_6 + I_6R_8 + I_2R_2 + (I_2 - I_1)R_3$$

$I_2 = 267\mu A$ $\quad$ $I_4 = 5.74mA$ $\quad$ $\boxed{I_o = -5.47mA}$

3.81 Use MATLAB to find the mesh currents in the network in Fig. P3.81. CS

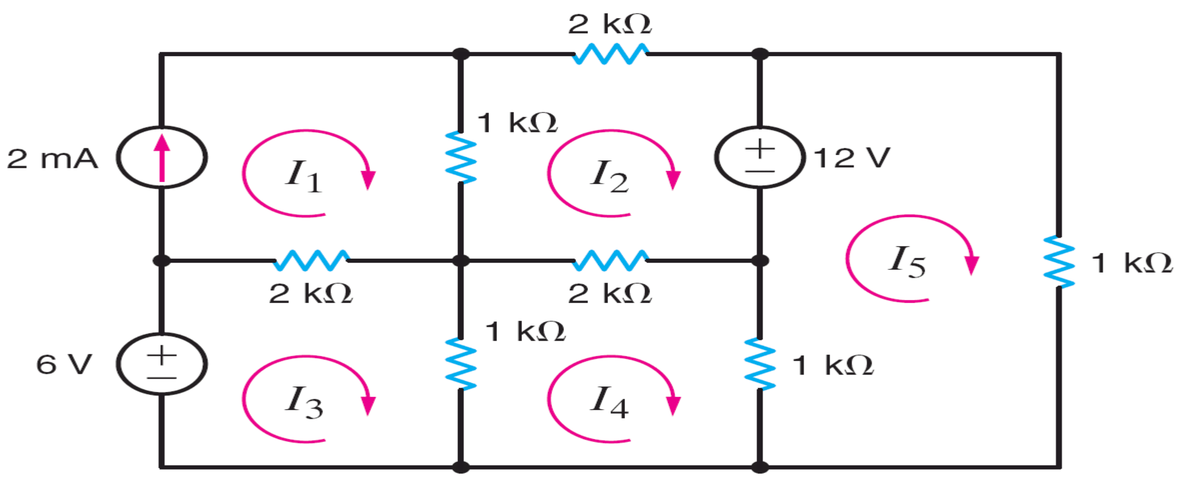
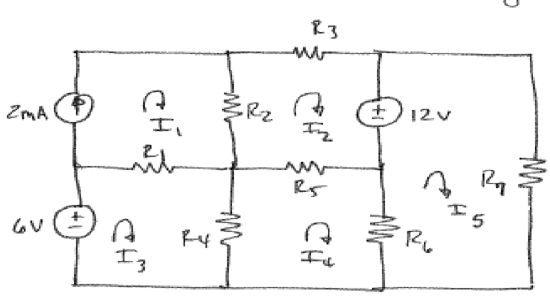


Figure P3.81

SOLUTION:

3.81 Find mesh currents using MATLAB.



$R_1 = R_3 = R_5 = 2k\Omega$

$R_2 = R_4 = R_6 = R_7 = 1k\Omega$

$I_1 = 2mA$

$$6 = (I_3 - I_1)R_1 + (I_3 - I_4)R_4$$

$$0 = (I_4 - I_3)R_4 + (I_4 - I_2)R_5 + (I_4 - I_5)R_6$$

$$-12 = I_2 R_3 + (I_2 - I_4)R_5 + (I_2 - I_1)R_2$$

$$12 = I_5 R_7 + (I_5 - I_4)R_6$$

In matrix form,

$$\begin{bmatrix} -2000 & 0 & 3000 & -1000 & 0 \\ 0 & -2000 & -1000 & 4000 & -1000 \\ -1000 & 5000 & 0 & -2000 & 0 \\ 0 & 0 & 0 & -1000 & 2000 \\ 1 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ I_5 \end{bmatrix} = \begin{bmatrix} 6 \\ 0 \\ -12 \\ 12 \\ 2\times10^{-3} \end{bmatrix}$$

Continued on the next page.

3_81.txt

```
MATLAB WORK

r*i = v

EDU»
r=[-2000,0,3000,-1000,0;0,-2000,-1000,4000,-1000;-1000,5000,0,-2000,0;0,0,0,-1000,20
00;1,0,0,0,0]

r =

       -2000           0        3000       -1000           0
           0       -2000       -1000        4000       -1000
       -1000        5000           0       -2000           0
           0           0           0       -1000        2000
           1           0           0           0           0

EDU» v=[6;0;-12;12;0.002]

v =

    6.0000
         0
  -12.0000
   12.0000
    0.0020


EDU» i=1000*inv(r)*v

i =

    2.0000
   -1.0986
    4.0845
    2.2535
    7.1268
```

3.82 Write mesh equations for the circuit in Fig. P3.82 using the assigned currents.

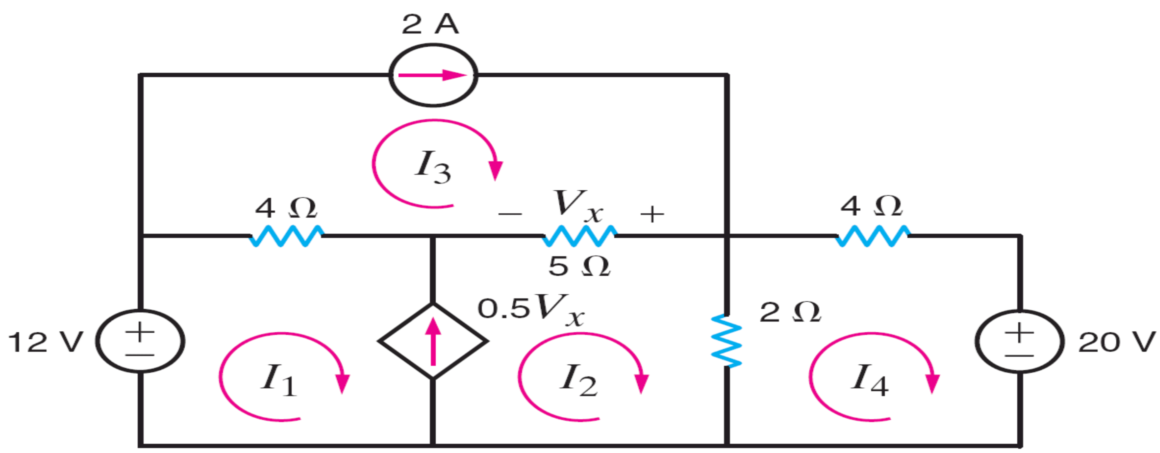
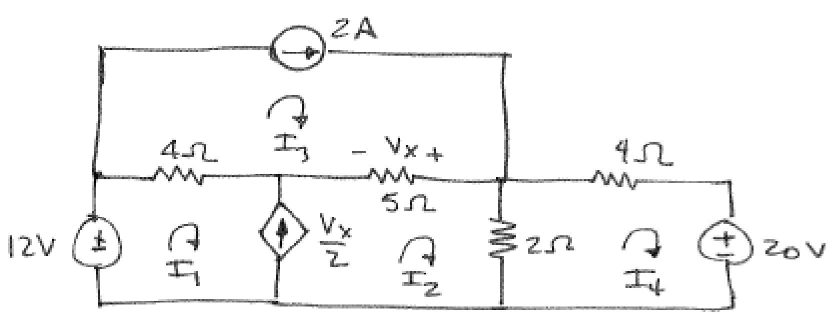


Figure P3.82

SOLUTION:

3.82 Write mesh equations.



$V_x = (I_3 - I_2)5$

① $I_3 = 2A$

$$I_2 - I_1 = \frac{V_x}{2} = \frac{(I_3 - I_2)5}{2}$$

② $3.5I_2 - I_1 - 2.5I_3 = 0$

③ $4I_4 + 2(I_4 - I_2) = -20$

④ $(I_1 - I_3)4 + (I_2 - I_3)5 + 2I_2 = 12$

3.83 Use mesh analysis to find V_o in the circuit in Fig. P3.83.
PSV

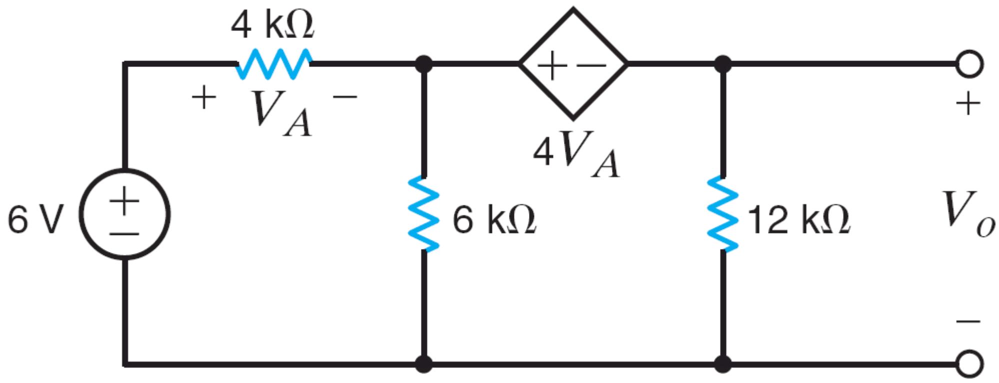
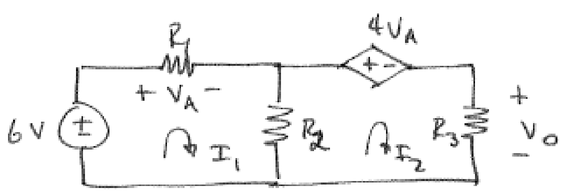


Figure P3.83

SOLUTION:

3.83 Find V_o using mesh analysis.



$R_1 = 4k\Omega$ $R_2 = 6k\Omega$ $R_3 = 12k\Omega$

$V_A = I_1 R_1$ $V_o = I_2 R_3$

$6 = I_1 R_1 + (I_1 - I_2) R_2$

$I_2 R_3 + (I_2 - I_1) R_2 + 4V_A = 0$

$6 = I_1 (R_1 + R_2) - I_2 R_2$

$I_2 (R_2 + R_3) + I_1 (4R_1 - R_2) = 0$

$I_2 = -0.25mA$

$\boxed{V_o = -3V}$

3.84 Find V_o in the circuit in Fig. P3.84 using mesh analysis.
cs

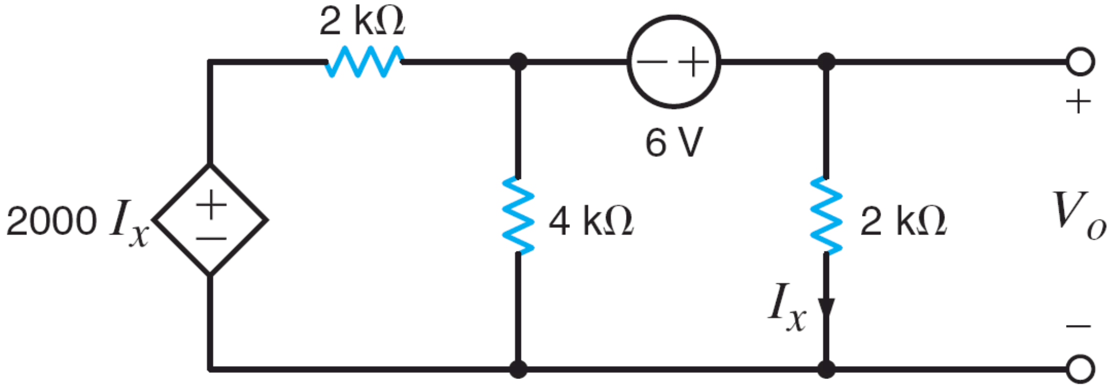
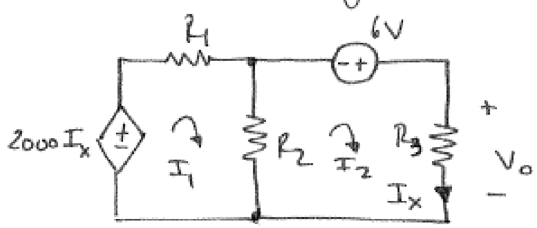


Figure P3.84

SOLUTION:

3.84 Find V_o using mesh analysis.



$R_1 = 2k\Omega \quad R_2 = 4k\Omega \quad R_3 = 2k\Omega$

$I_x = I_2 \qquad V_o = R_3 I_2$

$$2000\, I_x = I_1 R_1 + (I_1 - I_2) R_2$$

$$6 = I_2 R_3 + (I_2 - I_1) R_2$$

$I_2 = 3\text{ mA}$

$\boxed{V_o = 6\text{ V}}$

3.85 Use loop analysis to find V_o in the network in Fig. P3.85.

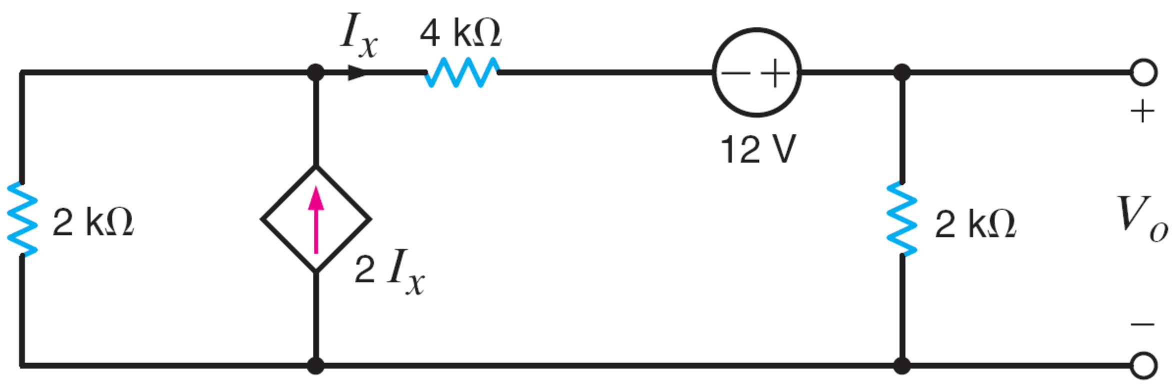
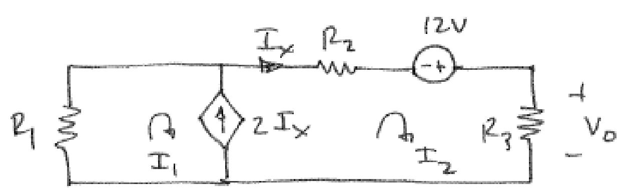


Figure P3.85

SOLUTION:

3.85 Find V_o using loop analysis.



$R_1 = 2k\Omega$ $R_2 = 4k\Omega$ $R_3 = 2k\Omega$

$I_x = I_2$ $V_o = R_3 I_2$

$I_1 R_1 + I_2 R_2 + I_2 R_3 = 12$ $2I_x = I_2 - I_1$

$I_2 = 3mA$ $\boxed{V_o = 6V}$

3.86 Use loop analysis to find V_o in the circuit in Fig. P3.86.

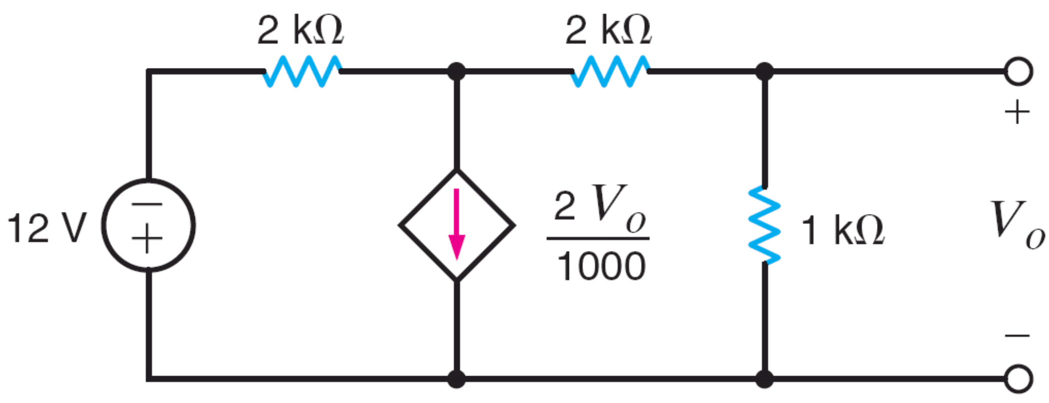
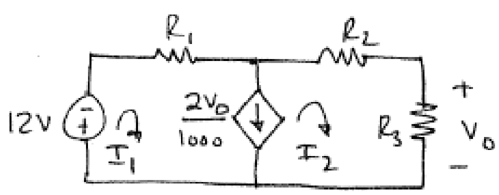


Figure P3.86

SOLUTION:

3.86 Find V_o using loop analysis.



$R_1 = 2k\Omega \quad R_2 = 2k\Omega \quad R_3 = 1k\Omega$

$V_o = R_3 I_2$

$$\frac{2V_o}{1000} = I_1 - I_2$$

$$-12 = I_1 R_1 + I_2 R_2 + I_2 R_3$$

$I_2 = -1.33 \text{ mA}$

$\boxed{V_o = -1.33 \text{ V}}$

3.87 Use both nodal analysis and mesh analysis to find V_o in the circuit in Fig. P3.87.

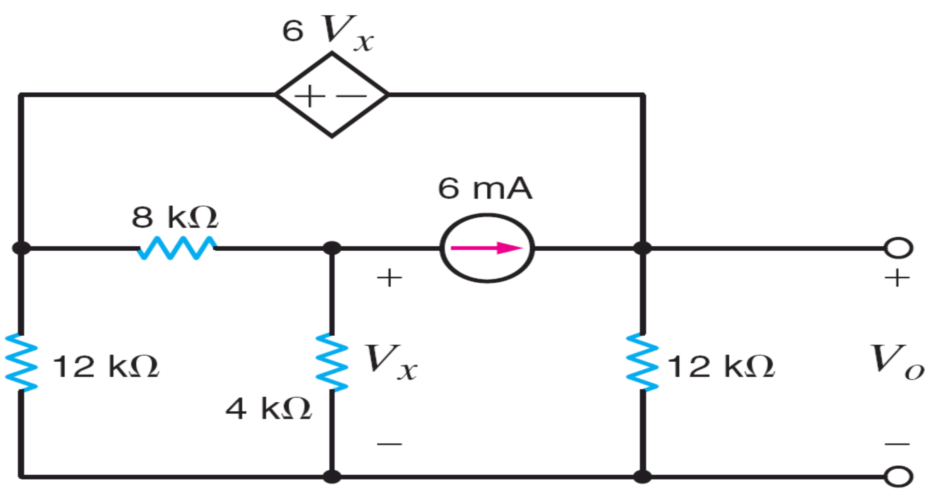
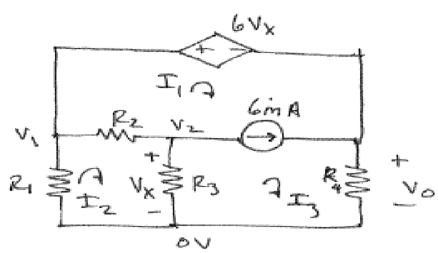


Figure P3.87

SOLUTION:

3.87 Use both nodal & mesh to find V_o.



$R_1 = 12k\Omega$ $R_2 = 8k\Omega$ $R_3 = 4k\Omega$ $R_4 = 12k\Omega$

Mesh

$I_3 - I_1 = 6mA$

$6V_x + R_4 I_3 + R_1 I_2 = 0$

$0 = I_2 R_2 + (I_2 - I_1) R_2 + (I_2 - I_3) R_3$

$V_x = (I_2 - I_3) R_3$

$V_o = I_3 R_4$

$I_3 = 12mA$

$\boxed{V_o = 144V}$

Nodal

$V_1 - V_o = 6V_x$

$V_x = V_2$

$\frac{V_2 - V_1}{R_2} + \frac{V_2}{R_3} + 6\times10^{-3} = 0$

$\frac{V_1}{R_1} + \frac{V_2}{R_3} + \frac{V_o}{R_4} = 0$

$\boxed{V_o = 144V}$

3.88 Using mesh analysis, find V_o in the circuit in Fig. P3.88.

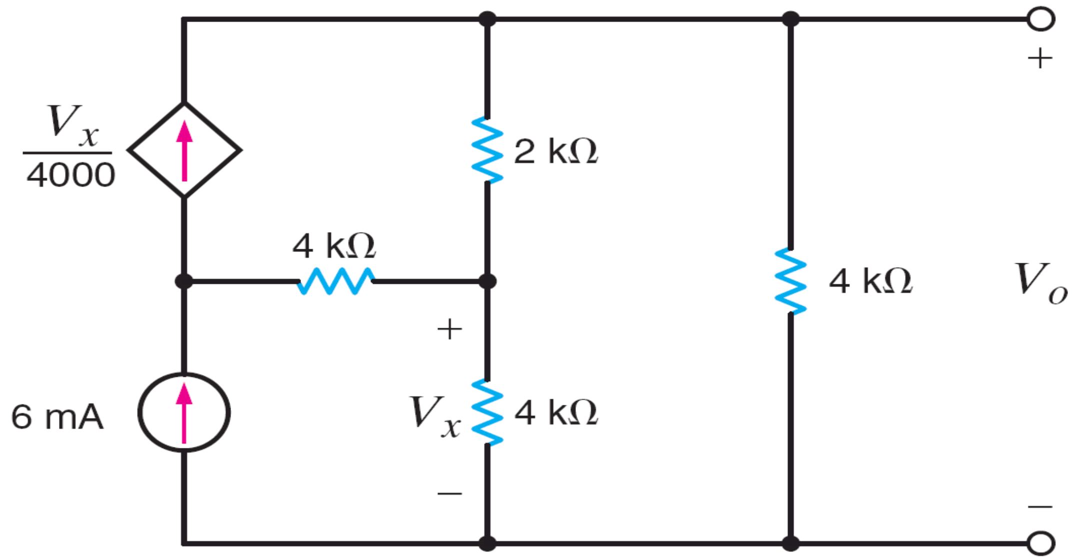
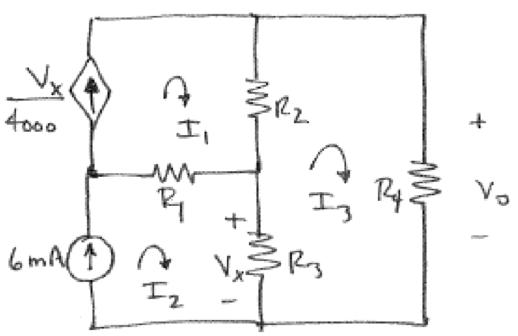


Figure P3.88

SOLUTION:

3.88 find V_o using mesh analysis.



$R_1 = R_3 = R_4 = 4k\Omega \qquad R_2 = 2k\Omega$

$V_x = R_3 (I_2 - I_3)$

$V_o = R_4 I_3$

$I_2 = 6mA$

$\frac{V_x}{4000} = I_1$

$0 = I_3 R_4 + (I_3 - I_1) R_2 + (I_3 - I_2) R_3$

$I_3 = 3mA$

$\boxed{V_o = 12V}$

3.89 Find V_o in the network in Fig. P3.89. **PSV**

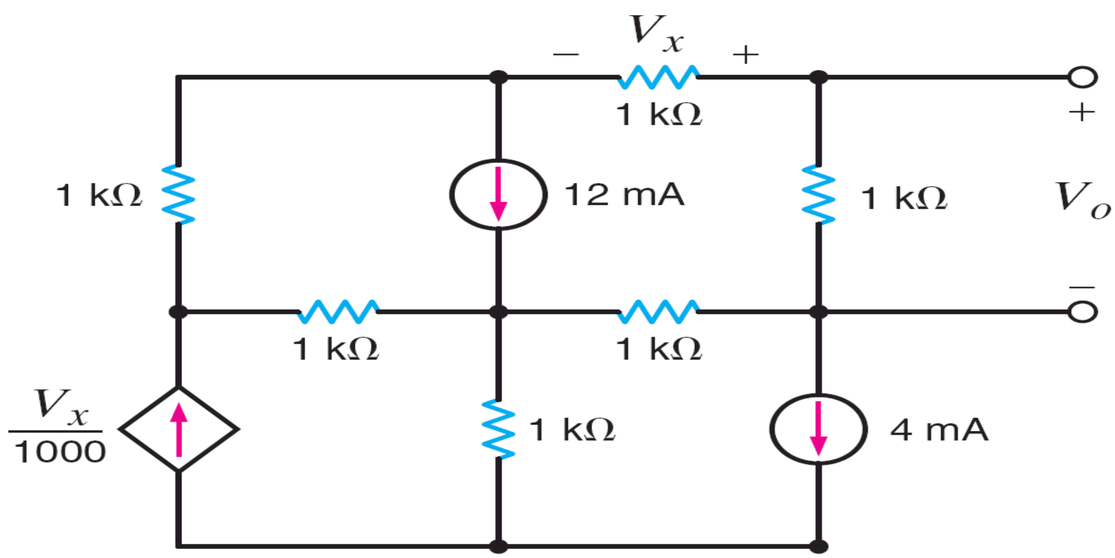
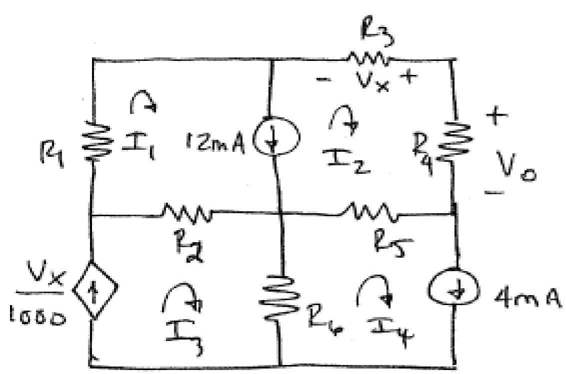


Figure P3.89

SOLUTION:

3.89 find V_o.



All R's = 1kΩ

$I_4 = 4mA$

$I_1 - I_2 = 12mA$

$\frac{V_x}{1000} = I_3$ $\quad V_x = -I_2 R_3$

$0 = I_1 R_1 + I_2 R_3 + I_2 R_4 + (I_2 - I_4) R_5 + (I_1 - I_3) R_2$

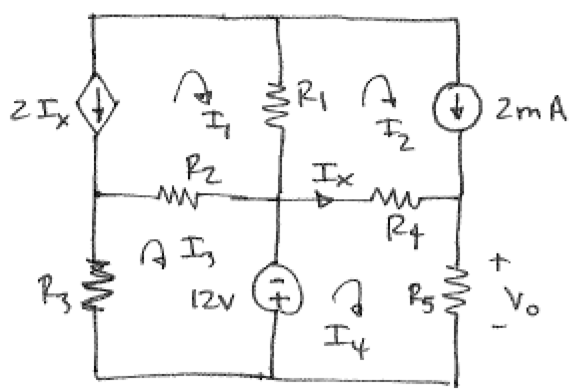
$V_o = I_2 R_4$

$I_2 = -3.33mA$ $\quad$ $\boxed{V_o = -3.33 \text{ V}}$

3.90 Solve Problem 3.54 using loop analysis.

SOLUTION:

3.90 find V_o by loop analysis.



all R's = 1kΩ

$I_2 = 2mA$

$2I_x = -I_1$

$I_x = I_4 - I_2$

$V_o = I_4 R_5$

$$12 = I_3 R_3 + (I_3 - I_1) R_2$$

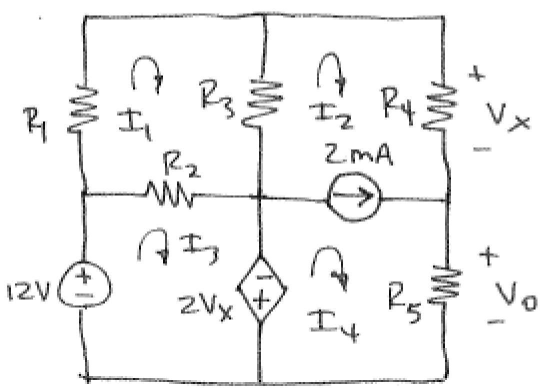
$$-12 = I_4 R_5 + (I_4 - I_2) R_4$$

$I_4 = -5mA$ $\boxed{V_o = -5V}$

3.91 Solve Problem 3.55 using loop analysis.

SOLUTION:

3.91 Find V_o using loop analysis.



$R_1 = R_2 = 2k\Omega$

$R_3 = R_4 = R_5 = 1k\Omega$

$I_4 - I_2 = 2mA$

$V_o = I_4 R_5$

$V_x = R_4 I_2$

$12 = I_3 R_2 - 2V_x$

$0 = I_1 R_1 + (I_1 - I_2) R_3 + (I_1 - I_3) R_2$

$12 = I_1 R_1 + I_2 R_4 + I_4 R_5$

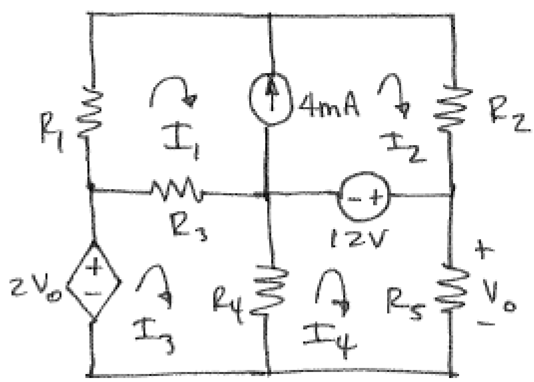
$I_4 = 2.5mA$

$\boxed{V_o = 2.5V}$

3.92 Solve Problem 3.56 using loop analysis.

SOLUTION:

3.92 Find V_o using loop analysis.



$R_1 = R_2 = R_3 = R_4 = 1k\Omega$

$R_5 = 2k\Omega$

$I_2 - I_1 = 4mA$

$V_o = R_5 I_4$

$2V_o = (I_3 - I_1)R_3 + (I_3 - I_4)R_4$

$12 = I_4 R_5 + (I_4 - I_3) R_4$

$+2V_o = I_1 R_1 + I_2 R_2 + I_4 R_5$

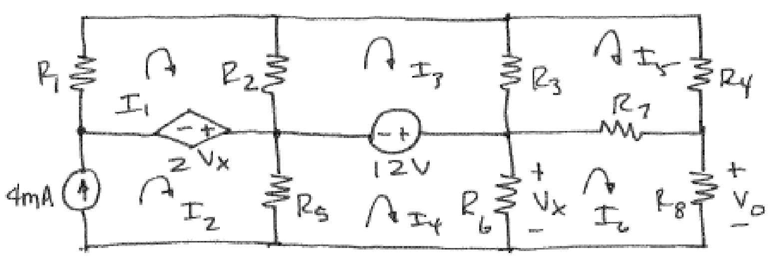
$I_4 = \infty$

$\boxed{V_o = \infty\ V}$

3.93 Solve Problem 3.57 using loop analysis.

SOLUTION:

3.93 Find V_o using loop analysis.



$R_1 = R_2 = R_3 = R_4 = R_8 = 1k\Omega$

$R_5 = R_6 = R_7 = 2k\Omega$

$V_o = R_8 I_6$

$I_2 = 4mA$

$I_1 R_1 + (I_1 - I_3) R_2 + 2V_x = 0$ $\quad V_x = (I_4 - I_6) R_6$

$12 = (I_4 - I_6) R_6 + (I_4 - I_2) R_5$

$-12 = (I_3 - I_1) R_2 + (I_3 - I_5) R_3$

$0 = I_5 R_4 + (I_5 - I_6) R_7 + (I_5 - I_3) R_3$

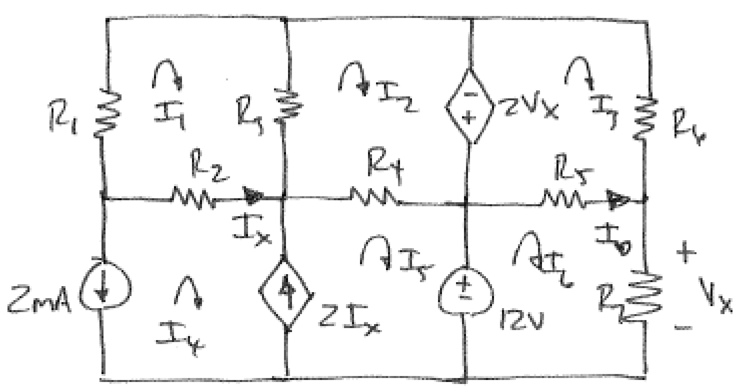
$0 = I_6 R_8 + (I_6 - I_4) R_6 + (I_6 - I_5) R_7$

$I_6 = 500\mu A$ $\quad$ $\boxed{V_o = 0.5V}$

3.94 Solve Problem 3.58 using loop analysis.

SOLUTION:

3.94 Find I_o using loop analysis



All R's = 1kΩ

$I_4 = -2mA$

$I_5 - I_4 = 2I_x$

$I_x = I_4 - I_1$

$I_o = I_6 - I_3$

$0 = I_1 R_1 + (I_1 - I_2) R_3 + R_2 (I_1 - I_4)$

$2V_x = (I_2 - I_5) R_4 + (I_2 - I_1) R_3$

$V_x = I_6 R_7$

$-2V_x = I_3 R_6 + (I_3 - I_6) R_5$

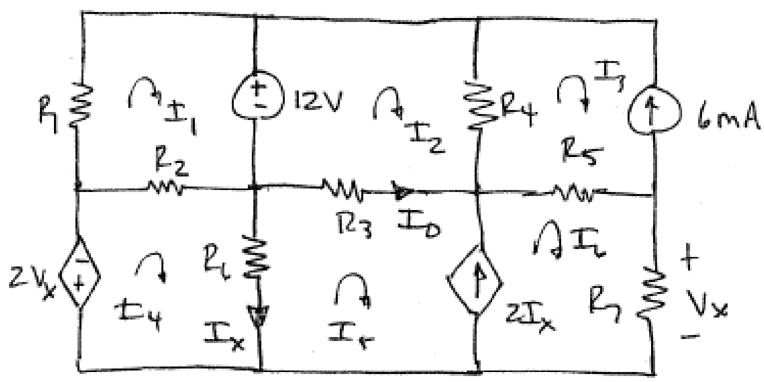
$12 = (I_6 - I_3) R_5 + I_6 R_7$

$I_o = 7.2 \text{ mA}$

3.95 Solve Problem 3.59 using loop analysis.

SOLUTION:

3.95 find I_o using loop analysis



All R's = 1kΩ

$I_3 = -6\,mA$

$2I_x = I_6 - I_5$

$I_x = I_4 - I_5$

$I_6 = I_5 - I_2$

$V_x = I_6 R_7$

$$-2V_x = (I_4 - I_1)R_2 + (I_4 - I_5)R_6$$

$$-12 = I_1 R_1 + (I_1 - I_4) R_2$$

$$12 = (I_2 - I_3) R_4 + (I_2 - I_5) R_3$$

$$0 = (I_5 - I_4) R_6 + (I_5 - I_2) R_3 + (I_6 - I_3) R_5 + I_6 R_7$$

$$\boxed{I_o = -2.88\,mA}$$

3.96 Use mesh analysis to determine the power delivered by the independent 3-V source in the network in Fig. P3.96.

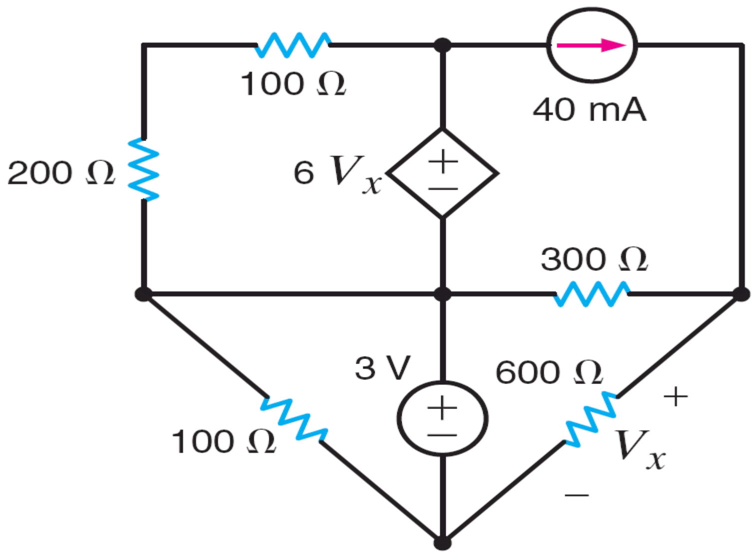
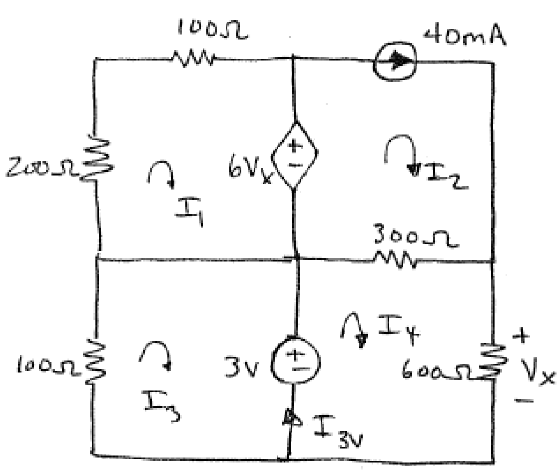


Figure P3.96

SOLUTION:

3.96 Find power delivered by 3-V source.



$$I_2 = 40\,mA$$

$$-6V_x = 300\,I_1$$

$$V_x = 600\,I_4$$

$$3 = 300\,(I_4 - I_2) + 600\,I_4$$

$$-3 = 100\,I_3$$

$$I_{3V} = I_4 - I_3 = 46.67\,mA$$

$$P_{3V} = 3\,I_{3V}$$

$$\boxed{P_{3V} = 140\,mW}$$

3.97 Use mesh analysis to find the power delivered by the current-controlled voltage source in the circuit in Fig. P3.97.

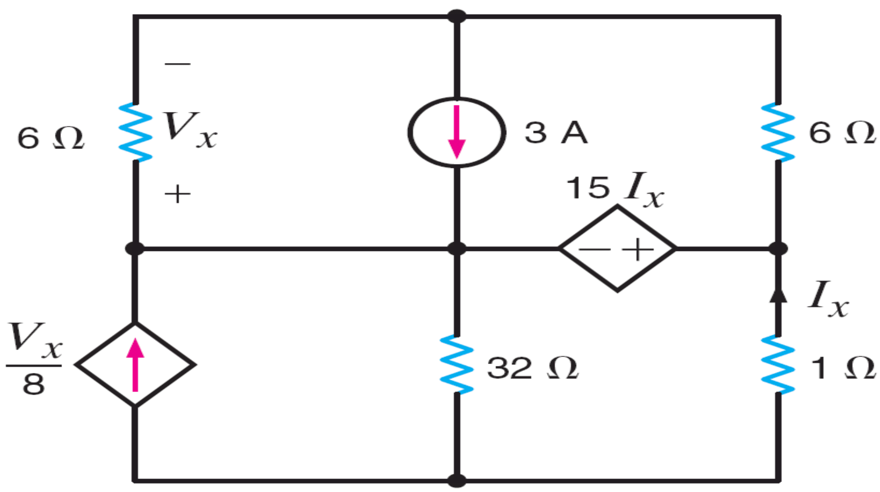
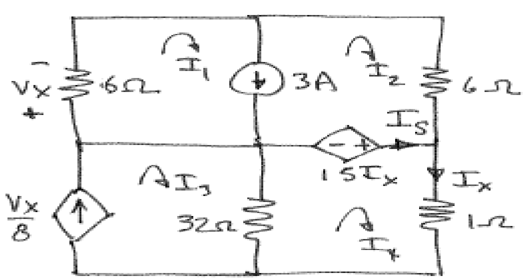


Figure P3.97

SOLUTION:

3.97 Find power delivered by the voltage source.



$I_1 - I_2 = 3$

$I_3 = V_x/8$

$V_x = 6I_1$

$I_x = I_4$

$I_s = I_4 - I_2$

$15I_x = I_4 + 32(I_4 - I_3)$

$-15I_x = 6I_1 + 6I_2$

$I_4 = 2A \qquad I_2 = 1A \qquad I_s = 1A$

$P_{ccvs} = (15I_x)I_s = 15I_4I_s$

$\boxed{P_{ccvs} = 30W}$

3FE-1 Find V_o in the circuit in Fig. 3PFE-1. CS

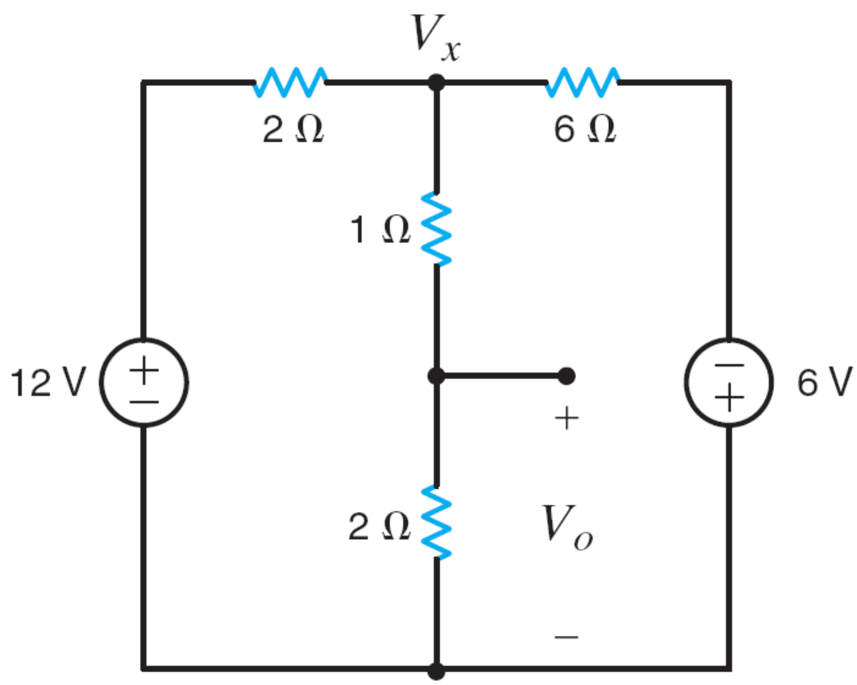
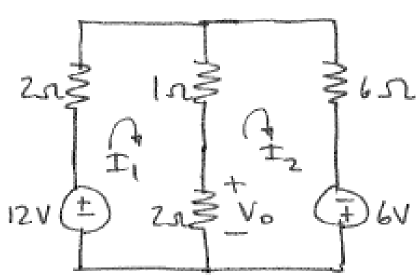


Figure 3PFE-1

SOLUTION

3FE-1 Find V_o.



$$12 = 2I_1 + (I_1 - I_2) + 2(I_1 - I_2)$$

$$6 = 2(I_2 - I_1) + (I_2 - I_1) + 6I_2$$

$$V_o = 2(I_1 - I_2)$$

Results: $I_1 = 3.5\text{A}$, $I_2 = 1.83\text{A}$

$$\boxed{V_o = 3.33\text{ V}}$$

3FE-2 Determine the power dissipated in the 6-ohm resistor in the network in Fig. 3PFE-2.

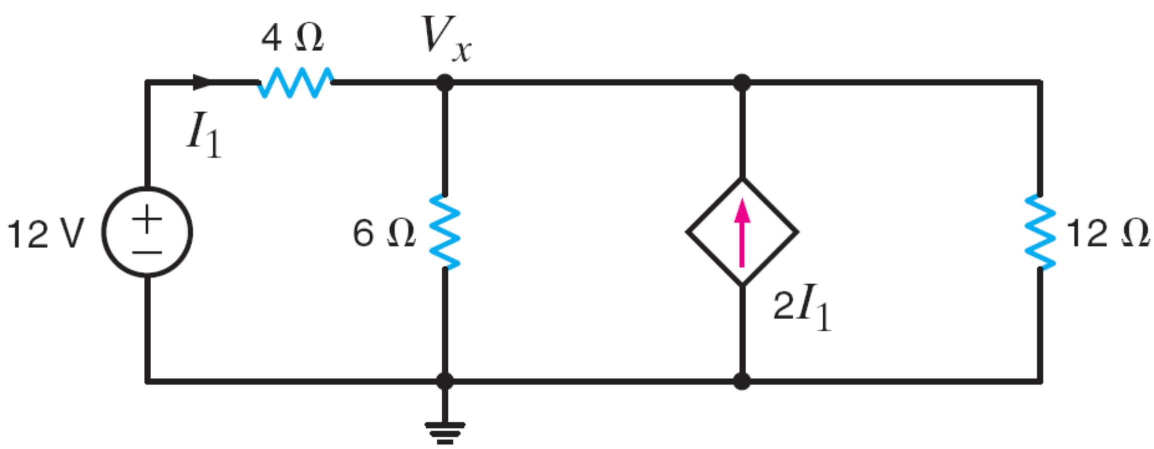
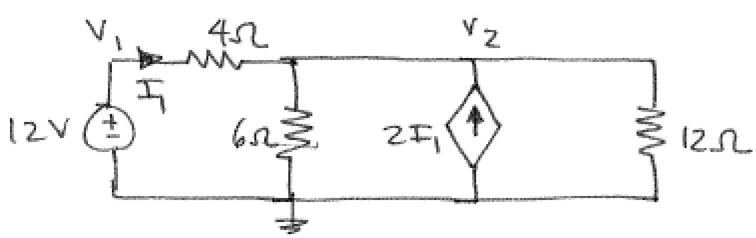


Figure 3PFE-2

SOLUTION

3FE-2 find power absorbed by 6-Ω resistor.



$$I_1 = (V_1 - V_2)/4$$

$$V_1 = 12\text{V}$$

$$\frac{V_2}{6} + \frac{V_2}{12} + \frac{V_2 - V_1}{4} = 2I_1$$

Results: $V_2 = 9\text{V}$

$$P_{6\Omega} = \frac{V_2^2}{6}$$

$$\boxed{P_{6\Omega} = 13.5\text{W}}$$

3FE-3 Find the current I_x in the 4-ohm resistor in the circuit in Fig. 3PFE-3. CS

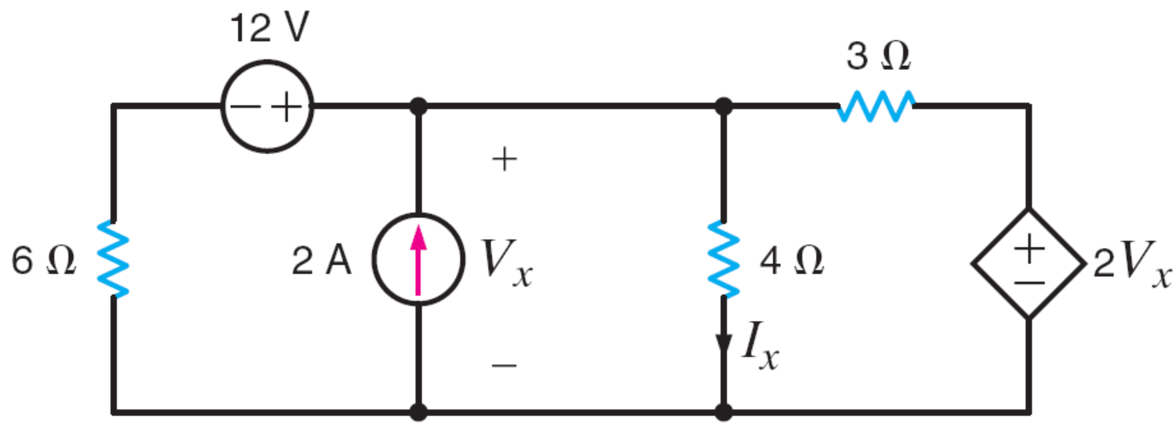
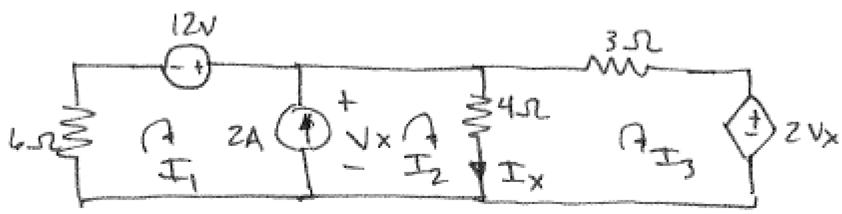


Figure 3PFE-3

SOLUTION

3FE-3 Find I_x.



$V_x = 4I_x$

$I_x = I_2 - I_3$

$I_2 - I_1 = 2$

$12 = 4(I_2 - I_3) + 6I_1$

$-2V_x = 4(I_3 - I_2) + 3I_3$

Results: $I_2 = -4A$, $I_3 = -16A$

$I_x = 12A$

3FE-4 Determine the voltage V_o in the circuit in Fig. 3PFE-4.

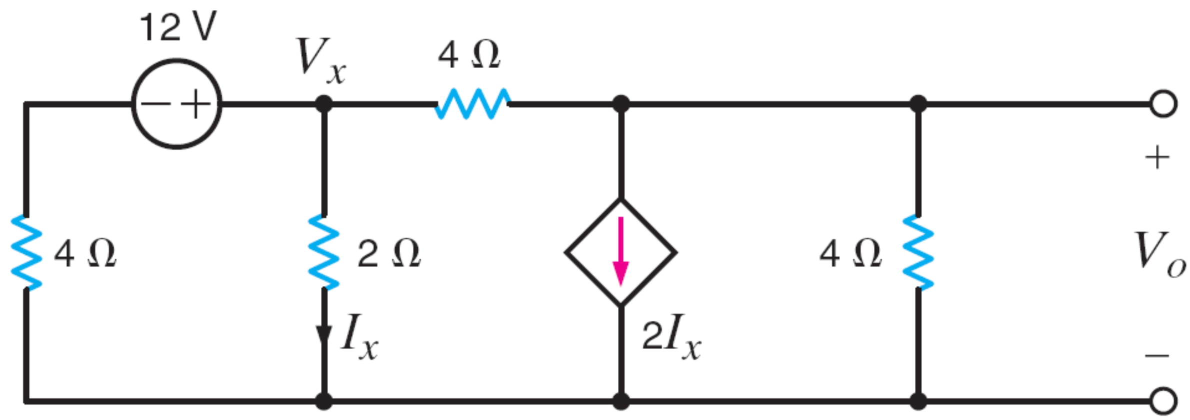
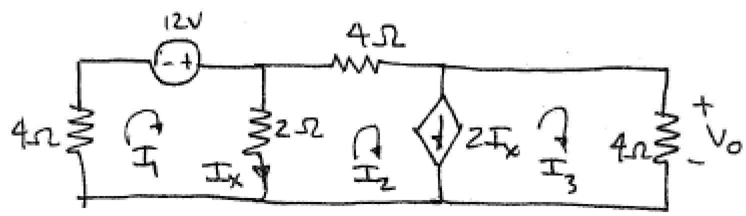


Figure 3PFE-4

SOLUTION

3FE-4 Find V_o.



$I_x = I_1 - I_2$

$V_o = 4I_3$

$2I_x = I_2 - I_3$

$4I_1 + 4I_2 + 4I_3 = 12$

$12 = 4I_1 + 2(I_1 - I_2)$

Results: $I_3 = -0.818\text{A}$

$\boxed{V_o = -3.27\text{V}}$