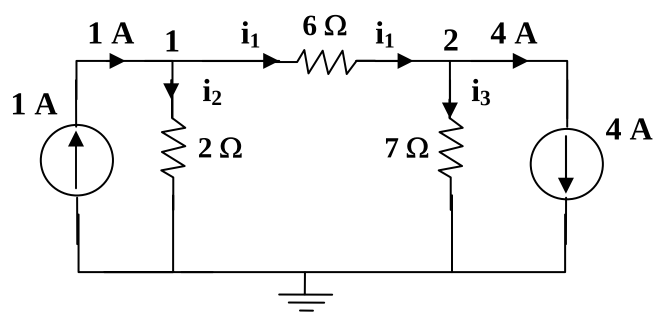
February 5, 2006

CHAPTER 3

P.P.3.1



At node 1,

$$1 = i_1 + i_2 \longrightarrow 1 = \frac{v_1 - v_2}{6} + \frac{v_1 - 0}{2}$$

or $6 = 4v_1 - v_2$ (1)

At node 2,

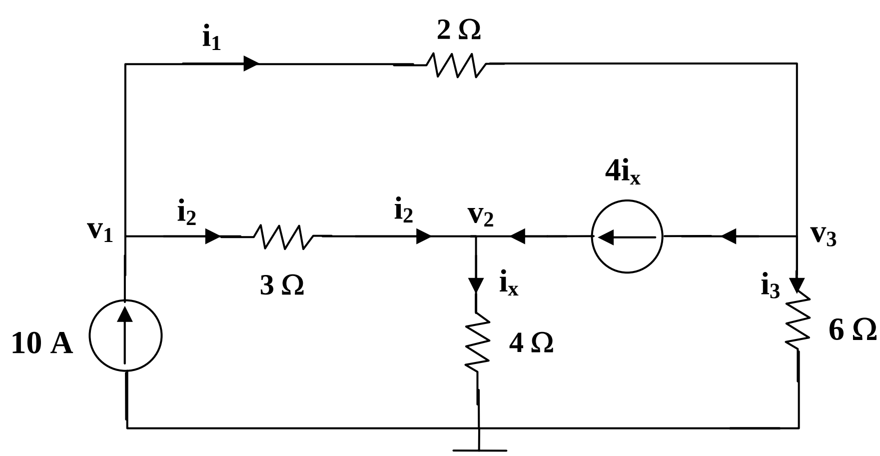
$$i_1 = 4 + i_3 \longrightarrow \frac{v_1 - v_2}{6} = 4 + \frac{v_2 - 0}{7}$$

or $168 = 7v_1 - 13v_2$ (2)

Solving (1) and (2) gives

$v_1 =$ **-2 V**, $v_2 =$ **-14 V**

P.P.3.2



At node 1,

$$10 = i_1 + i_2 = \frac{v_1 - v_3}{2} + \frac{v_1 - v_2}{3}$$

or $60 = 5v_1 - 2v_2 - 3v_3$ (1)

At node 2,

$$i_2 + 4i_x = i_x \longrightarrow \frac{v_1 - v_2}{3} + 3\frac{v_2}{4} = 0$$

or $4v_1 + 5v_2 = 0$ (2)

At node 3,

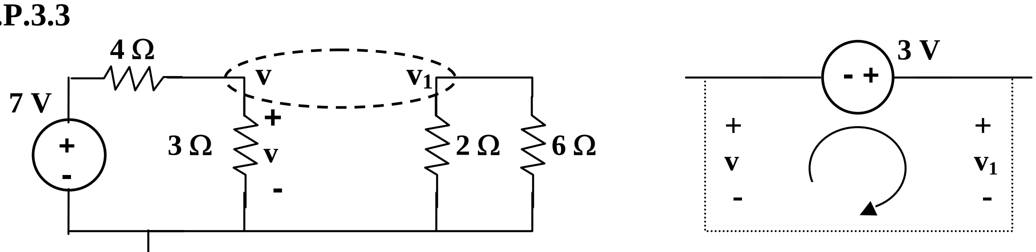
$$i_1 = i_3 + 4i_x \longrightarrow \frac{v_1 - v_3}{2} = \frac{v_3 - 0}{6} + 4\frac{v_2}{4}$$

or $-3v_1 + 6v_2 + 4v_3 = 0$ (3)

Solving (1) to (3) gives

v_1 = **80 V**, v_2 = **–64 V**, v_3 = **156 V**

P.P.3.3



(a) (b)

At the supernode in Fig. (a),

$$\frac{7 - v}{4} = \frac{v}{3} + \frac{v_1}{2} + \frac{v_1}{6}$$

or $21 = 7v + 8v_1$ (1)

Applying KVL to the loop in Fig. (b),

$- v - 3 + v_1 = 0 \longrightarrow v_1 = v + 3$ (2)

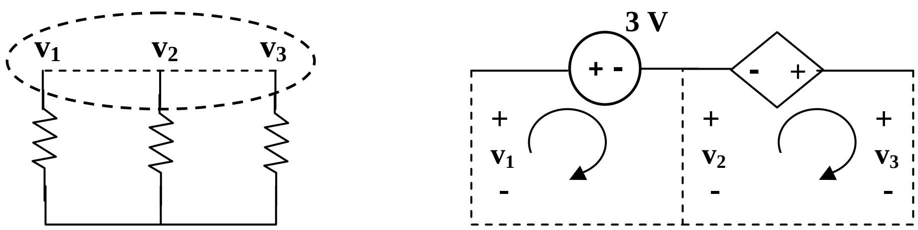
Solving (1) and (2),

$v = \underline{\mathbf{-\ 200\ mV}}$

$v_1 = v + 3 = 2.8$, $i_1 = \dfrac{v_1}{2} = 1.4$

$i_1 = \underline{\mathbf{1.4\ A}}$

P.P.3.4



(a) (b)

From Fig. (a),

$$\frac{v_1}{2} + \frac{v_2}{4} + \frac{v_3}{3} = 0 \longrightarrow 6v_1 + 3v_2 + 4v_3 = 0 \qquad (1)$$

From Fig. (b),

$$- v_1 + 10 + v_2 = 0 \longrightarrow v_1 = v_2 + 10 \qquad (2)$$

$$- v_2 - 5i + v_3 = 0 \longrightarrow v_3 = v_2 + 5i \qquad (3)$$

Solving (1) to (3), we obtain

$v_1 = \underline{\mathbf{3.043V}}$, $v_2 = \underline{\mathbf{-6.956\ V}}$, $v_3 = \underline{\mathbf{652.2\ mV}}$

P.P.3.5 We apply KVL to the two loops and obtain

$$- 12 + 18i_i - 12i_2 = 0 \longrightarrow 3i_i - 2i_2 = 2 \quad (1)$$

$$8 + 24i_2 - 12i_1 = 0 \longrightarrow - 3i_1 + 6i_2 = -2 \quad (2)$$

From (1) and (2) we get

$i_1 = \underline{\mathbf{666.7\ mA}}$, $i_2 = \underline{\mathbf{0A}}$

P.P.3.6 For mesh 1,

$$-20 + 6i_1 - 2i_2 - 4i_3 = 0 \longrightarrow 3i_1 - i_2 - 2i_3 = 10 \qquad (1)$$

For mesh 2,

$$10i_2 - 2i_1 - 8i_3 - 10i_0 = 0 = -i_1 + 5i_2 - 9i_3 \qquad (2)$$

But $i_0 = i_3$,

$$18i_3 - 4i_1 - 8i_2 = 0 \longrightarrow -2i_1 - 4i_2 + 9i_3 = 0 \qquad (3)$$

From (1) to (3),

$$\begin{bmatrix} 3 & -1 & -2 \\ -1 & 5 & -9 \\ -2 & -4 & 9 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 10 \\ 0 \\ 0 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 3 & -1 & -2 \\ -1 & 5 & -9 \\ -2 & -4 & 9 \\ 3 & -1 & -2 \\ -1 & 5 & -9 \end{vmatrix} = 135 - 8 - 18 - 20 - 108 - 9 = -28$$

$$\Delta_1 = \begin{vmatrix} 10 & -1 & -2 \\ 0 & 5 & -9 \\ 0 & -4 & 9 \\ 10 & -1 & -2 \\ 0 & 5 & -9 \end{vmatrix} = 450 - 360 = 90$$

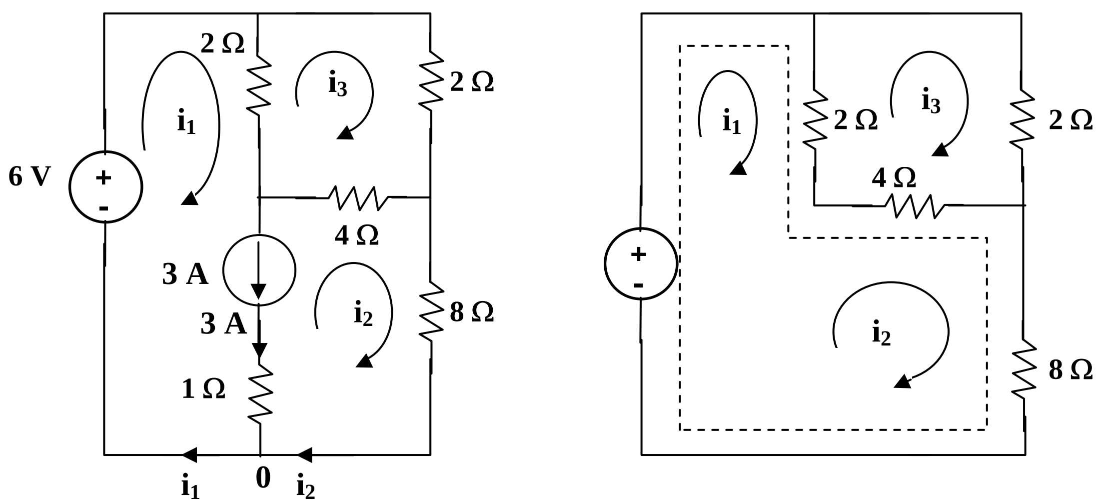
$$\Delta_2 = \begin{vmatrix} 3 & 10 & -2 \\ -1 & 0 & -9 \\ -2 & 0 & 9 \\ 3 & 10 & -2 \\ -1 & 0 & -9 \end{vmatrix} = 180 + 90 = 270$$

$$\Delta_3 = \begin{vmatrix} 3 & -1 & 10 \\ -1 & 5 & 0 \\ -2 & -4 & 0 \\ 3 & -1 & 10 \\ -1 & 5 & 0 \end{vmatrix} = 40 + 100 = 140$$

$$i_1 = \frac{\Delta_1}{\Delta} = \frac{90}{-28} = -3.214, \; i_2 = \frac{\Delta_2}{\Delta} = \frac{270}{-28} = -9.643, \; i_3 = \frac{\Delta_3}{\Delta} = \frac{140}{-28} = -5A$$

$i_0 = i_3 =$ **–5A**

P.P.3.7



(a) **(b)**

For the supermesh,

$$- 6 + 2i_1 - 2i_3 + 12i_2 - 4i_3 = 0 \longrightarrow i_1 + 6i_2 - 3i_3 = 3 \qquad (1)$$

For mesh 3,

$$8i_3 - 2i_1 - 4i_2 = 0 \longrightarrow - i_1 - 2i_2 + 4i_3 = 0 \qquad (2)$$

At node 0 in Fig. (a),

$$i_1 = 3 + i_2 \longrightarrow i_1 - i_2 = 3$$

Solving (1) to (3) yields

$i_1 =$ **3.474A**, $i_2 =$ **473.7 mA**, $i_3 =$ **1.1052A**

P.P.3.8 $G_{11} = 1/(1) + 1/(10) + 1/(5) = 1.3$, $G_{12} = -1/(5) = -0.2$,
$G_{33} = 1/(4) + 1 = 1.25$, $G_{44} = 1/(2) + 1/(4) = 0.75$,
$G_{12} = -1/(5) = -0.2$, $G_{13} = -1$, $G_{14} = 0$,
$G_{21} = -0.2$, $G_{23} = 0 = G_{26}$,
$G_{31} = -1$, $G_{32} = 0$, $G_{34} = -1/4 = -0.25$,
$G_{41} = 0$, $G_{42} = 0$, $G_{43} = 0.25$,
$i_1 = 0$, $i_2 = 2 - 1 = 1$, $i_3 = -1$, $i_4 = 3$.

Hence,

$$\underline{\begin{bmatrix} 1.3 & -0.2 & -1 & 0 \\ -0.2 & 0.2 & 0 & 0 \\ -1 & 0 & 1.25 & -0.25 \\ 0 & 0 & -0.25 & 0.75 \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{bmatrix} = \begin{bmatrix} 0 \\ 3 \\ -1 \\ 3 \end{bmatrix}}$$

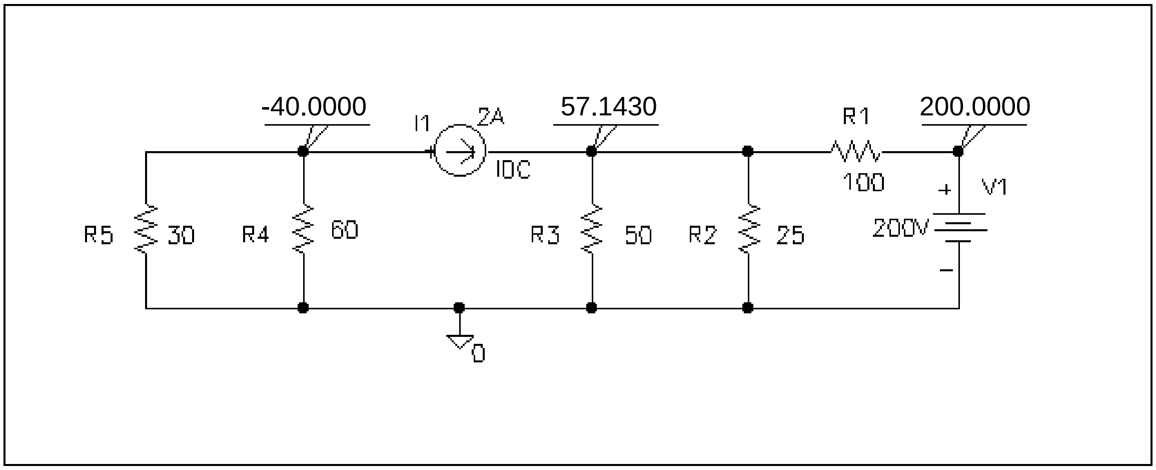
P.P.3.9 $R_{11} = 50 + 40 + 80 = 170$, $R_{22} = 40 + 30 + 10 = 80$,
$R_{33} = 30 + 20 = 50$, $R_{44} = 10 + 80 = 90$,
$R_{55} = 20 + 60 = 80$, $R_{12} = -40$, $R_{13} = 0$, $R_{14} = -80$,
$R_{15} = 0$, $R_{21} = -40$, $R_{23} = -30$, $R_{24} = -10$, $R_{25} = 0$,
$R_{31} = 0$, $R_{32} = -30$, $R_{34} = 0$, $R_{35} = -20$,
$R_{41} = -80$, $R_{42} = -10$, $R_{43} = 0$, $R_{45} = 0$,
$R_{51} = 0$, $R_{52} = 0$, $R_{53} = -20$, $R_{54} = 0$,
$v_1 = 24$, $v_2 = 0$, $v_3 = -12$, $v_4 = 10$, $v_5 = -10$

Hence the mesh-current equations are

$$\underline{\begin{bmatrix} 170 & -40 & 0 & -80 & 0 \\ -40 & 80 & -30 & -10 & 0 \\ 0 & -30 & 50 & 0 & -20 \\ -80 & -10 & 0 & 90 & 0 \\ 0 & 0 & -20 & 0 & 80 \end{bmatrix}\begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \end{bmatrix} = \begin{bmatrix} 24 \\ 0 \\ -12 \\ 10 \\ -10 \end{bmatrix}}$$

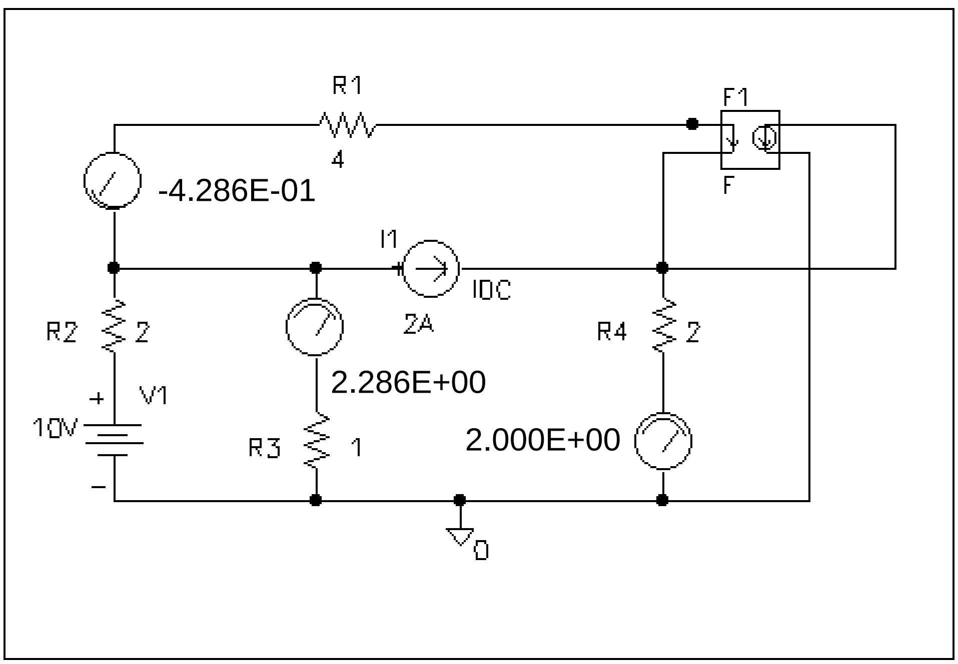
P.P.3.10 The schematic is shown below. It is saved and simulated by selecting Analysis/Simulate. The results are shown on the viewpoints:

$v_1 =$ **$\underline{-40\text{ V}}$**, $v_2 =$ **$\underline{57.14\text{ V}}$**, $v_3 =$ **$\underline{200\text{ V}}$**



P.P.3.11 The schematic is shown below. After saving it, it is simulated by choosing Analysis/Simulate. The results are shown on the IPROBES.

i_1 = **<u>–428.6 mA</u>**, i_2 = **<u>2.286 A</u>**, i_3 = **<u>2 A</u>**



P.P.3.12 For the input loop,

$$-5 + 10 \times 10^3 I_B + V_{BE} + V_0 = 0 \qquad (1)$$

For the outer loop,

$$-V_0 - V_{CE} - 500 I_0 + 12 = 0 \qquad (2)$$

But $V_0 = 200 I_E$ (3)

Also $I_C = \beta I_B = 100 I_B$, $\alpha = \beta/(1 + \beta) = 100/(101)$

$$I_C = \alpha I_E \longrightarrow I_E = I_C/(\alpha) = \beta I_B/(\alpha)$$

$$I_E = 100 (101/(100)) I_R = 101 I_B \qquad (4)$$

From (1), (3) and (4),

$$10{,}000 I_B + 200(101) I_R = 5 - V_{BE}$$

$$I_B = \frac{5 - 0.7}{10{,}000 + 20{,}000} = 142.38 \mu A$$

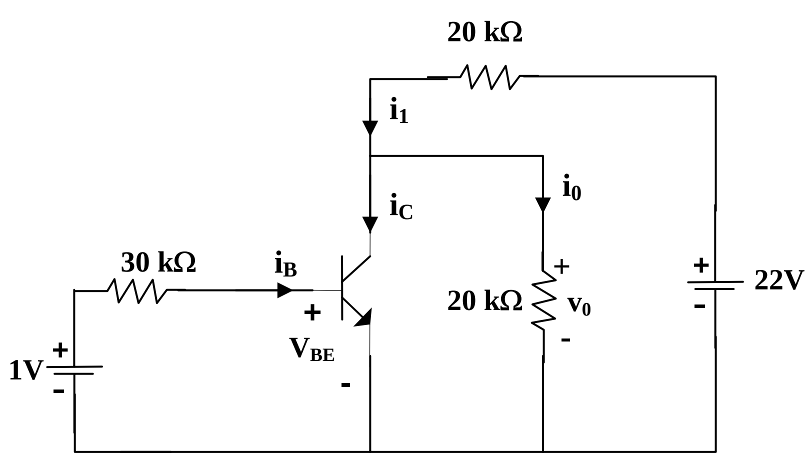
$V_0 = 200 I_E = 20{,}000 I_B =$ **<u>2.876 V</u>**

From (2),

$$V_{CE} = 12 - V_0 - 500 I_C = 9.124 - 500 \times 100 \times 142.38 \times 10^{-6}$$

$V_{CE} =$ **<u>1.984 V {often, this is rounded to 2.0 volts}</u>**

P.P.3.13



First of all, it should be noted that the circuit in the textbook should have a 22V source on the right hand side rather than the 10 V source.

$$i_B = \frac{1-0.7}{30k} = 10\mu A, \quad i_C = \beta i_B = 0.8 \text{ mA}$$

$$i_1 = i_C + i_0 \qquad (1)$$

Also, $-20ki_0 - 20ki_1 + 22 = 0 \longrightarrow i_1 = 1.1 \text{ mA} - i_0$ (2)

Equating (1) and (2),

$$1.1\text{mA} - i_0 = 0.8 \text{ mA} + i_0 \longrightarrow i_0 = \underline{\mathbf{150\ \mu A}}$$

$$v_0 = 20\ ki_0 = 20 \times 0.15 = \underline{\mathbf{3\ V}}$$