SOLUTIONS MANUAL

ESSENTIALS OF ELECTRICAL AND COMPUTER ENGINEERING

DAVID V. KERNS, JR. ▪ J. DAVID IRWIN

PEARSON
Prentice Hall

Upper Saddle River, New Jersey 07458

Associate Editor: *Alice Dworkin*
Supplements Editor: *Carole Snyder*
Executive Managing Editor: *Vince O'Brien*
Managing Editor: *David A. George*
Production Editor: *Barbara A. Till*
Supplement Cover Manager: *Daniel Sandin*
Manufacturing Buyer: *Ilene Kahn*

Pearson Prentice Hall
Pearson Education, Inc.
Upper Saddle River, NJ 07458

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-047841-5

Pearson Education Ltd., *London*
Pearson Education Australia Pty. Ltd., *Sydney*
Pearson Education Singapore, Pte. Ltd.
Pearson Education North Asia Ltd., *Hong Kong*
Pearson Education Canada, Inc., *Toronto*
Pearson Educación de Mexico, S.A. de C.V.
Pearson Education—Japan, *Tokyo*
Pearson Education Malaysia, Pte. Ltd.
Pearson Education, Inc., *Upper Saddle River, New Jersey*

Contents

CHAPTER 1 H.W. SOLUTIONS

1.1 $$F = k\frac{q_1 q_2}{d^2} \Rightarrow q_1 = \frac{F d^2}{k q_2} = \frac{(3\times10^{-3})(10^{-3}\,m)^2}{(8.99\times10^9)(1.6\times10^{-6})} = 2.09\times10^{-13}\,C.$$

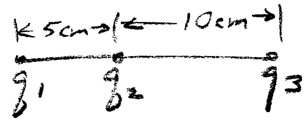
1.2 $$F = k\frac{q_1 q_2}{d^2} = (8.99\times10^9)\frac{(6.5\times10^{-12}C)^2}{(4\times10^{-6})^2} = 2.37\times10^{-2}\,N$$

1.3 $$F = k\frac{q_1 q_2}{d^2} = (8.99\times10^9)\frac{(0.03\times10^{-6})^2}{(10^{-2})^2} = 8.09\times10^{-2}\,N \text{ — Repulsive}$$

1.4 $$F = k\frac{q_1 q_2}{d^2} = (8.99\times10^9)\frac{(1.6\times10^{-19})^2}{[(5.3\times10^{-9})(10^{-2})]^2} = 8.19\times10^{-8}\,N$$

1.5 To solve problems of this type, first use the "like or unlike" charge rule to determine the direction of the force; then use Eq 1.1 to determine the magnitude

a) $q_1 = -2\,mC$; $q_2 = 4\,mC$; $q_3 = 10\,mC$



$$F_{q_1} = k\frac{q_1 q_2}{d_{12}^2} + k\frac{q_1 q_3}{d_{13}^2}$$ where $d_{12} = 5\,cm = 0.05\,m$, $d_{13} = 15\,cm = 0.15\,m$

Both q_2 & q_3 attract q_1 to the right.

$$F_{q_1} = (8.99\times10^9)(2\times10^{-3})\left[\frac{4\times10^{-3}}{(0.05)^2} + \frac{10\times10^{-3}}{(0.15)^2}\right]$$

$$F_{q_1} = 1.28\times10^7\,N$$

- The force on q_2 caused by q_1 is to the left; The force on q_2 caused by q_3 is also to the left. Therefore total force is the sum, and directed to the left

$$F_{q_2} = k\frac{q_2 q_1}{d_{12}^2} + k\frac{q_2 q_3}{d_{23}^2}$$ where $d_{12} = 0.05\,m$, $d_{23} = 0.10\,m$

$$F_{q_2} = (8.99\times10^9)\left[\frac{(4\,mC)(2\,mC)}{0.05^2} + \frac{(4\,mC)(10\,mC)}{0.10^2}\right]$$

$$F_{q_2} = (8.99\times10^9)\left[3.2\times10^{-3} + 4.0\times10^{-3}\right] = 6.47\times10^7\,N$$

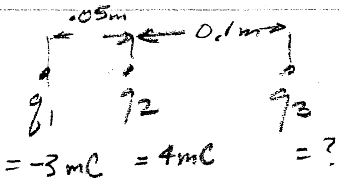
- The force on q_3 caused by q_1 is to the left; the force on q_3 caused by q_2 is to the right. Therefore if we let the right be defined as the "+" direction:

$$F_{q_3} = -k\frac{q_3 q_1}{d_{13}^2} + k\frac{q_3 q_2}{d_{23}^2}$$

$$= (8.99\times10^9)\left[\frac{(10\,mC)(2\,mC)}{0.15^2} + \frac{(10\,mC)(4\,mC)}{0.10^2}\right]$$

$$= (8.99\times10^9)\left[8.89\times10^{-4} + 4\times10^{-3}\right] = 4.40\times10^7\,N$$

b)



Assume the right is "+" direction

$$F_{q_2}\ (\text{from } q_1) = -k\frac{q_2 q_1}{d_{12}^2}$$
$$= -(8.99\times10^{9})\frac{(4mC)(3mC)}{(0.05)^2}$$
$$= -4.315\times10^{7}\ N$$

For the total force on q_2 to be zero, q_3 must create an equal and opposite force on q_2. Since q_2 is "+" q_3 must be "-" to create attractive force to the right.

$$F_{q_2}\ (\text{from } q_3) = 4.315\times10^{7}\ N = k\frac{(4mC)(q_3)}{(0.1)^2}$$
$$q_3 = -\frac{(4.315\times10^{7})(0.1)^2}{k\ (4mC)} = -1.2\times10^{-2}\ C$$

1.6 insulators: glass, rubber, ceramics, plastic, wood (dry)
conductors: iron, gold, salt water, silver, brass, copper

1.7 a) wet aluminum b) salt water c) copper

1.8
$$i = \frac{\Delta q}{\Delta t} = \frac{(8.2\times10^{21})(1.6\times10^{-19})}{10} = 131\ A$$

1.9
$$\Delta q = i\,\Delta t = (120)(6) = 720\ C$$
$$\#\text{ electrons} = \frac{720\ C}{1.6\times10^{-19}\ C/e} = 4.5\times10^{21}\ \text{electrons}$$

1.10
$$i = \frac{\Delta q}{\Delta t} = \frac{(3\times10^{19})(1.6\times10^{-19})}{5} = 0.96\ A$$

1.11 3A - 1A = 2A (away from the node)

1.12
$$I_H = \frac{I_T}{2} = \frac{6.5}{2} = 3.25\ A$$

1.13
$$i = 0.2\ A = \frac{\Delta q}{\Delta t} \Rightarrow \text{If } \Delta t = 1 \quad \Delta q = 0.2\ C$$
$$\#\text{electrons} = \frac{\Delta q}{q} = \frac{0.2\ C}{1.6\times10^{-19}} = 1.25\times10^{18}\ \text{electrons}$$

1.14 a) $150\text{-}10^{3}$ A b) 2 - 20 A c) 10^{4} A d) 10^{-8} A

1.15
$$V = \frac{dw}{dq} \cong \frac{\Delta w}{\Delta q} = \frac{3}{0.25} = 12\ V$$

1.16 a) $I = 0.5\ A$; $\#\text{ electrons/sec} = \frac{0.5}{1.6\times10^{-19}} = 3.125\times10^{18}\ e/sec$

sec in half hour = 60 × 30 = 1800

∴ # electrons in half-hour = $(1800)(3.125\times10^{18}) = 5.625\times10^{21}$

b) $P = VI = 12(0.5) = 6\ W.$

c) $E = P\Delta t = \left[6\ \frac{\text{Joules}}{\text{sec}}\right]\left[1800\ \text{sec}\right] = 1.08 \times 10^{4}\ J$

1.17 $W = Vq = (25 \times 10^{3})(1.6 \times 10^{-19}) = 4 \times 10^{-15}\ J$

1.18 $W = Vq = (1)(1.6 \times 10^{-19}) = 1.6 \times 10^{-19}\ J$

1.19 $\Delta W = V\Delta q$

$\Delta q = i\Delta t = (150)(1) = 150\ C$

$\Delta W = 12(150) = 1800\ J$

1.20 1) dc 2) dc 3) ac 4) dc 5) ac 6) dc

1.21 1) 10^{14} Hz 2) 10^{7} Hz 3) 10^{21} Hz

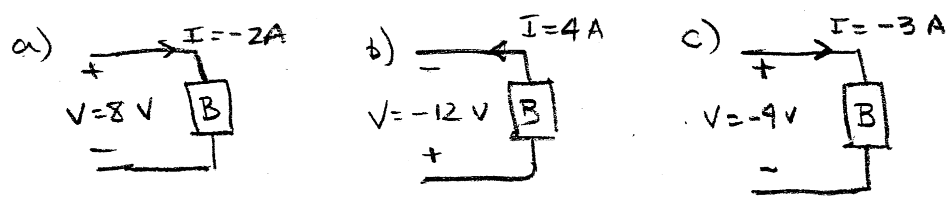
1.22 a) 10^{8} Hz b) 10^{16} Hz c) 10^{19} Hz

1.23 a) $V = -15\ V$; $I = 1\ A$

b) $V = 2\ V$; $I = 2\ A$

c) $V = 1\ V$; $I = -1\ A$

1.24



1.25

a) $P = VI = (3)(2) = 6\ W$ absorbing power (+ current enters + node)

b) $P = (10)(3) = 30W$ - absorbing power (+ current enters + node)

c) $P = VI = (6)(4) = 24W$ - supplying power (+ current exits + node)

1.26 a) A absorbing ; + current enters + node

B supplying ; + current exits + node

$P = VI = (3)(6) = 18\ W$ (constant)

$E = P \cdot t = 18 \cdot t$ $t = \#\text{ secs/hr} = 60 \cdot 60 = 3600$

$E = (18)(3600) = 64{,}800\ J$

b) A supplying ; + current exits + node

B absorbing ; + current enters + node

$P = VI = (6)(7) = 42\ W$

$E = P \cdot t = (42)(3600) = 151{,}200\ J$

1.27 a) $V_o = V_i \mu = (4.3)(25) = 107.5$ V

b) $V_o = V_i \mu = (30)(25) = 750$ V

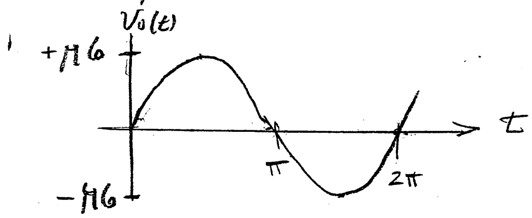
1.28 $i_o = \beta i_i \Rightarrow i_i = \frac{i_o}{\beta} = \frac{2\text{ mA}}{30} = 66.7\ \mu A$

1.29 $V_o = \mu V_i = (10^3)(3 \times 10^{-4}) = 0.30$ V

1.30 $V_o = \mu V_i = (48)(-3) = -144$

1.31 $\mu = \frac{V_o}{V_i} = \frac{30}{6} = 5$

1.32 $v_o = \mu V_i = \mu 6 \sin t$



1.33 a) $i_o = i_R = g\, v_i = (10^{-3})(6) = 6$ mA

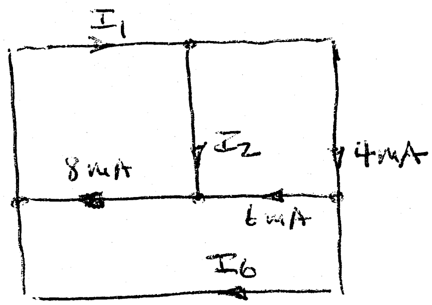
b) $i_o = i_R = g\, v_i = (10^{-3})(-9) = -9$ mA

1.34 a) $i_o = i_R = \beta i_i = (25)(1\text{mA}) = 25$ mA

b) $i_o = i_R = \beta i_i = (25)(-6\text{mA}) = -150\text{ mA} = -0.150$ A

2.1 $10 = I_1 + 4 \Rightarrow I_1 = 6mA$

2.2

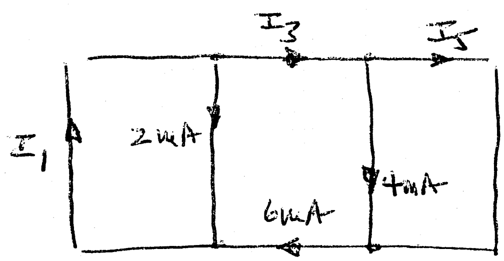


$4 = 6 + I_6 \Rightarrow I_6 = -2mA$

$I_2 + 6 = 8 \Rightarrow I_2 = 2mA$

$I_1 = I_2 + 4 \Rightarrow I_1 = 6mA$

2.3

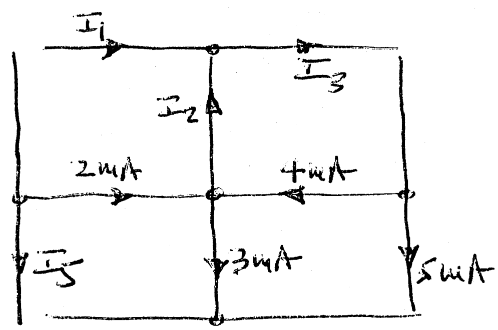


$I_3 = 6mA$

$6 = I_1 + 2 \Rightarrow I_1 = 4mA$

$I_5 + 4 = 6 \Rightarrow I_5 = 2mA$

2.4



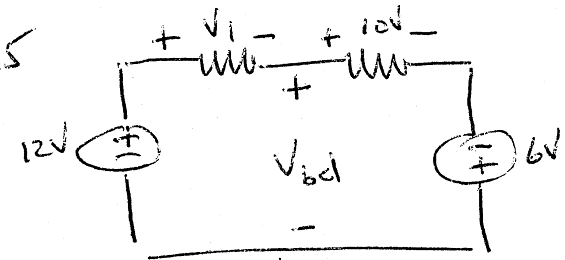
$I_3 = 4 + 5 \Rightarrow I_3 = 9mA$

$-I_2 + 2 + 4 - 3 = 0 \Rightarrow I_2 = 3mA$

$I_5 + 3 + 5 = 0 \Rightarrow I_5 = -8mA$

$-I_1 - 2 + 8 = 0 \Rightarrow I_1 = 6mA$

2.5



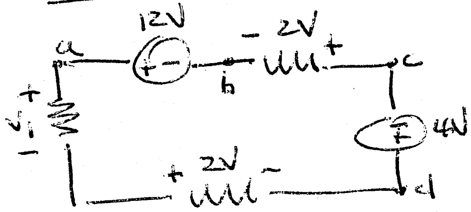
$-12 + V_1 + 10 - 6 = 0$

$V_1 = 8V$

$-V_{bd} + 10 - 6 = 0$

$V_{bd} = 4V$

2.6



$V_{bc} = -2V$

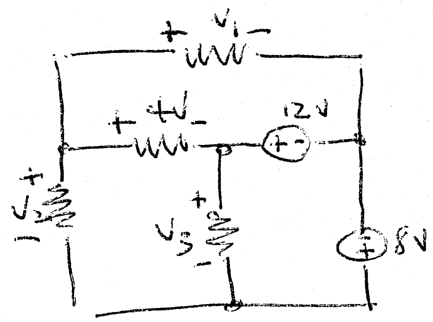
$-V_{da} + 4 + 2 - 12 = 0$

$V_{da} = -6V$

$-V_1 + 12 - 2 - 4 - 2 = 0$

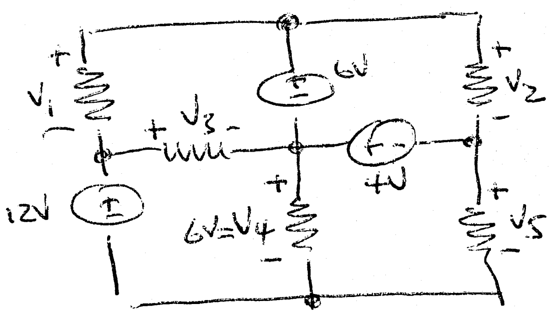
$V_1 = 4V$

2.7



$$V_1 - 12 - 4 = 0 \Rightarrow V_1 = 16V$$
$$-V_3 + 12 - 8 = 0 \Rightarrow V_3 = 4V$$
$$-V_2 + 4 + V_3 = 0 \Rightarrow V_2 = 8V$$

2.8



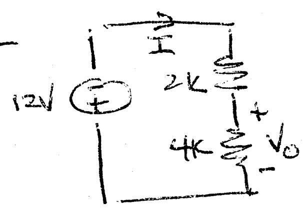
$$-6 + V_2 - 4 = 0 \Rightarrow V_2 = 10V$$
$$-6 + 4 + V_5 = 0 \Rightarrow V_5 = 2V$$
$$-12 + V_3 + 6 = 0 \Rightarrow V_3 = 6V$$
$$-V_1 + 6 - V_3 = 0 \Rightarrow V_1 = 0V$$

2.9 $I = 6/3k = 2mA$

2.10 $R = 12/2/k = 6k\Omega$

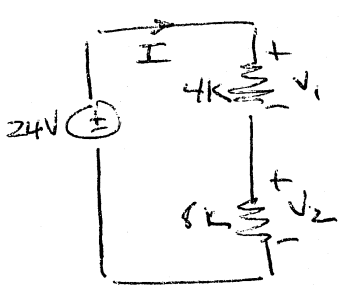
2.11 $V_s^2/2k = 8/k \Rightarrow V_s^2 = (2\times10^3)(8\times10^{-3}) = 16$; $V_s = \pm 4V$

2.12



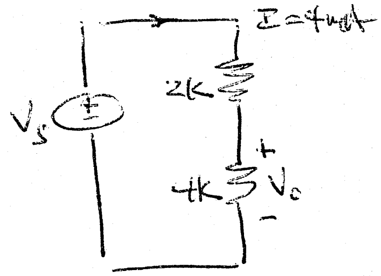
$$I = \frac{-12}{2k+4k} = -2mA$$
$$V_o = \left(-\frac{2}{k}\right)(4k) = -8V$$

2.13



$$I = \frac{24}{4k+8k} = 2mA$$
$$V_1 = 4kI = 8V$$
$$V_2 = 8kI = 16V$$

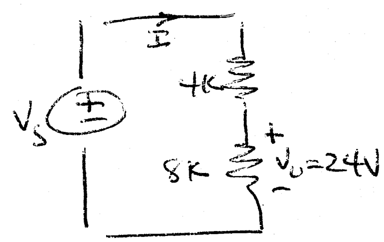
2.14



$$V_o = (4k)\left(\frac{4}{k}\right) = 16V$$

$$V_s = \frac{4}{k}(2k + 4k) = 24V$$

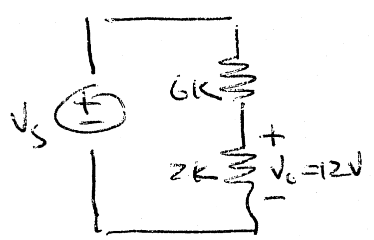
2.15



$$I = \frac{24}{8k} = 3mA$$

$$V_s = \frac{3}{k}(4k + 8k) = 36V$$

2.16

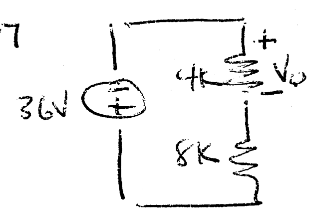


Voltage Div.

$$V_o = \frac{V_s(2k)}{6k + 2k} = 12$$

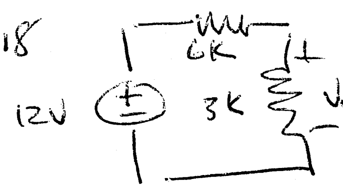
$$V_s = 48V$$

2.17



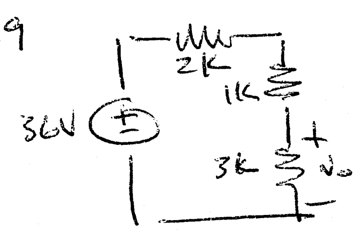
$$V_o = \frac{-36(4k)}{4k + 8k} = -12V$$

2.18



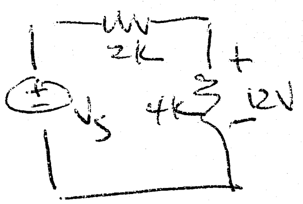
$$V_o = \frac{12(3k)}{6k + 3k} = 4V$$

2.19



$$V_o = \frac{36(3k)}{2k + 1k + 3k} = 18V$$

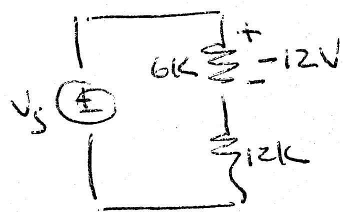
2.20



$$12 = \frac{V_S(4K)}{4K+2K}$$

$$V_S = 18V$$

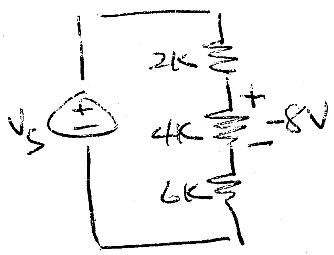
2.21



$$-12 = \frac{V_S(6K)}{6K+12K}$$

$$V_S = -36V$$

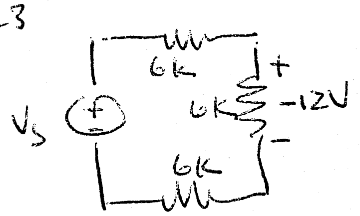
2.22



$$-8V = \frac{V_S(4K)}{2K+4K+6K}$$

$$V_S = -24V$$

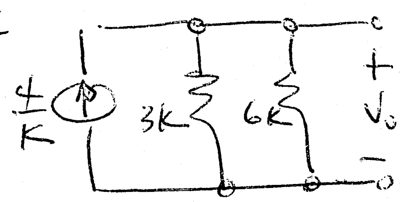
2.23



$$-12 = \frac{V_S(6K)}{(3)(6K)}$$

$$V_S = -36V$$

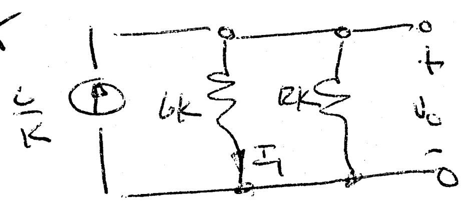
2.24



$$\frac{V_o}{3K} + \frac{V_o}{6K} = \frac{4}{K}$$

$$V_o = 8V$$

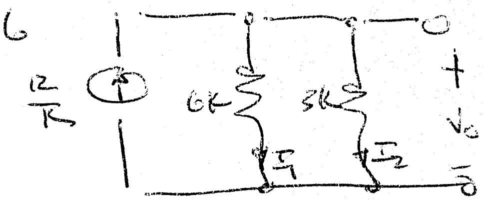
2.25



$$\frac{V_o}{6K} + \frac{V_o}{12K} = \frac{6}{K} \Rightarrow V_o = 24V$$

$$I_1 = \frac{24}{6K} = 4mA$$

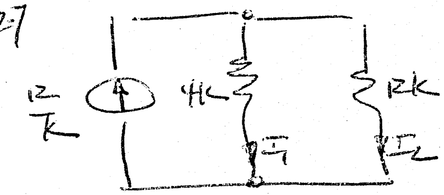
2.26



$$\frac{V_o}{6K} + \frac{V_o}{3K} = \frac{12}{K} \Rightarrow V_o = 24V$$

$$I_1 = \frac{24}{6K} = 4mA \quad I_2 = \frac{24}{3K} = 8mA$$

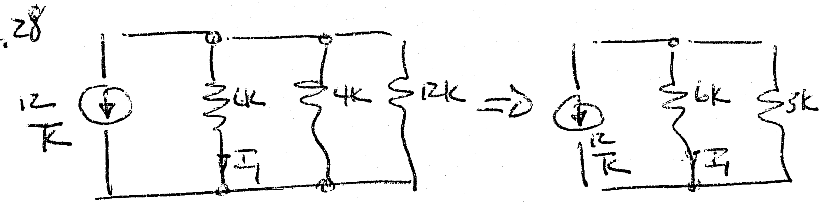
2.27



$$I_1 = \frac{12}{K}\left(\frac{12K}{4K+12K}\right) = 9mA$$

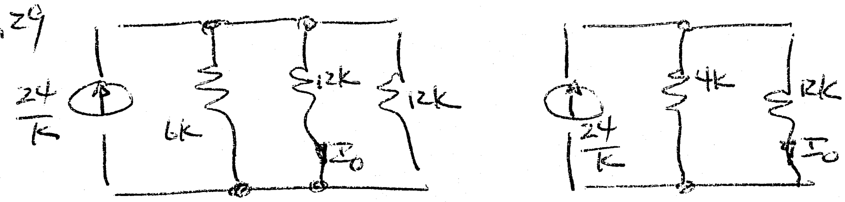
$$I_2 = \frac{12}{K}\left(\frac{4K}{4K+12K}\right) = 3mA$$

2.28



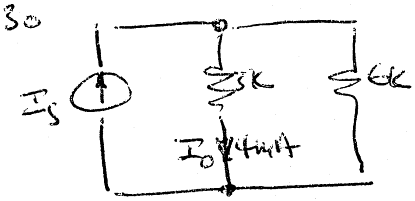
$$I_1 = \frac{-\frac{12}{K}(3K)}{3K+6K} = -4mA$$

2.29



$$I_o = \frac{\frac{24}{K}(4K)}{4K+12K} = 6mA$$

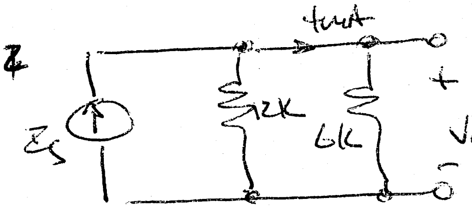
2.30



$$\frac{4}{K} = \frac{I_S(6K)}{3K+6K}$$

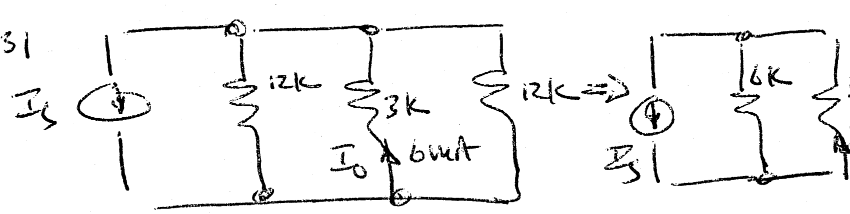
$$I_S = 6mA$$

2.32



$$V_o = \left(\frac{4}{K}\right)(6K) = 24V$$

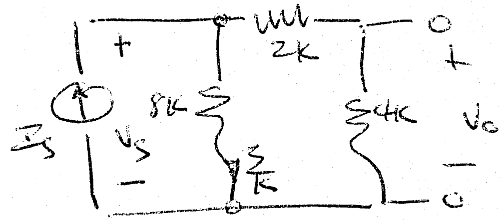
2.31



$$\frac{6}{K} = \frac{I_S(6K)}{6K+3K}$$

$$I_S = 9mA$$

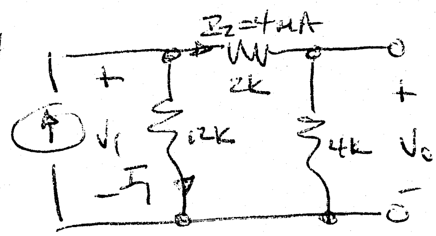
2,33



$V_s = \left(\frac{3}{k}\right)(8k) = 24V$

$V_o = \frac{24(4k)}{2k+4k} = 16V$

2,34

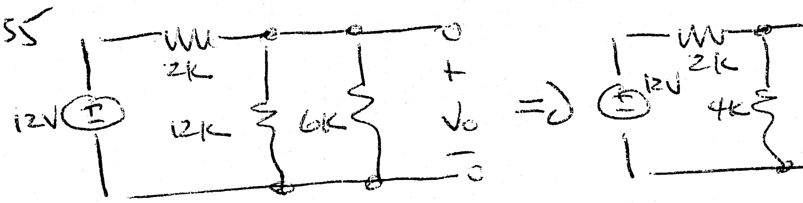


$V_o = I_2(4k) = 16V$

$V_1 = I_2(2k+4k) = 24V$

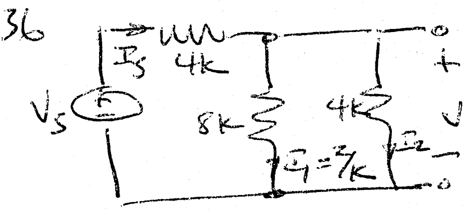
$I_1 = \frac{24}{12k} = 2mA$

2,35



$V_o = \frac{12(4k)}{2k+4k} = 8V$

2,36



$V_1 = 8kI_1 = 16V$

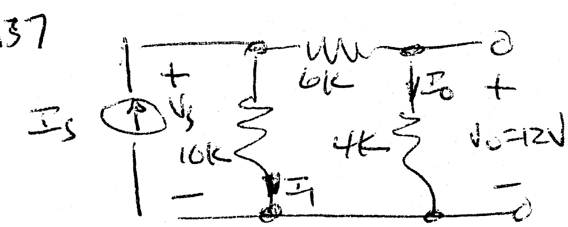
$I_2 = \frac{V_1}{4k} = 4mA$

$I_S = I_1 + I_2 = 6mA$

$V_S = 4kI_S + V_1$

$= 40V$

2,37



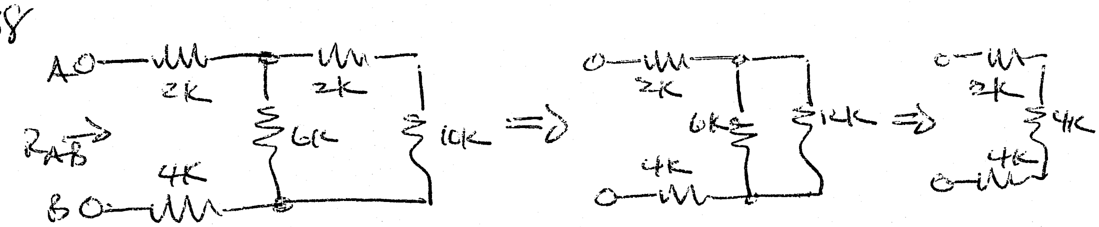
$I_o = \frac{12}{4k} = 3mA$

$V_S = I_o(4k+6k) = 30V$

$I_1 = V_S/10k = 3mA$

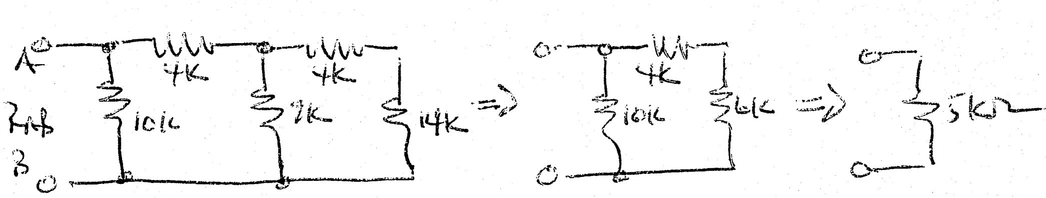
$I_S = I_1 + I_o = 6mA$

2,38

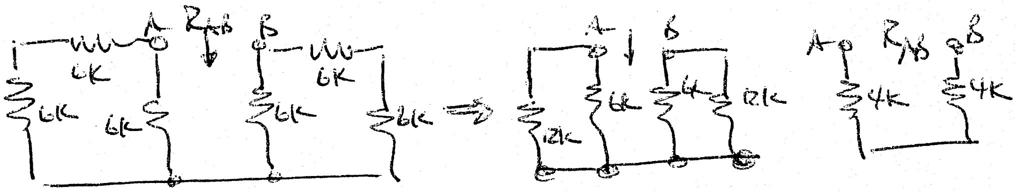


$R_{AB} = 10k\Omega$

2.39

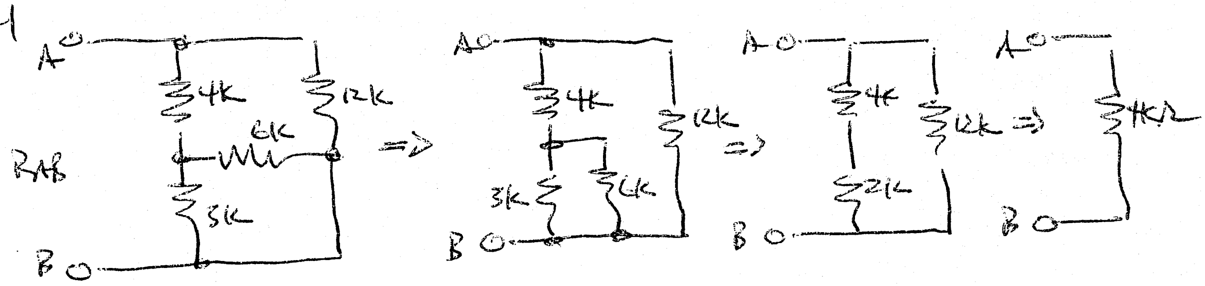


2.40

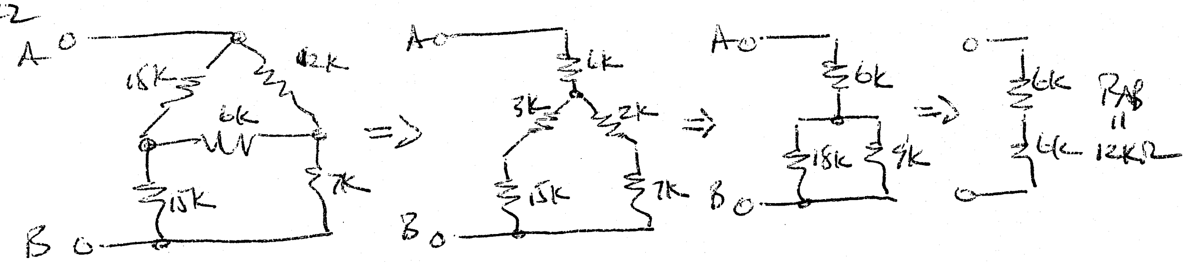


$R_{AB} = 8K\Omega$

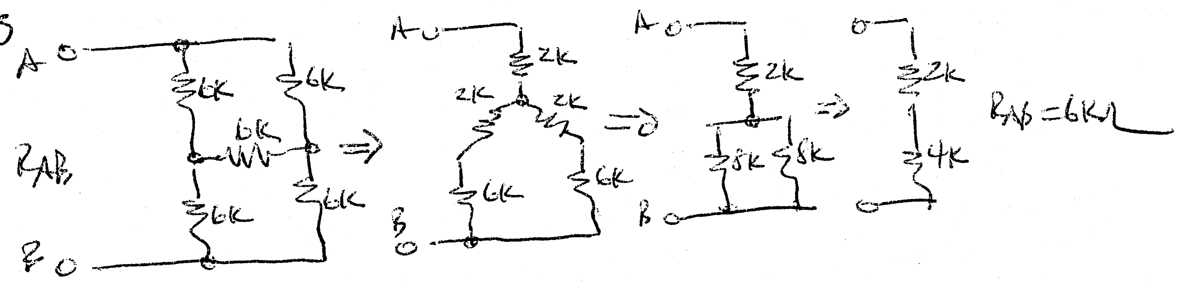
2.41



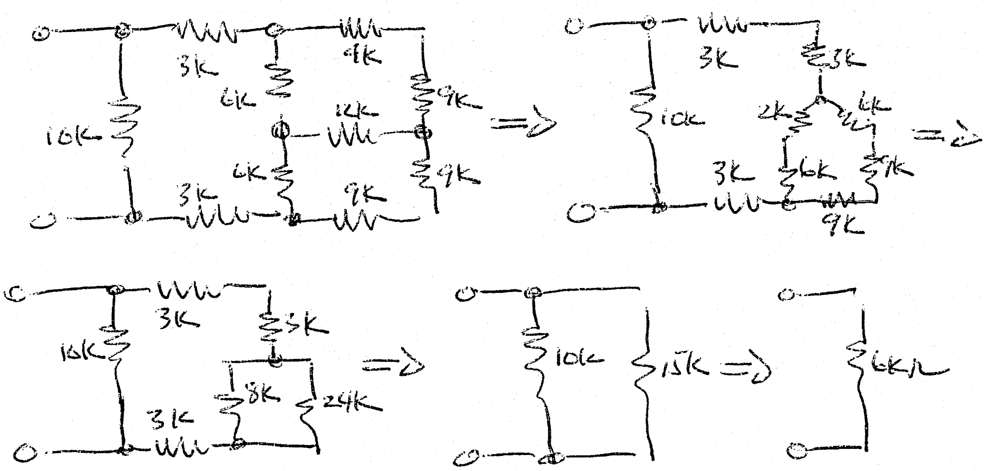
2.42



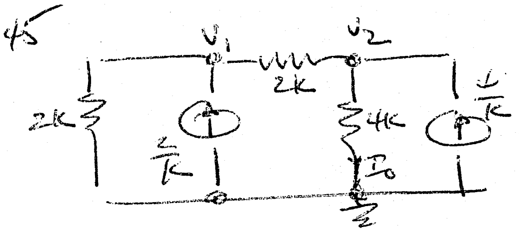
2.43



2.44



2.45



$$v_1\left(\frac{1}{2k}+\frac{1}{2k}\right) - v_2\left(\frac{1}{2k}\right) = \frac{2}{k}$$

$$-v_1\left(\frac{1}{2k}\right) + v_2\left(\frac{1}{2k}+\frac{1}{4k}\right) = \frac{4}{k}$$

$$v_1 - \frac{1}{2}v_2 = 2$$

$$-\frac{1}{2}v_1 + \frac{3}{4}v_2 = 4$$

$$\begin{pmatrix} 1 & -1/2 \\ -1/2 & 3/4 \end{pmatrix}\begin{pmatrix} v_1 \\ v_2 \end{pmatrix} = \begin{pmatrix} 2 \\ 4 \end{pmatrix}$$

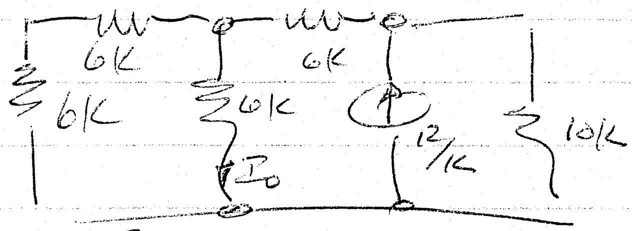
$$\Delta = (1)(3/4) - (-1/2)(-1/2) = \frac{3}{4} - \frac{1}{4} = \frac{1}{2}$$

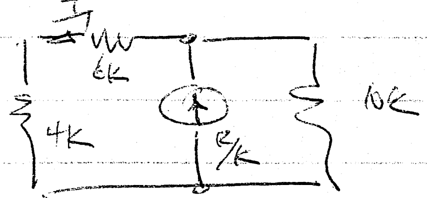
$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = 2\begin{pmatrix} 3/4 & 1/2 \\ 1/2 & 1 \end{pmatrix}\begin{pmatrix} 2 \\ 4 \end{pmatrix}$$

$$\begin{pmatrix} v_1 \\ v_2 \end{pmatrix} = \begin{pmatrix} 2\left(\frac{6}{4}+2\right) \\ 2(1+4) \end{pmatrix} = \begin{bmatrix} 2(3\tfrac{1}{2}) \\ 2(5) \end{bmatrix} = \begin{bmatrix} 7 \\ 10 \end{bmatrix}$$

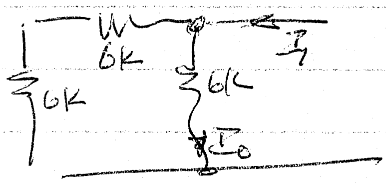
$$I_0 = \frac{10}{4k} = 2.5\,mA$$

2.46



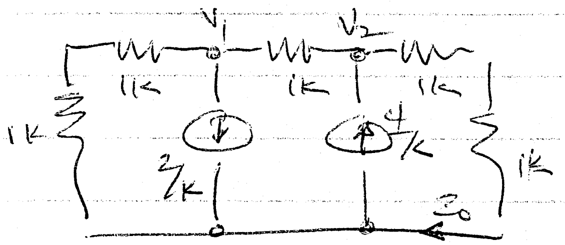


$I_1 = \frac{12}{k} / 2 = \frac{6}{k}$



$I_0 = \frac{I_1 (12k)}{18k} = \frac{\left(\frac{6}{k}\right)(12k)}{18k} = \frac{4}{k} A$

2.47



$V_1\left(\frac{1}{k} + \frac{1}{2k}\right) - V_2\left(\frac{1}{k}\right) = -\frac{2}{k}$

$-V_1\left(\frac{1}{k}\right) + V_2\left(\frac{1}{k} + \frac{1}{2k}\right) = \frac{4}{k}$

$V_1\left(\frac{3}{2}\right) - V_2 = -2$

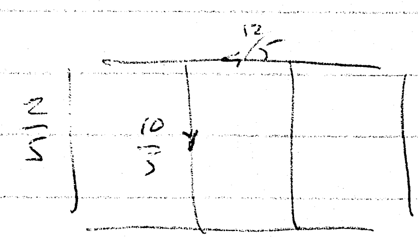
$-V_1 + V_2\left(\frac{3}{2}\right) = 4$

$\Delta = \frac{9}{4} - (-1)(-1) = \frac{9}{4} - \frac{4}{4} = \frac{5}{4}$

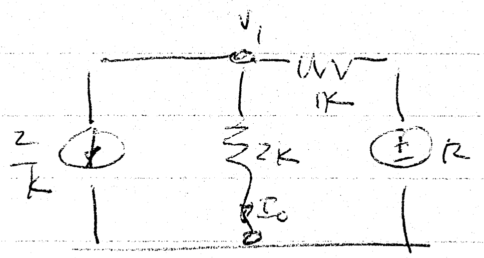
$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \frac{4}{5}\begin{bmatrix} 3/2 & 1 \\ 1 & 3/2 \end{bmatrix}\begin{bmatrix} -2 \\ 4 \end{bmatrix}$

$V_1 = \frac{4}{5}\left[-3+4\right] = \frac{4}{5}$

$V_2 = \frac{4}{5}\left(-2+6\right) = \frac{16}{5}$



2.48



$$2 + \frac{v_1}{2K} + \frac{v_1 - 12}{1K} = 0$$

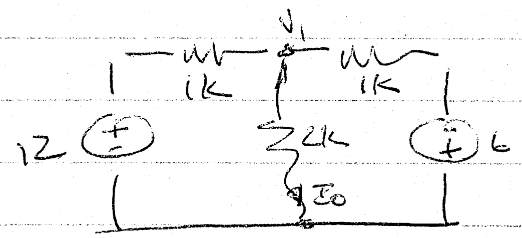
$$2 + \frac{v_1}{2} + \frac{v_1}{1} - 12 = 0$$

$$\frac{3}{2} v_1 = 10$$

$$v_1 = \frac{20}{3} V$$

$$I_0 = \frac{v_1}{2K} = \frac{10}{3K} A$$

2.49



$$\frac{v_1 - 12}{1K} + \frac{v_1}{2K} + \frac{v_1 + 6}{1K} = 0$$

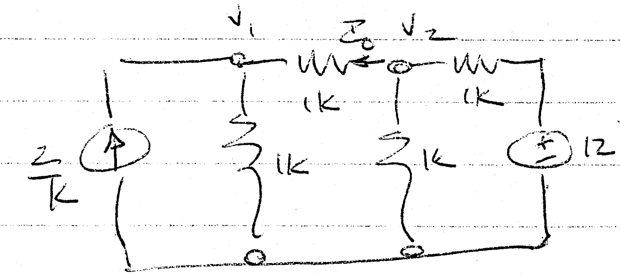
$$v_1 - 12 + \frac{v_1}{2} + v_1 + 6 = 0$$

$$\frac{5}{2} v_1 = 6$$

$$v_1 = \frac{12}{5} V$$

$$I_0 = \frac{v_1}{2K} = \frac{6}{5K} A$$

2.50



$$v_1\left(\frac{1}{k} + \frac{1}{k}\right) - v_2\left(\frac{1}{k}\right) = \frac{2}{k}$$

$$-v_1\left(\frac{1}{k}\right) + v_2\left(\frac{1}{k} + \frac{1}{k} + \frac{1}{k}\right) = \frac{12}{k}$$

$$2v_1 - v_2 = 2$$

$$-v_1 + 3v_2 = 12$$

$$2v_1 - 2 = v_2$$

$$-v_1 + 3(2v_1 - 2) = 12$$

$$5v_1 - 6 = 12$$

$$v_1 = \frac{18}{5} V$$

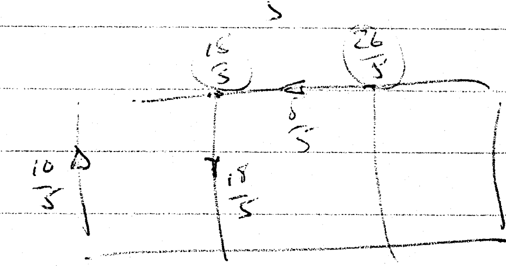
$$2v_1 - v_2 = 2$$

$$2\left(\frac{18}{5}\right) - v_2 = 2$$

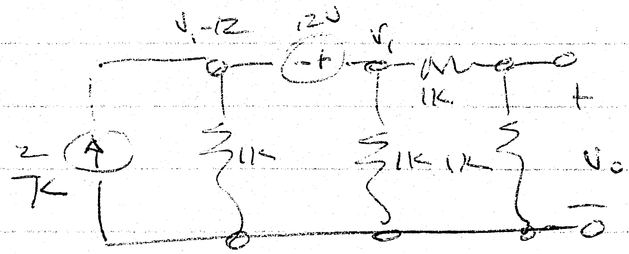
$$\frac{36}{5} - 2 = v_2$$

$$\frac{36 - 10}{5} = v_2$$

$$\frac{26}{5} V = v_2$$



2.51



$$\frac{V_1-12}{1k}+\frac{V_1}{1k}+\frac{V_1}{2k}=\frac{2}{k}$$

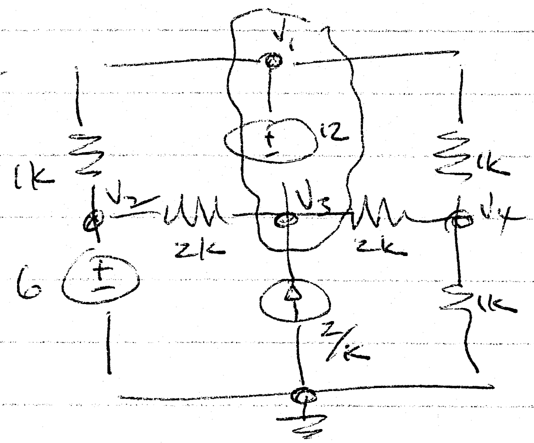
$$V_1+V_1+\frac{V_1}{2}=14$$

$$\tfrac{5}{2}V_1=14$$

$$V_1=\frac{28}{5}\,V$$

$$V_0=\frac{1}{2}V_1=\frac{14}{5}\,V$$

2.52



$$\frac{V_1-6}{k}+\frac{V_3-6}{2k}+\frac{V_1-V_4}{1k}+\frac{V_3-V_4}{2k}=\frac{2}{k}$$

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

$$\frac{V_4-V_1}{1k}+\frac{V_4-V_3}{2k}+\frac{V_4}{k}=0$$

$$V_1-6+\frac{V_3}{2}-3+V_1-V_4+\frac{V_3}{2}-\frac{V_4}{2}=2$$

$$V_4-V_1+\frac{V_4}{2}-\frac{V_3}{2}+V_4=0$$

$$V_1=V_3+12$$

$$V_3+12-6+\frac{V_3}{2}-3+V_3+12-V_4+\frac{V_3}{2}-\frac{V_4}{2}=2$$

$$V_4-V_3-12+\frac{V_4}{2}-\frac{V_3}{2}+V_4=0$$

$$3V_3-\tfrac{3}{2}V_4=-13$$

$$-\tfrac{3}{2}V_3+\tfrac{5}{2}V_4=12$$

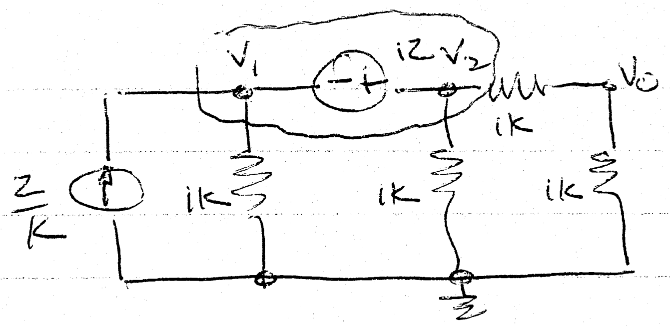
$$\Delta=(3)(\tfrac{5}{2})-(-\tfrac{3}{2})(-\tfrac{3}{2})=\frac{15}{2}-\frac{9}{4}=\frac{21}{4}$$

$$\begin{pmatrix}V_3\\V_4\end{pmatrix}=\frac{4}{21}\begin{bmatrix}5/2 & 3/2\\ 3/2 & 3\end{bmatrix}\begin{pmatrix}-13\\12\end{pmatrix}$$

$$V_3=\frac{4}{21}\left(\frac{-65}{2}+\frac{36}{2}\right)=\left(\frac{4}{21}\right)\left(\frac{-29}{2}\right)=-\frac{58}{21}\,V$$

$$V_4=\frac{4}{21}\left(\frac{-39}{2}+\frac{72}{2}\right)=\left(\frac{4}{21}\right)\left(\frac{33}{2}\right)=+\frac{66}{21}\,V$$

2.53



$$V_2 - V_1 = 12$$

$$-\frac{2}{1k} + \frac{V_1}{1k} + \frac{V_2}{1k} + \frac{V_2 - V_0}{1k} = 0$$

$$\frac{V_0 - V_2}{1k} + \frac{V_0}{1k} = 0$$

$$-V_1 + V_2 = 12$$
$$V_1 + 2V_2 - V_0 = 2$$
$$-V_2 + 2V_0 = 0$$

$$\begin{bmatrix} -1 & 1 & 0 \\ 1 & 2 & -1 \\ 0 & -1 & 2 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_0 \end{bmatrix} = \begin{bmatrix} 12 \\ 2 \\ 0 \end{bmatrix}$$