

Block A: Unit 2

Q1. [Problem 3.7]

Solution:

- Known quantities:

Circuit shown in Figure P3.7 with known source currents and resistances, $R_1 = 3\Omega$, $R_2 = 1\Omega$, $R_3 = 6\Omega$.

- Find:

The currents I_1 , I_2 using node voltage analysis.

- Analysis:

At node 1:

$$\left(\frac{v_1 - v_2}{3}\right) + \frac{v_2}{1} = 1$$

At node 2:

$$\frac{v_2 - v_1}{1} + \frac{v_2}{6} = -2$$

Solving, we find that:

$$\begin{aligned} v_1 &= -1.5\text{V} \\ v_2 &= -3\text{V} \end{aligned}$$

Then,

$$\begin{aligned} I_1 &= \frac{v_1}{3} = -0.5\text{A} \\ I_2 &= \frac{v_2}{6} = -0.5\text{A} \end{aligned}$$

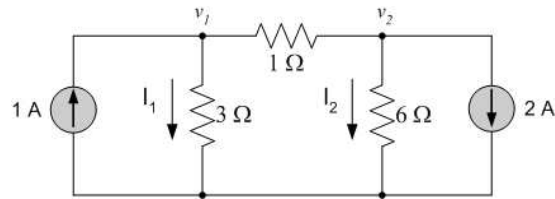


Figure P3.7

Q2. [Problem 3.3]

Solution:

- Known quantities:

Circuit shown in Figure P3.3

- Find:

Voltage v across the 0.25Ω resistor.

- Analysis:

At node 1:

$$\frac{v_1 - v_2}{1} + \frac{v_1 - v_3}{0.5} = -2$$

At node 2:

$$\frac{v_2 - v_1}{1} + \frac{v_2}{0.25} = 3$$

At node 3:

$$\frac{v_3 - v_1}{0.25} + \frac{v_3}{0.33} = -3$$

Solving for v_2 , we find $v_2 = 0.34\text{V}$ and, therefore, $v = 0.34\text{V}$.

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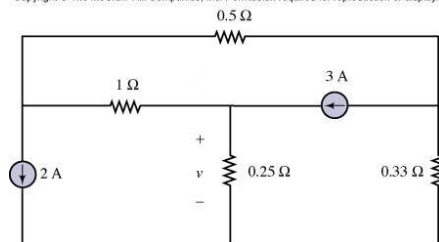


Figure P3.3

Q3. [Problem 3.10]**Solution:**

• Known quantities:

The current source value, the voltage source value and the resistance values for the circuit shown in Figure P3.10.

• Find:

The three node voltages indicated in Figure P3.10 using node voltage analysis.

• Analysis:

At node 1:

$$\frac{v_1}{200} + \frac{v_1 - v_2}{75} = 0.2 \text{ A}$$

At node 2:

$$\frac{v_2 - v_1}{75} + \frac{v_2}{25} + \frac{v_2 - v_3}{50} + i = 0$$

At node 3:

$$-i + \frac{v_3 - v_2}{50} + \frac{v_3}{100} = 0$$

For the voltage source we have: $v_3 + 10 = v_2$

Solving the system, we obtain:

$v_1 = 14.24 \text{ V}$, $v_2 = 4.58 \text{ V}$, $v_3 = -5.42 \text{ V}$ and, finally, $i = -254 \text{ mA}$.

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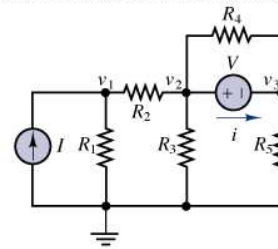


Figure P3.10

Q4. [Problem 3.12]**Solution:**

• Known quantities:

Circuit shown in Figure P3.12.

• Find:

Power delivered to the load resistance.

• Analysis:

KCL at node 1:

$$\frac{V_1}{R_1} + \frac{V_1 - V_s - V_2}{R_V} = 0.5$$

$$\text{Or } 3V_1 - V_2 = 6 \quad (\text{Eq. 1})$$

KCL at node 2:

$$\frac{V_1 - V_s - V_2}{R_V} = \frac{V_2}{R_1 \parallel (R_2 + R_L)}$$

$$\text{Or } 14V_2 - 4V_1 = -16 \quad (\text{Eq. 2})$$

substitute Eq. 1 into Eq. 2, yield $V_2 = -0.6316$

and by voltage divider:

$$V_L = \left(\frac{R_L}{R_2 + R_L} \right) V_2 = -0.316 \text{ V}$$

$$P_L = \frac{V_L^2}{R_L} = 25 \text{ mW}$$

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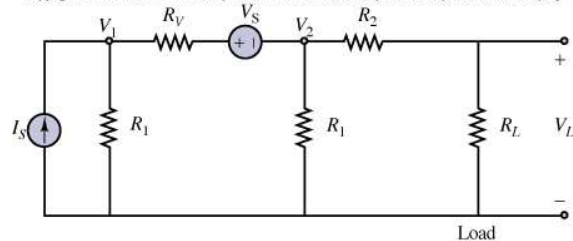


Figure P3.12

Q5. [Problem 3.14]Solution:

• Known quantities:
Circuit shown in Figure P3.14.

• Find:
Current i_1 and i_2 .

• Analysis:
For mesh #1:

$$i_1(1+3)+i_2(-3)=1$$

For mesh #2:

$$i_1(-3)+i_2(3+2)=-2$$

Solving,

$$\begin{aligned} i_1 &= -0.091\text{A} \\ i_2 &= -0.455\text{A} \end{aligned}$$

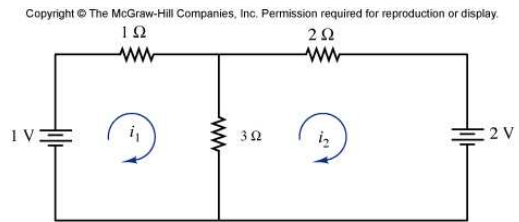


Figure P3.14

Q6. [Problem 3.16]Solution:

• Known quantities:
Circuit shown in Figure P3.16.

• Find:
Voltage across the 3Ω resistance.

• Analysis:
Meshes 1, 2 and 3 are clockwise from the left

For mesh #1:

$$i_1(1+2+3)+i_2(-2)+i_3(-3)=2$$

For mesh #2:

$$i_1(-2)+i_2(2+2+1)+i_3(-1)=-1$$

For mesh #3:

$$i_1(-3)+i_2(-1)+i_3(3+1+1)=0$$

Solving,

$$i_1 = 0.5224\text{ A}$$

$$i_2 = 0.0746\text{ A}$$

$$i_3 = 0.3284\text{ A}$$

$$\text{and } v = 3(i_1 - i_3) = 3(0.194) = 0.5821\text{ V}.$$

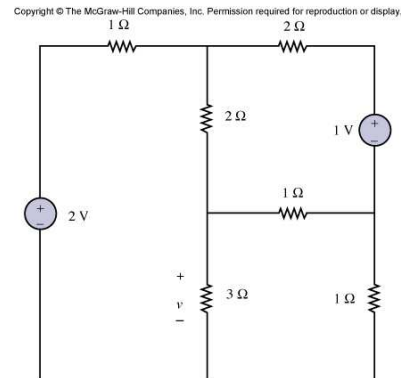


Figure P3.16

Q7. [Problem 3.18]Solution:

• Known quantities:
Circuit shown in Figure P3.18.

- Find:
Voltage across the current source.

- Analysis:
Meshes 1, 2 and 3 go from left to right.
For mesh #1:

$$i_1(2+3) + i_2(-3) + i_3(0) = 2$$

For meshes #2 and #3:

$$i_1(-3) + i_2(1+3) + i_3(3+2) = 0$$

For the current source:

$$i_1(0) + i_2(1) + i_3(-1) = -2$$

Solving,

$$i_3 = 0.778\text{A}$$

$$\text{and } v = i_3(3+2) = 3.89\text{V}.$$

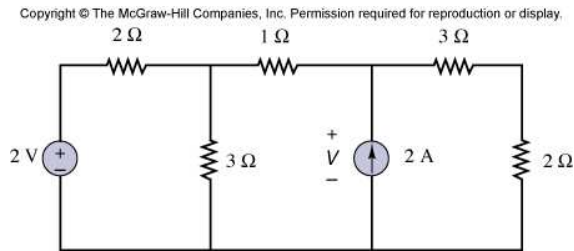


Figure P3.18

Q8. [Problem 3.43]

Solution:

- Known quantities:
The values of the voltage sources and of the resistors in the circuit of Figure P3.43:

$$V_{S1} = V_{S2} = 450\text{V}$$

$$R_1 = 7\Omega, R_2 = 5\Omega, R_3 = 10\Omega, R_4 = R_5 = 1\Omega$$

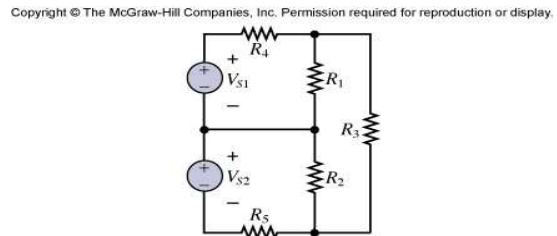


Figure P3.43

- Find:
The component of the current through R_3 that is due to V_{S2} , using superposition.

- Analysis:
Suppress V_{S1} by replacing it with a short circuit. Redraw the circuit. A solution using equivalent resistances looks reasonable. R_1 and R_4 are in parallel:

$$R_{14} = \frac{R_1 R_4}{R_1 + R_4} = \frac{(7)(1)}{7+1} = 0.875\Omega$$

R_{14} is in series with R_3 :

$$R_{143} = R_{14} + R_3 = 0.875 + 10 = 10.875\Omega$$

$$R_{eq} = R_5 + (R_2 \parallel R_{143}) = R_5 + \frac{R_2 R_{143}}{R_2 + R_{143}} = 1 + \frac{(5)(10.875)}{5+10.875} = 4.425\Omega$$

$$\text{OL: } I_S = \frac{V_{S2}}{R_{eq}} = \frac{450}{4.425} = 101.695\text{A}$$

$$\text{CD: } I_{R3-2} = \frac{I_S R_2}{R_2 + R_{143}} = \frac{(101.695)(5)}{5+10.875} = 32.03\text{A}$$

Q9. [Problem 3.42]

Solution:

- Known quantities:
The values of the voltage sources and of the resistors in the circuit of Figure P3.42:

$$V_{S1} = V_{S2} = 12\text{V}$$

$$R_1 = R_2 = R_3 = 1\text{k}\Omega$$

- Find:
The voltage across R_2 using superposition.

- Analysis:

Specify the polarity of the voltage across R_2 . Suppress the voltage source V_{S1} by replacing it with a short circuit. Redraw the circuit, see (a).

$$R_{eq} = R_1 \parallel R_3 = \frac{1}{2} 1\text{k}\Omega = 0.5\text{k}\Omega$$

$$V_{R2-2} = V_{S2} \frac{R_2}{R_2 + R_{eq}} = \frac{(12)(1000)}{1000 + 500} = 8\text{V}$$

Suppress the voltage source V_{S2} by replacing it with a short circuit. Redraw the circuit, see (b).

$$R_{eq} = R_2 \parallel R_3 = \frac{1}{2} 1\text{k}\Omega = 0.5\text{k}\Omega$$

$$V_{R2-1} = -V_{S1} \frac{R_{eq}}{R_1 + R_{eq}} = \frac{(12\text{V})(0.5\text{k}\Omega)}{1\text{k}\Omega + 0.5\text{k}\Omega} = -4\text{V}$$

$$V_{R2} = V_{R2-1} + V_{R2-2} = -4\text{V} + 8\text{V} = 4\text{V}$$

Note: Although superposition is necessary to solve some circuits, it is a very inefficient and very cumbersome way to solve a circuit. This method should, if at all possible, be avoided. It must be used when the sources in a circuit are AC sources with different frequencies, or where some sources are DC and others are AC.

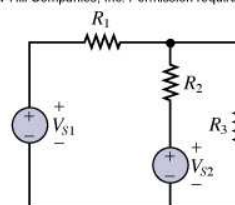
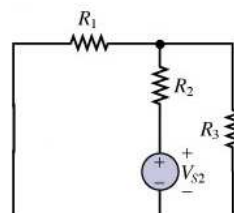
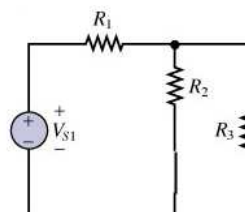


Figure P3.42



(a)



(b)

Q10. [Problem 3.46]

Solution:

- Known quantities:

The values of the resistors, of the voltage source and of the current source in the circuit of Figure P3.10.

- Find:

The current through the voltage source using superposition.

- Analysis:

(1) Suppress voltage source V . Redraw the circuit, see (a).

For mesh (a): $i_a = 0$

For mesh (b): $i_b(200 + 75 + 25) + i_c(-25) - 40 = 0$

For mesh (c): $i_b(-25) + i_c(25 + 100) = 0$

Solving,

$i_b = 136\text{mA}$ and $i_c = 27\text{mA}$.

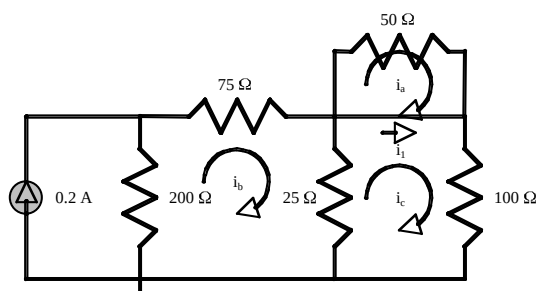
Therefore, $i_1 = i_c = 27\text{mA}$.

(2) Suppress current source I . Redraw the circuit, see (b).

For mesh (a): $i_a(50) - 10 = 0$

For mesh (b): $i_b(200 + 75 + 25) + i_c(-25) = 0$

For mesh (c): $i_b(-25) + i_c(25 + 100) = -10$



(a)

Solving,

$$i_a = 200 \text{ mA}, i_b = -6.8 \text{ mA} \text{ and } i_c = -81 \text{ mA}.$$

Therefore,

$$i_2 = i_c - i_a = -281 \text{ mA}.$$

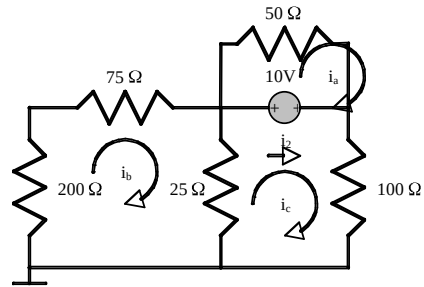
Using the principle of superposition, $i = i_1 + i_2 = -254 \text{ mA}$.

Then v_1 , v_2 and v_3 can be calculated as:

$$v_3 = 100(i_{c(1)} + i_{c(2)}) = -5.42$$

$$v_2 = v_3 + 10 = 4.58$$

$$v_1 = v_2 + 75(i_{b(1)} + i_{b(2)}) = 14.24$$



(b)