وزارة التعليم العالي والبحث العلمي
جامعة المستقبل

LEC : FOUR

Course Name : Fundamentals of Electricity Instructor
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Stage : First
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Lecture Title : **Open and Short Circuits, Source Transformation**

VOLTAGE SOURCES IN PARALLEL

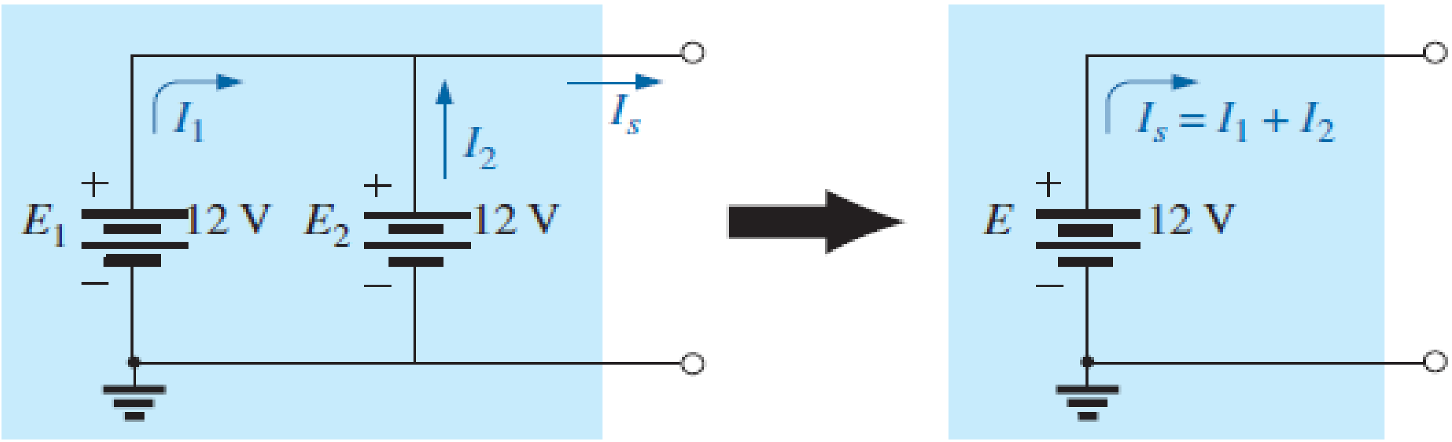
Voltage sources can be placed in parallel only if they have the same voltage.

The primary reason for placing two or more batteries or supplies in parallel is to increase the current rating above that of a single supply.

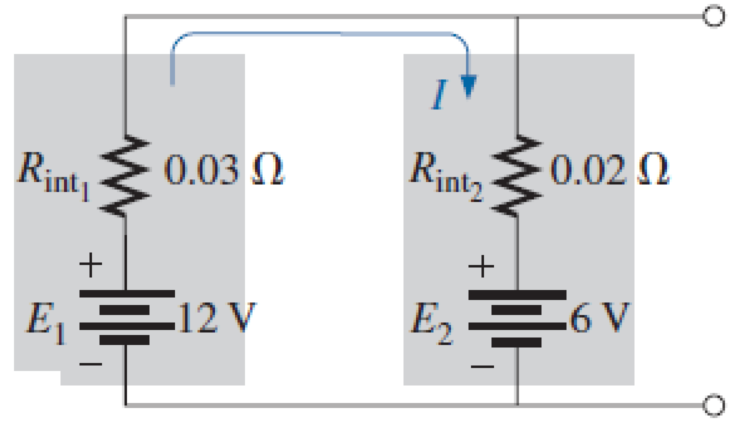
For example, in Fig shown, two ideal batteries of 12 V have been placed in parallel. The total source current using Kirchhoff's current law is now the sum of the rated currents of each supply. The resulting power available will be twice that of a single supply if the rated supply current of each is the same. That is,

with $\quad I_1 = I_2 = I$

then $\quad P_T = E(I_1 + I_2) = E(I + I) = E(2I) = 2(EI) = 2P_{(\text{one supply})}$

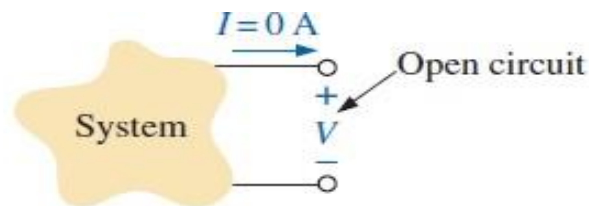


If for some reason two batteries of different voltages are placed in parallel, both will become ineffective or damaged because the battery with the larger voltage rapidly discharges through the battery with the smaller terminal voltage.



The only current-limiting resistors in the network are the internal resistances, resulting in a very high discharge current for the battery with the larger supply voltage.

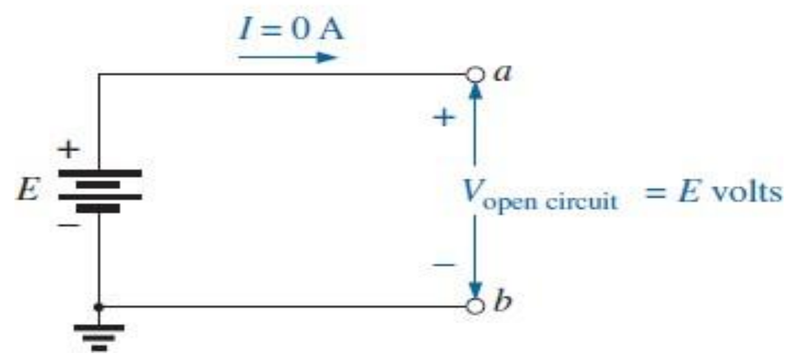
$$I = \frac{E_1 - E_2}{R_{int_1} + R_{int_2}} = \frac{12\text{ V} - 6\text{ V}}{0.03\ \Omega + 0.02\ \Omega} = \frac{6\text{ V}}{0.05\ \Omega} = 120\text{ A}$$



(a)

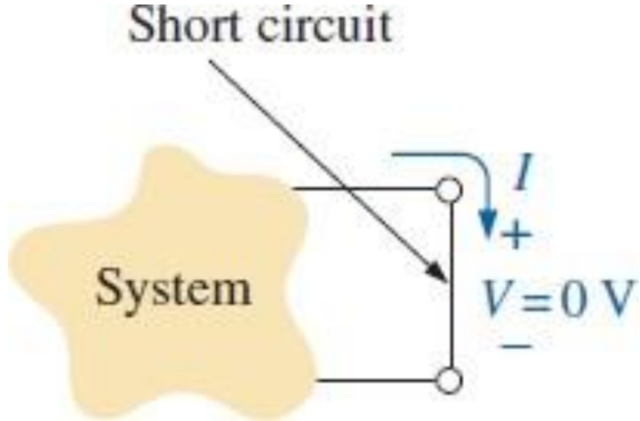
OPEN AND SHORT CIRCUITS

An **open circuit** is two isolated terminals not connected by an element of any kind, as shown in Fig.



An open circuit can have a potential difference (voltage) across its terminals, but the current is always zero amperes.

A short circuit can carry a current of a level determined by the external circuit, but the potential difference (voltage) across its terminals is always zero volts.

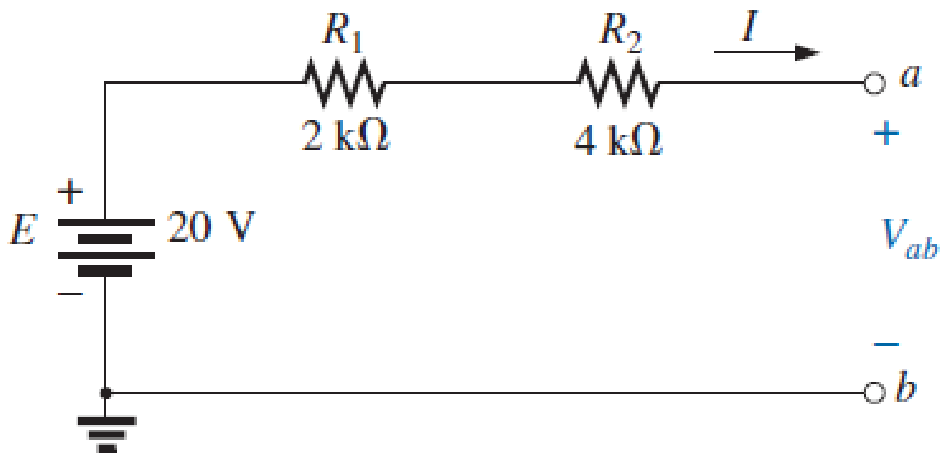


EXAMPLE 3.10 Determine voltage *Vab for the network in Fig.*

The open circuit requires that *I be zero amperes.*
The voltage drop across both resistors is therefore zero volts since

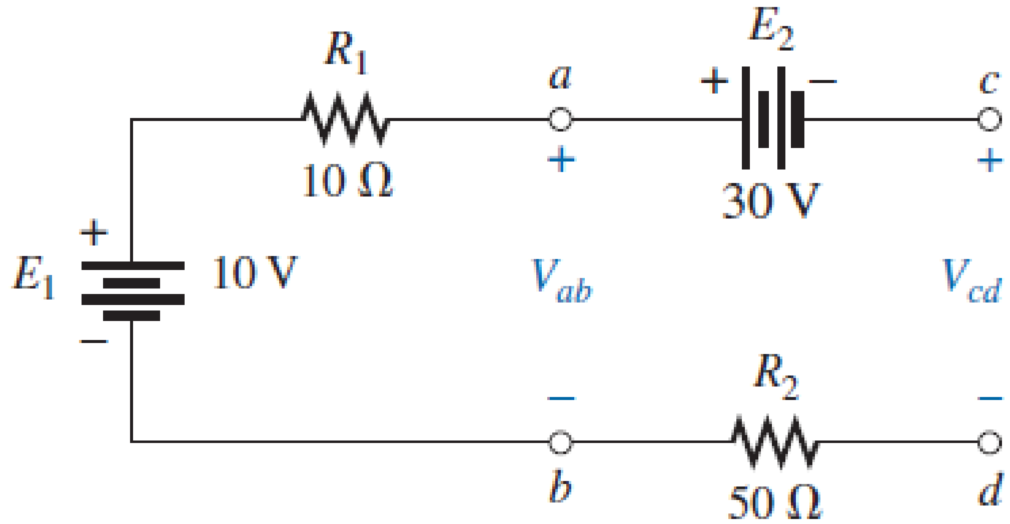
$$V = IR = (0)R = 0 \text{ V}.$$

Applying Kirchhoff's voltage law around the closed loop,



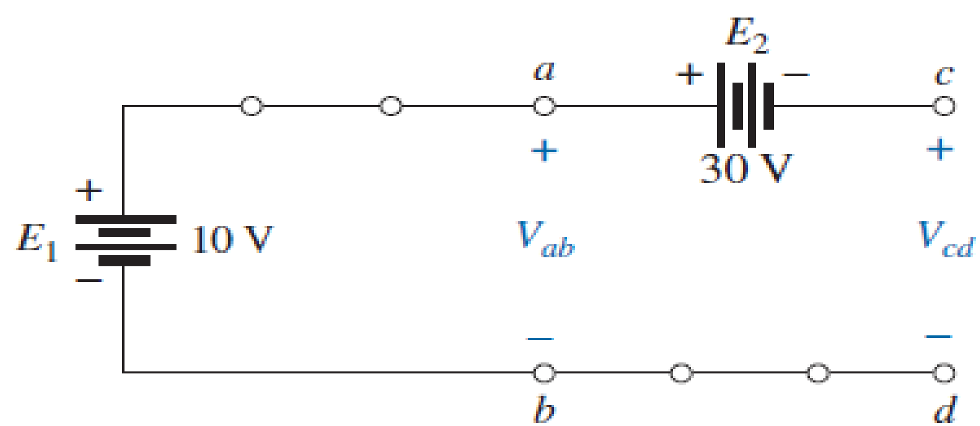
$$V_{ab} = E = 20 \text{ V}$$

EXAMPLE 3.11 Determine voltages Vab and Vcd for the network in Fig.



The current through the system is zero amperes due to the open circuit, resulting in a 0 V drop across each resistor.
Both resistors can therefore be replaced by short circuits, as shown

$$V_{ab} = E_1 = \mathbf{10\ V}$$



Voltage *Vcd requires an application of Kirchhoff's voltage law:*

$$+E_1 - E_2 - V_{cd} = 0$$

$$V_{cd} = E_1 - E_2 = 10\ \text{V} - 30\ \text{V} = \mathbf{-20\ V}$$

SUMMARY TABLE

Series and Parallel Circuits		
Series	**Duality**	**Parallel**
$R_T = R_1 + R_2 + R_3 + \cdots + R_N$	$R \rightleftarrows G$	$G_T = G_1 + G_2 + G_3 + \cdots + G_N$
R_T increases (G_T decreases) if additional resistors are added in series	$R \rightleftarrows G$	G_T increases (R_T decreases) if additional resistors are added in parallel
Special case: two elements	$R \rightleftarrows G$	$G_T = G_1 + G_2$
$R_T = R_1 + R_2$		and $R_T = \dfrac{1}{\dfrac{1}{R_1} + \dfrac{1}{R_2}} = \dfrac{R_1 R_2}{R_1 + R_2}$
I the same through series elements	$I \rightleftarrows V$	V the same across parallel elements
$E = V_1 + V_2 + V_3$	$E, V \rightleftarrows I$	$I_T = I_1 + I_2 + I_3$
Largest V across largest R	$V \rightleftarrows I$ and $R \rightleftarrows G$	Greatest I through largest G (smallest R)
$V_x = \dfrac{R_x E}{R_T}$	$E, V \rightleftarrows I$ and $R \rightleftarrows G$	$I_x = \dfrac{G_x I_T}{G_T} = \dfrac{R_T I_T}{R_x}$ with $I_1 = \dfrac{R_2 I_T}{R_1 + R_2}$ and $I_2 = \dfrac{R_1 I_T}{R_1 + R_2}$
$P = EI_T$	$E \rightleftarrows I$ and $I \rightleftarrows E$	$P = I_T E$
$P = I^2 R$	$I \rightleftarrows V$ and $R \rightleftarrows G$	$P = V^2 G = V^2/R$
$P = V^2/R$	$V \rightleftarrows I$ and $R \rightleftarrows G$	$P = I^2/G = I^2 R$

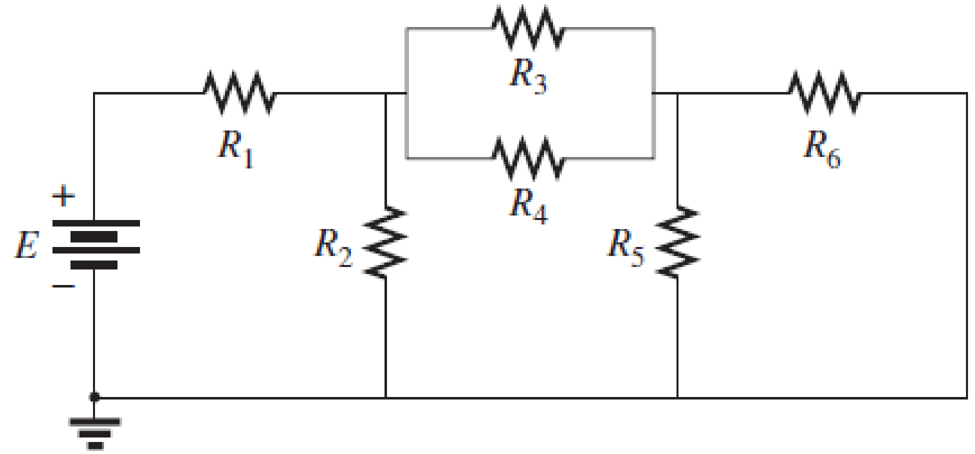
PROBLEMS

SECTION 6.2 Parallel Resistors

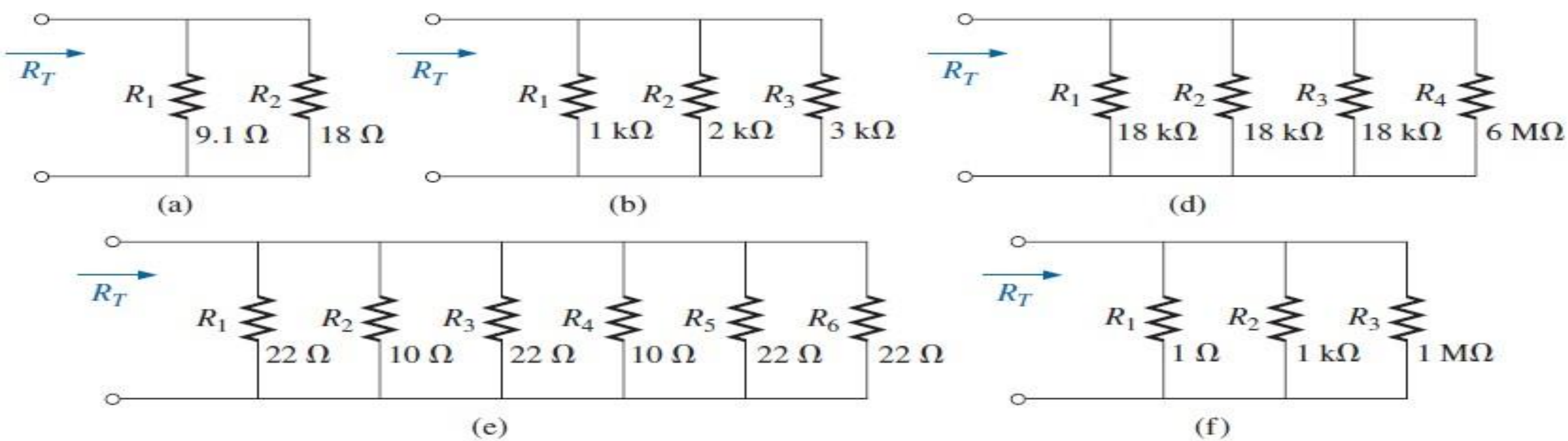
2. For the network in Fig. :

a. Find the elements (voltage sources and/or resistors) that are in parallel.

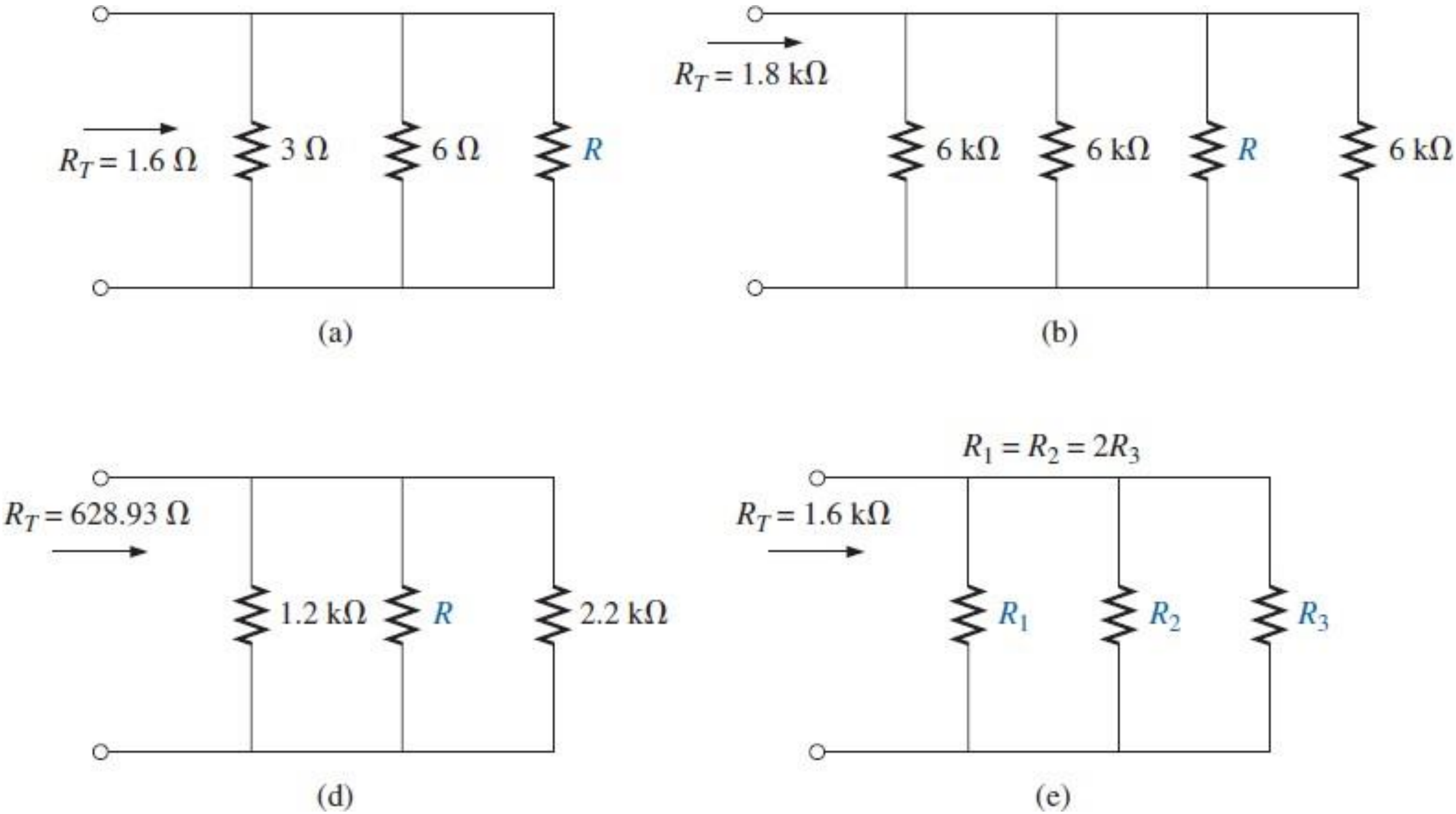
b. Find the elements (voltage sources and/or resistors) that are in series.



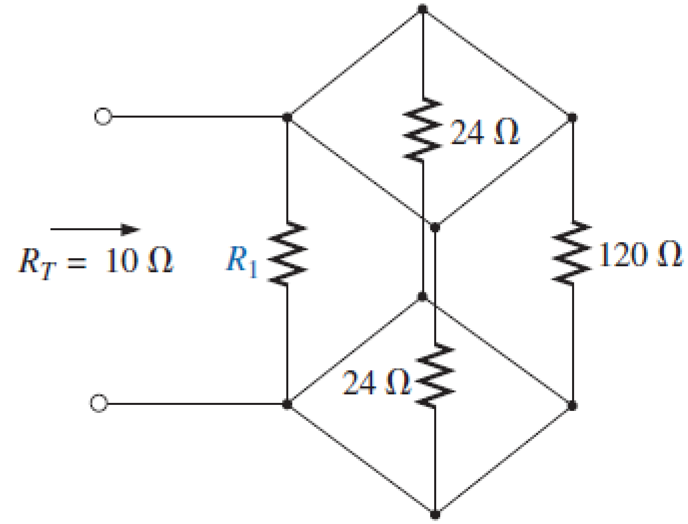
3. Find the total resistance for each configuration in Fig. Note that only standard value resistors were used.



5. The total resistance of each of the configurations in Fig. is specified. Find the unknown resistance.



9. Determine *R1 for the network in Fig.*



SECTION 6.3 Parallel Circuits

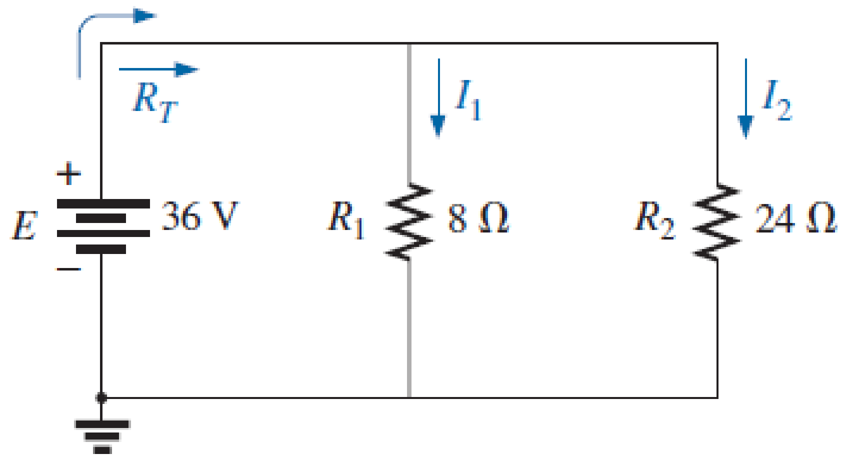
10. For the parallel network in Fig. :

a. Find the total resistance.

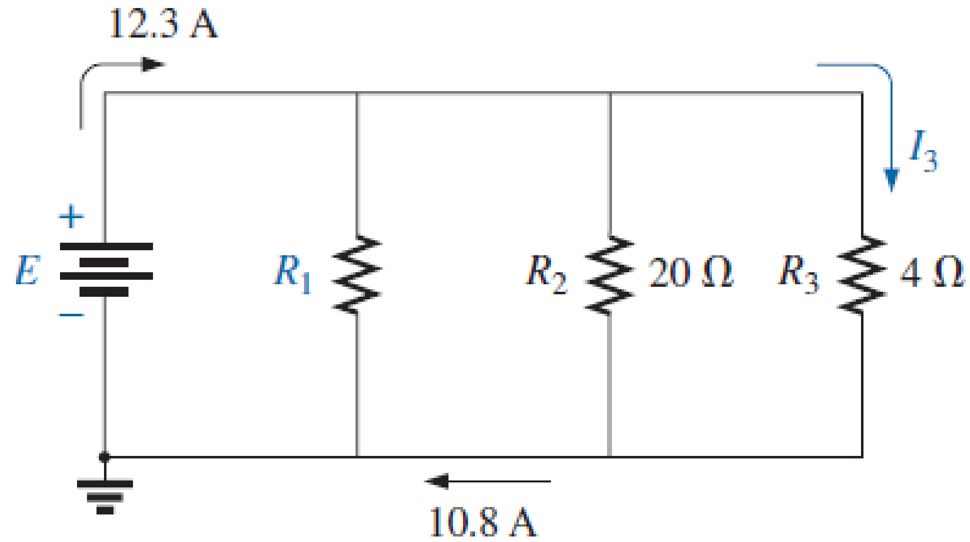
b. What is the voltage across each branch?

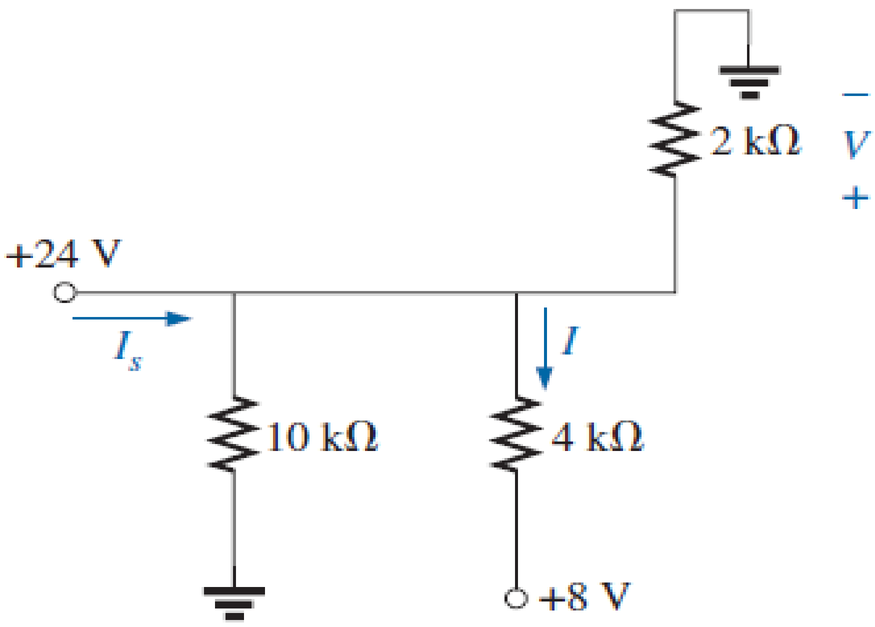
c. Determine the source current and the current through each branch.

d.Verify that the source current equals the sum of the branch currents.



16. Given the information provided in Fig. , find the unknown quantities: *E, R1, and I3.*





18. For the network in Fig. :

a. Find the current *I.*

b. Determine the voltage *V.*

c. Calculate the source current *Is.*

SECTION 6.4 Power Distribution in a Parallel Circuit

19. For the configuration in Fig. :

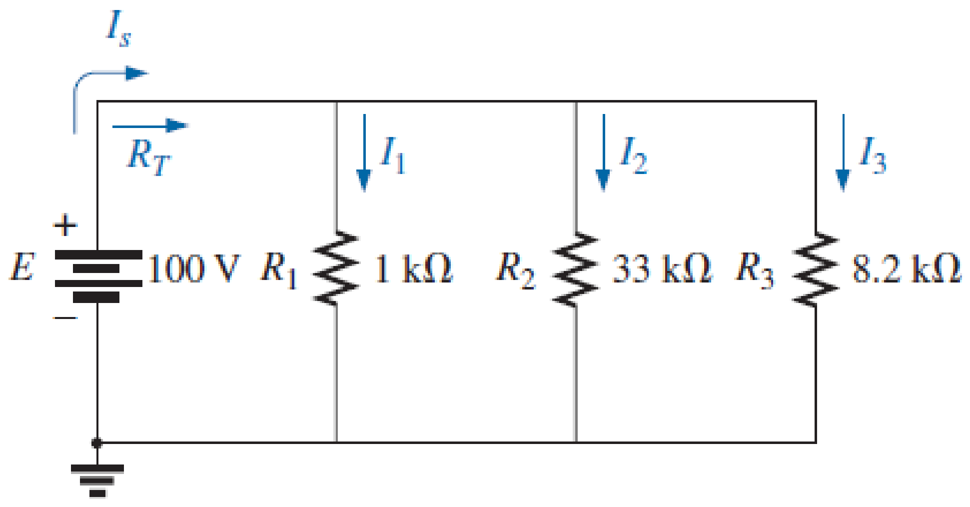
a.Find the total resistance and the current through each branch.

b. Find the power delivered to each resistor.

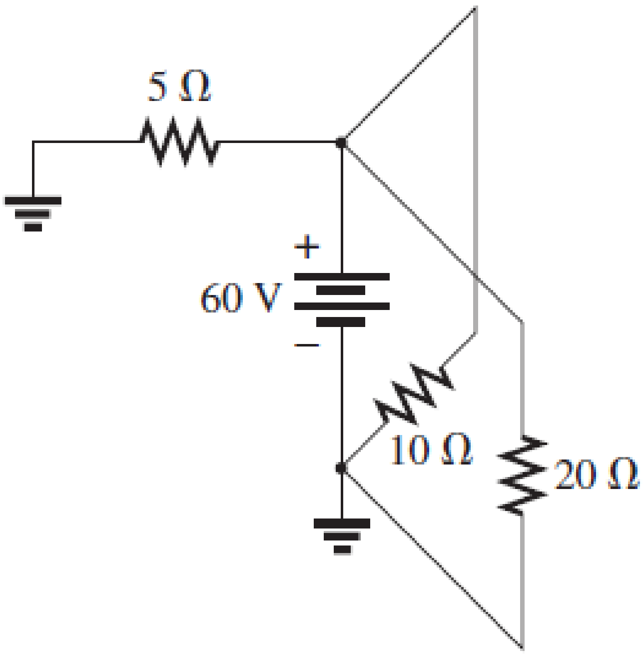
c. Calculate the power delivered by the source.

d.Compare the power delivered by the source to the sum of the powers delivered to the resistors.

e.Which resistor received the most power? Why?



21. Determine the power delivered by the dc battery in Fig.



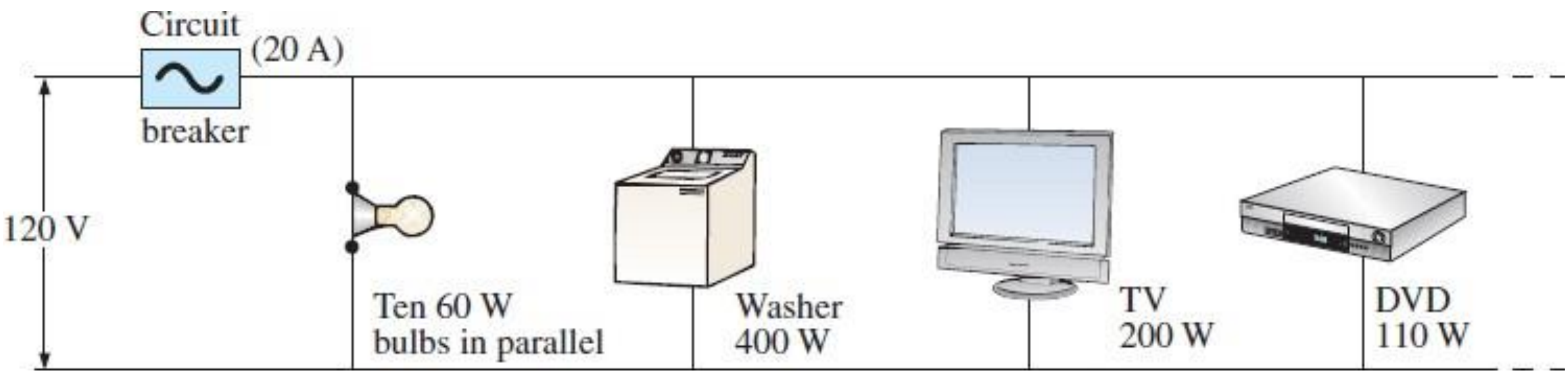
22. A portion of a residential service to a home is depicted in Fig.

a. Determine the current through each parallel branch of the system.

b. Calculate the current drawn from the 120 V source. Will the 20 A breaker trip?

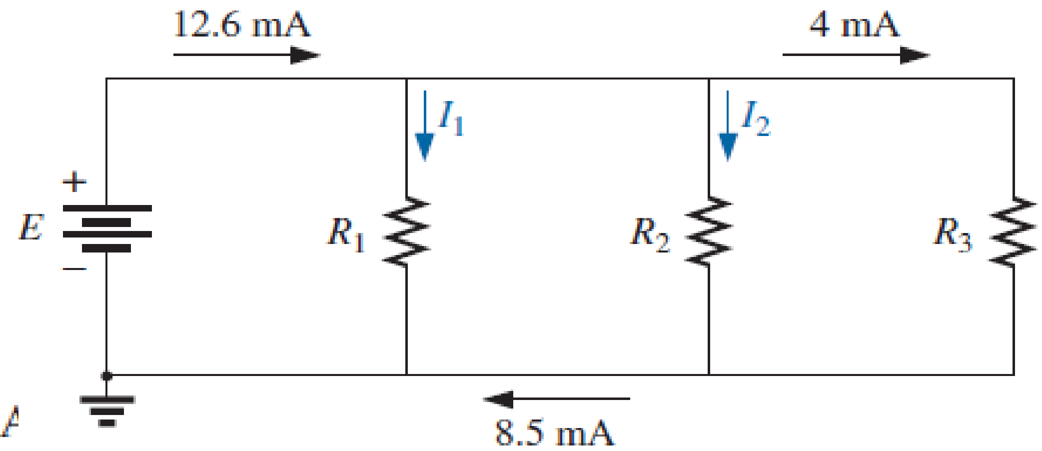
c. What is the total resistance of the network?

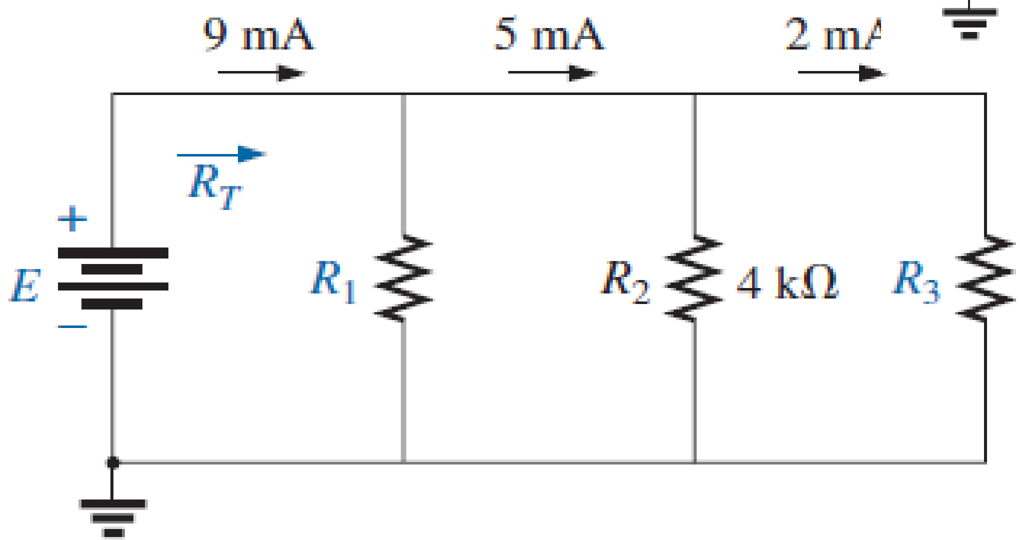
d. Determine the power delivered by the source. How does it compare to the sum of the wattage ratings appearing in Fig.?



SECTION 6.5 Kirchhoff's Current Law

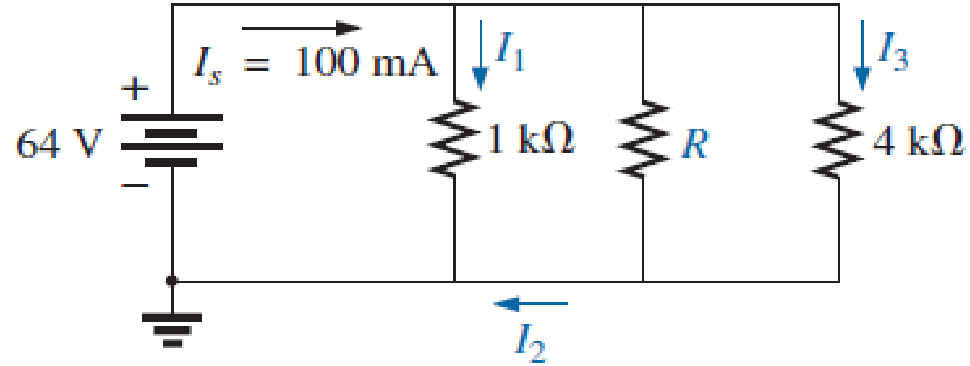
24. Using Kirchhoff's current law, determine the unknown currents for the parallel network in Fig.



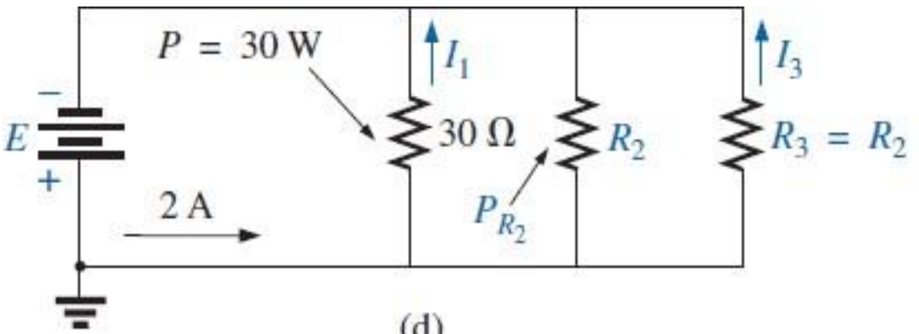


27. Using the information provided in Fig. , find the branch resistors *R1 and R3, the total resistance RT, and the voltage* source *E.*

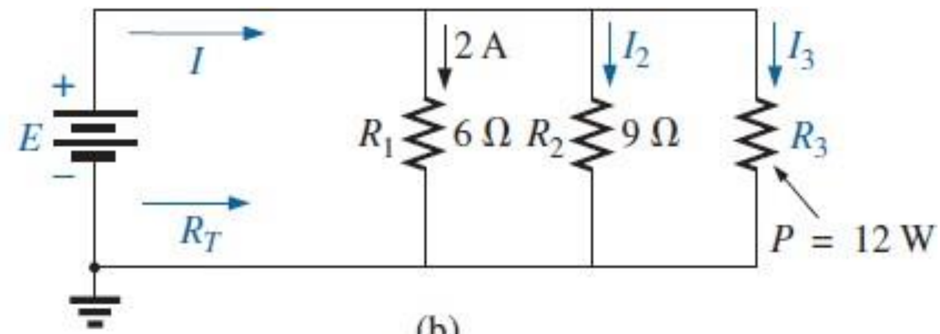
28. Find the unknown quantities for the networks in Fig. using the information provided.



(c)



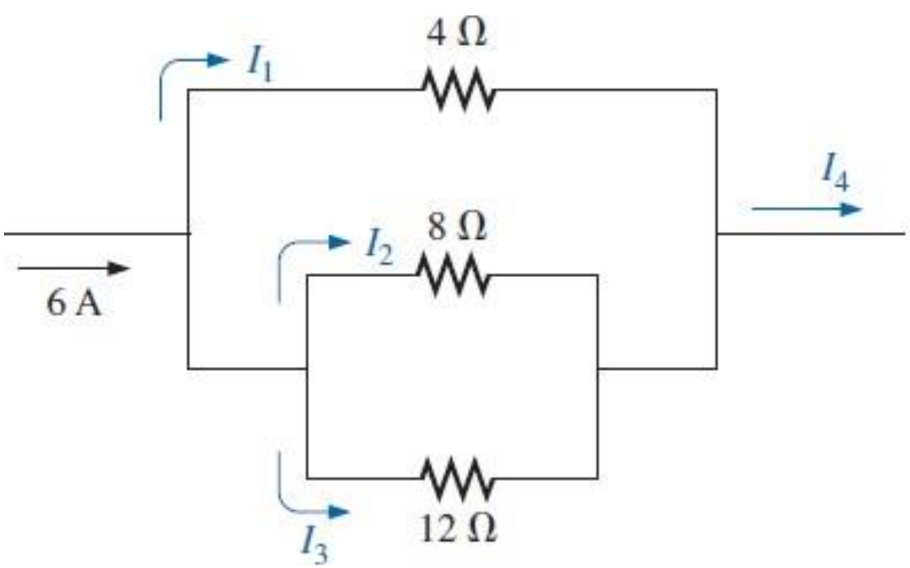
(d)



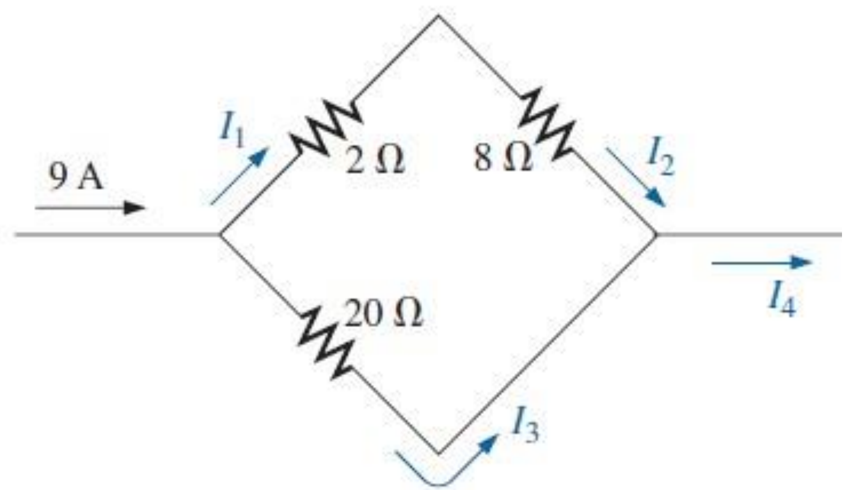
(b)

SECTION 6.6 Current Divider Rule

30. Determine the currents for the configurations in Fig.

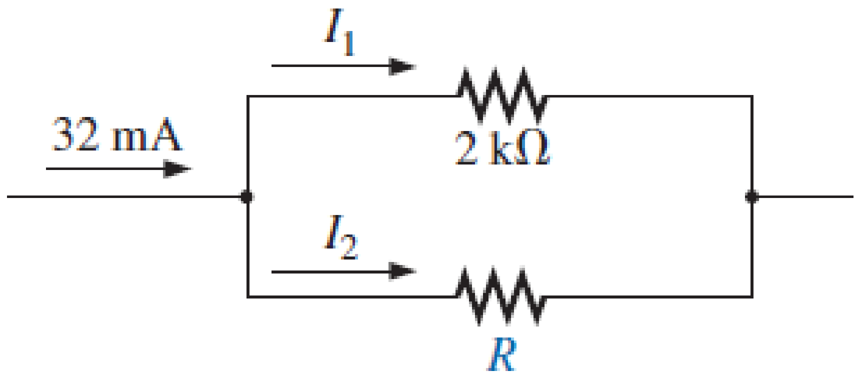


(c)

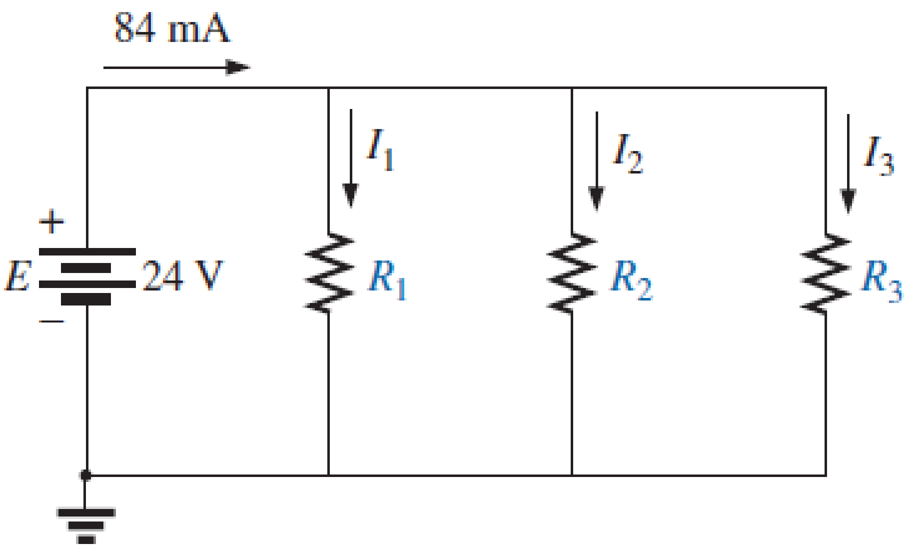


(d)

33. a. Find resistor R for the network in Fig. that will ensure that $I_1 = 3I_2$.
b. Find I_1 and I_2.

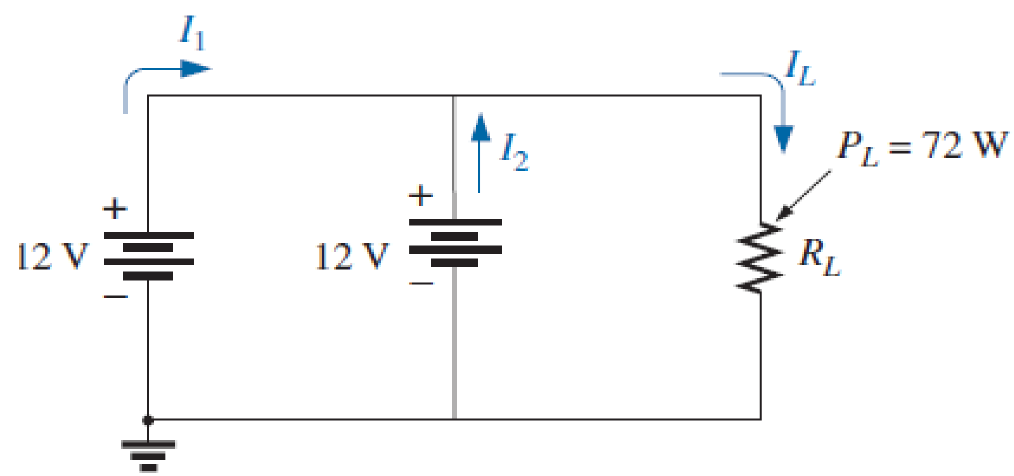


34. Design the network in Fig. such that $I_2 = 2I_1$ and $I_3 = 2I_2$.

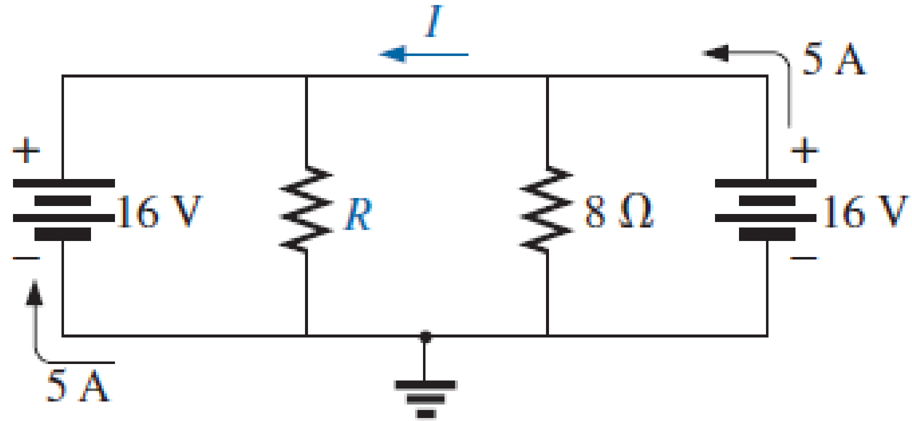


SECTION 6.7 Voltage Source in Parallel

35. Assuming identical supplies in Fig.
a. Find the indicated currents.
b. Find the power delivered by each source.
c.Find the total power delivered by both sources, and compare it to the power delivered to the load RL.



37. Assuming identical supplies, determine the current *I and resistance R for the parallel network in Fig.*



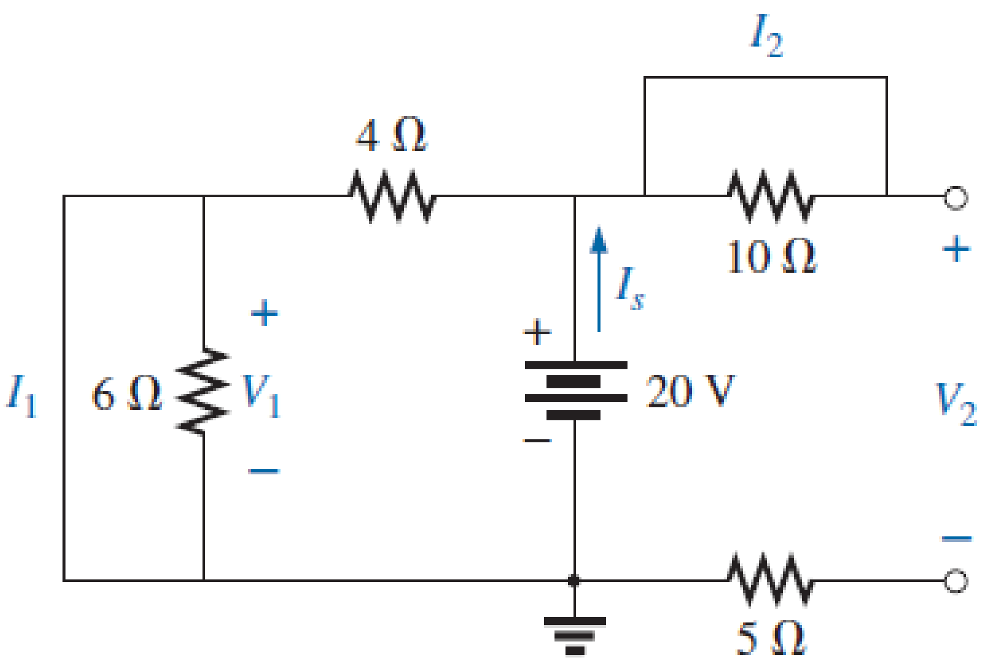
SECTION 6.8 Open and Short Circuits

40. For the network in Fig. , determine

a. the short-circuit currents *I1 and I2.*

b. the voltages *V1 and V2.*

c. the source current *Is* .



GOOD LUCK