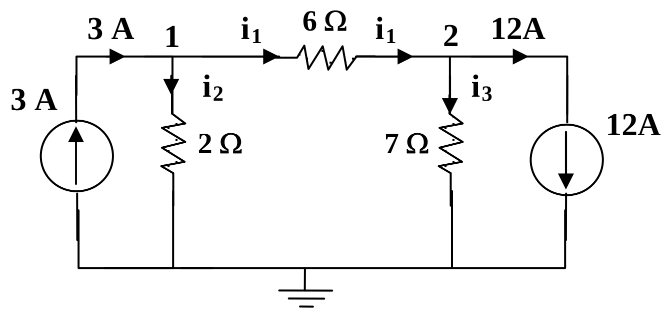
CHAPTER 3

P.P.3.1



At node 1,

$$-3 + i_1 + i_2 = 0 \text{ or } \frac{v_1 - v_2}{6} + \frac{v_1 - 0}{2} = 3$$

or $4v_1 - v_2 = 18$ (1)

At node 2,

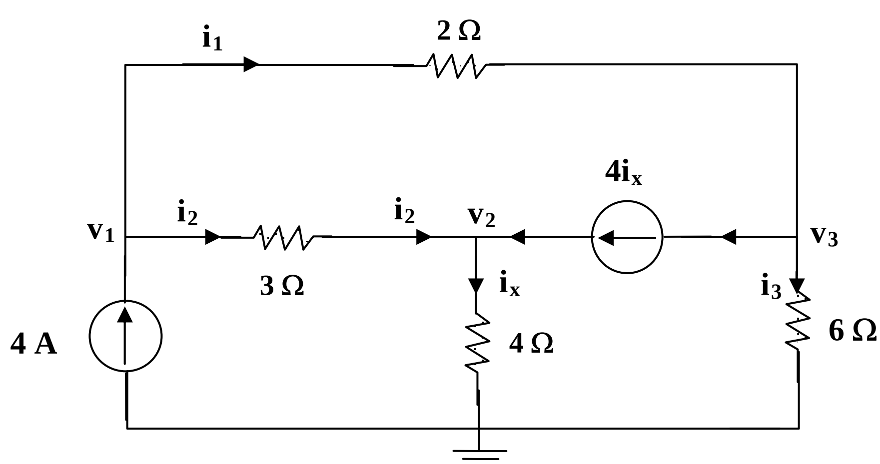
$$-i_1 + i_3 + 12 = 0 \text{ or } i_1 = 12 + i_3 \text{ or } \frac{v_1 - v_2}{6} = 12 + \frac{v_2 - 0}{7}$$

or $7v_1 - 13v_2 = 504$ (2)

Solving (1) and (2) gives

$v_1 = \mathbf{-6\ V}$, $v_2 = \mathbf{-42\ V}$

P.P.3.2



At node 1,

$$-4 + i_1 + i_2 = 0 = -4 + \frac{v_1 - v_3}{2} + \frac{v_1 - v_2}{3}$$

or $5v_1 - 2v_2 - 3v_3 = 24$ (1)

At node 2,

$-i_2 + i_x - 4i_x = 0 = -i_2 - 3i_x = 0$ where $i_x = [(v_2 - 0)/4]$ or

$$\frac{v_1 - v_2}{3} + 3\frac{v_2}{4} = 0 \text{ which leads to } 4v_1 + 5v_2 = 0 \qquad (2)$$

At node 3,

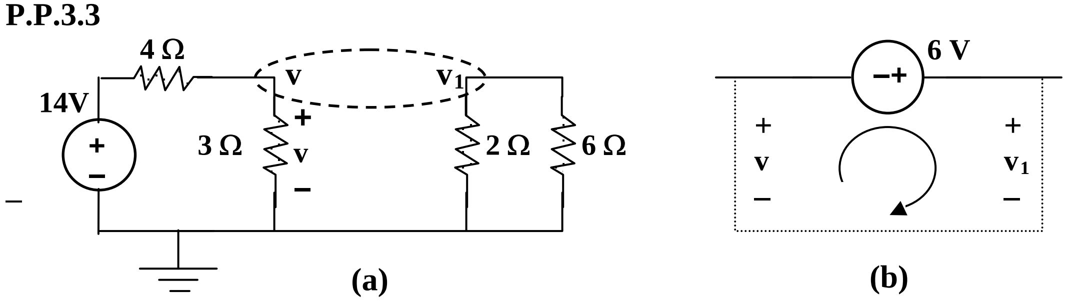
$$-i_1 + i_3 + 4i_x = 0 = \frac{v_3 - v_1}{2} + \frac{v_3 - 0}{6} + 4\frac{v_2}{4}$$

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

Solving (1) to (3) gives

$v_1 =$ **32 V**, $v_2 =$ **–25.6 V**, $v_3 =$ **62.4 V**

P.P.3.3



At the supernode in Fig. (a),

$$\frac{14 - v}{4} = \frac{v}{3} + \frac{v_1}{2} + \frac{v_1}{6}$$

or $42 = 7v + 8v_1$ (1)

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

$-v - 6 + v_1 = 0 \longrightarrow v_1 = v + 6$ (2)

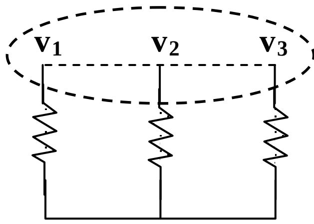
Solving (1) and (2),

$$v = \mathbf{-400\ mV}$$

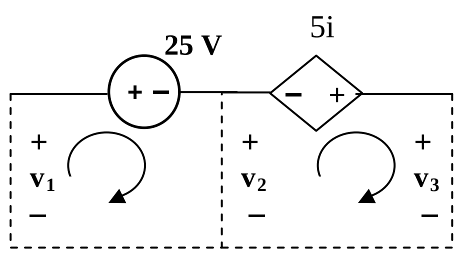
$$v_1 = v + 6 = 5.6,\ i_1 = \frac{v_1}{2} = 2.8$$

$$i_1 = \mathbf{2.8\ A}$$

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),

$$-v_1 + 25 + v_2 = 0 \longrightarrow v_1 = v_2 + 25 \qquad (2)$$

$$-v_2 - 5i + v_3 = 0 \longrightarrow v_3 = v_2 + 2.5v_1 \qquad (3)$$

Solving (1) to (3), we obtain

$$v_1 = \mathbf{7.608\ V},\ v_2 = \mathbf{-17.39\ V},\ v_3 = \mathbf{1.6305\ V}$$

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

$-45 + 2i_1 + 12(i_i - i_2) + 4i_1 = 0$ or

$-45 + 18i_i - 12i_2 = 0$ which leads to $3i_i - 2i_2 = 7.5$ (1)

$12(i_2 - i_1) + 9i_2 + 30 + 3i_2 = 0$ or

$30 + 24i_2 - 12i_1 = 0$ which leads to $-3i_1 + 6i_2 = -7.5$
(2)

From (1) and (2) we get

$$i_1 = \mathbf{2.5\ A},\ i_2 = \mathbf{0A}$$

P.P.3.6 For mesh 1,

$$-16 + 6i_1 - 2i_2 - 4i_3 = 0 \longrightarrow 3i_1 - i_2 - 2i_3 = 8 \qquad (1)$$

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),

$$\begin{bmatrix} 3 & -1 & -2 \\ -1 & 5 & -9 \\ -2 & -4 & 9 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 8 \\ 0 \\ 0 \end{bmatrix}$$

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

$$\Delta_1 = \begin{vmatrix} 8 & -1 & -2 \\ 0 & 5 & -9 \\ 0 & -4 & 9 \\ 8 & -1 & -2 \\ 0 & 5 & -9 \end{vmatrix} = 360 - 288 = 72$$

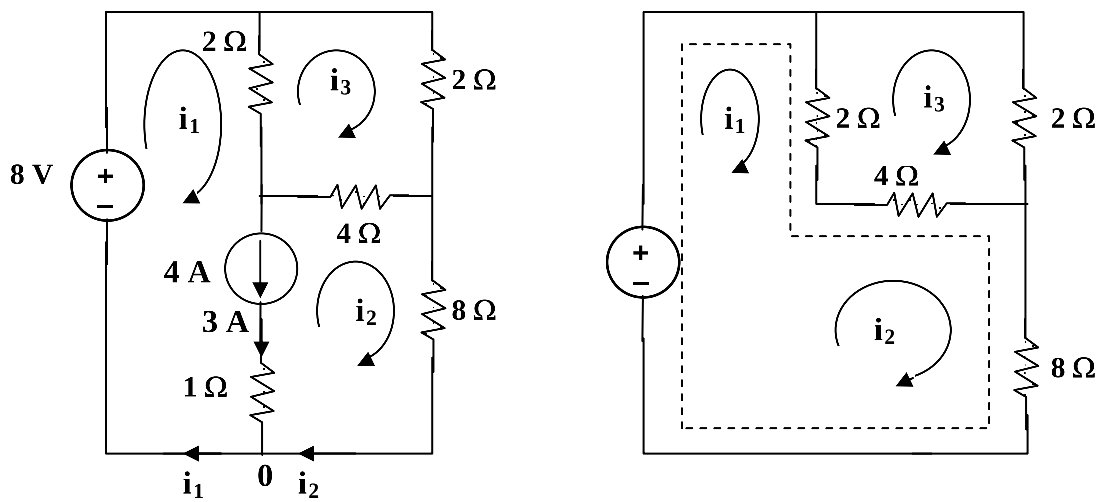
$$\Delta_2 = \begin{vmatrix} 3 & 8 & -2 \\ -1 & 0 & -9 \\ -2 & 0 & 9 \\ 3 & 8 & -2 \\ -1 & 0 & -9 \end{vmatrix} = 144 + 72 = 216$$

$$\Delta_3 = \begin{vmatrix} 3 & -1 & 8 \\ -1 & 5 & 0 \\ -2 & -4 & 0 \\ 3 & -1 & 8 \\ -1 & 5 & 0 \end{vmatrix} = 32 + 80 = 112$$

$$i_1 = \frac{\Delta_1}{\Delta} = \frac{72}{-28} = -2.571,\ i_2 = \frac{\Delta_2}{\Delta} = \frac{216}{-28} = -7.714,\ i_3 = \frac{\Delta_3}{\Delta} = \frac{112}{-28} = -4\text{A}$$

$$I_o = i_3 = \mathbf{-4\ A}$$

P.P.3.7



(a) (b)

For the supermesh,

$-8 + 2i_1 - 2i_3 + 12i_2 - 4i_3 = 0$ or $i_1 + 6i_2 - 3i_3 = 4$ (1)

For mesh 3,

$8i_3 - 2i_1 - 4i_2 = 0$ or $-i_1 - 2i_2 + 4i_3 = 0$ (2)

At node 0 in Fig. (a),

$i_1 = 4 + i_2 \longrightarrow i_1 - i_2 = 4$

Solving (1) to (3) yields

$i_1 =$ **4.632 A**, $i_2 =$ **631.6 mA**, $i_3 =$ **1.4736 A**

P.P.3.8 $G_{11} = 1/(1) + 1/(20) + 1/(5) = 1.25$, $G_{12} = –1/(5) = –0.2$,
$G_{33} = 1/(4) + 1 = 1.25$, $G_{44} = 1/(1) + 1/(4) = 1.25$,
$G_{12} = –1/(5) = –0.2$, $G_{13} = –1$, $G_{14} = 0$,
$G_{21} = –0.2$, $G_{23} = 0 = G_{26}$,
$G_{31} = –1$, $G_{32} = 0$, $G_{34} = –1/4 = –0.25$,
$G_{41} = 0$, $G_{42} = 0$, $G_{43} = 0.25$,
$i_1 = 0$, $i_2 = 3+2 = 5$, $i_3 = –3$, $i_4 = 2$.

Hence,

$$\begin{bmatrix} \mathbf{1.25} & \mathbf{-0.2} & \mathbf{-1} & \mathbf{0} \\ \mathbf{-0.2} & \mathbf{0.2} & \mathbf{0} & \mathbf{0} \\ \mathbf{-1} & \mathbf{0} & \mathbf{1.25} & \mathbf{-0.25} \\ \mathbf{0} & \mathbf{0} & \mathbf{-0.25} & \mathbf{1.25} \end{bmatrix} \begin{bmatrix} \boldsymbol{v_1} \\ \boldsymbol{v_2} \\ \boldsymbol{v_3} \\ \boldsymbol{v_4} \end{bmatrix} = \begin{bmatrix} \mathbf{0} \\ \mathbf{5} \\ \mathbf{-3} \\ \mathbf{2} \end{bmatrix}$$

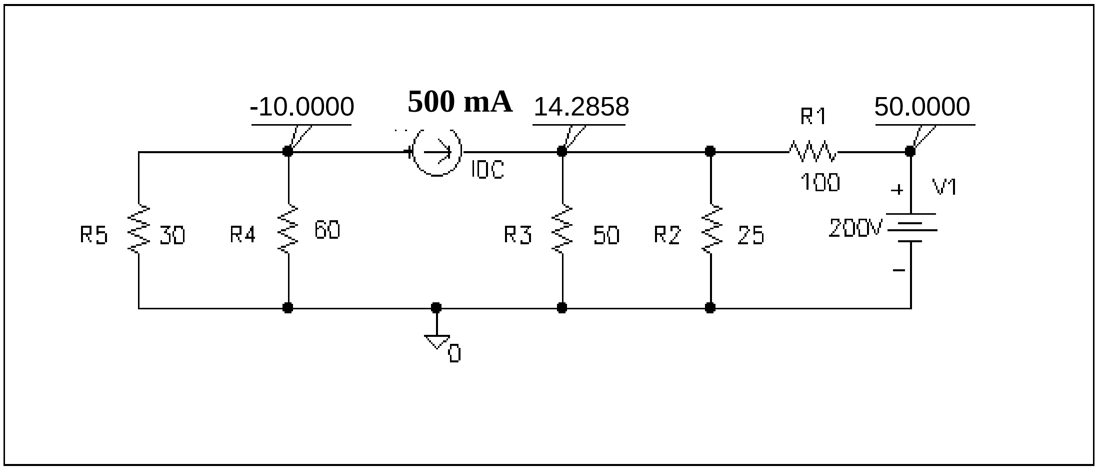
P.P.3.9 $R_{11} = 50 + 20 + 80 = 150$, $R_{22} = 20 + 30 + 15 = 65$,
$R_{33} = 30 + 20 = 50$, $R_{44} = 15 + 80 = 95$,
$R_{55} = 20 + 60 = 80$, $R_{12} = –40$, $R_{13} = 0$, $R_{14} = –80$,
$R_{15} = 0$, $R_{21} = –40$, $R_{23} = –30$, $R_{24} = –15$, $R_{25} = 0$,
$R_{31} = 0$, $R_{32} = –30$, $R_{34} = 0$, $R_{35} = –20$,
$R_{41} = –80$, $R_{42} = –15$, $R_{43} = 0$, $R_{45} = 0$,
$R_{51} = 0$, $R_{52} = 0$, $R_{53} = –20$, $R_{54} = 0$,
$v_1 = 30$, $v_2 = 0$, $v_3 = –12$, $v_4 = 20$, $v_5 = –20$

Hence the mesh-current equations are

$$\begin{bmatrix} \mathbf{150} & \mathbf{-40} & \mathbf{0} & \mathbf{-80} & \mathbf{0} \\ \mathbf{-40} & \mathbf{65} & \mathbf{-30} & \mathbf{-15} & \mathbf{0} \\ \mathbf{0} & \mathbf{-30} & \mathbf{50} & \mathbf{0} & \mathbf{-20} \\ \mathbf{-80} & \mathbf{-15} & \mathbf{0} & \mathbf{95} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{-20} & \mathbf{0} & \mathbf{80} \end{bmatrix} \begin{bmatrix} \boldsymbol{i_1} \\ \boldsymbol{i_2} \\ \boldsymbol{i_3} \\ \boldsymbol{i_4} \\ \boldsymbol{i_5} \end{bmatrix} = \begin{bmatrix} \mathbf{30} \\ \mathbf{0} \\ \mathbf{-12} \\ \mathbf{20} \\ \mathbf{-20} \end{bmatrix}$$

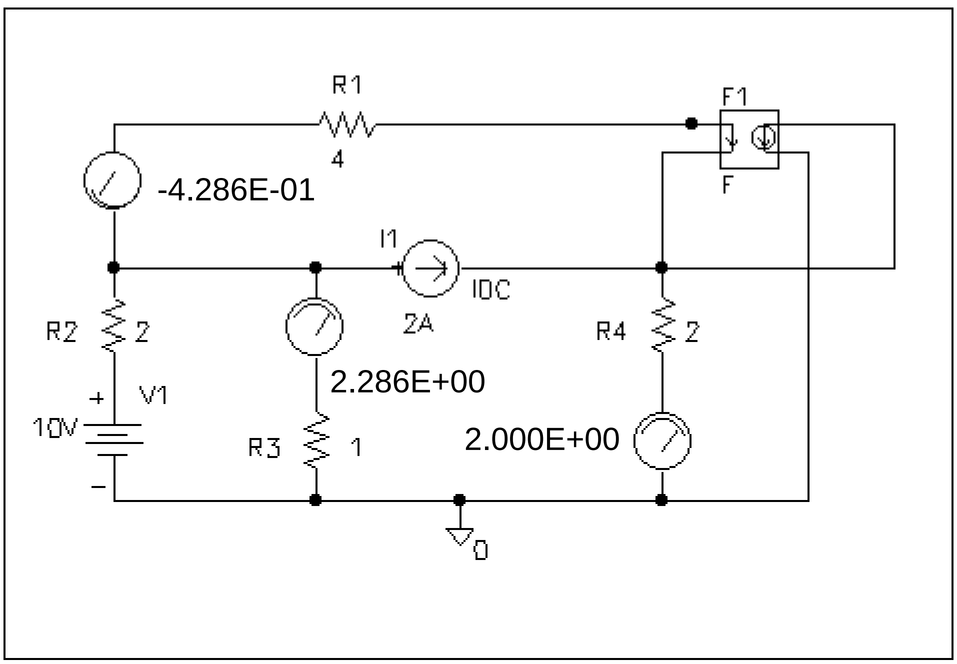
P.P.3.10 The schematic is shown below. It is saved and simulated by selecting Analysis/Simulate. The results are shown on the viewpoints:

$v_1 =$ **–10 V**, $v_2 =$ **14.286 V**, $v_3 =$ **50 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 = **–428.6 mA**, i_2 = **2.286 A**, i_3 = **2 A**



P.P.3.12 For the input loop,

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

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),

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

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

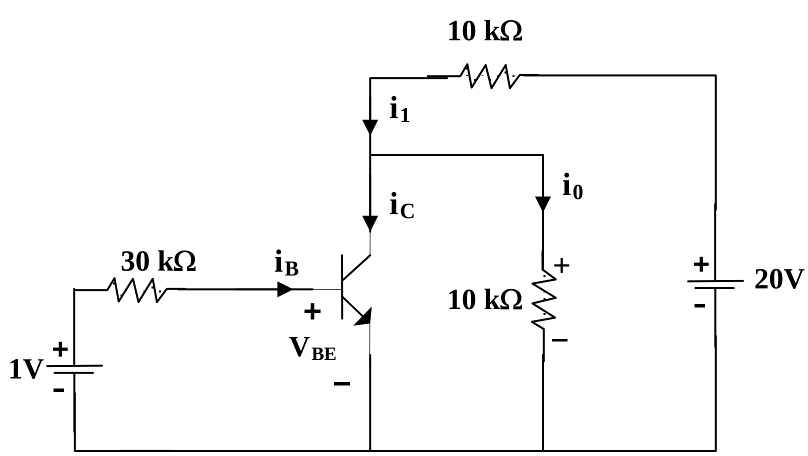
$V_0 = 200 I_E = 20{,}000 I_B =$ **2.876 V**

From (2),

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

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

P.P.3.13



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

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

Also, $-10ki_0 - 10ki_1 + 20 = 0 \longrightarrow i_1 = 2 \text{ mA} - i_0$ (2)

Equating (1) and (2),

$$2 \text{ mA} - i_0 = 0.8 \text{ mA} + i_0 \longrightarrow i_0 = \mathbf{600\ \mu A}$$

$$v_0 = 20\ ki_0 = 20x10^3\ x600x10^{-6} = \mathbf{12\ V}$$