Kingdom of Saudi Arabia
Ministry of Education
Prince Sattam bin Abdulaziz University
College of Engineering
Department of Electrical Engineering

جامعة الأمير سطام بن عبدالعزيز
PRINCE SATTAM BIN ABDULAZIZ UNIVERSITY
كلية الهندسة \ قسم الهندسة الكهربائية
COLLEGE OF ENGINEERING / DEPARTMENT OF ELECTRICAL ENGINEERING

المملكة العربية السعودية
وزارة التعليم
جامعة الأمير سطام بن عبدالعزيز
كلية الهندسة
قسم الهندسة الكهربائية

Course Name:

EE 2010 Electric Circuits I

Homework No. (1): Circuit Variables and Circuit Elements

Academic Year 1447H -2025G/2026G

Student Name		**Group No.**
ID No.		**First Semester**

Teaching Assistant/Lecturer	**Notes**		**Total**	$\overline{}$ 10
Eng.: **Signature**			**Instructors Names:** **Prof. Fayez F. M. El-Sousy** **Dr. Erhab Youssef** **Signatures**	

Answer the Following Questions:

1. The numerical values for the currents and voltages in the circuit shown in Figure (1) are given in Table (1). Find the total power developed in the circuit.

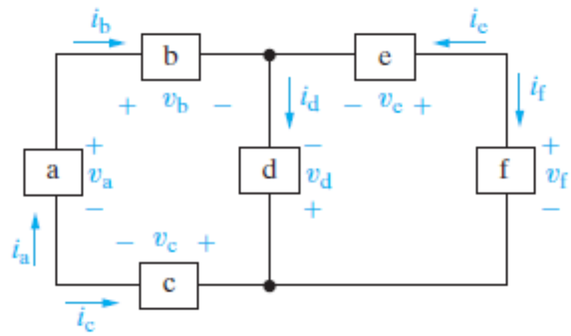


Figure (1)

Table (1)

Element	Voltage (V)	Current (mA)
a	40	−4
b	−24	−4
c	−16	4
d	−80	−1.5
e	40	2.5
f	120	−2.5

We use the passive sign convention to determine whether the power equation is $p = vi$ or $p = -vi$ and substitute into the power equation the values for v and i, as shown below:

$$p_a = -v_a i_a = -(40)(-4 \times 10^{-3}) = 160 \text{ mW}$$

$$p_b = v_b i_b = (-24)(-4 \times 10^{-3}) = 96 \text{ mW}$$

$$p_c = -v_c i_c = -(-16)(4 \times 10^{-3}) = 64 \text{ mW}$$

$$p_d = -v_d i_d = -(-80)(-1.5 \times 10^{-3}) = -120 \text{ mW}$$

$$p_e = v_e i_e = (40)(2.5 \times 10^{-3}) = 100 \text{ mW}$$

$$p_f = v_f i_f = (120)(-2.5 \times 10^{-3}) = -300 \text{ mW}$$

Remember that if the power is positive, the circuit element is absorbing power, whereas is the power is negative, the circuit element is developing power. We can add the positive powers together and the negative powers together — if the power balances, these power sums should be equal:
$\sum P_{\text{dev}} = 120 + 300 = 420$ mW;
$\sum P_{\text{abs}} = 160 + 96 + 64 + 100 = 420$ mW
Thus, the power balances and the total power absorbed in the circuit is 420 mW.

2. The numerical values for the currents and voltages in the circuit in Figure (2) are given in Table (2). Find the total power developed and the total power absorbed in the circuit.

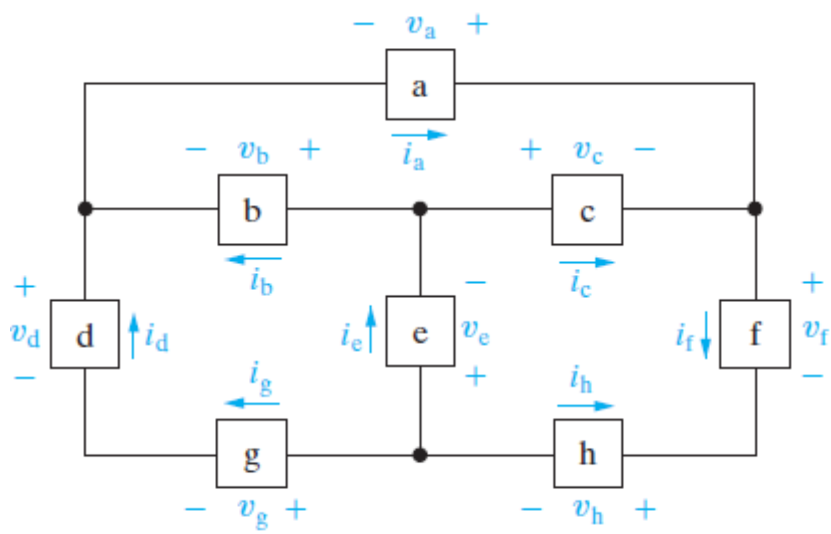


Figure (2)

Table (2)

Element	Voltage (V)	Current (A)
a	46.16	6.0
b	14.16	4.72
c	−32.0	−6.4
d	22.0	1.28
e	−33.6	−1.68
f	66.0	0.4
g	2.56	1.28
h	−0.4	0.4

From the diagram and the table we have

$$p_a = -v_a i_a = -(46.16)(6) = -276.96 \text{ W}$$
$$p_b = v_b i_b = (14.16)(4.72) = 66.8352 \text{ W}$$
$$p_c = v_c i_c = (-32)(-6.4) = 204.8 \text{ W}$$
$$p_d = -v_d i_d = -(22)(1.28) = -28.16 \text{ W}$$
$$p_e = v_e i_e = (-33.6)(-1.68) = 56.448 \text{ W}$$
$$p_f = v_f i_f = (66)(0.4) = 26.4 \text{ W}$$
$$p_g = v_g i_g = (2.56)(1.28) = 3.2768 \text{ W}$$
$$p_h = -v_h i_h = -(-0.4)(0.4) = 0.16 \text{ W}$$
$$\sum P_{del} = 276.96 + 28.16 = 305.12 \text{ W}$$
$$\sum P_{abs} = 66.8352 + 204.8 + 56.448 + 26.4 + 3.2768 + 0.16 = 357.92 \text{ W}$$

Therefore, $\sum P_{del} \neq \sum P_{abs}$

3. The voltage and power values for each of the elements shown in Fig. 3 are given in Table 3.

a) Show that the interconnection of the elements satisfies the power check.

b) Find the value of the current through each of the elements using the values of power and voltage and the current directions shown in the figure.

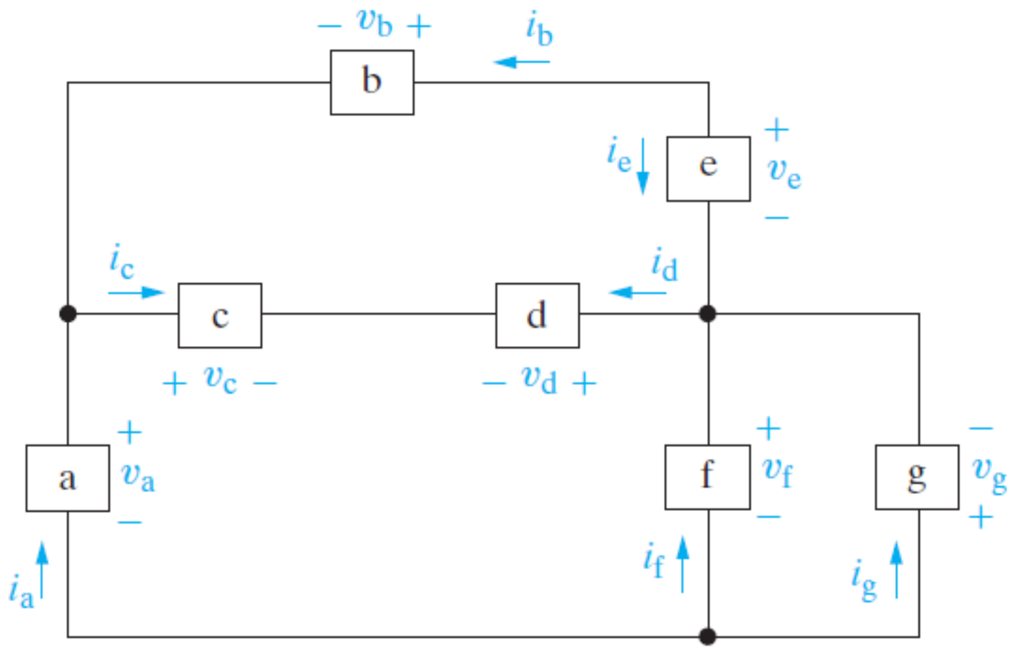


Figure (3)

Table (3)

Element	Power (kW)	Voltage (V)
a	0.6 supplied	400
b	0.05 supplied	−100
c	0.4 absorbed	200
d	0.6 supplied	300
e	0.1 absorbed	−200
f	2.0 absorbed	500
g	1.25 supplied	−500

[a] Remember that if the circuit element is absorbing power, the power is positive, whereas if the circuit element is supplying power, the power is negative. We can add the positive powers together and the negative powers together — if the power balances, these power sums should be equal: $\sum P_{\rm sup} = 600 + 50 + 600 + 1250 = 2500$ W;
$\sum P_{\rm abs} = 400 + 100 + 2000 = 2500$ W
Thus, the power balances.

[b] The current can be calculated using $i = p/v$ or $i = -p/v$, with proper application of the passive sign convention:

$$
\begin{aligned}
i_{\rm a} &= -p_{\rm a}/v_{\rm a} = -(-600)/(400) = 1.5\ \text{A} \\
i_{\rm b} &= p_{\rm b}/v_{\rm b} = (-50)/(-100) = 0.5\ \text{A} \\
i_{\rm c} &= p_{\rm c}/v_{\rm c} = (400)/(200) = 2.0\ \text{A} \\
i_{\rm d} &= p_{\rm d}/v_{\rm d} = (-600)/(300) = -2.0\ \text{A} \\
i_{\rm e} &= p_{\rm e}/v_{\rm e} = (100)/(-200) = -0.5\ \text{A} \\
i_{\rm f} &= -p_{\rm f}/v_{\rm f} = -(2000)/(500) = -4.0\ \text{A} \\
i_{\rm g} &= p_{\rm g}/v_{\rm g} = (-1250)/(-500) = 2.5\ \text{A}
\end{aligned}
$$

4. For the circuit shown in Figure (4),

(a) Is the interconnection of ideal sources in the circuit shown in Figure (4) valid? Explain.

(b) Identify which sources are developing power and which sources are absorbing power.

(c) Verify that the total power developed in the circuit equals the total power absorbed.

(d) Repeat (a)-(c), reversing the polarity of 20 V source.

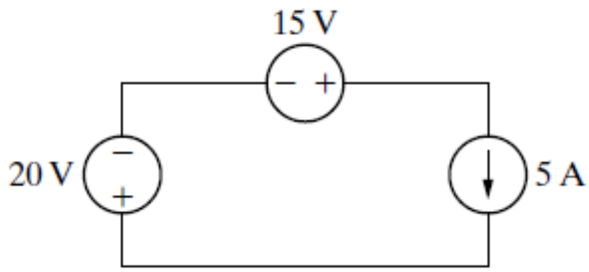


Figure (4)

[**a**] Yes, independent voltage sources can carry the 5 A current required by the connection; independent current source can support any voltage required by the connection, in this case 5 V, positive at the bottom.

[**b**] 20 V source: absorbing

15 V source: developing (delivering)

5 A source: developing (delivering)

[**c**]
$$P_{20\text{V}} = (20)(5) = 100 \text{ W} \quad \text{(abs)}$$
$$P_{15\text{V}} = -(15)(5) = -75 \text{ W} \quad \text{(dev/del)}$$
$$P_{5\text{A}} = -(5)(5) = -25 \text{ W} \quad \text{(dev/del)}$$
$$\sum P_{\text{abs}} = \sum P_{\text{del}} = 100 \text{ W}$$

[**d**] The interconnection is valid, but in this circuit the voltage drop across the 5 A current source is 35 V, positive at the top; 20 V source is developing (delivering), the 15 V source is developing (delivering), and the 5 A source is absorbing:

$$P_{20\text{V}} = -(20)(5) = -100 \text{ W} \quad \text{(dev/del)}$$
$$P_{15\text{V}} = -(15)(5) = -75 \text{ W} \quad \text{(dev/del)}$$
$$P_{5\text{A}} = (35)(5) = 175 \text{ W} \quad \text{(abs)}$$
$$\sum P_{\text{abs}} = \sum P_{\text{del}} = 175 \text{ W}$$

5. If the interconnection shown in Figure (5) is valid, .find power developed by the current sources. If the interconnection is not valid, explain why.

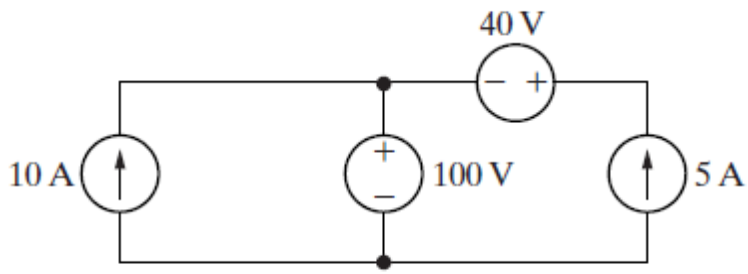
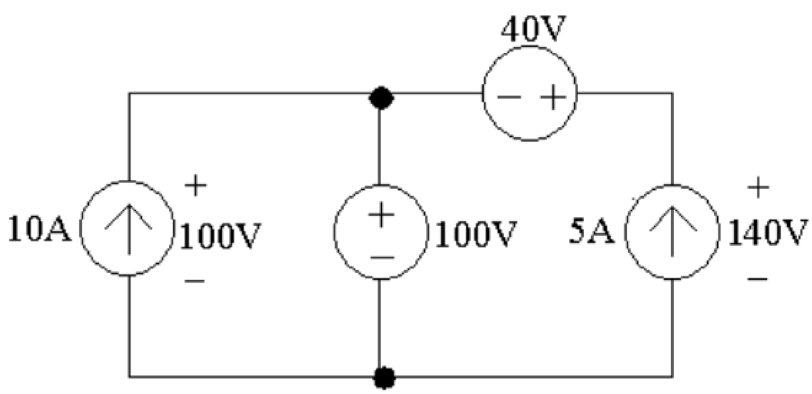


Figure (5)

The interconnection is valid. The 10 A current source has a voltage drop of 100 V, positive at the top, because the 100 V source supplies its voltage drop across a pair of terminals shared by the 10 A current source. The right hand branch of the circuit must also have a voltage drop of 100 V from the left terminal of the 40 V source to the bottom terminal of the 5 A current source, because this branch shares the same terminals as the 100 V source. This means that the voltage drop across the 5 A current source is 140 V, positive at the top. Also, the two voltage sources can carry the current required of the interconnection. This is summarized in the figure below:



From the values of voltage and current in the figure, the power supplied by the current sources is calculated as follows:

$$P_{10\text{A}} = -(100)(10) = -1000\text{ W} \quad (1000\text{ W supplied})$$

$$P_{5\text{A}} = -(140)(5) = -700\text{ W} \quad (700\text{ W supplied})$$

$$\sum P_{\text{dev}} = 1700\text{ W}$$

6. If the interconnection in Figure (6) is valid, find the total power developed in the circuit. If the interconnection is not valid, explain why.

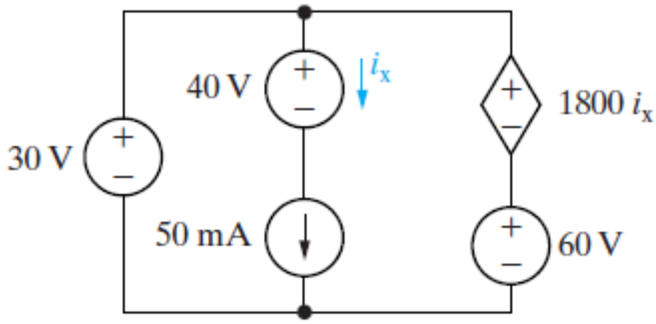
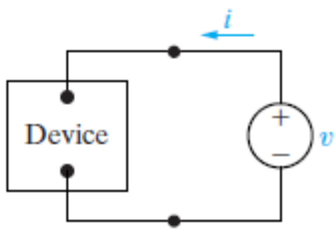


Figure (6)

The interconnection is invalid. In the middle branch, the value of the current i_x must be 50 mA, since the 50 mA current source supplies current in this branch in the same direction as the current i_x. Therefore, the voltage supplied by the dependent voltage source in the right hand branch is $1800(0.05) = 90$ V. This gives a voltage drop from the top terminal to the bottom terminal in the right hand branch of $90 + 60 = 150$ V. But the voltage drop between these same terminals in the left hand branch is 30 V, due to the voltage source in that branch. Therefore, the interconnection is invalid.

7. A variety of voltage source values were applied to the device shown in Fig. 7(a). The power absorbed by the device for each value of voltage is recorded in the table given in Fig. 7 (b). Use the values in the table to construct a circuit model for the device consisting of a single resistor from the table given in Fig. 7(c).



(a)

v (V)	p (mW)
−8	640
−4	160
4	160
8	640
12	1440
16	2560

(b)

Resistors (5% tolerance)[Ω]					
10	100	1.0 k	10k	100k	1.0 M
	120	1.2 k	12 k	120 k	
15	150	1.5 k	15 k	150 k	1.5 M
	180	1.8 k	18 k	180 k	
22	220	2.2 k	22 k	220 k	2.2 M
	270	2.7 k	27 k	270 k	
33	330	3.3 k	33 k	330 k	3.3 M
	390	3.9 k	39 k	390 k	
47	470	4.7 k	47 k	470 k	4.7 M
	560	5.6 k	56 k	560 k	
68	680	6.8 k	68 k	680 k	6.8 M

(c)

Fig. 7

Since we know the device is a resistor, we can use the power equation. From Fig.

$$p = vi = \frac{v^2}{R} \qquad \text{so} \qquad R = \frac{v^2}{p}$$

Using the values in the table of Fig.

$$R = \frac{(-8)^2}{640 \times 10^{-3}} = \frac{(-4)^2}{160 \times 10^{-3}} = \frac{(4)^2}{160 \times 10^{-3}} = \frac{(8)^2}{640 \times 10^{-3}}$$

$$= \frac{(12)^2}{1440 \times 10^{-3}} = \frac{(16)^2}{2560 \times 10^{-3}} = 100\,\Omega$$

8. For the circuit shown in Fig. (8) find the following:
(a) Find the currents i_1 and i_2
(b) Find the voltage v_o.
(c) Verify that the total power developed equals the total power dissipated.

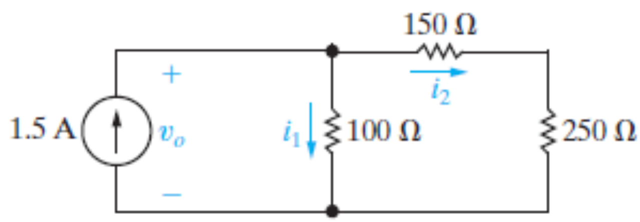


Fig. (8)

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[a] Write a KCL equation at the top node:

$$-1.5 + i_1 + i_2 = 0 \qquad \text{so} \qquad i_1 + i_2 = 1.5$$

Write a KVL equation around the right loop:

$$-v_1 + v_2 + v_3 = 0$$

From Ohm's law,

$$v_1 = 100i_1, \qquad v_2 = 150i_2, \qquad v_3 = 250i_2$$

Substituting,

$$-100i_1 + 150i_2 + 250i_2 = 0 \qquad \text{so} \qquad -100i_1 + 400i_2 = 0$$

Solving the two equations for i_1 and i_2 simultaneously,

$$i_1 = 1.2\,\text{A} \qquad \text{and} \qquad i_2 = 0.3\,\text{A}$$

[b] Write a KVL equation clockwise around the left loop:

$$-v_o + v_1 = 0 \qquad \text{but} \qquad v_1 = 100i_1 = 100(1.2) = 120\,\text{V}$$

$$\text{So} \qquad v_o = v_1 = 120\,\text{V}$$

[c] Calculate power using $p = vi$ for the source and $p = Ri^2$ for the resistors:

$$p_{\text{source}} = -v_o(1.5) = -(120)(1.5) = -180\,\text{W}$$

$$p_{100\Omega} = 1.2^2(100) = 144\,\text{W}$$

$$p_{150\Omega} = 0.3^2(150) = 13.5\,\text{W}$$

$$p_{250\Omega} = 0.3^2(250) = 22.5\,\text{W}$$

$$\sum P_{\text{dev}} = 180\,\text{W} \qquad \sum P_{\text{abs}} = 144 + 13.5 + 22.5 = 180\,\text{W}$$

9. The current i_o, in the circuit in Fig. (8) is 1 A.
(a) Find i_1.
(b) Find the power dissipated in each resistor.
(c) Verify that the total power dissipated in the circuit equals the power developed by the 150 V source

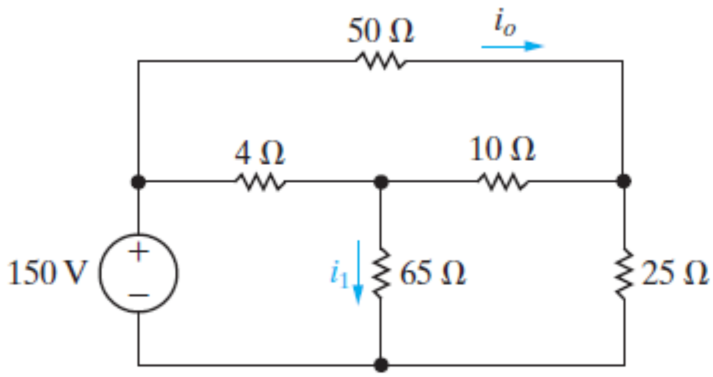
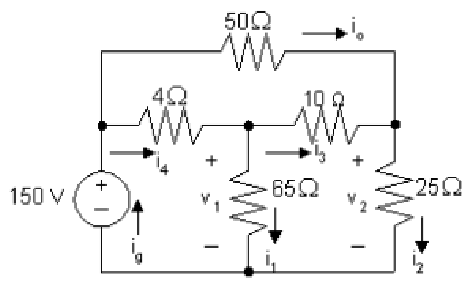


Fig. (9)

[a]



$$v_2 = 150 - 50(1) = 100\text{V}$$

$$i_2 = \frac{v_2}{25} = 4\text{A}$$

$$i_3 + 1 = i_2, \qquad i_3 = 4 - 1 = 3\text{A}$$

$$v_1 = 10i_3 + 25i_2 = 10(3) + 25(4) = 130\text{V}$$

$$i_1 = \frac{v_1}{65} = \frac{130}{65} = 2\text{A}$$

Note also that

$$i_4 = i_1 + i_3 = 2 + 3 = 5\text{ A}$$

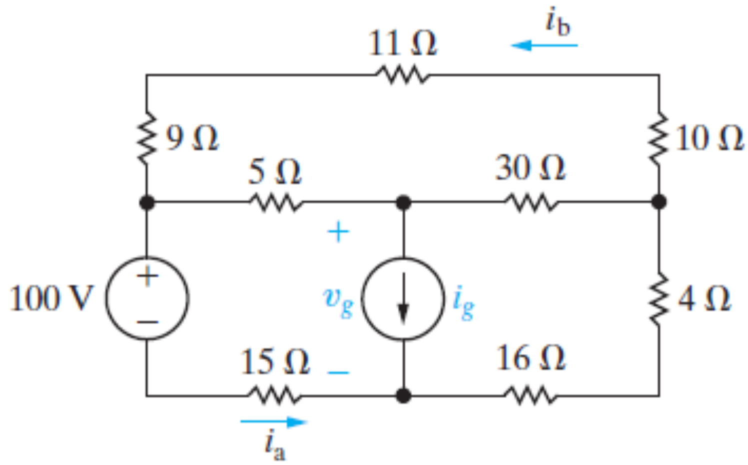
$$i_g = i_4 + i_o = 5 + 1 = 6\text{ A}$$

[b]
$$\begin{aligned} p_{4\Omega} &= 5^2(4) = 100\text{ W} \\ p_{50\Omega} &= 1^2(50) = 50\text{ W} \\ p_{65\Omega} &= 2^2(65) = 260\text{ W} \\ p_{10\Omega} &= 3^2(10) = 90\text{ W} \\ p_{25\Omega} &= 4^2(25) = 400\text{ W} \end{aligned}$$

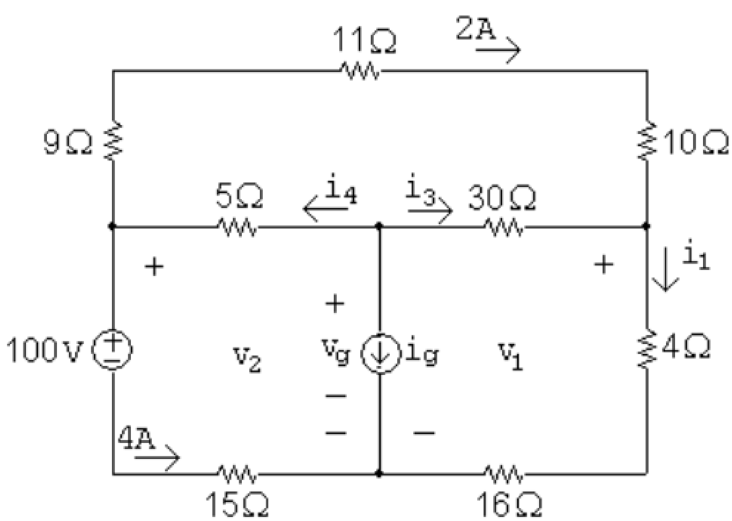
[c] $\sum P_{\text{dis}} = 100 + 50 + 260 + 90 + 400 = 900\text{ W}$

$$P_{\text{dev}} = 150i_g = 150(6) = 900\text{ W}$$

10. The currents i_a and i_b in the circuit shown in Fig. (10) are 4 A and -2 A, respectively.
(a) Find i_g.
(b) Find the power dissipated in each resistor.
(c) Find v_g.
(d) Show that the power delivered by the current source is equal to the power absorbed by all the other elements.



[a]



$$v_2 = 100 + 4(15) = 160\,\text{V}; \qquad v_1 = 160 - (9 + 11 + 10)(2) = 100\,\text{V}$$

$$i_1 = \frac{v_1}{4 + 16} = \frac{100}{20} = 5\,\text{A}; \qquad i_3 = i_1 - 2 = 5 - 2 = 3\,\text{A}$$

$$v_g = v_1 + 30i_3 = 100 + 30(3) = 190\,\text{V}$$

$$i_4 = 2 + 4 = 6\,\text{A}$$

$$i_g = -i_4 - i_3 = -6 - 3 = -9\,\text{A}$$

[b] Calculate power using the formula $p = Ri^2$:

$$p_{9\,\Omega} = (9)(2)^2 = 36\,\text{W}; \qquad p_{11\,\Omega} = (11)(2)^2 = 44\,\text{W}$$

$$p_{10\,\Omega} = (10)(2)^2 = 40\,\text{W}; \qquad p_{5\,\Omega} = (5)(6)^2 = 180\,\text{W}$$

$$p_{30\,\Omega} = (30)(3)^2 = 270\,\text{W}; \qquad p_{4\,\Omega} = (4)(5)^2 = 100\,\text{W}$$

$$p_{16\,\Omega} = (16)(5)^2 = 400\,\text{W}; \qquad p_{15\,\Omega} = (15)(4)^2 = 240\,\text{W}$$

[c] $v_g = 190\,\text{V}$

[d] Sum the power dissipated by the resistors:

$$\sum p_{\text{diss}} = 36 + 44 + 40 + 180 + 270 + 100 + 400 + 240 = 1310\,\text{W}$$

The power associated with the sources is

$$p_{\text{volt-source}} = (100)(4) = 400\,\text{W}$$

$$p_{\text{curr-source}} = v_g i_g = (190)(-9) = -1710\,\text{W}$$

Thus the total power dissipated is $1310 + 400 = 1710$ W and the total power developed is 1710 W, so the power balances.

11. For the circuit shown in Fig. (11), find the voltage v_o, and the total power supplied in the circuit.

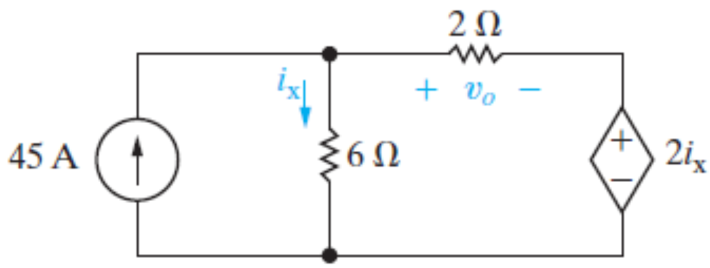
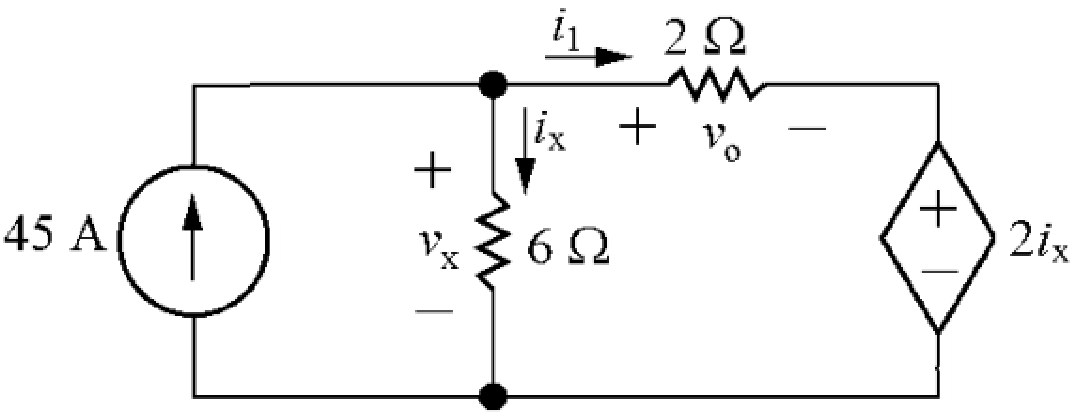


Fig. (11)



$-v_x + v_o + 2i_x = 0 \qquad \text{(KVL)}$

$v_x = 6i_x \qquad \text{(Ohm's law)}$

Therefore

$-6i_x + v_o + 2i_x = 0 \quad \text{so} \quad v_o = 4i_x$

Thus

$$i_x = \frac{v_o}{4}$$

Also,

$$i_1 = \frac{v_o}{2} \qquad \text{(Ohm's law)}$$

$45 = i_x + i_1 \qquad \text{(KCL)}$

Substituting for the currents i_x and i_1:

$$45 = \frac{v_o}{4} + \frac{v_o}{2} = \frac{3v_o}{4}$$

Thus

$$v_o = 45\left(\frac{4}{3}\right) = 60\,\text{V}$$

The only two circuit elements that could supply power are the two sources, so calculate the power for each source:

$$v_x = 6i_x = 6\frac{v_o}{4} = 6(60/4) = 90\,\text{V}$$

$$p_{45\text{V}} = -45v_x = -45(90) = -4050\,\text{W}$$

$$p_{\text{d.s.}} = (2i_x)i_1 = 2(v_o/4)(v_o/2) = 2(60/4)(60/2) = 900\,\text{W}$$

Only the independent voltage source is supplying power, so the total power supplied is 4050 W.

12. Find (a) i_o, (b) i_1, and (c) i_2, in the circuit in Fig. (12).

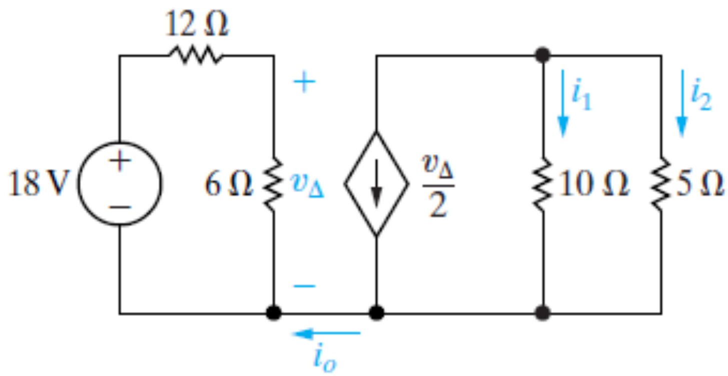
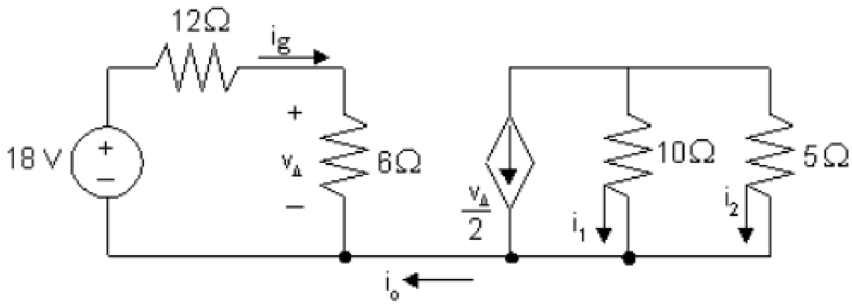


Fig. (12)

[a] $i_o = 0$ because no current can exist in a single conductor connecting two parts of a circuit.

[b]



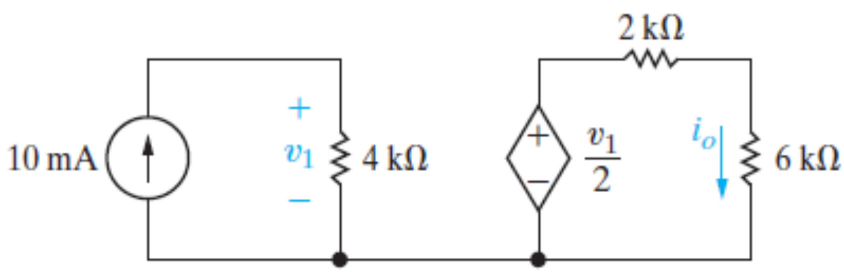
$$18 = (12 + 6)i_g \qquad i_g = 1 \text{ A}$$

$$v_\Delta = 6i_g = 6\text{V} \qquad v_\Delta/2 = 3 \text{ A}$$

$10i_1 = 5i_2$, so $i_1 + 2i_1 = -3$ A; therefore, $i_1 = -1$ A

[c] $i_2 = 2i_1 = -2$ A.

13. Consider the circuit shown in shown in Fig. (13).
(a) Find i_o,
(b) Verify the value of i_o by showing that the power generated in the circuit equals the power absorbed in the circuit.



$$v_1 = (4000)(0.01) = 40\text{ V} \qquad \text{(Ohm's law)}$$

$$\frac{v_1}{2} = 2000i_o + 6000i_o = 8000i_o \qquad \text{(KVL)}$$

Thus,

$$i_o = \frac{v_1/2}{8000} = \frac{40/2}{8000} = 0.0025 = 2.5\text{ mA}$$

Calculate the power for all components:

$$p_{10\text{mA}} = -(0.01)v_1 = -(0.01)(40) = -0.4\text{ W}$$

$$p_{\text{d.s.}} = -(v_1/2)i_o = -(40/2)(2.5 \times 10^{-3}) = -0.05\text{ W}$$

$$p_{4\text{k}} = \frac{v_1^2}{4000} = \frac{40^2}{4000} = 0.4\text{ W}$$

$$p_{2\text{k}} = 2000i_o^2 = 2000(2.5 \times 10^{-3})^2 = 0.0125\text{ W}$$

$$p_{6\text{k}} = 6000i_o^2 = 6000(2.5 \times 10^{-3})^2 = 0.0375\text{ W}$$

Therefore,

$$p_{\text{total}} = -0.4 - 0.05 + 0.4 + 0.0125 + 0.0375 = 0$$

Thus the power in the circuit balances.