## OBJECTIVE 2–2 CONNECTION CONSTRAINTS (SECT. 2–2)

Given a circuit composed of two-terminal elements:
(a) Identify nodes and loops in the circuit.
(b) Identify elements connected in series and in parallel.
(c) Use Kirchhoff's laws (KCL and KVL) to find selected signal variables.
See Examples 2–4, 2–5, 2–6 and Exercises 2–1, 2–2, 2–3, 2–4, 2–5

**2–10** In Figure P2–10 $i_2 = 2$ A and $i_3 = -5$ A. Find $i_1$ and $i_4$.

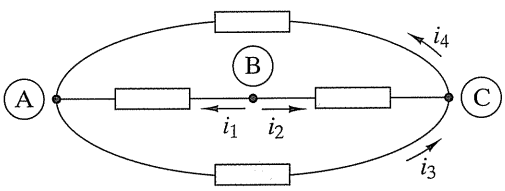


FIGURE P2–10

**2–11** For the circuit in Figure P2–11:
- **(a)** Identify the nodes and at least two loops.
- **(b)** Identify any elements connected in series or in parallel.
- **(c)** Write KCL and KVL connection equations for the circuit.

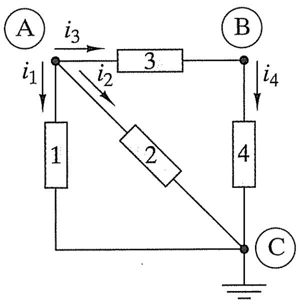


FIGURE P2–11

**2–12** In Figure P2–11 $i_2 = 10$ mA and $i_4 = 20$ mA. Find $i_1$ and $i_3$.

**2–13** For the circuit in Figure P2–13:
- **(a)** Identify the nodes and at least three loops in the circuit.
- **(b)** Identify any elements connected in series or in parallel.
- **(c)** Write KCL and KVL connection equations for the circuit.

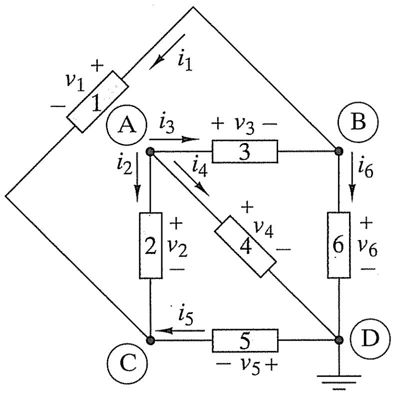


FIGURE P2–13

**2–14** In Figure P2–13 $v_2 = 5$V, $v_3 = -8$V, and $v_4 = 3$V. Find $v_1$, $v_5$, and $v_6$.

**2–15** The circuit in Figure P2–15 is organized around the three signal lines A, B, and C.
- **(a)** Identify the nodes and at least three loops in the circuit
- **(b)** Write KCL connection equations for the circuit.
- **(c)** If $i_1 = -20$ mA, $i_2 = -12$ mA, and $i_3 = 50$ mA, find $i_4$, $i_5$, and $i_6$.

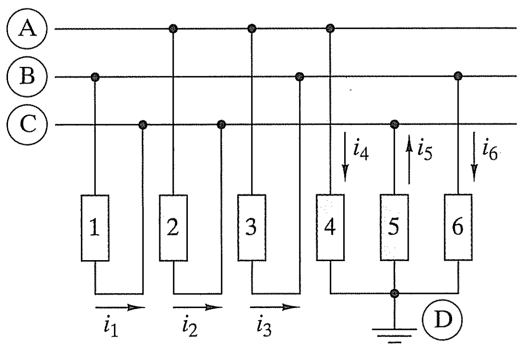


FIGURE P2–15

**2–16** In Figure P2–16 $v_2 = 10$ V, $v_3 = 10$ V, and $v_4 = 10$ V. Find $v_1$ and $v_5$.

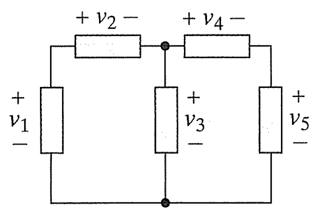


FIGURE P2–16

**2–17** In Figure P2–17 $i_2 = 2$ A, $i_3 = -5$ A, and $i_4 = 4$ A. Find $i_1$ and $i_5$.

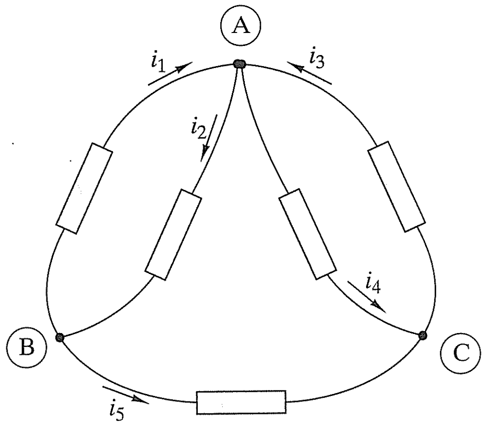


FIGURE P2–17

**2–18** Use the passive sign convention to assign voltages variables consistent with the currents in Figure P2–17. Write three KVL connection equations using these voltage variables.

**2–19** The KCL equations for a three-node circuit are:

$$\text{Node A: } -i_1 + i_2 - i_4 = 0$$

$$\text{Node B: } -i_2 - i_3 + i_5 = 0$$

$$\text{Node C: } i_1 + i_3 + i_4 - i_5 = 0$$

Draw the circuit diagram and indicate the reference directions for the element currents.

## OBJECTIVE 2–3 COMBINED CONSTRAINTS (SECT. 2–3)

Given a circuit consisting of independent sources and linear resistors, use the element constraints and connection constraints to find selected signal variables.
See Examples 2–7, 2–8, 2–9, 2–10 and Exercise 2–6

**2–20** Find $v_x$ and $i_x$ in Figure P2–20.

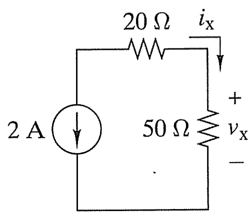


FIGURE P2–20

**2–21** Find $v_x$ and $i_x$ in Figure P2–21.

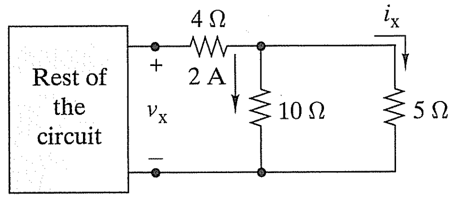


FIGURE P2–21

**2–22** In Figure P2–22:

**(a)** Use the passive sign convention to assign a voltage and current variable to every element.
**(b)** Use KVL to find the voltage across each resistor.
**(c)** Use Ohm's law to find the current through each resistor.
**(d)** Use KCL to find the current through each voltage source.

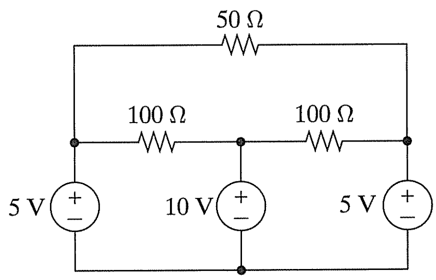


FIGURE P2–22

**2–23** Find $v_x$ in Figure P2–23.

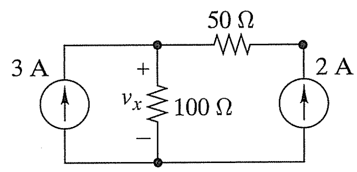


FIGURE P2–23

**2–24** Figure P2–24 shows a subcircuit connected to the rest of the circuit at four points.

**(a)** Use element and connection constraints to find $v_x$ and $i_x$.
**(b)** Show that the sum of the currents into the rest of the circuit is zero.

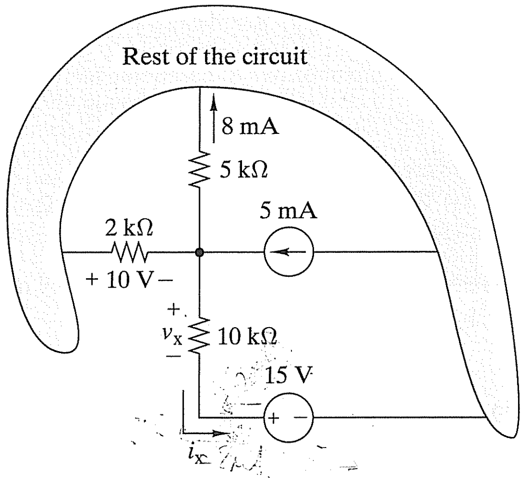


FIGURE P2–24

**2–25** In Figure P2–25 $i_x = -0.5$ mA. Find the value of $R$.

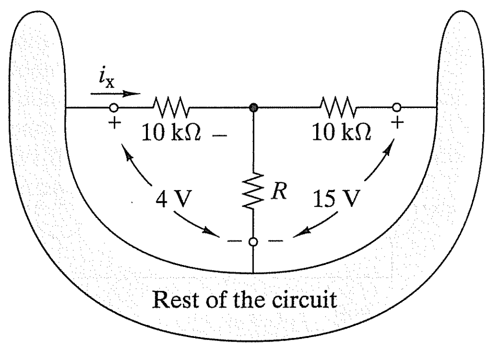


FIGURE P2–25

**2–26** Figure P2–26 shows a resistor with one terminal connected to ground and the other connected to an arrow. The arrow symbol is used to indicate a connection to one terminal of a voltage source whose other terminal is connected to ground. The label next to the arrow indicates the source voltage at the ungrounded terminal. Find the voltage across, current through, and power dissipated in the resistor.

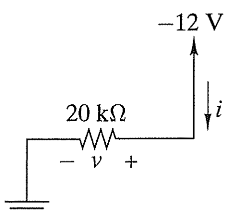


FIGURE P2–26

## OBJECTIVE 2–4 EQUIVALENT CIRCUITS (SECT. 2–4)

(a) Given a circuit consisting of linear resistors, find the equivalent resistance between a specified pair of terminals.
(b) Given a circuit consisting of a source-resistor combination, find an equivalent source-resistor circuit.

See Example 2–11, 2–12 and Exercises 2–7, 2–8, 2–9

**2–27** Find the equivalent resistance $R_{EQ}$ in Figure P2–27.

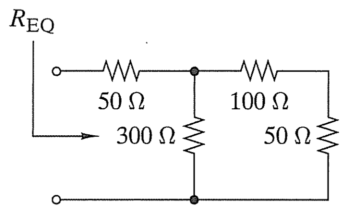


FIGURE P2–27

**2–28** Find the equivalent resistance $R_{EQ}$ in Figure P2–28.

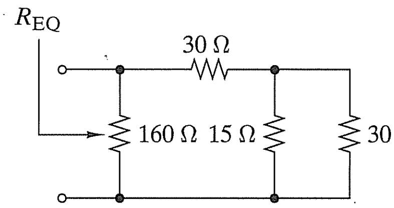


FIGURE P2–28

**2–29** Find $R_{EQ}$ in Figure P2–29 when the switch is open. Repeat when the switch is closed.

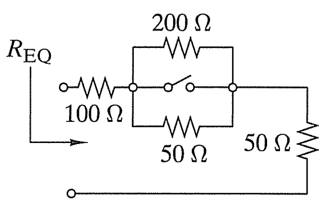


FIGURE P2–29

**2–30** In Figure P2–30 find the equivalent resistance between terminals A–B, A–C, A–D, B–C, B–D, and C–D.

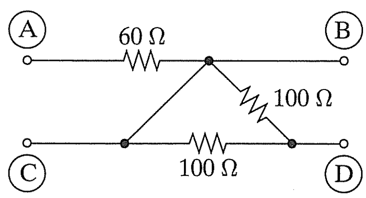


FIGURE P2–30

**2–31** In Figure P2–31 find the equivalent resistance between terminals A–B, A–C, A–D, B–C, B–D, and C–D.

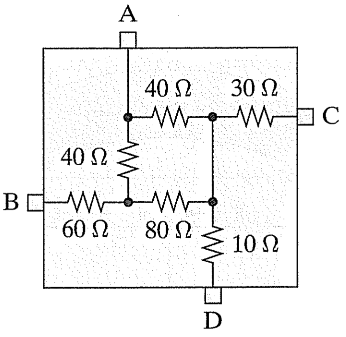


FIGURE P2–31

**2–32** Select a value of $R_L$ in Figure P2–32 so that $R_{EQ} = 25\ k\Omega$.

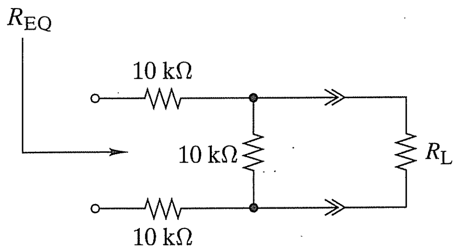


FIGURE P2–32

**2–33** Repeat Problem 2–32 for $R_{EQ} = 15\ k\Omega$. *Caution:* $R_L$ must be positive.

**2–34** Find the equivalent practical voltage source at terminals A and B in Figure P2–34.

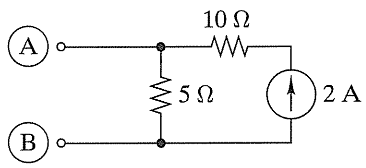


FIGURE P2–34

**2–35** In Figure P2–35 the $i$–$v$ characteristic network N is $v + 50i = 5$ V. Find the equivalent practical current source for the network.

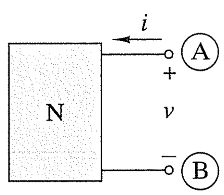


FIGURE P2–35

**2–36** Select the value of $R_x$ in Figure P2–36 so that $R_{EQ} = 60\ k\Omega$.

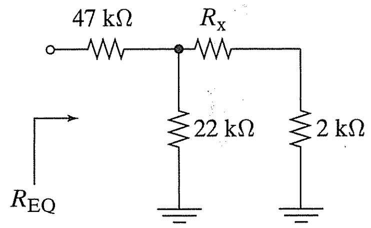


FIGURE P2–36

**2–37** **D** Show how to interconnect standard 3.9-kΩ resistors to obtain equivalent resistances of $1\ k\Omega \pm 5\%$, $5\ k\Omega \pm 5\%$, and $10\ k\Omega \pm 5\%$.

**2–38** Select the value of $R$ in Figure P2–38 so that $R_{AB} = R_L$.

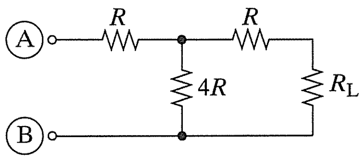


FIGURE P2–38

**2–39** What is the range of $R_{EQ}$ in Figure P2–39?

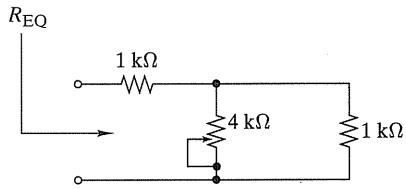


FIGURE P2–39

**2–40** Find the equivalent resistance between terminals A and B in Figure P2–40.

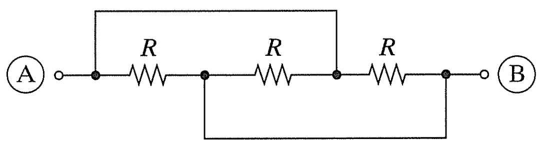


FIGURE P2–40

## OBJECTIVE 2–5 VOLTAGE AND CURRENT DIVISION (SECT. 2–5)

(a) Given a circuit with elements connected in series or in parallel, use voltage or current division to find specified voltages or currents.

(b) Design a voltage or current divider that delivers specified output signals within stated constraints.

See Examples 2–13, 2–14, 2–16, 2–17, 2–18 and Exercises 2–10, 2–11, 2–12

**2–41** Use voltage division in Figure P2–41 to obtain an expression for $v_L$ in terms of $R$, $R_L$, and $v_S$.

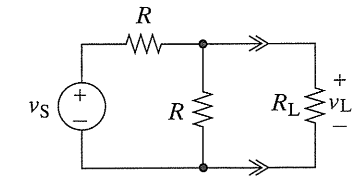


FIGURE P2–41

**2–42** Use current division in Figure P2–42 to obtain an expression for $v_L$ in terms of $R$, $R_L$, and $i_S$.

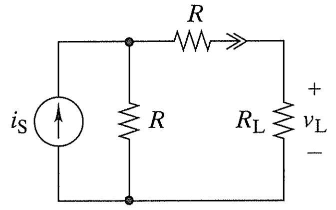


FIGURE P2–42

**2–43** Find $i_x$ in Figure P2–43.

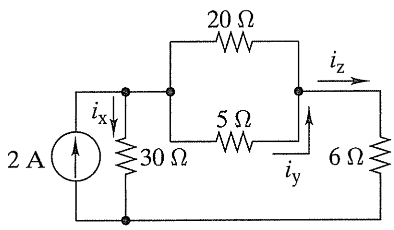


FIGURE P2–43

**2–44** Find $i_y$ and $i_z$ in Figure P2–43.

**2–45** Find the range of values of $v_O$ in Figure P2–45.

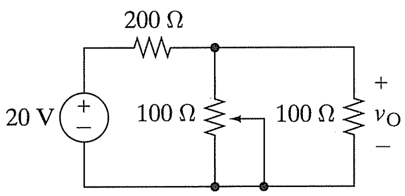


FIGURE P2–45

**2–46** Figure P2–46 shows a resistance divider connected in a general circuit.

**(a)** What is the relationship between $v_1$ and $v_2$ when $i_1 = 0$?

**(b)** What is the relationship between $v_1$ and $v_2$ when $i_2 = 0$?

**(c)** What is the relationship between $i_1$ and $i_2$ when $v_1 = 0$?

**(d)** What is the relationship between $i_1$ and $i_2$ when $v_2 = 0$?

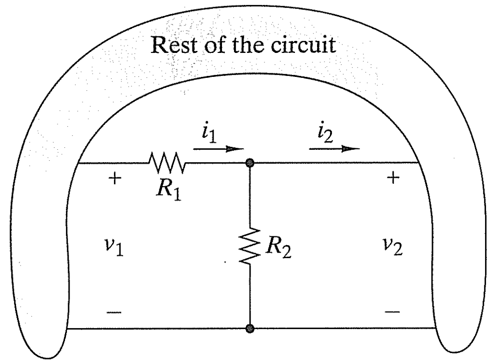


FIGURE P2–46

**2–47** **D** Figure P2–47 shows an ammeter circuit consisting of a D'Arsonval meter, a two-position selector switch, and two shunt resistors. A current of 0.5 mA produces full-scale deflection of the D'Arsonval meter, whose internal resistance is $R_M = 50\ \Omega$. Select the shunt resistance $R_1$ and $R_2$ so that $i_x = 10$ mA produces full-scale deflection when the switch is in position A, and $i_x = 50$ mA produces full-scale deflection when the switch is in position B.

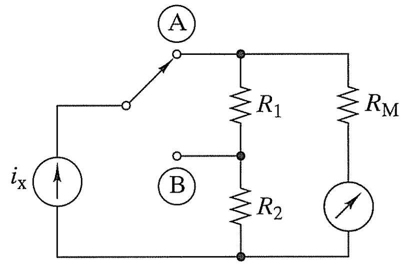


FIGURE P2–47

**2–48** **D** Select values for $R_1$, $R_2$, and $R_3$ in Figure P 2–48 so the voltage divider produces the two output voltages shown.

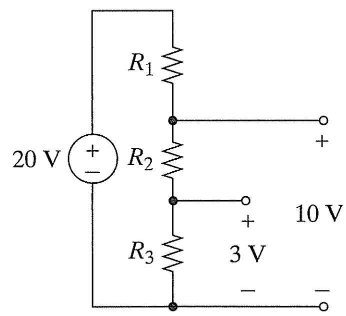


FIGURE P2–48

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vhen $v_2 = 0$?
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tance $R_1$ and
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B.
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ltages shown.



**2–49** **D** Select a value of $R_x$ in Figure P2–49 so that $v_L = 3$ V.

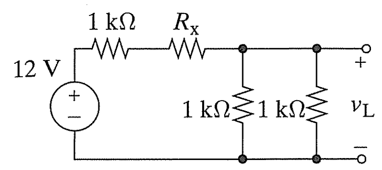


FIGURE P2–49

**2–50** **D** Select a value of $R_x$ in Figure P2–50 so that $v_L = 6$ V. *Caution:* $R_x$ must be positive.

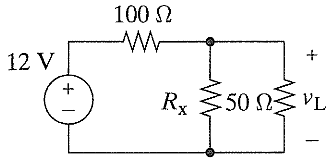


FIGURE P2–50

## Objective 2–6 Circuit Reduction (Sect. 2–6)

Given a circuit consisting of linear resistors and an independent source, find selected signal variables using successive application of series/parallel equivalence, source transformations, and voltage/current division.
See Example 2–20, 2–21, 2–22, 2–23 and Exercises 2–13, 2–14, 2–15

**2–51** Use circuit reduction to find $v_x$ and $i_x$ in Figure P2–51.

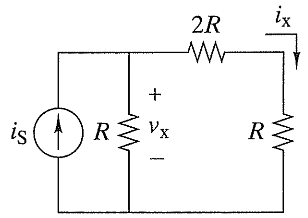


FIGURE P2–51

**2–52** Use circuit reduction to find $i_x$ in Figure P2–52.

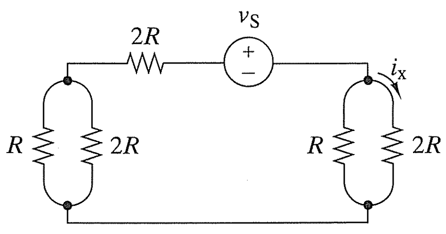


FIGURE P2–52

**2–53** Use circuit reduction to find $v_x$ in Figure P2–53.

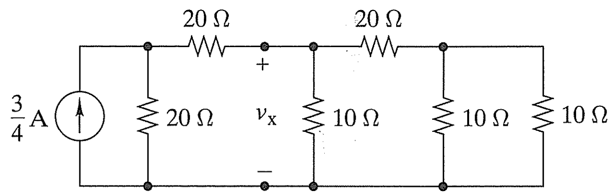


FIGURE P2–53

**2–54** Use circuit reduction to find $v_x$ and $i_x$ in Figure P2–54.

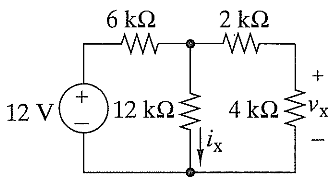


FIGURE P2–54

**2–55** Use source transformation to find $i_x$ in Figure P2–55.

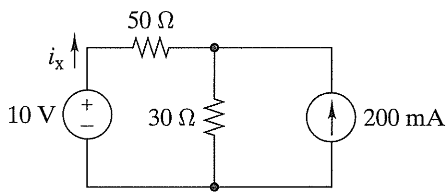


FIGURE P2–55

**2–56** Use source transformation to find $i_x$ in Figure P2–56.

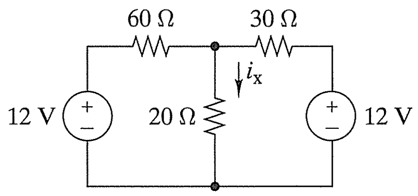


FIGURE P2–56

**2–57** Use source transformations in Figure P2–57 to relate $v_O$ to $v_1$, $v_2$, and $v_3$.

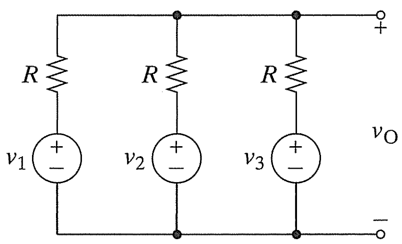


FIGURE P2–57