

PROBLEMS

Section 3.2 Kirchhoff's Laws

P3.2-1 Consider the circuit shown in Figure P 3.2-1. Determine the values of the power supplied by branch *B* and the power supplied by branch *F*.

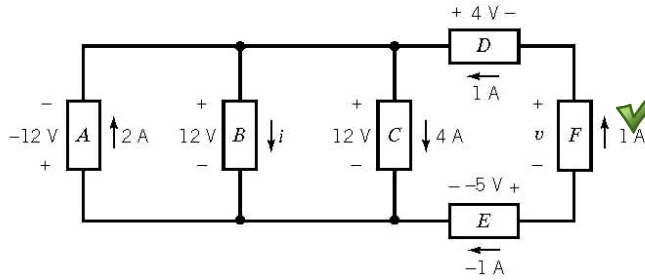


FIGURE P 3.2-1

P3.2-2 Determine the values of i_2 , i_4 , v_2 , v_3 , and v_6 in Figure P 3.2-2.

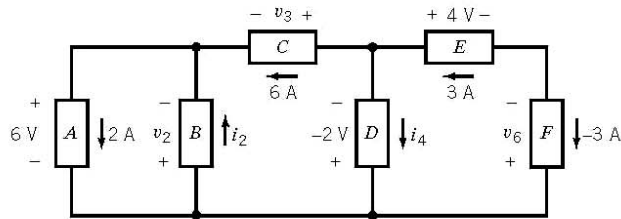


FIGURE P 3.2-2

P3.2-3 Consider the circuit shown in Figure P 3.2-3.

- Suppose that $R_1 = 6 \Omega$ and $R_2 = 3 \Omega$. Find the current i and the voltage v .
- Suppose, instead, that $i = 1.5 \text{ A}$ and $v = 2 \text{ V}$. Determine the resistances R_1 and R_2 .
- Suppose, instead, that the voltage source supplies 24 W of power and that the current source supplies 9 W of power. Determine the current i , the voltage v , and the resistances R_1 and R_2 .

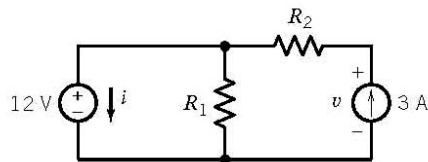


FIGURE P 3.2-3

P3.2-4 Determine the power absorbed by each of the resistors in the circuit shown in Figure P 3.2-4.

Answer: The 4- Ω resistor absorbs 100 W, the 6- Ω resistor absorbs 24 W, and the 8- Ω resistor absorbs 72 W.

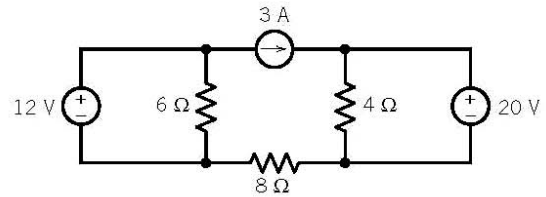


FIGURE P 3.2-4

P3.2-5 Determine the power absorbed by each of the resistors in the circuit shown in Figure P 3.2-5.

Answer: The 4- Ω resistor absorbs 16 W, the 6- Ω resistor absorbs 24 W, and the 8- Ω resistor absorbs 8 W.

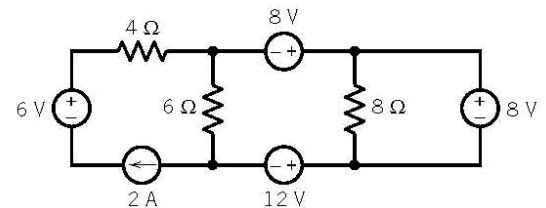


FIGURE P 3.2-5

P3.2-6 Determine the power supplied by each current source in the circuit of Figure P 3.2-6.

Answer: The 2-mA current source supplies 6 mW and the 1-mA current source supplies -7 mW.

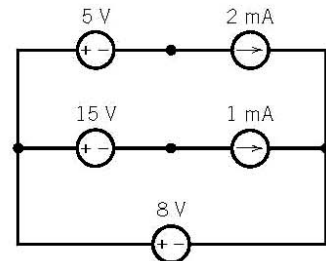


FIGURE P 3.2-6

P3.2-7 Determine the power supplied by each voltage source in the circuit of Figure P 3.2-7.

Answer: The 2-V voltage source supplies 2 mW and the 3-V voltage source supplies -6 mW.

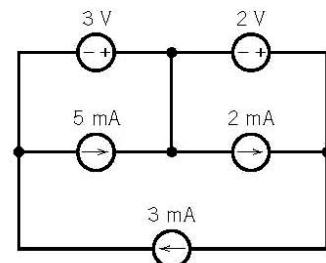


FIGURE P 3.2-7

P3.2-8 What is the value of the resistance R in Figure P 3.2-8.?

Hint: Assume an ideal ammeter. An ideal ammeter is equivalent to a short circuit.

Answer: $R = 4 \Omega$

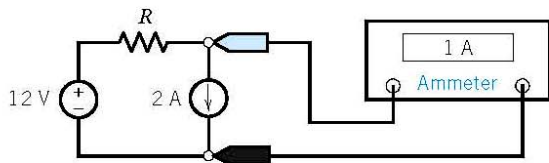


FIGURE P 3.2-8

P 3.2-9 The voltmeter in Figure P 3.2-9 measures the value of the voltage across the current source to be 56 V. What is the value of the resistance R ?

Hint: Assume an ideal voltmeter. An ideal voltmeter is equivalent to an open circuit.

Answer: $R = 10 \Omega$

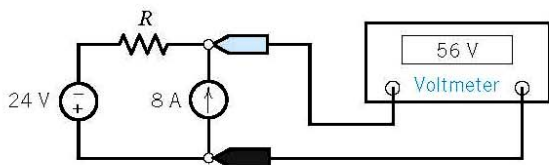


FIGURE P 3.2-9

P 3.2-10 Determine the values of the resistances R_1 and R_2 in Figure P 3.2-10.

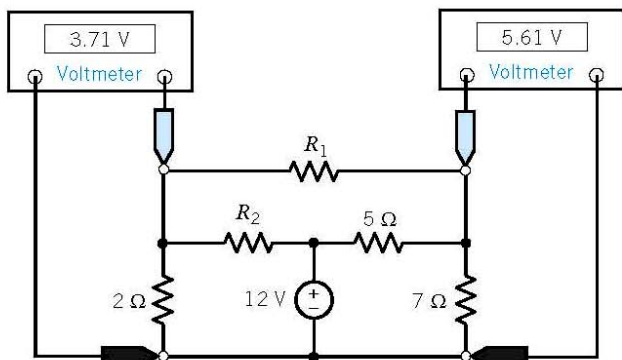


FIGURE P 3.2-10

P 3.2-11 The circuit shown in Figure P 3.2-11 consists of five voltage sources and four current sources. Express the power supplied by each source in terms of the voltage source voltages and the current source currents.

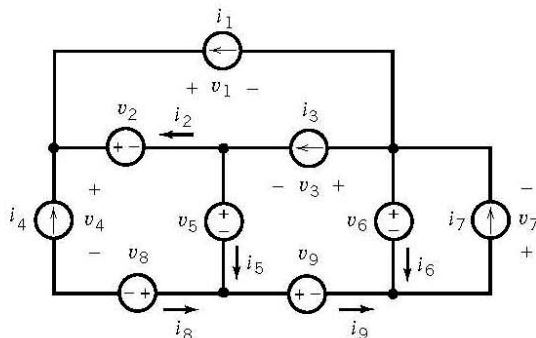


FIGURE P 3.2-11

P 3.2-12 Determine the power received by each of the resistors in the circuit shown in Figure P 3.2-12.

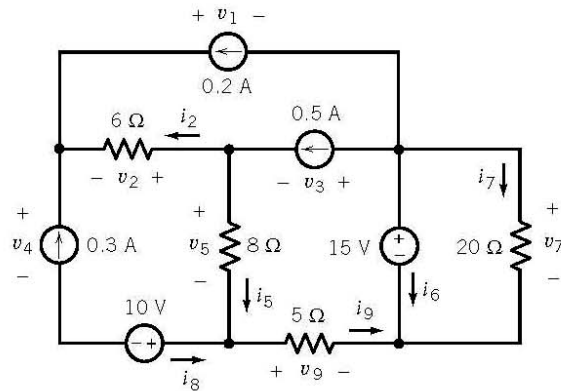


FIGURE P 3.2-12

P 3.2-13 Determine the voltage and current of each of the circuit elements in the circuit shown in Figure P 3.2-13.

Hint: You'll need to specify reference directions for the element voltages and currents. There is more than one way to do that, and your answers will depend on the reference directions that you choose.

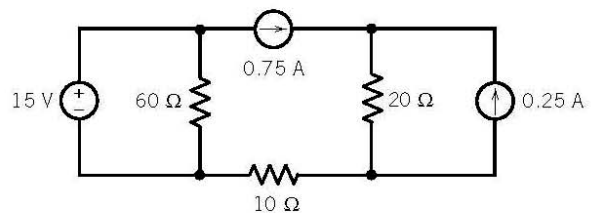


FIGURE P 3.2-13

P 3.2-14 Determine the voltage and current of each of the circuit elements in the circuit shown in Figure P 3.2-14.

Hint: You'll need to specify reference directions for the element voltages and currents. There is more than one way to do that, and your answers will depend on the reference directions that you choose.

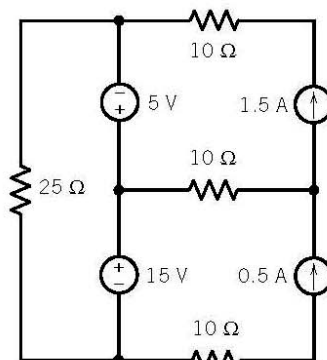


FIGURE P 3.2-14

P 3.2-15 Determine the value of the current that is measured by the meter in Figure P 3.2-15.

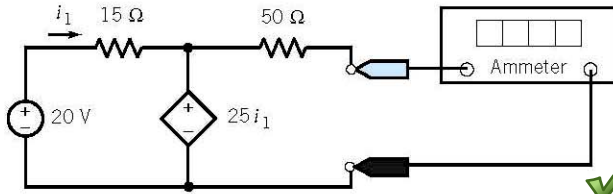


FIGURE P 3.2-15

P 3.2-16 Determine the value of the current that is measured by the meter in Figure P 3.2-16.

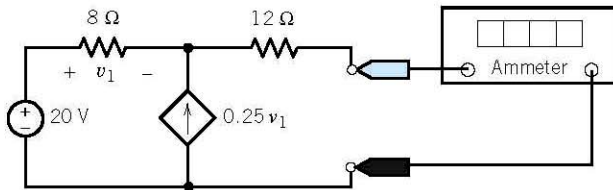


FIGURE P 3.2-16

P 3.2-17 Determine the value of the voltage that is measured by the meter in Figure P 3.2-17.

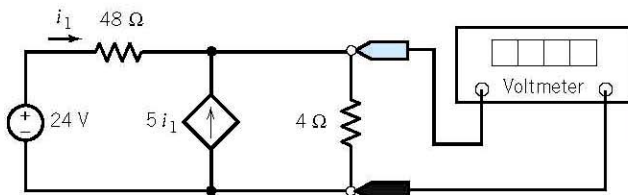


FIGURE P 3.2-17

P 3.2-18 Determine the value of the voltage that is measured by the meter in Figure P 3.2-18.

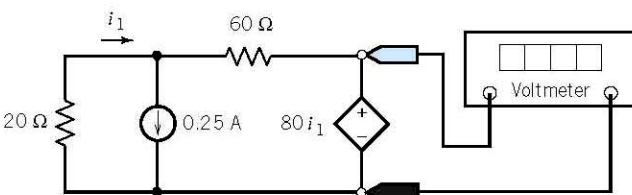


FIGURE P 3.2-18

P 3.2-19 The voltage source in Figure P 3.2-19 supplies 4.8 W of power. The current source supplies 3.6 W. Determine the values of the resistances, R_1 and R_2 .

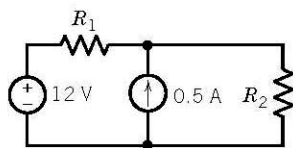


FIGURE P 3.2-19

P 3.2-20 Determine the current i in Figure P 3.2-20.
Answer: $i = 4$ A

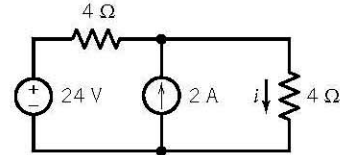
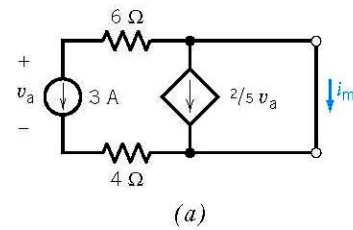


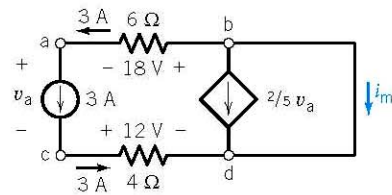
FIGURE P 3.2-20

P 3.2-21 Determine the value of the current i_m in Figure P 3.2-21a.

Hint: Apply KVL to the closed path a-b-d-c-a in Figure P 3.2-21b to determine v_a . Then apply KCL at node b to find i_m .
Answer: $i_m = 9$ A.



(a)



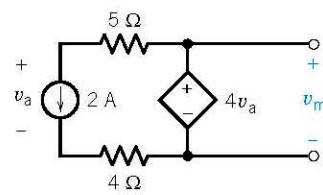
(b)

FIGURE P 3.2-21 (a) A circuit containing a VCCS. (b) The circuit after labeling the nodes and some element currents and voltages.

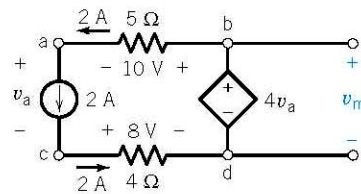
P 3.2-22 Determine the value of the voltage v_m in Figure P 3.2-22a.

Hint: Apply KVL to the closed path a-b-d-c-a in Figure P 3.2-22b to determine v_a .

Answer: $v_m = 24$ V



(a)



(b)

FIGURE P 3.2-22 (a) A circuit containing a VCVS. (b) The circuit after labeling the nodes and some element currents and voltages.

Section 3.3 Series Resistors and Voltage Division

P3.3-1 Use voltage division to determine the voltages v_1 , v_2 , v_3 , and v_4 in the circuit shown in Figure P 3.3-1.

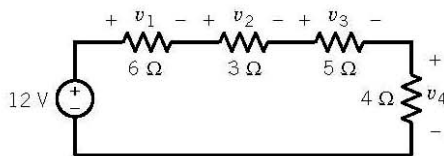


FIGURE P 3.3-1

P3.3-2 Consider the circuits shown in Figure P 3.3-2.

- (a) Determine the value of the resistance R in Figure P 3.3-2b that makes the circuit in Figure P 3.3-2b equivalent to the circuit in Figure P 3.3-2a.
- (b) Determine the current i in Figure P 3.3-2b. Because the circuits are equivalent, the current i in Figure P 3.3-2a is equal to the current i in Figure P 3.3-2b.
- (c) Determine the power supplied by the voltage source.

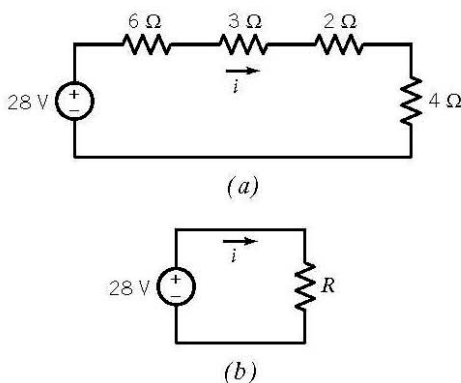


FIGURE P 3.3-2

P3.3-3 The ideal voltmeter in the circuit shown in Figure P 3.3-3 measures the voltage v .

- (a) Suppose $R_2 = 100 \Omega$. Determine the value of R_1 .
- (b) Suppose, instead, $R_1 = 100 \Omega$. Determine the value of R_2 .
- (c) Suppose, instead, that the voltage source supplies 1.2 W of power. Determine the values of both R_1 and R_2 .

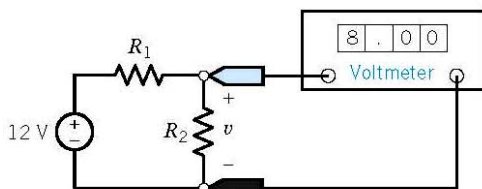


FIGURE P 3.3-3

P3.3-4 Determine the voltage v in the circuit shown in Figure P 3.3-4.

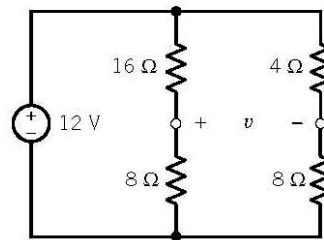


FIGURE P 3.3-4

P3.3-5 The model of a cable and load resistor connected to a source is shown in Figure P 3.3-5. Determine the appropriate cable resistance, R , so that the output voltage, v_o , remains between 9 V and 13 V when the source voltage, v_s , varies between 20 V and 28 V. The cable resistance can only assume integer values in the range $20 < R < 100 \Omega$.

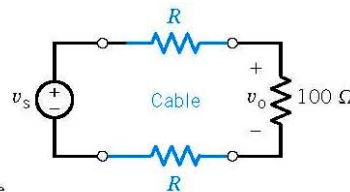


FIGURE P 3.3-5
Circuit with a cable.

P3.3-6 The input to the circuit shown in Figure P 3.3-6 is the voltage of the voltage source, v_a . The output of this circuit is the voltage measured by the voltmeter, v_b . This circuit produces an output that is proportional to the input, that is

$$v_b = k v_a$$

where k is the constant of proportionality.

- (a) Determine the value of the output, v_b , when $R = 240 \Omega$ and $v_a = 18 \text{ V}$.
- (b) Determine the value of the power supplied by the voltage source when $R = 240 \Omega$ and $v_a = 18 \text{ V}$.
- (c) Determine the value of the resistance, R , required to cause the output to be $v_b = 2 \text{ V}$ when the input is $v_a = 18 \text{ V}$.
- (d) Determine the value of the resistance, R , required to cause $v_b = 0.2v_a$ (that is, the value of the constant of proportionality is $k = \frac{2}{10}$).

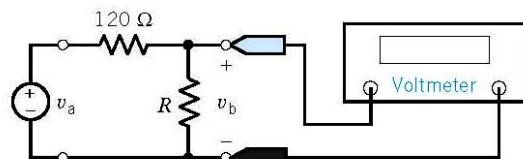


FIGURE P 3.3-6

P3.3-7 Determine the value of voltage v in the circuit shown in Figure P 3.3-7.

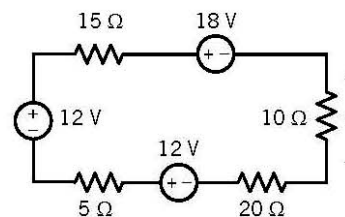


FIGURE P 3.3-7

P3.3-8 Determine the power supplied by the dependent source in the circuit shown in Figure P 3.3-8.

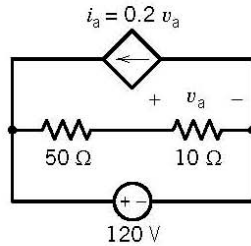


FIGURE P 3.3-8

P3.3-9 A potentiometer can be used as a transducer to convert the rotational position of a dial to an electrical quantity. Figure P 3.3-9 illustrates this situation. Figure P 3.3-9a shows a potentiometer having resistance R_p connected to a voltage source. The potentiometer has three terminals, one at each end and one connected to a sliding contact called a wiper. A voltmeter measures the voltage between the wiper and one end of the potentiometer.

Figure P 3.3-9b shows the circuit after the potentiometer is replaced by a model of the potentiometer that consists of two resistors. The parameter a depends on the angle, θ , of the dial. Here $a = \frac{\theta}{360^\circ}$, and θ is given in degrees. Also, in Figure P 3.3-9b, the voltmeter has been replaced by an open circuit and the voltage measured by the voltmeter, v_m , has been labeled. The input to the circuit is the angle θ , and the output is the voltage measured by the meter, v_m .

- Show that the output is proportional to the input.
- Let $R_p = 1 \text{ k}\Omega$ and $v_s = 24 \text{ V}$. Express the output as a function of the input. What is the value of the output when $\theta = 45^\circ$? What is the angle when $v_m = 10 \text{ V}$?

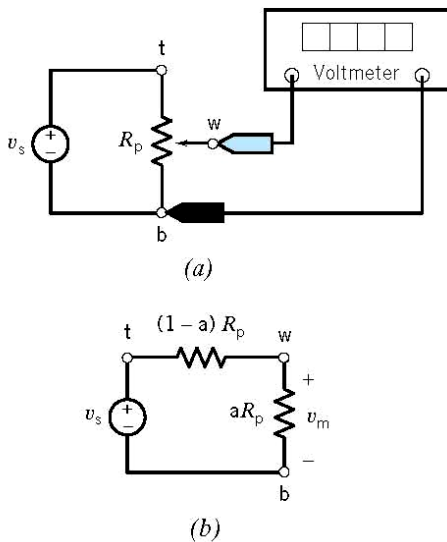


FIGURE P 3.3-9

P3.3-10 Determine the value of the voltage measured by the meter in Figure P 3.3-10.

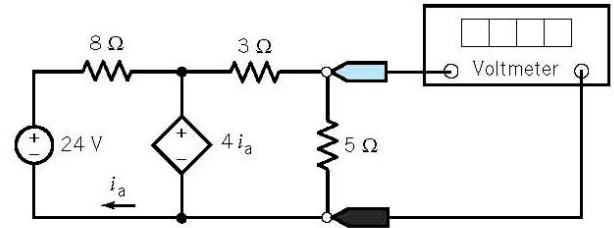


FIGURE P 3.3-10

P3.3-11 For the circuit of Figure P 3.3-11, find the voltage v_3 and the current i and show that the power delivered to the three resistors is equal to that supplied by the source.

Answer: $v_3 = 3 \text{ V}$, $i = 1 \text{ A}$

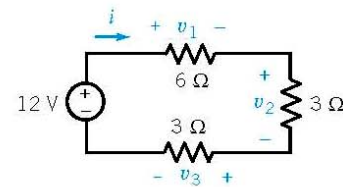


FIGURE P 3.3-11

P 3.3-12 Consider the voltage divider shown in Figure P 3.3-12 when $R_1 = 6 \Omega$. It is desired that the output power absorbed by $R_1 = 6 \Omega$ be 6 W . Find the voltage v_o and the required source v_s .

Answer: $v_s = 14 \text{ V}$, $v_o = 6 \text{ V}$

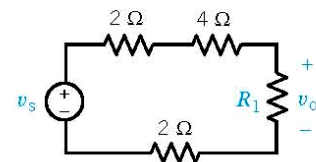


FIGURE P 3.3-12

Section 3.4 Parallel Resistors and Current Division

P3.4-1 Use current division to determine the currents i_1 , i_2 , i_3 , and i_4 in the circuit shown in Figure P 3.4-1.

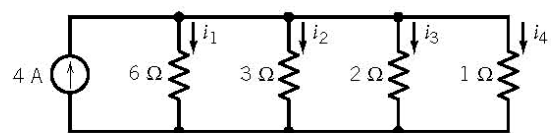


FIGURE P 3.4-1

P3.4-2 Consider the circuits shown in Figure P 3.4-2.

- Determine the value of the resistance R in Figure P 3.4-2b that makes the circuit in Figure P 3.4-2b equivalent to the circuit in Figure P 3.4-2a.

- (b) Determine the voltage v in Figure P 3.4-2b. Because the circuits are equivalent, the voltage v in Figure P 3.4-2a is equal to the voltage v in Figure P 3.4-2b.
- (c) Determine the power supplied by the current source.

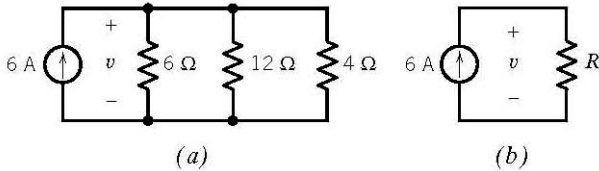


FIGURE P 3.4-2

P 3.4-3 The ideal voltmeter in the circuit shown in Figure P 3.4-3 measures the voltage v .

- (a) Suppose $R_2 = 12 \Omega$. Determine the value of R_1 and of the current i .
- (b) Suppose, instead, $R_1 = 12 \Omega$. Determine the value of R_2 and of the current i .
- (c) Instead, choose R_1 and R_2 to minimize the power absorbed by any one resistor.

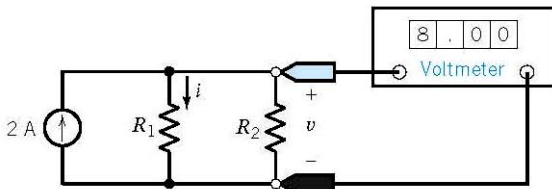


FIGURE P 3.4-3

P 3.4-4 Determine the current i in the circuit shown in Figure P 3.4-4.

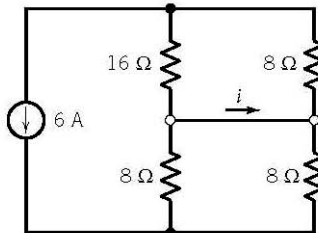


FIGURE P 3.4-4

P 3.4-5 Consider the circuit shown in Figure P 3.4-5 when $4 \Omega \leq R_1 \leq 6 \Omega$ and $R_2 = 10 \Omega$. Select the source i_s so that v_o remains between 9 V and 13 V.

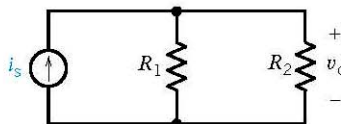


FIGURE P 3.4-5

P 3.4-6 The input to the circuit shown in Figure P 3.4-6 is the current of the current source, i_a . The output of this circuit is the current measured by the ammeter, i_b . This circuit produces an output that is proportional to the input, that is

$$i_b = k i_a$$

where k is the constant of proportionality.

- (a) Determine the value of the output, i_b , when $R = 24 \Omega$ and $i_a = 1.8 \text{ A}$.
- (b) Determine the value of the resistance, R , required to cause the output to be $i_b = 1.6 \text{ A}$ when the input is $i_a = 2 \text{ A}$.
- (c) Determine the value of the resistance, R , required to cause $i_b = 0.4 i_a$ (that is, the value of the constant of proportionality is $k = \frac{4}{10}$).

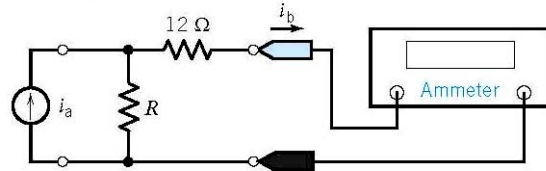


FIGURE P 3.4-6

***P 3.4-7** Figure P 3.4-7 shows a transistor amplifier. The values of R_1 and R_2 are to be selected. Resistances R_1 and R_2 are used to bias the transistor, that is, to create useful operating conditions. In this problem, we want to select R_1 and R_2 so that $v_b = 5 \text{ V}$. We expect the value of i_b to be approximately $10 \mu\text{A}$. When $i_1 \leq 10 i_b$, it is customary to treat i_b as negligible, that is, to assume $i_b = 0$. In that case R_1 and R_2 comprise a voltage divider.

- (a) Select values for R_1 and R_2 so that $v_b = 5 \text{ V}$ and the total power absorbed by R_1 and R_2 is no more than 5 mW.
- (b) An inferior transistor could cause i_b to be larger than expected. Using the values of R_1 and R_2 from part (a), determine the value of v_b that would result from $i_b = 15 \mu\text{A}$.

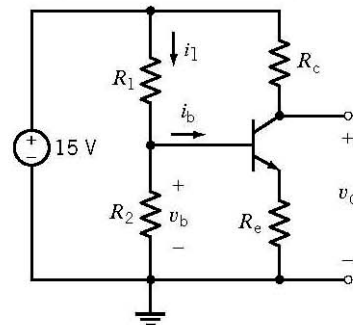


FIGURE P 3.4-7

P 3.4-8 Determine the value of the current i in the circuit shown in Figure P 3.4-8.

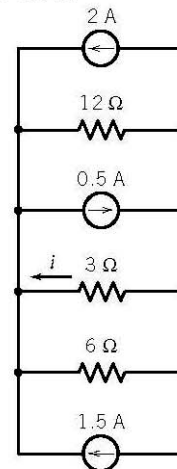


FIGURE P 3.4-8

P3.4-9 Determine the value of the voltage v in Figure P 3.4-9.

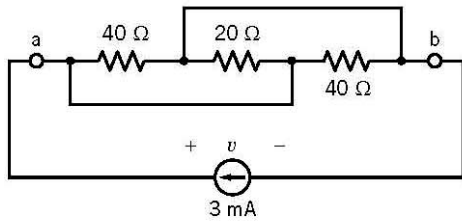


FIGURE P 3.4-9

P3.4-10 A solar photovoltaic panel may be represented by the circuit model shown in Figure P 3.4-10, where R_L is the load resistor. Determine the values of the resistances R_1 and R_L .

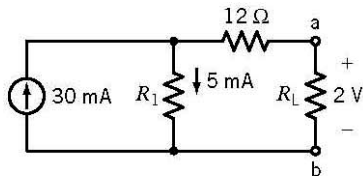


FIGURE P 3.4-10

P3.4-11 Determine the power supplied by the dependent source in Figure P 3.4-11.

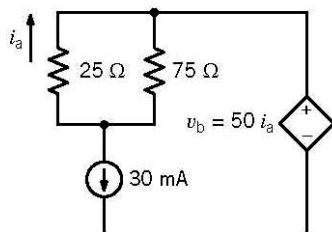


FIGURE P 3.4-11

P3.4-12 The voltmeter in Figure P 3.4-12 measures the value of the voltage v_m .

- Determine the value of the resistance R .
- Determine the value of the power supplied by the current source.

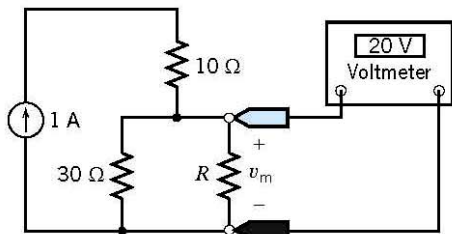


FIGURE P 3.4-12

***P3.4-13** Determine the values of the resistances R_1 and R_2 for the circuit shown in Figure P 3.4-13.

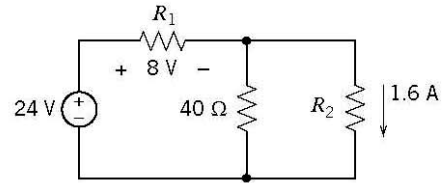


FIGURE P 3.4-13

***P3.4-14** Determine the values of the resistances R_1 and R_2 for the circuit shown in Figure P 3.4-14.

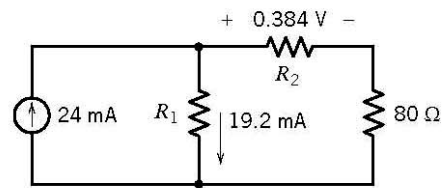


FIGURE P 3.4-14

P3.4-15 Determine the value of the current measured by the meter in Figure P 3.4-15.

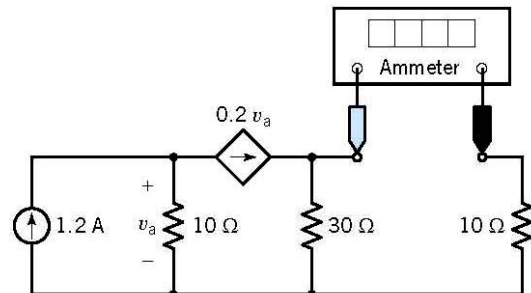


FIGURE P 3.4-15

Section 3.5 Series Voltage Sources and Parallel Current Sources

***P3.5-1** Determine the power supplied by each source in the circuit shown in Figure P 3.5-1.

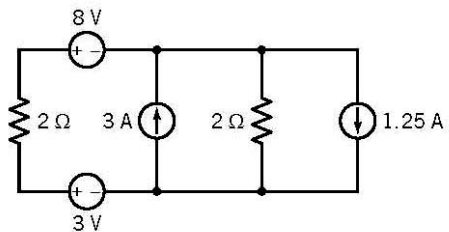


FIGURE P 3.5-1

P3.5-2 Determine the power supplied by each source in the circuit shown in Figure P 3.5-2.

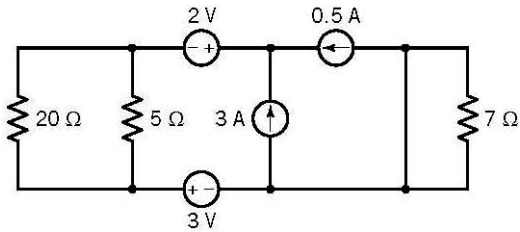


FIGURE P 3.5-2

P 3.5-3 Determine the power received by each resistor in the circuit shown in Figure P 3.5-3.

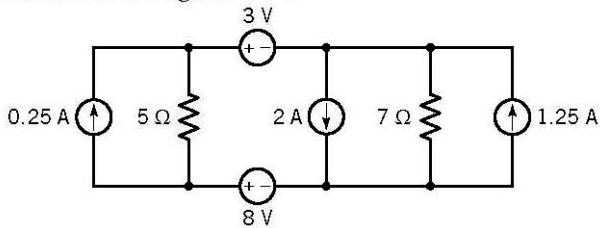


FIGURE P 3.5-3

Section 3.6 Circuit Analysis

P 3.6-1 The circuit shown in Figure P 3.6-1a has been divided into two parts. In Figure P 3.6-1b, the right-hand part has been replaced with an equivalent circuit. The left-hand part of the circuit has not been changed.

- (a) Determine the value of the resistance R in Figure P 3.6-1b that makes the circuit in Figure P 3.6-1b equivalent to the circuit in Figure P 3.6-1a.
- (b) Find the current i and the voltage v shown in Figure P 3.6-1b. Because of the equivalence, the current i and the voltage v shown in Figure P 3.6-1a are equal to the current i and the voltage v shown in Figure P 3.6-1b.
- (c) Find the current i_2 shown in Figure P 3.6-1a using current division.

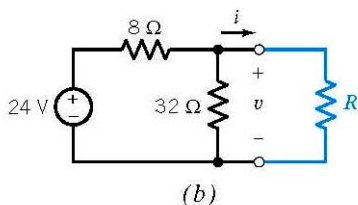
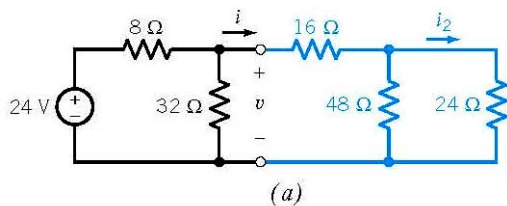


FIGURE P 3.6-1

P 3.6-2 The circuit shown in Figure P 3.6-2a has been divided into three parts. In Figure P 3.6-2b, the rightmost part has been replaced with an equivalent circuit. The rest of the circuit has not been changed. The circuit is simplified further in Figure 3.6-2c.

Now the middle and rightmost parts have been replaced by a single equivalent resistance. The leftmost part of the circuit is still unchanged.

- (a) Determine the value of the resistance R_1 in Figure P 3.6-2b that makes the circuit in Figure P 3.6-2b equivalent to the circuit in Figure P 3.6-2a.
- (b) Determine the value of the resistance R_2 in Figure P 3.6-2c that makes the circuit in Figure P 3.6-2c equivalent to the circuit in Figure P 3.6-2b.
- (c) Find the current i_1 and the voltage v_1 shown in Figure P 3.6-2c. Because of the equivalence, the current i_1 and the voltage v_1 shown in Figure P 3.6-2b are equal to the current i_1 and the voltage v_1 shown in Figure P 3.6-2c.
Hint: $24 = 6(i_1 - 2) + i_1 R_2$
- (d) Find the current i_2 and the voltage v_2 shown in Figure P 3.6-2b. Because of the equivalence, the current i_2 and the voltage v_2 shown in Figure P 3.6-2a are equal to the current i_2 and the voltage v_2 shown in Figure P 3.6-2b.
Hint: Use current division to calculate i_2 from i_1 .
- (e) Determine the power absorbed by the 3-Ω resistance shown at the right of Figure P 3.6-2a.

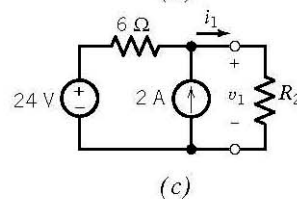
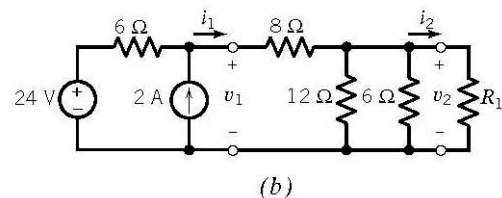
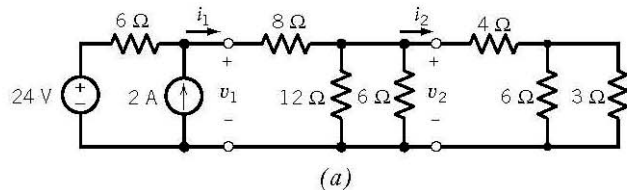


FIGURE P 3.6-2

P 3.6-3 Find i using appropriate circuit reductions and the current divider principle for the circuit of Figure P 3.6-3.

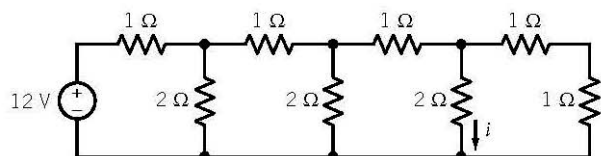


FIGURE P 3.6-3

P 3.6-4

- (a) Determine values of R_1 and R_2 in Figure P 3.6-4b that make the circuit in Figure P 3.6-4b equivalent to the circuit in Figure P 3.6-4a.
- (b) Analyze the circuit in Figure P 3.6-4b to determine the values of the currents i_a and i_b .
- (c) Because the circuits are equivalent, the currents i_a and i_b shown in Figure P 3.6-4b are equal to the currents i_a and i_b shown in Figure P 3.6-4a. Use this fact to determine values of the voltage v_1 and current i_2 shown in Figure P 3.6-4a.

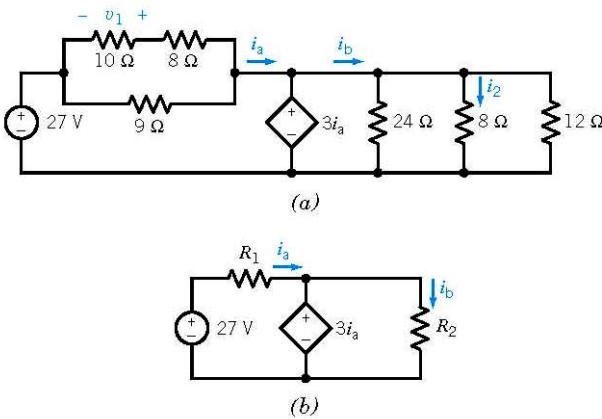


FIGURE P 3.6-4

P 3.6-5 The voltmeter in the circuit shown in Figure P 3.6-5 shows that the voltage across the $30\text{-}\Omega$ resistor is 6 volts. Determine the value of the resistance R_1 .

Hint: Use the voltage division twice.

Answer: $R_1 = 40\ \Omega$

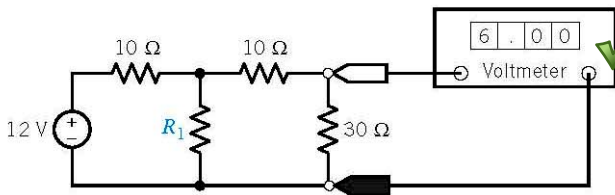


FIGURE P 3.6-5

P 3.6-6 Determine the voltages v_a and v_c and the currents i_b and i_d for the circuit shown in Figure P 3.6-6.

Answer: $v_a = -2\text{ V}$, $v_c = 6\text{ V}$, $i_b = -16\text{ mA}$, and $i_d = 2\text{ mA}$

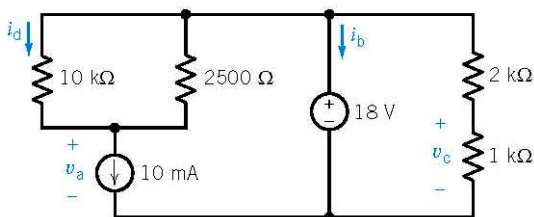


FIGURE P 3.6-6

P 3.6-7 Determine the value of the resistance R in Figure P 3.6-7.

Answer: $R = 28\text{ k}\Omega$

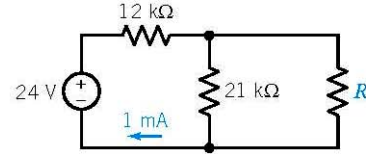


FIGURE P 3.6-7

P 3.6-8 Most of us are familiar with the effects of a mild electric shock. The effects of a severe shock can be devastating and often fatal. Shock results when current is passed through the body. A person can be modeled as a network of resistances. Consider the model circuit shown in Figure P 3.6-8. Determine the voltage developed across the heart and the current flowing through the heart of the person when he or she firmly grasps one end of a voltage source whose other end is connected to the floor. The heart is represented by R_h . The floor has resistance to current flow equal to R_f , and the person is standing barefoot on the floor. This type of accident might occur at a swimming pool or boat dock. The upper-body resistance R_u and lower-body resistance R_L vary from person to person.

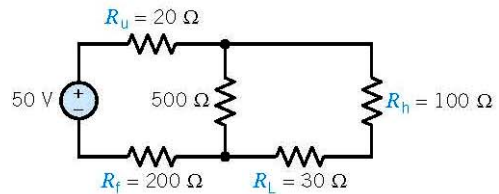


FIGURE P 3.6-8

P 3.6-9 Determine the value of the current i in Figure P 3.6-9.

Answer: $i = 0.5\text{ mA}$

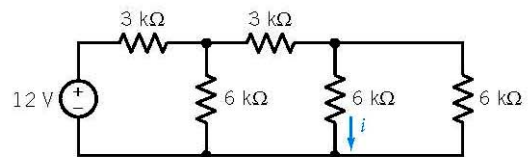


FIGURE P 3.6-9

P 3.6-10 Determine the values of i_a , i_b , and v_c in Figure P 3.6-10.

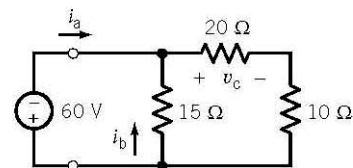


FIGURE P 3.6-10

P 3.6-11 Find i and $R_{eq\ a-b}$ if $v_{ab}=40\text{ V}$ in the circuit of Figure P 3.6-11.
Answer: $R_{eq\ a-b}=8\ \Omega, i=5/6\text{ A}$

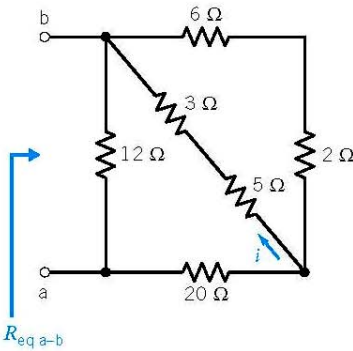


FIGURE P 3.6-11 $R_{eq\ a-b}$

P 3.6-12 The ohmmeter in Figure P 3.6-12 measures the equivalent resistance, R_{eq} , of the resistor circuit. The value of the equivalent resistance, R_{eq} , depends on the value of the resistance R .

- (a) Determine the value of the equivalent resistance, R_{eq} , when $R=18\ \Omega$.
- (b) Determine the value of the resistance R required to cause the equivalent resistance to be $R_{eq}=18\ \Omega$.

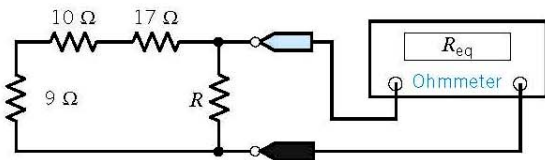


FIGURE P 3.6-12

P 3.6-13 The source $v_s=240\text{ volts}$ is connected to three equal resistors as shown in Figure P 3.6-13. Determine R when the voltage source delivers 1920 W to the resistors.
Answer: $R=45\ \Omega$

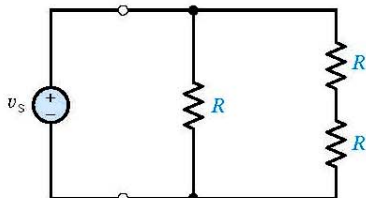


FIGURE P 3.6-13

P 3.6-14 Find the R_{eq} at terminals a–b in Figure P 3.6-14. Also determine $i, i_1,$ and i_2 .
Answer: $R_{eq}=8\ \Omega, i=5\text{ A}, i_1=5/3\text{ A}, i_2=5/2\text{ A}$

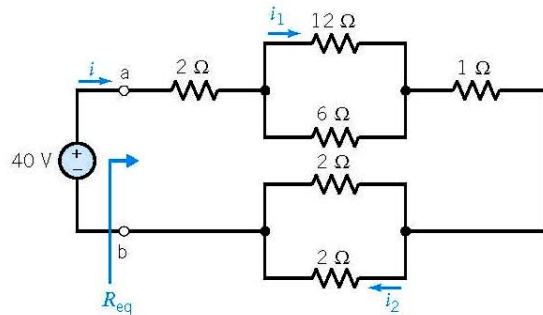


FIGURE P 3.6-14

P 3.6-15 All of the resistances in the circuit shown in Figure P 3.6-15 are multiples of R . Determine the value of R .

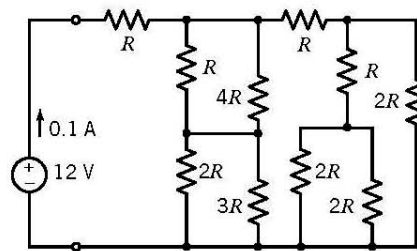


FIGURE P 3.6-15

P 3.6-16 The circuit shown in Figure P 3.6-16 contains seven resistors, each having resistance R . The input to this circuit is the voltage source voltage, v_s . The circuit has two outputs, v_a and v_b . Express each output as a function of the input.

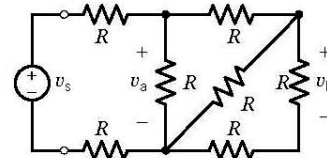


FIGURE P 3.6-16

P 3.6-17 The circuit shown in Figure P 3.6-17 contains three $10\text{-}\Omega, 1/4\text{-W}$ resistors. (Quarter-watt resistors can dissipate $1/4\text{ W}$ safely.) Determine the range of voltage source voltages, v_s , such that none of the resistors absorbs more than $1/4\text{ W}$ of power.

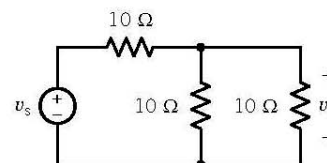


FIGURE P 3.6-17

P 3.6-18 The four resistors shown in Figure P 3.6-18 represent strain gauges. Strain gauges are transducers that measure the strain that results when a resistor is stretched or compressed. Strain gauges are used to measure force, displacement, or pressure. The four strain gauges in Figure P 3.6-18 each have a nominal (unstrained) resistance of $120\ \Omega$ and can each absorb 0.2 mW safely. Determine the range of voltage source voltages, v_s , such that no strain gauge absorbs more than 0.2 mW of power.

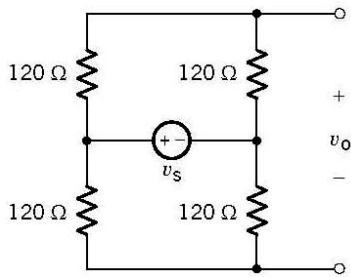


FIGURE P 3.6-18

P 3.6-19 The circuit shown in Figure P 3.6-19b has been obtained from the circuit shown in Figure P 3.6-19a by replacing series and parallel combinations of resistances by equivalent resistances.

- (a) Determine the values of the resistances R_1 , R_2 , and R_3 in Figure P 3.6-19b so that the circuit shown in Figure P 3.6-19b is equivalent to the circuit shown in Figure P 3.6-19a.
- (b) Determine the values of v_1 , v_2 , and i in Figure P 3.6-19b.
- (c) Because the circuits are equivalent, the values of v_1 , v_2 , and i in Figure P 3.6-19a are equal to the values of v_1 , v_2 , and i in Figure P 3.6-19b. Determine the values of v_4 , i_5 , i_6 , and v_7 in Figure P 3.6-19a.

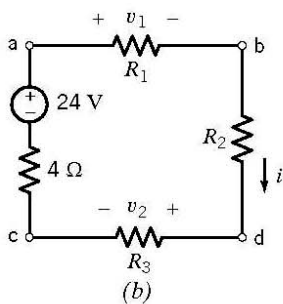
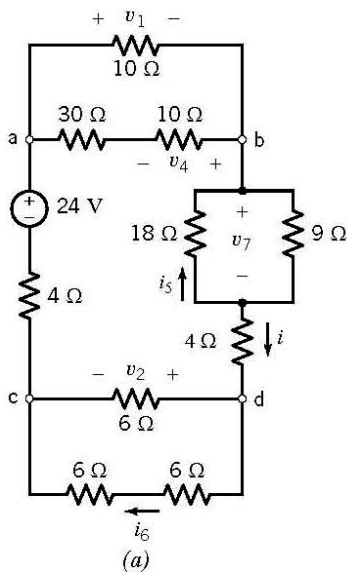


FIGURE P 3.6-19

P 3.6-20 Determine the values of v_1 , v_2 , i_3 , v_4 , v_5 , and i_6 in Figure P 3.6-20.

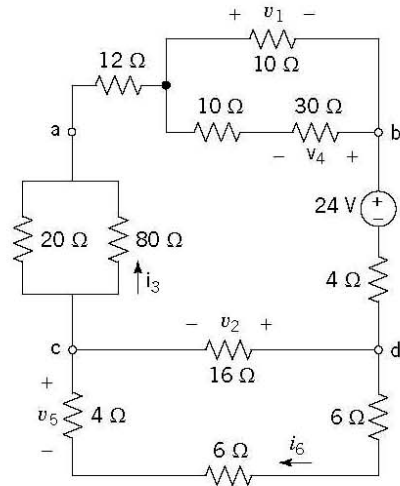


FIGURE P 3.6-20

P 3.6-21 Determine the values of i , v , and R_{eq} by the circuit model shown in Figure P 3.6-21, given that $v_{ab} = 18$ V.

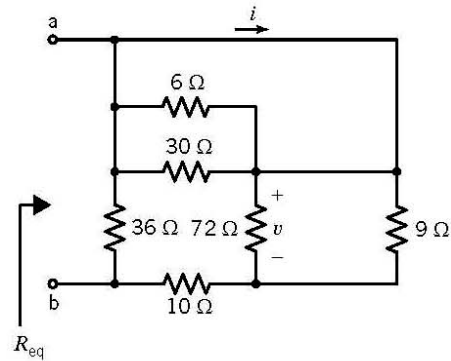


FIGURE P 3.6-21

P 3.6-22 Determine the value of the resistance R in the circuit shown in Figure P 3.6-22, given that $R_{eq} = 9 \Omega$.
Answer: $R = 15 \Omega$

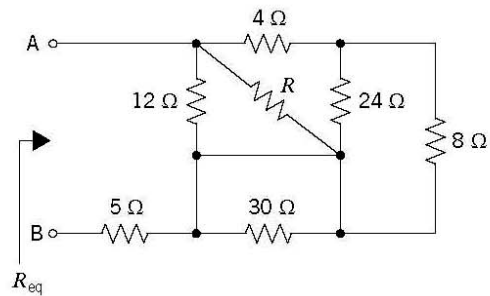


FIGURE P 3.6-22

P3.6-23 Determine the value of the resistance R in the circuit shown in Figure P 3.6-23, given that $R_{eq} = 50 \Omega$.

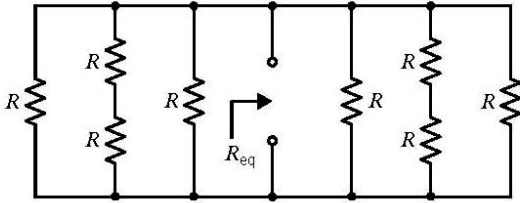


FIGURE P 3.6-23

P 3.6-24 Determine the values of r , the gain of the CCVS, and g , the gain of the VCCS, for the circuit shown in Figure P 3.6-24.

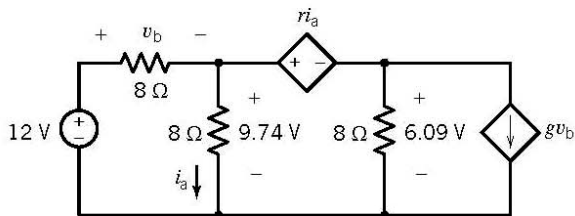


FIGURE P 3.6-24

P 3.6-25 The input to the circuit in Figure P 3.6-25 is the voltage of the voltage source, v_s . The output is the voltage measured by the meter, v_o . Show that the output of this circuit is proportional to the input. Determine the value of the constant of proportionality.

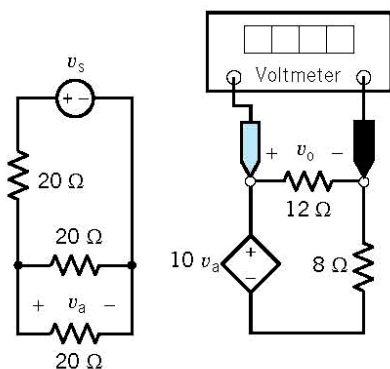


FIGURE P 3.6-25

P 3.6-26 The input to the circuit in Figure P 3.6-26 is the voltage of the voltage source, v_s . The output is the current measured by the meter, i_o . Show that the output of this circuit is proportional to the input. Determine the value of the constant of proportionality.

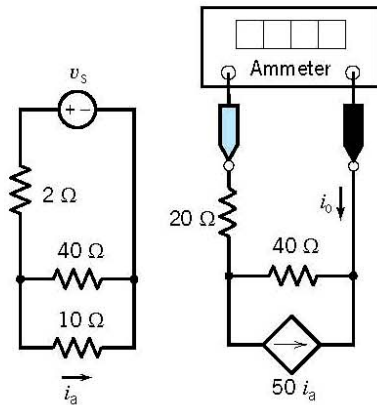


FIGURE P 3.6-26

P3.6-27 Determine the voltage measured by the voltmeter in the circuit shown in Figure P 3.6-27.

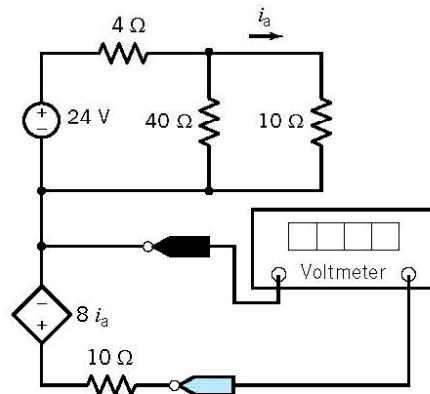


FIGURE P 3.6-27

P3.6-28 Determine the current measured by the ammeter in the circuit shown in Figure P 3.6-28.

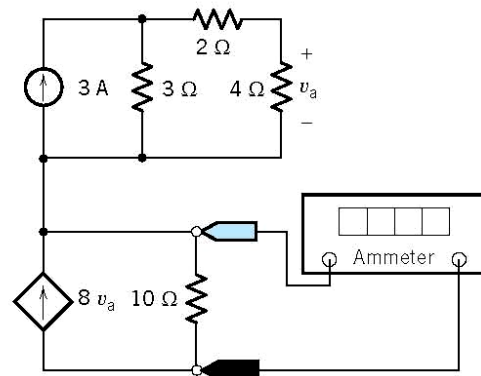


FIGURE P 3.6-28

P 3.6-29 Determine the value of the resistance R that causes the voltage measured by the voltmeter in the circuit shown in Figure P 3.6-29 to be 4 V.

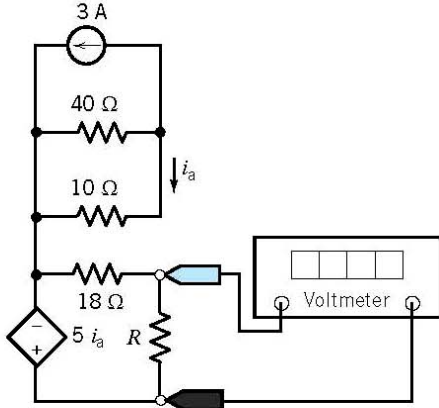


FIGURE P 3.6-29

P 3.6-30 The input to the circuit shown in Figure P 3.6-30 is the voltage of the voltage source, v_s . The output is the current measured by the meter, i_m .

- Suppose $v_s = 15$ V. Determine the value of the resistance R that causes the value of the current measured by the meter to be $i_m = 5$ A.
- Suppose $v_s = 15$ V and $R = 24$ Ω. Determine the current measured by the ammeter.
- Suppose $R = 24$ Ω. Determine the value of the input voltage, v_s , that causes the value of the current measured by the meter to be $i_m = 3$ A.

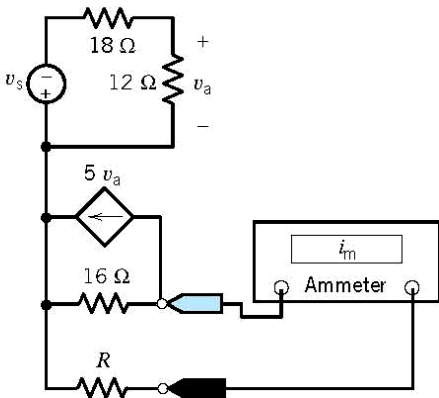


FIGURE P 3.6-30

P 3.6-31 The ohmmeter in Figure P 3.6-31 measures the equivalent resistance of the resistor circuit connected to the meter probes.

- Determine the value of the resistance R required to cause the equivalent resistance to be $R_{eq} = 12$ Ω.
- Determine the value of the equivalent resistance when $R = 14$ Ω.

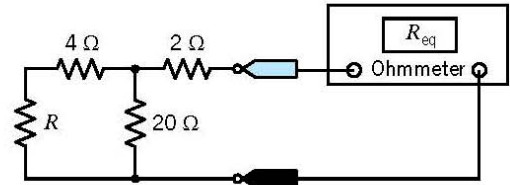


FIGURE P 3.6-31

P 3.6-32 The voltmeter in Figure P 3.6-32 measures the voltage across the current source.

- Determine the value of the voltage measured by the meter.
- Determine the power supplied by each circuit element.

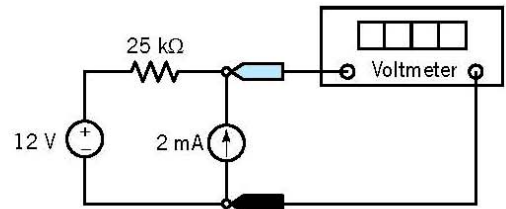


FIGURE P 3.6-32

P 3.6-33 Determine the resistance measured by the ohmmeter in Figure P 3.6-33.

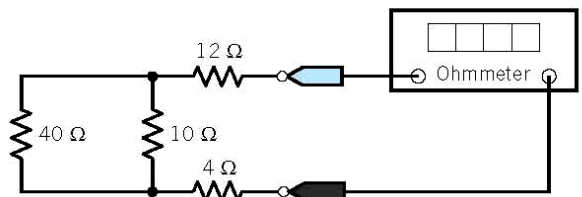


FIGURE P 3.6-33

P 3.6-34 Determine the resistance measured by the ohmmeter in Figure P 3.6-34.

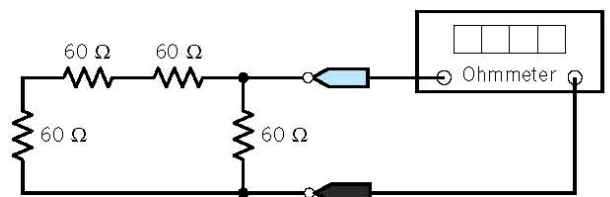


FIGURE P 3.6-34

Section 3.8 How Can We Check...?

P 3.8-1 A computer analysis program, used for the circuit of Figure P 3.8-1, provides the following branch currents and voltages: i_1 A = -0.833, i_2 A = -0.333, i_3 A = -1.167, and $v = -2.0$ V. Are these answers correct?

Hint: Verify that KCL is satisfied at the center node and that KVL is satisfied around the outside loop consisting of the two 6-Ω resistors and the voltage source.

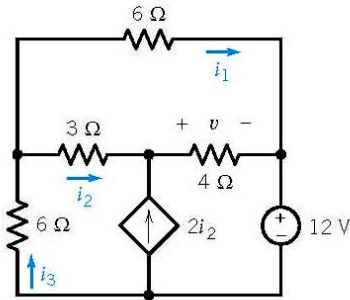


FIGURE P 3.8-1

P 3.8-2 The circuit of Figure P 3.8-2 was assigned as a homework problem. The answer in the back of the textbook says the current, i , is 1.25 A. Verify this answer using current division.

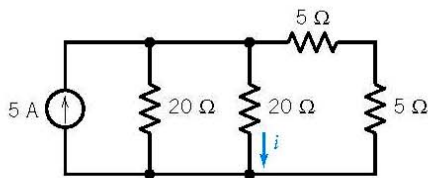


FIGURE P 3.8-2

P 3.8-3 The circuit of Figure P 3.8-3 was built in the lab and v_o was measured to be 6.25 V. Verify this measurement using the voltage divider principle.

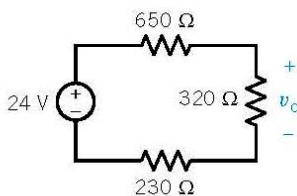


FIGURE P 3.8-3

P 3.8-4 The circuit of Figure P 3.8-4 represents an auto's electrical system. A report states that $i_H = 9$ A, $i_B = -9$ A, and $i_A = 19.1$ A. Verify that this result is correct.

Hint: Verify that KCL is satisfied at each node and that KVL is satisfied around each loop.

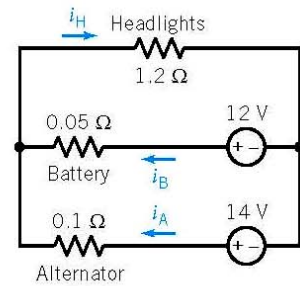


FIGURE P 3.8-4
Electric circuit model of an automobile's electrical system.

P 3.8-5 Computer analysis of the circuit in Figure P 3.8-5 shows that $i_a = -0.5$ mA and $i_b = -2$ mA. Was the computer analysis done correctly?

Hint: Verify that the KVL equations for all three meshes are satisfied when $i_a = -0.5$ mA and $i_b = -2$ mA.

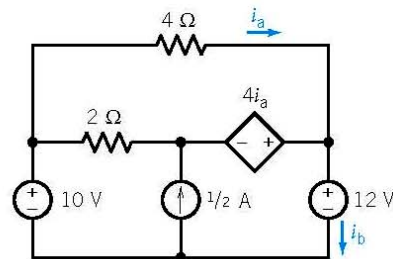


FIGURE P 3.8-5

P 3.8-6 Computer analysis of the circuit in Figure P 3.8-6 shows that $i_a = 0.5$ mA and $i_b = 4.5$ mA. Was the computer analysis done correctly?

Hint: First, verify that the KCL equations for all five nodes are satisfied when $i_a = 0.5$ mA and $i_b = 4.5$ mA. Next, verify that the KVL equation for the lower left mesh (a-e-d-a) is satisfied. (The KVL equations for the other meshes aren't useful because each involves an unknown voltage.)

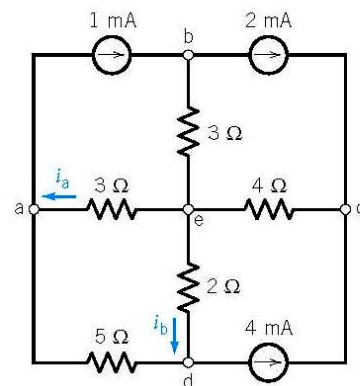


FIGURE P 3.8-6

P 3.8-7 Verify that the element currents and voltages shown in Figure P 3.8-7 satisfy Kirchhoff's laws:

- (a) Verify that the given currents satisfy the KCL equations corresponding to nodes a, b, and c.
- (b) Verify that the given voltages satisfy the KVL equations corresponding to loops a-b-d-c-a and a-b-c-d-a.

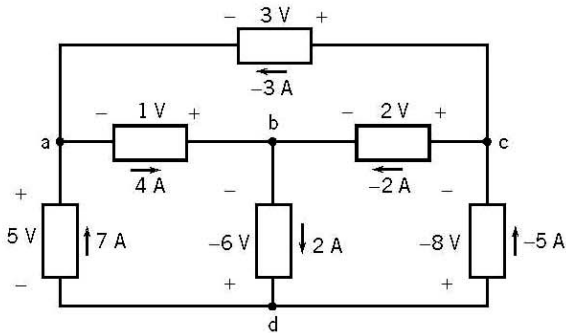
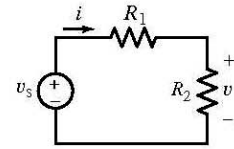


FIGURE P 3.8-7

***P3.8-8** Figure P 3.8-8 shows a circuit and some corresponding data. The tabulated data provides values of the current, i , and voltage, v , corresponding to several values of the resistance R_2 .

- (a) Use the data in rows 1 and 2 of the table to find the values of v_s and R_1 .
- (b) Use the results of part (a) to verify that the tabulated data are consistent.
- (c) Fill in the missing entries in the table.



(a)

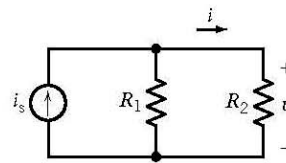
R_2, Ω	i, A	v, V
0	2.4	0
10	1.2	12
20	0.8	16
30	?	18
40	0.48	?

(b)

FIGURE P 3.8-8

***P3.8-9** Figure P 3.8-9 shows a circuit and some corresponding data. The tabulated data provide values of the current, i , and voltage, v , corresponding to several values of the resistance R_2 .

- (a) Use the data in rows 1 and 2 of the table to find the values of i_s and R_1 .
- (b) Use the results of part (a) to verify that the tabulated data are consistent.
- (c) Fill in the missing entries in the table.



(a)

R_2, Ω	i, A	v, V
10	4/3	40/3
20	6/7	120/7
40	1/2	20
80	?	?

(b)

FIGURE P 3.8-9

DESIGN PROBLEMS

DP3-1 The circuit shown in Figure DP 3-1 uses a potentiometer to produce a variable voltage. The voltage v_m varies as a knob connected to the wiper of the potentiometer is turned. Specify the resistances R_1 and R_2 so that the following three requirements are satisfied:

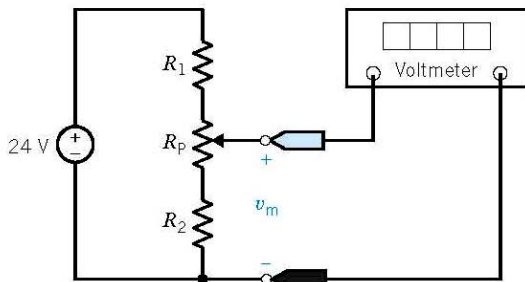


FIGURE DP 3-1

1. The voltage v_m varies from 8 V to 12 V as the wiper moves from one end of the potentiometer to the other end of the potentiometer.
2. The voltage source supplies less than 0.5 W of power.
3. Each of R_1 , R_2 , and R_p dissipates less than 0.25 W.

DP3-2 The resistance R_L in Figure DP 3-2 is the equivalent resistance of a pressure transducer. This resistance is specified to be $200 \Omega \pm 5$ percent. That is, $190 \Omega \leq R_L \leq 210 \Omega$. The voltage source is a $12 V \pm 1$ percent source capable of supplying 5 W. Design this circuit, using 5 percent, 1/8-watt resistors for R_1 and R_2 , so that the voltage across R_L is

$$v_o = 4 V \pm 10\%$$

(A 5 percent, 1/8-watt 100- Ω resistor has a resistance between 95 and 105 Ω and can safely dissipate 1/8-W continuously.)

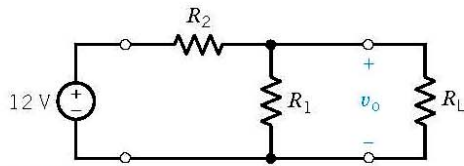
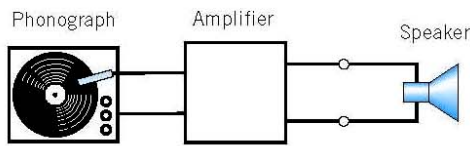
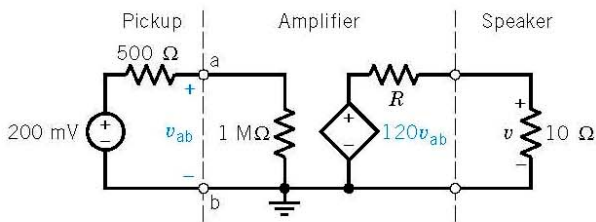


FIGURE DP 3-2

DP 3-3 A phonograph pickup, stereo amplifier, and speaker are shown in Figure DP 3-3a and redrawn as a circuit model as shown in Figure DP 3-3b. Determine the resistance R so that the voltage v across the speaker is 16 V. Determine the power delivered to the speaker.



(a)



(b)

FIGURE DP 3-3 A photograph stereo system.

DP3-4 A Christmas tree light set is required that will operate from a 6-V battery on a tree in a city park. The heavy-duty battery can provide 9A for the four-hour period of operation each night. Design a parallel set of lights (select the maximum number of lights) when the resistance of each bulb is 12Ω .

DP 3-5 The input to the circuit shown in Figure DP 3-5 is the voltage source voltage, v_s . The output is the voltage v_o . The output is related to the input by

$$v_o = \frac{R_2}{R_1 + R_2} v_s = g v_s$$

The output of the voltage divider is proportional to the input. The constant of proportionality, g , is called the gain of the voltage divider and is given by

$$g = \frac{R_2}{R_1 + R_2}$$

The power supplied by the voltage source is

$$p = v_s i_s = v_s \left(\frac{v_s}{R_1 + R_2} \right) = \frac{v_s^2}{R_1 + R_2} = \frac{v_s^2}{R_{in}}$$

where

$$R_{in} = R_1 + R_2$$

is called the input resistance of the voltage divider.

- (a) Design a voltage divider to have a gain, $g = 0.65$.
- (b) Design a voltage divider to have a gain, $g = 0.65$, and an input resistance, $R_{in} = 2500 \Omega$.

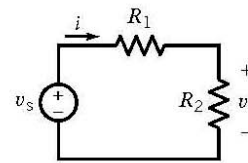


FIGURE DP 3-5

DP3-6 The input to the circuit shown in Figure DP 3-6 is the current source current, i_s . The output is the current i_o . The output is related to the input by

$$i_o = \frac{R_1}{R_1 + R_2} i_s = g i_s$$

The output of the current divider is proportional to the input. The constant of proportionality, g , is called the gain of the current divider and is given by

$$g = \frac{R_1}{R_1 + R_2}$$

The power supplied by the current source is

$$p = v_s i_s = \left[i_s \left(\frac{R_1 R_2}{R_1 + R_2} \right) \right] i_s = \frac{R_1 R_2}{R_1 + R_2} i_s^2 = R_{in} i_s^2$$

where

$$R_{in} = \frac{R_1 R_2}{R_1 + R_2}$$

is called the input resistance of the current divider.

- (a) Design a current divider to have a gain, $g = 0.65$.
- (b) Design a current divider to have a gain, $g = 0.65$, and an input resistance, $R_{in} = 10000 \Omega$.

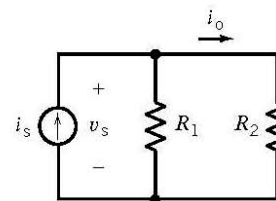


FIGURE DP 3-6

DP 3-7 Design the circuit shown in Figure DP 3-7 to have an output $v_o = 8.5$ V when the input is $v_s = 12$ V. The circuit should require no more than 1 mW from the voltage source.

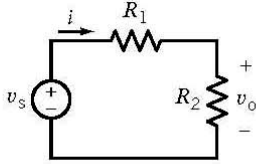


FIGURE DP 3-7

DP 3-8 Design the circuit shown in Figure DP 3-8 to have an output $i_o = 1.8$ mA when the input is $i_s = 5$ mA. The circuit should require no more than 1 mW from the current source.

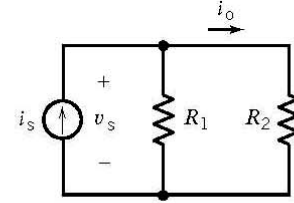


FIGURE DP 3-8