Problems

Section 1.2

1.1 The line described in Assessment Problem 1.7 is 845 mi in length. The line contains four conductors, each weighing 2526 lb per 1000 ft. How many kilograms of conductor are in the line?

1.2 A 32-inch monitor contains 3840 × 2160 picture elements, or pixels. Each pixel is represented in 24 bits of memory. A byte of memory is 8 bits.

a) How many megabytes (MB) of memory are required to store the information displayed on the monitor?

b) To display a video on the monitor, the image must be refreshed 30 times per second. How many terabytes (TB) of memory are required to store a 2 hr video?

c) For the video described in part (b), how fast must the image data in memory be moved to the monitor? Express your answer in gigabits per second (Gb/s).

1.3 Some species of bamboo can grow (250 mm/day). Assume individual cells in the plant are 10 μm long.

a) How long, on average, does it take a bamboo stalk to grow 1 cell length?

b) How many cell lengths are added in one week, on average?

1.4 A hand-held video player displays 480 × 320 picture elements (pixels) in each frame of the video. Each pixel requires 2 bytes of memory. Videos are displayed at a rate of 30 frames per second. How many hours of video will fit in a 32 gigabyte memory?

1.5 The 16 gigabyte (GB = 2^{30} bytes) flash memory chip for an MP3 player is 11 mm by 15 mm by 1 mm. This memory chip holds 20,000 photos.

a) How many photos fit into a cube whose sides are 1 mm?

b) How many bytes of memory are stored in a cube whose sides are 200 μm?

1.6 There are approximately 260 million passenger vehicles registered in the United States. Assume that the battery in the average vehicle stores 540 watt-hours (Wh) of energy. Estimate (in gigawatt-hours) the total energy stored in US passenger vehicles.

Section 1.4

1.7 The current entering the upper terminal of Fig. 1.5 is

$$i = 24 \cos 4000t \text{ A}$$

Assume the charge at the upper terminal is zero at the instant the current is passing through its maximum value. Find the expression for $q(t)$.

1.8 How much energy is imparted to an electron as it flows through a 6 V battery from the positive to the negative terminal? Express your answer in attojoules.

1.9 In electronic circuits it is not unusual to encounter currents in the microampere range. Assume a 35 μA current, due to the flow of electrons. What is the average number of electrons per second that flow past a fixed reference cross section that is perpendicular to the direction of flow?

1.10 There is no charge at the upper terminal of the element in Fig. 1.5 for $t < 0$. At $t = 0$ a current of $125e^{-2500t}$ mA enters the upper terminal.

a) Derive the expression for the charge that accumulates at the upper terminal for $t > 0$.

b) Find the total charge that accumulates at the upper terminal.

c) If the current is stopped at $t = 0.5$ ms, how much charge has accumulated at the upper terminal?

1.11 The current at the terminals of the element in Fig. 1.5 is

$$i = 0, \qquad t < 0;$$

$$i = 40te^{-500t} \text{ A}, \qquad t \geq 0.$$

a) Find the expression for the charge accumulating at the upper terminal.

b) Find the charge that has accumulated at $t = 1$ ms.

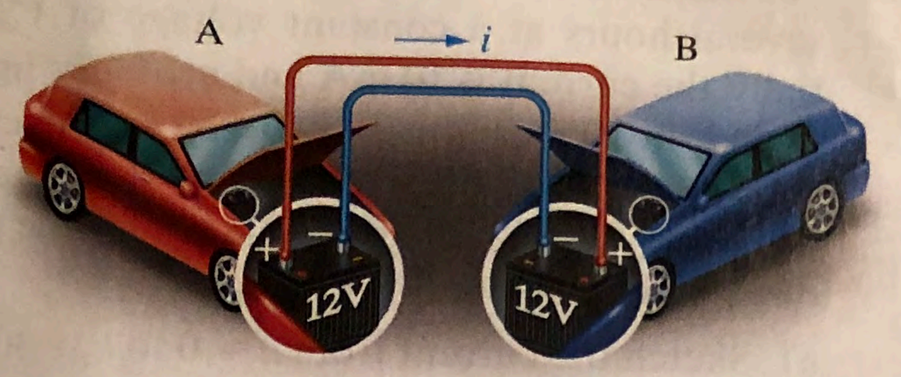
Sections 1.5–1.6

1.12 When a car has a dead battery, it can often be started by connecting the battery from another car across its terminals. The positive terminals are connected together as are the negative terminals. The connection is illustrated in Fig. P1.12. Assume the current i in Fig. P1.12 is measured and found to be 40 A.

a) Which car has the dead battery?

b) If this connection is maintained for 1.5 min, how much energy is transferred to the dead battery?

Figure P1.12



1.13 Two electric circuits, represented by boxes A and B, are connected as shown in Fig. P1.13. The reference direction for the current i in the interconnection and the reference polarity for the voltage v across the interconnection are as shown in the figure. For each of the following sets of numerical values, calculate the power in the interconnection and state whether the power is flowing from A to B or vice versa.

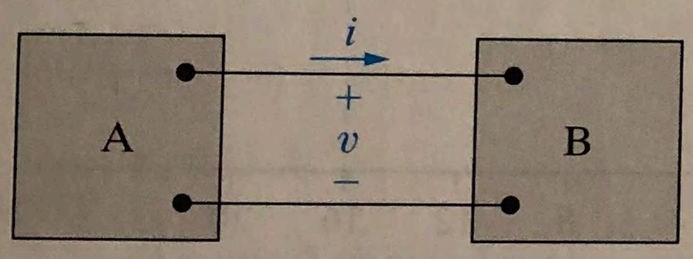
a) $i = 6\text{ A}, \quad v = 30\text{ V}$

b) $i = -8\text{ A}, \quad v = -20\text{ V}$

c) $i = 4\text{ A} \quad v = -60\text{ V}$

d) $i = -9\text{ A}, \quad v = 40\text{ V}$

Figure P1.13



1.14 One 12 V battery supplies 100 mA to a boom box. How much energy does the battery supply in 4 h?

1.15 The references for the voltage and current at the terminals of a circuit element are as shown in Fig. 1.6(d). The numerical values for v and i are −20 V and 5 A.

a) Calculate the power at the terminals and state whether the power is being absorbed or delivered by the element in the box.

b) Given that the current is due to electron flow, state whether the electrons are entering or leaving terminal 2.

c) Do the electrons gain or lose energy as they pass through the element in the box?

1.16 Repeat Problem 1.15 with a current of −5 A.

1.17 The manufacturer of a 6 V dry-cell flashlight battery says that the battery will deliver 15 mA for 60 continuous hours. During that time the voltage will drop from 6 V to 4 V. Assume the drop in voltage is linear with time. How much energy does the battery deliver in this 60 h interval?

1.18 PSPICE MULTISIM The voltage and current at the terminals of the circuit element in Fig. 1.5 are zero for $t < 0$. For $t \geq 0$ they are

$$v = 75 - 75e^{-1000t}\text{ V},$$

$$i = 50e^{-1000t}\text{ mA}.$$

a) Find the maximum value of the power delivered to the circuit.

b) Find the total energy delivered to the element.

1.19 The voltage and current at the terminals of the circuit element in Fig. 1.5 are zero for $t < 0$. For $t \geq 0$ they are

$$v = 15e^{-250t}\text{ V},$$

$$i = 40e^{-250t}\text{ mA}.$$

a) Calculate the power supplied to the element at 10 ms.

b) Calculate the total energy delivered to the circuit element.

1.20 PSPICE MULTISIM The voltage and current at the terminals of the circuit element in Fig. 1.5 are zero for $t < 0$. For $t \geq 0$ they are

$$v = (1500t + 1)e^{-750t}\text{ V}, \quad t \geq 0;$$

$$i = 40e^{-750t}\text{ mA}, \quad t \geq 0.$$

a) Find the time when the power delivered to the circuit element is maximum.

b) Find the maximum value of p in milliwatts.

c) Find the total energy delivered to the circuit element in microjoules.

1.21 The voltage and current at the terminals of the circuit element in Fig. 1.5 are zero for $t < 0$. For $t \geq 0$ they are

$$v = 50e^{-1600t} - 50e^{-400t}\text{ V},$$

$$i = 5e^{-1600t} - 5e^{-400t}\text{ mA}.$$

a) Find the power at $t = 625\ \mu\text{s}$.

b) How much energy is delivered to the circuit element between 0 and 625 μs?

c) Find the total energy delivered to the element.

1.22 PSPICE MULTISIM The voltage and current at the terminals of the circuit element in Fig. 1.5 are zero for $t < 0$. For $t \geq 0$ they are

$$v = (10{,}000t + 5)e^{-400t}\ \text{V},$$

$$i = (40t + 0.05)e^{-400t}\ \text{A}.$$

a) At what instant of time is maximum power delivered to the element?

b) Find the maximum power in watts.

c) Find the total energy delivered to the element in microjoules.

1.23 PSPICE MULTISIM The voltage and current at the terminals of the circuit element in Fig. 1.5 are zero for $t < 0$ and $t > 40$ s. In the interval between 0 and 40 s the expressions are

$$v = t(1 - 0.025t)\ \text{V}, \quad 0 < t < 40\ \text{s};$$

$$i = 4 - 0.2t\ \text{A}, \quad 0 < t < 40\ \text{s}.$$

a) At what instant of time is the power being delivered to the circuit element maximum?

b) What is the power at the time found in part (a)?

c) At what instant of time is the power being extracted from the circuit element maximum?

d) What is the power at the time found in part (c)?

e) Calculate the net energy delivered to the circuit at 0, 10, 20, 30 and 40 s.

1.24 PSPICE MULTISIM The voltage and current at the terminals of the element in Fig. 1.5 are

$$v = 250\cos 800\pi t\ \text{V}, \quad i = 8\sin 800\pi t\ \text{A}.$$

a) Find the maximum value of the power being delivered to the element.

b) Find the maximum value of the power being extracted from the element.

c) Find the average value of p in the interval $0 \leq 1 \leq 2.5$ ms.

d) Find the average value of p in the interval $0 \leq t \leq 15.625$ ms.

1.25 PSPICE MULTISIM The voltage and current at the terminals of the circuit element in Fig. 1.5 are zero for $t < 0$. For $t \geq 0$ they are

$$v = 100e^{-50t}\sin 150t\ \text{V},$$

$$i = 20e^{-50t}\sin 150t\ \text{A}.$$

a) Find the power absorbed by the element at $t = 20$ ms.

b) Find the total energy absorbed by the element.

1.26 An industrial battery is charged over a period of several hours at a constant voltage of 120 V. Initially, the current is 10 mA and increases linearly to 15 mA in 10 ks. From 10 ks to 20 ks, the current is constant at 15 mA. From 20 ks to 30 ks the current decreases linearly to 10 mA. At 30 ks the power is disconnected from the battery.

a) Sketch the current from $t = 0$ to $t = 30$ ks.

b) Sketch the power delivered to the battery from $t = 0$ to $t = 30$ ks.

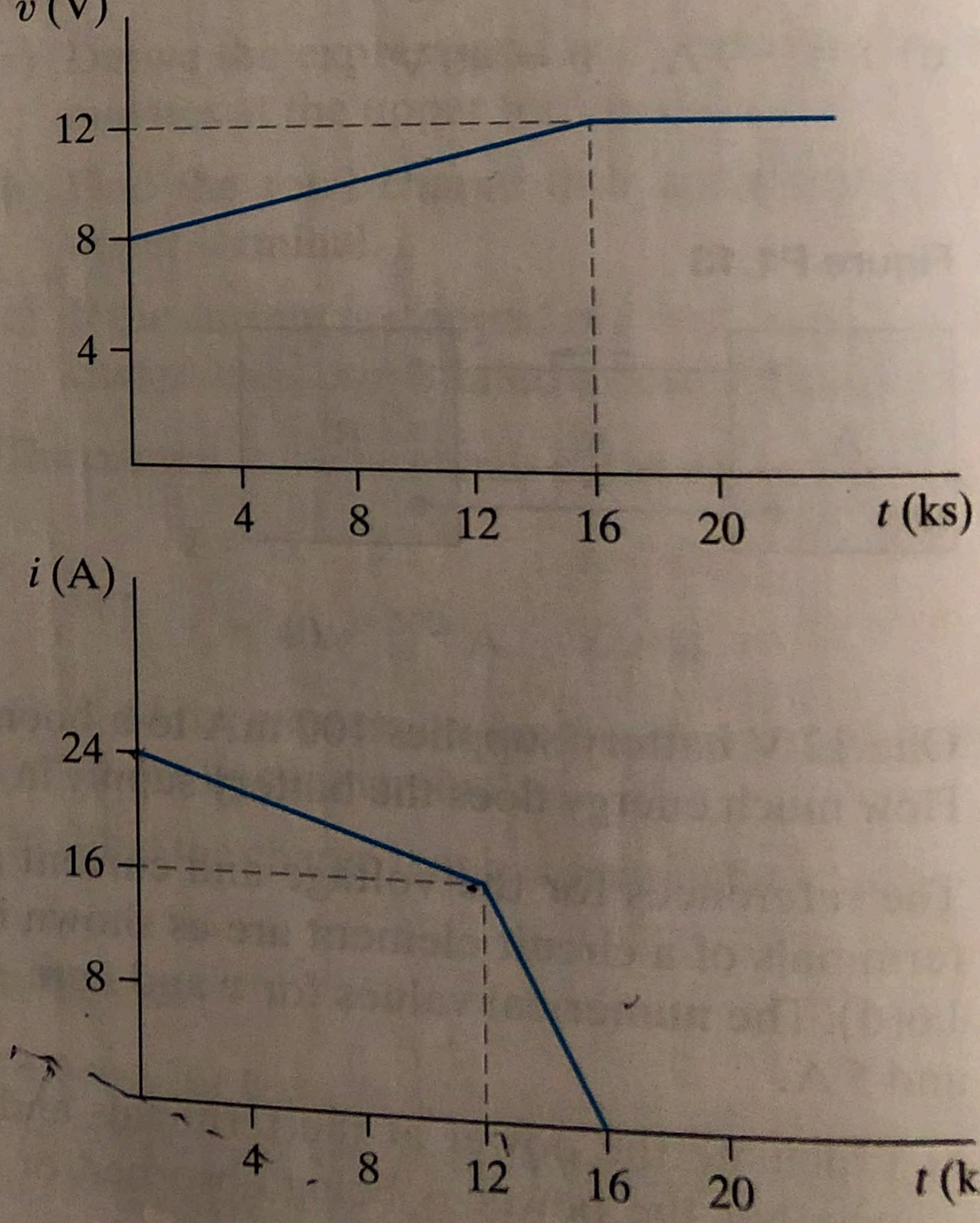
c) Using the sketch of the power, find the total energy delivered to the battery.

1.27 PSPICE MULTISIM The voltage and current at the terminals of an automobile battery during a charge cycle are shown in Fig. P1.27.

a) Calculate the total charge transferred to the battery.

b) Calculate the total energy transferred to the battery.

Figure P1.27

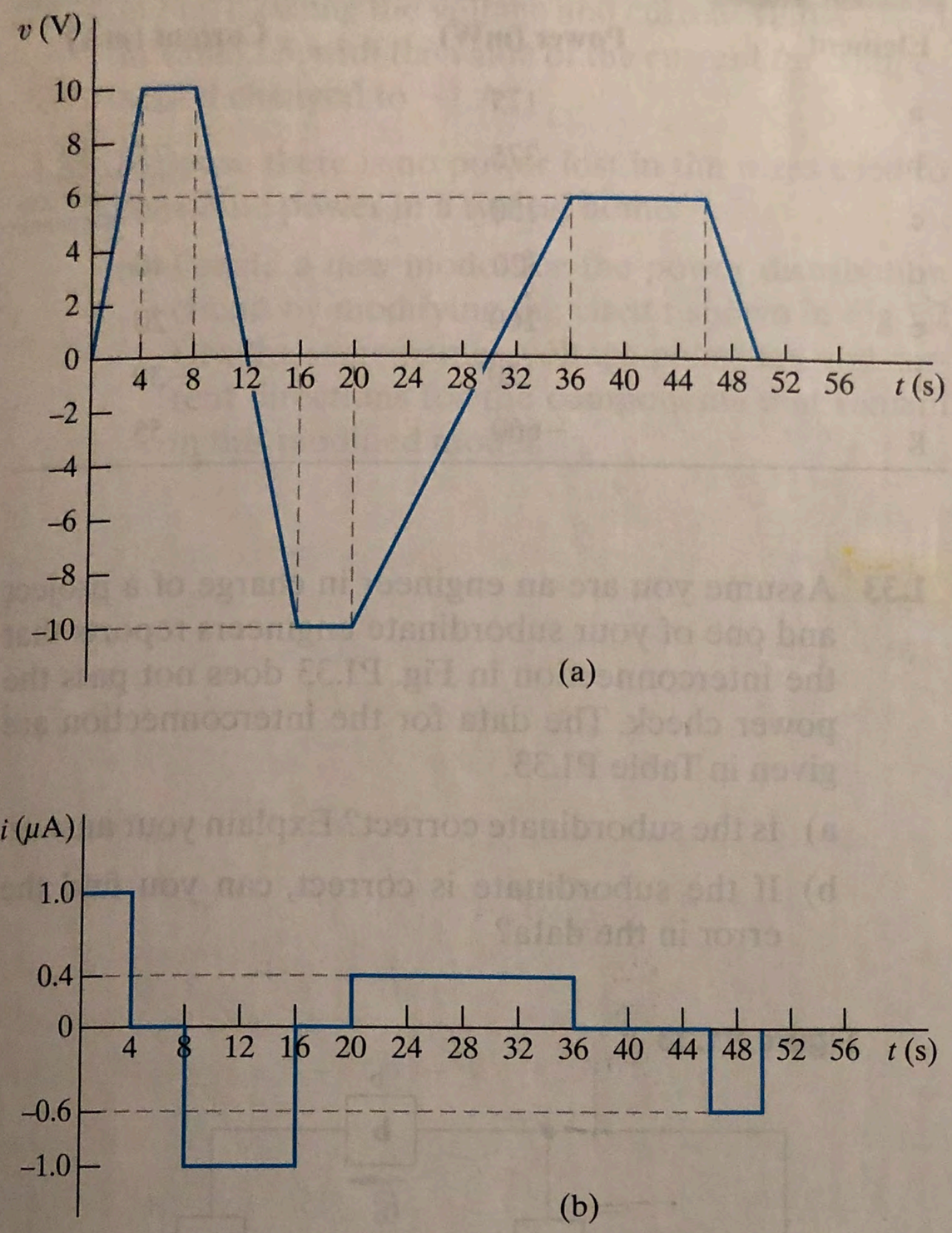


1.28 The voltage and current at the terminals of the circuit element in Fig. 1.5 are shown in Fig. P1.28.

a) Sketch the power versus t plot for $0 \leq t \leq 50$ s.

b) Calculate the energy delivered to the circuit element at $t = 4, 12, 36$, and 50 s.

Figure P1.28



1.29 The numerical values for the currents and voltages in the circuit in Fig. P1.29 are given in Table P1.29. Find the total power developed in the circuit.

Figure P1.29

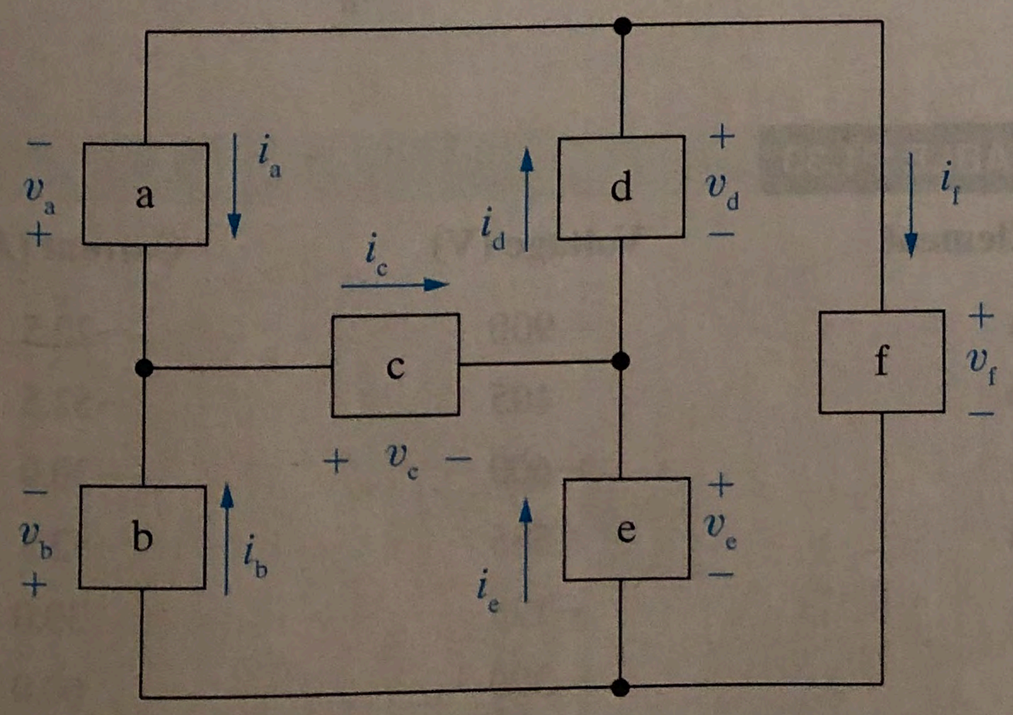


TABLE P1.29

Element	Voltage (V)	Current (mA)
a	−18	−51
b	−18	45
c	2	−6
d	20	−20
e	16	−14
f	36	31

1.30 The voltage and power values for each of the elements shown in Fig. P1.30 are given in Table P1.30.

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 P1.30

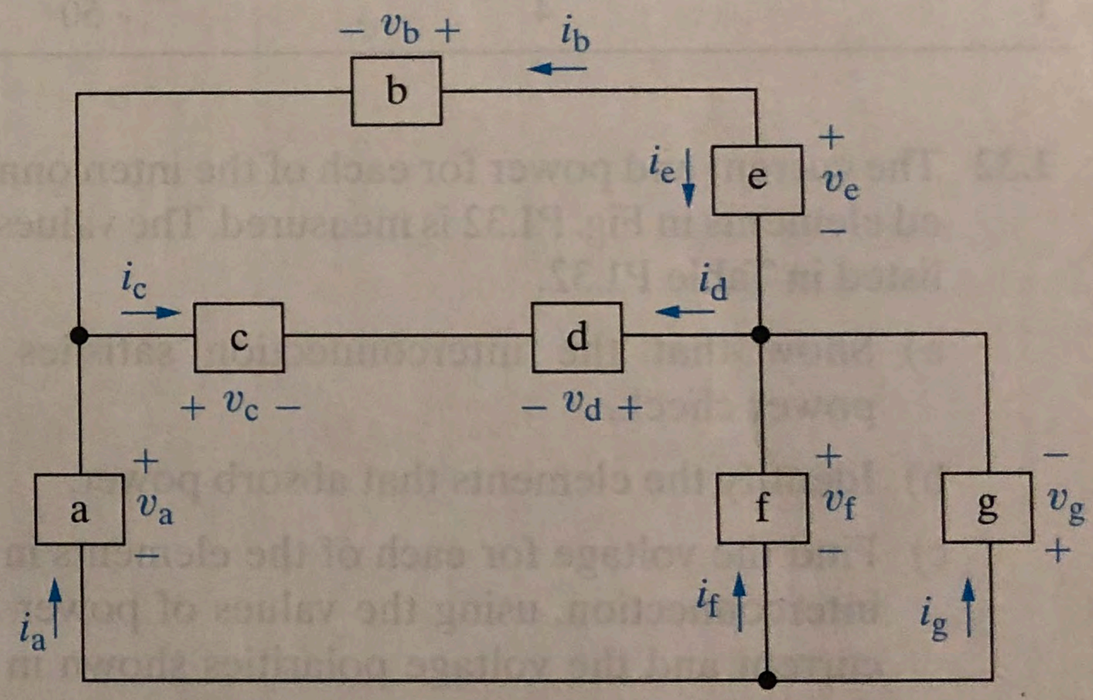


TABLE P1.30

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

1.31 The numerical values of the voltages and currents in the interconnection seen in Fig. P1.31 are given in Table P1.31. Does the interconnection satisfy the power check?

Figure P1.31

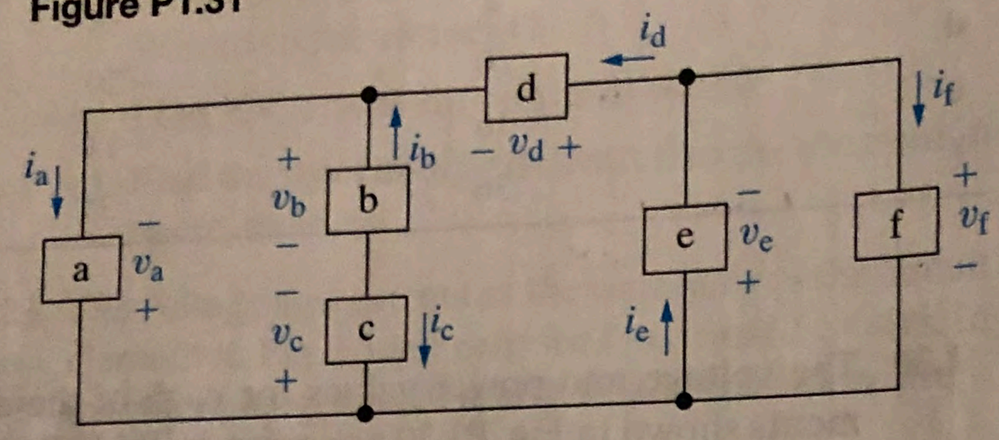


TABLE P1.31

Element	Voltage (kV)	Current (mA)
a	−3	−250
b	4	−400
c	1	400
d	1	150
e	−4	200
f	4	50

1.32 The current and power for each of the interconnected elements in Fig. P1.32 is measured. The values are listed in Table P1.32.

a) Show that the interconnection satisfies the power check.

b) Identify the elements that absorb power.

c) Find the voltage for each of the elements in the interconnection, using the values of power and current and the voltage polarities shown in the figure.

Figure P1.32

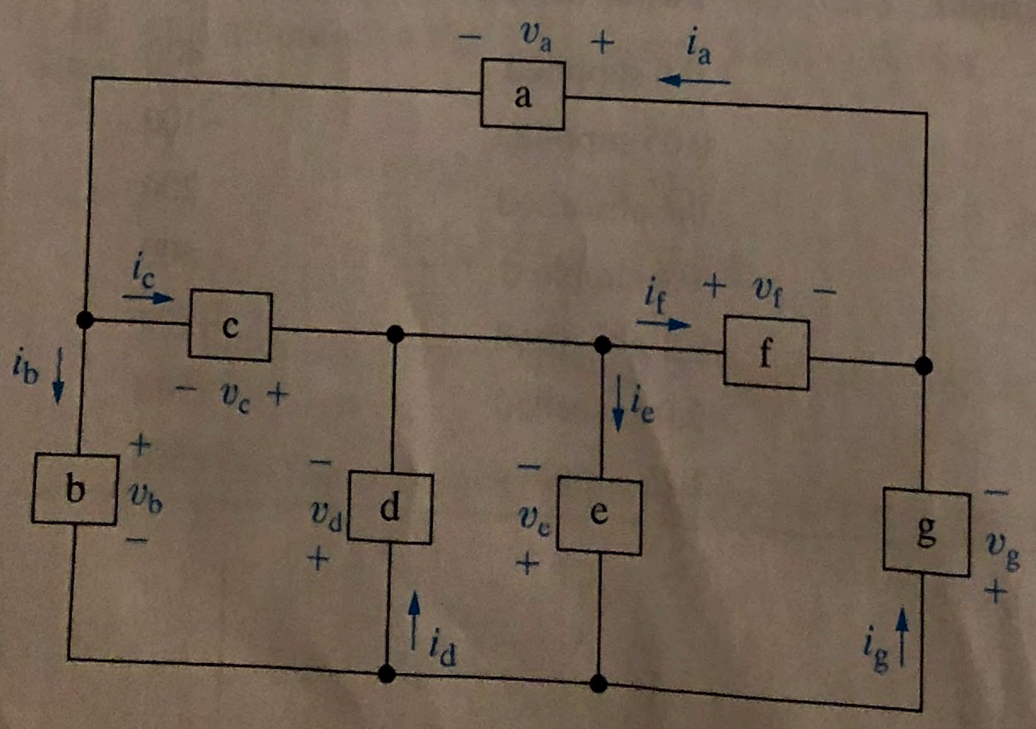


TABLE P1.32

Element	Power (mW)	Current (mA)
a	175	25
b	375	75
c	150	−50
d	−320	40
e	160	20
f	120	−30
g	−660	55

1.33 Assume you are an engineer in charge of a project and one of your subordinate engineers reports that the interconnection in Fig. P1.33 does not pass the power check. The data for the interconnection are given in Table P1.33.

a) Is the subordinate correct? Explain your answer.

b) If the subordinate is correct, can you find the error in the data?

Figure P1.33

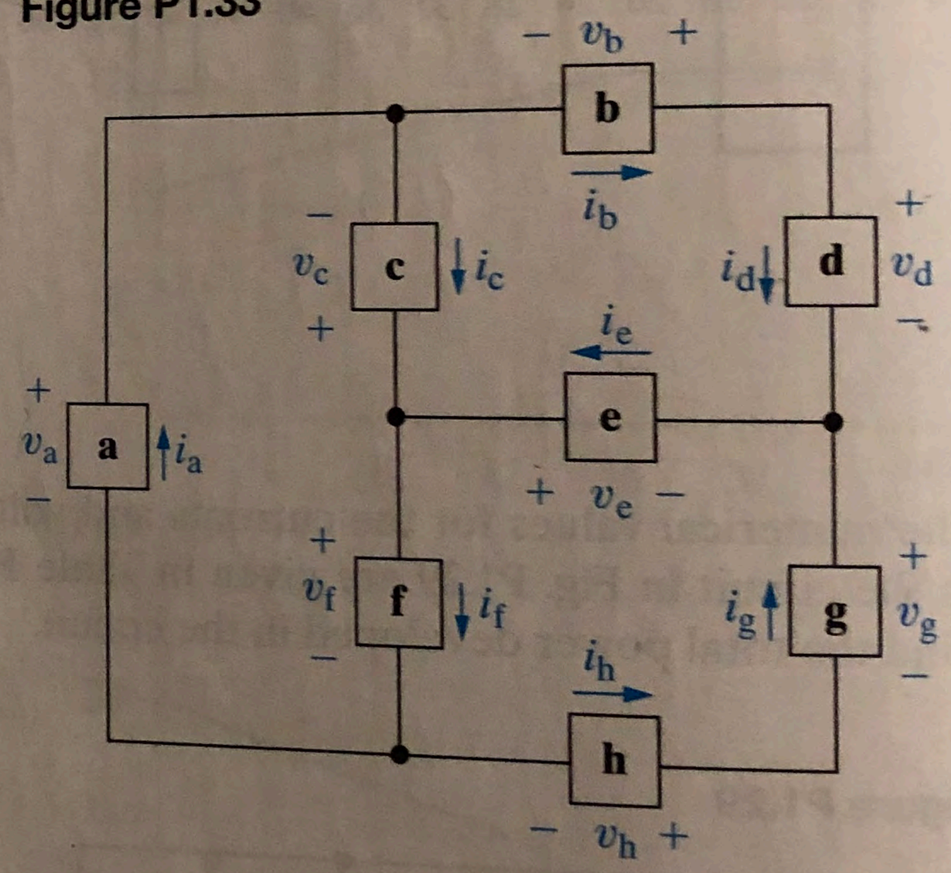


TABLE P1.33

Element	Voltage (V)	Current (A)
a	900	−22.5
b	105	−52.5
c	−600	−30.0
d	585	−52.5
e	−120	30.0
f	300	60.0
g	585	82.5
h	−165	82.5

1.34 PRACTICAL PERSPECTIVE Show that the power balances for the circuit shown in Fig. 1.7, using the voltage and current values given in Table 1.5, with the value of the current for component d changed to −1 A.

1.35 PRACTICAL PERSPECTIVE Suppose there is no power lost in the wires used to distribute power in a typical home.

a) Create a new model for the power distribution circuit by modifying the circuit shown in Fig 1.7. Use the same names, voltage polarities, and current directions for the components that remain in this modified model.

b) The following voltages and currents are calculated for the components:

$v_a = 120$ V $\quad i_a = -10$ A

$v_b = 120$ V $\quad i_b = 10$ A

$v_f = -120$ V $\quad i_f = 3$ A

$v_g = 120$ V

$v_h = -240$ V $\quad i_h = -7$ A

If the power in this modified model balances, what is the value of the current in component g?