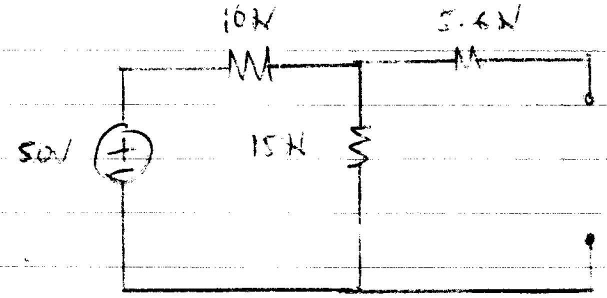
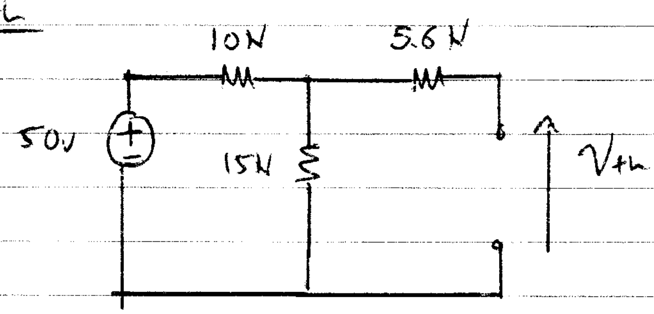
HW3 SOLUTIONS

3.49

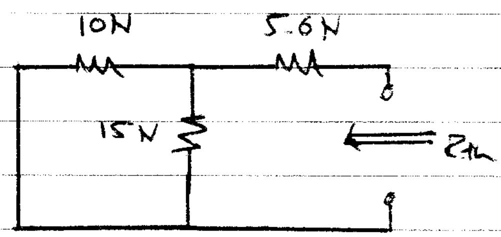


Find V_{th}



$$V_{th} = \left(\frac{50}{15k + 10k}\right) 15k = \underline{30V}$$

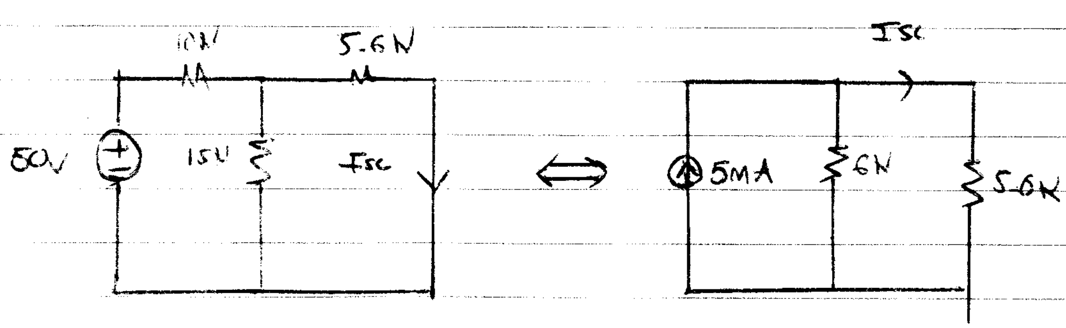
Find R_{th}



$$R_{th} = 5.6k + \frac{10k \times 15k}{10k + 15k}$$

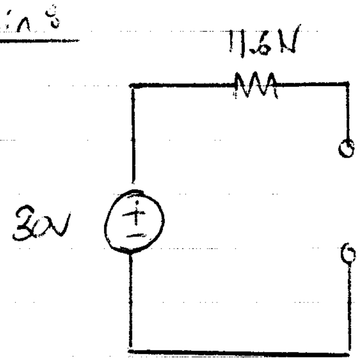
$$= \underline{11.6k}$$

Find I_{sc}

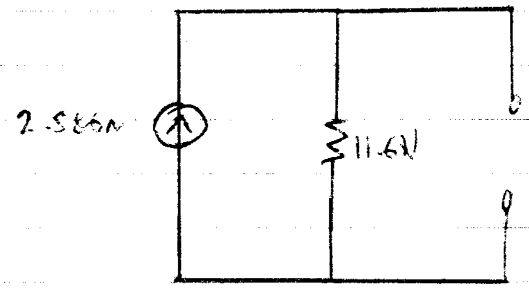


$$I_{sc} = \frac{5m \times \left(\frac{6k \times 5.6k}{6k + 5.6k}\right)}{5.6k} = \underline{2.586mA}$$

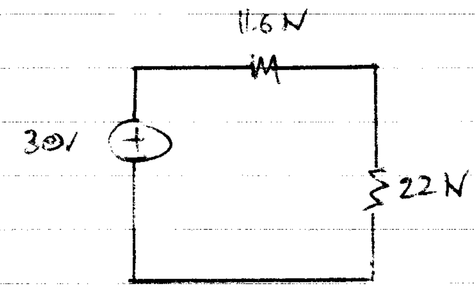
Thevenin :



Norton :



(b) $R_L = 22k$,

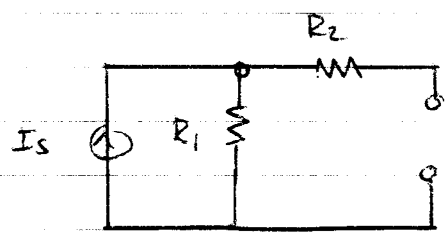


$$I_L = \frac{30}{11.6k + 22k}$$

$$= \underline{0.8929\ mA}$$

3.50

(a)

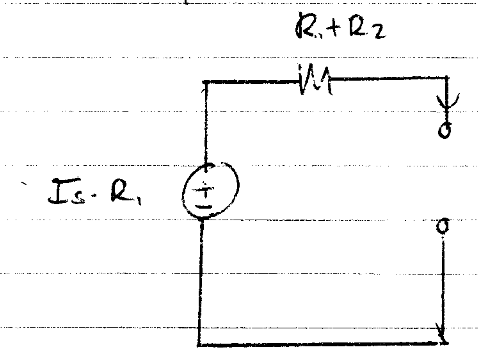


$R_{th} = R_1 + R_2$

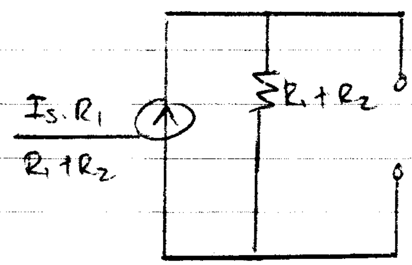
$V_{th} = \cancel{I_s // \frac{R_1 R_2}{R_1 + R_2}} \quad I_s \cdot R_1$

$$I_{sc} = \frac{I_s \cdot \left(\dfrac{R_1 \cdot R_2}{R_1 + R_2}\right)}{R_2} = \frac{I_s \cdot R_1}{R_1 + R_2}$$

Thevenin circuit:

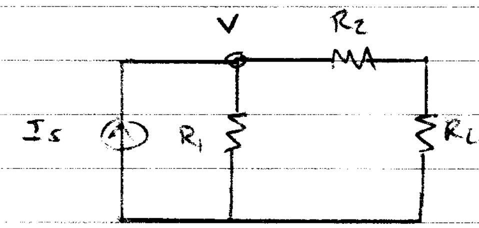


Norton:



(b) $$I_L = \frac{I_s \cdot R_1}{R_1+R_2+R_L}$$

(c)

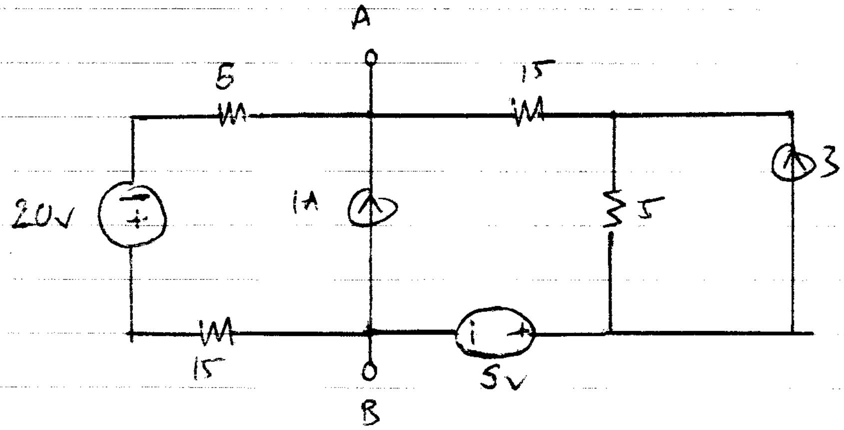


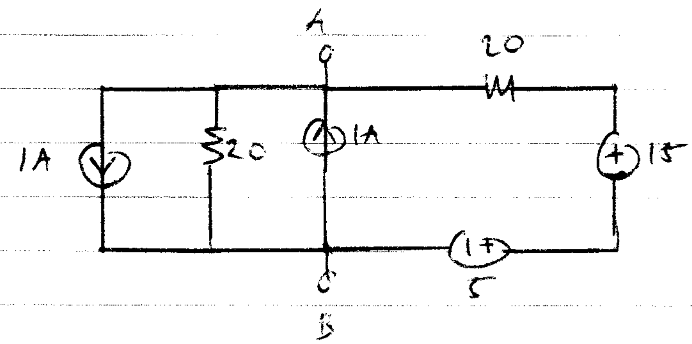
By current division:

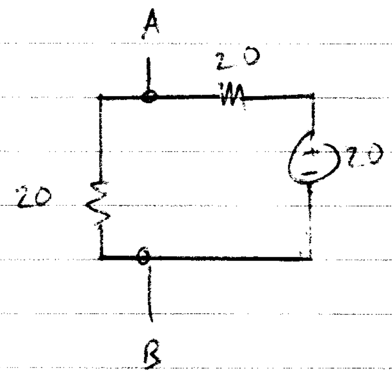
$$I_L = \frac{I_s \times \frac{(R_2+R_L)\times R_1}{(R_2+R_L+R_1)}}{(R_2+R_L)}$$

$$= \underline{\frac{I_s \cdot R_1}{R_2+R_L+R_1}}$$

3.62







so

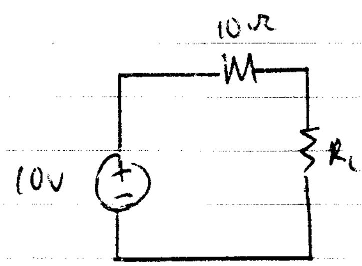
$$V_{th} = \left(\frac{20}{20+20}\right) 20$$

$$= 10V$$

$$I_{sc} = \frac{20}{20} = 1\,A$$

$$\underline{R_{th} = 10\,\Omega}$$

Which resistor?

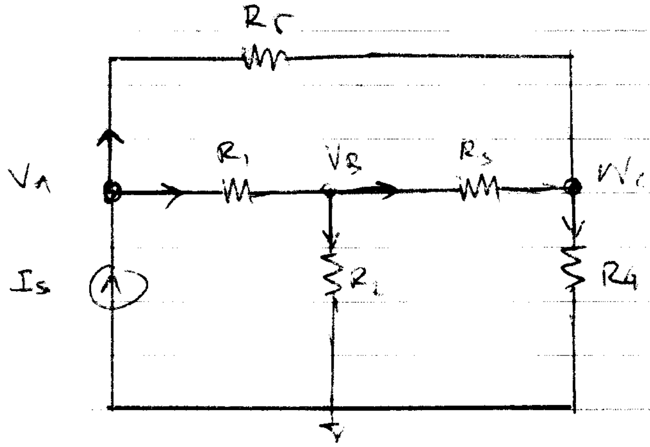


$$5 = \left(\frac{10}{10+R_L}\right) R_L$$

$$50 + 5R_L = 10R_L$$

$$\underline{R_L = 10\,\Omega}$$

3.1



AT NODE A

$$I_S + \frac{V_A - V_C}{R_5} = \frac{V_A - V_B}{R_1} , \quad I_S = \frac{V_A}{R_1} - \frac{V_B}{R_1} + \frac{V_A}{R_5} + \frac{V_C}{R_5}$$

AT NODE B

$$\frac{V_B}{R_2} + \frac{V_B - V_C}{R_3} = \frac{V_A - V_B}{R_1} , \quad 0 = \frac{V_B}{R_2} + \frac{V_B}{R_3} - \frac{V_C}{R_3} - \frac{V_A}{R_1} + \frac{V_B}{R_1}$$

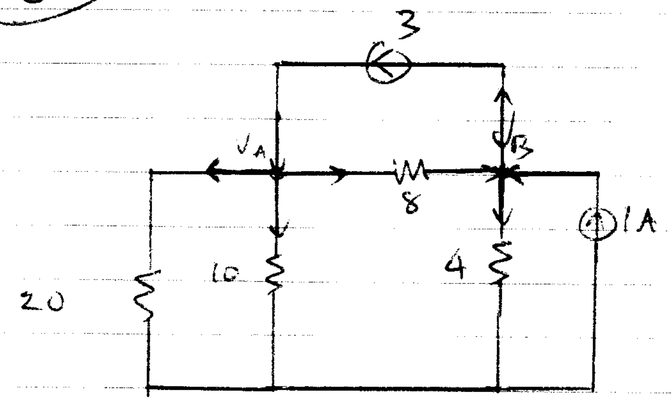
AT NODE C

$$\frac{V_C}{R_4} = \frac{V_B - V_C}{R_3} + \frac{V_A - V_C}{R_5} , \quad \frac{V_C}{R_4} + \frac{V_C}{R_3} + \frac{V_C}{R_5} - \frac{V_B}{R_3} - \frac{V_A}{R_5} = 0$$

COMBINE INTO SYSTEM

$$\begin{bmatrix} \frac{1}{R_1} + \frac{1}{R_5} & \frac{-1}{R_1} & \frac{-1}{R_5} \\ -1/R_1 & 1/R_2 + 1/R_3 + 1/R_1 & -1/R_3 \\ -1/R_5 & -1/R_3 & 1/R_4 + 1/R_3 + 1/R_5 \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ V_C \end{bmatrix} = \begin{bmatrix} i_S \\ 0 \\ 0 \end{bmatrix}$$

6 3.4



AT NODE A

$$\frac{V_A}{20} + \frac{V_A}{10} + \frac{V_A - V_B}{8} = 3$$

AT NODE B

$$1 + \frac{V_A - V_B}{8} = 3 + \frac{V_B}{4}$$

COMBINING INTO SYSTEM OF EQUATIONS

$$\begin{bmatrix} 11/40 & -1/8 \\ -1/8 & 3/8 \end{bmatrix} \begin{bmatrix} V_A \\ V_B \end{bmatrix} = \begin{bmatrix} 3 \\ -2 \end{bmatrix}$$

Solving this gives us

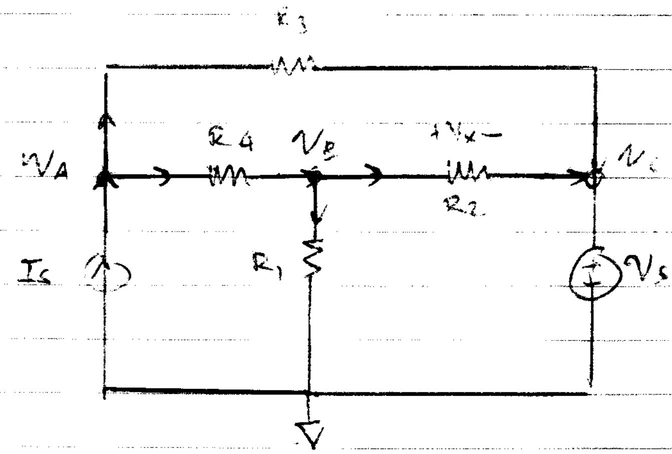
$$V_A = 10V$$
$$V_B = -2V$$

$$V_x = V_b = \underline{\underline{-2V}}$$

$$I_s = \frac{10}{20} = \underline{\underline{0.5A}}$$

7

(3.5)



choose ground here

AT NODE A

$$I_s = \frac{v_A - v_s}{R_3} + \frac{v_A - v_B}{R_4}$$

AT NODE B

$$\frac{v_B}{R_1} + \frac{v_B - v_s}{R_2} = \frac{v_A - v_B}{R_4}$$

SYSTEM OF EQUATIONS

$$\begin{bmatrix} \frac{1}{R_3} + \frac{1}{R_4} & -\frac{1}{R_4} \\ -\frac{1}{R_4} & \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_4} \end{bmatrix} \begin{bmatrix} v_A \\ v_B \end{bmatrix} = \begin{bmatrix} I_s + v_s/R_3 \\ v_s/R_2 \end{bmatrix}$$

(b) Solving gives us

$$\begin{bmatrix} \frac{1}{10k} + \frac{1}{10k} & -\frac{1}{10k} \\ -\frac{1}{10k} & \frac{1}{10k} + \frac{1}{10k} + \frac{1}{10k} \end{bmatrix} \begin{bmatrix} V_A \\ V_B \end{bmatrix} = \begin{bmatrix} 1m + \frac{25}{10k} \\ 25/10k \end{bmatrix}$$

$\Rightarrow$ $V_A = 26v$
$V_B = 17v$

$$\boxed{\begin{aligned} v_x &= -8V \\ I_x &= -0.1mA \end{aligned}}$$

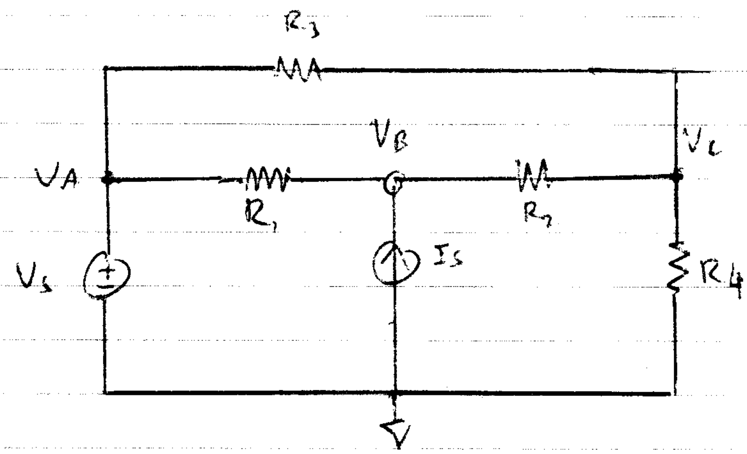
9.7

$$v_A = v_s$$

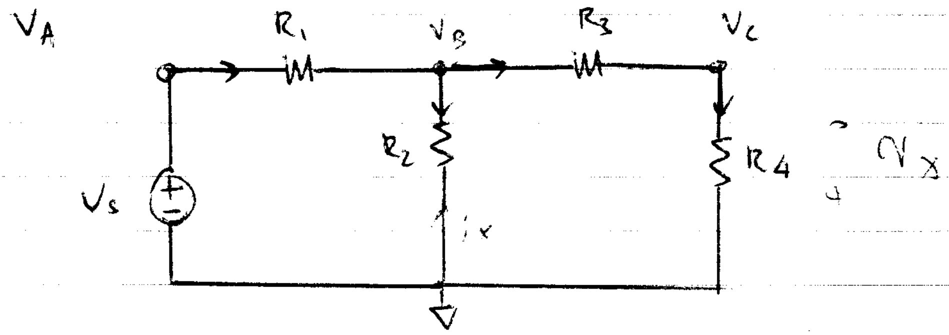
$$\frac{v_B - v_A}{R_1} + \frac{v_B - v_C}{R_2} - i_s = 0$$

$$\frac{v_C - v_A}{R_3} + \frac{v_C - v_B}{R_2} + \frac{v_C}{R_4} = 0$$

$$v_D = 0$$



3.16



$$v_A = v_s$$

$$\frac{v_A - v_B}{R_1} = \frac{v_B}{R_2} + \frac{v_B - v_C}{R_3}$$

$$\frac{v_C}{R_4} = \frac{v_B - v_C}{R_3} \quad , \quad \left(\frac{1}{R_3} + \frac{1}{R_4}\right) v_C = \frac{v_B}{R_3}$$

$$\begin{bmatrix} 1/R_1 + 1/R_2 + 1/R_3 & -1/R_3 \\ -1/R_3 & 1/R_4 + 1/R_3 \end{bmatrix} \begin{bmatrix} v_B \\ v_C \end{bmatrix} = \begin{bmatrix} v_s/R_1 \\ 0 \end{bmatrix}$$

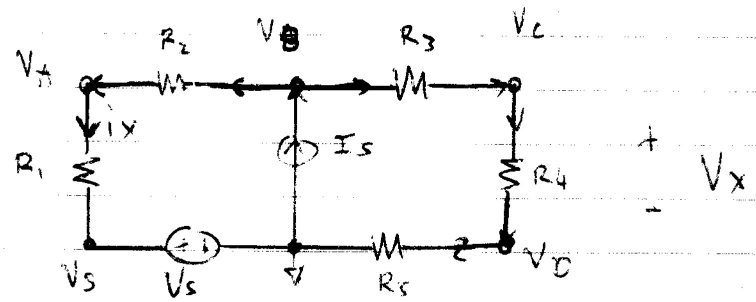
Then $v_x = -v_C$

$$i_x = -\frac{v_B}{R_2}$$

$$i_A = -i_x$$

$$i_B = \frac{v_C}{R_4}$$

3.18



$$\frac{V_A - V_s}{R_1} = \frac{V_A - V_B}{R_2}$$

$$I_s = \frac{V_B - V_A}{R_2} + \frac{V_B - V_C}{R_3}$$

$$\frac{V_B - V_C}{R_3} = \frac{V_C - V_D}{R_4}$$

$$\frac{V_C - V_D}{R_4} = \frac{V_D}{R_5}$$

$$\begin{bmatrix} 1/R_1 + 1/R_2 & -1/R_2 & 0 & 0 \\ -1/R_2 & 1/R_2 + 1/R_3 & -1/R_3 & 0 \\ 0 & -1/R_3 & 1/R_3 - 1/R_4 & -1/R_4 \\ 0 & 0 & -1/R_4 & 1/R_4 + 1/R_5 \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ V_C \\ V_D \end{bmatrix} = \begin{bmatrix} V_s/R_1 \\ I_s \\ 0 \\ 0 \end{bmatrix}$$

Substitute values and solve,

$V_A = 29.2\,V$

$V_B = 37\,V$

$V_C = 33.3\,V$

$V_D = 14.8\,V$

$$v_x = v_C - v_D$$
$$= \underline{18.5V}$$

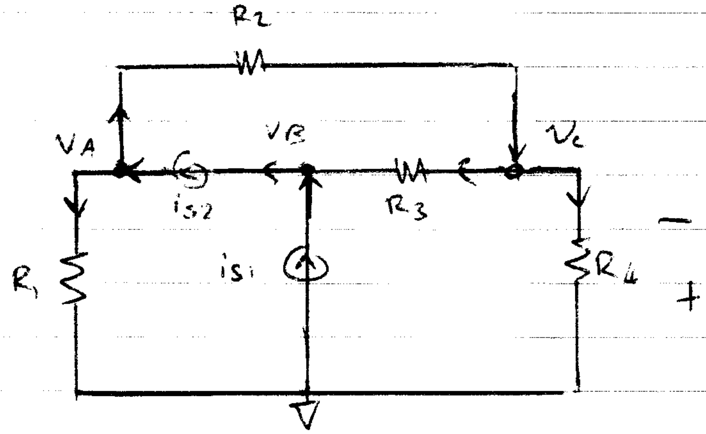
$$i_x = \frac{v_B - v_S}{R_1 + R_2} = \underline{\underline{2.6mA}}$$

(c) Power dissipation

$$= (V_B)^2 / (R_3 + R_4 + R_5) + \frac{(v_B - v_S)^2}{R_1 + R_2}$$

$$= \underline{0.3076 W}$$

3.14



$$\frac{v_A}{R_1} + \frac{v_A - v_C}{R_2} = i_{s2}$$

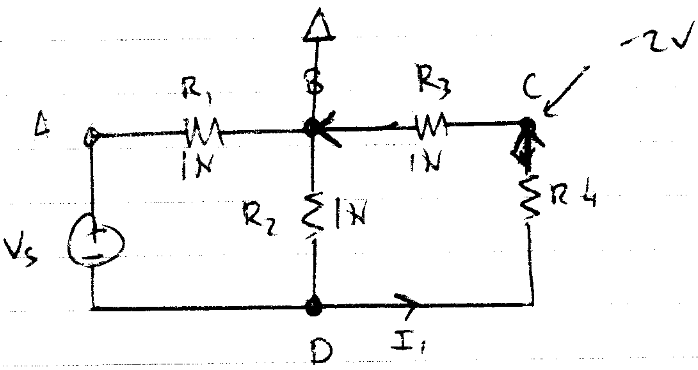
$$-i_{s2} + \frac{v_C - v_B}{R_3} + i_{s1} = 0$$

$$\frac{v_A - v_C}{R_2} + \frac{v_C}{R_4} = \frac{v_C - v_B}{R_3}$$

$$\begin{bmatrix} 1/R_1 + 1/R_2 & 0 & -1/R_2 \\ 0 & 1/R_3 & -1/R_3 \\ -1/R_2 & -1/R_3 & 1/R_2 + 1/R_3 + 1/R_4 \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ V_C \end{bmatrix} = \begin{bmatrix} i_{s2} \\ i_{s1} - i_{s2} \\ 0 \end{bmatrix}$$

$$\underline{\underline{v_x = -v_c}}$$

3.24



$v_C = -2V$

$v_D = -2V + R_4 \cdot I_1$

$= -2V + 1N\left(\frac{2}{1N}\right)$

$= \underline{\underline{-4V}}$

$v_A = v_D + v_S$

$= \underline{\underline{6v}}$