ELECTRICAL AND ELECTRONICS FOR DESIGN (SRSD 3092) Semester II 2019/2020

(INTRODUCTION)

Week 1-1

Prepared by : DR NELIDYA MD YUSOFF

Lecturers

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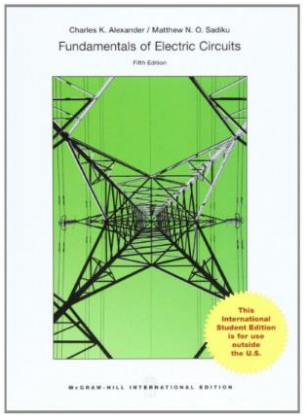
Synopsis

This course introduces basic electrical and electronics for non-electrical students. The topic covers direct current (DC), alternating current (AC), basic semiconductor device such as PN Junction diodes, zener diode and bipolar transistor. Furthermore, it also covers the application of diode in series and parallel configuration, DC analysis for simple BJT circuit configuration.

INTRODUCTION

- Two credits – 2 Hours/week
- Timetable: Wednesday – 2 hours (9 – 11 am)

  Bilik Kuliah 8, Level 14
- Text Book: Fundamentals of Electric Circuits by C.K.Alexander



References:

- Worked Example In Electrical Technology, B.L.Thejara.
- Electrical Technology, Seventh Edition, Hughes, Edward, Longman.
- Electrical Machinery, Ryff, Peter F, Prentice Hall.
- Schaum Outline Series, Electric Circuits, McGraw Hill.

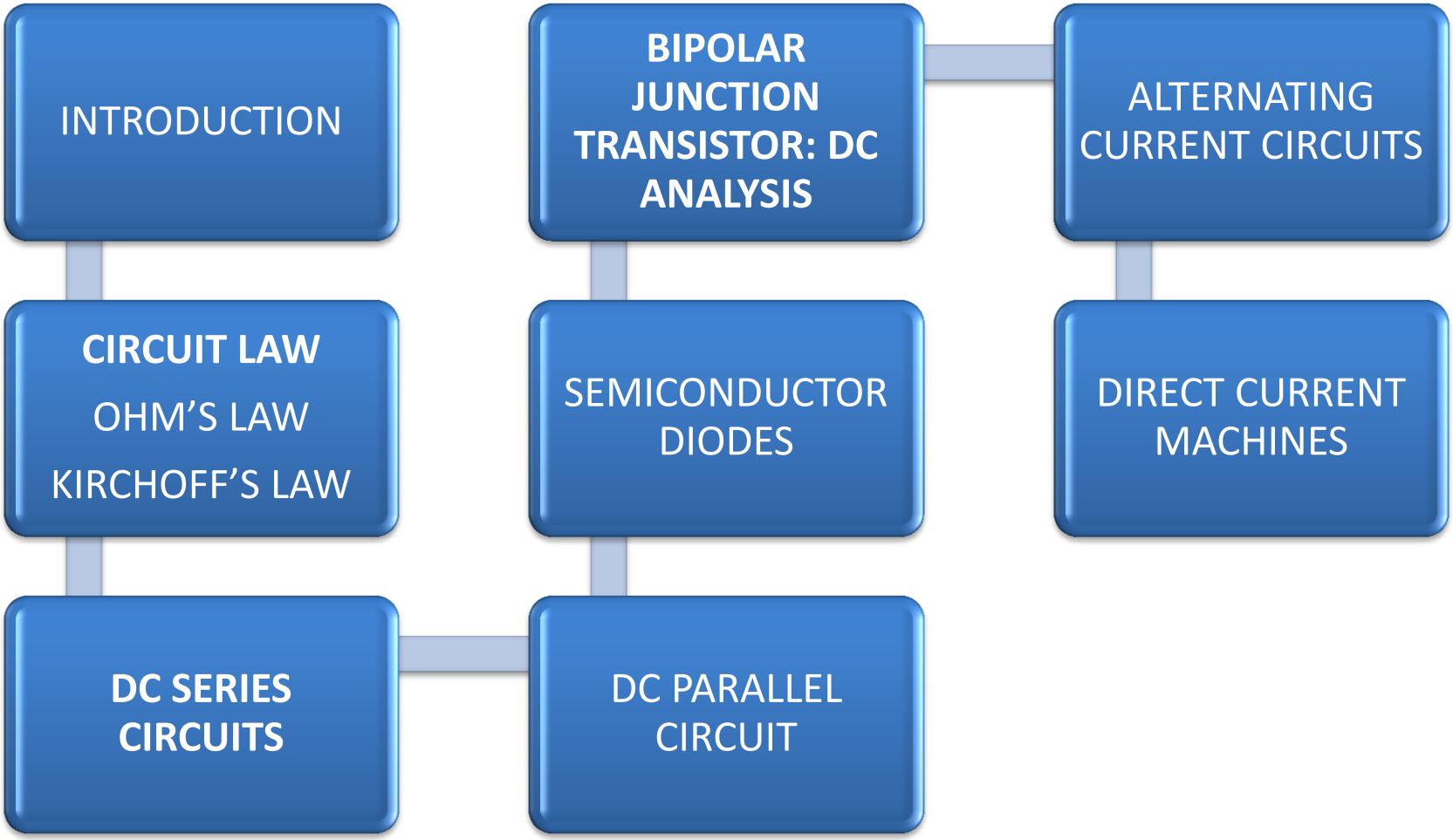
Course Outcome

No.	Course Learning Outcome	Programme Learning Outcome(s) Addressed	Assessment Methods	KPI
1.	Recognize the basic operations of electronic devices.	PO1	Q,T, ASG, F	0.5
2.	Analyse circuitry with diode and BJT component	PO1, PO3	Q,T, ASG, F	0.5
3.	Apply basic electrical circuit laws and methods in analysing DC and AC circuit	PO1, PO3	Q,T, ASG, F	0.5
4.	Familiarize with the concept and operation principle of the DC machine. Be able to calculate simple calculations determining parameters associated with DC machine.	PO1	Q, ASG, F	0.5

Assessment

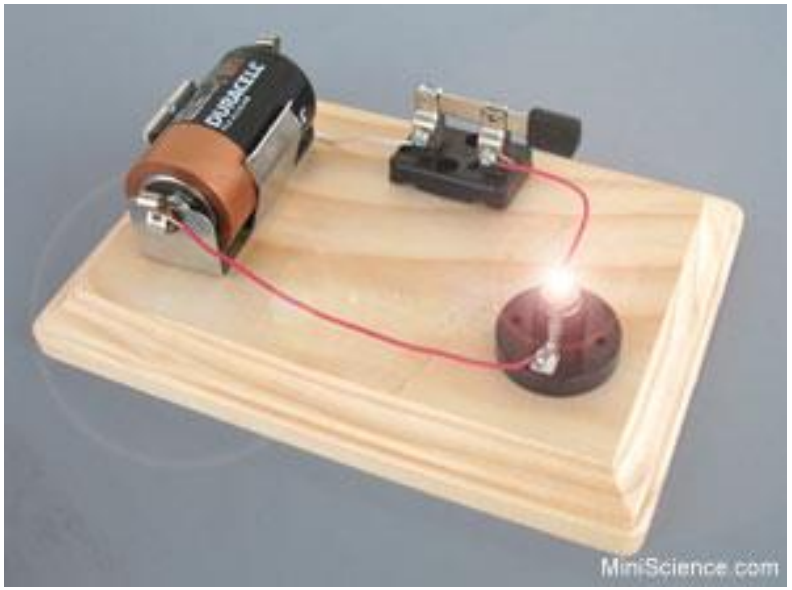
No	Assessment	Number	% each	% total	Week
1	Test	2	20	40	7 and 13
2	Assignment	2	5	10	4,9 and 12
3	Quizzes	4	2.5	10	3,6,11 and 15
4	Final Exam	1	40	40	
	Overall Total			100	

Course Contents

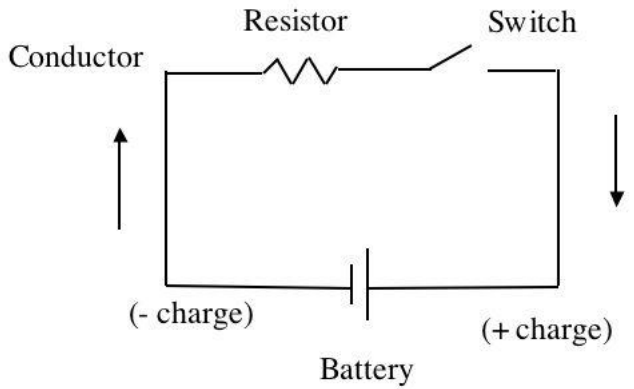


BASIC CIRCUIT CONCEPTS

An electric circuit is formed by interconnecting components having different electric properties



Basic Electrical Circuit (Diagram)



Home Appliances

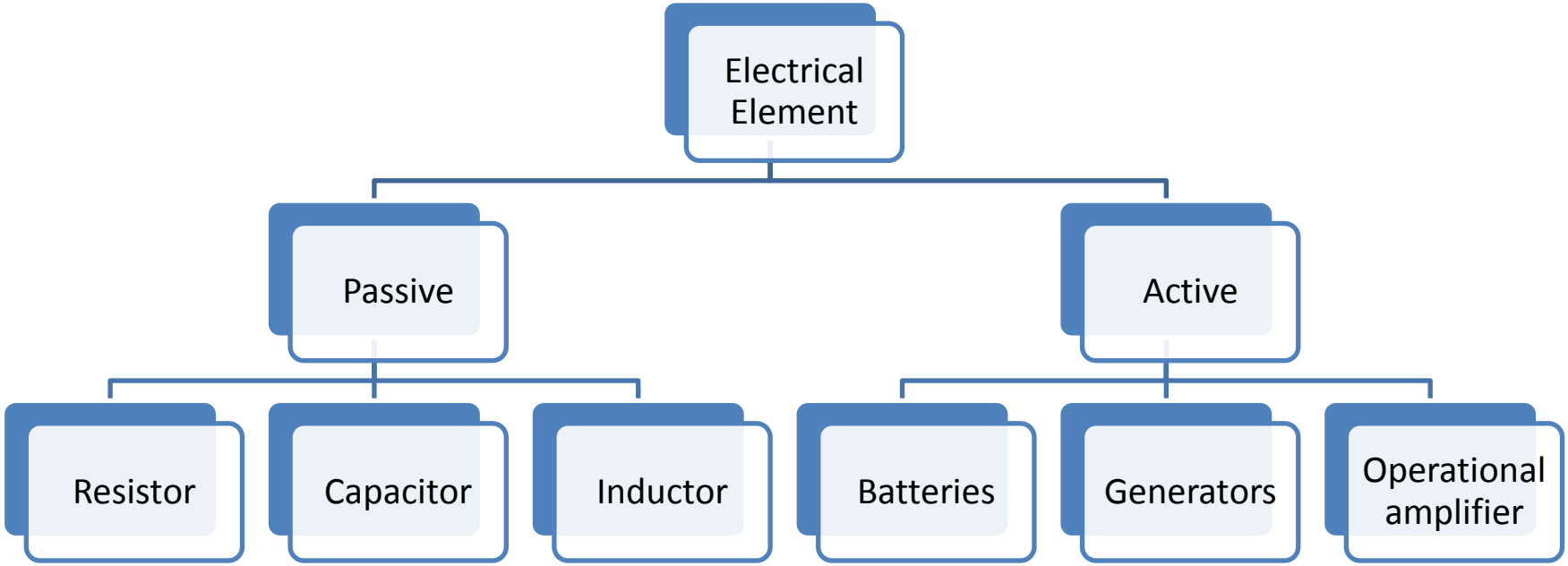
ELECTRICAL AND ELECTRONICS FOR DESIGN (SRSD 3092) Semester II 2019/2020

(Basic Electric Circuit)
Week 1-2

Prepared by : DR NELIDYA MD YUSOFF

What is a circuit?

Interconnection of electrical elements



Function: To transfer energy from one point to another

Passive and Active Elements

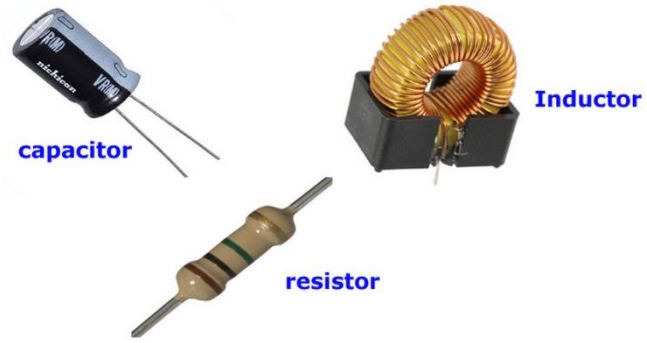
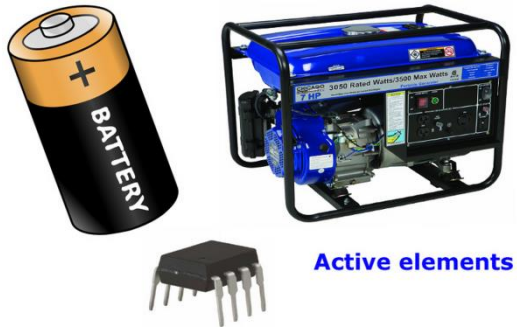


Figure: passive elements



Passive Element

Drop Energy (Take energy from circuit)

Active Element

Generate Energy

Circuit Element Symbols

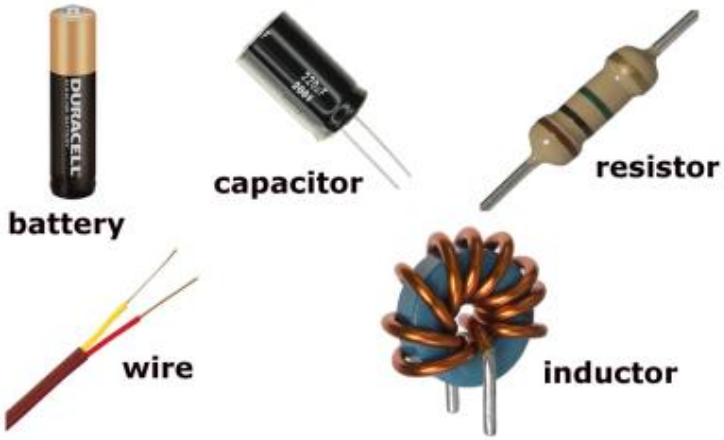
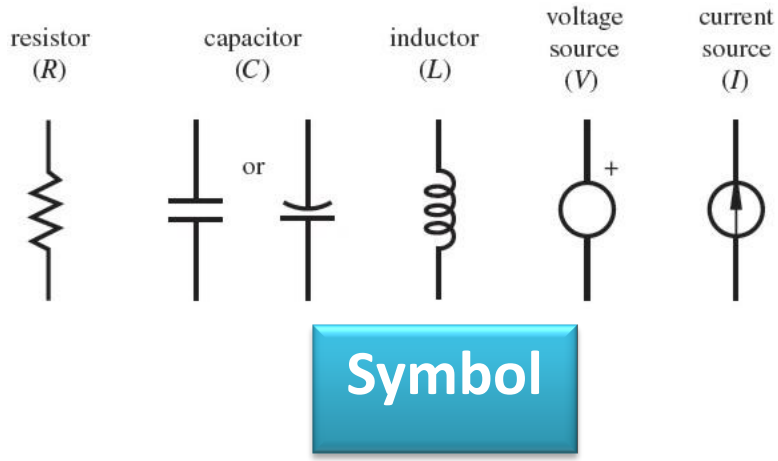
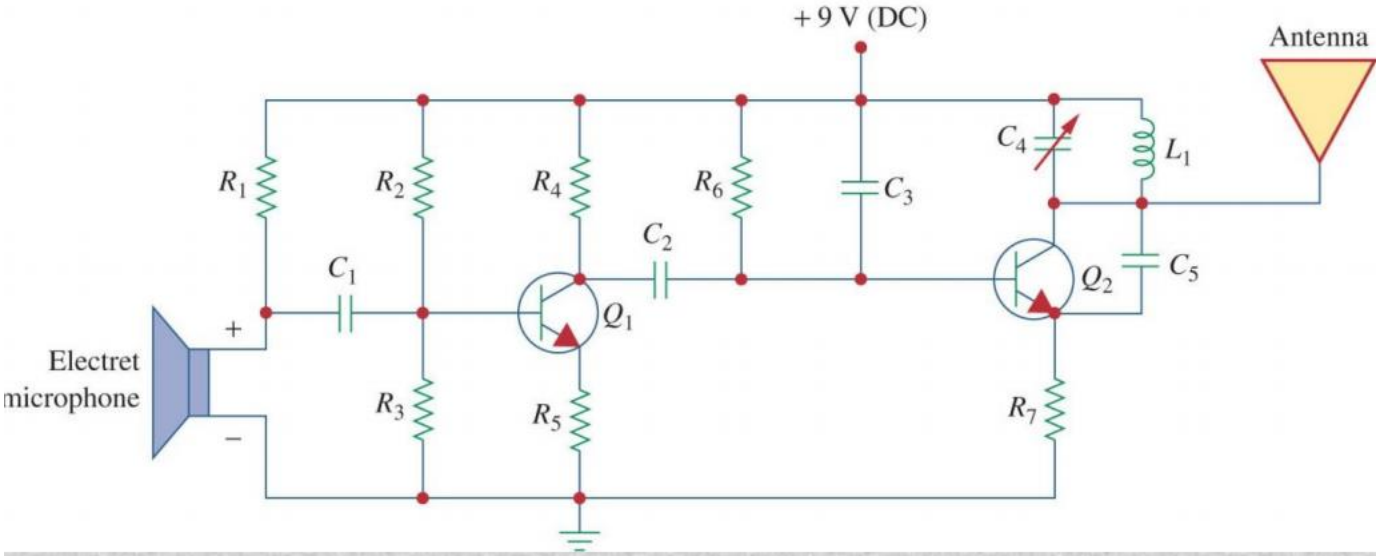


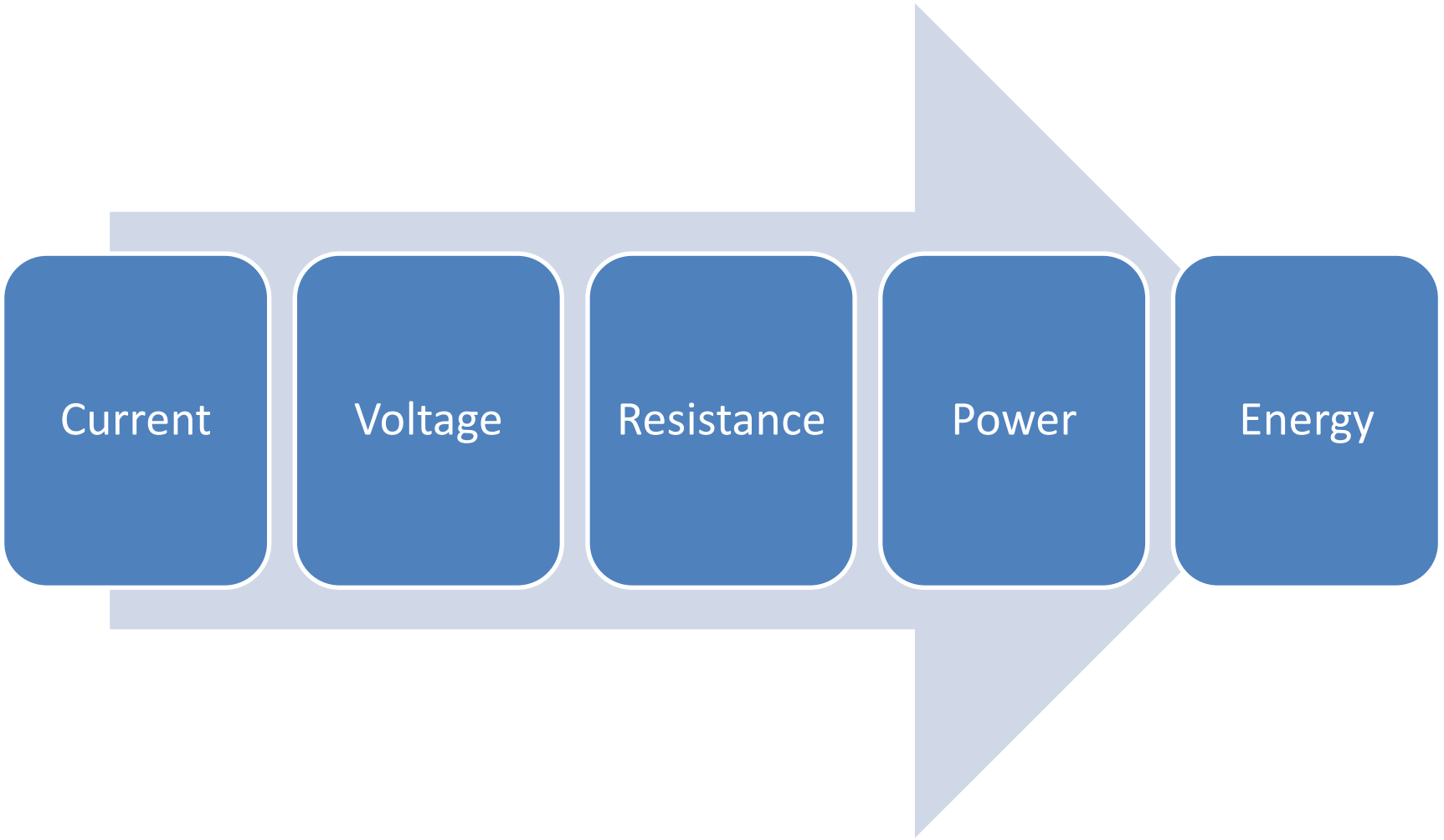
Figure: Some practical circuit element



Example of Electric Circuit



Basic Circuit Concepts



Class Activity #1

Numbered Head Together

Instruction:

Each group will get ONE topic

Discuss and present

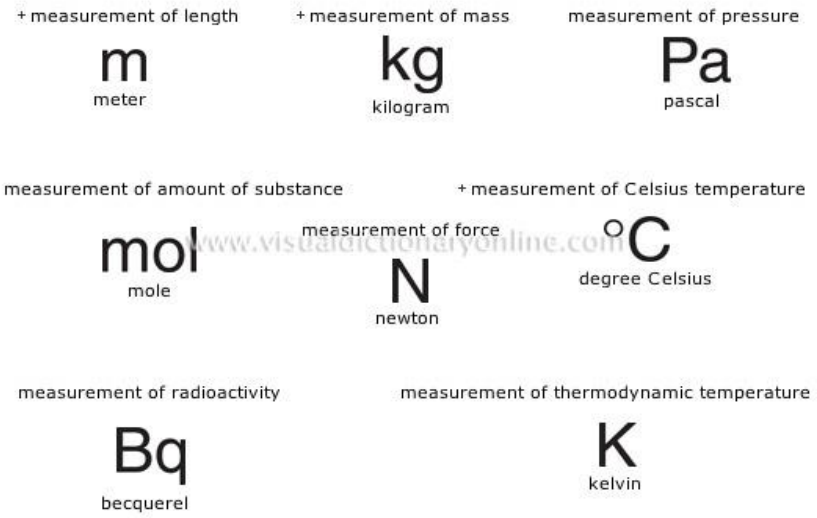
Group	Topic
1	Current
2	Voltage
3	Resistance
4	Power

Units

- When taking measurements, we must use units to quantify values

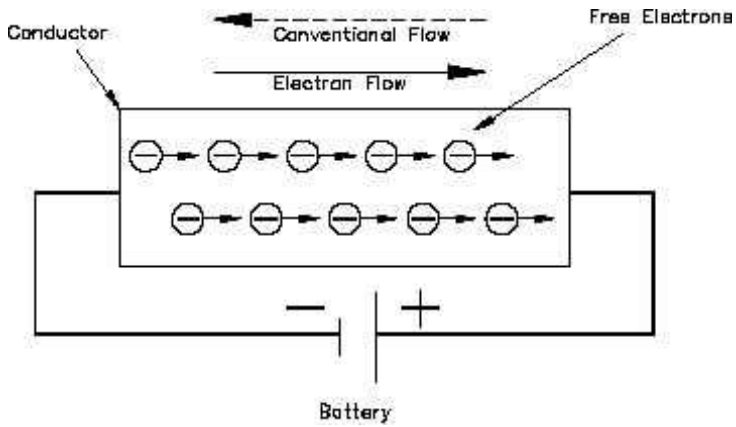
MEGA	KILO	MICRO	NANO

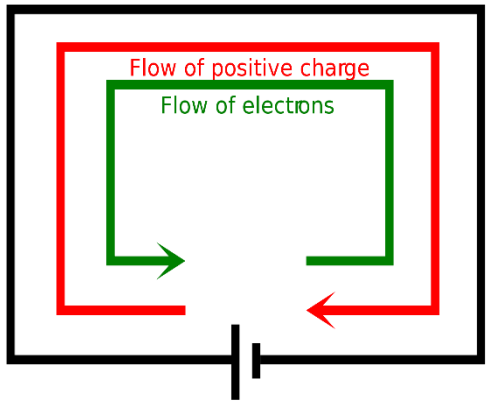
- Use International Systems of Units



CURRENT

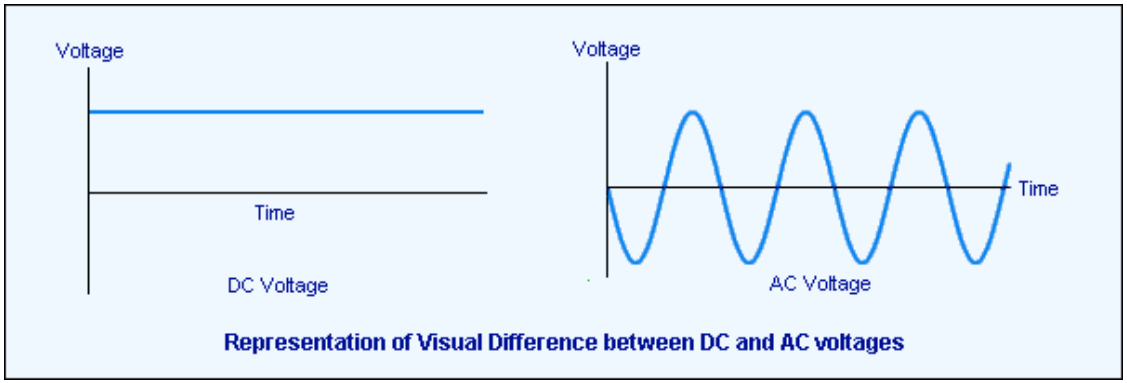
- An **electric current** is a flow of **electric** charge. In **electric** circuits this charge is often carried by moving electrons in a wire. It can also be carried by ions in an electrolyte, or by both ions and electrons such as in a plasma.





Type of Currents

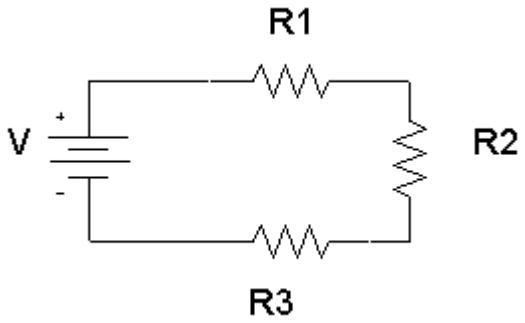
- Two types of current
- Direct current (DC) and Alternating Current (AC)
- DC: Common source – Battery
- AC: Common source – main power

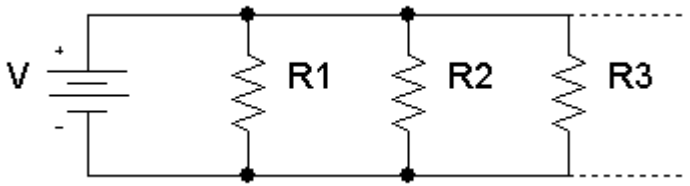


Representation of Visual Difference between DC and AC voltages

RESISTANCE

- The electrical **resistance** of a circuit component or device is **defined** as the ratio of the voltage applied to the electric current which flows through it: If the **resistance** is constant over a considerable range of voltage, then Ohm's law, I = V/R, can be used to predict the behavior of the material.





POWER

- The electric power in watts associated with a complete electric circuit or a circuit component represents the rate at which energy is converted from the electrical energy of the moving charges to some other form, e.g., heat, mechanical energy, or energy stored in electric fields or magnetic fields. For a resistor in a DC Circuit the power is given by the product of applied voltage and the electric current:

$$P = VI$$

where V = voltage

I= current

ELECTRICAL AND ELECTRONICS FOR DESIGN (SRSD 3092) Semester II 2019/2020

(Ohm's Law)
Week 2-2

Prepared by : DR NELIDYA MD YUSOFF

Resistivity, R

- Materials tend to **resist** the flow of electricity through them.
- This property is called "**resistance**"
- The resistance of an object is a function of its length, l, and cross sectional area, A, and the material's resistivity

$$R = \rho \frac{l}{A}$$

Resistivity of Common Materials

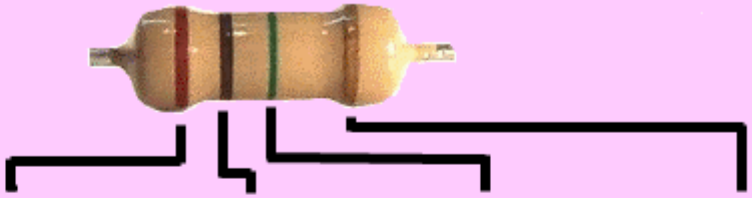
TABLE 2.1

Resistivities of common materials.

Material	Resistivity ($\Omega \cdot m$)	Usage
Silver	1.64×10^{-8}	Conductor
Copper	1.72×10^{-8}	Conductor
Aluminum	2.8×10^{-8}	Conductor
Gold	2.45×10^{-8}	Conductor
Carbon	4×10^{-5}	Semiconductor
Germanium	47×10^{-2}	Semiconductor
Silicon	6.4×10^{2}	Semiconductor
Paper	10^{10}	Insulator
Mica	5×10^{11}	Insulator
Glass	10^{12}	Insulator
Teflon	3×10^{12}	Insulator

Resistors Colour Coding

4 Band Resistor Color Coding



COLOR	1ST BAND	2ND BAND	MULTIPLIER	TOLERANCE
BLACK	0	0	x1Ω	
BROWN	1	1	x10Ω	±1%
RED	2	2	x100Ω	±2%
ORANGE	3	3	x1000Ω	
YELLOW	4	4	x10000Ω	
GREEN	5	5	x100000Ω	±0.5%
BLUE	6	6	x1000000Ω	±0.25
VIOLET	7	7	x10000000Ω	±0.10
GREY	8	8		±0.05
WHITE	9	9		
GOLD			0.1	±5%
SILVER			0.01	±10%

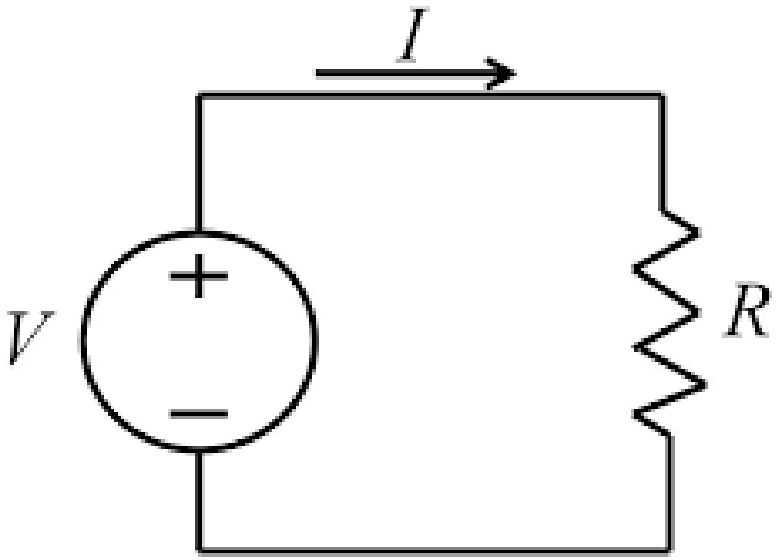
Ohm's Law

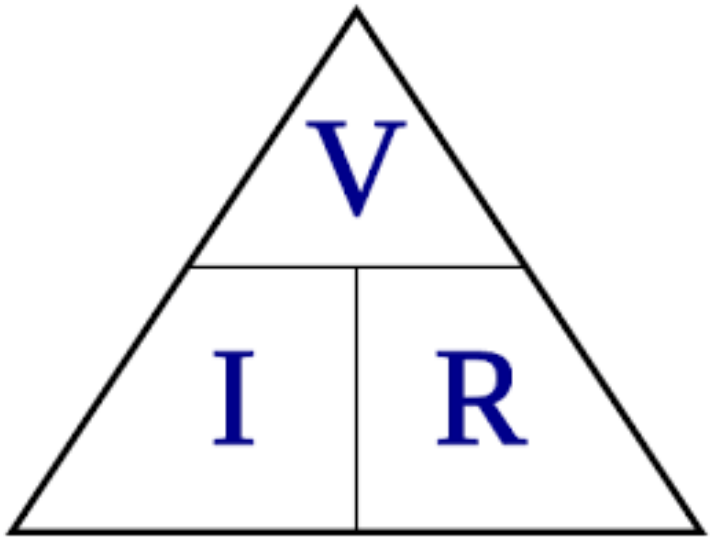
The voltage, *v* across a resistor is directly proportional to the current, *i* flowing through the resistor.

$$V = IR$$

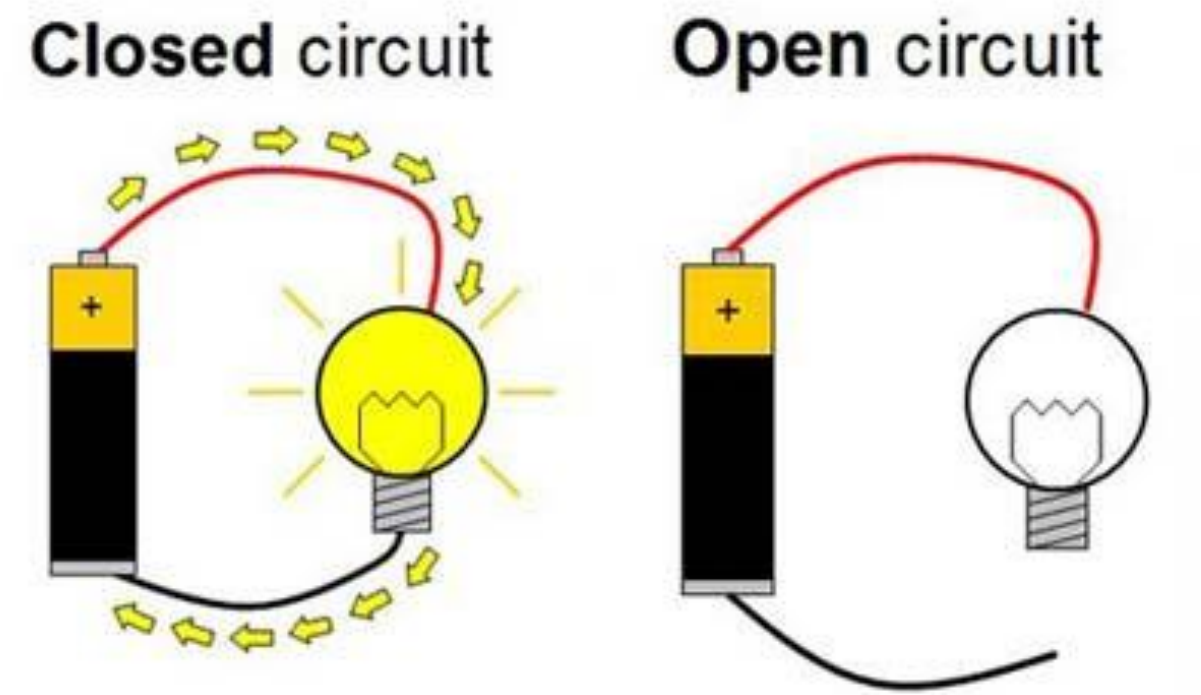
Voltage [volts, v] = current [amperes, A] x Resistance [ohms, Ω]

Ohm's Law



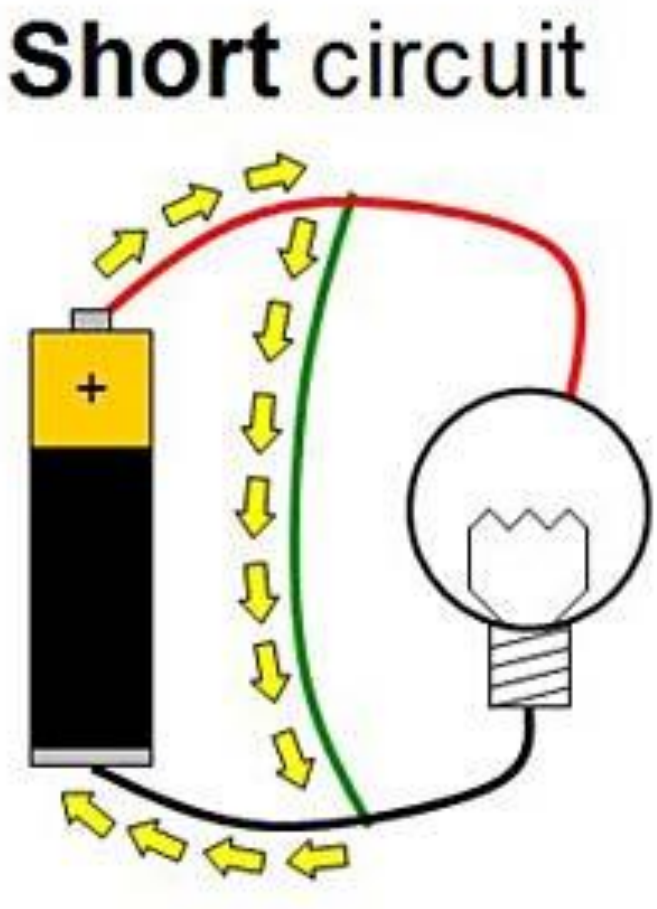


Closed and Open Circuits



Short Circuits

- Zero resistance
- Any current may flow through the short
- In practice this is a connecting wire



Power Dissipation

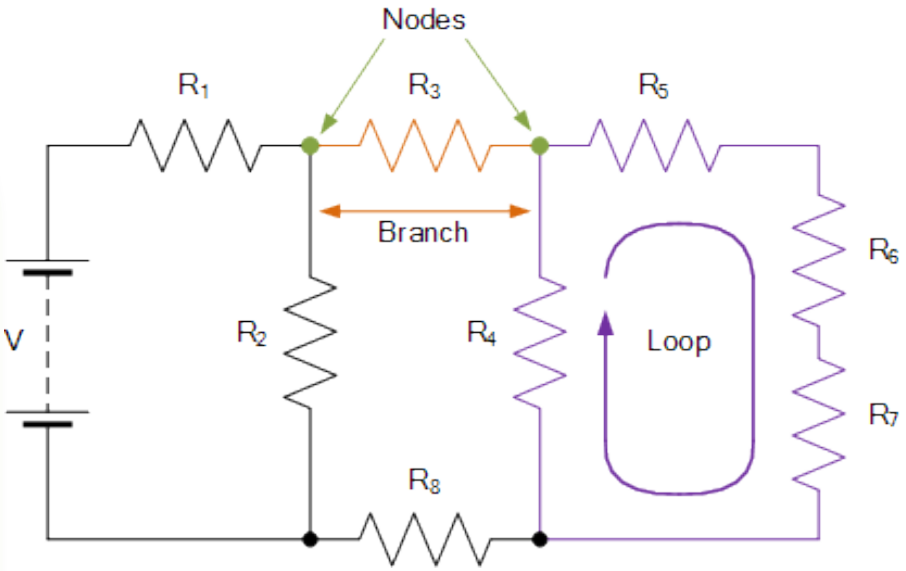
- Running current through a resistor dissipates power.

$$p = vi = i^2 R = \frac{v^2}{R}$$

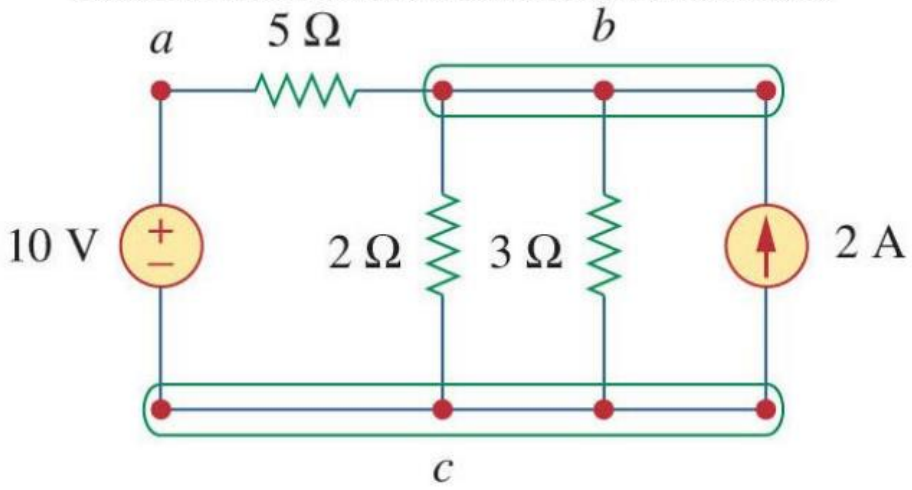
- The power dissipated is a non-linear function of current or voltage
- Power dissipated is always positive
- A resistor can never generate power

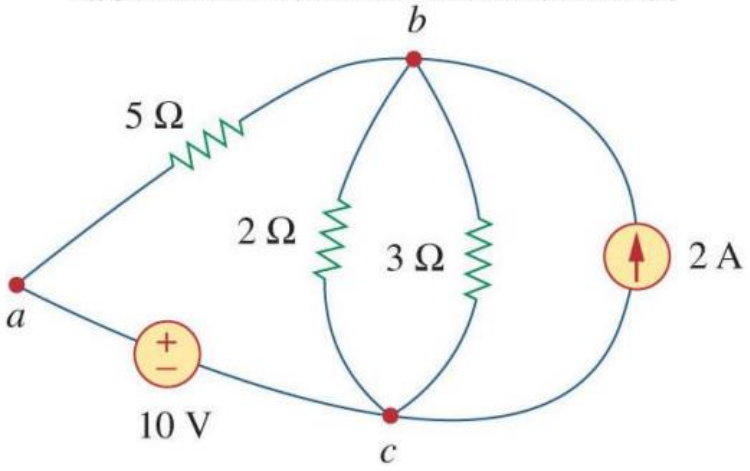
Nodes, Branches and Loops

- **Branch**: a single element such as a voltage source or a resistor
- **Node**: The point of connection between two or more branches
- **Loop**: Any closed path in a circuit



Example of nodes, branches and Loops

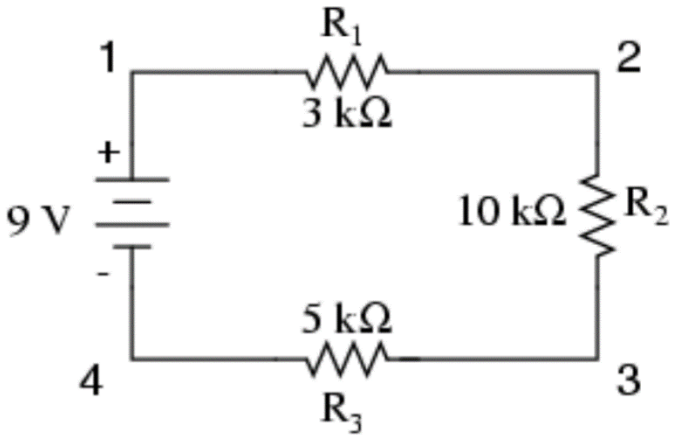


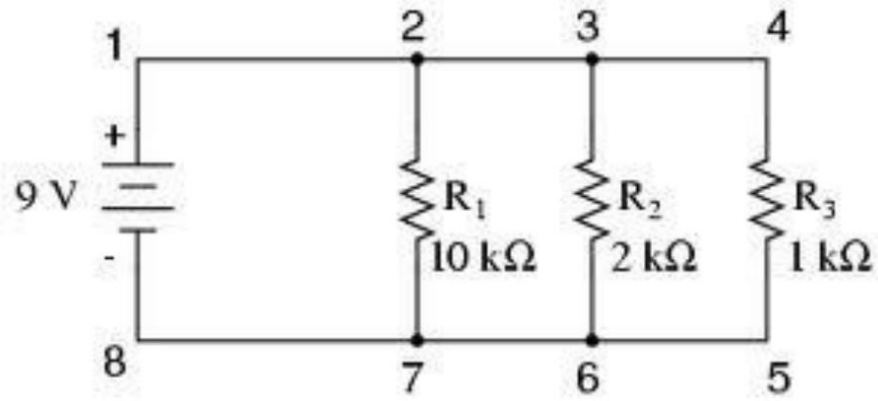


Network Topology

Series:

- Share a single node
- Carry the same current



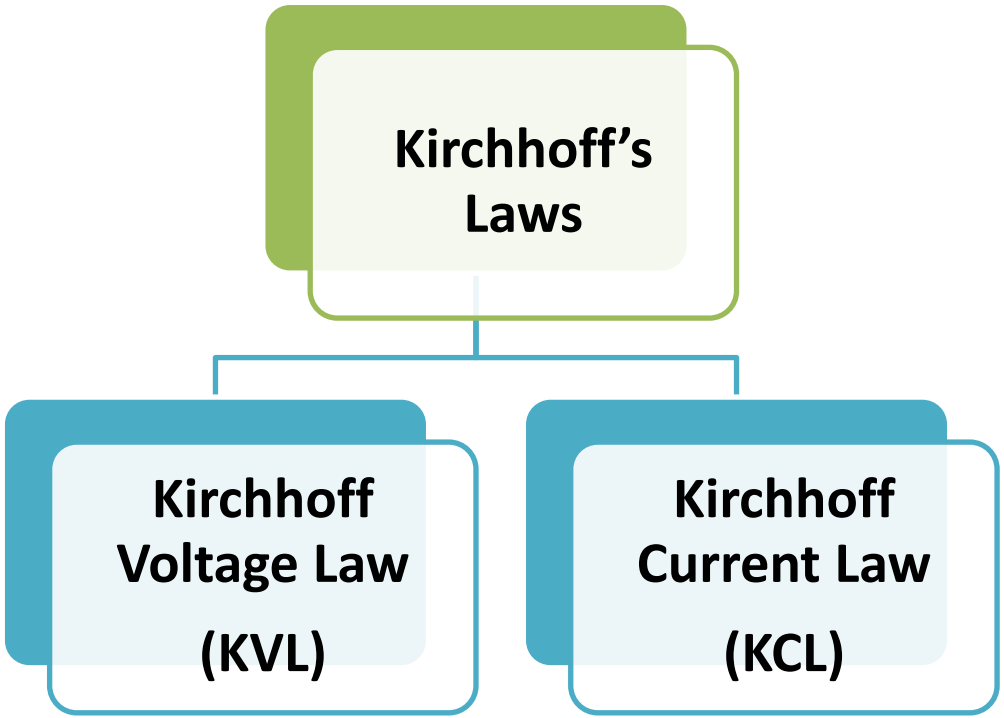


Parallel:

- Connected to the same two nodes
- Same voltage

Kirchhoff's Laws

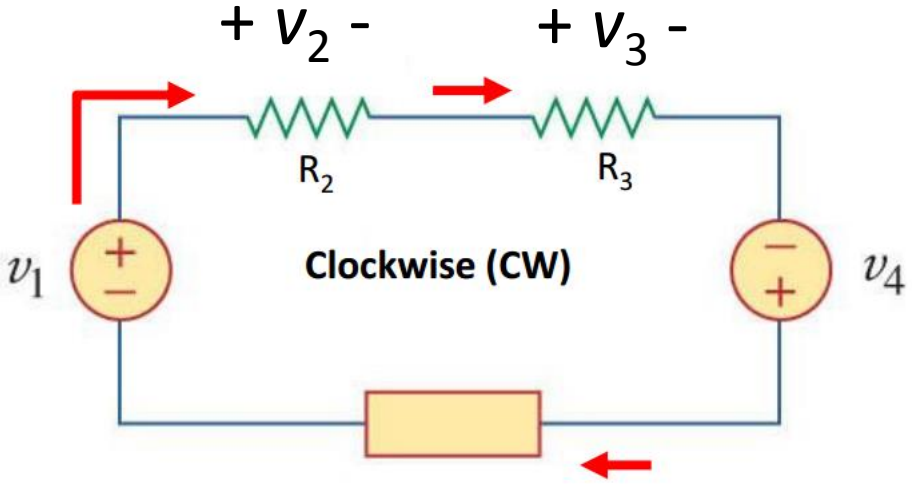
- Ohm's law is not sufficient for circuit analysis
- Kirchhoff's laws complete the needed tools



Kirchhoff Voltage Law (KVL)

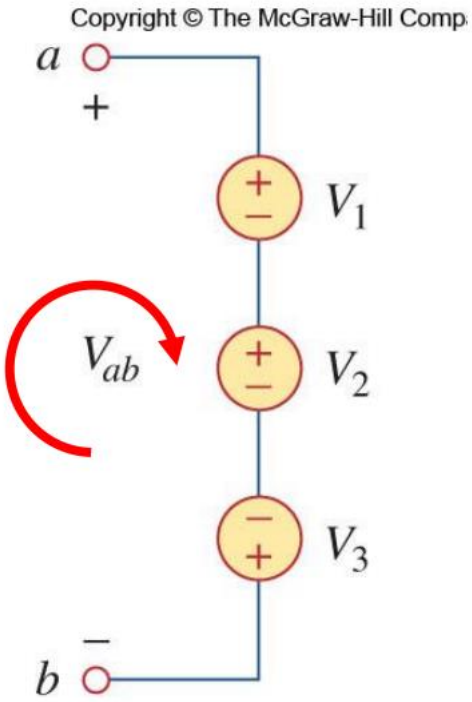
- Kirchhoff's voltage law is based on conservation of energy
- It states that the algebraic sum of voltages around a closed path (or loop) is zero.
- It can be expressed as:

$$\sum_{m=1}^{M} v_m = 0$$



KVL

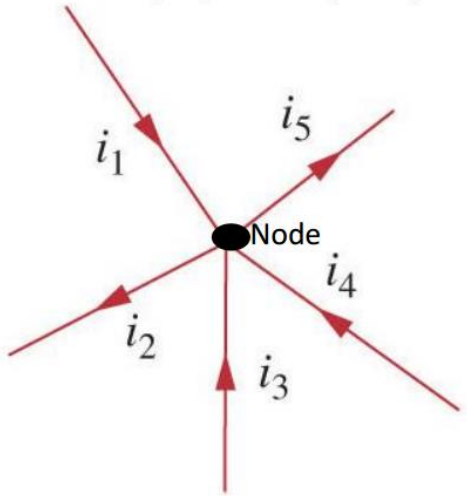
- Find the V_{ab}



Kirchhoff Current Law (KCL)

- Kirchhoff's current law is based on conservation of charge
- It states that the algebraic sum of currents entering a node (or a closed boundary) is zero.
- It can be expressed as:

$$\sum_{n=1}^{N} i_n = 0$$



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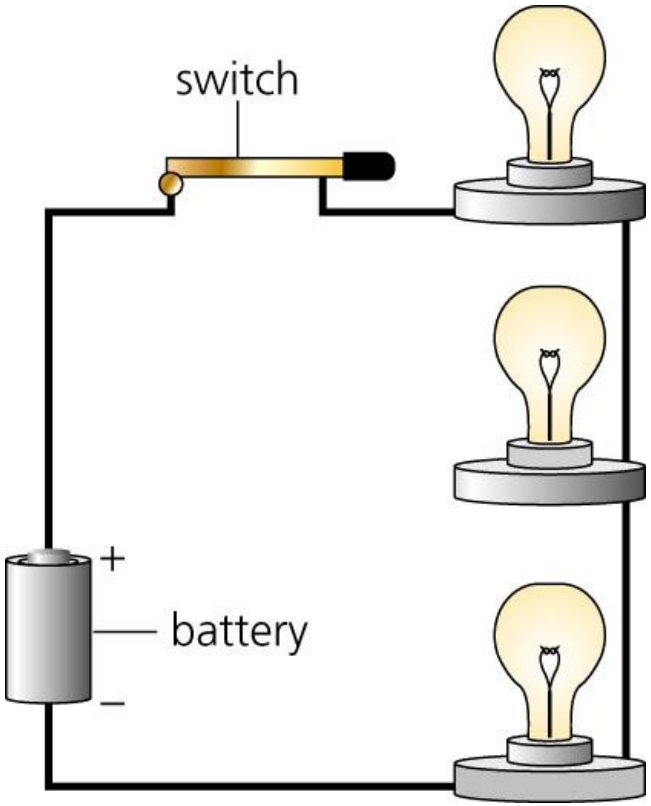
ELECTRICAL AND ELECTRONICS FOR DESIGN (SRSD 3092) Semester II 2019/2020

DC SERIES CIRCUITS

Prepared by : DR NELIDYA MD YUSOFF

DC SERIES CIRCUITS

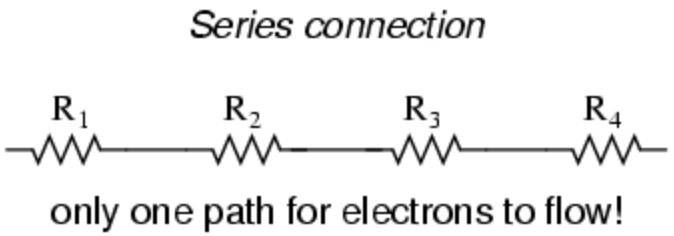


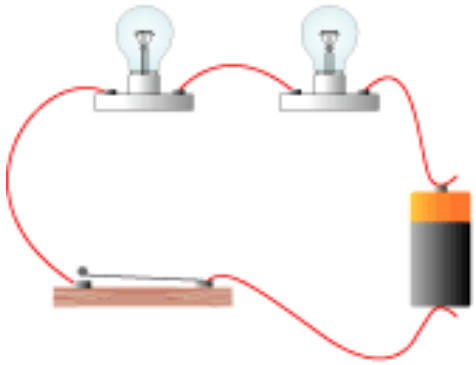
Topics

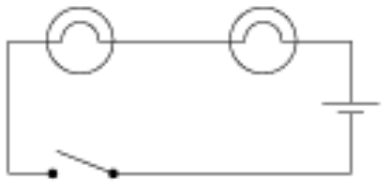
- Series Circuits
  - Series Resistors
- Voltage Sources in Series
- Kirchhoff's Voltage Law
- Voltage Division in a Series Circuit
  - Voltage Divider Rule (VDR)
- Open circuit, closed circuit

Series circuit

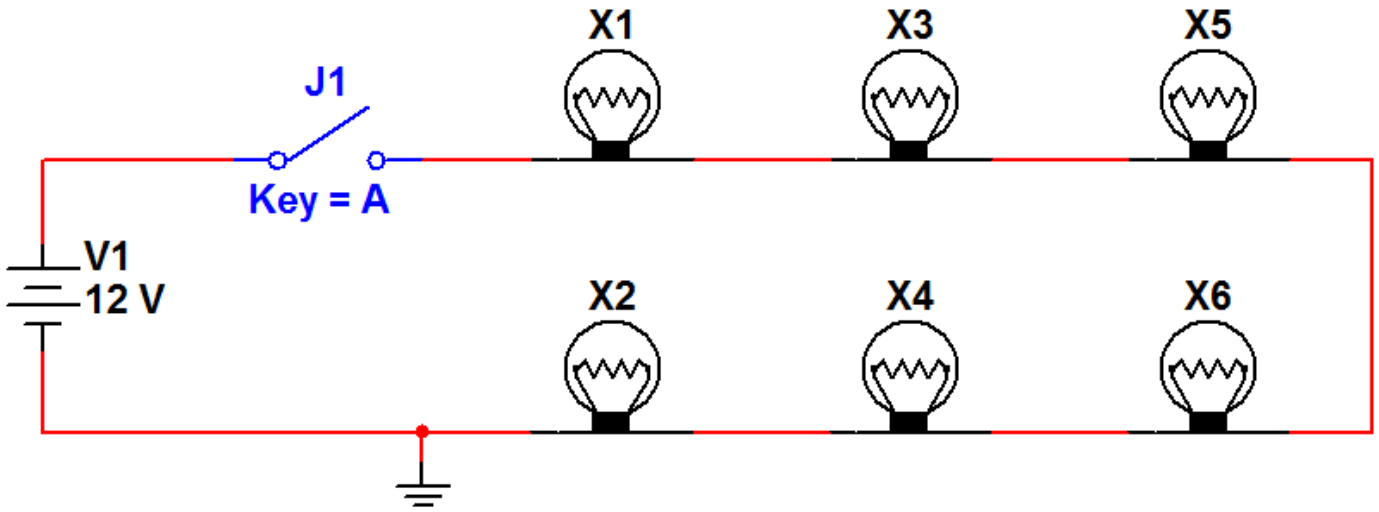
- A **series circuit** has more than one resistor *(anything that uses electricity to do work)* and
- Charges must move in "series" first going to one resistor then the next.
- If one of the items in the circuit is broken then no charge will move through the circuit because there is only one path.
- There is no alternative route



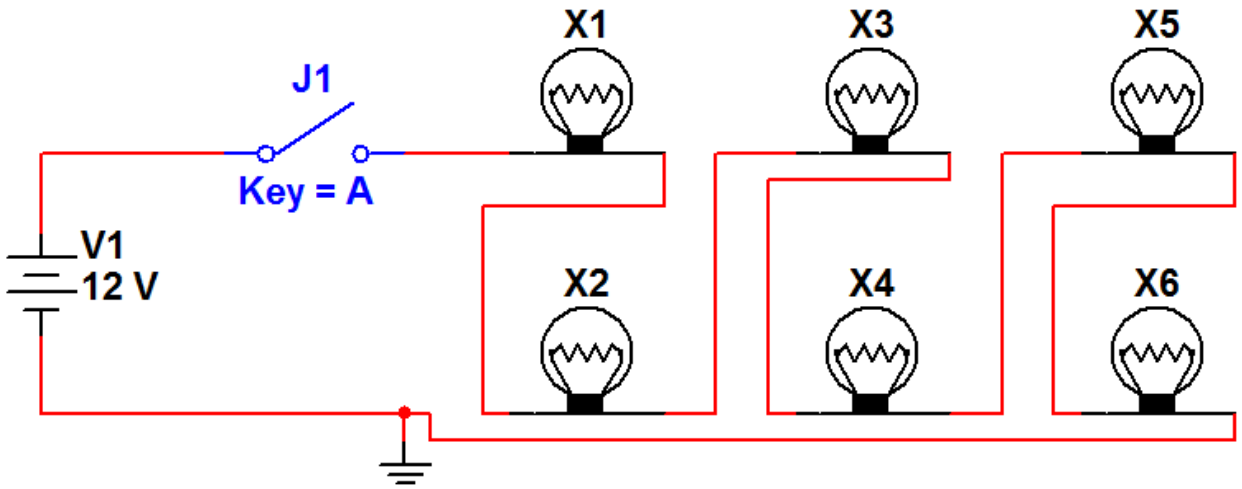




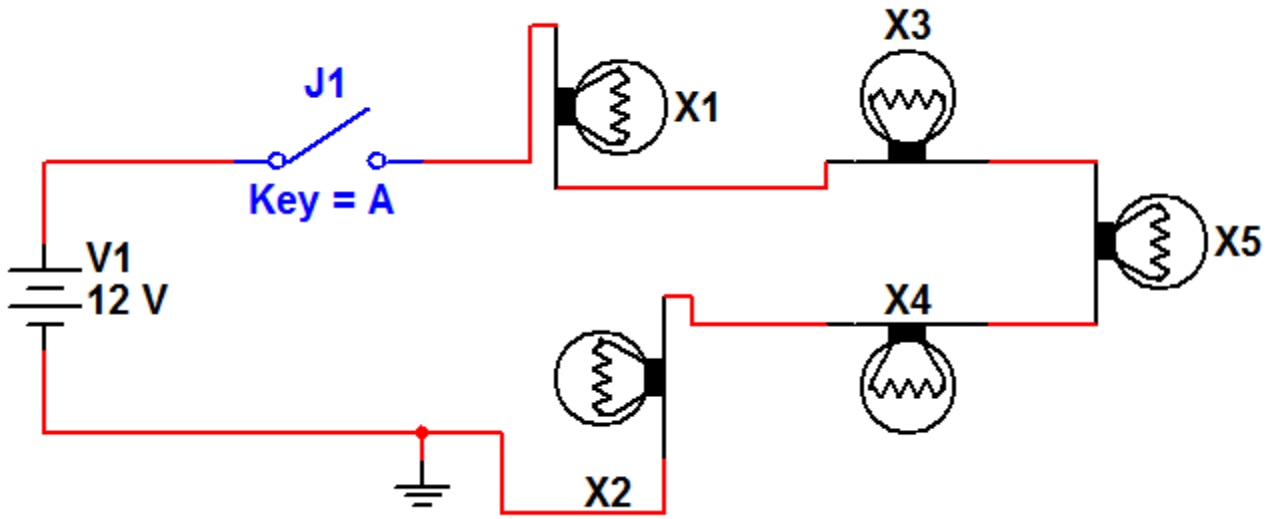
Series circuit 1



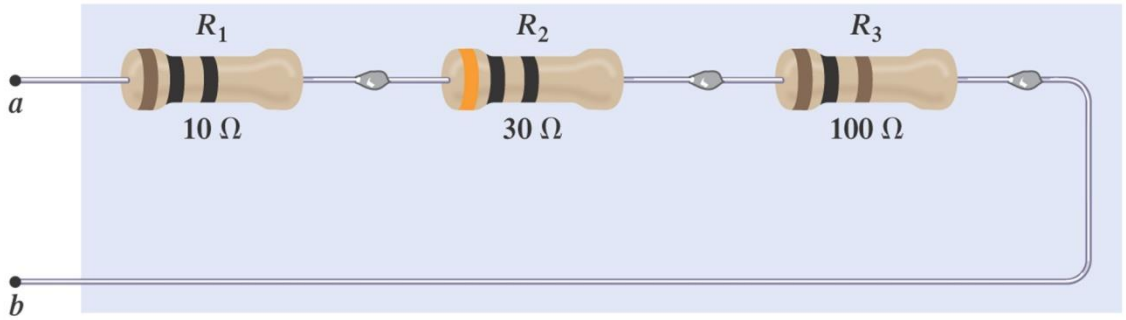
Series circuit 2

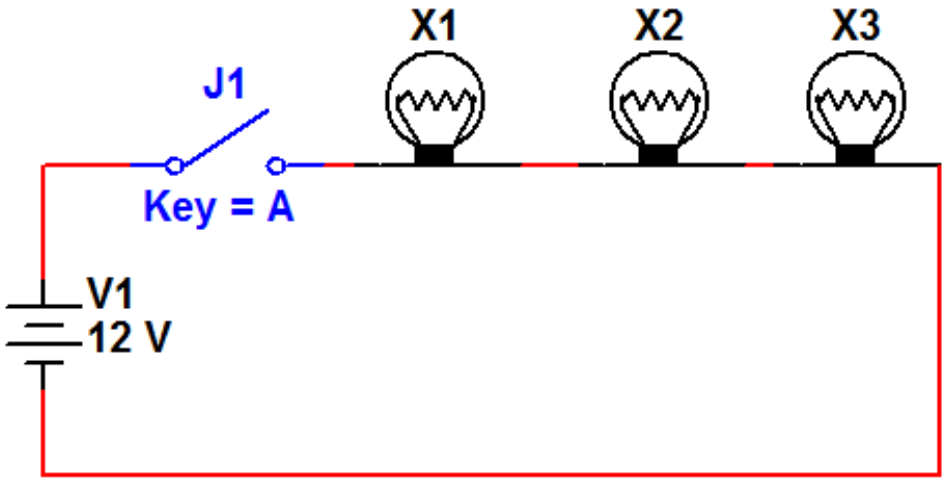


Series circuit 3



Series connection of resistors and lamps.

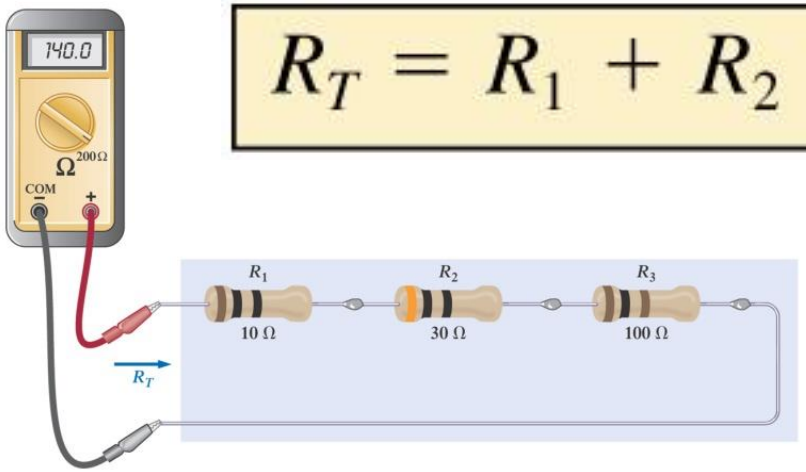


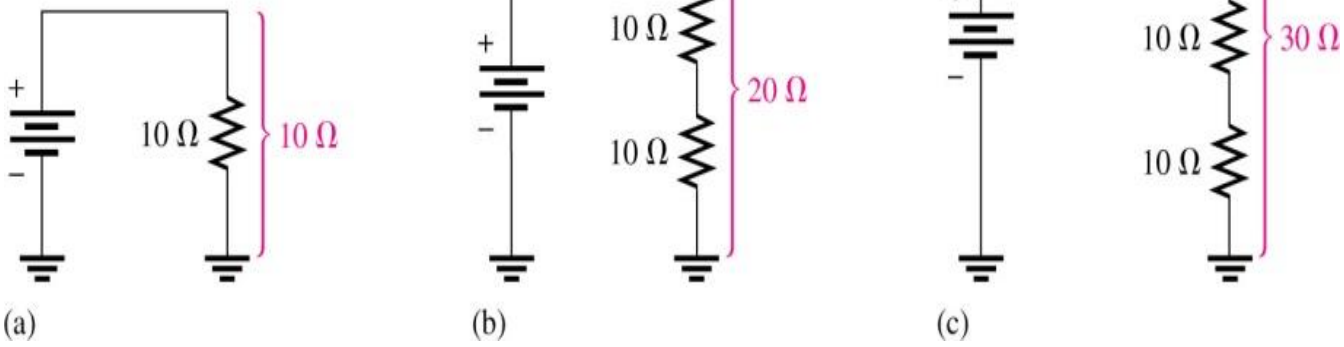


Total Series Resistance

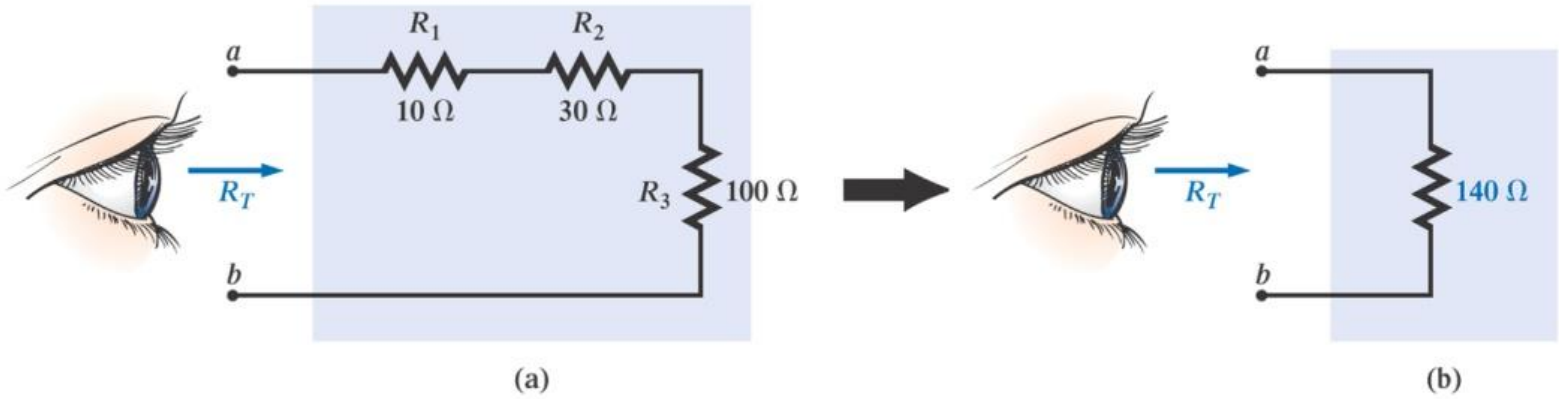
The total resistance of a series circuit is equal to the sum of the resistances of each individual series resistor.

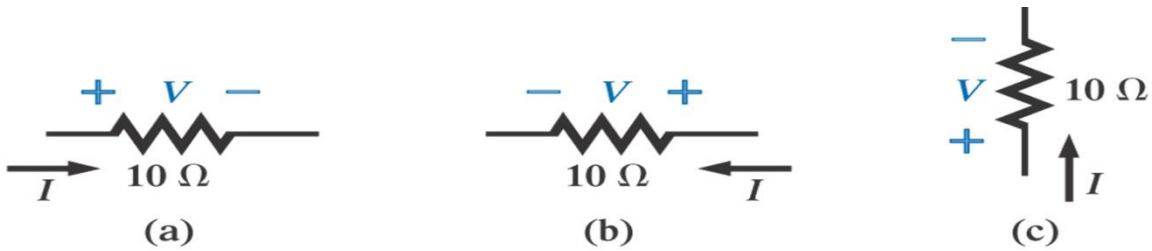
$$R_T = R_1 + R_2 + R_3 + R_4 + \cdots + R_N$$





Resistance "seen" at the terminals of a series circuit, R_T.

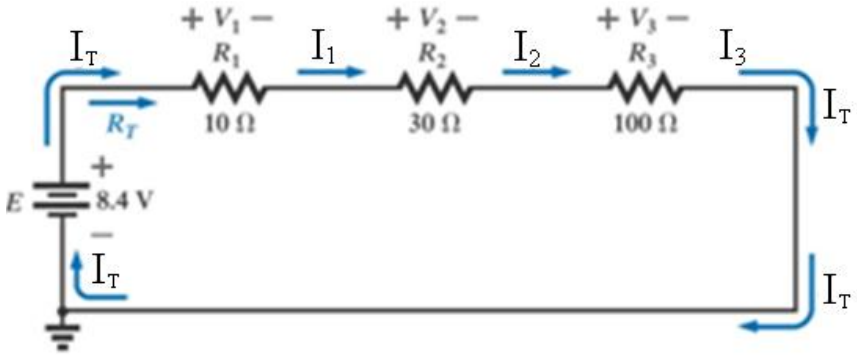




The polarities across a resistor as determined by the direction of the current

Ohm's Law in Series Circuits

- Current through one of the series resistor is the same as the current through each of the other resistors and is the total current.



$$I_T = I_1 = I_2 = I_3$$

Ohm's Law in Series Circuits

- If you know the total voltage and the total resistance, you can determine the total current by using:

$$I_T = \frac{V_T}{R_T}$$

$$V_T = V_1 + V_2 + V_3 = E$$

$$R_t = R_1 + R_2 + R_3$$

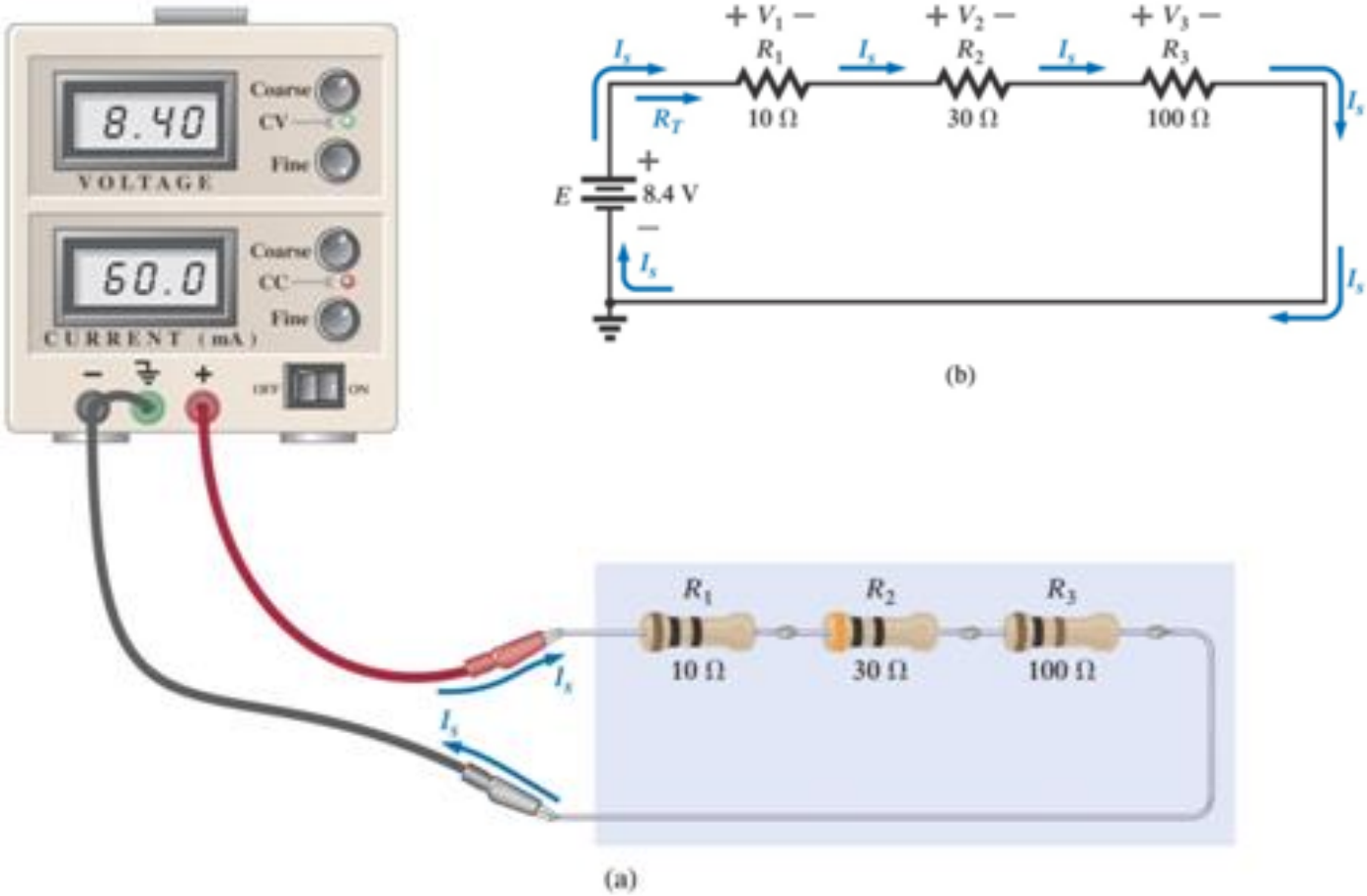
Ohm's Law in Series Circuits

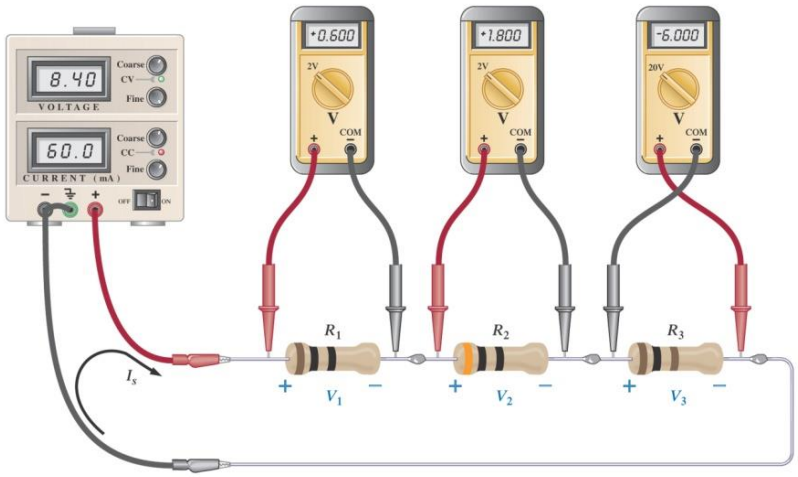
- If you know the voltage drop across one of the series resistors, you can determine the current by using:

$$I_T = I_1 = I_2 = I_3$$

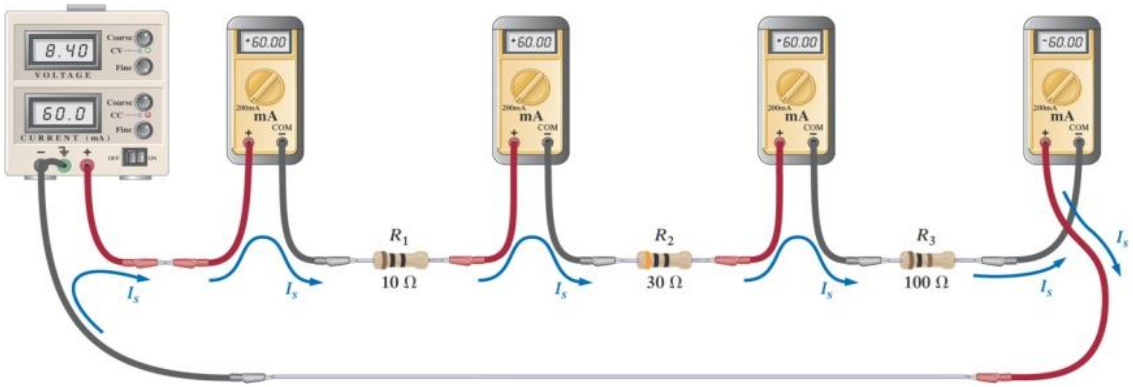
$$I = \frac{V_1}{R_1} = \frac{V_2}{R_2} = \frac{V_3}{R_3} = \frac{V_T}{R_T}$$

Applying a laboratory dc supply set at 8.4 V to the series circuit of (a) actual circuit; (b) schematic representation showing that the current is the same at every point.



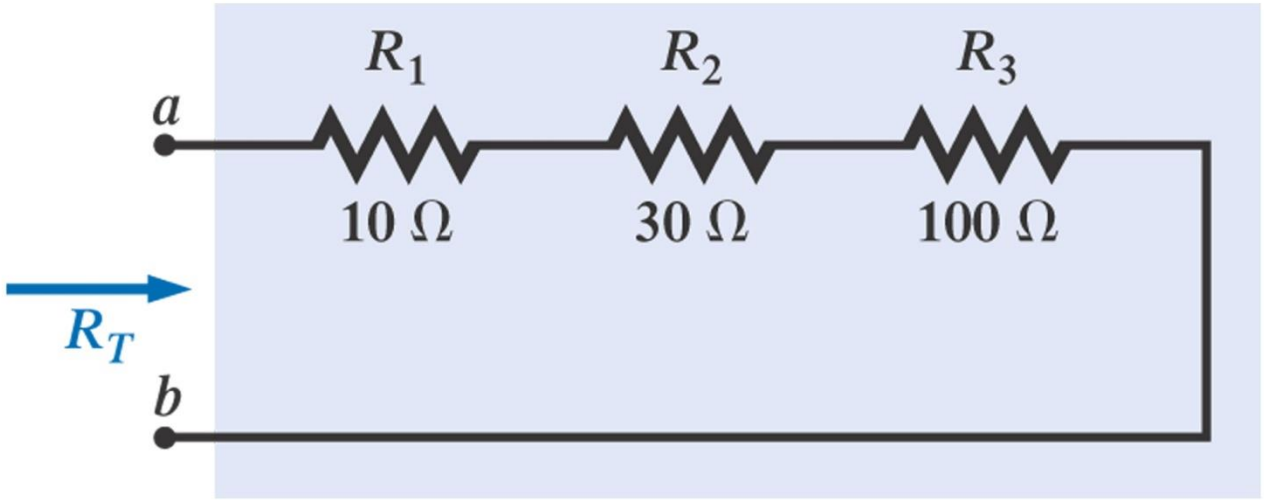


Measuring voltage

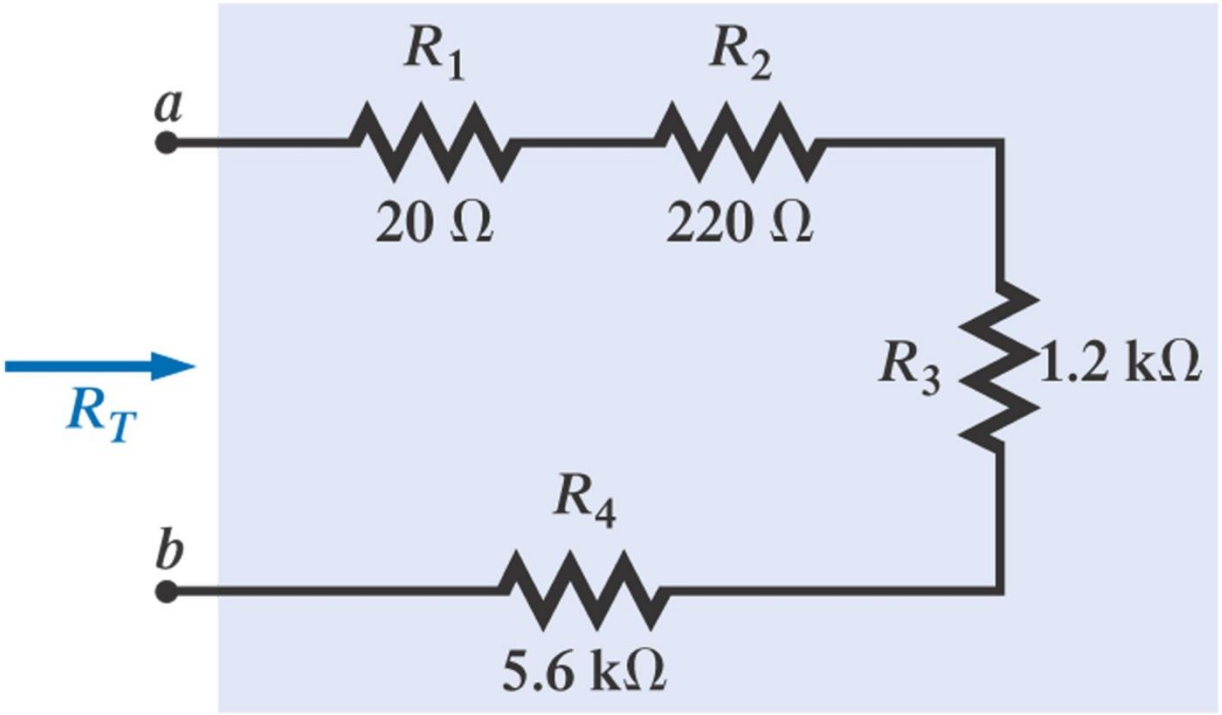


Measuring current

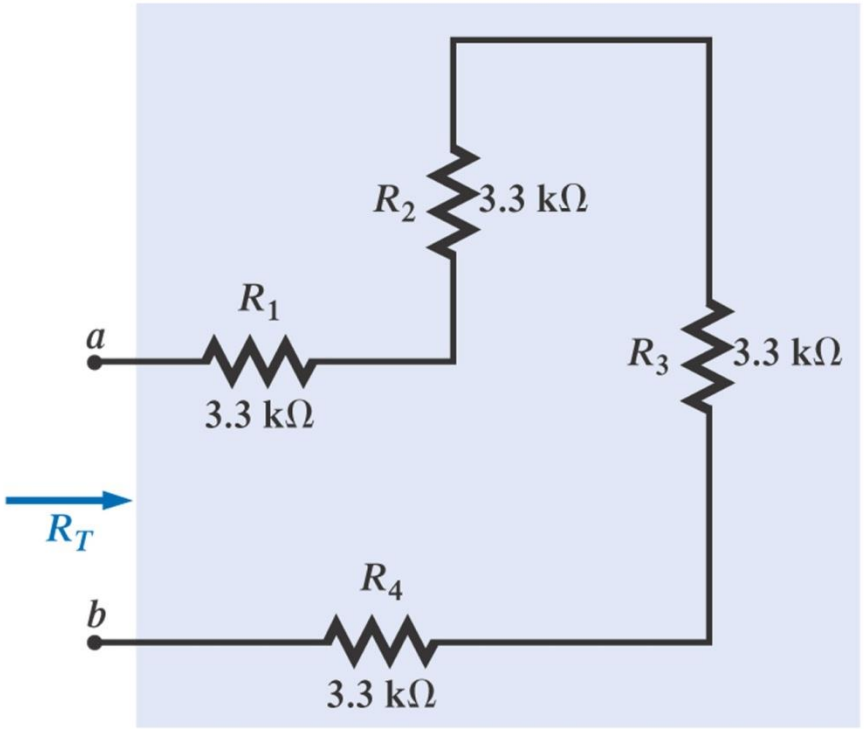
Example: Find R_T



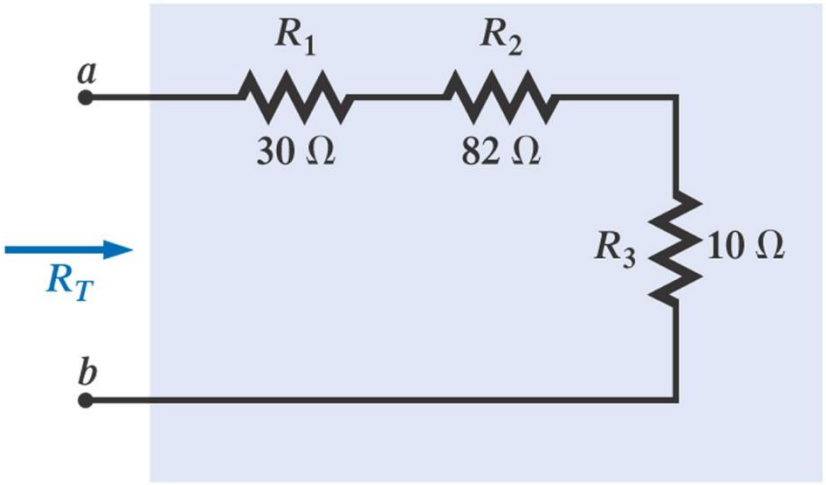
Example: Find R_T



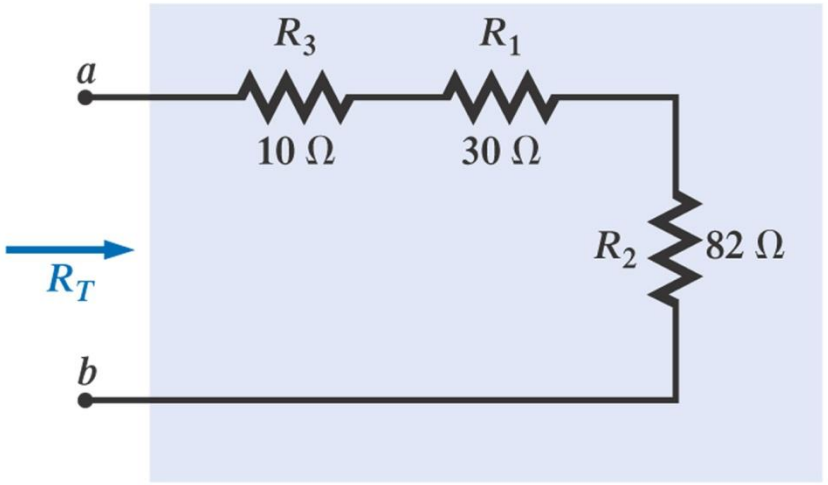
Example: Find R_T



Example: Find R_T

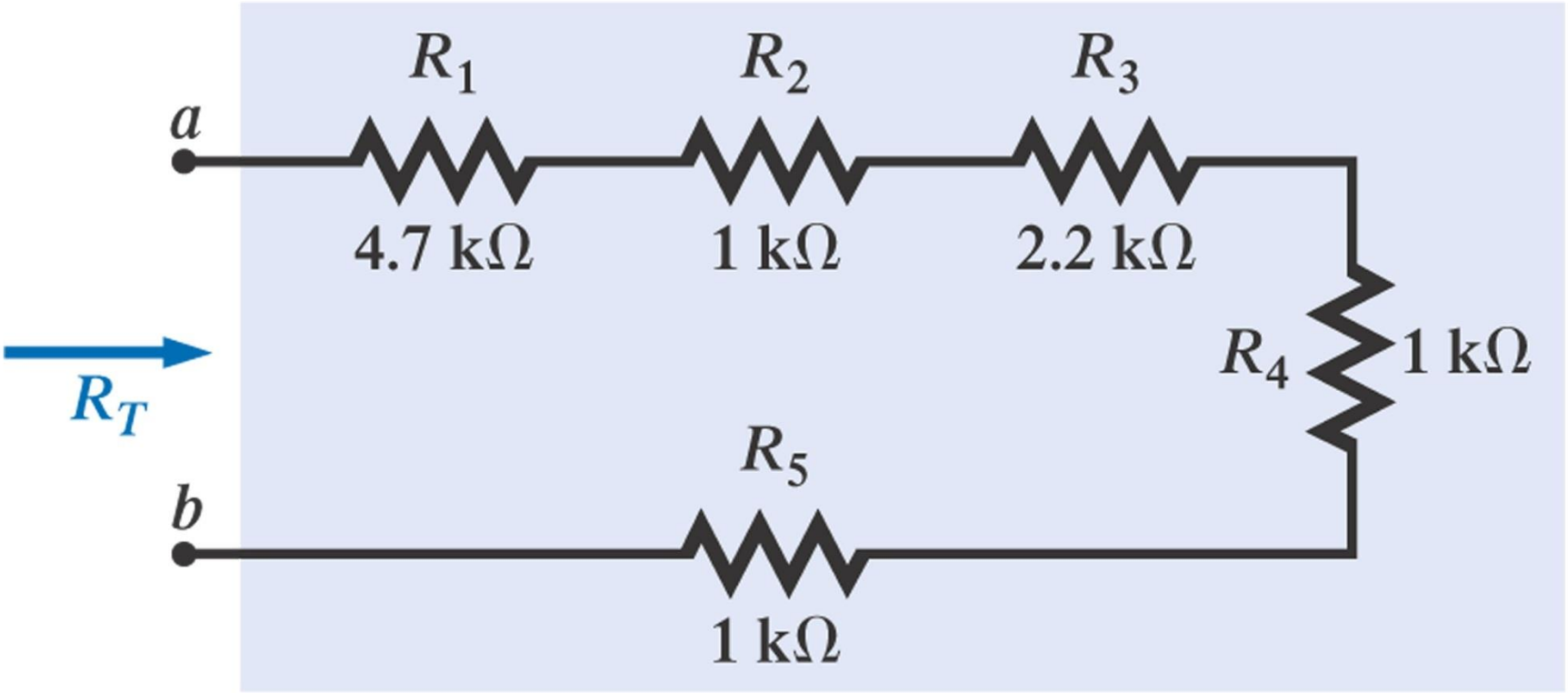


(a)

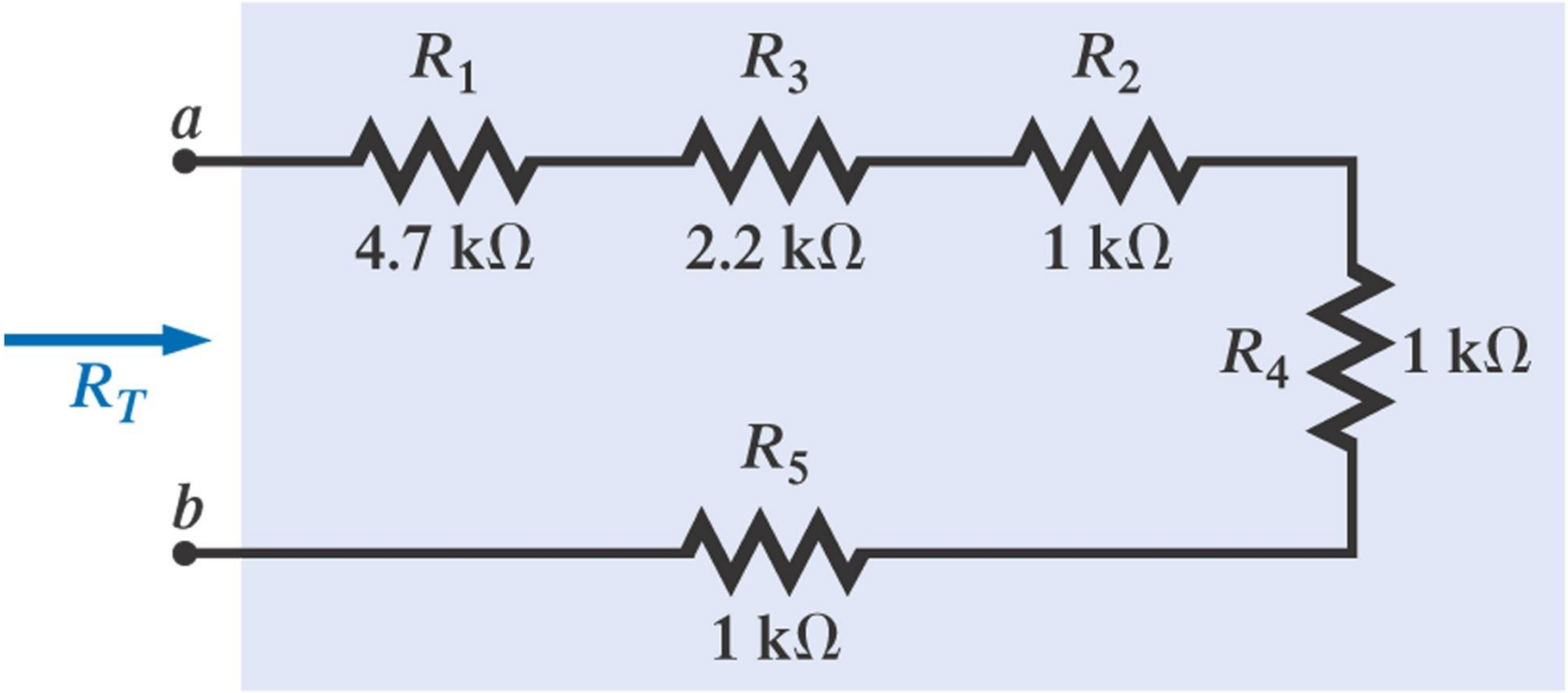


(b)

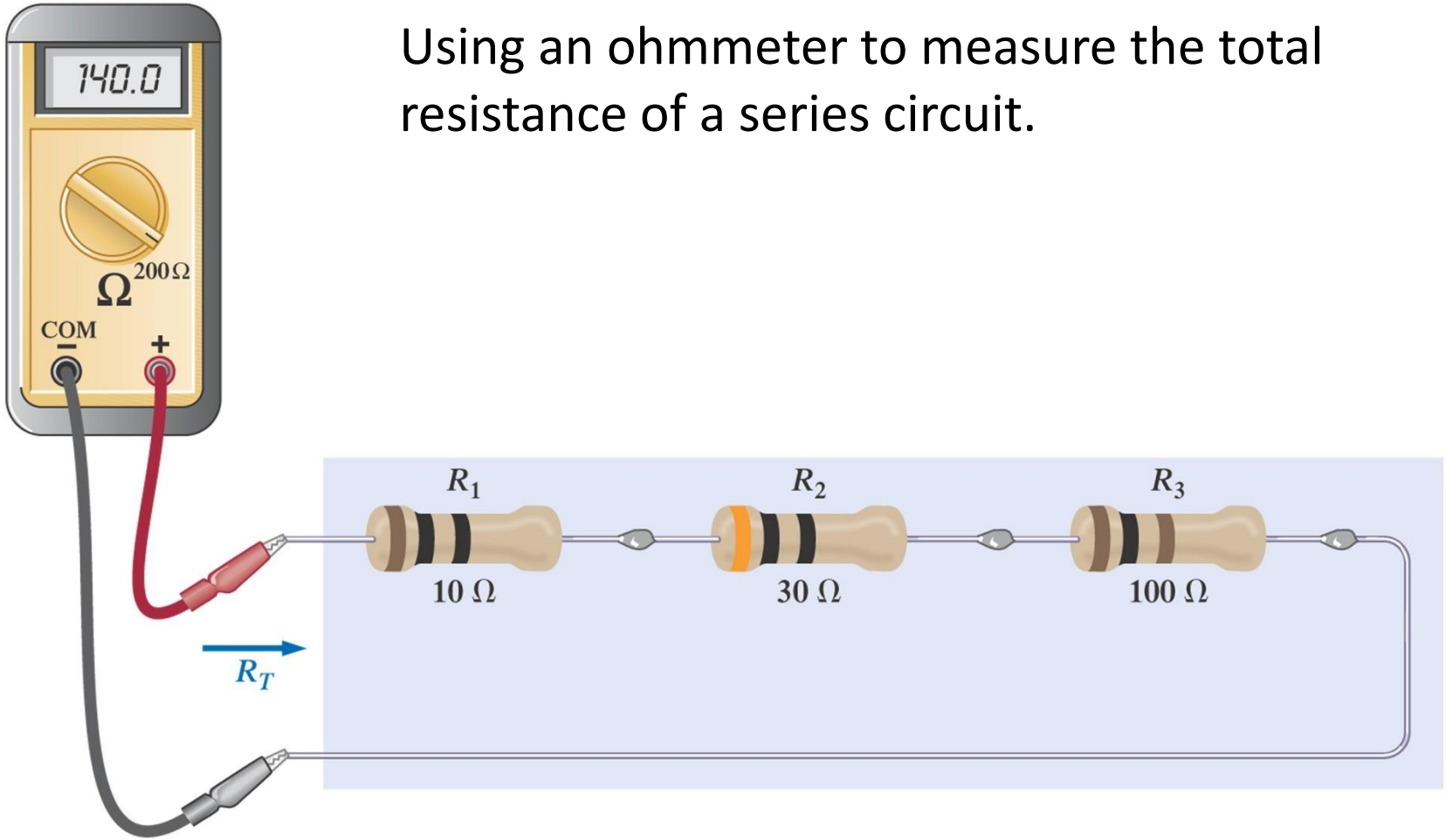
Example: Find R_T



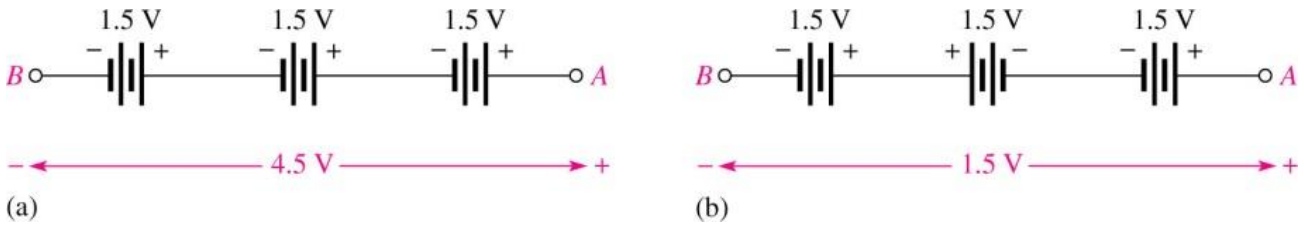
Example: Find R_T



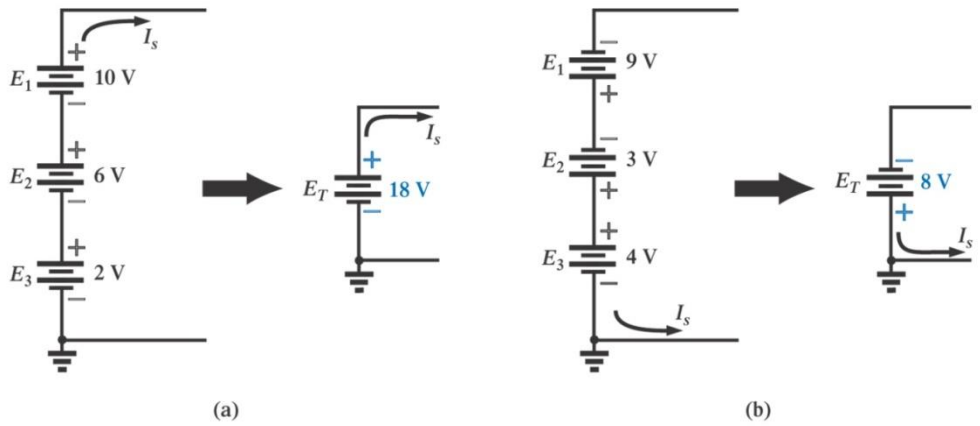
Using an ohmmeter to measure the total resistance of a series circuit.



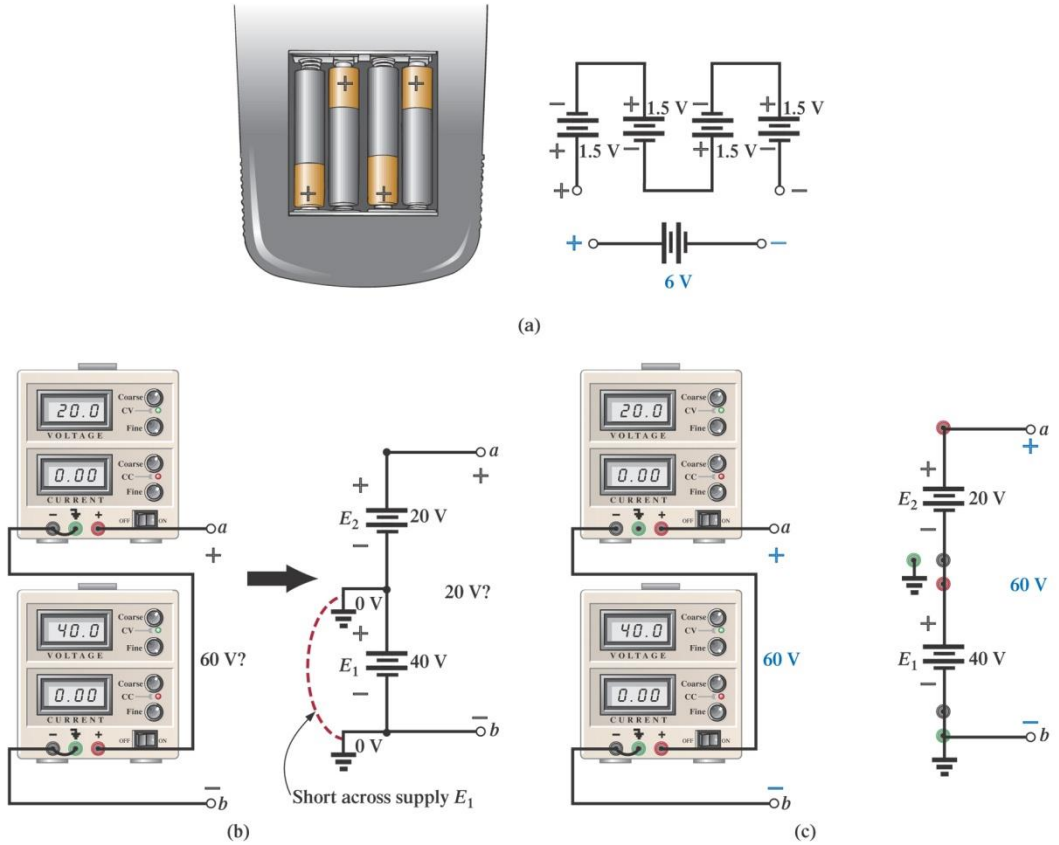
Voltage Sources in Series



When two or more voltage sources are in series, the total voltage is equal to the the algebraic sum (including polarities of the sources) of the individual source voltages.

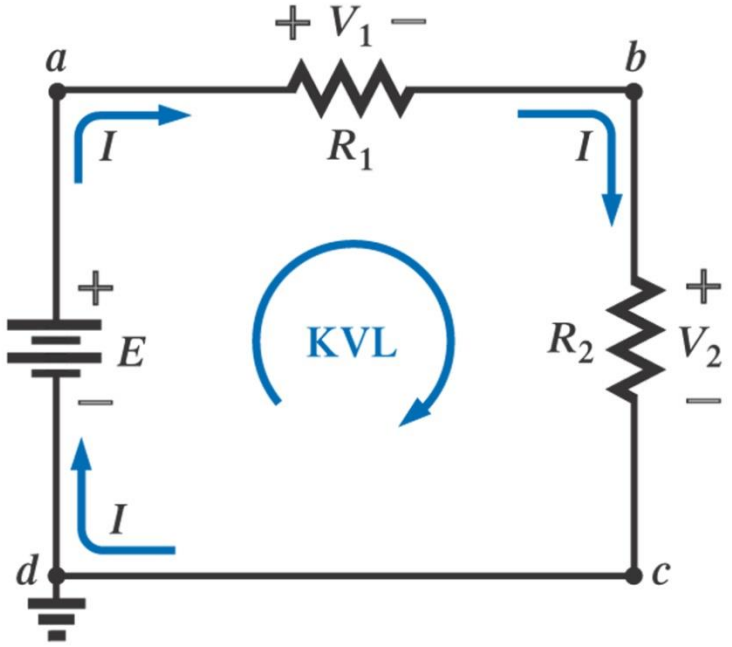


Series connection of dc supplies: (a) four 1.5 V batteries in series to establish a terminal voltage of 6V; (b) incorrect connections for two series dc supplies; (c) correct connection of two series supplies to establish 60 V at the output terminals.



Kirchhoff's Voltage Law

- The algebraic sum of the potential rises and drops around a closed path (or loop) is zero



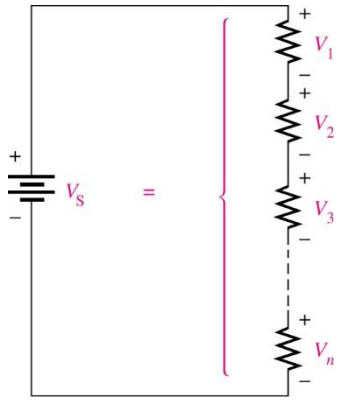
$$\Sigma_{\circlearrowright} V = 0$$

(Kirchhoff's voltage law in symbolic form)

$$0 = E - V_1 - V_2$$

Kirchhoff's Voltage Law

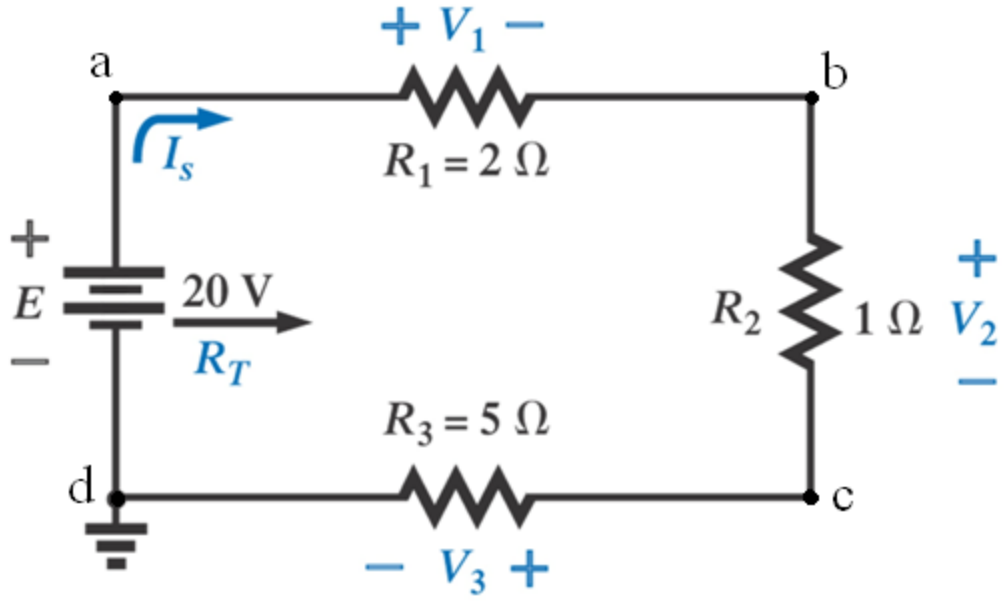
The sum of all the voltage drops around a single closed loop in a circuit is equal to the total source voltage in that loop.



$$\Sigma_{\circlearrowright} V = 0$$

$$V_S = V_1 + V_2 + V_3 + V_4 + \cdots + V_N$$

Example: Series circuit to be analyzed



$$R_T = R_{ab} + R_{bc} + R_{cd}$$

$$R_T = R_1 + R_2 + R_3$$

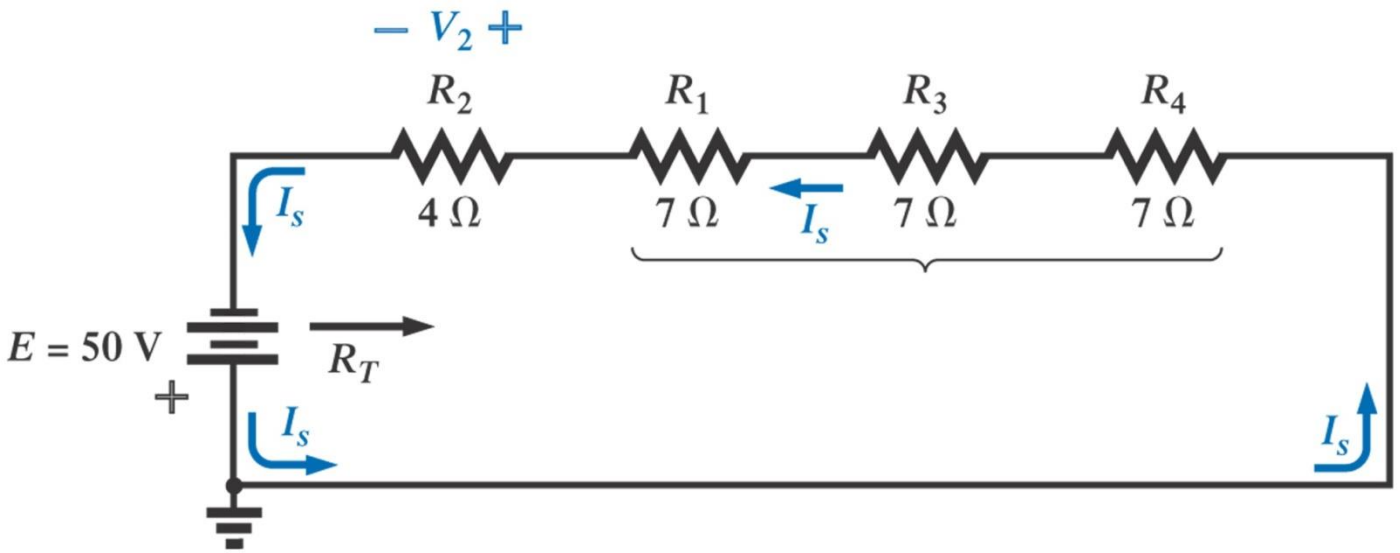
$$R_T = R_{da} = R_{ad}$$

$$0 = V_{ab} + V_{bc} + V_{cd} + V_{da}$$

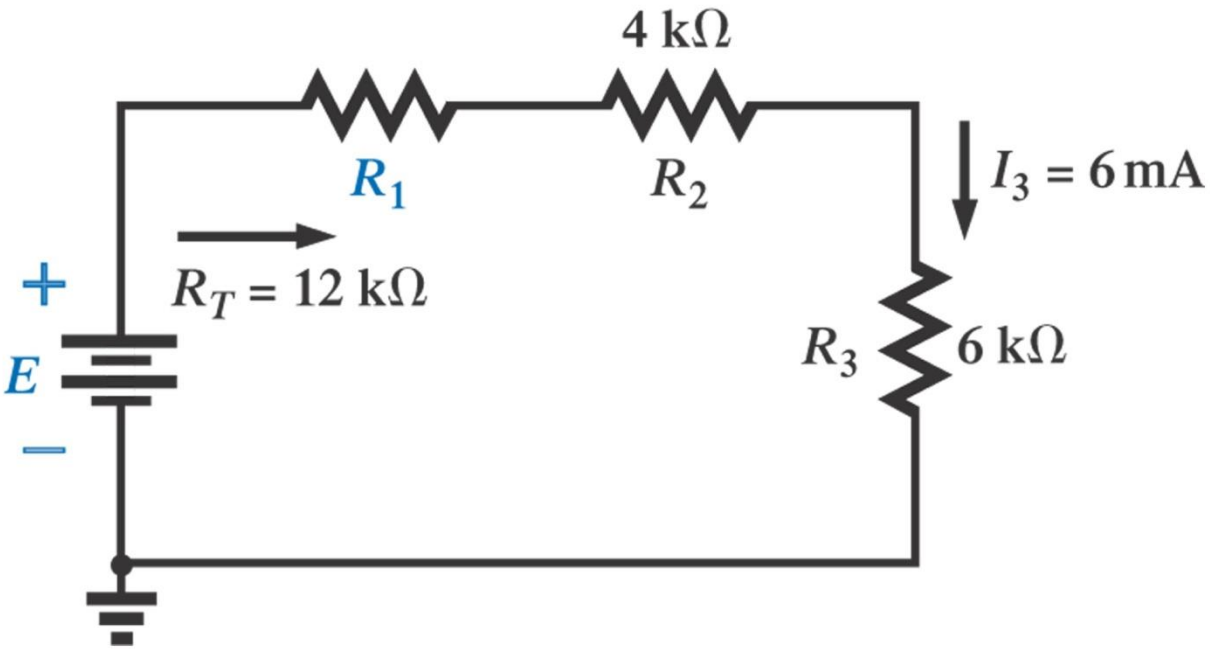
$$0 = V_1 + V_2 + V_3 - E$$

$$V_{ab} = V_a - V_b = V_1$$

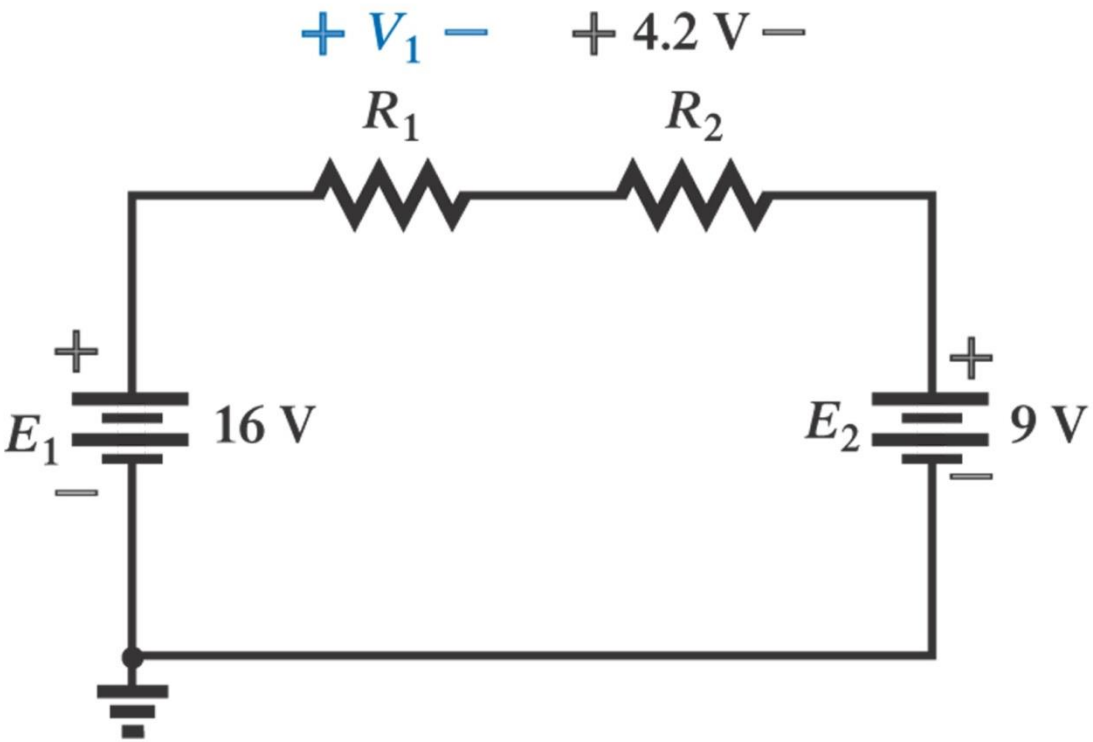
Example: Series circuit to be analyzed



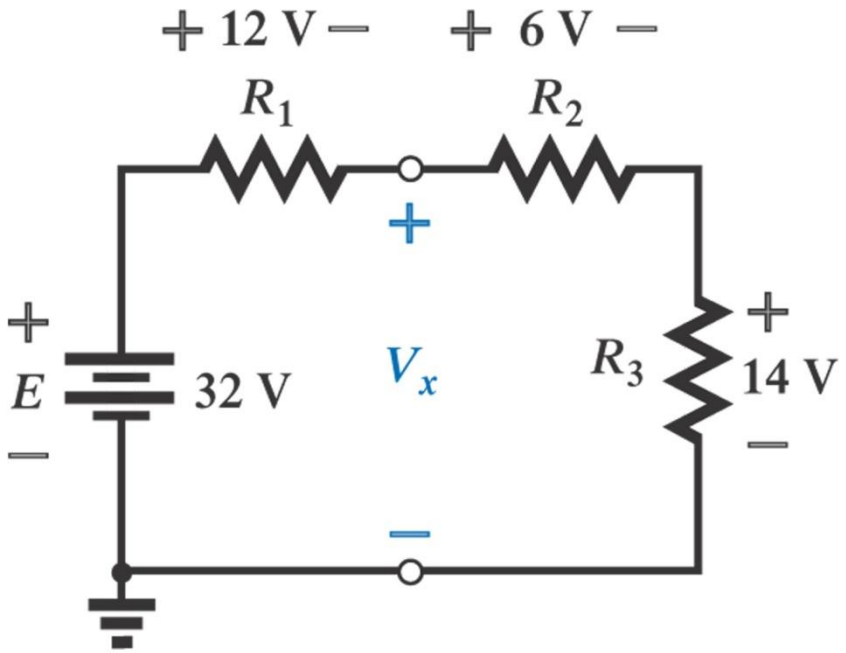
Example: Series circuit to be analyzed



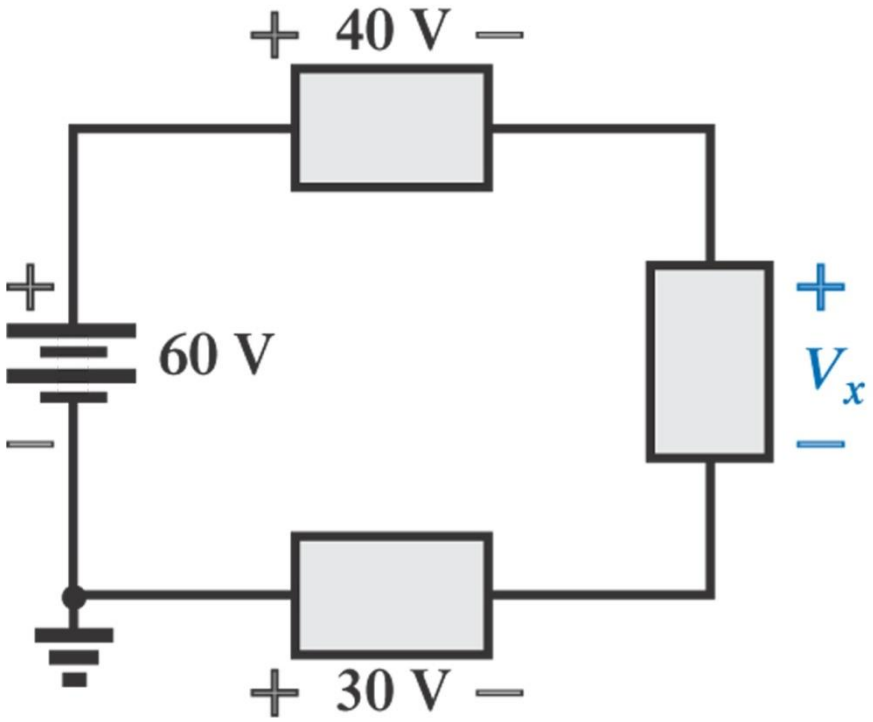
Example: Series circuit to be examined.



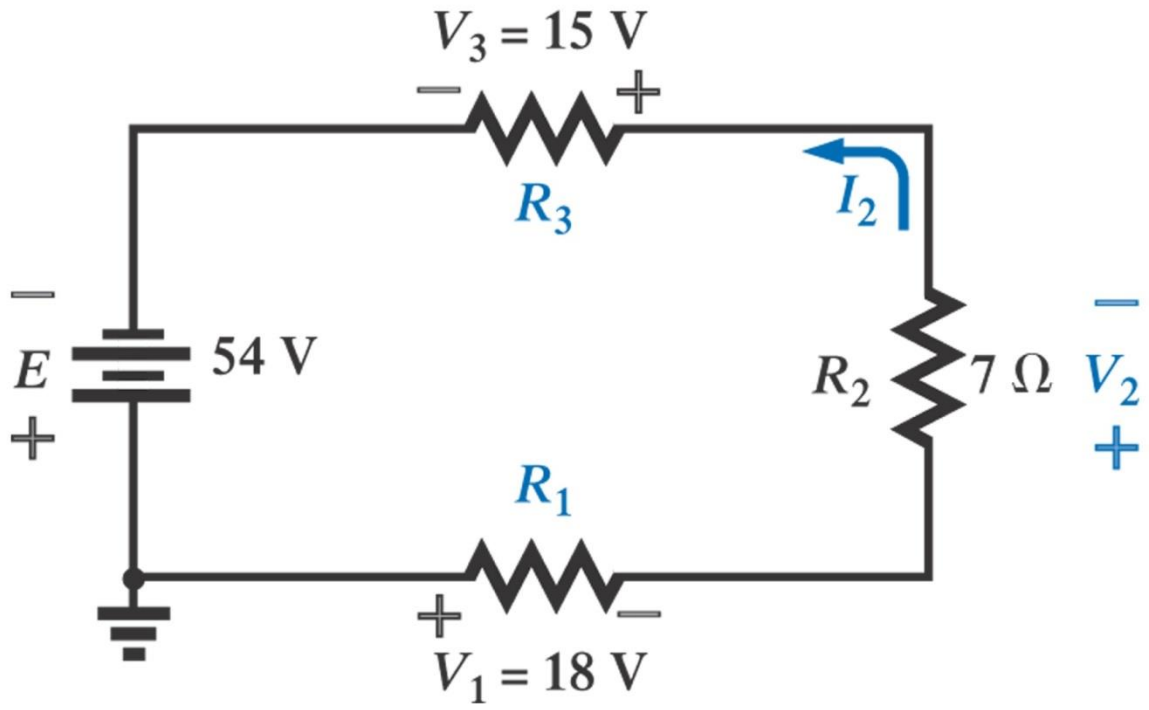
Example: Series dc circuit to be analyzed.



Example: Series configuration to be examined.



Example: Series configuration to be examined.



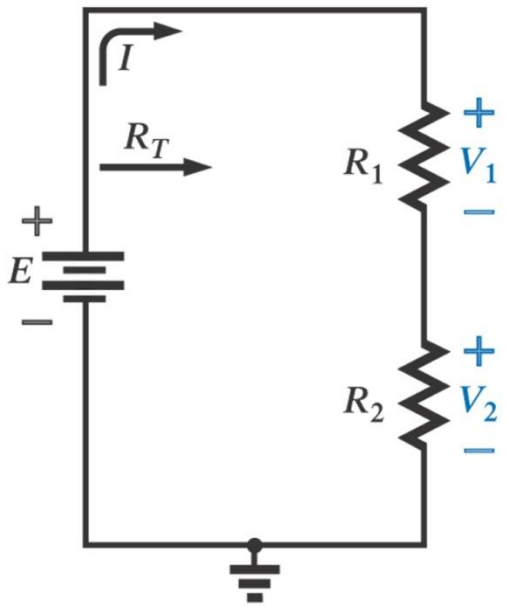
Voltage-Divider Rule

- The voltage across a resistor in a series circuit is equal to the value of that resistor times the total voltage applied, divided by the total resistance of the series configuration

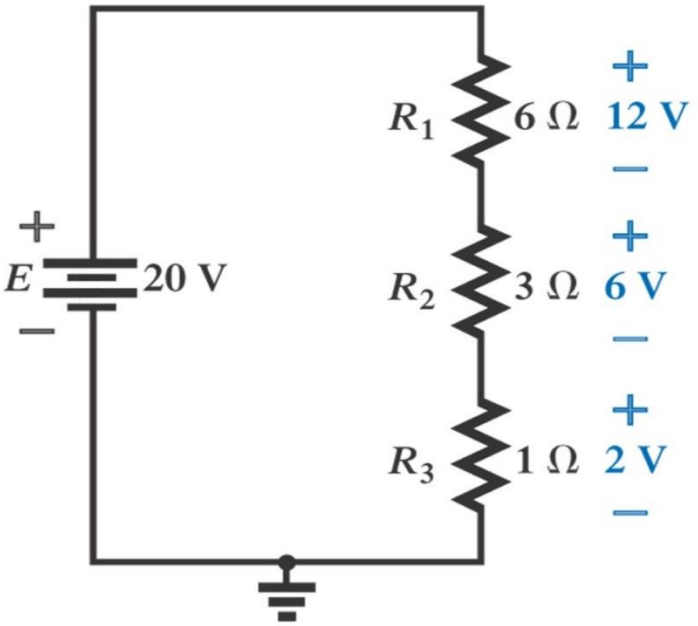
$$I = \frac{V_1}{R_1} = \frac{V_2}{R_2} = \frac{V_T}{R_T} = \frac{E}{R_T}$$

$$V_2 = R_2 \frac{E}{R_T}$$

$$V_x = R_x \frac{E}{R_T}$$



- How the voltage will divide across series resistive elements.
- The ratio of the resistive values determines the voltage division of a series dc circuit.

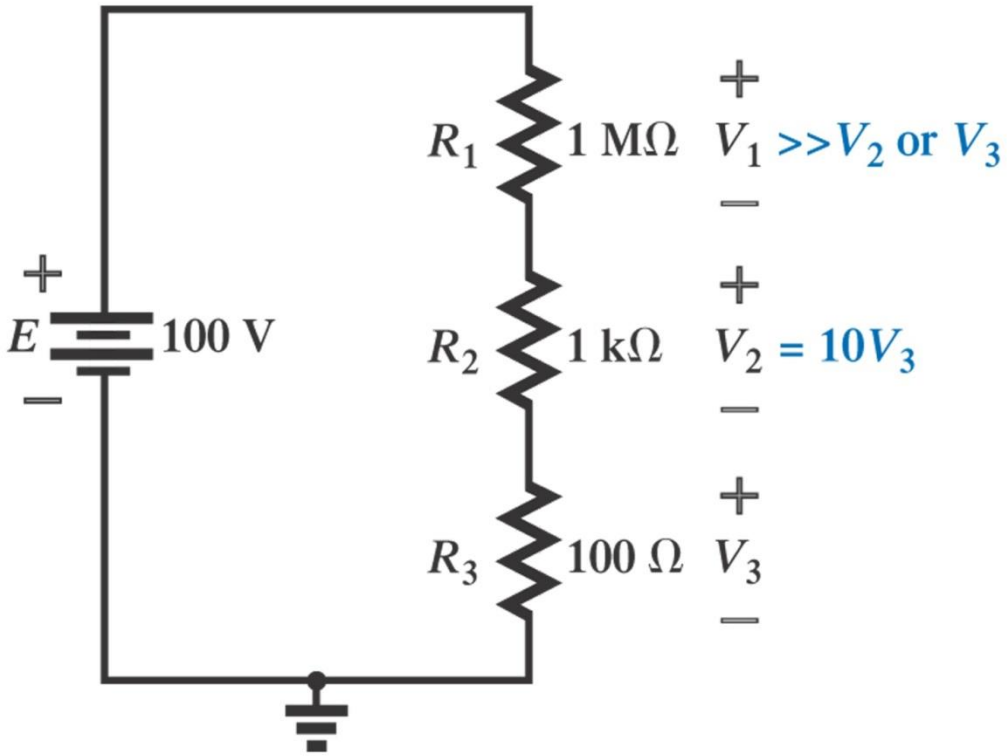


$$I = \frac{E}{R_T}$$

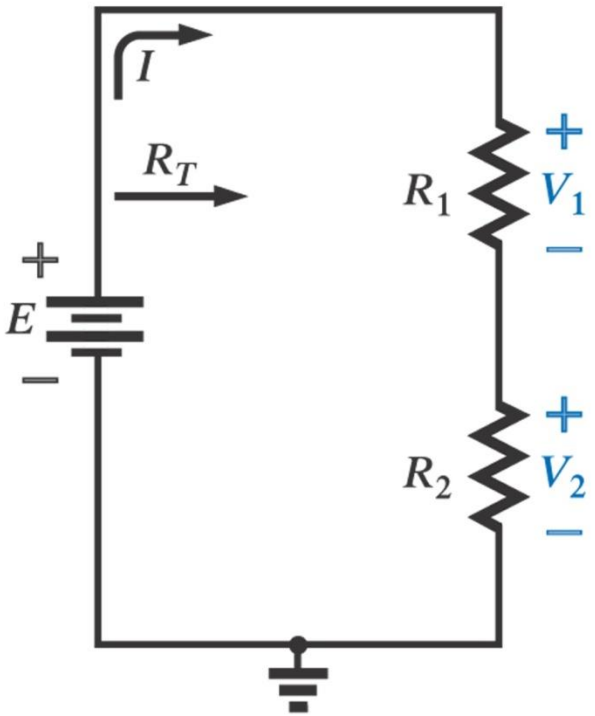
$$I = \frac{V_1}{R_1} = \frac{V_2}{R_2}$$

$$V_x = R_x \frac{E}{R_T}$$

The **largest** of the **series resistive** elements will capture the **major share** of the applied voltage.



Example: Developing the voltage divider rule.



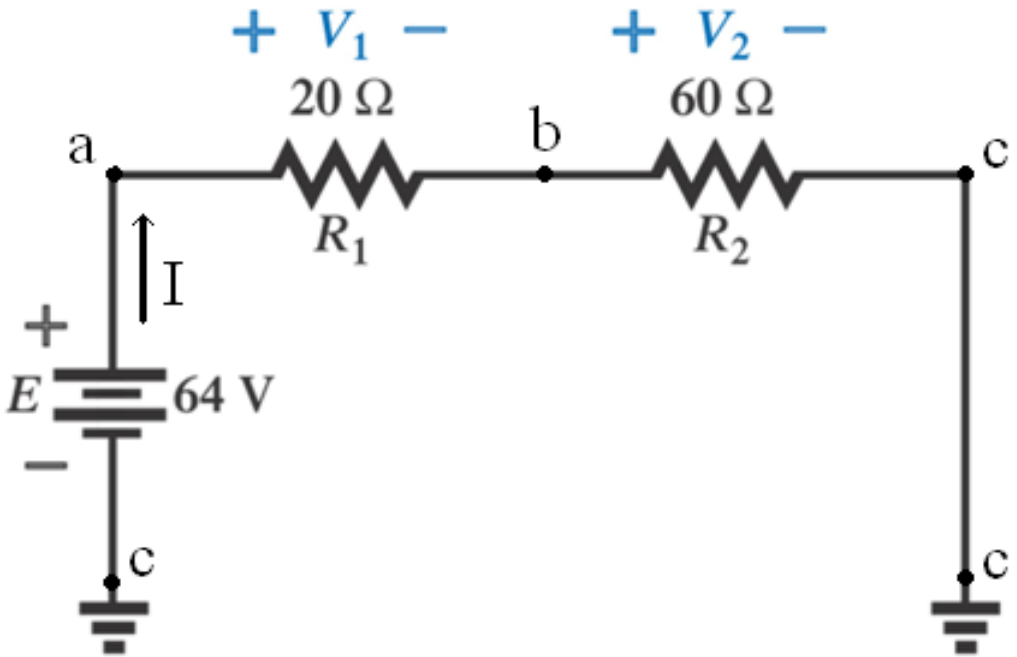
$$I = \frac{E}{R_T}$$

$$I = \frac{V_1}{R_1} = \frac{V_2}{R_2}$$

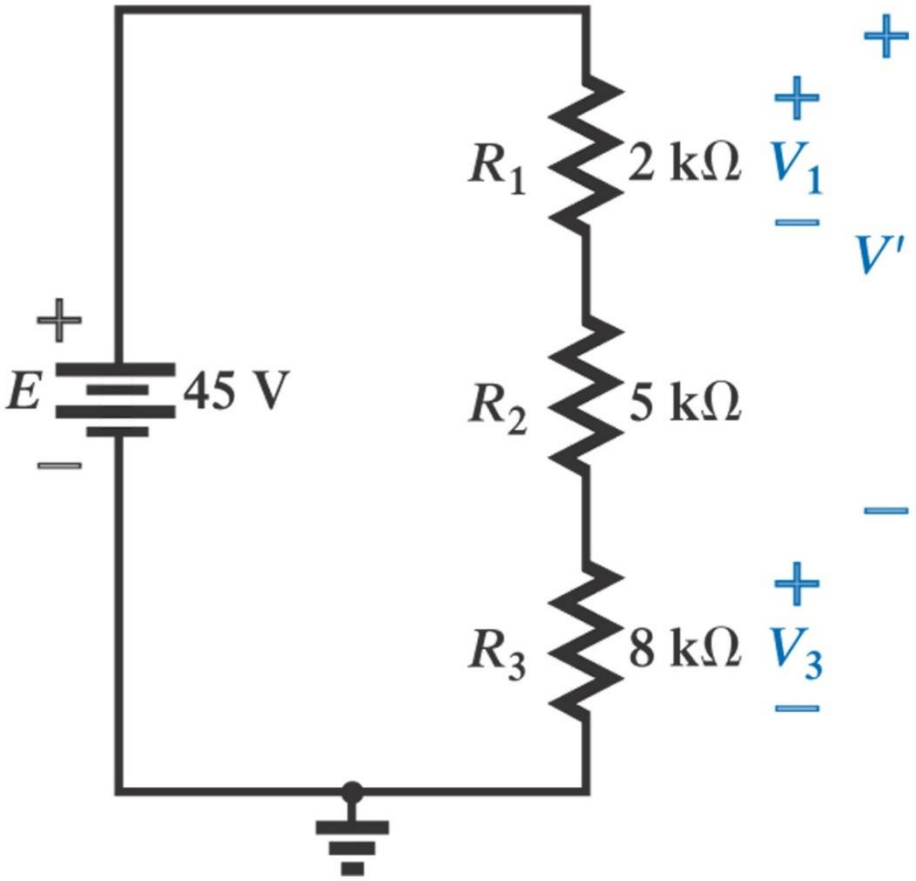
$$V_x = R_x \frac{E}{R_T}$$

Example:

In the series circuit, find V_1 & V_2 using the voltage divider rule.



Example: Series circuit to be investigated.

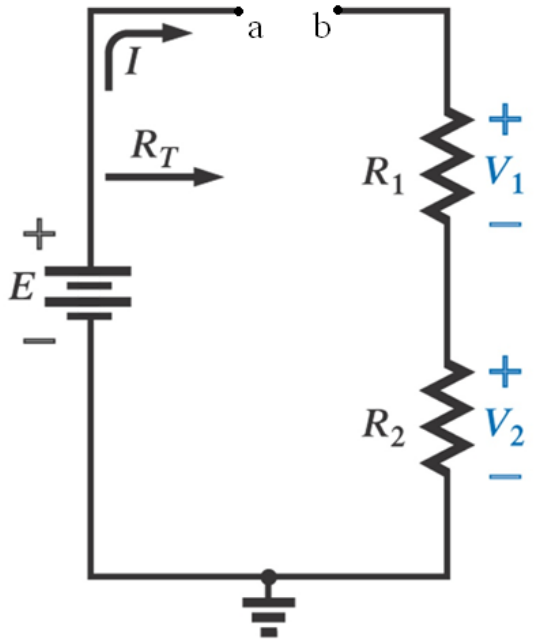


Open Circuit

$$I_T = I_1 = I_2 = 0$$

$$E = V_{ab} + V_1 + V_2$$

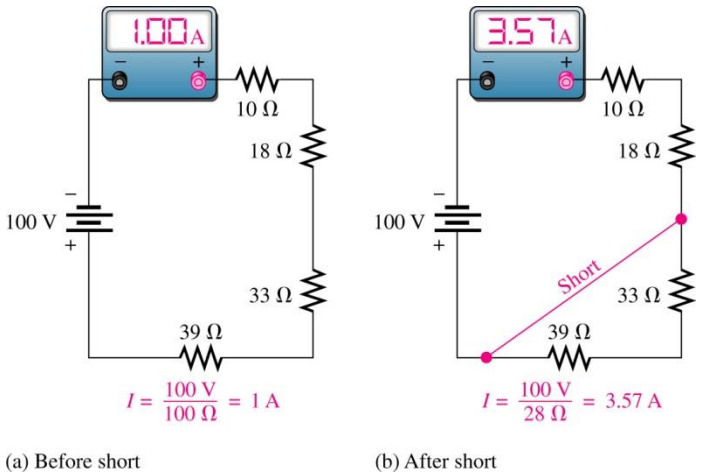
$$E = V_{ab} + 0 + 0$$



- The most common failure in a series circuit is an open.
- When an open occurs in a series circuit, all of the source voltage appears across the open.

Short Circuit

- When there is a short, a portion of the series resistance is bypassed, thus reducing the total resistance.
- A short in a series circuit results in more current than normal.



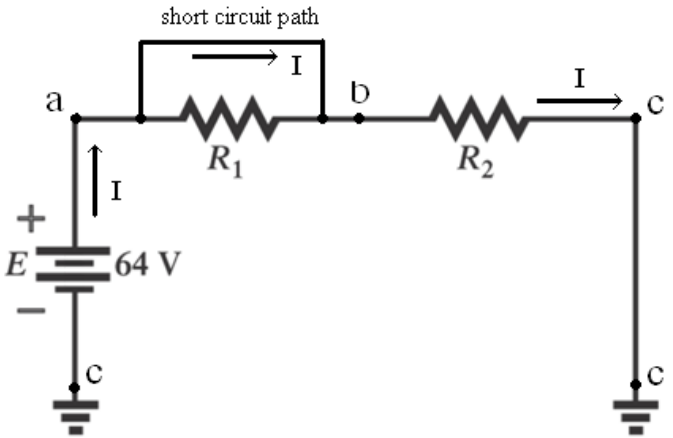
Short Circuit

$$V_{ab} = V_a - V_b = V_{R1}$$

$$short\ circuit: V_a = V_b$$

$$V_a - V_b = V_{ab} = 0$$

$$I_{R1} = 0$$



all the current flow along the short circuit path

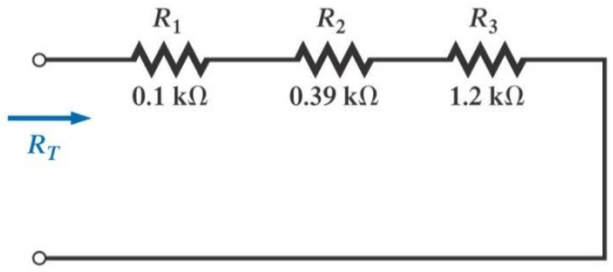
$$0 = E - V_1 - V_2$$

$$0 = E - 0 - V_2$$

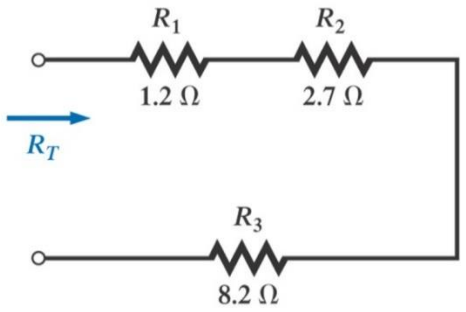
$$E = V_2 = IR_2$$

$$I = \frac{V_2}{R_2} = \frac{E}{R_2}$$

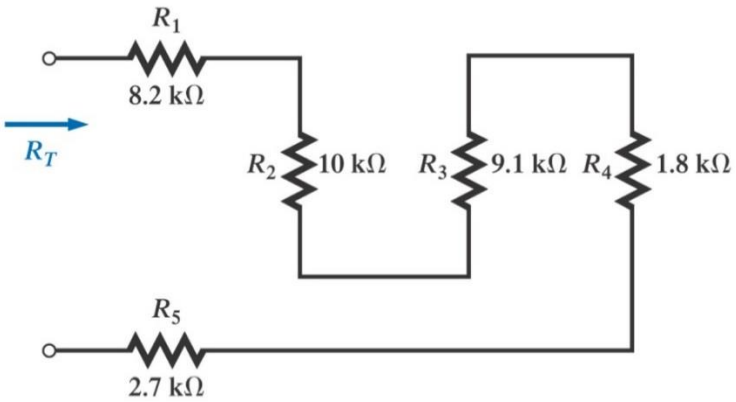
Problem 2 : Determines the measured resistance, R_T



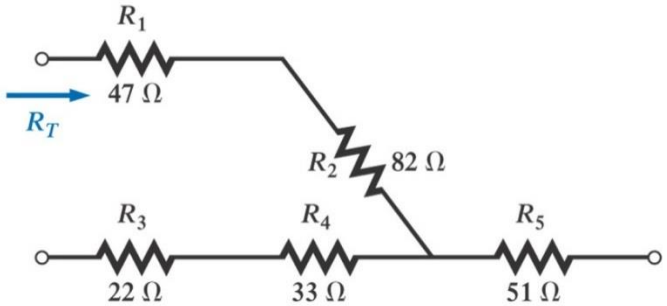
(a)



(b)

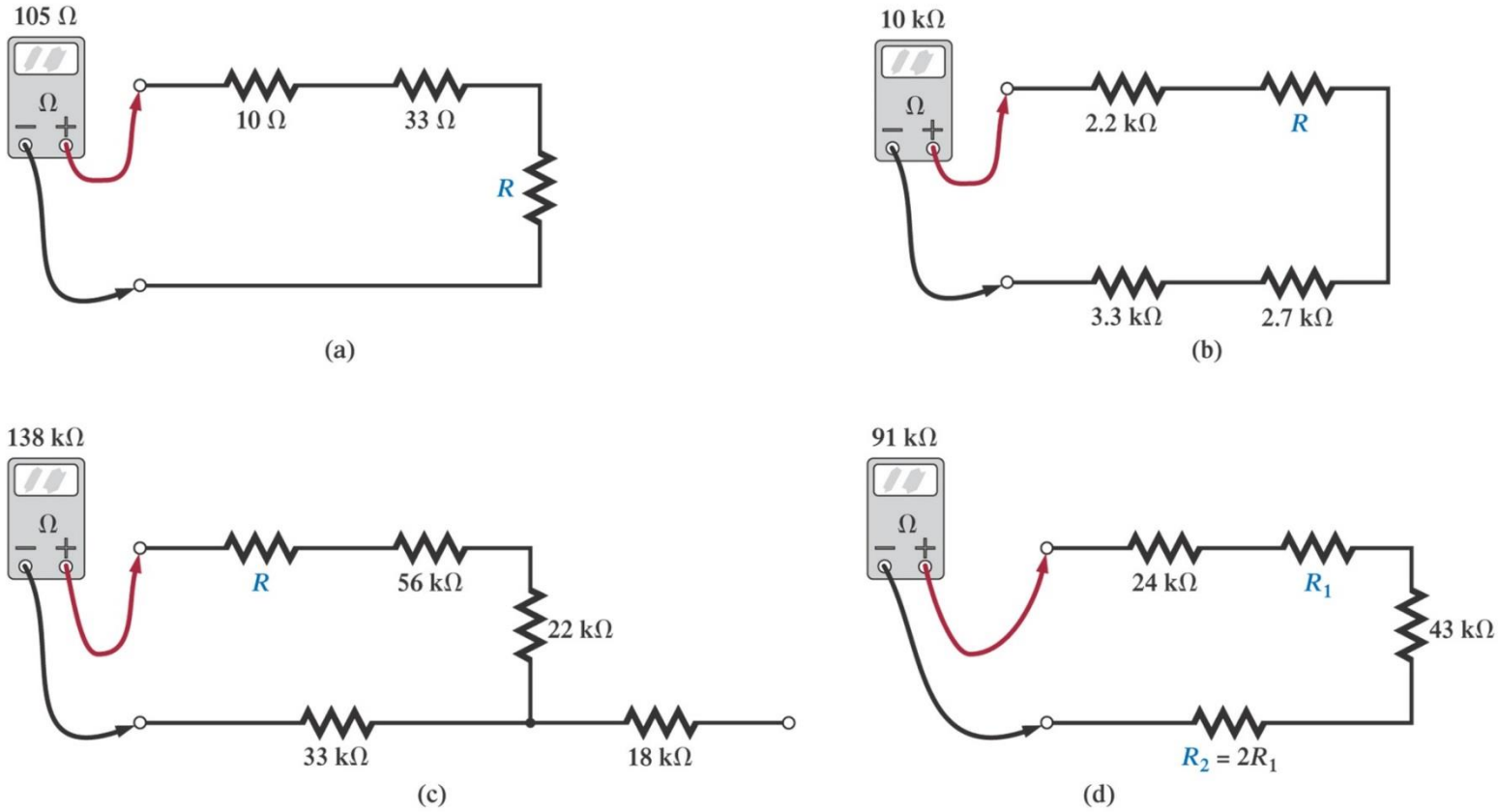


(c)

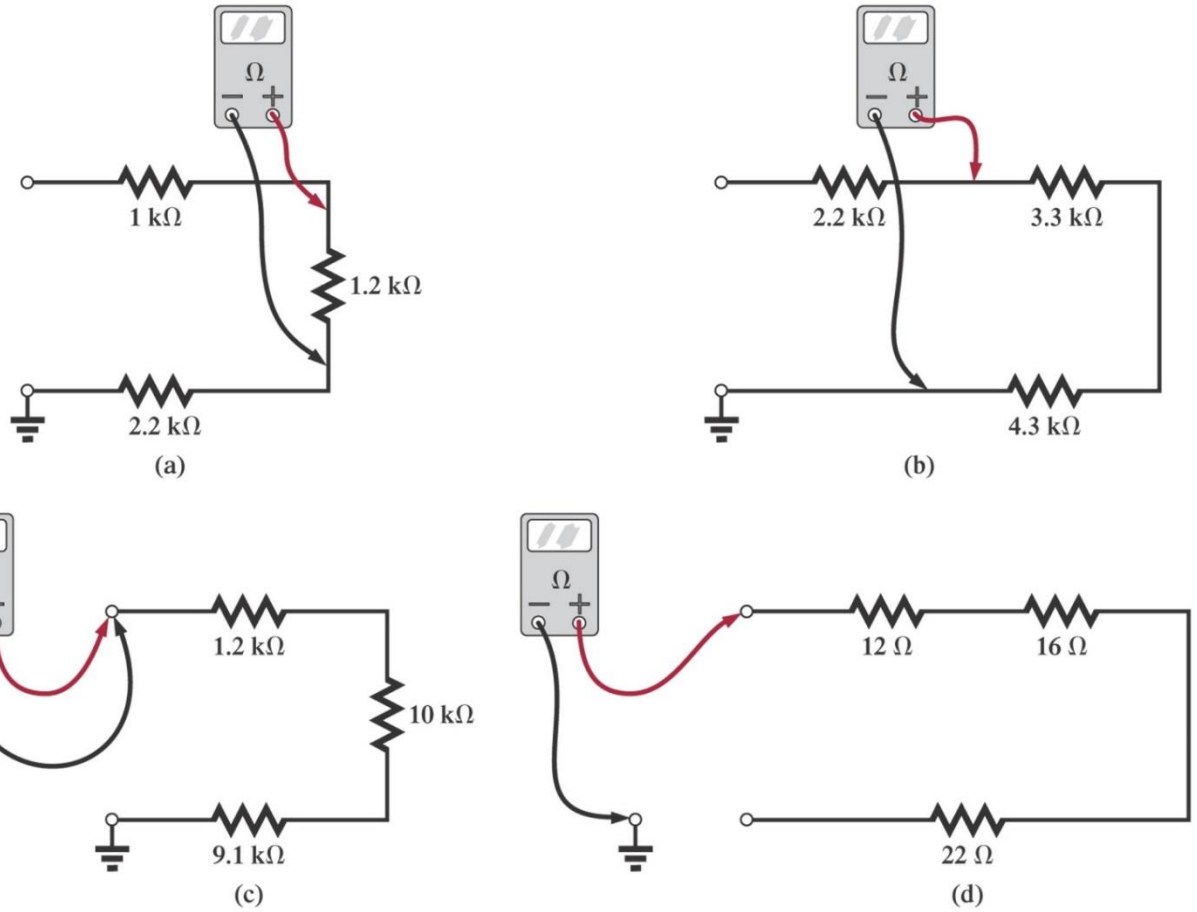


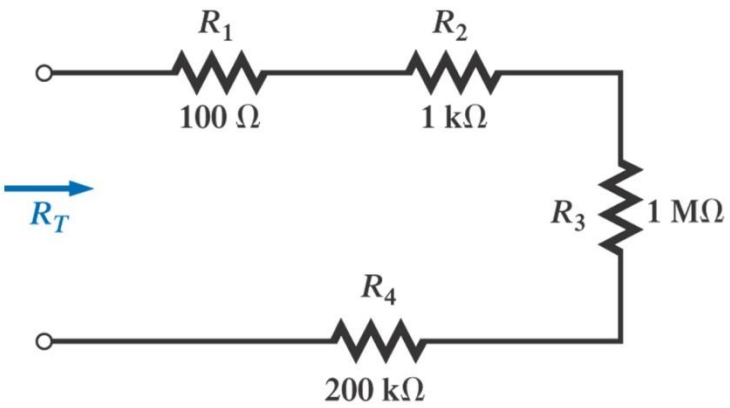
(d)

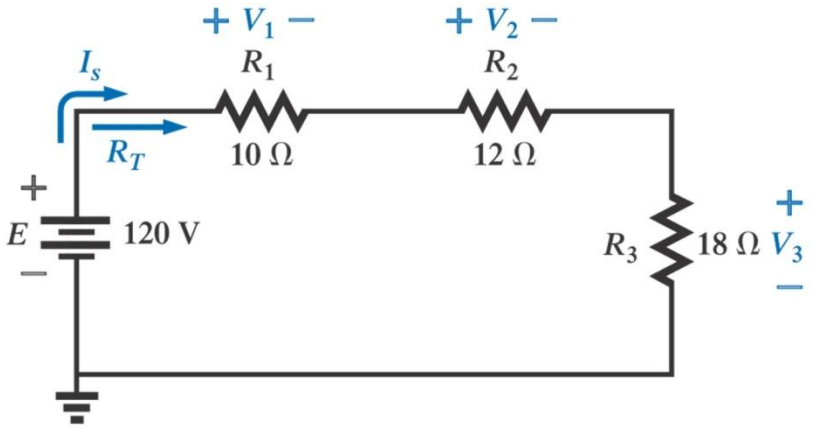
Problem 5 : Determines the unknown resistance

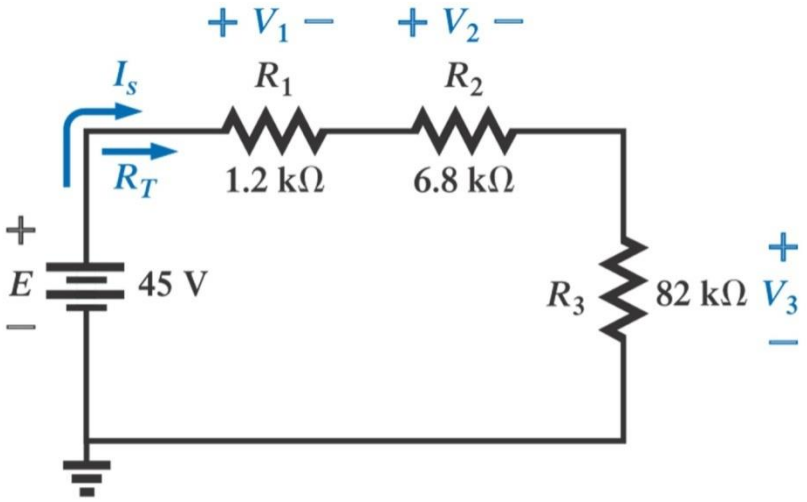


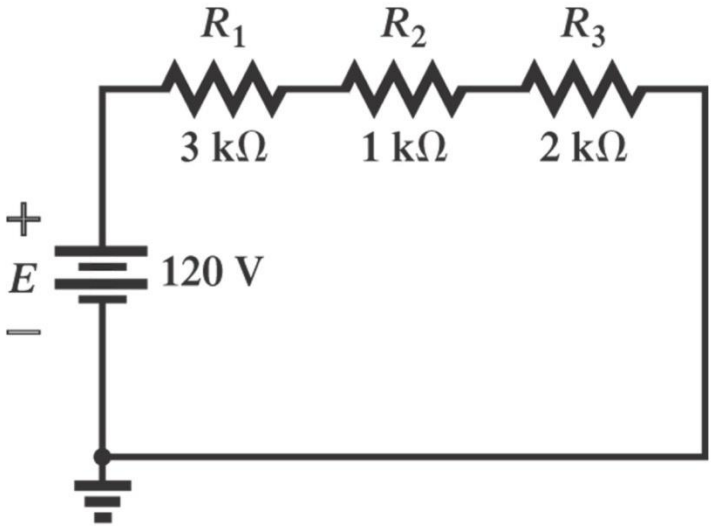
Problem 6 : Determines the measured resistance.

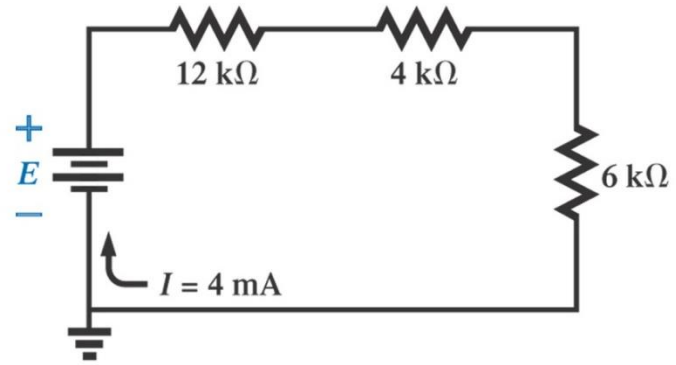




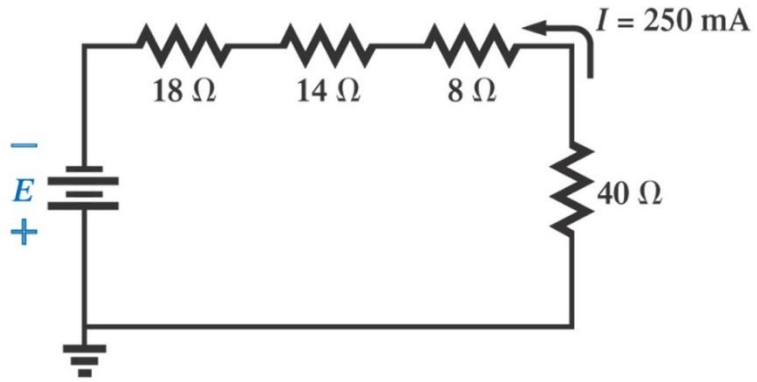




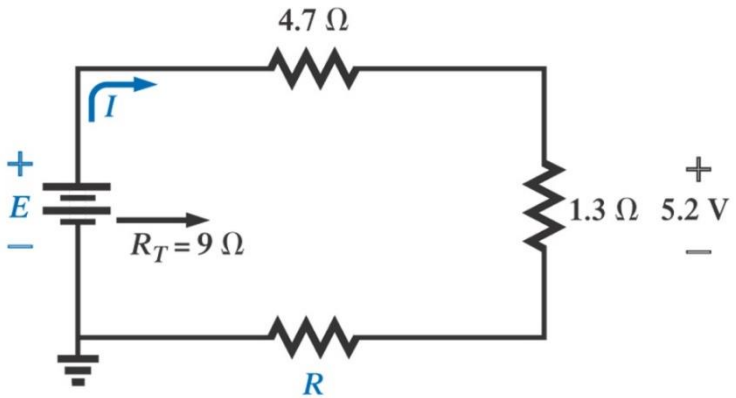



12 kΩ
4 kΩ
6 kΩ
+
E
−
I = 4 mA

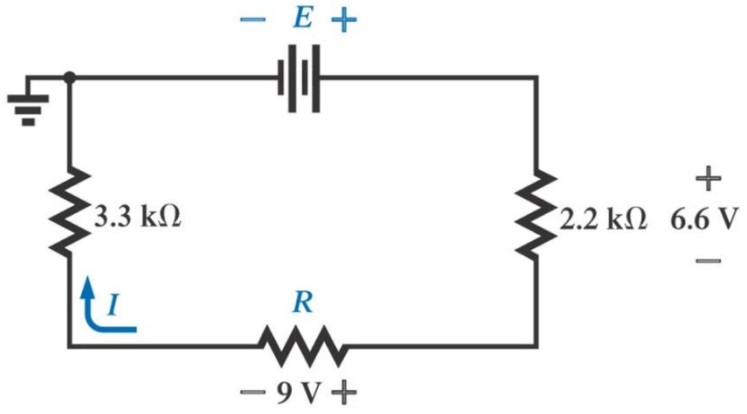
(a)


I = 250 mA
18 Ω
14 Ω
8 Ω
40 Ω
−
E
+

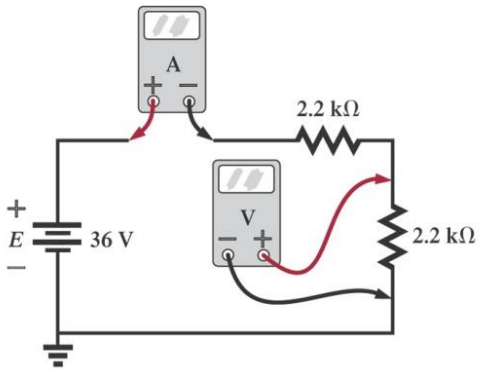
(b)


4.7 Ω
I
+
E
−
R_T = 9 Ω
1.3 Ω
+
5.2 V
−
R

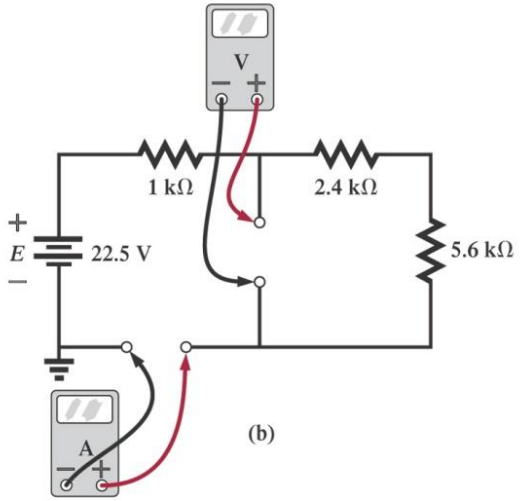
(a)


− E +
3.3 kΩ
2.2 kΩ
+
6.6 V
−
I
R
− 9 V +

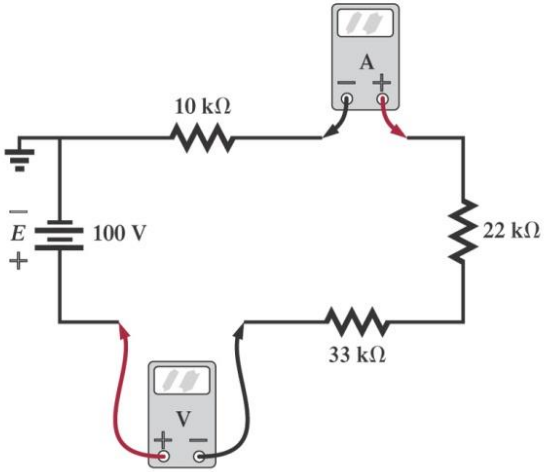
(b)



(a)

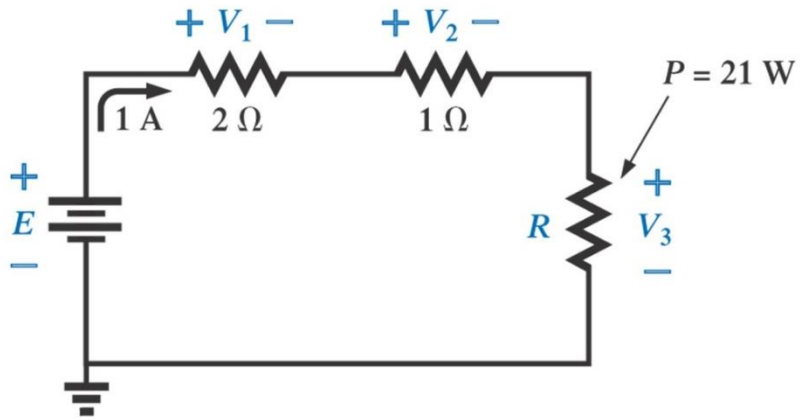


(b)



R_{int}(meter) = 10 MΩ

(c)



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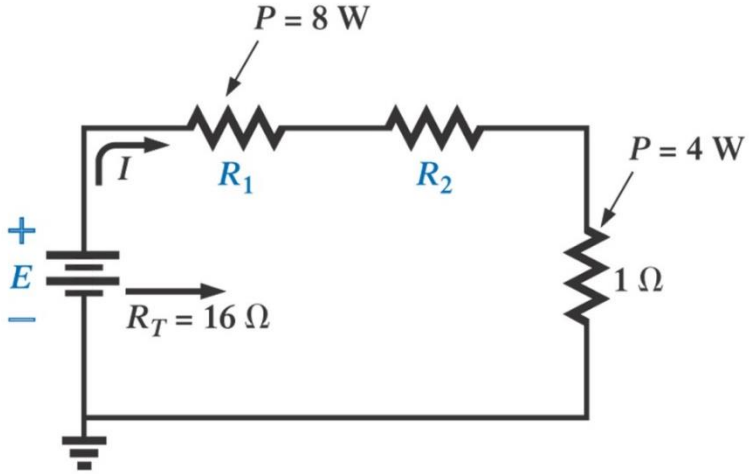

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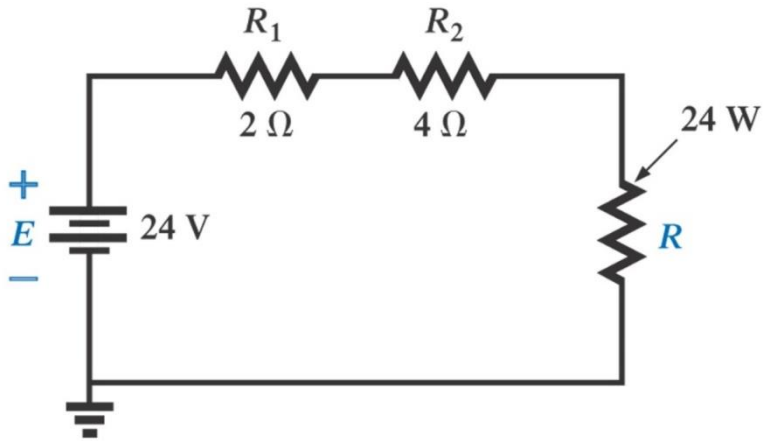

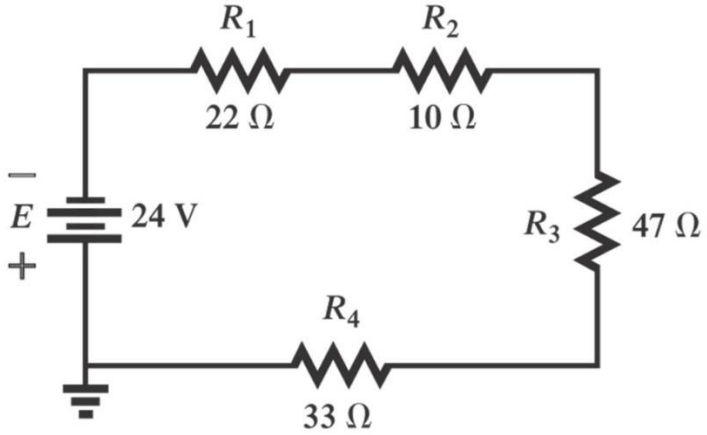

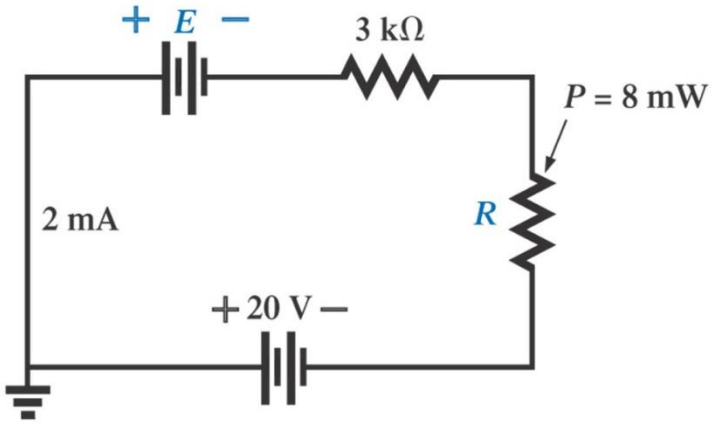

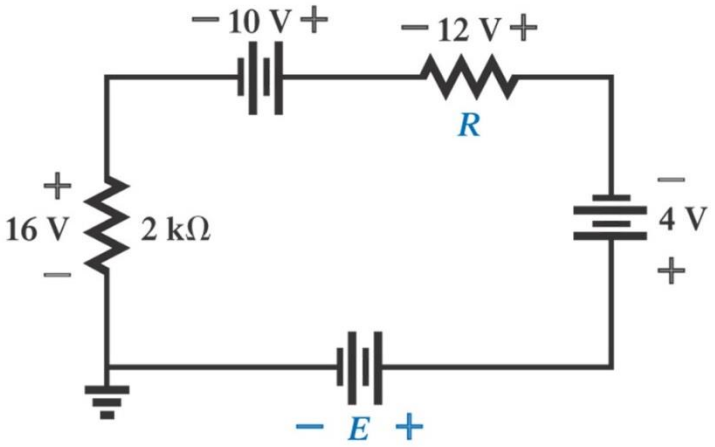

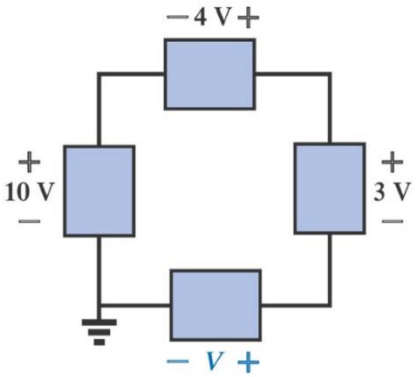

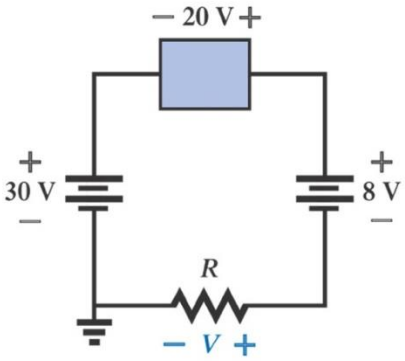

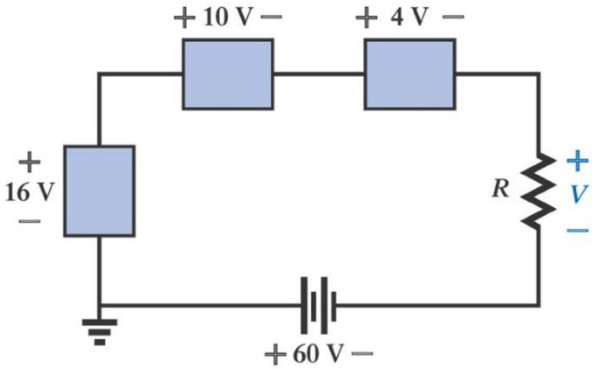

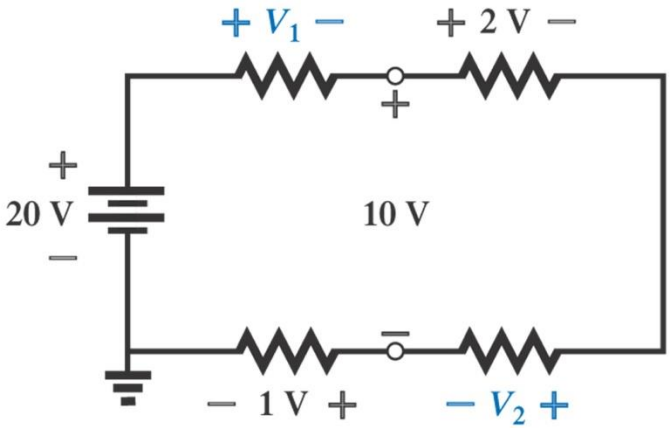

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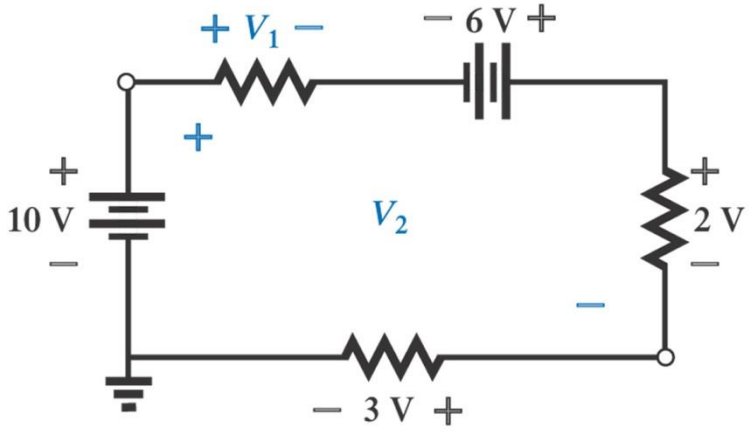

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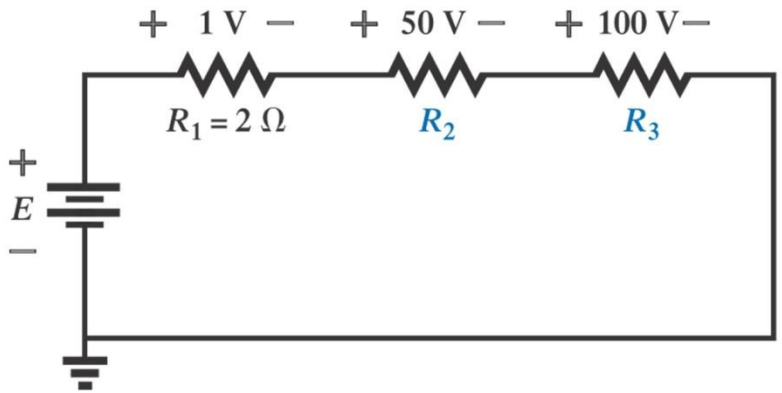
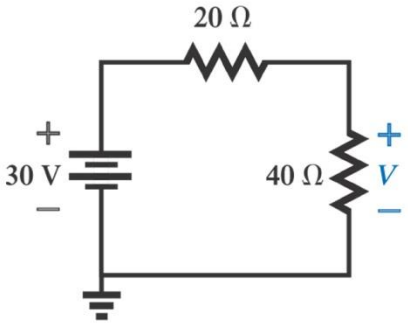
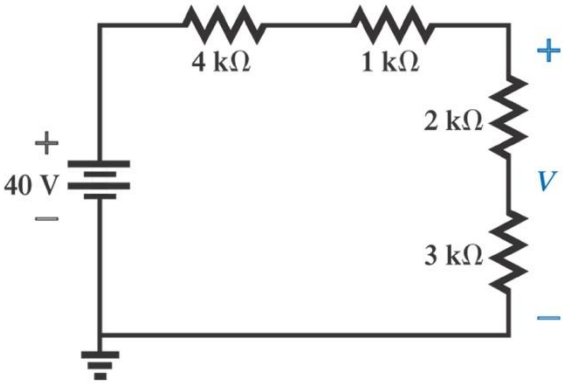
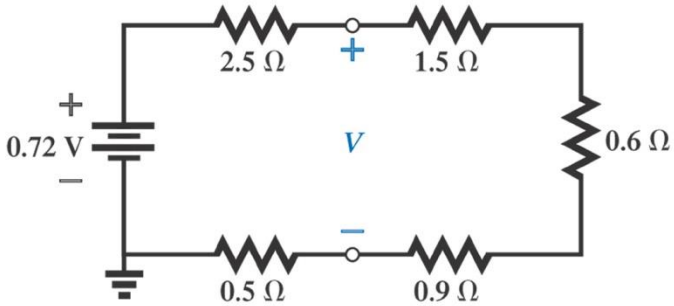


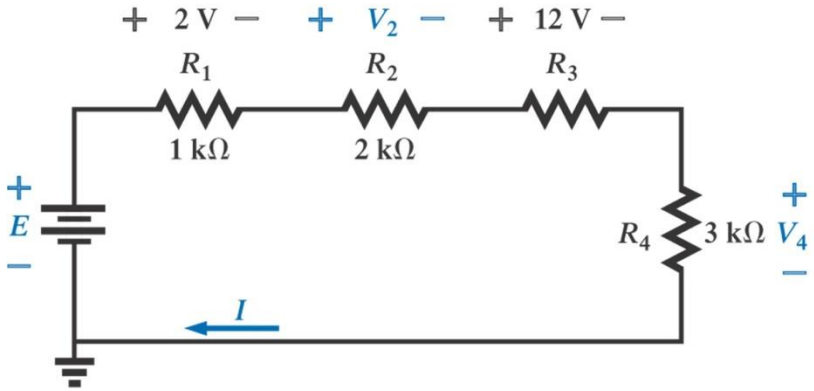


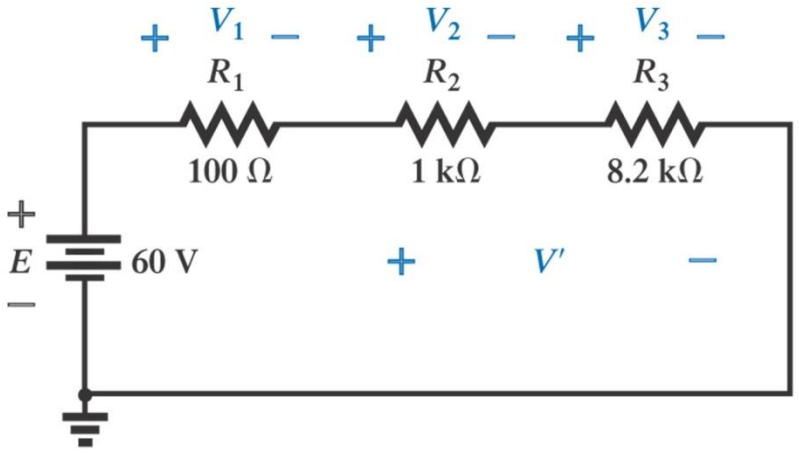
(a)

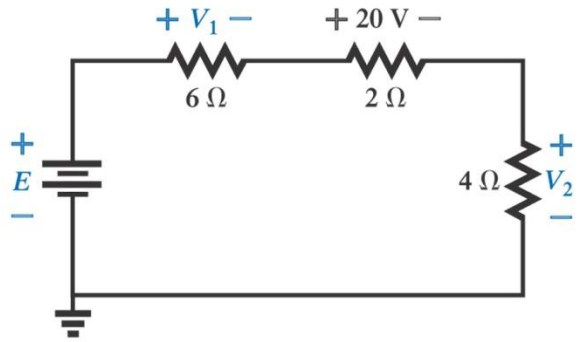


(b)

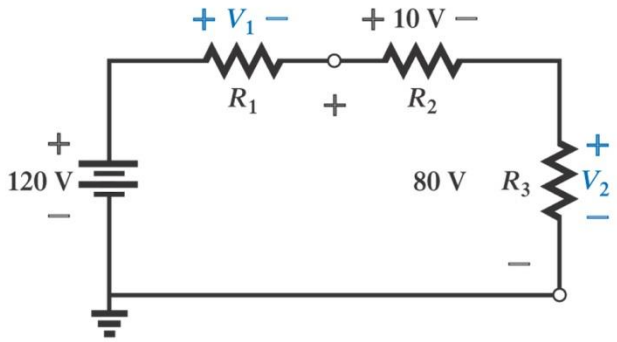




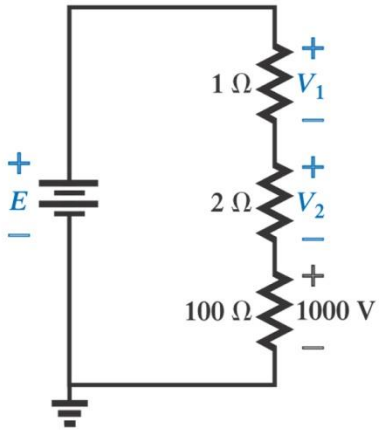




(a)



(b)



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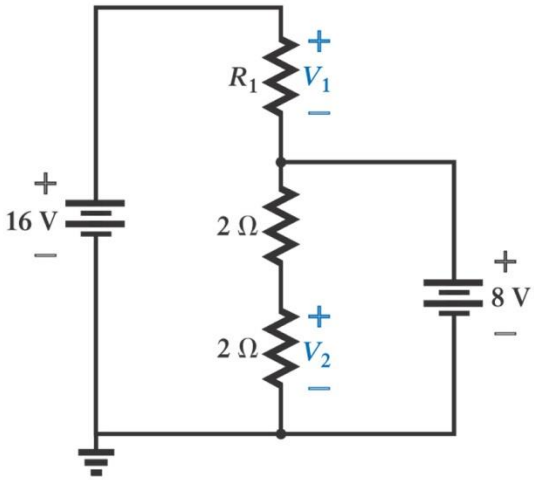

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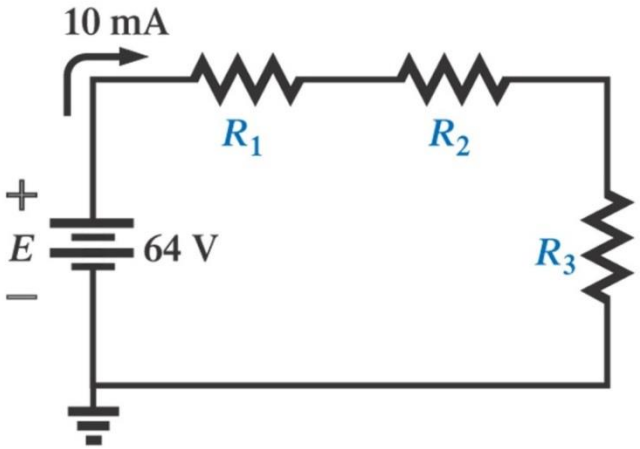
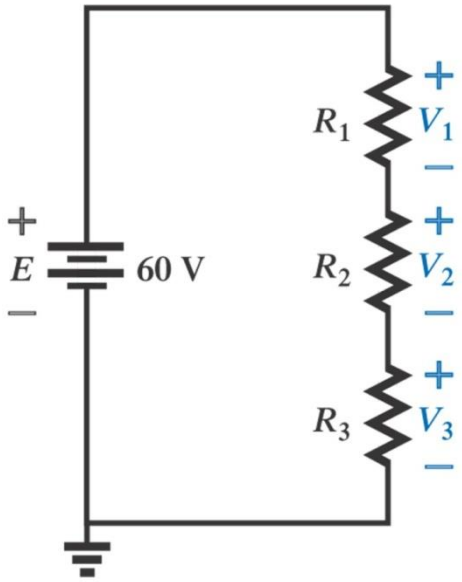
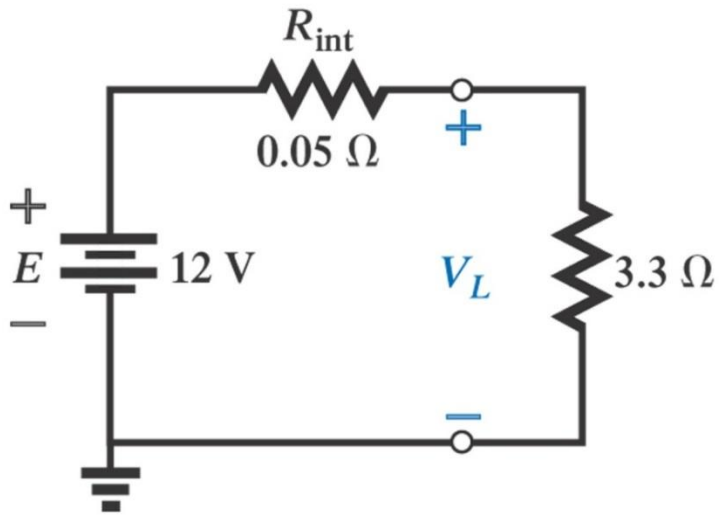
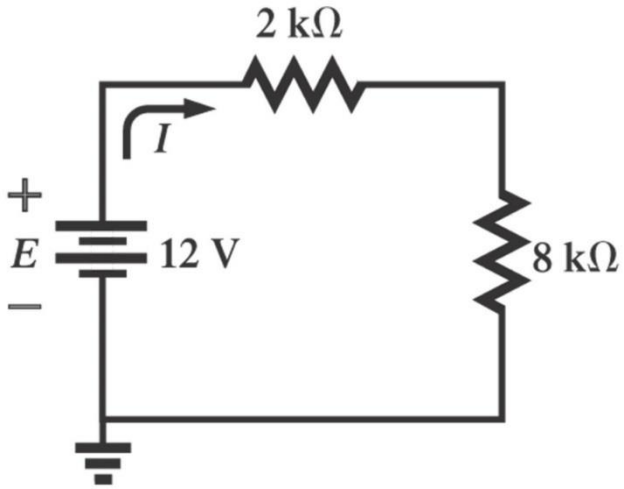








ELECTRICAL AND ELECTRONICS FOR DESIGN (SRSD 3092) Semester II 2015/2016

(PARALLEL CIRCUIT)
Week 3-1

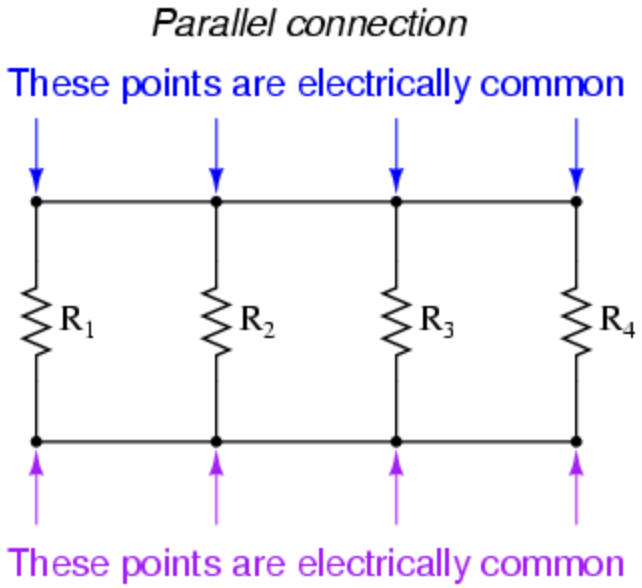
Prepared by : DR NELIDYA MD YUSOFF

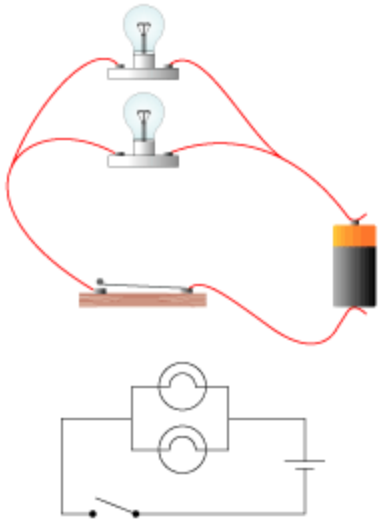
Topics

- 6.1 Parallel Resistors
- 6.2 Parallel Circuits
- 6.3 Power Distribution in a Parallel Circuit
- 6.4 Kirchhoff's Current Law
- 6.5 Current Divider Rule
- 6.6 Voltage Sources in Parallel

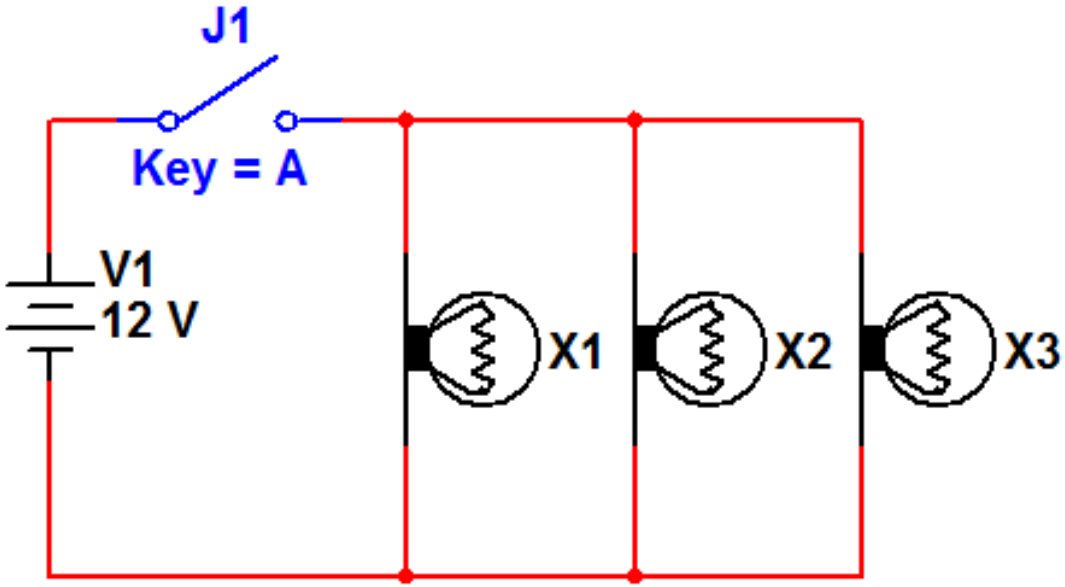
Parallel circuit

- All components are connected across each other's leads.
- There are never more than two sets of electrically common points, no matter how many components are connected.



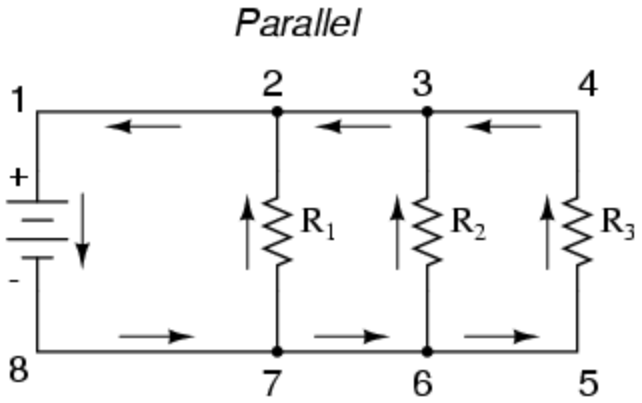


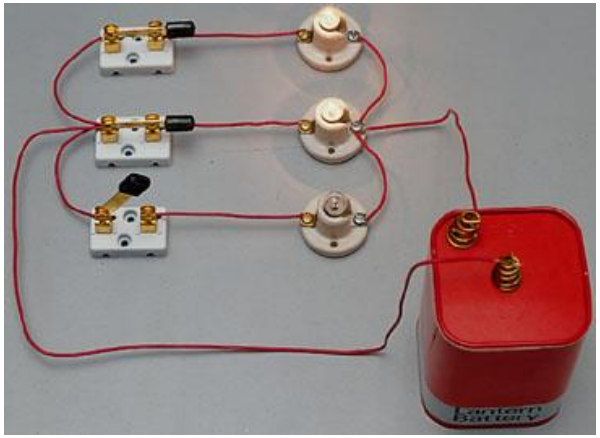
Parallel circuit

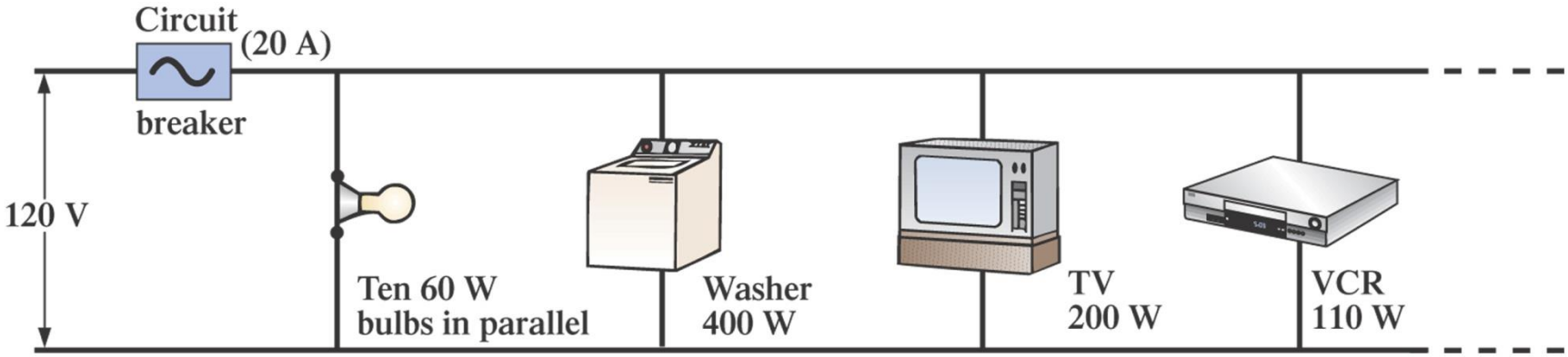


Example of a parallel circuit

- 3 resistors form more than one continuous path for electrons to flow.
- Each individual path (through R_1, R_2, and R_3) is called a *branch*.
- All components are connected between the same set of electrically common points.
- Looking at the schematic diagram, we see that points 1, 2, 3, and 4 are all electrically common. So are points 8, 7, 6, and 5.

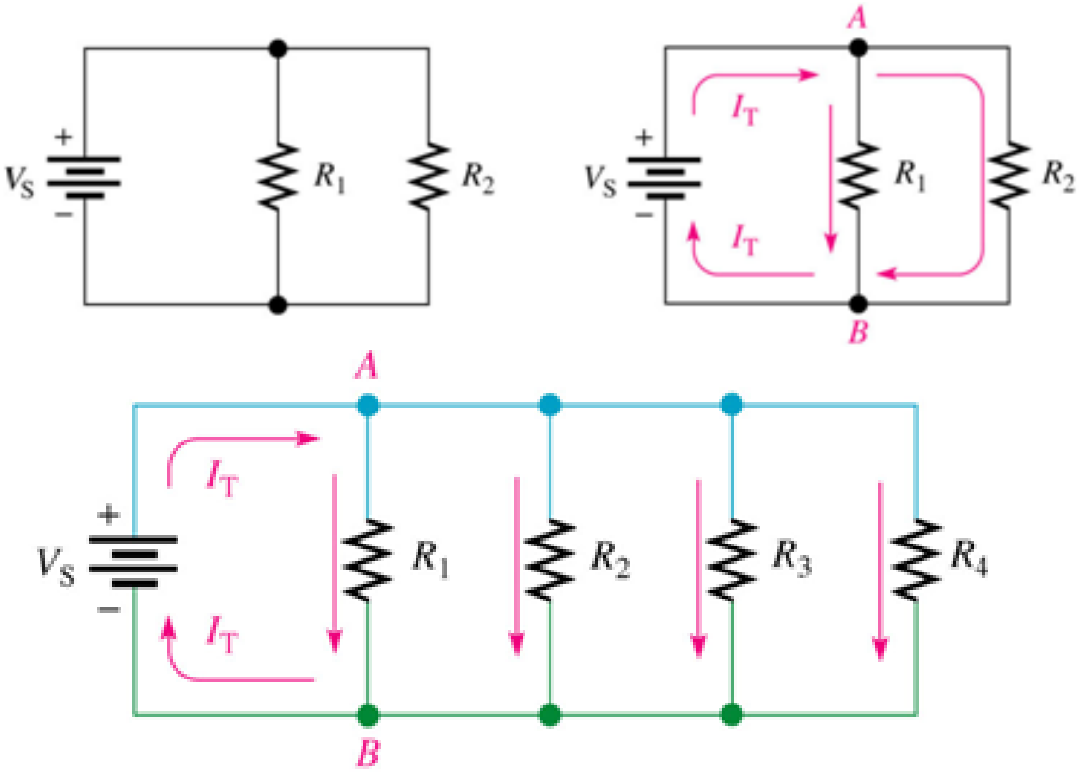




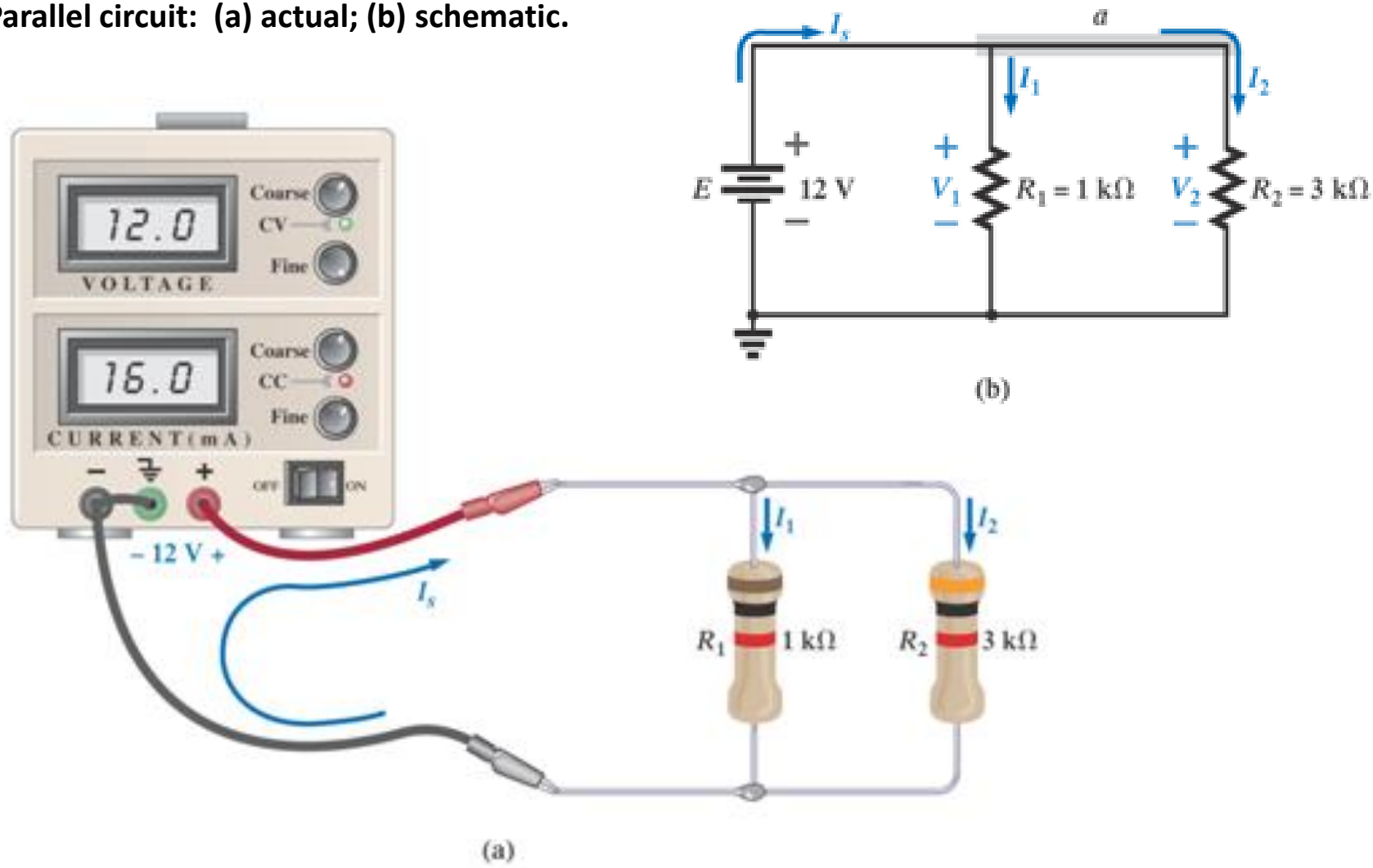


Resistors in Parallel

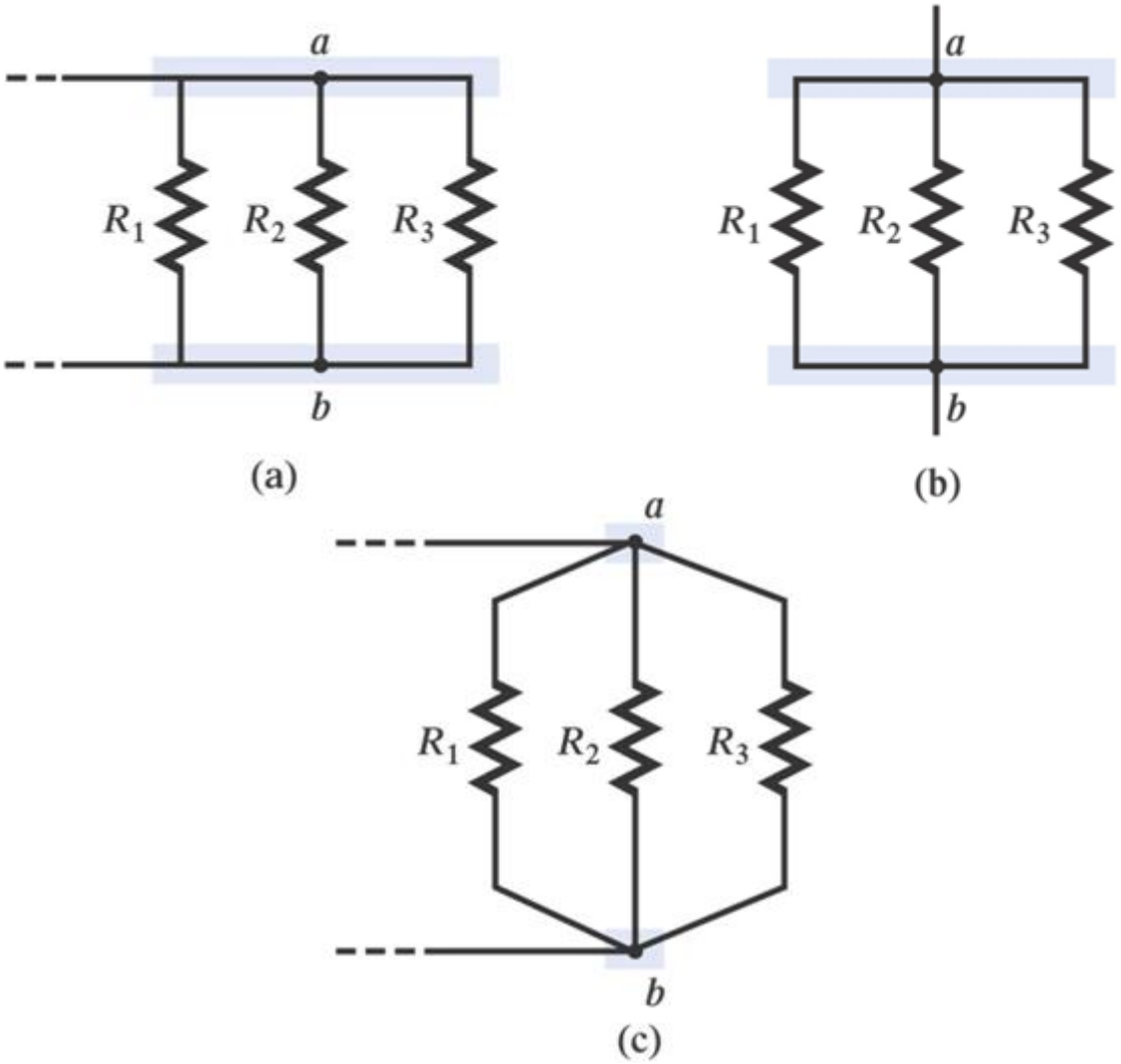
- Two elements, branches or circuits are in parallel if they have two, and only two points in common
- Each current path is called a branch.
- A parallel circuit is one that has more than one branch.



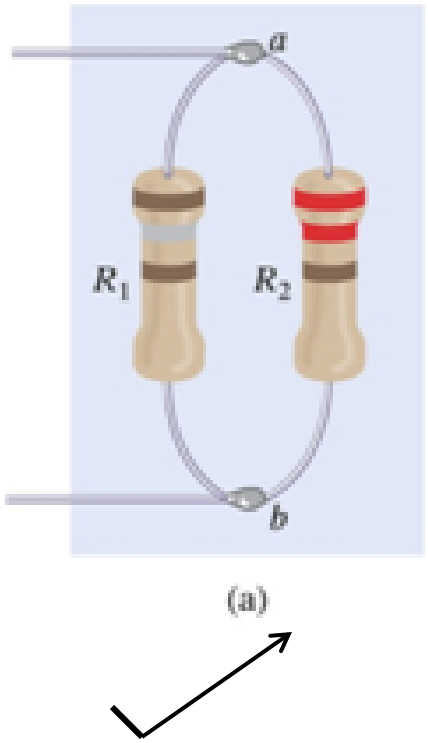
Parallel circuit: (a) actual; (b) schematic.



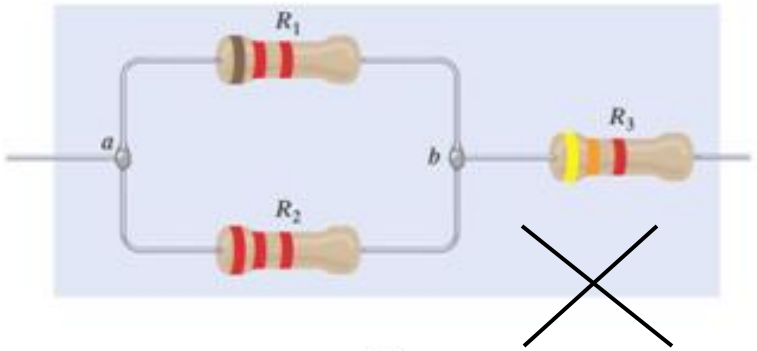
Schematic representations of three parallel resistors.



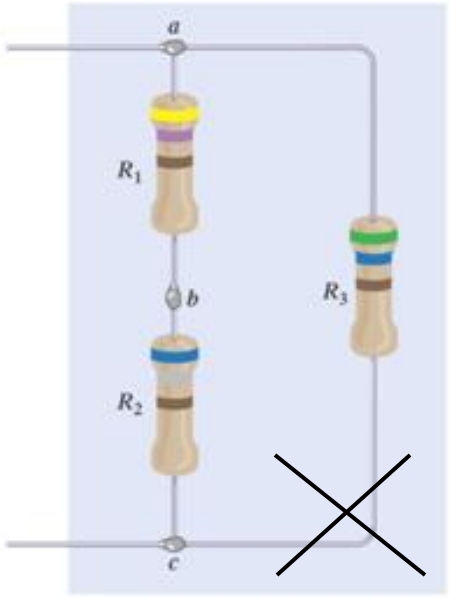
(a) Parallel resistors; (b) R_1 and R_2 are in parallel; (c) R_3 is in parallel with the series combination of R_1 and R_2.



(a)



(b)



(c)

Parallel Circuits

- Identifying Parallel Circuits

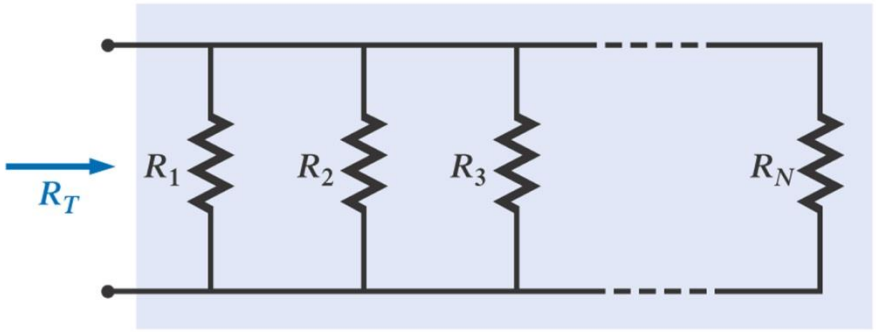
  If there is more than one current path (branch) between two separate points (nodes), then there is a parallel circuit between those two points.

- Voltage in Parallel Circuits

  The voltage across any given branch of a parallel circuit is equal to the voltage across each of the other branches in parallel

Total Parallel Resistance

- When resistors are connected in parallel, the total resistance of the circuit decreases.
- The total resistance of a parallel circuit is always less than the value of the smallest resistor.



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N}$$

Parallel Resistors

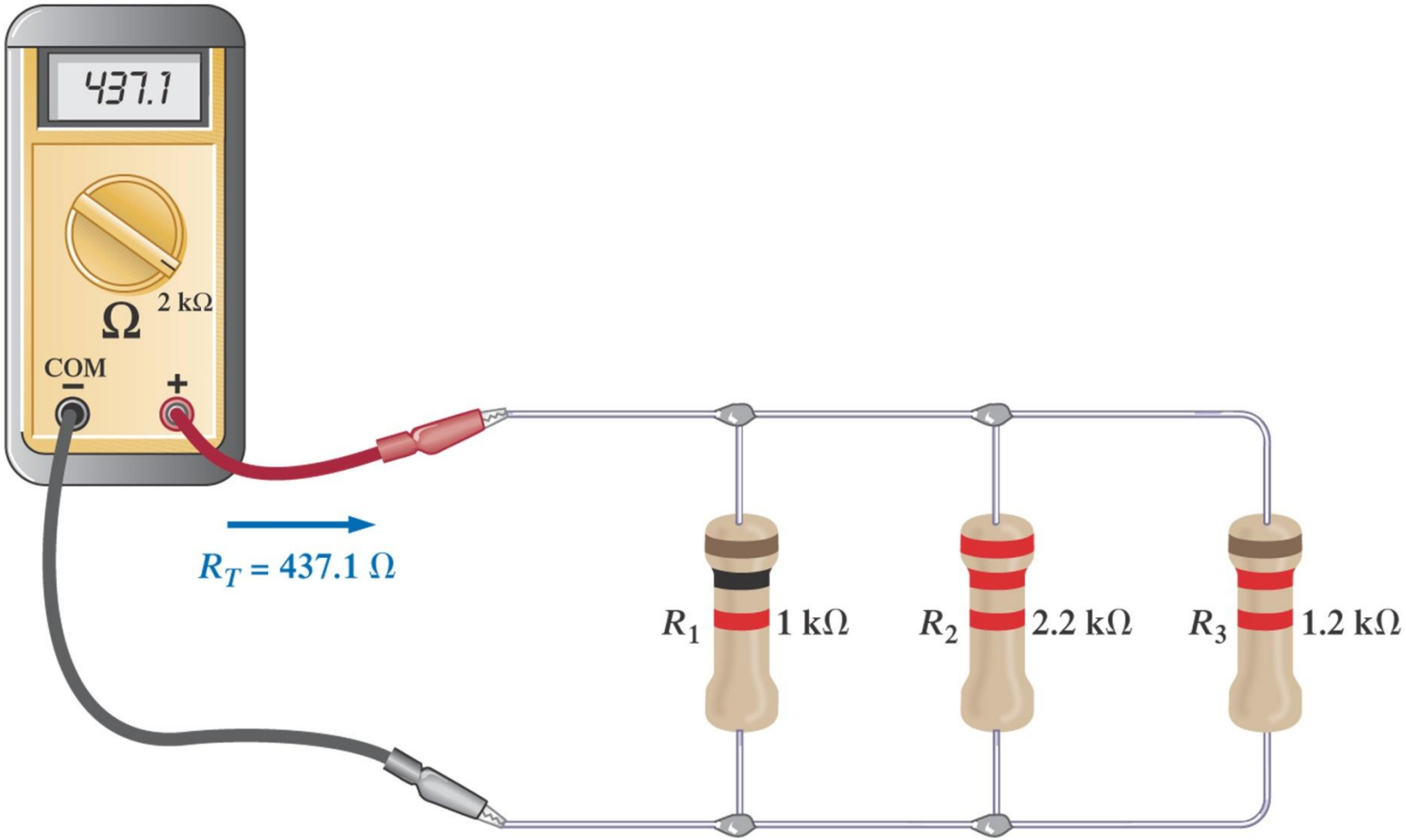
- For resistors in parallel

  The total resistance of two parallel resistors is the product of their values divided by their sum

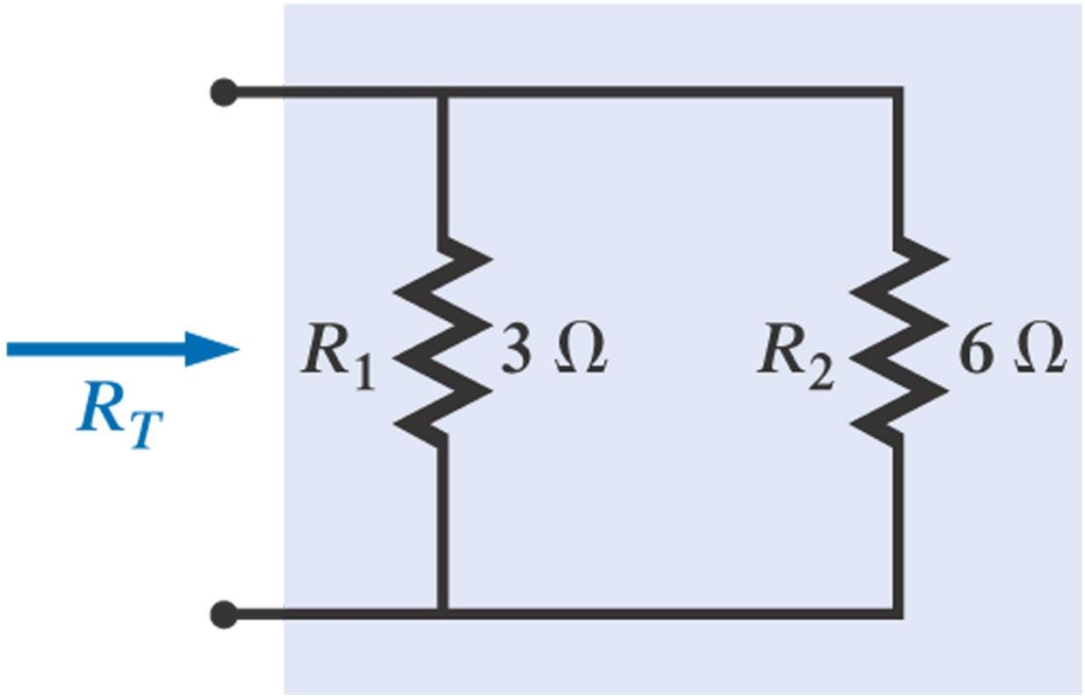
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2 + R_1}{R_1 R_2}$$

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

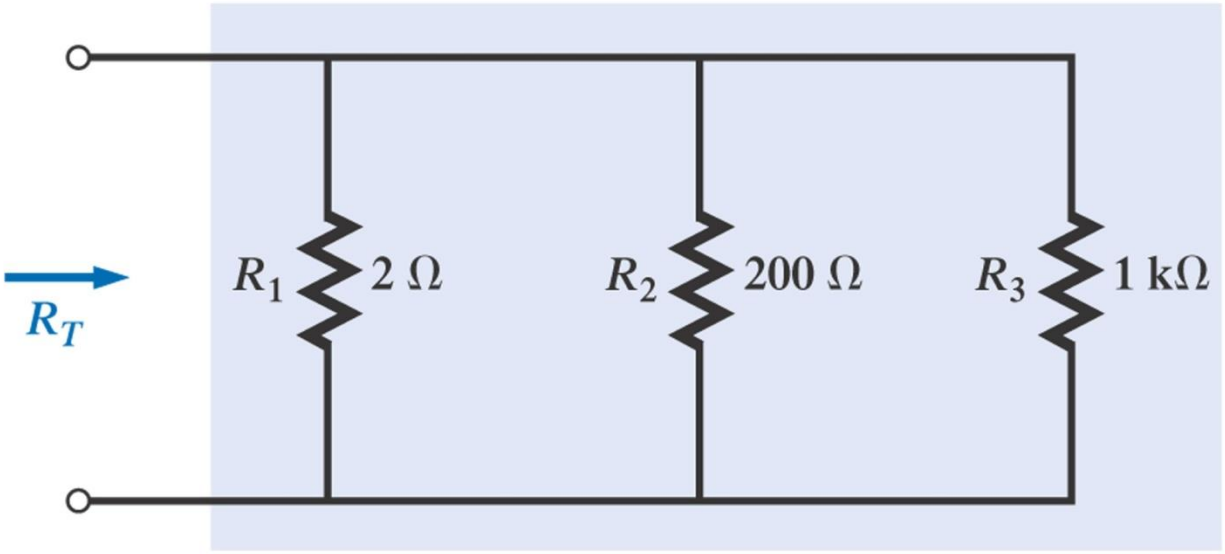
Using an ohmmeter to measure the total resistance of a parallel network.



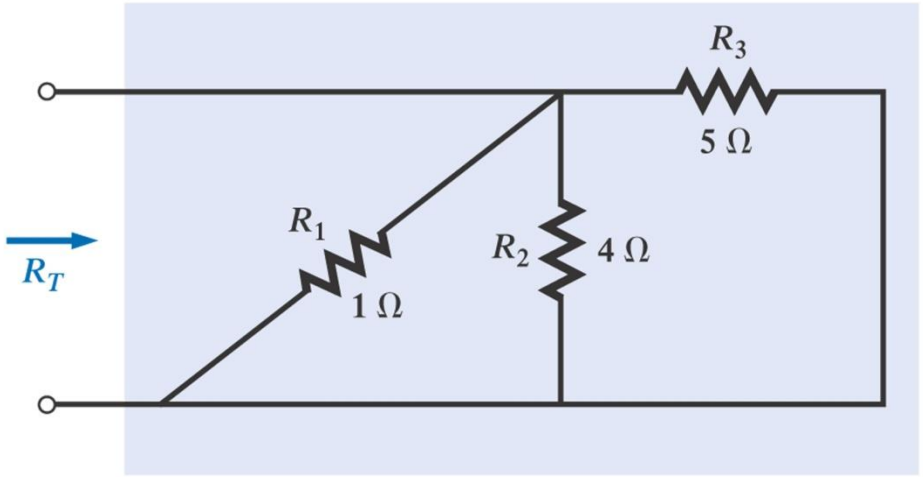
Parallel resistors



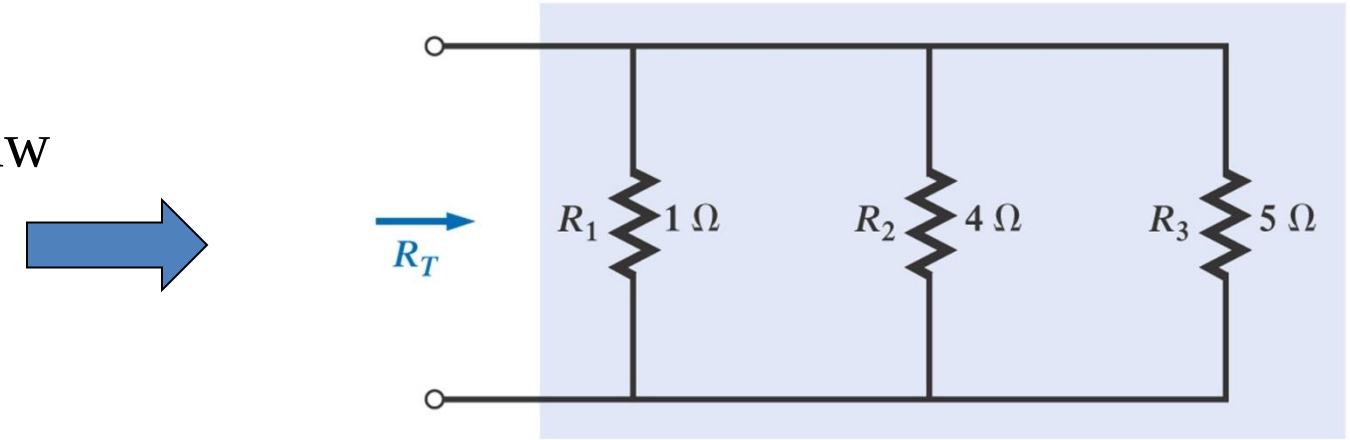
Parallel resistors



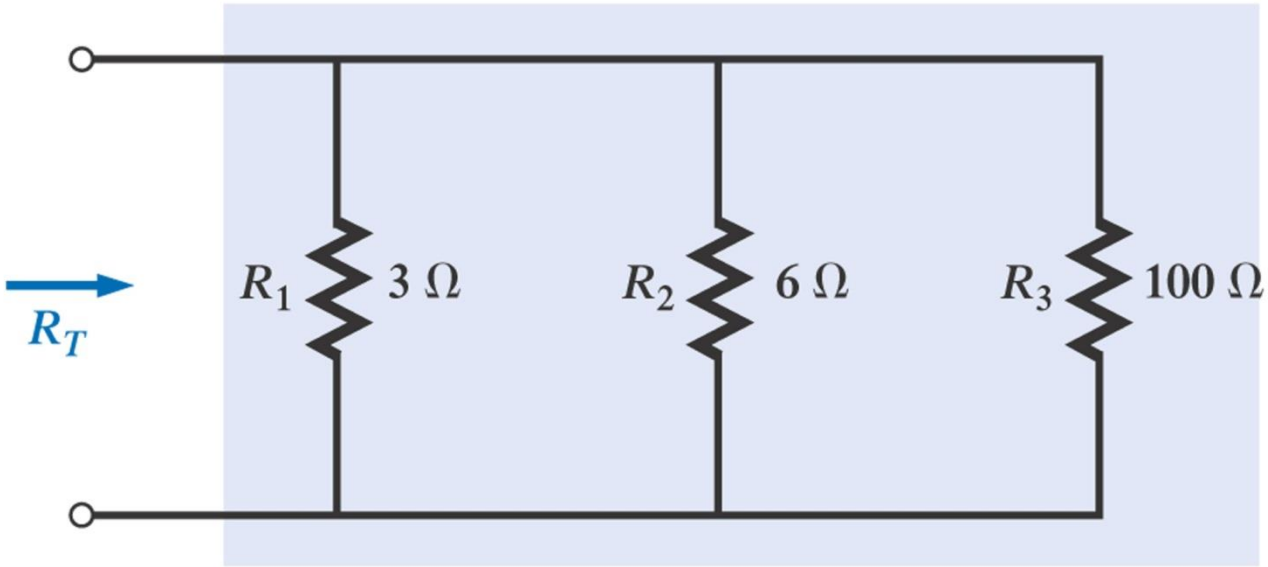
Network to be investigated



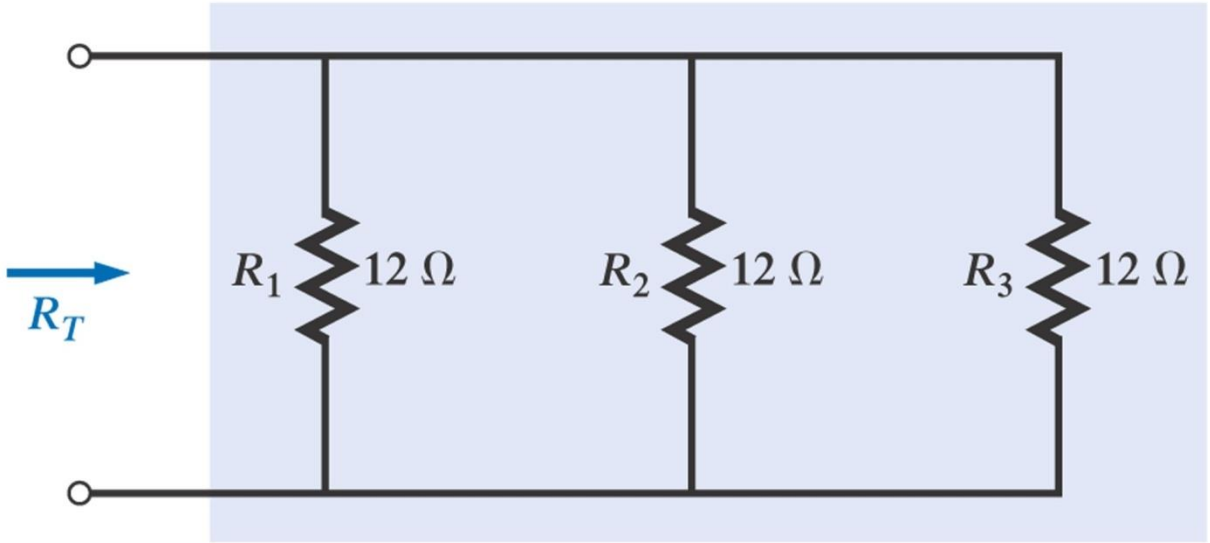
Redraw



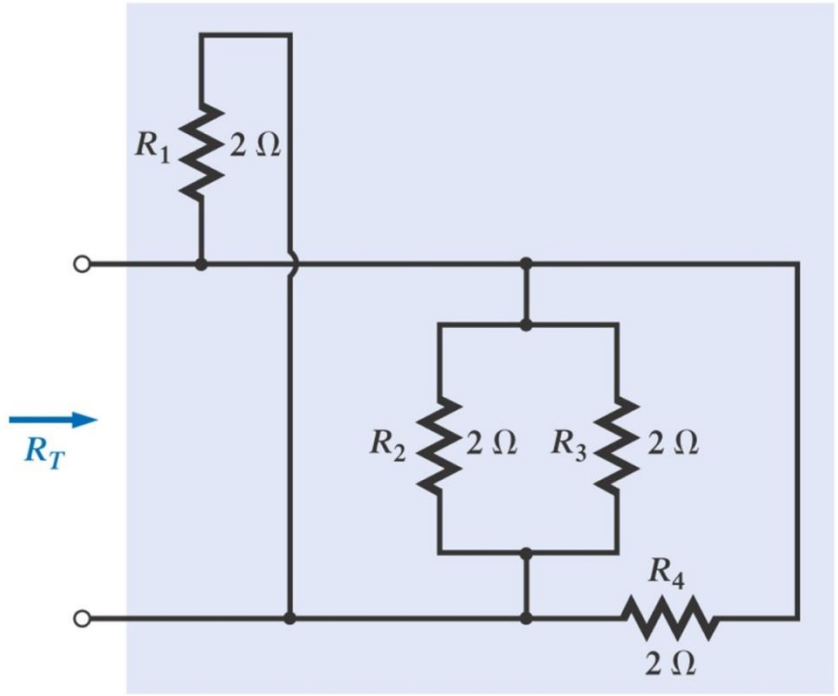
Adding a parallel 100 Ω resistor to the network



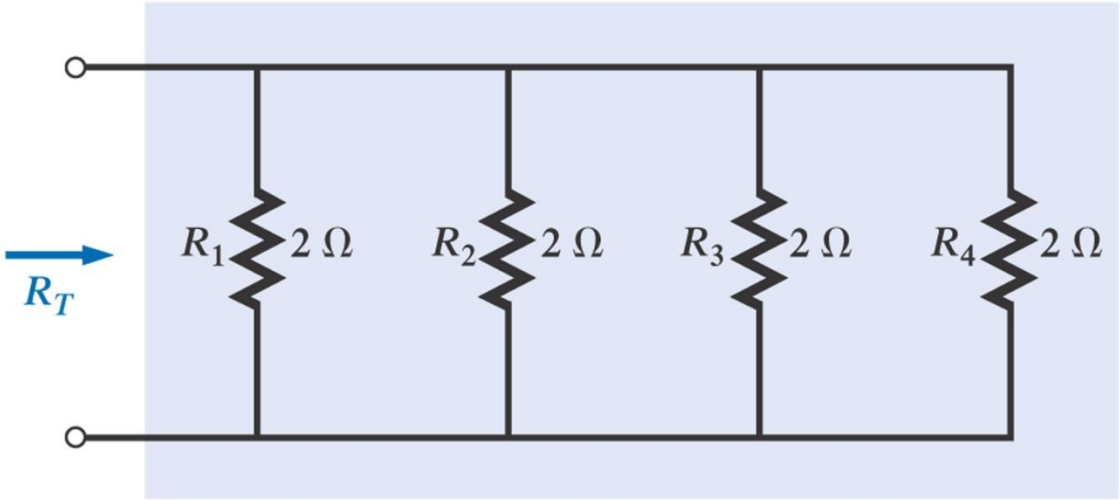
Three equal parallel resistors to be investigated



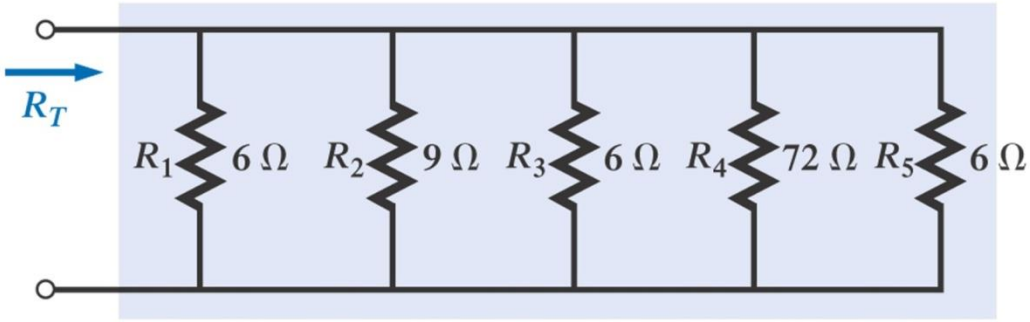
Parallel configuration

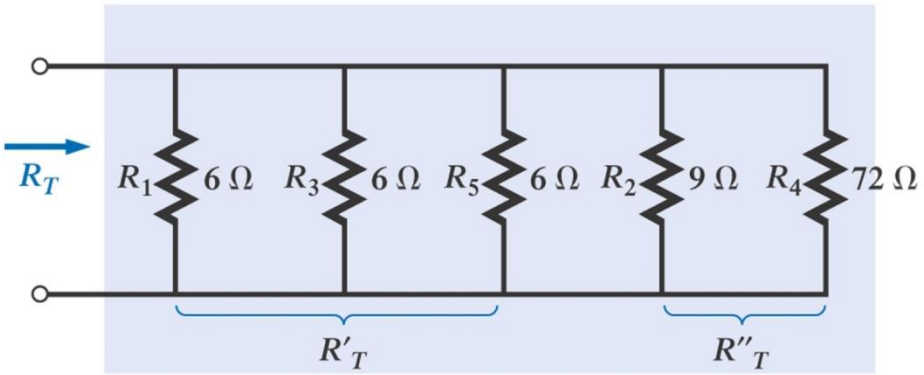


Redraw

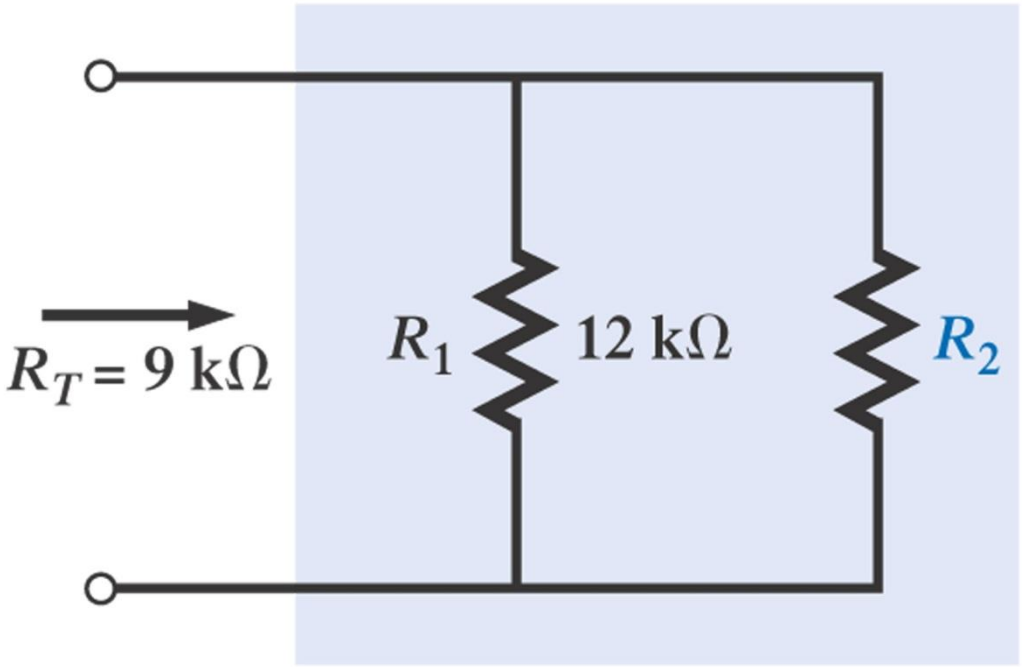


Parallel network for Example



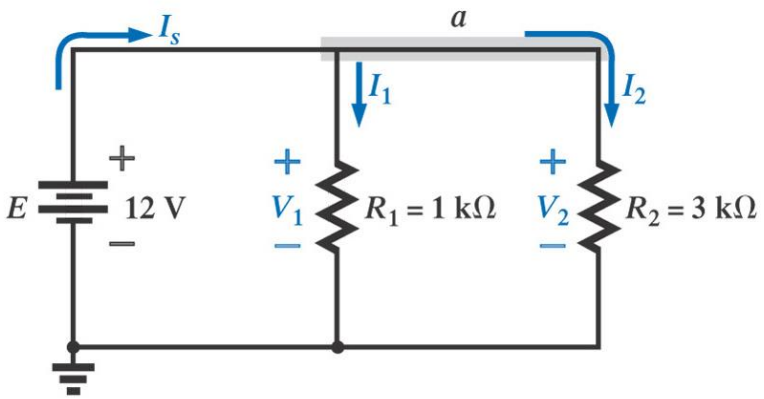


Parallel network for Example



Parallel Resistors

- The voltage is the same across parallel elements
- The source does not "see" the parallel combination, it only reacts to the total resistance
- The source current is:

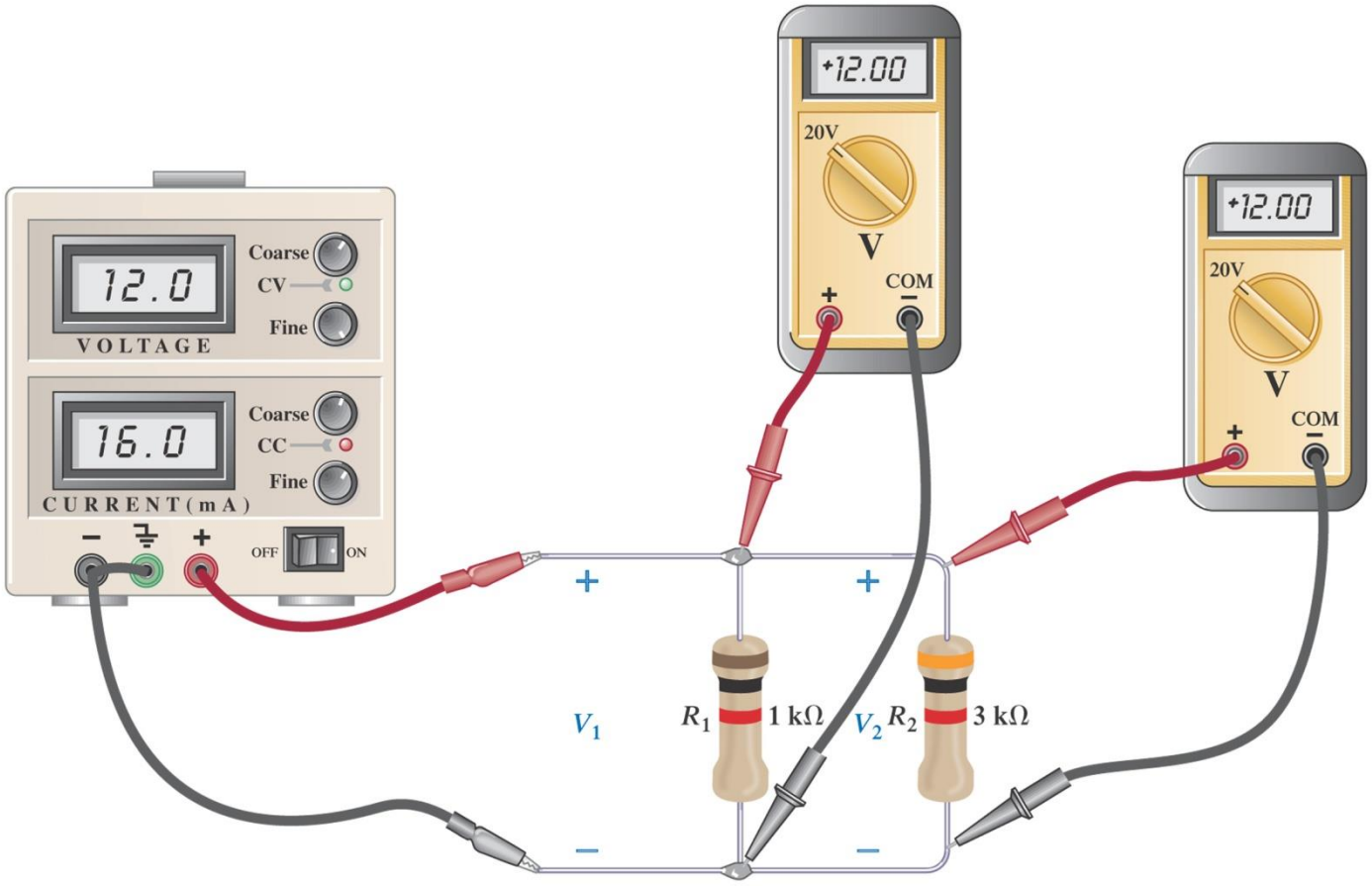


(b)

$$V_{ab} = E = V_1 = V_2$$

$$I_s = \frac{E}{R_T}$$

The voltages of a parallel dc network.



Parallel Resistors

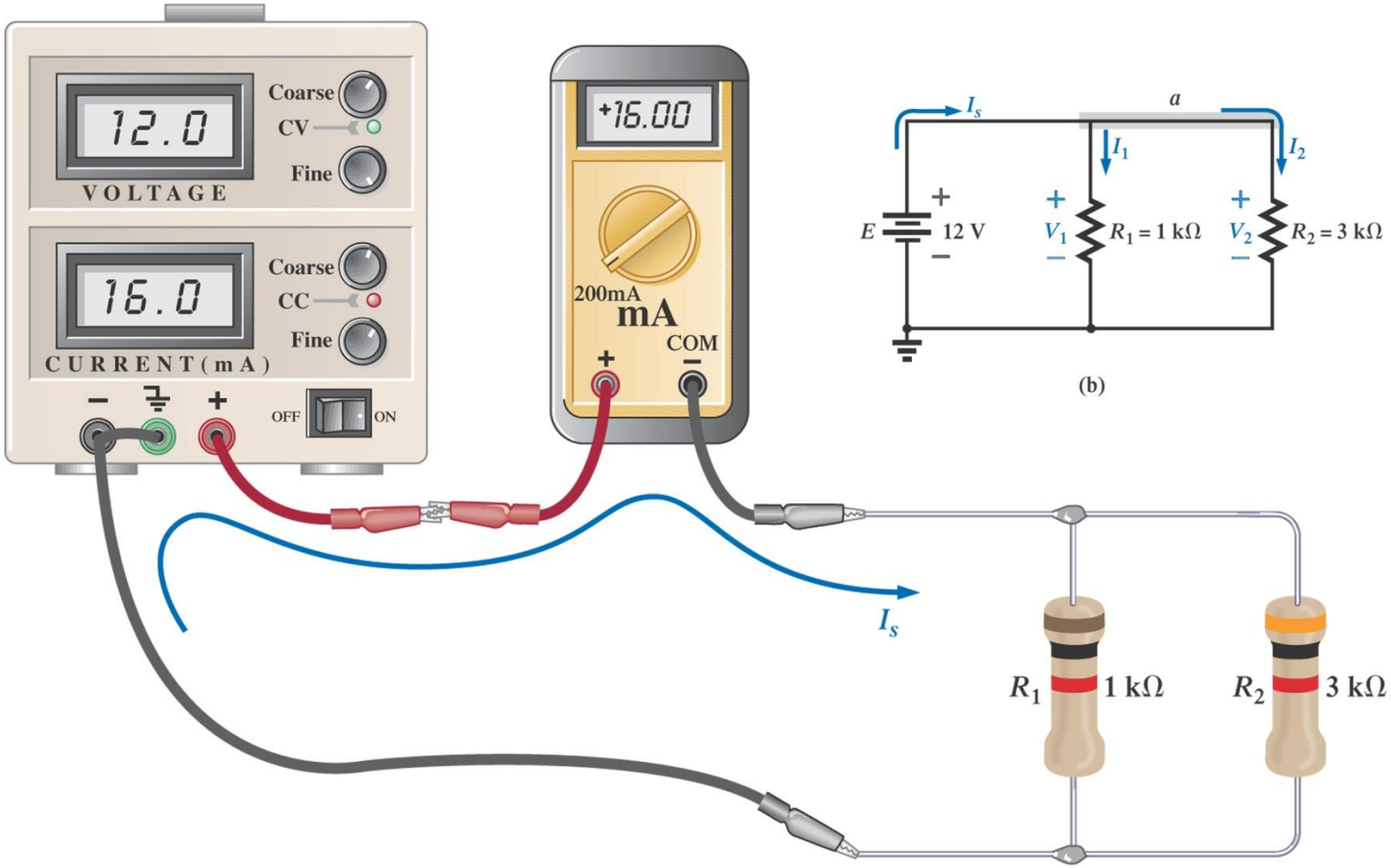
- Since the voltage is the same across parallel elements, the current through each resistor can be determined using Ohm's law

$$I_1 = \frac{V_1}{R_1} = \frac{E}{R_1} \quad \text{and} \quad I_2 = \frac{V_2}{R_2} = \frac{E}{R_2}$$

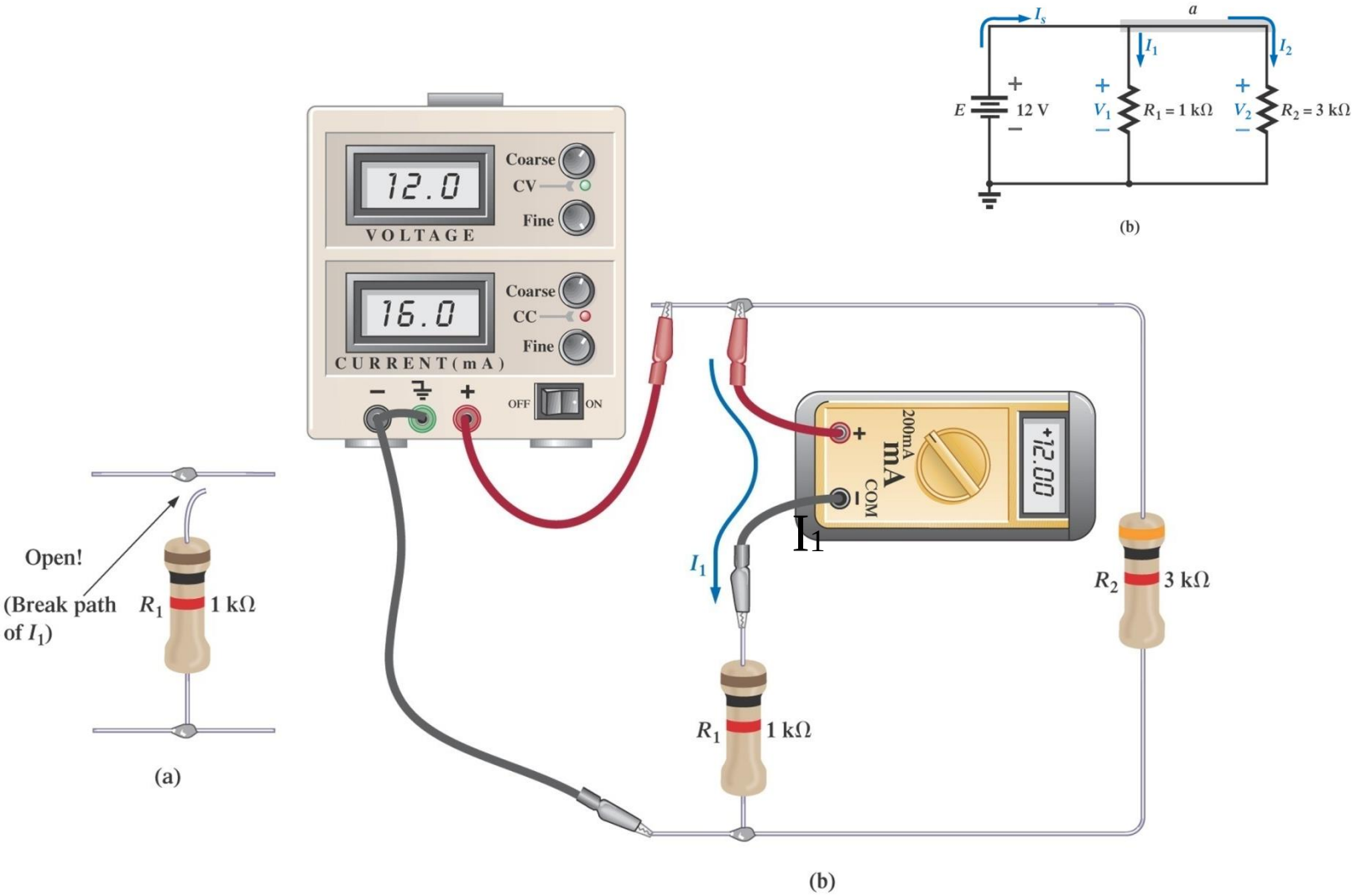
Parallel Resistors

- For parallel resistors, the **greatest** **current** will exist in the branch with the **least resistance**
  - current always seeks the path of least resistance

To measure current through a resistor in a parallel circuit, break the **connection at the point of interest** and insert the ammeter with the current entering the positive (red) lead



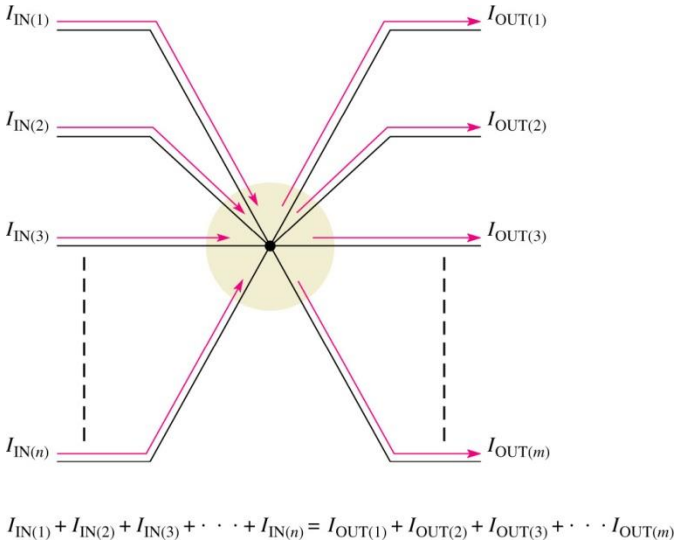
Measuring the current through resistor R_1.



Kirchhoff's Current Law (KCL)

The sum of the currents into a junction (total current in) is equal to the sum of the currents out of that junction (total current out).

$$I_{IN(1)} + I_{IN(2)} + \ldots + I_{IN(n)} = I_{OUT(1)} + I_{OUT(2)} + \ldots + I_{OUT(m)}$$



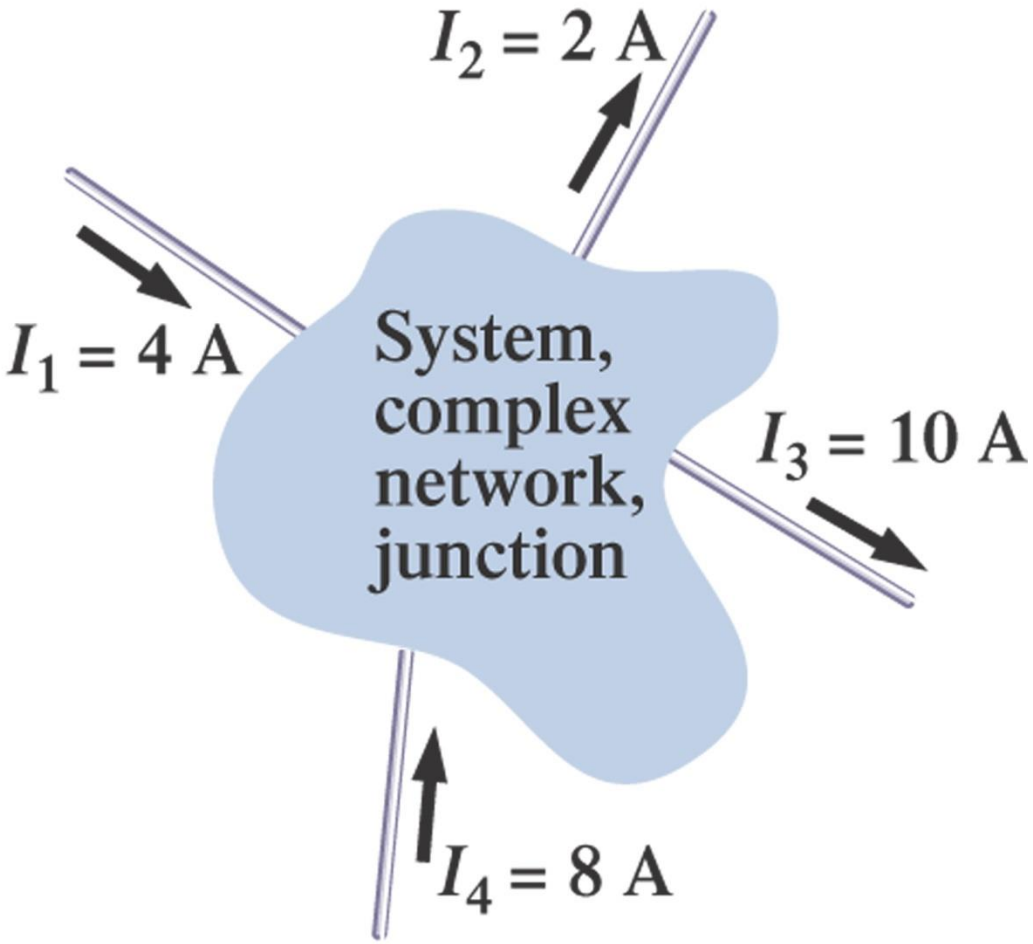
Kirchhoff's Current Law

- Kirchhoff's current Law (KCL) can be stated another way:

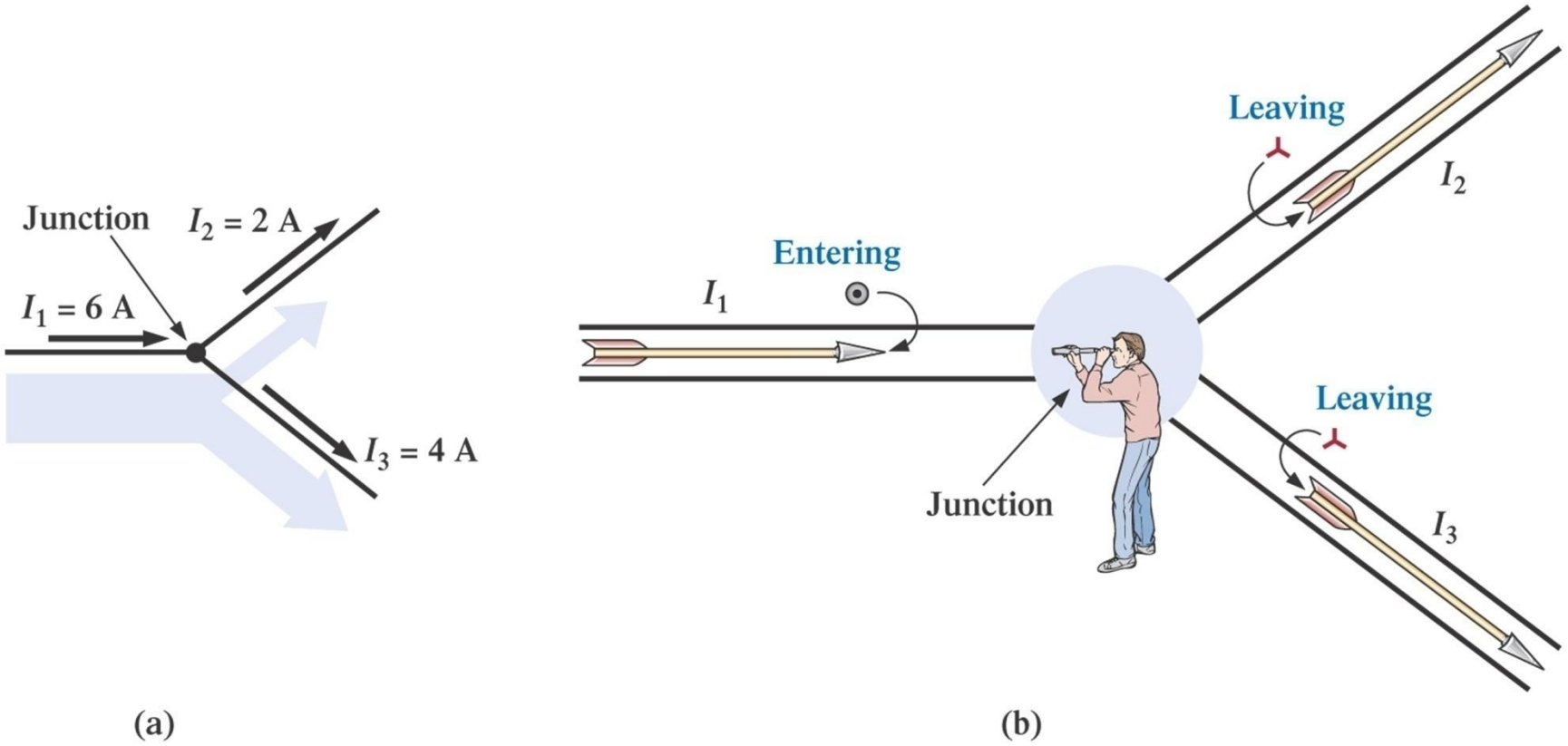
The algebraic sum of all the currents entering and leaving a junction is equal to zero.

$$\sum I_i = \sum I_o$$

Introducing Kirchhoff's current law.

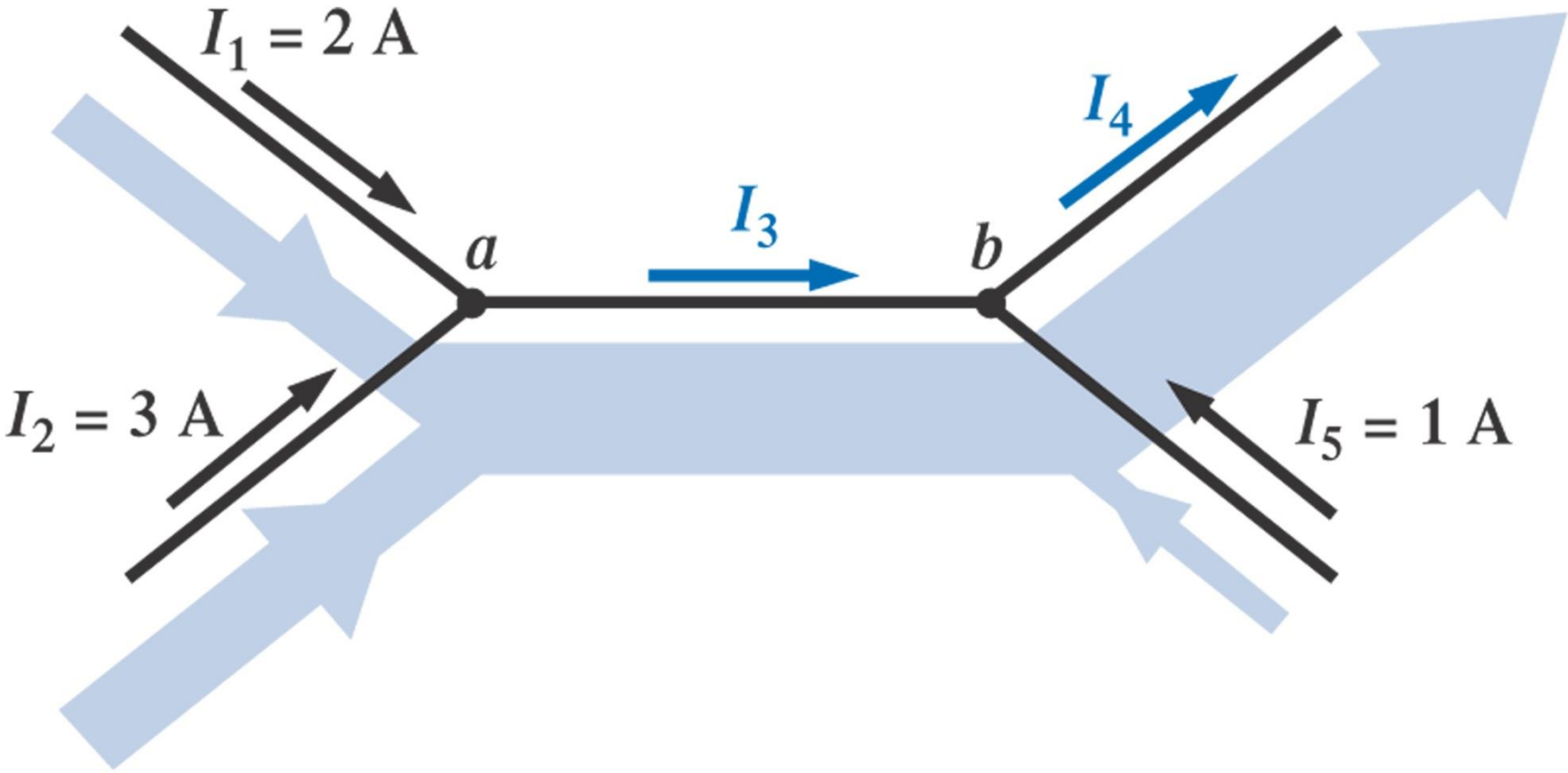


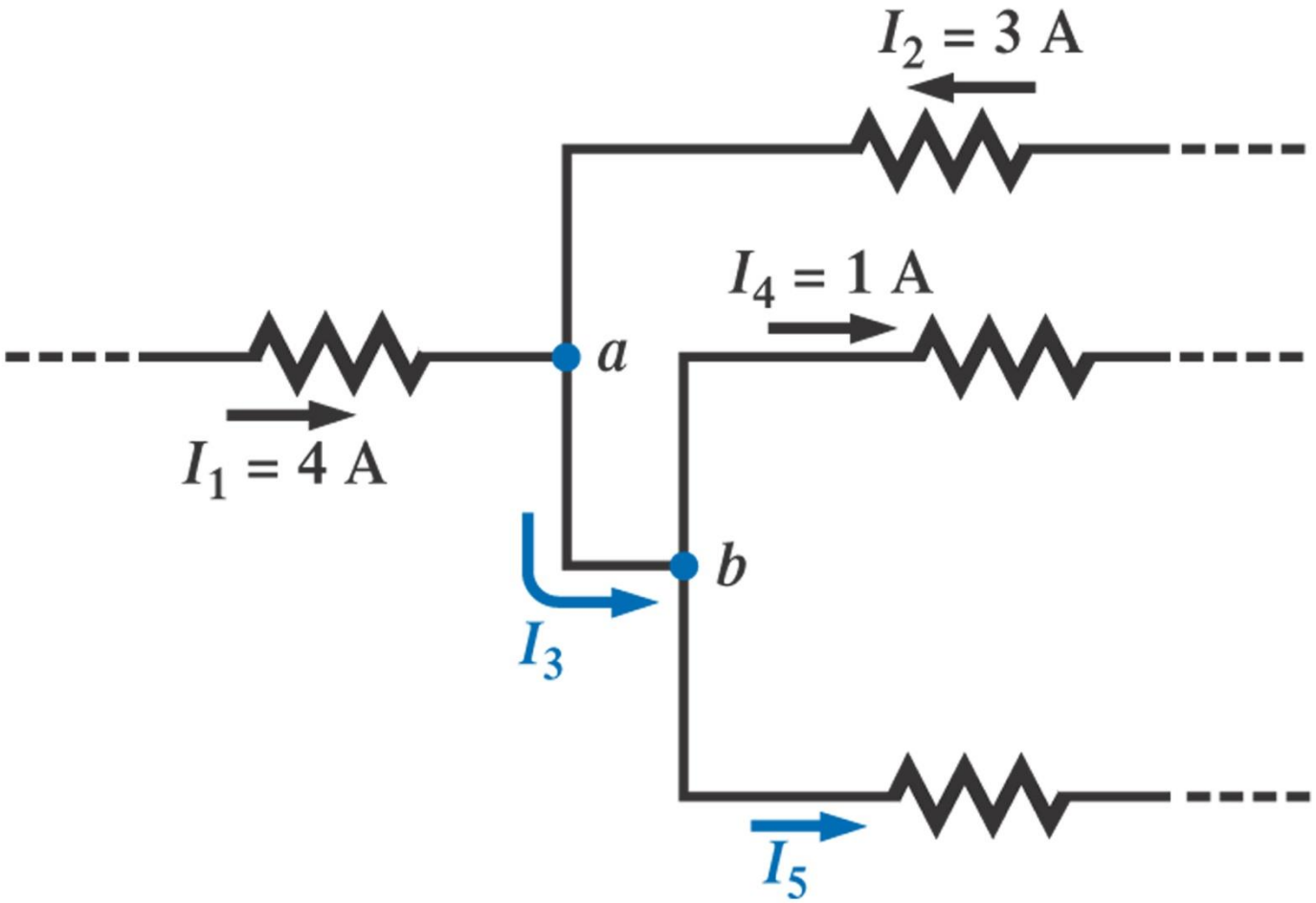
(a) Demonstrating Kirchhoff's current law; (b) determining whether a current is entering or leaving a junction.



Water analogy for the junction

Two-node configuration for Example





Kirchhoff's Current Law

- If the direction of the current is not known:
  - make an **assumption** about the direction and then check out the result
  - if the result is negative, the wrong direction was assumed
  - if positive, the correct direction was assumed
  - in either case, the **magnitude** of the current will be **correct**

Parallel Resistors

- For resistors in parallel

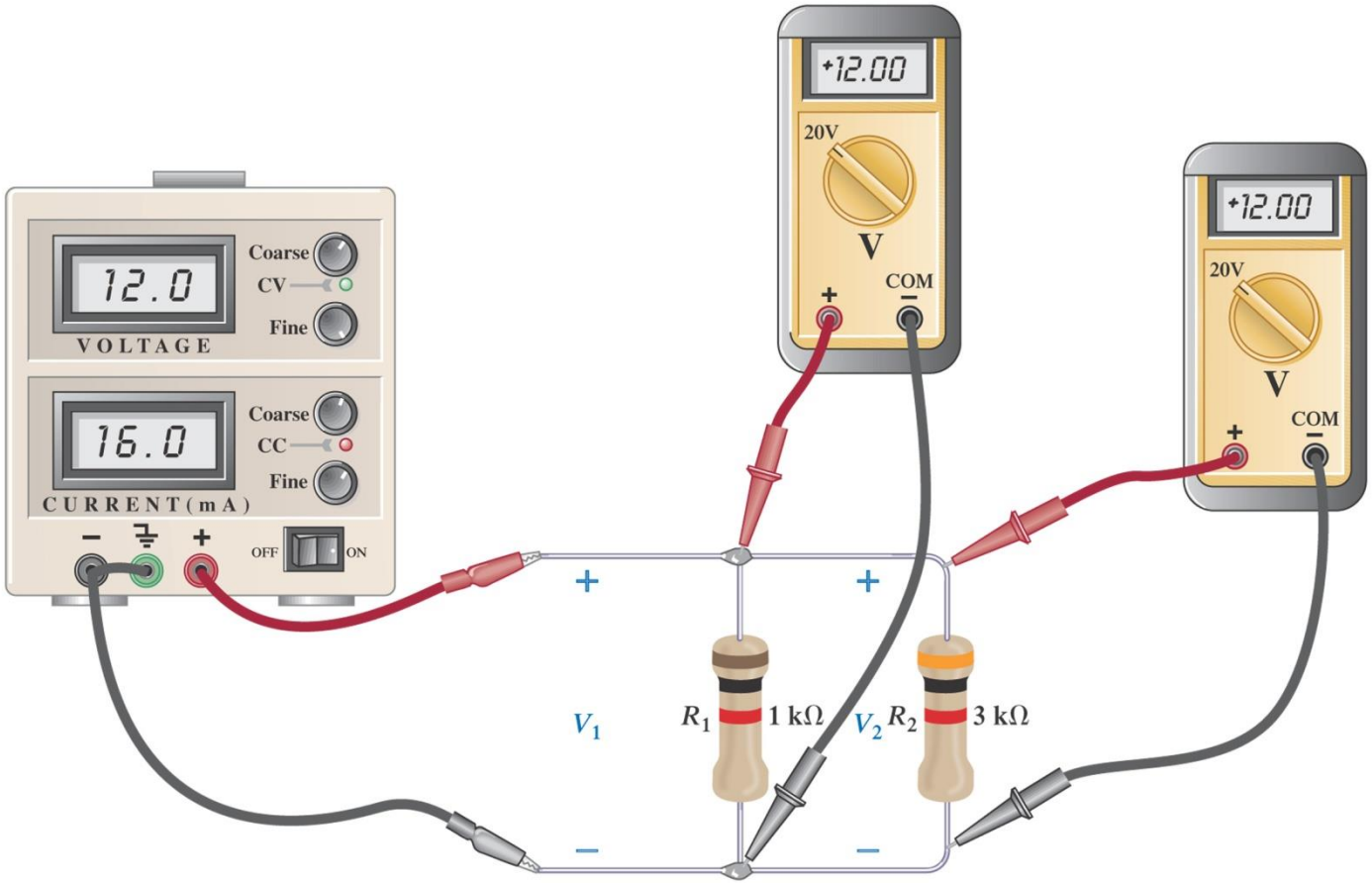
  The total resistance of two parallel resistors is the product of their values divided by their sum

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2 + R_1}{R_1 R_2}$$

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

Parallel Resistors

the voltage is the same across parallel elements



Parallel Resistors

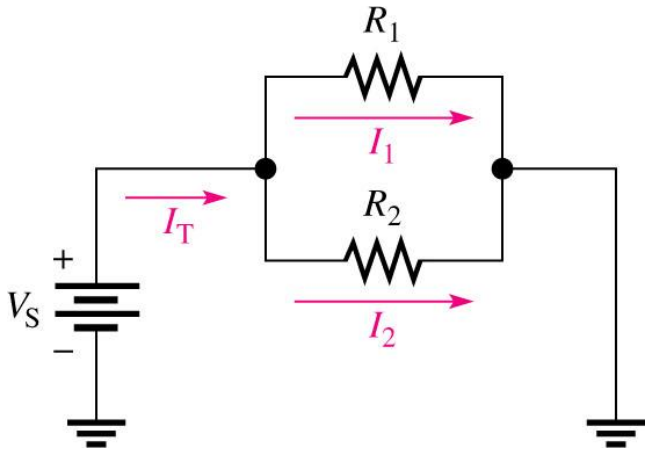
- Since the voltage is the same across parallel elements, the current through each resistor can be determined using Ohm's law

$$I_1 = \frac{V_1}{R_1} = \frac{E}{R_1} \quad \text{and} \quad I_2 = \frac{V_2}{R_2} = \frac{E}{R_2}$$

Current Dividers

A parallel circuit acts as a current divider because the current entering the junction of parallel branches "divides" up into several individual branch currents.

The total current divides among parallel resistors into currents with values inversely proportional to the resistance values.



Current Divider Rule:

$$I_x = \frac{R_T}{R_x} I_T$$

Current Divider Rule

- The current entering parallel resistive elements will split as the inverse of their resistive values
  - The voltage across parallel resistor is the same.
  - the current through equal parallel resistors will be the same.
- The **Current Divider Rule**:

$$I_x = \frac{R_T}{R_x} I_T$$

Current Divider Rule

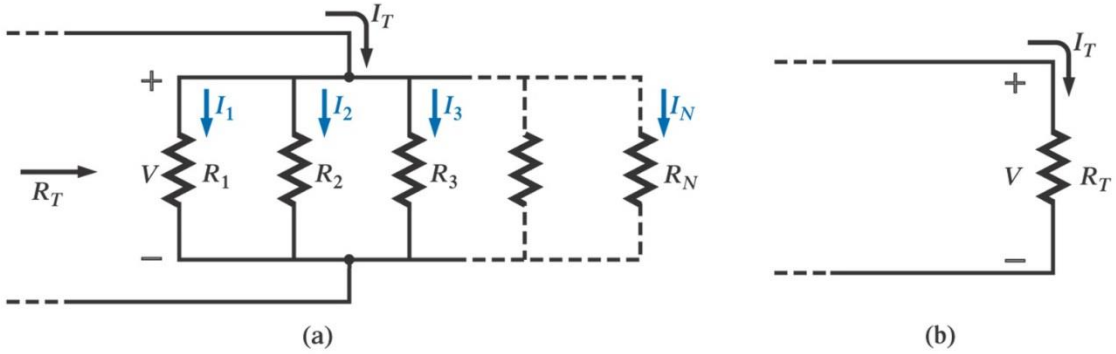
- For two parallel resistors, the current through one is equal to the *other* resistor times the total entering current divided by the *sum* of the two resistors

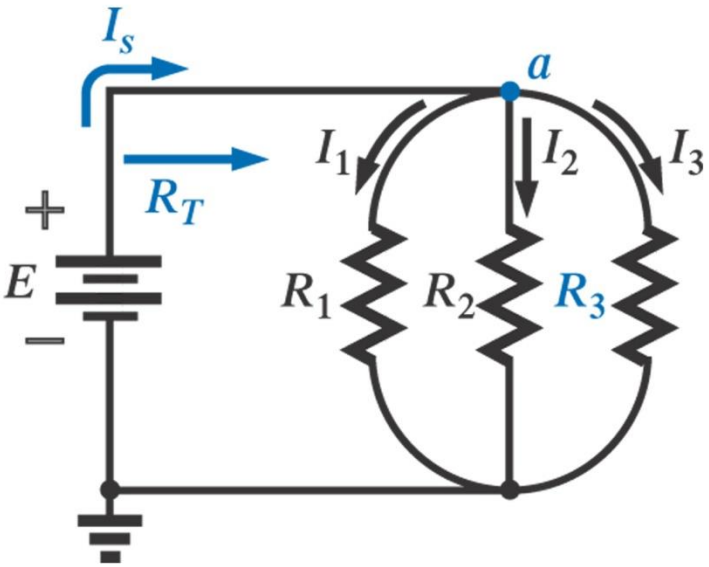
$$I_1 = \left(\frac{R_2}{R_1 + R_2}\right) I_T$$

$$I_2 = \left(\frac{R_1}{R_1 + R_2}\right) I_T$$

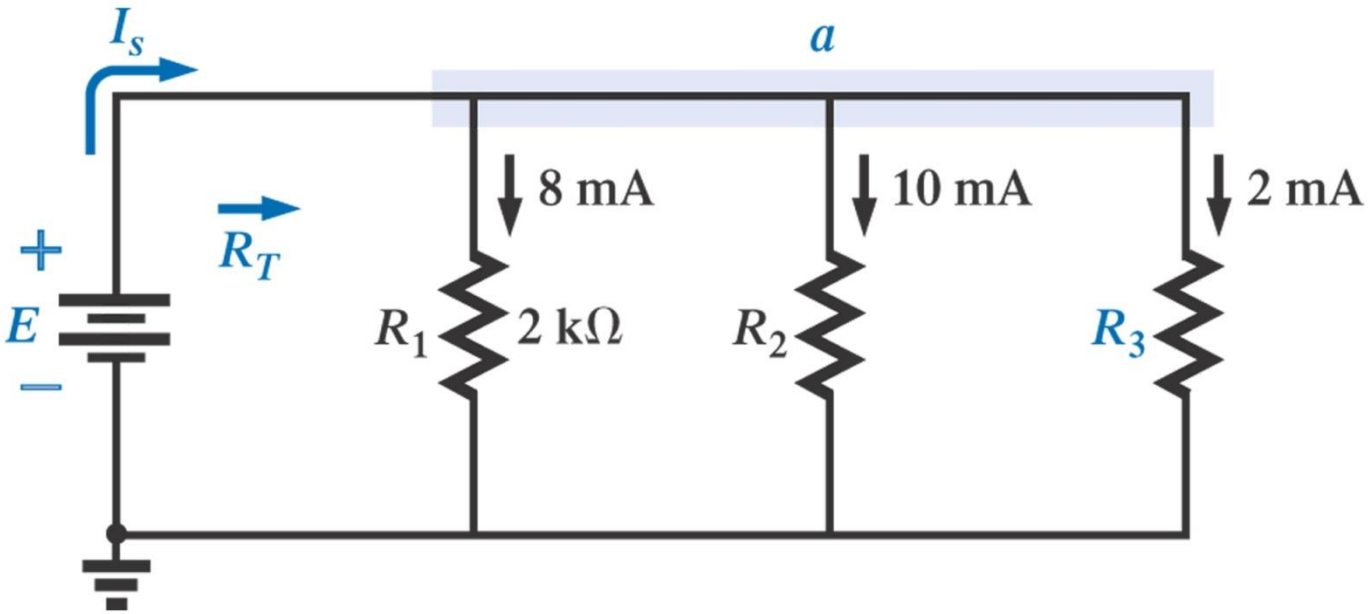
Current Divider Rule

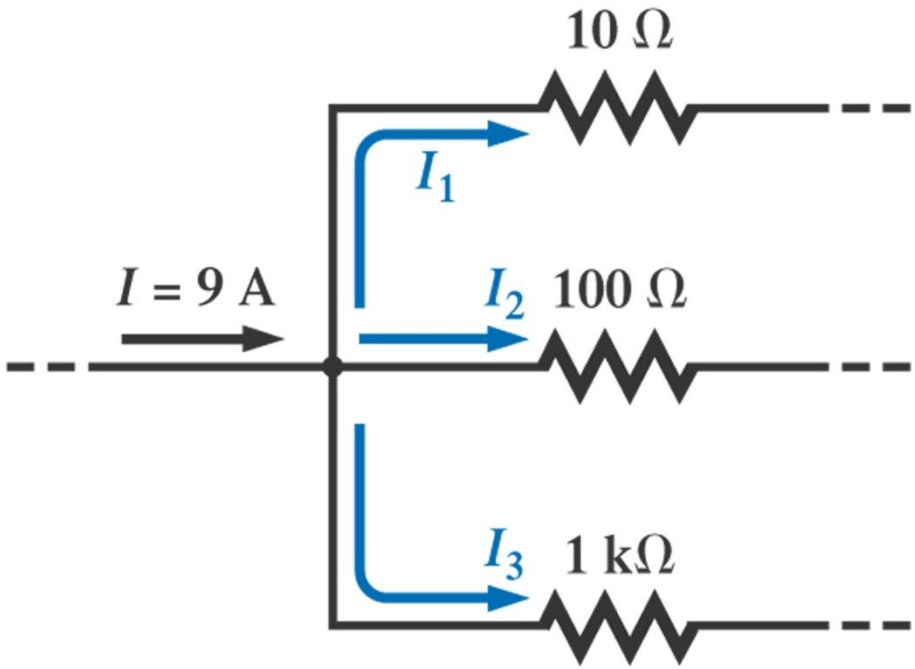
- In words:
  - The current through any branch of a parallel resistive network is equal to the total resistance of the parallel network divided by the resistor of interest and multiplied by the total current entering the parallel configuration

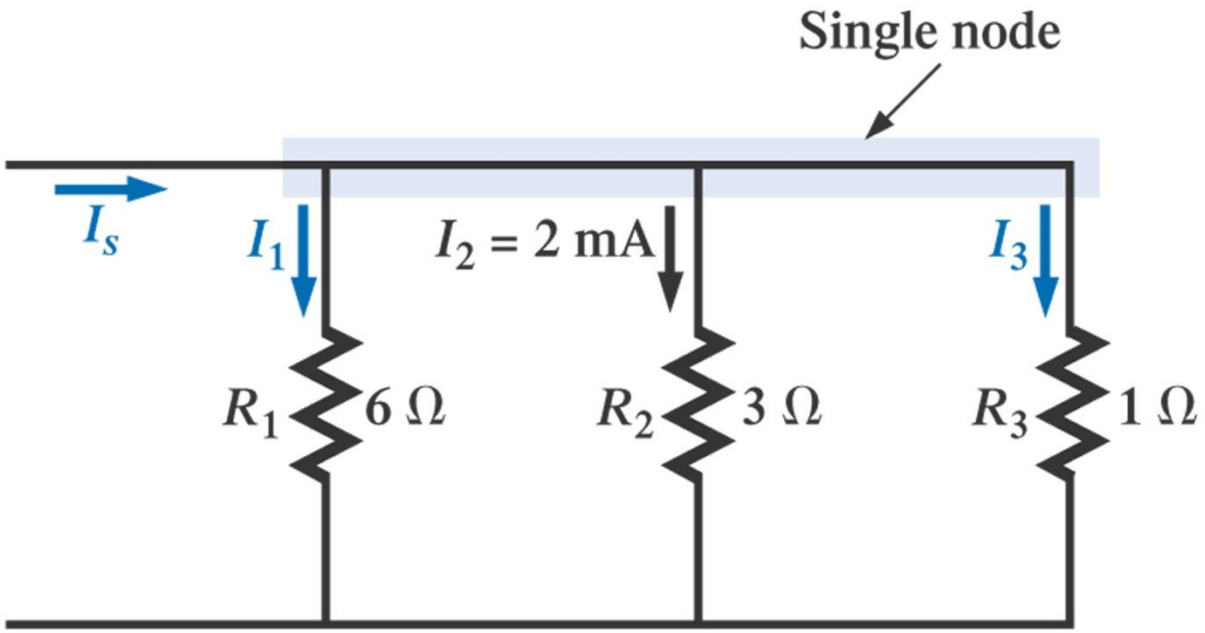




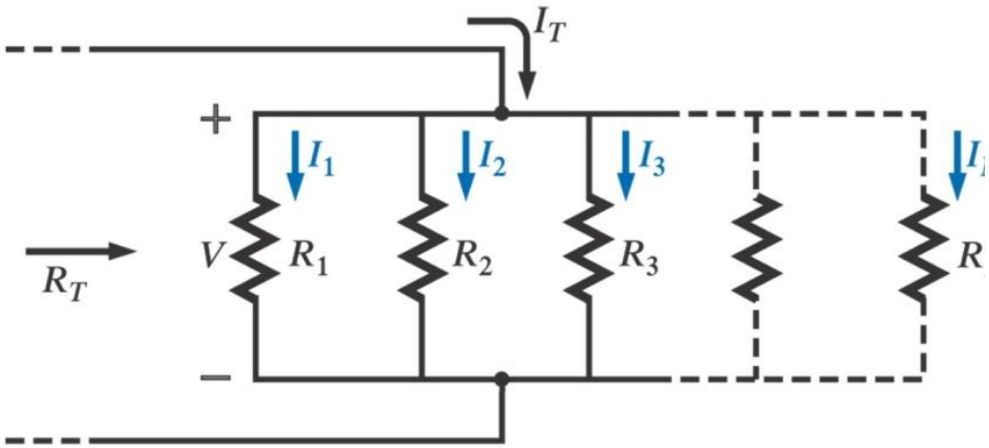
Redraw if required



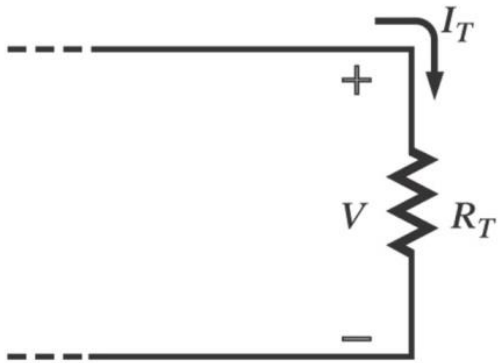




Deriving the current divider rule: (a) parallel network of *N* parallel resistors; (b) reduced equivalent of part (a).

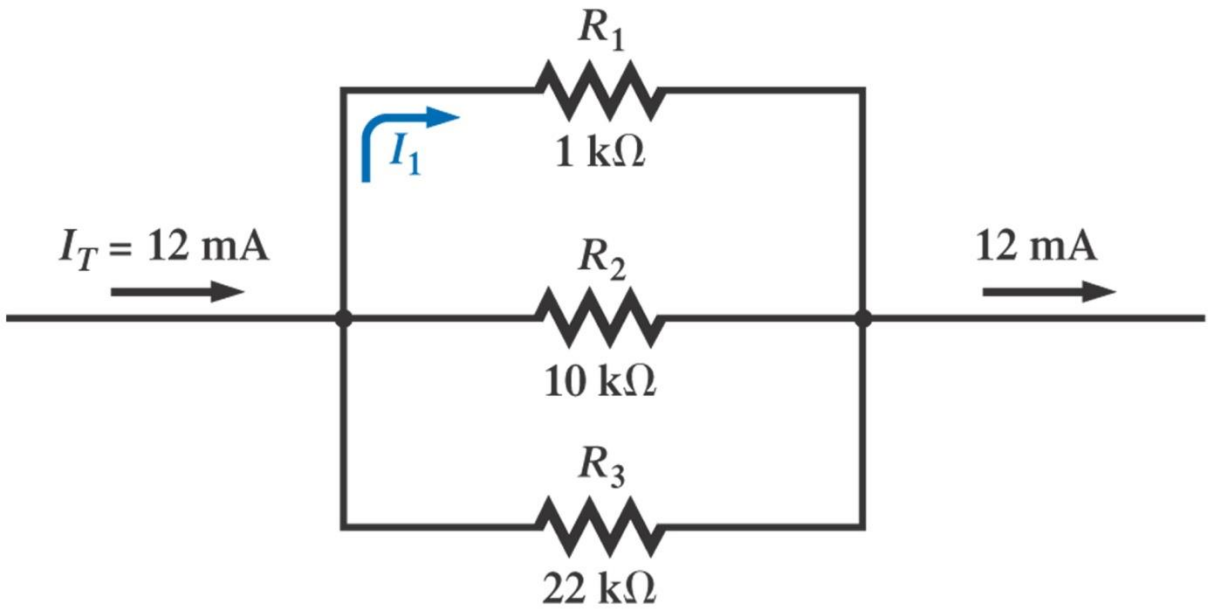


(a)

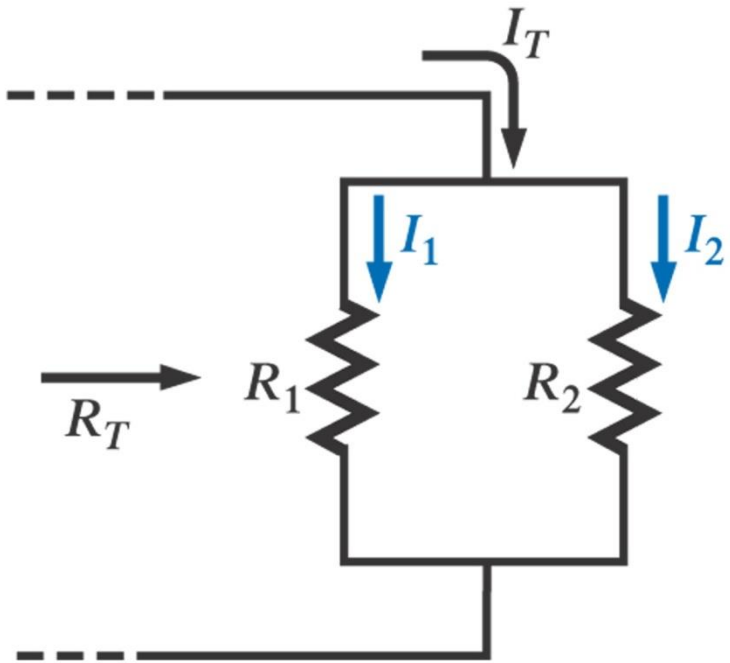


(b)

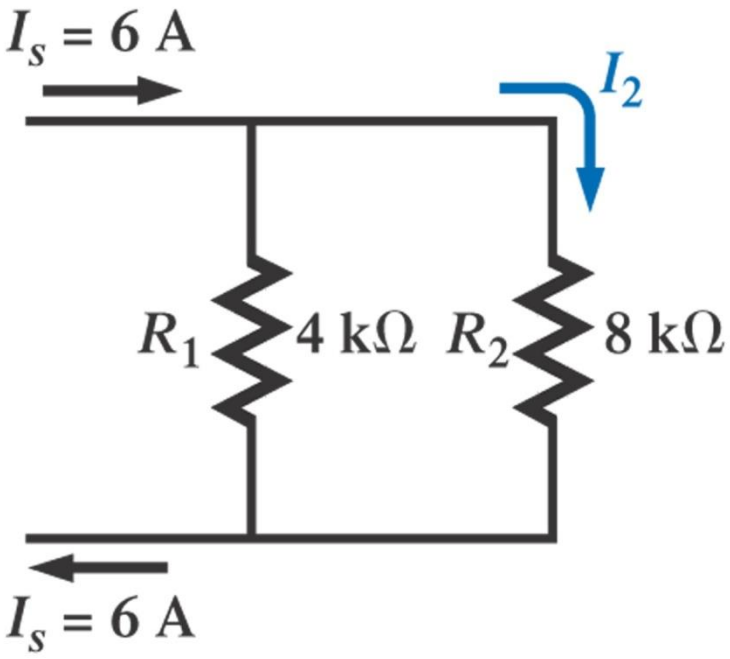
Using the current divider rule to calculate current I_1



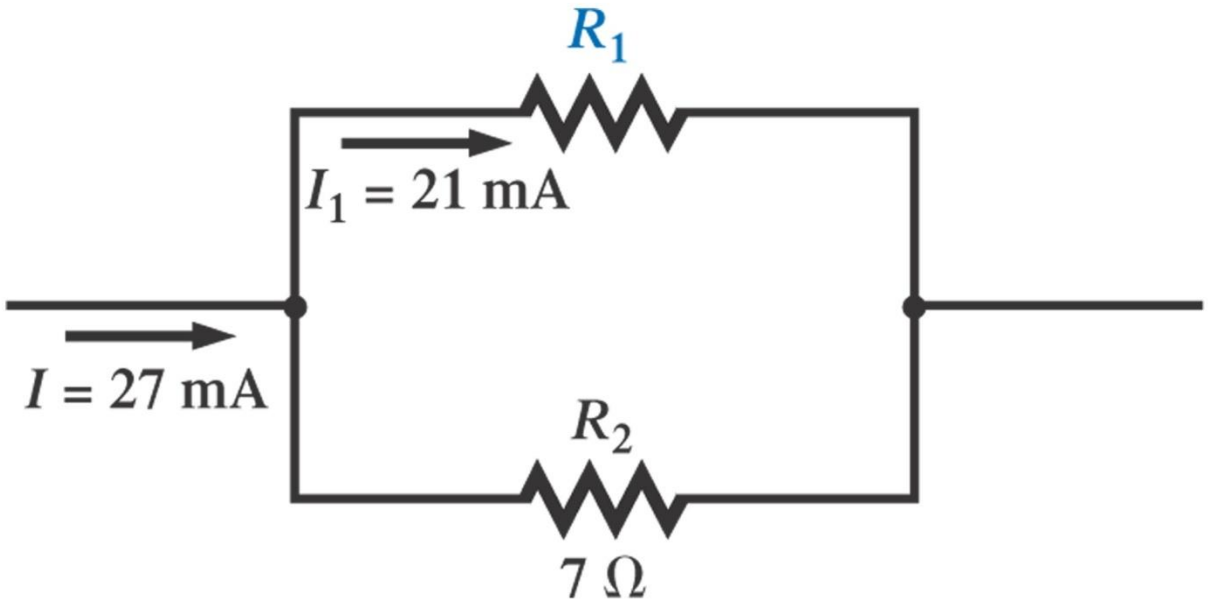
Deriving the current divider rule for the special case of only two parallel resistors.



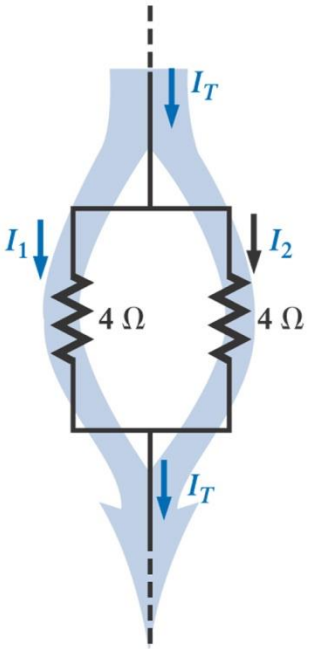
Using the current divider rule to determine current I_2



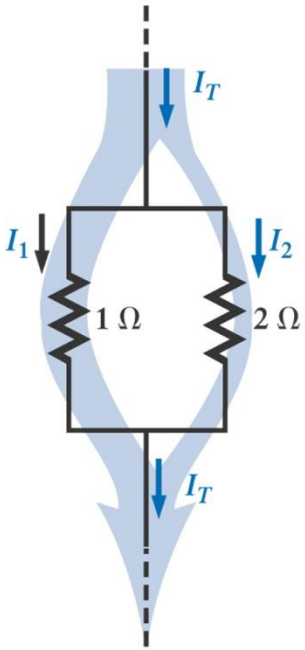
A design-type problem for two parallel resistors



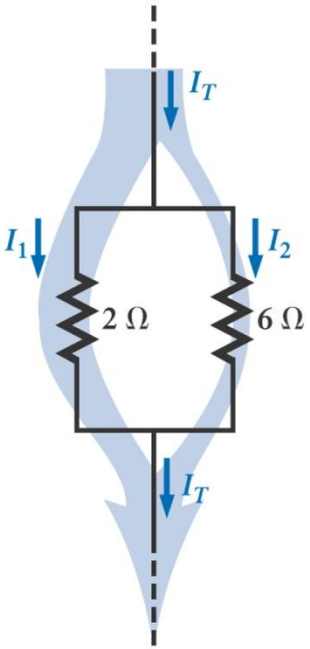
Demonstrating how current will divide through equal and unequal parallel resistors.



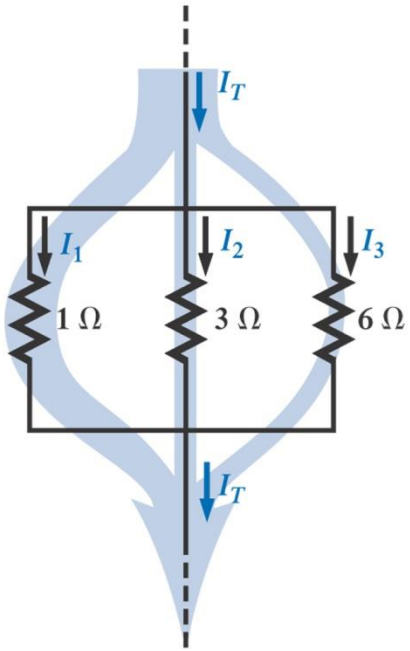
$$I_1 = I_2 = \frac{I_T}{2}$$



$$I_1 = 2I_2$$

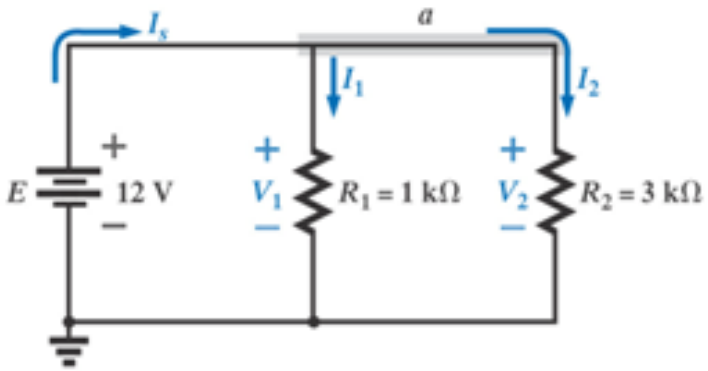


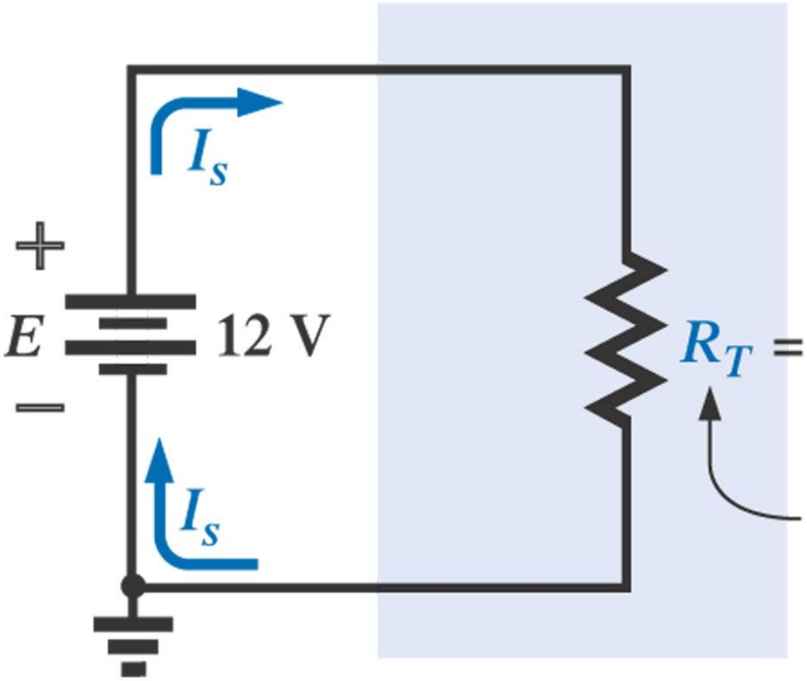
$$I_1 = \left(\frac{6}{2}\right) I_2 = 3I_2$$



$$I_1 = 6I_3$$
$$I_1 = 3I_2$$
$$I_2 = \left(\frac{6}{3}\right) I_3 = 2I_3$$

Replacing the parallel resistors of Fig. 6.20 with the equivalent total resistance.

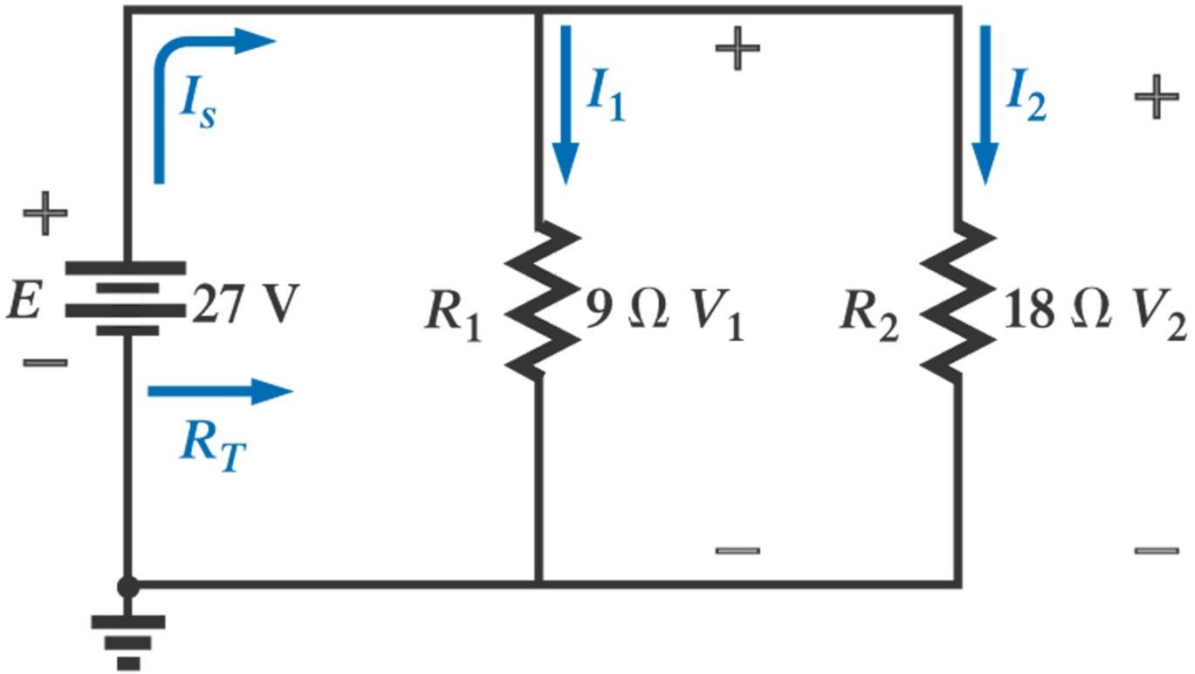




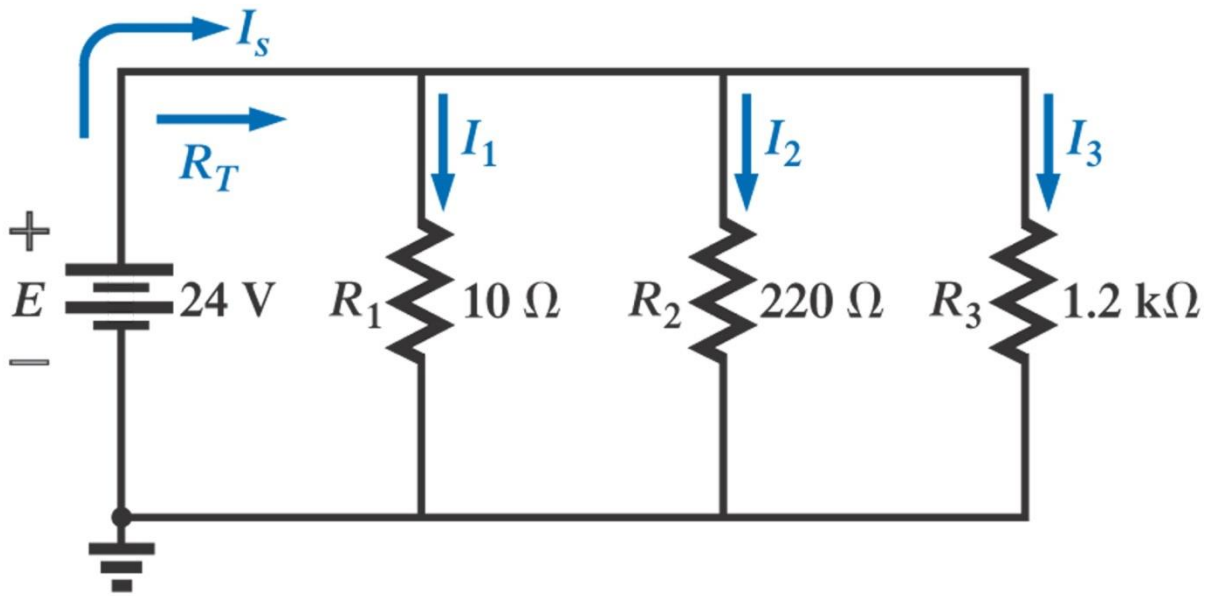
$$R_T = \frac{(1\ \text{k}\Omega)(3\ \text{k}\Omega)}{1\ \text{k}\Omega + 3\ \text{k}\Omega} = 0.75\ \text{k}\Omega$$

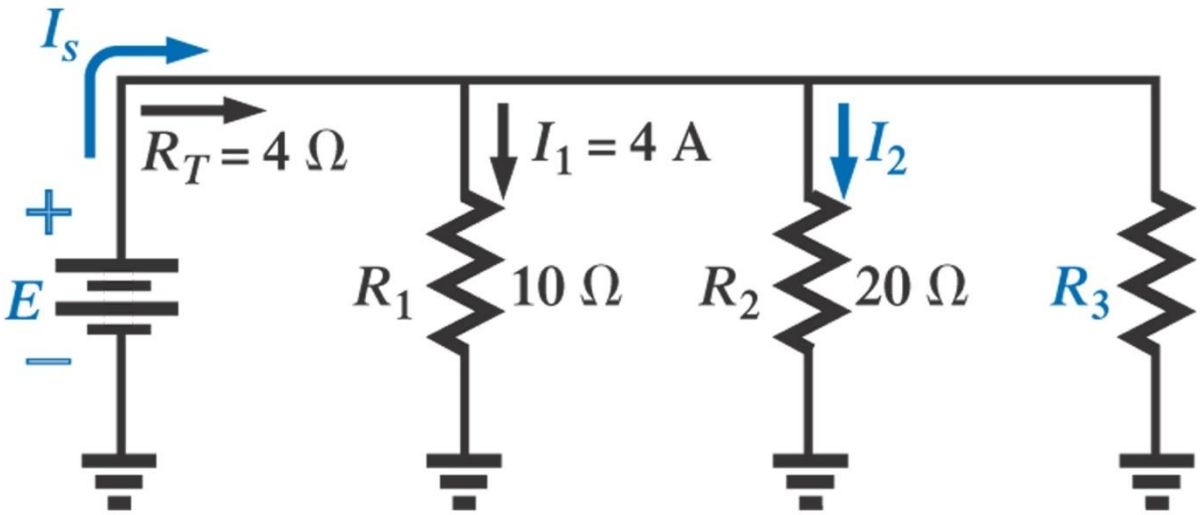
Equivalent resistance

Parallel circuit for Example



Parallel network for Example

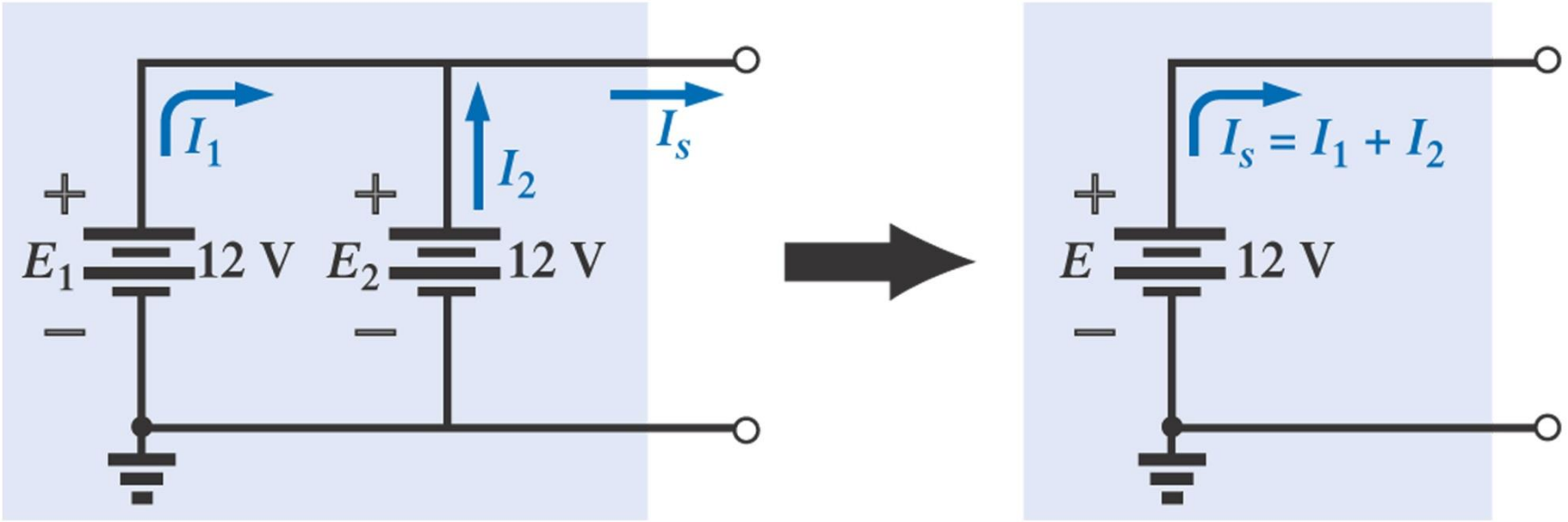




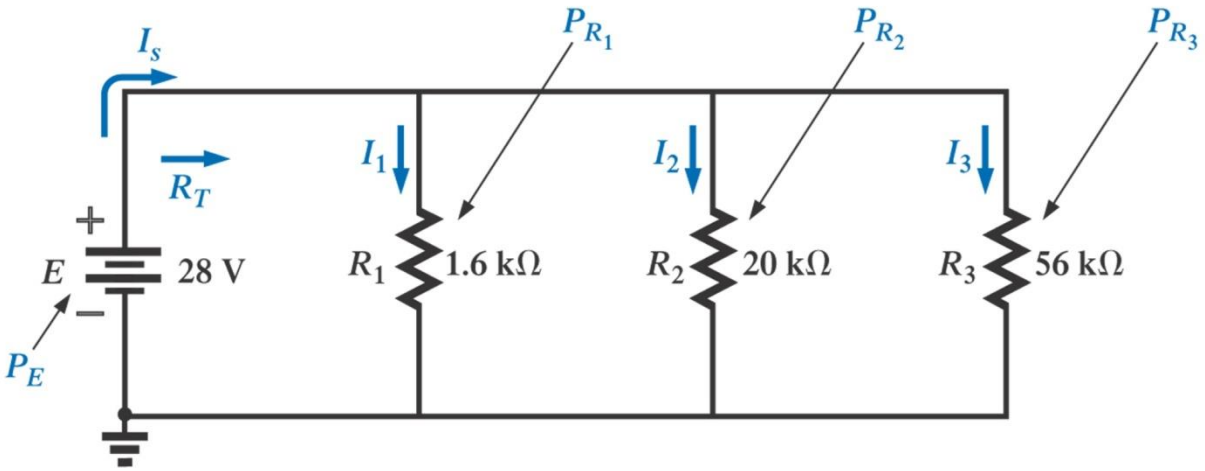
Voltage Sources in Parallel

- Voltage sources can only be placed in parallel if they have the **same voltage**
  - the primary reason for placing two or more batteries or supplies in parallel would be to **increase the current rating** above that of a single supply
  - the total source current using Kirchhoff's current law is the sum of the rated currents of each supply

Demonstrating the effect of placing two ideal supplies of the same voltage in parallel.

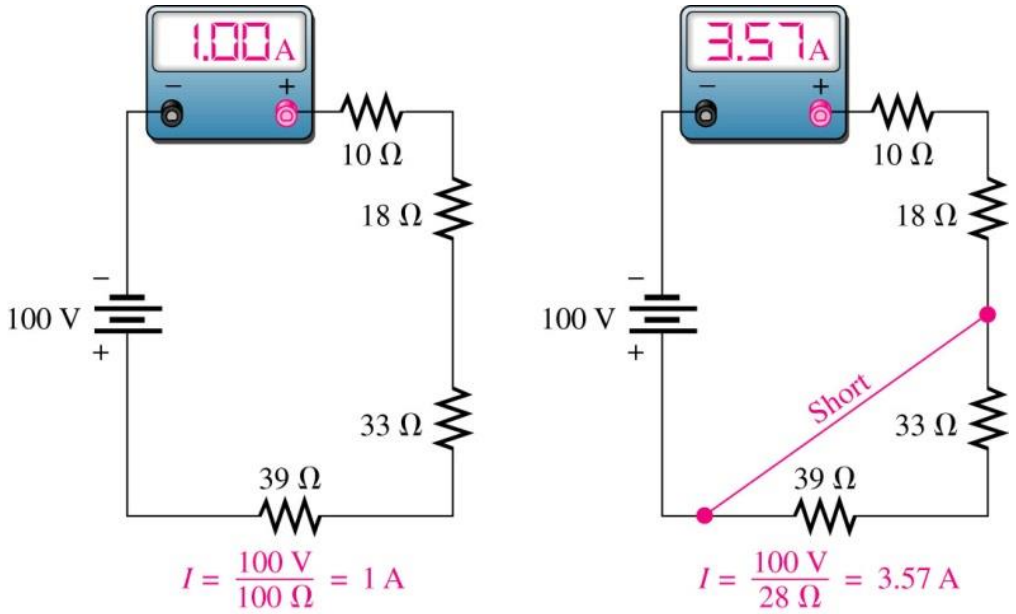


Parallel network for Example



Short Circuit

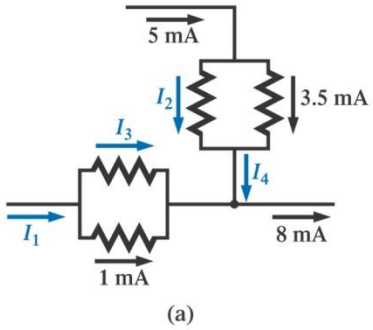
- When there is a short, a portion of the series resistance is bypassed, thus reducing the total resistance.
- A short in a series circuit results in more current than normal.



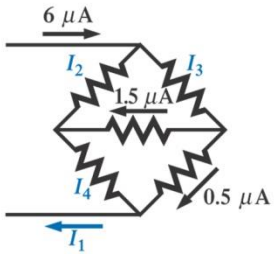
(a) Before short

(b) After short

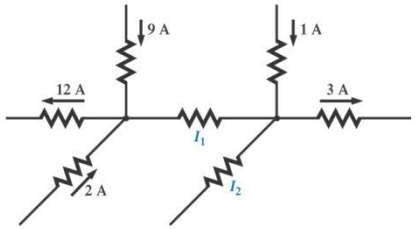
Example:



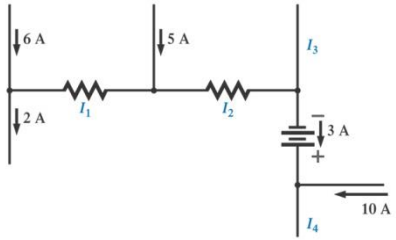
(a)



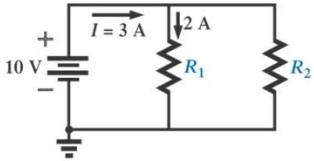
(b)



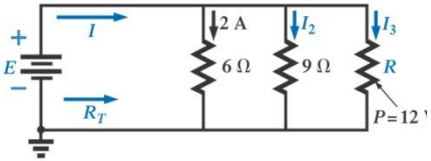
(a)



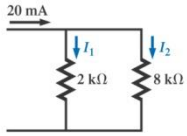
(b)



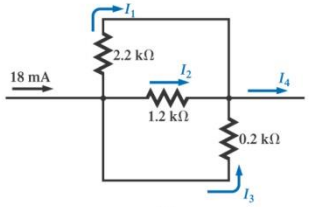
(a)



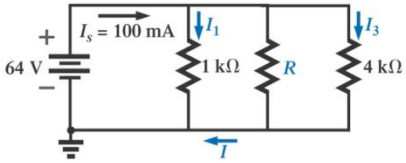
(b)



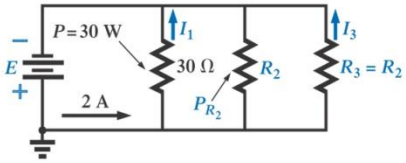
(a)



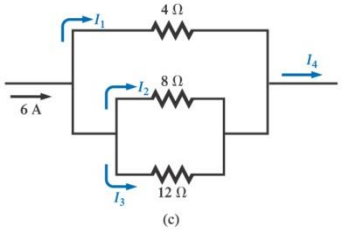
(b)



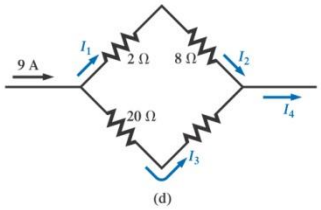
(c)



(d)

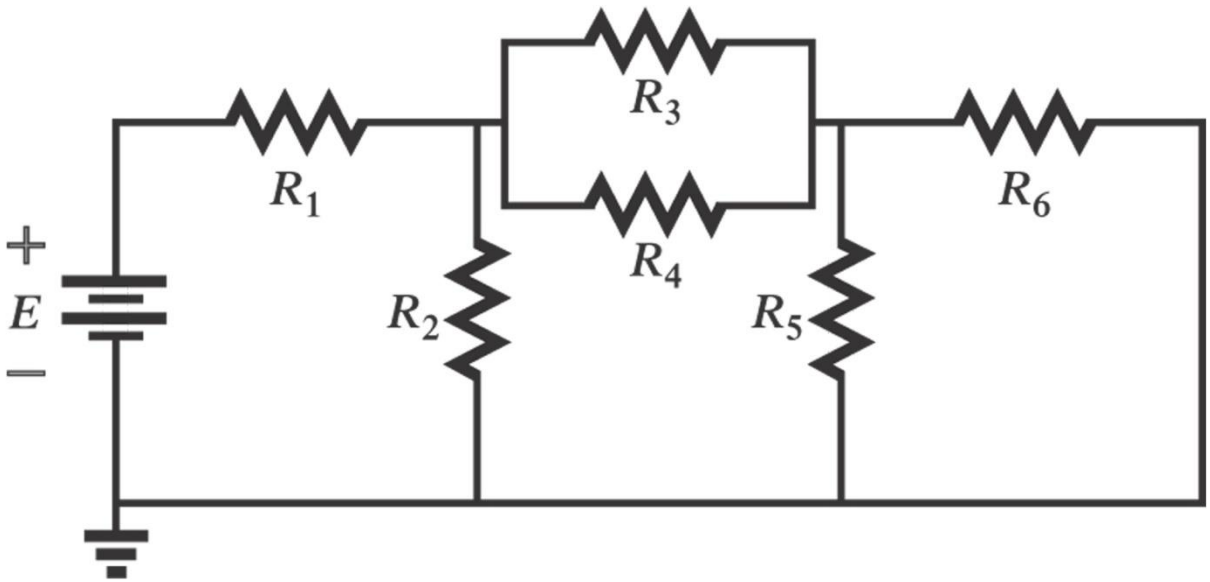


(c)



(d)

Problem 2:



Problem 3:

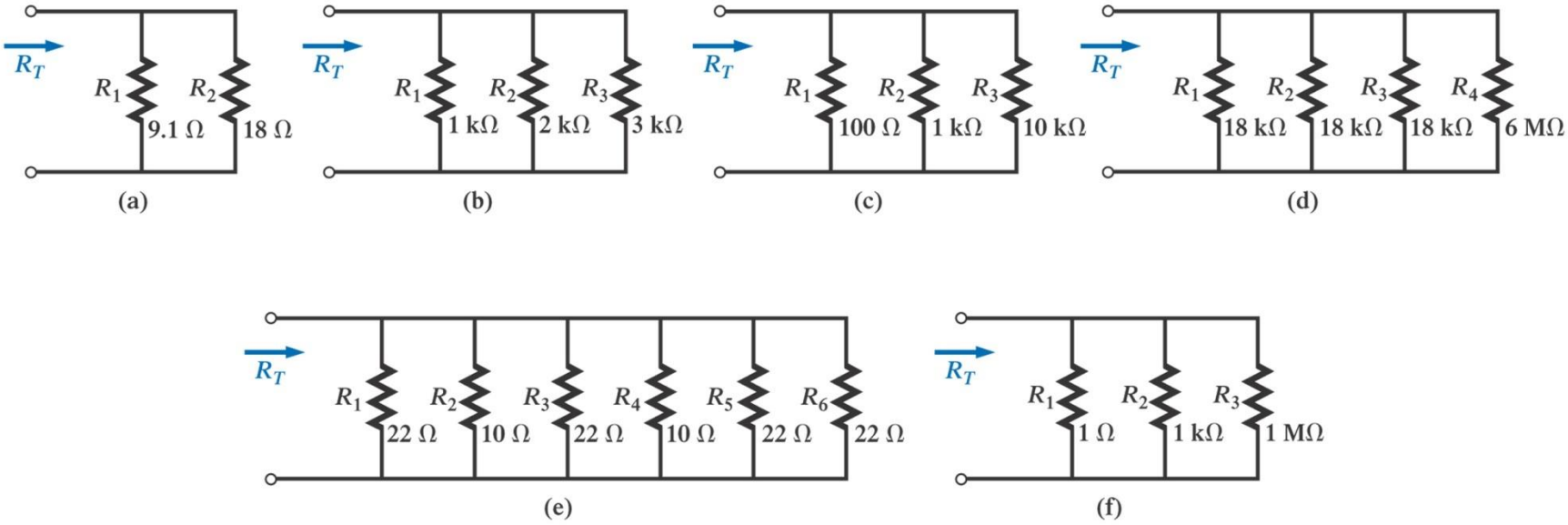


FIGURE 6-64 Problem 5.

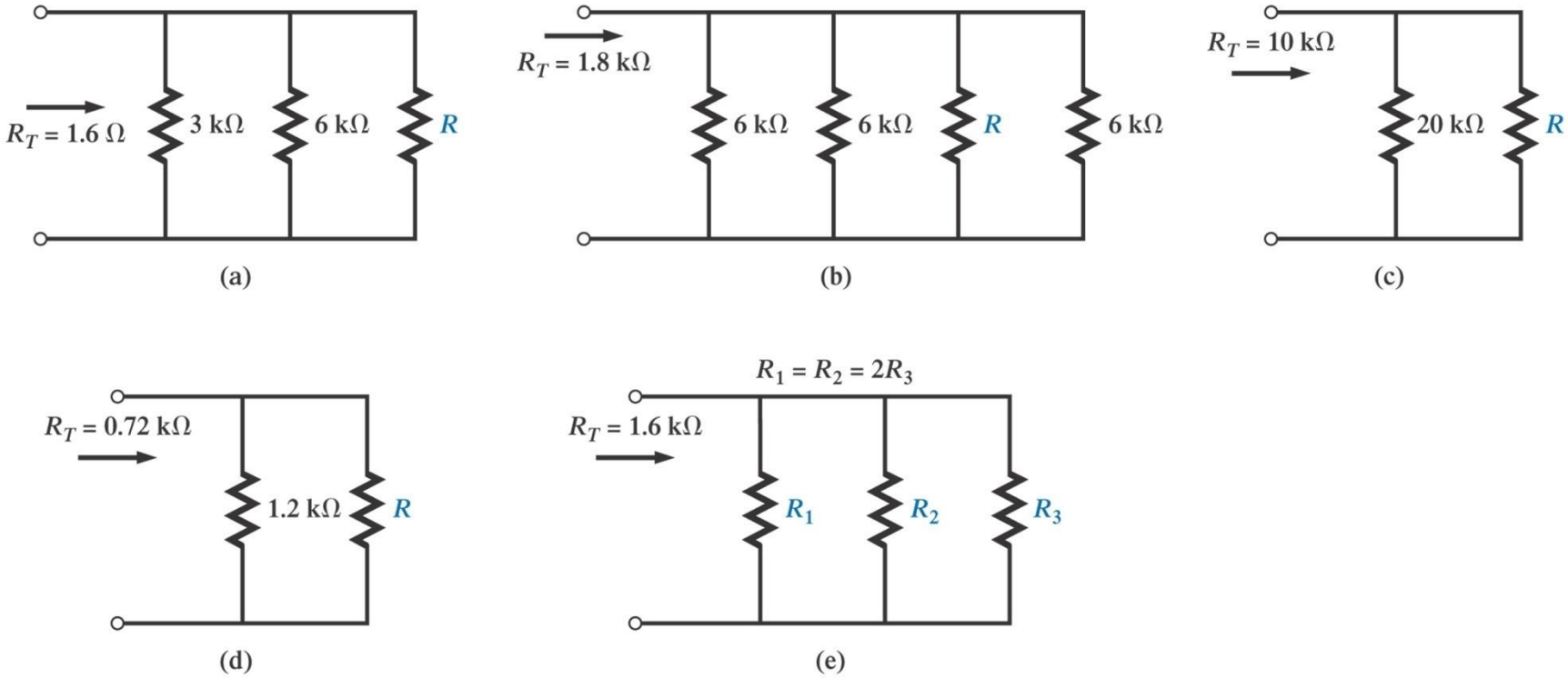


FIGURE 6-65 Problem 6.

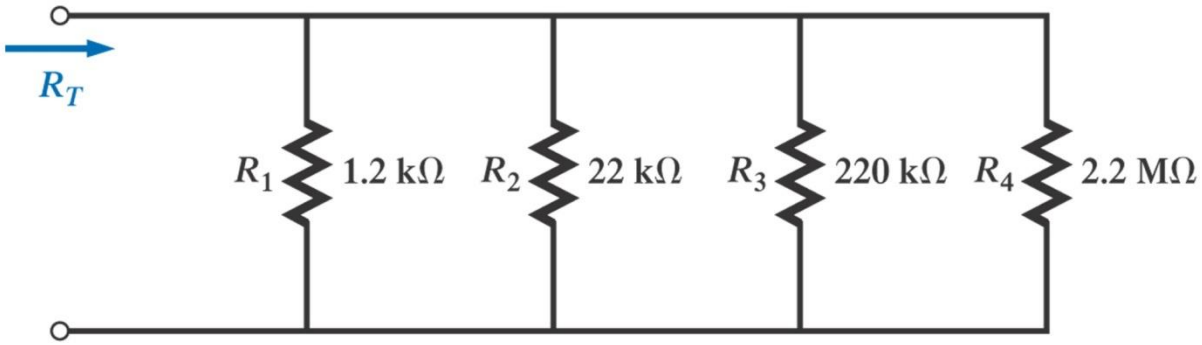


FIGURE 6-67 Problem 8.

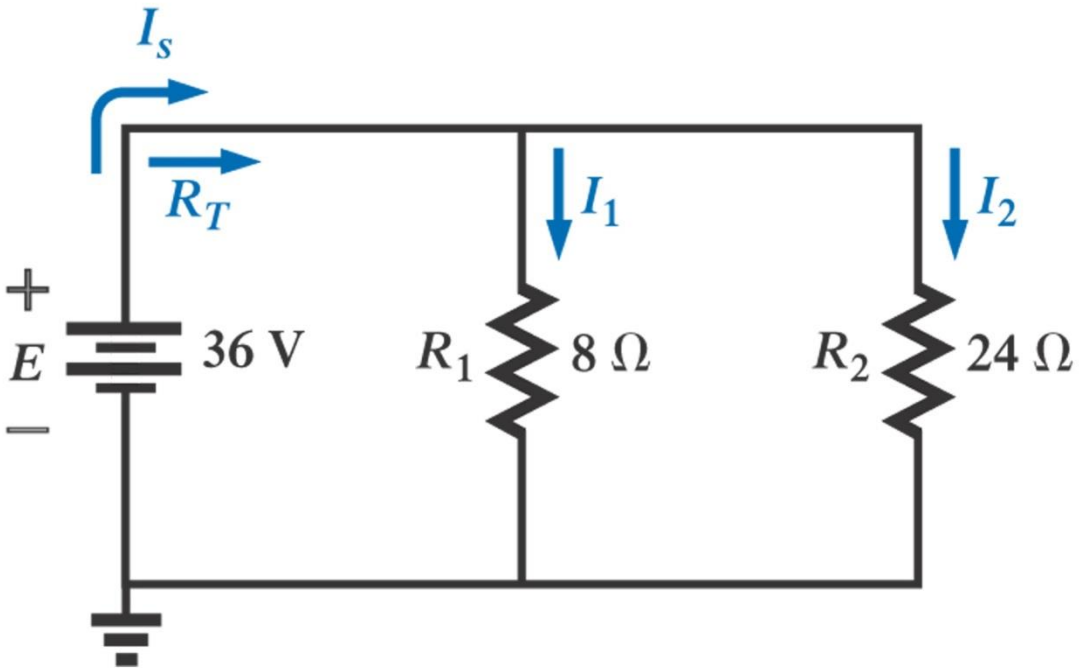


FIGURE 6-68 Problems 9 and 12.

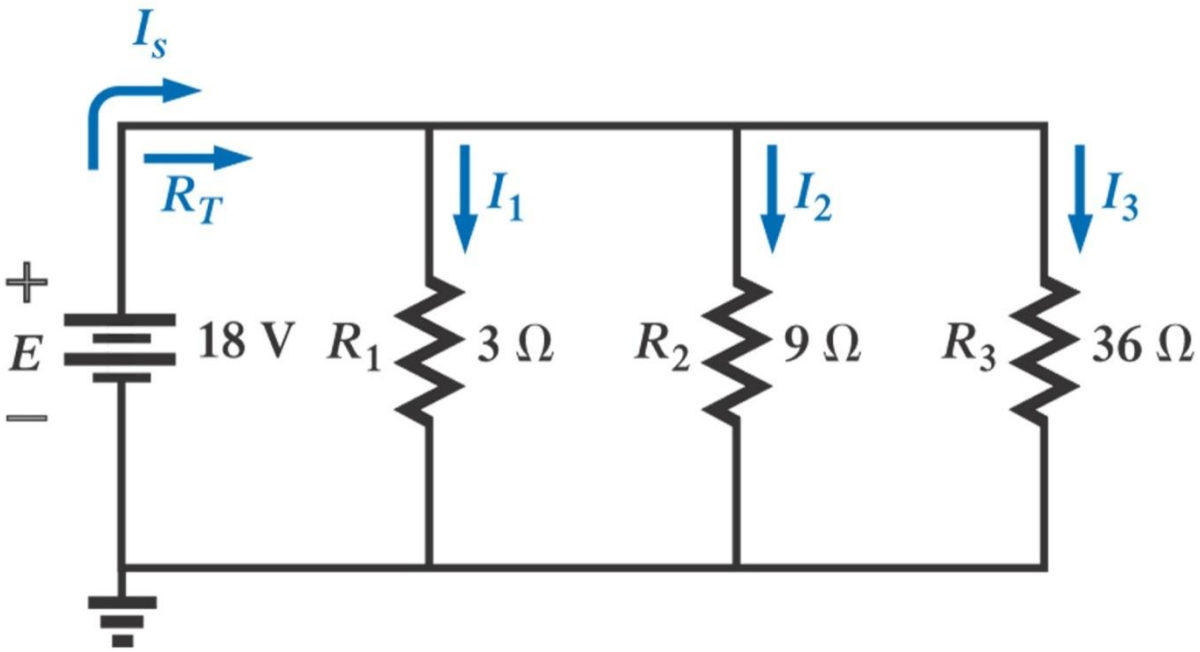


FIGURE 6-69 Problem 10.

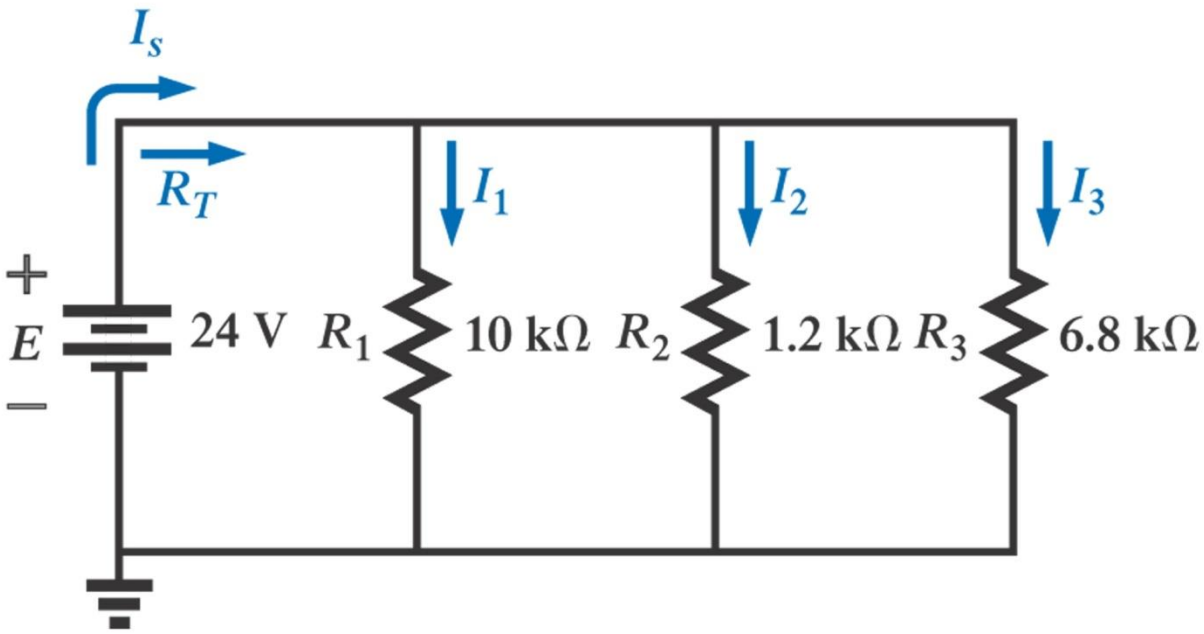


FIGURE 6-70 Problem 11.

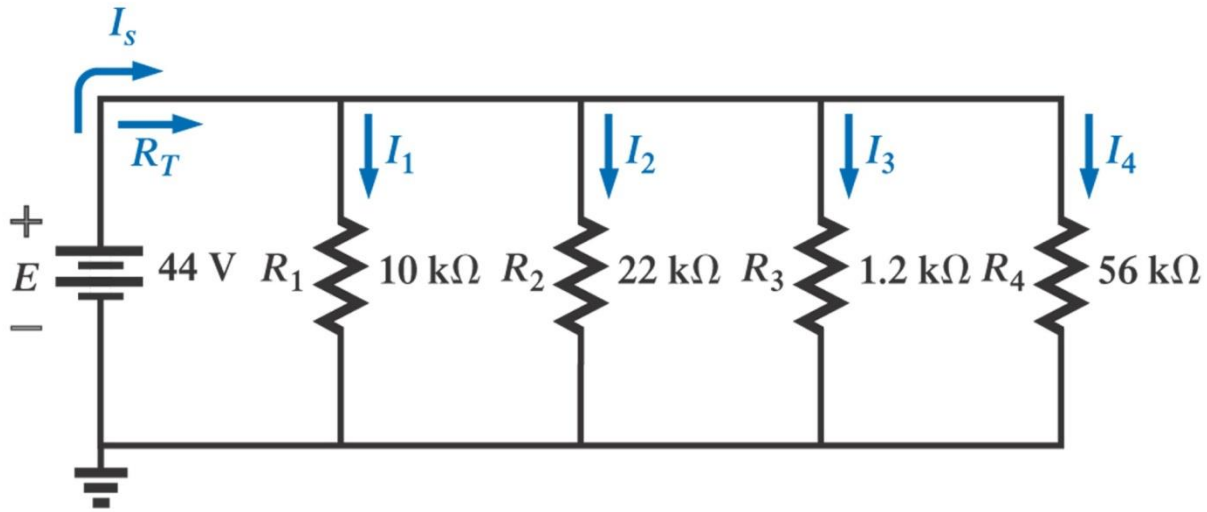


FIGURE 6-72 Problem 14.

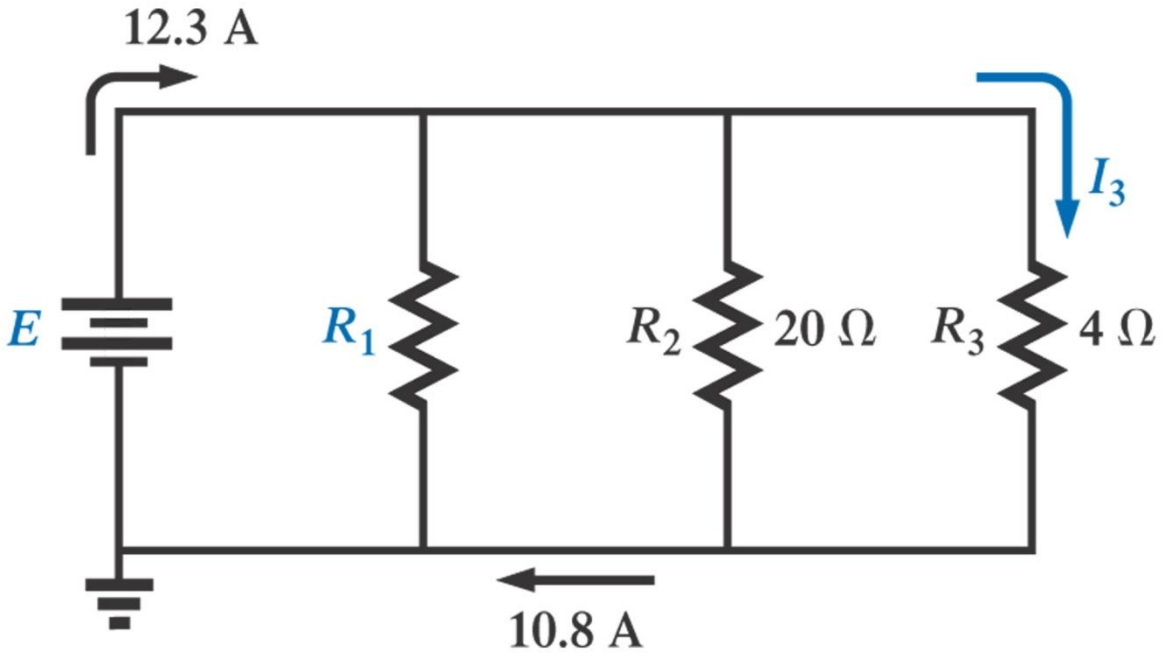


FIGURE 6-73 Problem 15.

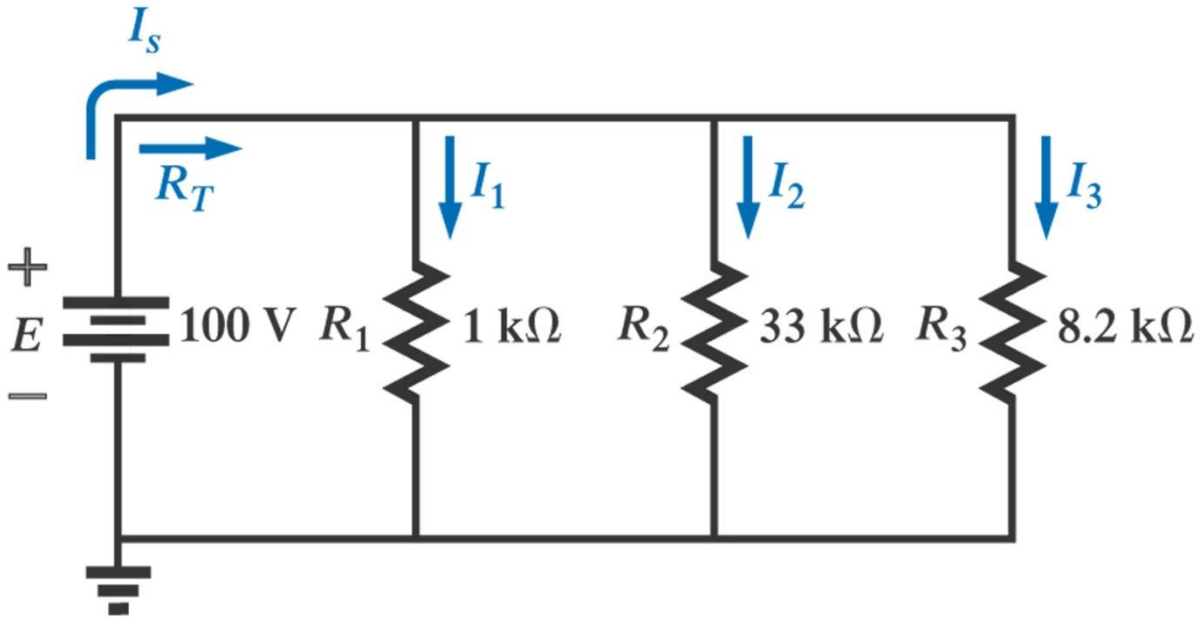


FIGURE 6-77 Problem 19.

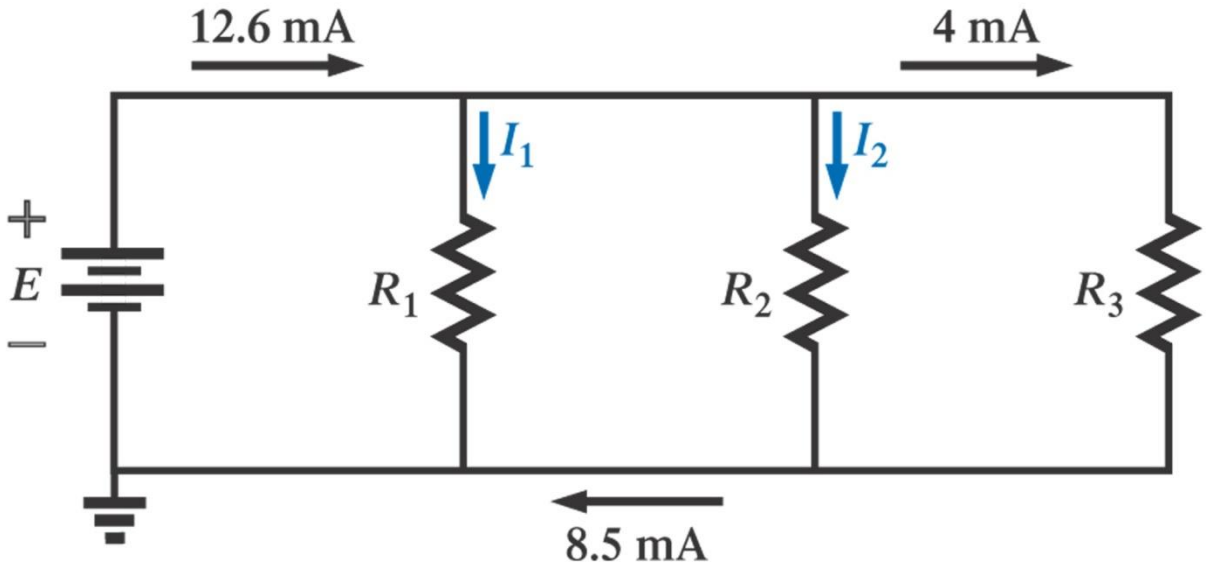
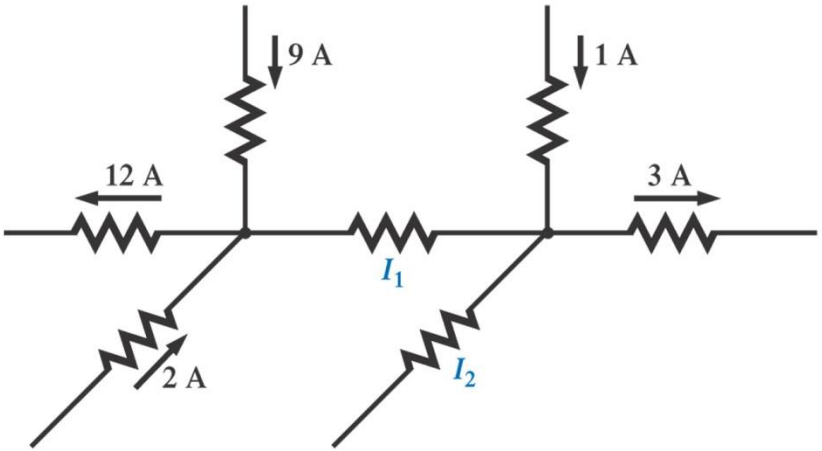
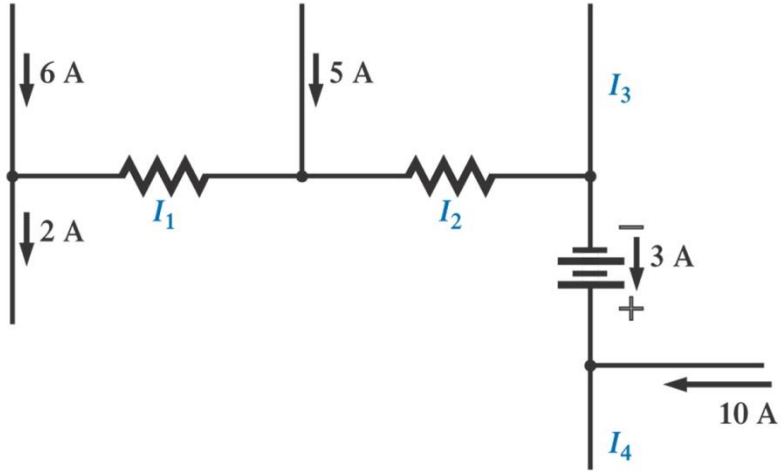


FIGURE 6-78 Problem 20.

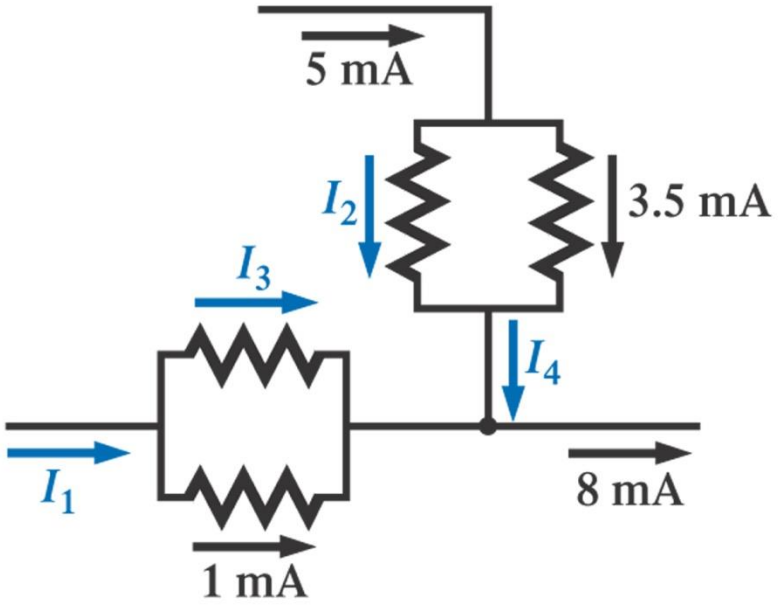


(a)

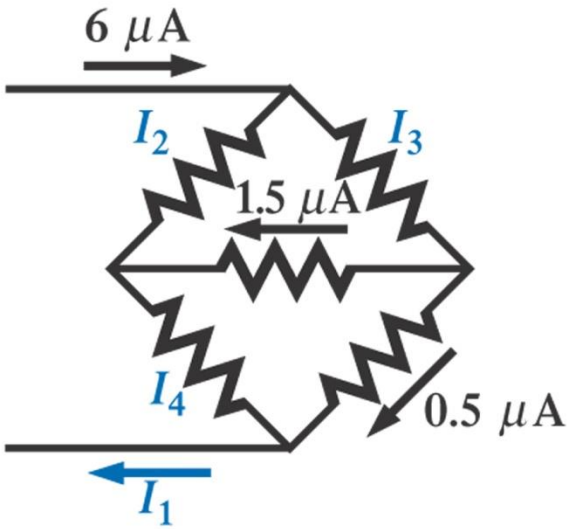


(b)

FIGURE 6-79 Problem 21.



(a)



(b)

FIGURE 6-80 Problem 22.

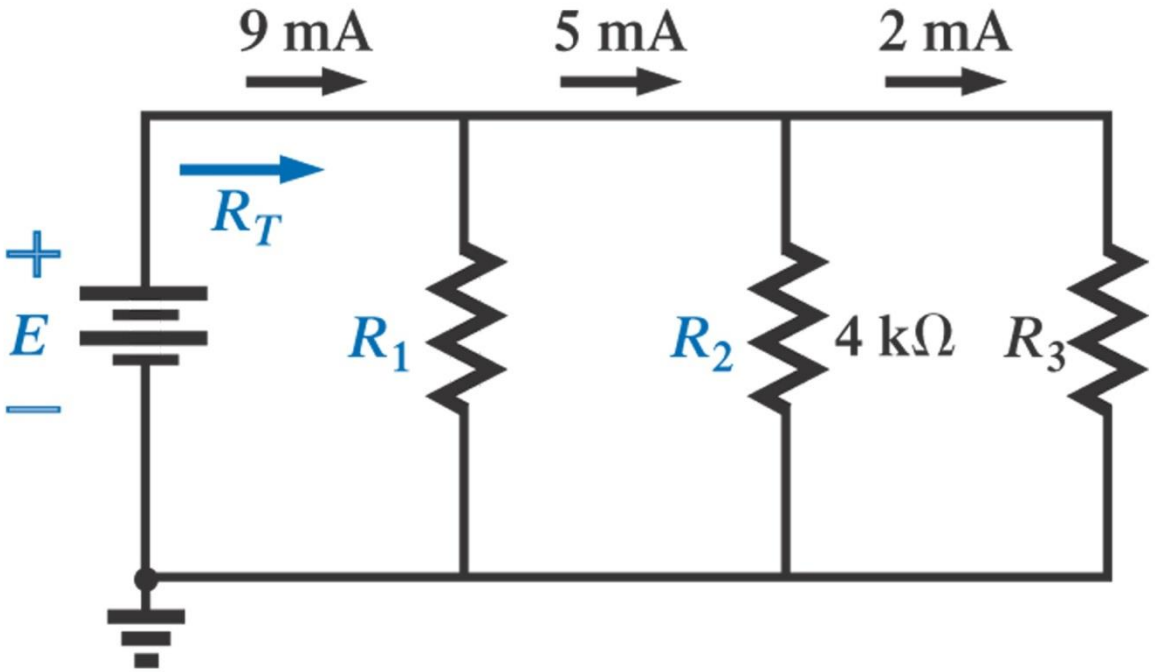
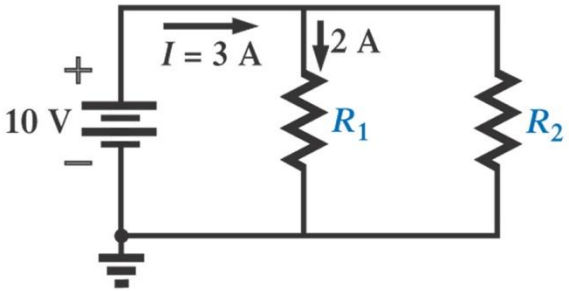
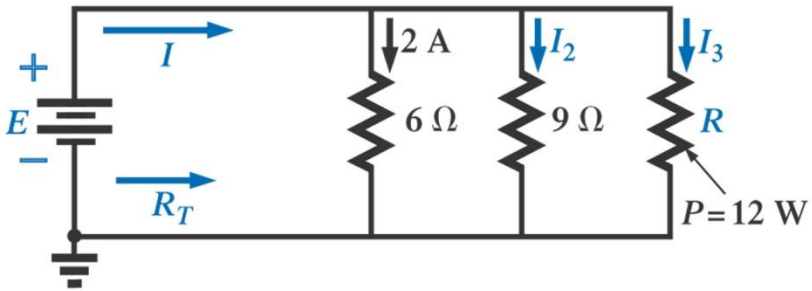


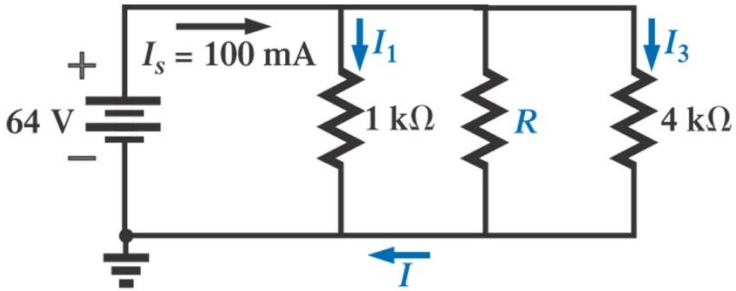
FIGURE 6-81 Problem 23.



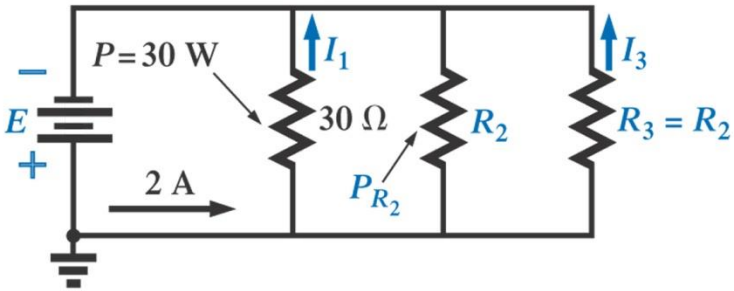
(a)



(b)



(c)



(d)

FIGURE 6-82 Problem 24.

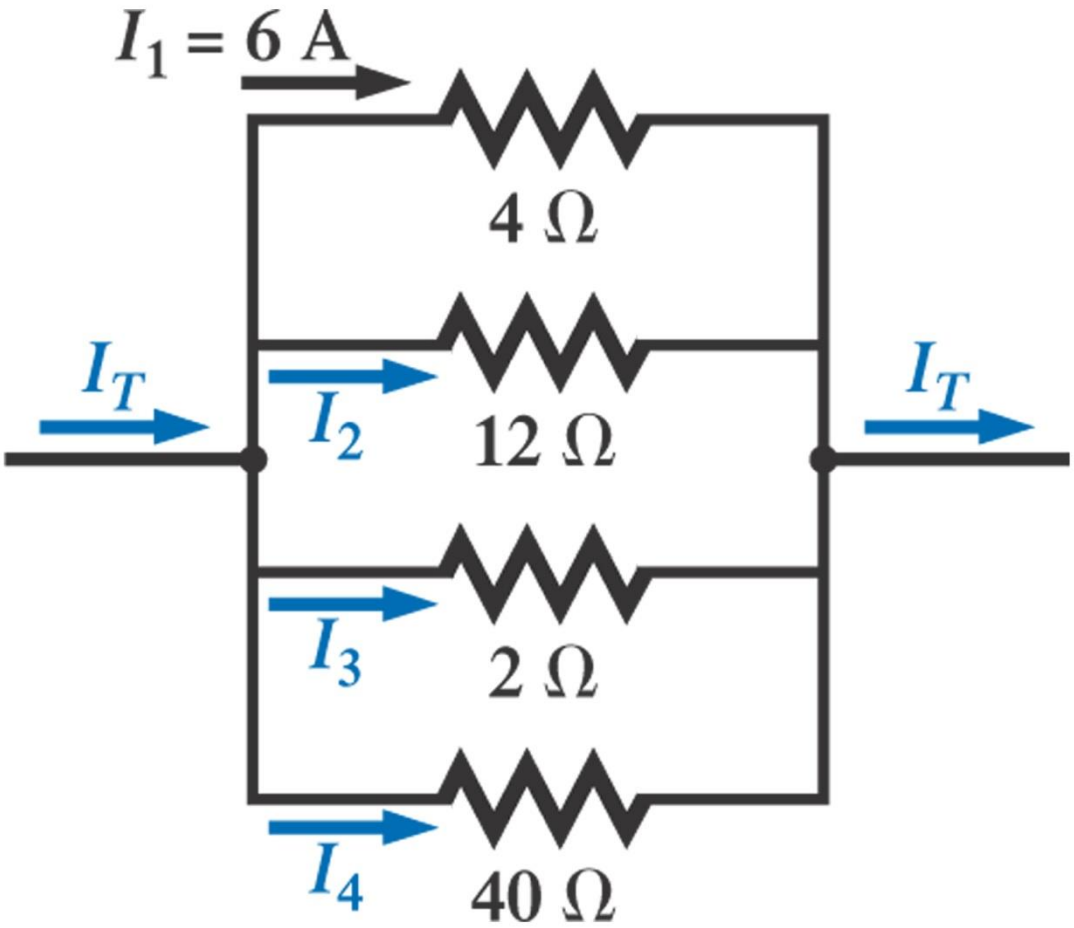
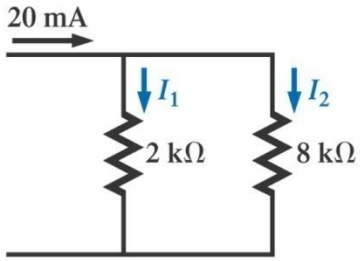
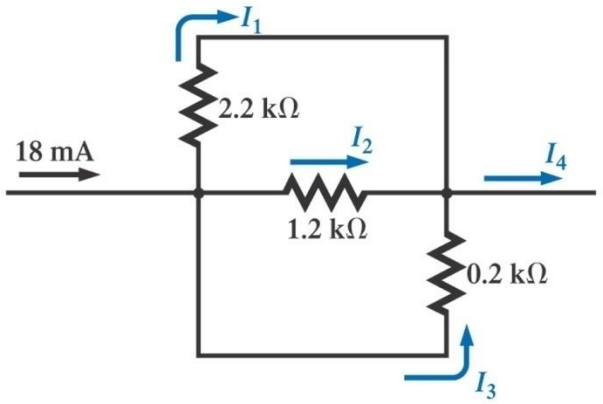


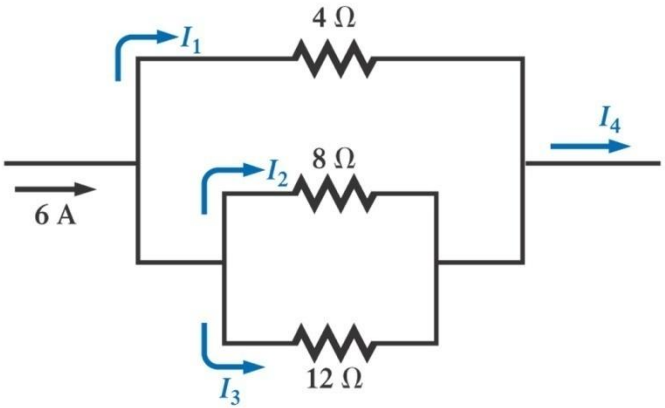
FIGURE 6-83 Problem 25.



(a)



(b)



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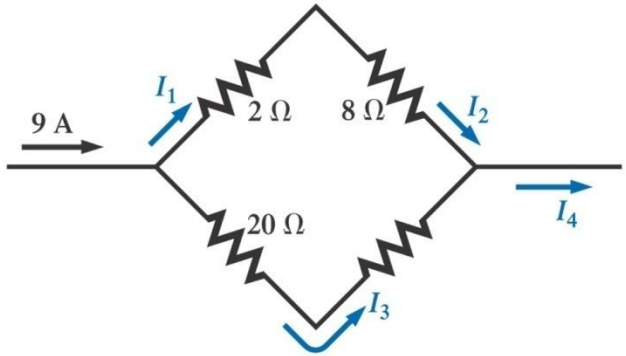

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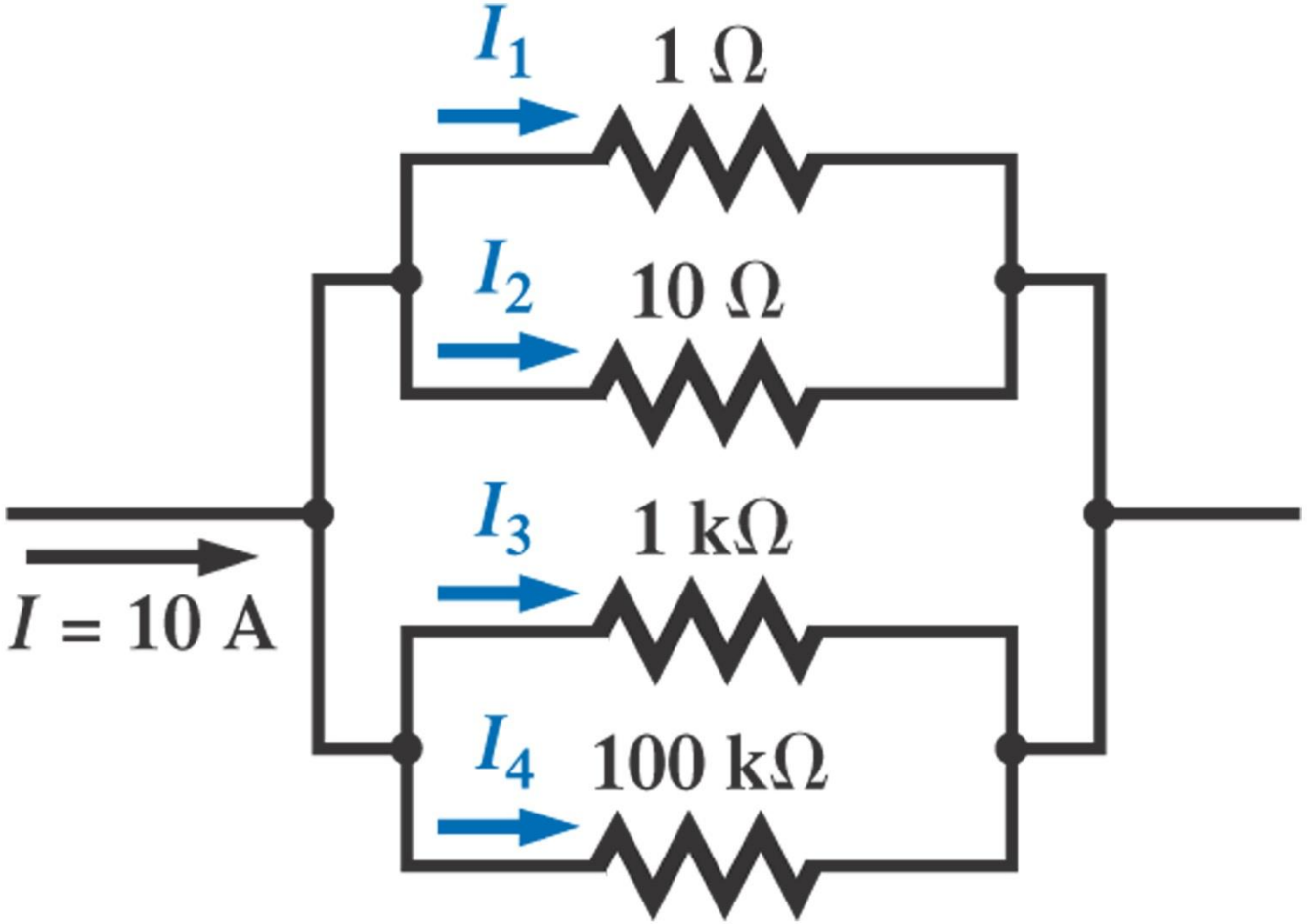
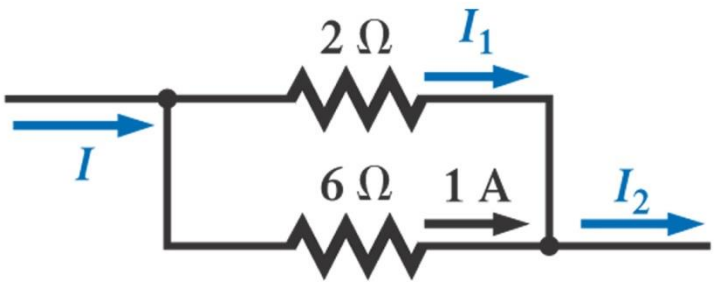
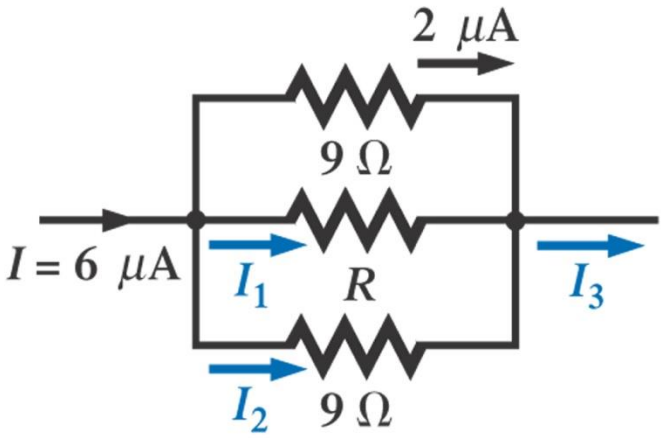

I_1
1 Ω
I_2
10 Ω
I_3
1 kΩ
I_4
100 kΩ
I = 10 A



(a)



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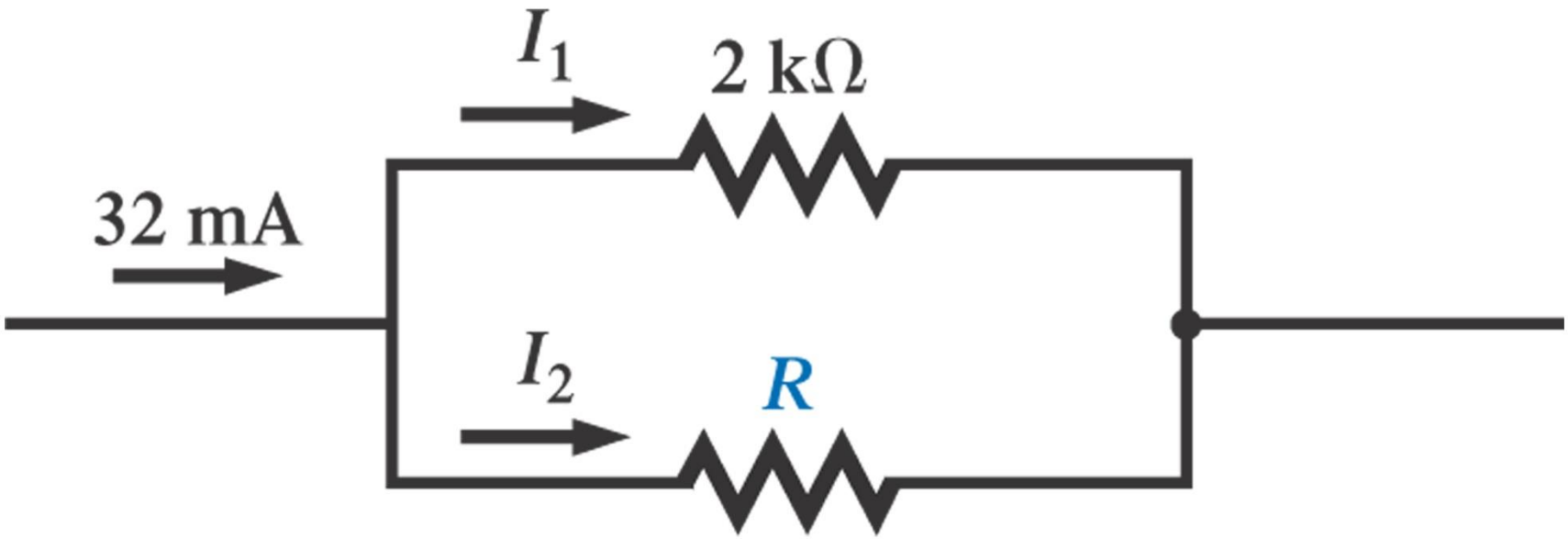


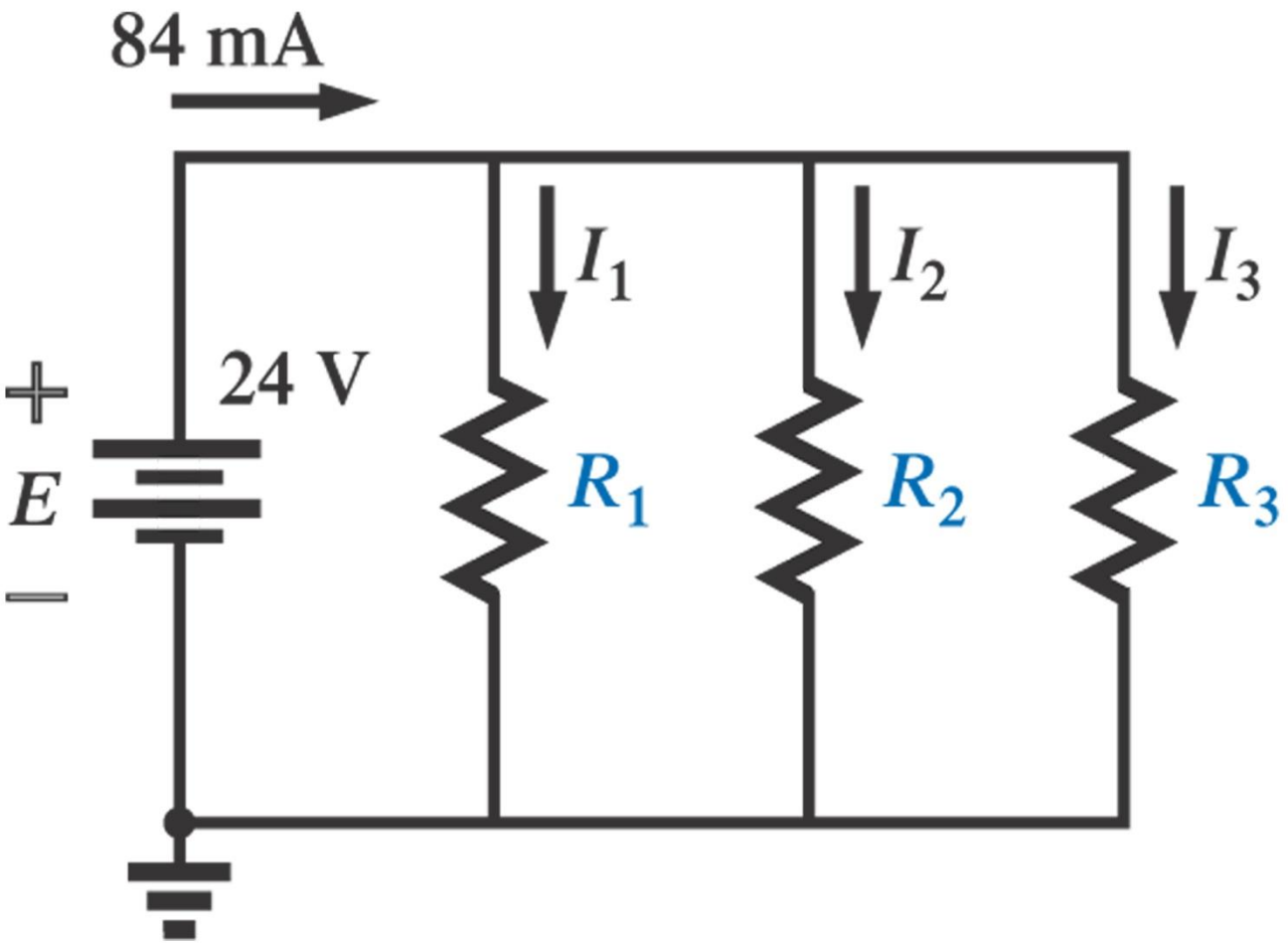
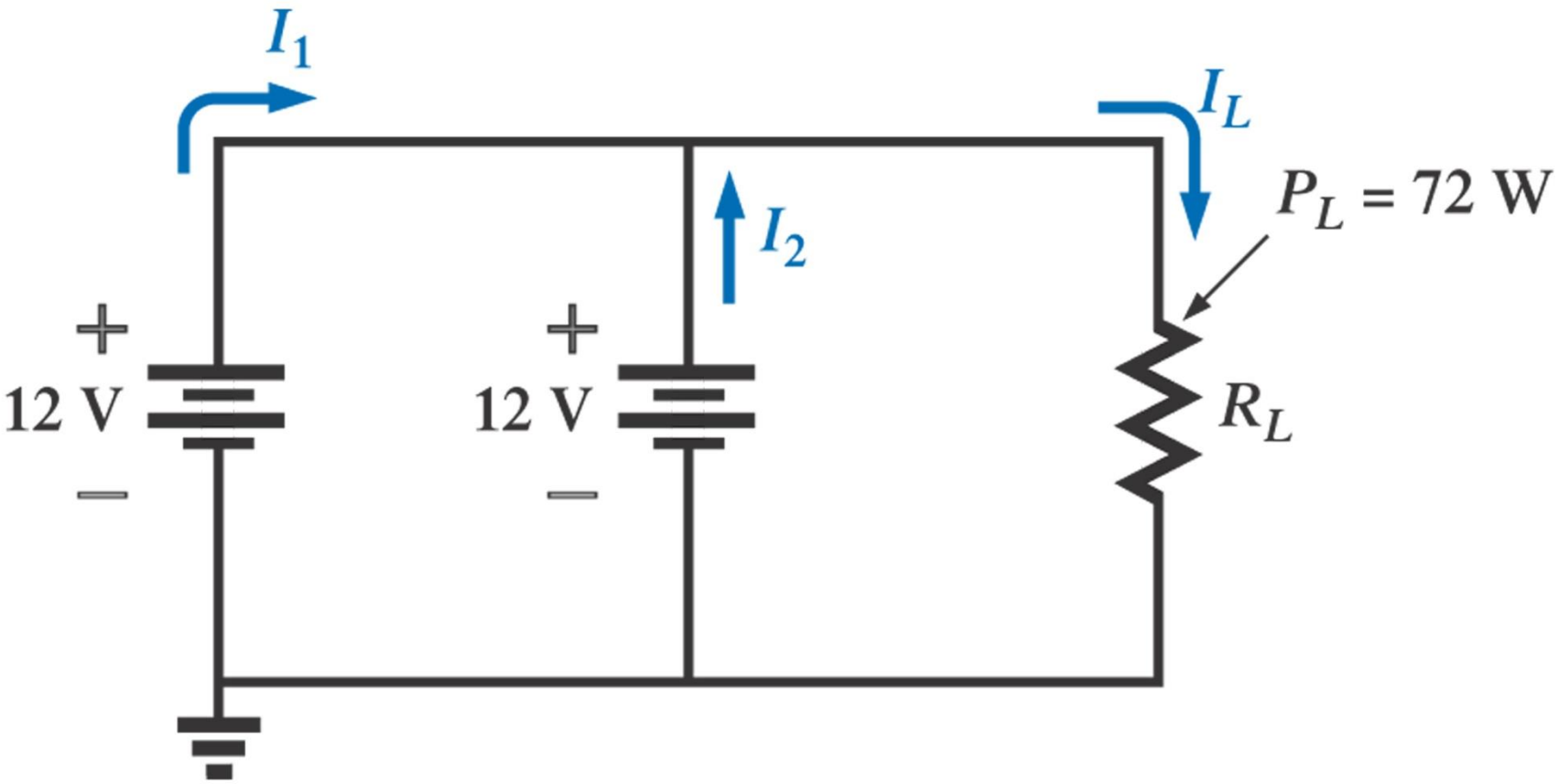


FIGURE 6-88 Problem 30



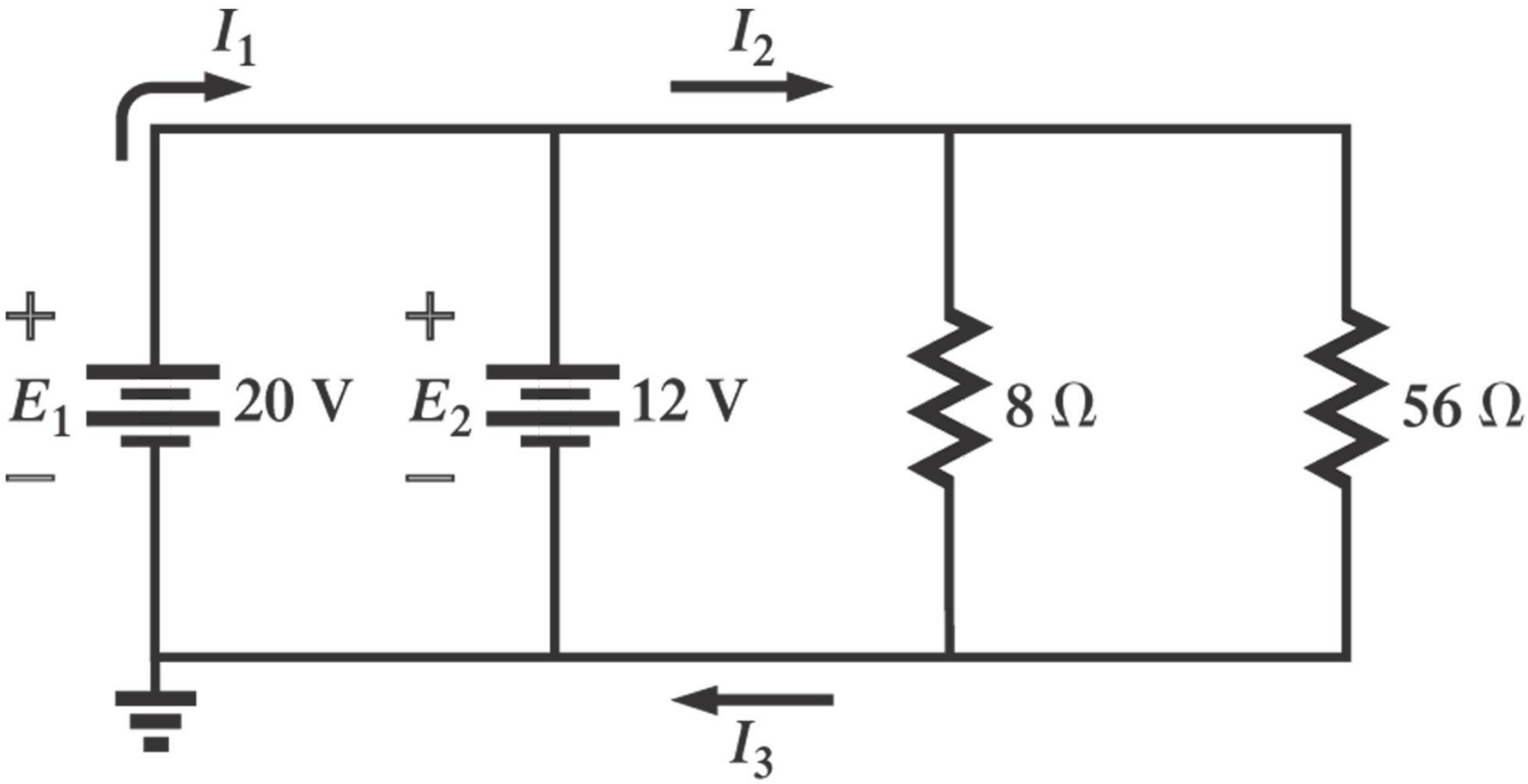

I_1
I_2
+
E_1
20 V
−
+
E_2
12 V
−
8 Ω
56 Ω
I_3

FIGURE 6-90 Problem 32.

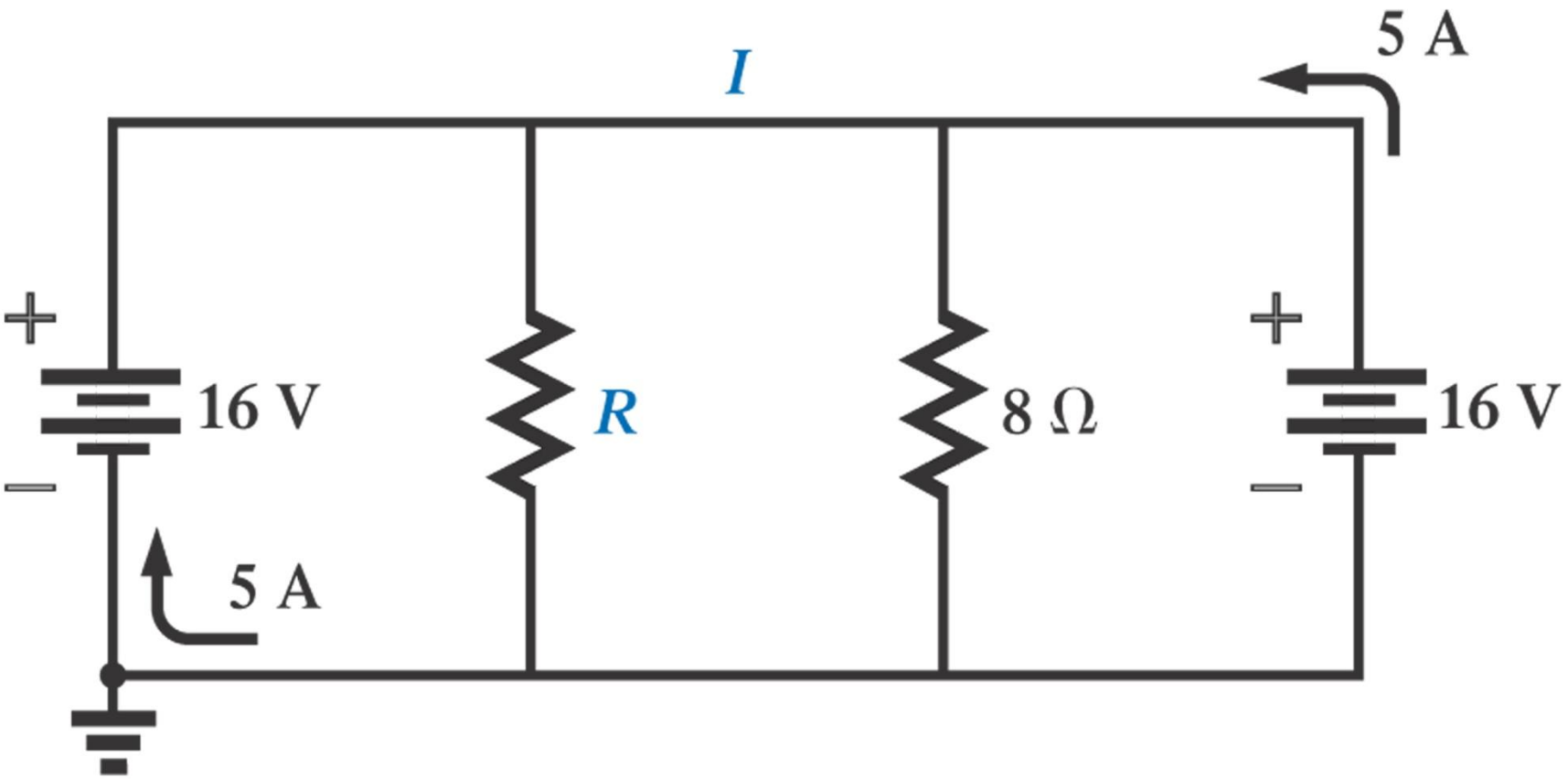


FIGURE 6-93 Problem 35.