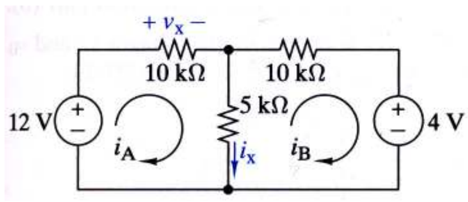
MAE140 Win12 HW4 Solutions

T R & T, 3.9, 3.10, 3.12, 3.15 a) and c), 3.20 a) and b), 3.22, 3.26, 4.2, 4.6, 4.13

3-9



(a) To write mesh-current equations by inspection, we note that the total resistances in mesh A and B are $10k\Omega + 5k\Omega$, and $10k\Omega + 5k\Omega$, respectively. The resistance common to meshes A and B is $5k\Omega$. Using these observations, we write the mesh equations as,

$$\text{Mesh A}: (10k\Omega + 5k\Omega)i_A - 5k\Omega i_B - 12V = 0$$

$$\text{Mesh B}: (10k\Omega + 5k\Omega)i_B - 5k\Omega i_A + 4V = 0$$

(b) Solving the equations, we can get:

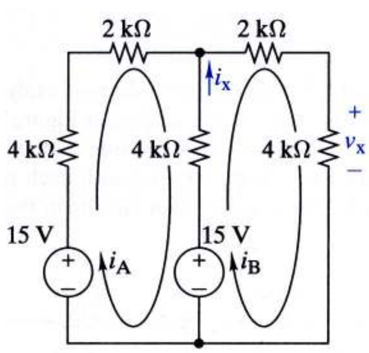
$$i_A = 0.8mA, i_B = 0mA$$

(c) Using the results,

$$v_X = 10k\Omega i_A = 8V$$

$$i_X = i_A - i_B = 0.8mA$$

3-10



(a) Writing mesh-current equations by inspection, we can get:

$$Mesh\ A: (4k\Omega + 2k\Omega + 4k\Omega)i_A - 4k\Omega i_B - 15V + 15V = 0$$

$$Mesh\ B: (4k\Omega + 2k\Omega + 4k\Omega)i_B - 4k\Omega i_A - 15V = 0$$

(b) Solving the matrix, we can get

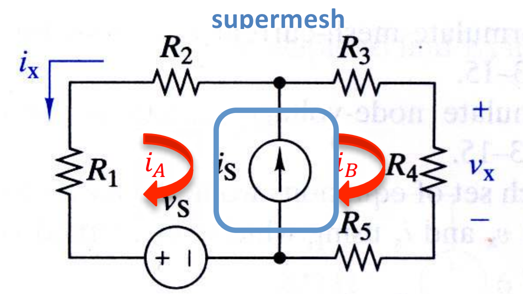
$$i_A = 0.7143\ mA, i_B = 1.7857\ mA$$

(c) Using the results,

$$v_x = 4k\Omega\ i_B = 7.14V$$

$$i_x = i_B - i_A = 1.07\ mA$$

3-12



(a) Creating a supermesh as shown in the figure, we can get

$$i_S = i_B - i_A$$

$$(R_1 + R_2)i_A + (R_1 + R_2 + R_3)i_B - v_S = 0$$

(b) Using the given values, we can get

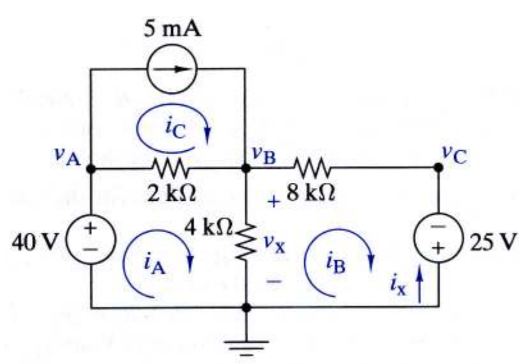
$$i_A = -25mA, \qquad i_B = 75mA$$

So we obtain,

$$v_x = i_B R_4 = 18.75V$$
$$i_x = -i_A = 0.025\ A$$

(c) The total power $P = i_A^2(R_1 + R_2) + i_B^2(R_3 + R_4 + R_5) - i_A v_S = 3.75W$.
Please pay attention to the direction of the current and voltage.

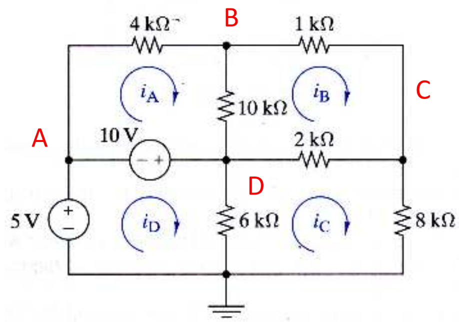
3-15



(a) Writing mesh-current equations by inspection, we can get:
$Mesh\ A$: $i_A(2k\Omega + 4k\Omega) - i_B \cdot 4k\Omega - i_C \cdot 2k\Omega = 40V$
$Mesh\ B$: $-i_A \cdot 4k\Omega + i_B(4k\Omega + 8k\Omega) = 25V$
$Mesh\ C$: $i_C = 5mA$

(c) Node voltage; there is only one equation to solve.

3-20



(a) Writing the mesh-current equations by inspection, we can get:

$Mesh\ A: (4k\Omega + 10k\Omega)i_A - 10k\Omega \cdot i_B + 10 = 0$

$Mesh\ B: -10k\Omega i_A + (1k\Omega + 10k\Omega + 2k\Omega)i_B - 2k\Omega i_C = 0$

$Mesh\ C: -2k\Omega i_B + (2k\Omega + 8k\Omega + 6k\Omega)i_C - 6k\Omega i_D = 0$

$Mesh\ D: 6k\Omega i_D - 6k\Omega i_C - 10 - 5 = 0$

Write in matrix form:

$$\begin{bmatrix} (4k\Omega + 10k\Omega) & -10k\Omega & 0 & 0 \\ -10k\Omega & (1k\Omega + 10k\Omega + 2k\Omega) & -2k\Omega & 0 \\ 0 & -2k\Omega & (2k\Omega + 8k\Omega + 6k\Omega) & -6k\Omega \\ 0 & 0 & -6k\Omega & 6k\Omega \end{bmatrix} \begin{bmatrix} i_A \\ i_B \\ i_C \\ i_D \end{bmatrix} = \begin{bmatrix} -10 \\ 0 \\ 0 \\ 15 \end{bmatrix}$$

Solving the equations, we can get

$$i_A = -1.2565\ mA$$
$$i_B = -0.7592\ mA$$
$$i_C = 1.3482\ mA$$
$$i_D = 3.8482\ mA$$

(b) By looking at the figure, we can find $v_A = 5V$, $v_D = 15V$. Then we can write the node-voltage equations.

Node B: $-\frac{1}{4}v_A + \left(\frac{1}{4} + \frac{1}{10} + 1\right)v_B - v_C - \frac{1}{10}v_D = 0$

Node C: $-v_B + \left(1 + \frac{1}{2} + \frac{1}{8}\right)v_C - \frac{1}{2}v_D = 0$

Solving the equations, we can get

$v_B = 10.0262$ V

$v_C = 10.7853$ V

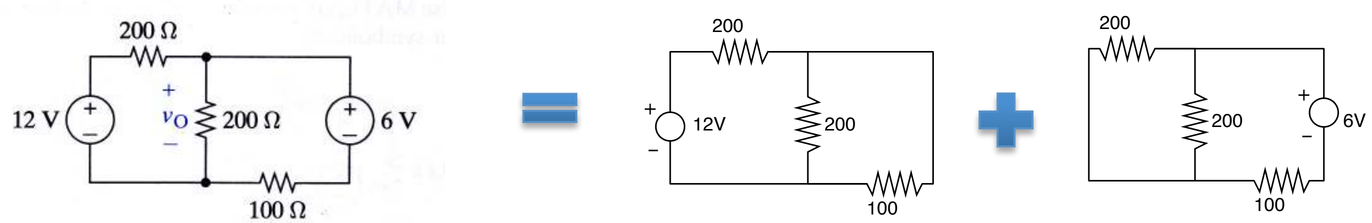
It's obvious that node-voltage needs less effort.

3-22

Using current division, we can get

$$i_O = \left[\frac{\frac{1}{R_3 + R_4}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3 + R_4}}\right] i_S \quad \Rightarrow \quad K = \frac{i_O}{i_S} = \frac{\frac{1}{R_3 + R_4}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3 + R_4}}$$

3-26



$$v_{O1} = 12V \cdot \left(\frac{200||100}{200+200||100}\right) = 3V \qquad v_{O2} = 6V \cdot \left(\frac{200||200}{100+200||200}\right) = 3V$$

$$v_O = v_{O1} + v_{O2} = 6V$$

4-2

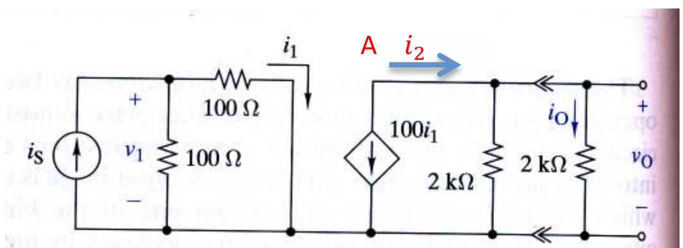


FIGURE P4–2

Using the current division in the input circuit, we can get

$$i_1 = \frac{100}{100+100} i_S = \frac{1}{2} i_S$$

Similarly, the output current i_O can be found in the output circuit by current division.

$$i_O = \frac{2}{2+2} i_2 = \frac{1}{2} i_2$$

At node A, KCL requires that $i_2 = -100 i_1 = -50 i_S$. So we can get

$$i_O = \frac{1}{2} i_2 = -25 i_S \;\Rightarrow\; \frac{i_O}{i_S} = -25$$

Using Ohm's law, we can get

$$v_O = 2000 i_O = -5\times10^4 i_S$$

$$v_1 = 100 i_1 = 50 i_S$$

$$\frac{v_O}{v_1} = \frac{-5\times10^4 i_S}{20 i_S} = -1000$$

The power supplied by the independent current source is

$$P_S = (100||100) i_S^2 = 0.2\ mW$$

The power delivered to the $2k\Omega$ load is

$$P_O = 2000 i_O^2 = 5W$$

4–6 Find an expression for the current gain i_O/i_S in Figure P4–6. (*Hint:* Apply KCL at node A.)

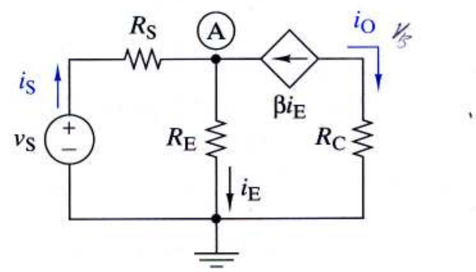


FIGURE P4–6

Applying KCL at node A, we can get:

$$i_S + \beta i_E - i_E = 0 \;\Rightarrow\; i_E = \frac{1}{1-\beta} i_S$$

$$i_O = -\beta i_E = \frac{\beta}{\beta - 1} i_S \;\Rightarrow\; \frac{i_O}{i_S} = \frac{\beta}{\beta - 1}$$

4–13 Find R_{IN} in Figure P4–13.

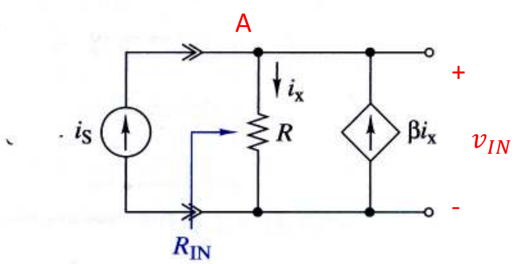


FIGURE P4–13

Using Ohm's law, we can get

$$R_{IN} = \frac{v_{IN}}{i_S} = \frac{i_X R}{i_S}$$

At node A, applying KCL,

$$i_S - i_X + \beta i_X = 0 \;\Rightarrow\; i_X = \frac{1}{1-\beta} i_S$$

So the result is

$$R_{IN} = \frac{1}{1-\beta} R$$