ECE 35 Homework #2 (Spring 2023, Taur)

All homework problems come from the textbook, "Introduction to Electric Circuits", by Svoboda & Dorf, 9th Edition.

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

(a) Suppose that $R_1 = 8\ \Omega$ and $R_2 = 4\ \Omega$. Find the current i and the voltage v.

(b) Suppose, instead, that $i = 2.25$ A and $v = 42$ V. Determine the resistances R_1 and R_2.

(c) 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.

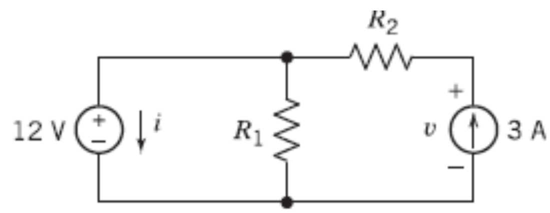
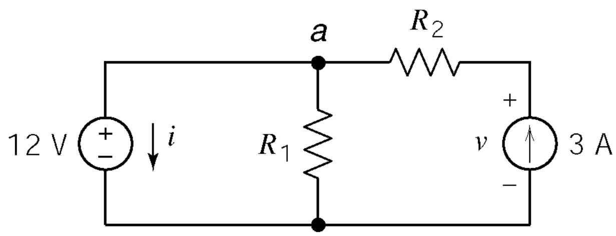


Figure P 3.2-3

Solution:



KVL : $-12 - R_2(3) + v = 0$ (outside loop)

$$v = 12 + 3R_2 \quad \text{or} \quad R_2 = \frac{v-12}{3}$$

KCL $\quad i + \frac{12}{R_1} - 3 = 0$ (top node)

$$i = 3 - \frac{12}{R_1} \quad \text{or} \quad R_1 = \frac{12}{3-i}$$

(a)

$$v = 12 + 3(4) = 24 \text{ V} \quad \text{and} \quad i = 3 - \frac{12}{8} = 1.5 \text{ A}$$

(b)

$$R_2 = \frac{42-12}{3} = \underline{10\ \Omega}\ ; \ R_1 = \frac{12}{3-2.25} = \underline{16\ \Omega}$$

(c)

$24 = -12\,i$, because 12 and i adhere to the passive convention.

$$\therefore\ \underline{i = -2 \text{ A}} \quad \text{and} \quad R_1 = \frac{12}{3+2} = \underline{2.4\ \Omega}$$

$9 = 3v$, because 3 and v do not adhere to the passive convention

$$\therefore\ \underline{v = 3 \text{ V}} \quad \text{and} \quad R_2 = \frac{3-12}{3} = \underline{-3\ \Omega}$$

The situations described in (b) and (c) cannot occur if R1 and R2 are required to be nonnegative.

P 3.2-12 Determine the voltage and current of each of the circuit elements in the circuit shown in Figure P 3.2-12.

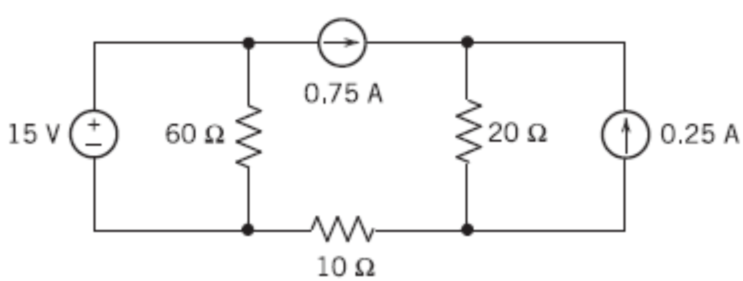
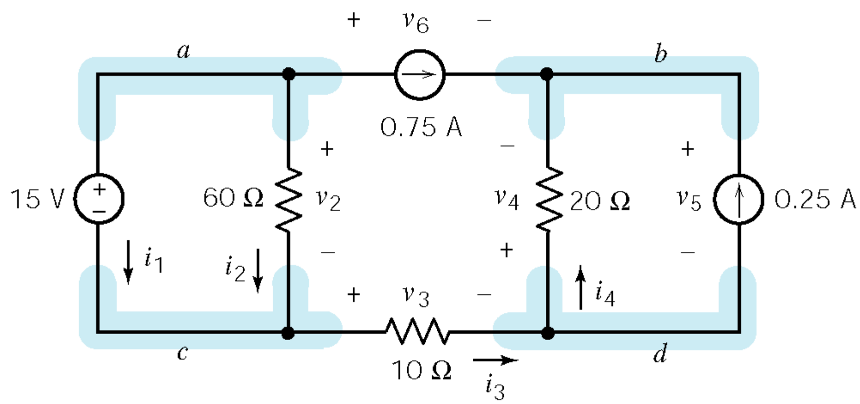


Figure P 3.2-12

Solution: We can label the circuit as follows:



The subscripts suggest a numbering of the circuit elements. Apply KCL at node *b* to get

$$i_4 + 0.25 + 0.75 = 0 \quad \Rightarrow \quad i_4 = -1.0 \text{ A}$$

Next, apply KCL at node *d* to get

$$i_3 = i_4 + 0.25 = -1.0 + 0.25 = -0.75 \text{ A}$$

Next, apply KVL to the loop consisting of the voltage source and the 60 Ω resistor to get

$$v_2 - 15 = 0 \quad \Rightarrow \quad v_2 = 15 \text{ V}$$

Apply Ohm's law to each of the resistors to get

$$i_2 = \frac{v_2}{60} = \frac{15}{60} = 0.25 \text{ A}, \qquad v_3 = 10\, i_3 = 10(-0.75) = -7.5 \text{ V}$$

and

$$v_4 = 20 i_4 = 20(-1) = -20 \text{ V}$$

Next, apply KCL at node *c* to get

$$i_1 + i_2 = i_3 \quad \Rightarrow \quad i_1 = i_3 - i_2 = -0.75 - 0.25 = -1.0 \text{ A}$$

Next, apply KVL to the loop consisting of the 0.75 A current source and three resistors to get

$$v_6 - v_4 - v_3 - v_2 = 0 \quad \Rightarrow \quad v_6 = v_4 + v_3 + v_2 = -20 + (-7.5) + 15 = -12.5 \text{ V}$$

Finally, apply KVL to the loop consisting of the 0.25 A current source and the 20 Ω resistor to get

$$v_5 + v_4 = 0 \quad \Rightarrow \quad v_5 = -v_4 = -(-20) = 20 \text{ V}$$

P 3.2-18 Determine the value of the current i_m in Figure P 3.2-18*a*.

Hint: Apply KVL to the closed path a-b-d-c-a in Figure P 3.2-18*b* to determine v_a. Then apply KCL at node b to find i_m.

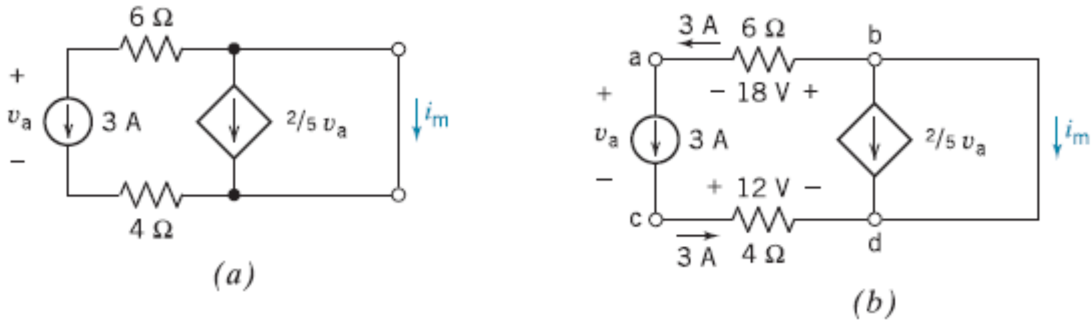


Figure P 3.2-18

Solution:

$$-18+0-12-v_a=0 \quad\Rightarrow\quad v_a=-30\text{ V} \quad \text{and} \quad i_m=\frac{2}{5}v_a+3 \quad\Rightarrow\quad i_m=9\ \text{A}$$

P3.2-26 Consider the circuit shown in Figure P3.2-26. Determine the values of

(a) The current i_a in the 20-Ω resistor.

(b) The voltage v_b across the 10-Ω resistor.

(c) The current i_c in the independent voltage source.

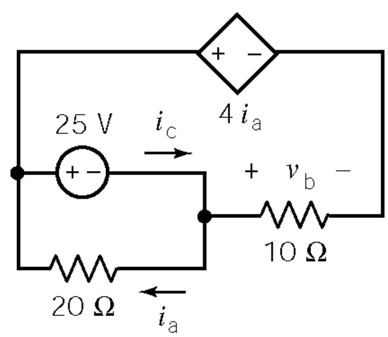
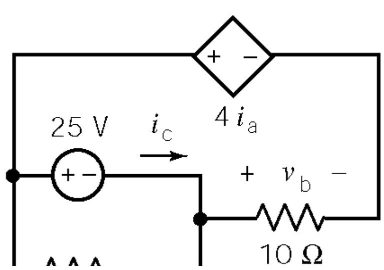


Figure P3.2-26

Solution:



P3.2-28 Consider the circuit shown in Figure 3.2-28.

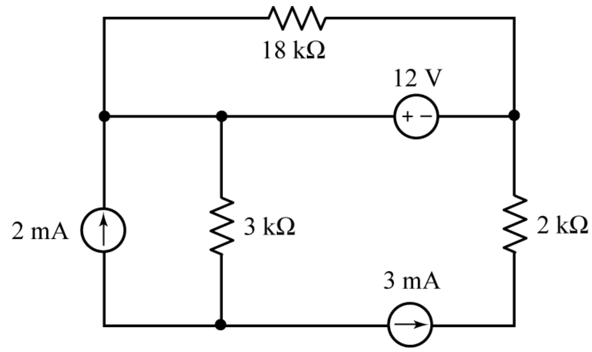


Figure 3.2-28

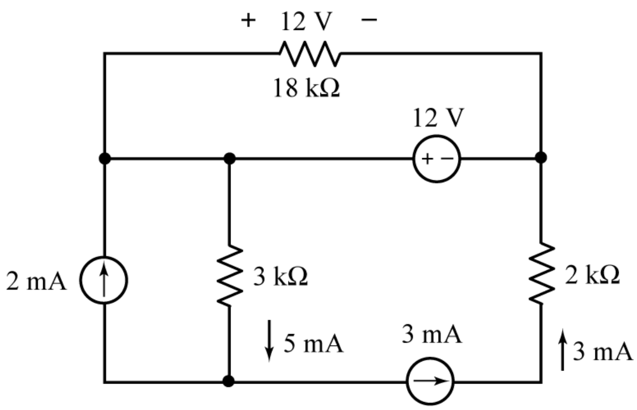
a. Determine the value of the power supplied by each independent source.

b. Determine the value of the power received by each resistor.

c. Is power conserved?

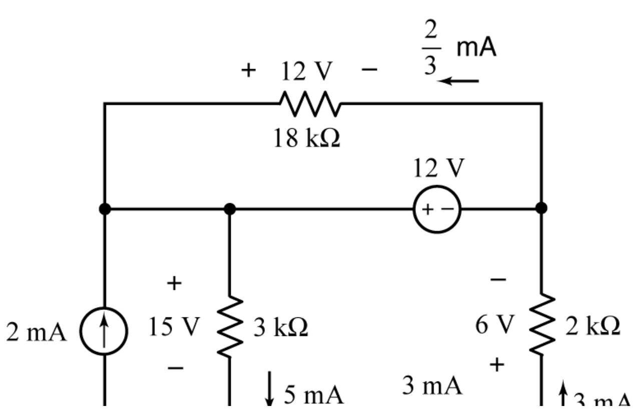
Solution:

Apply KCL twice and KVL to get

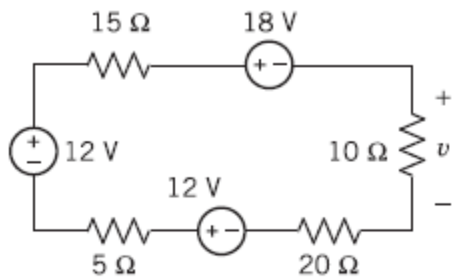


Apply Ohm's law 3 times to get

Note: The 2/3 mA below should be flipped to →



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



Solution:

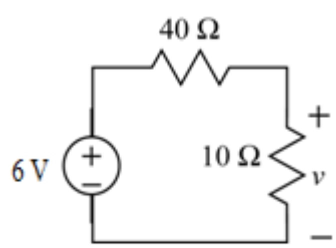
All the elements are connected in series.

Replace the series voltage sources with a single equivalent voltage having voltage

$$12 + 12 - 18 = 6 \text{ V}.$$

Replace the series 15 Ω, 5 Ω and 20 Ω resistors by a single equivalent resistance of

$$15 + 5 + 20 = 40\ \Omega.$$



By voltage division

$$v = \left(\frac{10}{10+40}\right)6 = \frac{6}{5} = 1.2 \text{ V}$$

P 3.4-8 Determine the value of the voltage v in Figure P 3.4-8.

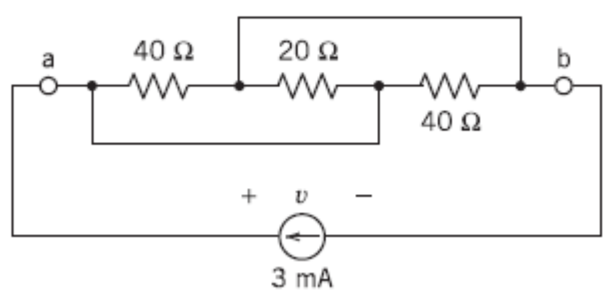
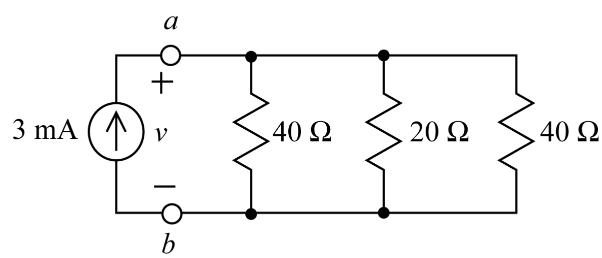


Figure P 3.4-8

Solution:

Each of the resistors is connected between nodes *a* and *b*. The resistors are connected in parallel and the circuit can be redrawn like this:



Then $$40 \parallel 20 \parallel 40 = 10\Omega$$

so $$v = 10(0.003) = 0.03 = 30\text{ mV}$$

P 3.4-9 Determine the power supplied by the dependent source in Figure P 3.4-9.

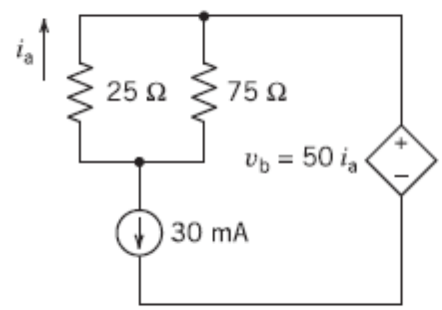
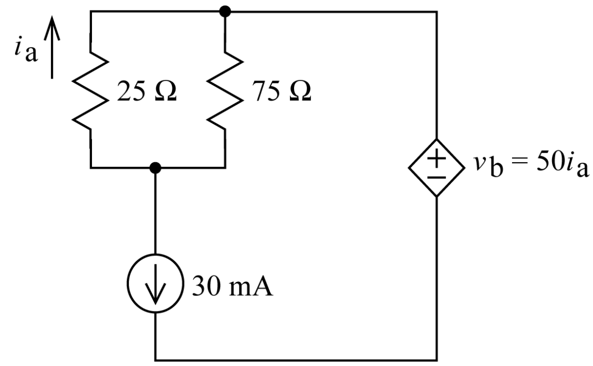


Figure P 3.4-9

Solution:

Use current division to get



$$i_a = -\frac{75}{25+75}\left(30\times10^{-3}\right) = -22.5 \text{ mA}$$

so

$$v_b = 50\left(-22.5\times10^{-3}\right) = -1.125 \text{ V}$$

The power supplied by the dependent source is given by

$$p = -\left(30\times10^{-3}\right)\left(-1.125\right) = 33.75 \text{ mW}$$

P 3.4-10 Determine the values of the resistances R_1 and R_2 for the circuit shown in Figure P 3.4-10.

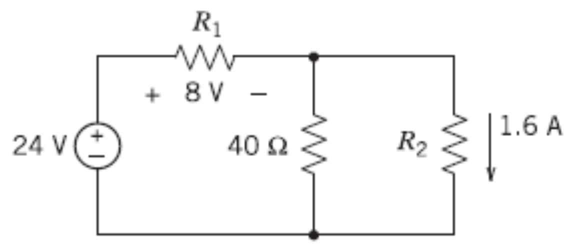


Figure P 3.4-10

Solution:

Using voltage division

$$8 = \frac{R_1}{R_1 + \dfrac{40R_2}{R_2+40}} \times 24 \quad \Rightarrow \quad \frac{1}{3} = \frac{R_1\left(R_2+40\right)}{R_1R_2 + 40\left(R_1+R_2\right)}$$

$$\Rightarrow \quad R_1R_2 + 40\left(R_1+R_2\right) = 3R_1R_2 + 120R_1 \quad \Rightarrow \quad R_1 = \frac{40R_2}{2R_2+80}$$

Using KVL

$$24 = 8 + R_2\left(1.6\right) \quad \Rightarrow \quad R_2 = 10 \ \Omega$$

Then

$$R_1 = \frac{40\left(10\right)}{2\left(10\right)+80} = 4 \ \Omega$$

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

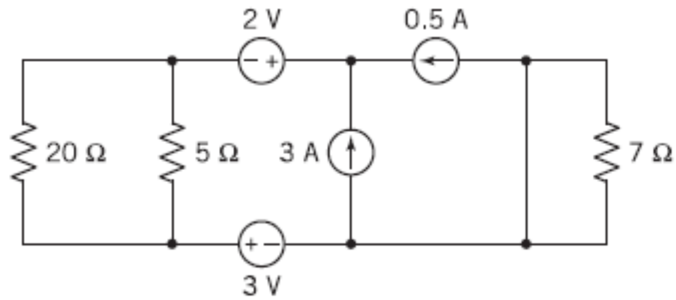


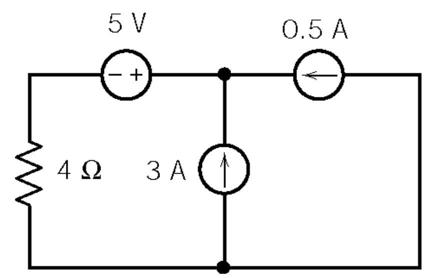
Figure P 3.5-2

Solution:

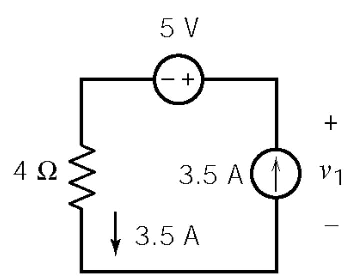
The 20-Ω and 5-Ω resistors are connected in parallel. The equivalent resistance is $\frac{20 \times 5}{20+5} = 4\ \Omega$. The 7-Ω resistor is connected in parallel with a short circuit, a 0-Ω resistor. The equivalent resistance is $\frac{0 \times 7}{0+7} = 0\ \Omega$, a short circuit.

The voltage sources are connected in series and can be replaced by a single equivalent voltage source.

After doing so, and labeling the resistor currents, we have the circuit shown.



The parallel current sources can be replaced by an equivalent current source.



Apply KVL to get

$$-5 + v_1 - 4(3.5) = 0 \quad \Rightarrow \quad v_1 = 19\ \text{V}$$

The power supplied by each sources is:

Source	Power delivered
8-V voltage source	$-2(3.5) = -7$ W
3-V voltage source	$-3(3.5) = -10.5$ W
3-A current source	$3 \times 19 = 57$ W
0.5-A current source	$0.5 \times 19 = 9.5$ W

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

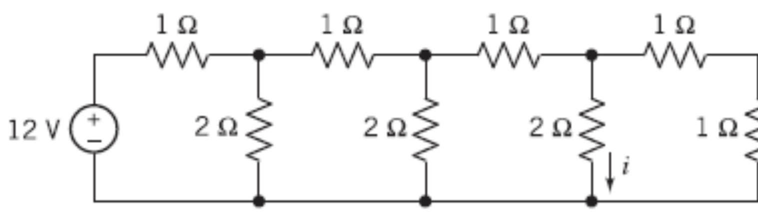
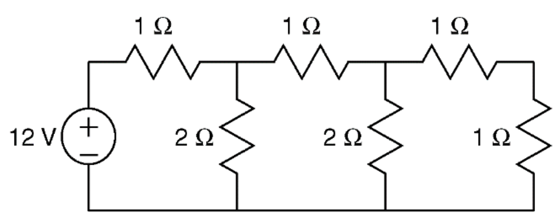
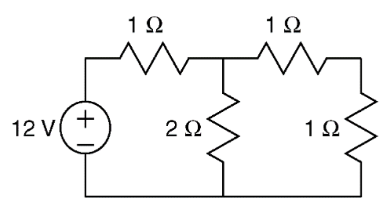


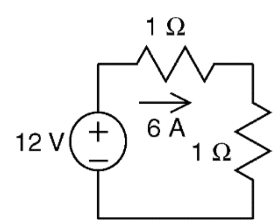
Figure P 3.6-3

Solution:

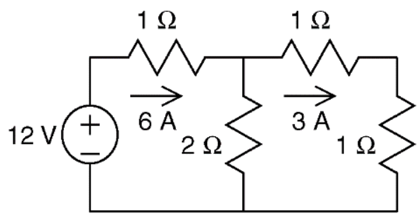
Reduce the circuit from the right side by repeatedly replacing series 1 Ω resistors in parallel with a 2 Ω resistor by the equivalent 1 Ω resistor

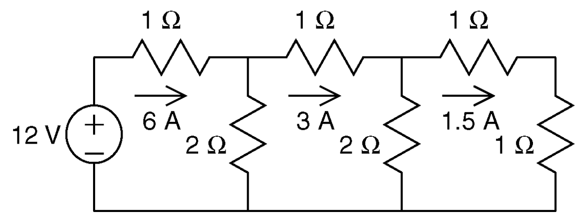


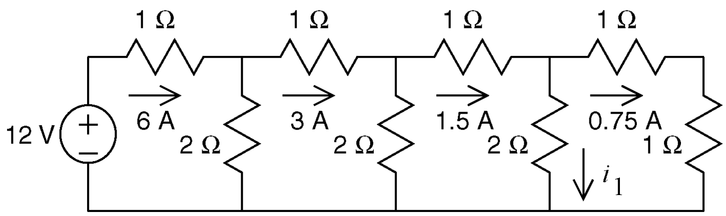




This circuit has become small enough to be easily analyzed. The vertical 1 Ω resistor is equivalent to a 2 Ω resistor connected in parallel with series 1 Ω resistor:







$$i_1 = \frac{1+1}{2+(1+1)}(1.5) = 0.75 \text{ A}$$

P 3.6-20 Determine the values of i, v, and R_{eq} by the circuit model shown in Figure P 3.6-20, given that v_{ab} = 18 V.

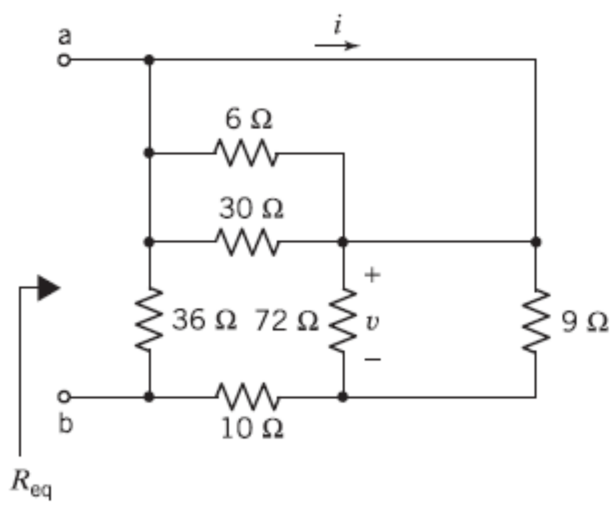
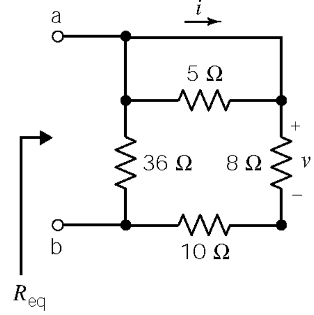


Figure P 3.6-20

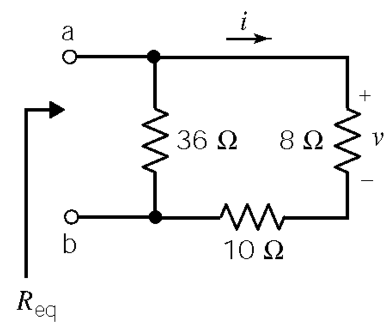
Solution:



Replace parallel resistors by equivalent resistors:

6 || 30 = 5 Ω and 72 || 9 = 8 Ω

A short circuit in parallel with a resistor is equivalent to a short circuit.



$$R_{eq} = 36 \,||\, (8+10) = 12\ \Omega$$

Using voltage division when v_{ab} = 18 V:

$$v = \frac{8}{8+10} v_{ab} = \frac{4}{9}(18) = 8\ \text{V}$$

$$i = \frac{v}{8} = 1\ \text{A}$$

P 3.6-21 Determine the value of the resistance R in the circuit shown in Figure P 3.6-22, given that $R_{eq} = 9\ \Omega$.

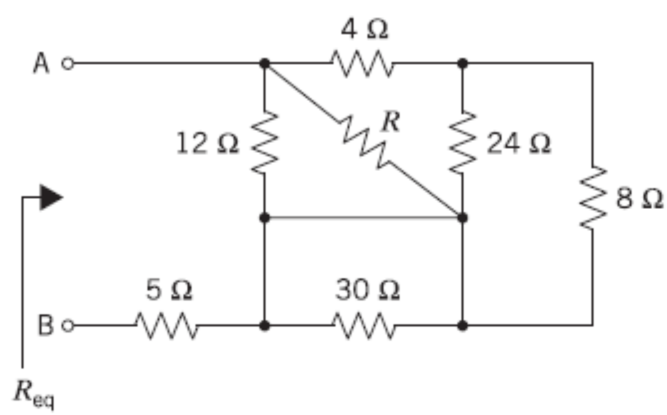
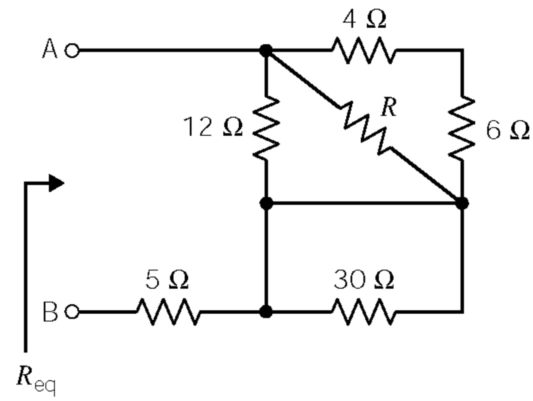


Figure P 3.6-22

Solution:

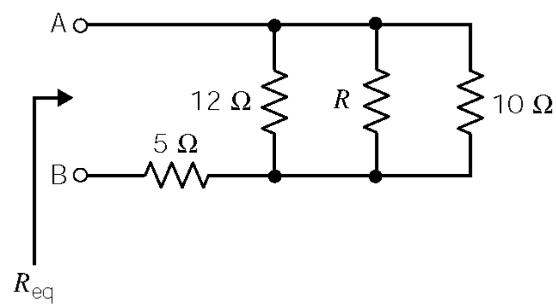
Replace parallel resistors by an equivalent resistor:



$$8 \,||\, 24 = 6\ \Omega$$

A short circuit in parallel with a resistor is equivalent to a short circuit.

Replace series resistors by an equivalent resistor:



$$4+6 = 10\ \Omega$$

Now

$$9 = R_{eq} = 5 + \left(12 \parallel R \parallel 10\right)$$

$$4 = \frac{R \times \frac{60}{11}}{R + \frac{60}{11}} \quad \Rightarrow \quad R = 15\ \Omega$$

So

P 3.6-28 Determine the value of the resistance *R* that causes the voltage measured by the voltmeter in the circuit shown in Figure P 3.6-28 to be 6 V.

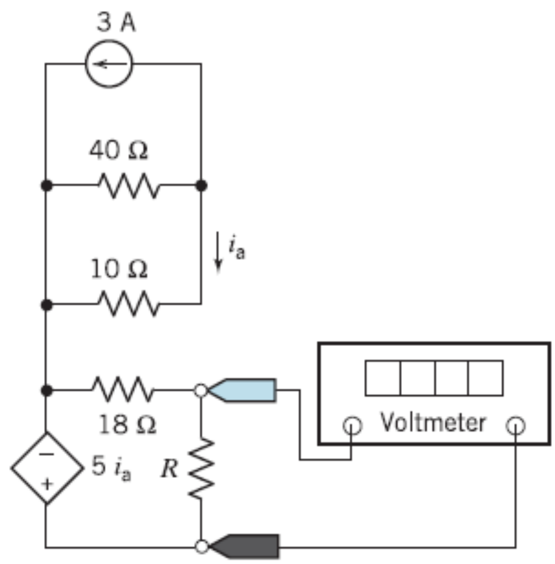


Figure P 3.6-28

Solution:
Use current division in the top part of the circuit to get

$$i_a = \left(\frac{40}{40+10}\right)(-3) = -2.4 \text{ A}$$

Next, denote the voltage measured by the voltmeter as v_m and use voltage division in the bottom part of the circuit to get

$$v_m = \left(\frac{R}{18+R}\right)(-5\, i_a) = \left(\frac{-5\,R}{18+R}\right) i_a$$

Combining these equations gives:

$$v_m = \left(\frac{-5\,R}{18+R}\right)(-2.4) = \frac{12\,R}{18+R}$$

When v_m = 6 V,

$$6 = \frac{12\,R}{18+R} \quad \Rightarrow \quad R = \frac{6\times 18}{12-6} = 18 \;\Omega$$

P3.6-47 Determine the values of the voltages, v_1 and v_2, and of the current, i_3, in the circuit shown in Figure P3.6-47.

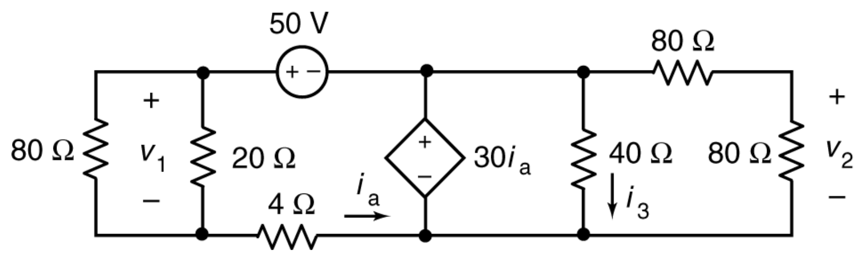
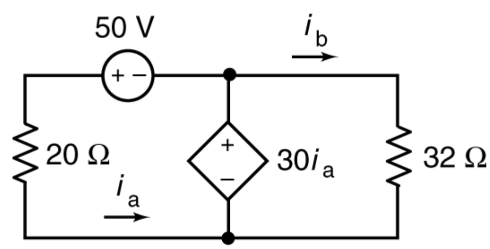


Figure P3.6-47

Solution:

Replace series and parallel combinations of resistors by equivalent resistors to get



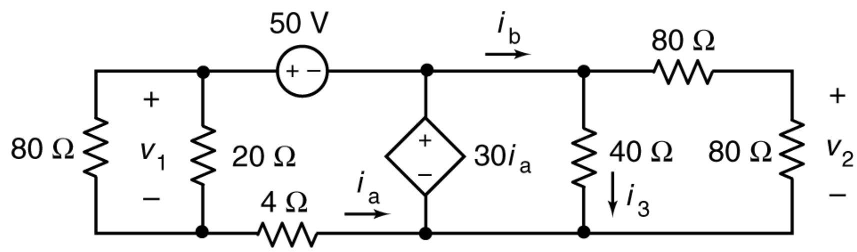
($4+(80\,||\,20)=4+16=20\ \Omega$ and $40||(80+80)=40\,||\,160=32\ \Omega.$) Next, apply KVL to the left mesh to get

$$50+30i_a-20i_a=0 \;\Rightarrow\; i_a=\frac{50}{20-10}=-5\text{ A} \quad \text{and} \quad 30i_a=-150\text{ V}$$

Ohm's law gives

$$i_b=\frac{30i_a}{32}=\frac{-150}{32}=-4.6875\text{ A}$$

Label i_b on the original circuit



Finally $v_1 = (80 \| 20) i_a = 16(-5) = -80 \text{ V}$, $v_2 = \frac{1}{2}(30 i_a) = -75 \text{ V}$

and $$i_3 = \frac{80+80}{40+(80+80)} i_b = \frac{4}{5}(-4.6875) = -3.75 \text{ A}$$