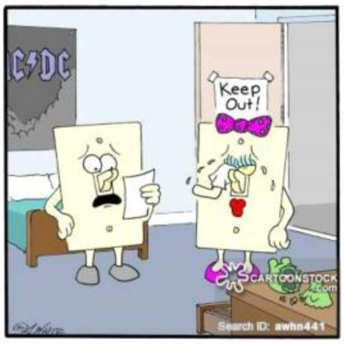
4 How are circuits used in practical applications

May 21, 2019 9:55 AM

science 9

UNIT 3 : PHYSICS



"Dear Mom and Dad, I'm running away from home to join the circuits."

BOOK 4: HOW ARE CIRCUITS USED IN PRACTICAL APPLICATIONS?

name: Key block: ______

1

PART A:VOLTAGE, CURRENT, AND RESISTANCE IN A CIRCUIT ARE RELATED BY OHM'S LAW

Resistance is the property of any material that slows down the flow of e$^-$ and converts electrical energy into other forms of energy. *For example: Light Bulb*

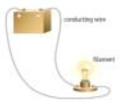


Figure 8.15B The filament has more resistance than the conducting wire. As the electrons "squeeze" through the filament, heat and light energy are produced.

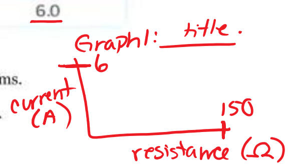
The filament's high resistance *causes the electrons' electrical energy to be converted into* heat *and* light *energy.*

The wire that connects the battery to the light bulb has very low *resistance, and therefore the electrons traveling through this wire* lose almost no *electrical energy.*

Graphing Activity: Comparing Current and Resistance

The table shown below lists the resistance of some common home appliances. The last column shows the current that passes through each appliance when connected to a 120 V *source (standard household voltage).*

Appliance	Resistance (Ω)	Current (A)
Lamp	150	0.8
Laptop computer	60	2.0
Toaster	20	6.0



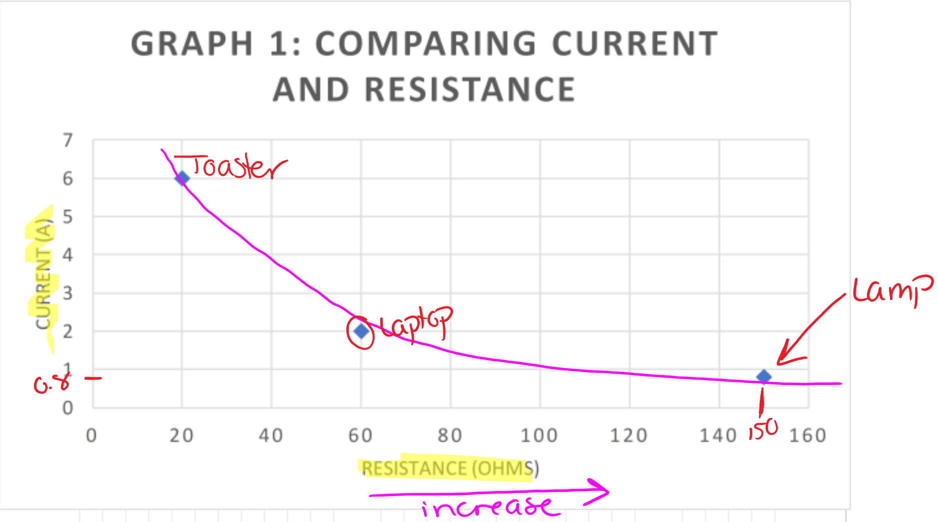
Draw a graph of resistance versus current for these items.

Put ***resistance on the x-axis*** and ***current on the y-axis***.

Analyze your graph.

How is current related to resistance? For example, when the resistance increases, what happens to the current?

when the resistance increases, the current decreases.


GRAPH 1: COMPARING CURRENT AND RESISTANCE
CURRENT (A)
RESISTANCE (OHMS)
Toaster
Laptop
Lamp
0.8
150
increase

3

Voltage is the difference in electric potential energy per unit of charge between one point in the circuit and another point in the circuit.

When you increase the voltage connected to the circuit, the current will also increase. In other words, voltage is proportional to current.

Figure 8.17 Georg Ohm (1789–1854)

Georg Ohm, a German physicist (Figure 8.17), studied the relationship between voltage and current and realized that there was another factor involved.

"wires" "electron flow"

Imagine two different tubes filled with identical marbles tipped the same amount...they DO NOT have to have the same current.

Figure 8.18 Even though both tubes have the same potential difference, the tube on the left has a greater "current" of marbles.

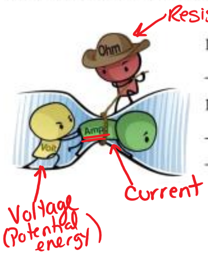
Figure 8.18 shows a tube with a large diameter and a tube with a smaller diameter both held at the same angle. (resistance)

The number of marbles leaving the larger tube is greater than that of the smaller tube. Even though both tubes have the same potential difference (voltage), they have different "currents" of marbles.

filled with same # of marbles

The smaller tube does not allow the marbles to flow as freely as the larger tube.

In other words, the smaller tube has more resistance (less flow).



If a battery is connected to an electric circuit that has a large resistance, less current will flow.

If the same battery is connected to a lower resistance circuit, more current will flow.

OHM'S LAW CALCULATIONS

Georg Ohm discovered that when he raised ↑ the electrical potential difference (voltage), the current increase for a given resistance in a conductor.

He developed the relationship now known as "Ohm's Law", shown in the box below.

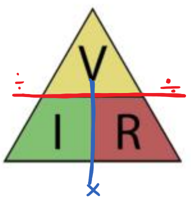
> **Ohm's Law**
> The voltage between two points in a circuit is equal to the current times the resistance. $V = I \cdot R$
>
> *V* is the symbol for electrical potential difference, *I* is the symbol for current, and *R* is the symbol for resistance.

By rearranging the variables in Ohm's law, it is possible to calculate any of the variables if the value of the other two are known.

V = $I \times R$

I = $\frac{V}{R}$ or $(V \div R)$

R = $\frac{V}{I}$ or $(V \div I)$



Example

Imagine that you are testing an electrical toy. You are going to plug it into your home outlet, which provides an electrical potential difference of 120 V. The wires are small and you do not want the current to go above 1.5 A. How high must the resistance of the electrical toy be?

$R = ?$

Solution

Because you want to determine a resistance, you will need to rearrange the formula $\boxed{V = IR}$ into the formula $R = \frac{V}{I} = \frac{\text{voltage}}{\text{current}}$

$R = \frac{120\,V}{1.5\,A}$ "volts" "amps"

$\boxed{R = 80\,\Omega}$ "ohms"

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PRACTICE

1. List the three symbols used in Ohm's law. Explain what each symbol represents and give the units for each of the variables.

Resistance (ohms)

Voltage (volts)

$V = I \cdot R$

Current (Amps)

2. A television that is plugged into a wall socket has an electrical potential difference of 120 V. If a current of 1.25 A is flowing through the television, what is its resistance (Ω)?

$$R = \frac{V}{I} = \frac{120V}{1.25A} = 96\ \Omega$$

3. The filament of a flashlight bulb has a resistance of 40 Ω. If a 6.0 V battery is used in the circuit, what is the current?

$$I = \frac{V}{R} = \frac{6.0V}{40\Omega} = 0.15\ A$$

4. A circuit board has a resistance of 12 Ω and requires a current of 0.25 A. What electrical potential difference is required to operate the circuit board?

$$V = I \cdot R = (0.25A) \cdot (12\ \Omega) = 3V$$

5. The current through a load in a circuit is 1.5 A. If the potential difference across the load is 12 V, what is the resistance of the load?

$$R = \frac{V}{I} = \frac{12V}{1.5A} = 8\ \Omega$$

6. The resistance of a car headlight is 15 Ω. If there is a current of 0.80 A through the headlight, what is the voltage across the headlight?

$$V = I \cdot R = (0.80A) \cdot (15\ \Omega) = 12V$$

7. A 60 V potential difference is measured across a load that has a resistance of 15 Ω. What is the current through this load?

$$I = \frac{V}{R} = \frac{60V}{15\Omega} = 4\ A$$

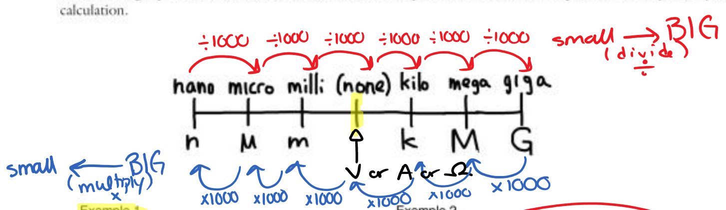
Converting prefixes

Prefixes are used to indicate the magnitude of a value. size

"milli-amp"

milli (m) represents one-thousandth (example: 25 mA = $\frac{25}{1000}$ A = 0.025 A) small current
kilo (k) represents one thousand (example: 5.0 kΩ = 5000 Ω) large resistance
mega (M) represents one million (example: 12 MV = 12 000 000 V)

When solving a problem where some of the units contain prefixes, first convert the prefixes before you do your calculation.



Example 1

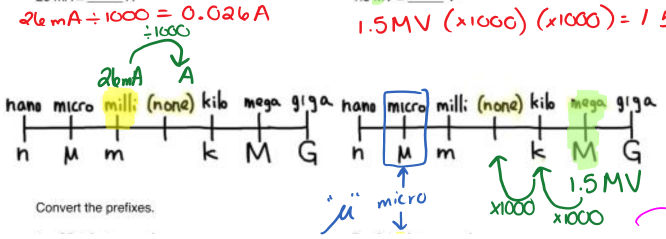
26 mA = 0.026 A

26 mA ÷ 1000 = 0.026 A

Example 2

1.5 MV = _____ V

1.5 MV (x1000) (x1000) = 1 500 000 V



Convert the prefixes.

1. 25 mA = _____ A

0.025 A

2. 12 kV = _____ V

12 000 V

3. 44.2 mV = _____ V

0.0442 V

4. 250 kΩ = _____ Ω

250 000 Ω

5. 16 MA = _____ A

16 000 000 A

6. 3 MΩ = _____ Ω

3 000 000 Ω

7. 2.1 μA = _____ A

0.0000021 A

8. 4.13 MV = _____ V

4 130 000 V

9. 3.21 GV = _____ V

3 210 000 000 V

10. 1.01 MΩ = _____ Ω

1 010 000 Ω

11. 0.13 mA = _____ A

0.00013 A

12. 0.05 mA = _____ A

0.00005 A

Finish in class

start in class (finish for HW)

READING ABOUT: RESISTANCE & OHMS LAW PG 10-11

STOP & READ THIS!

Complete the following reading about resistance & ohms law Be sure to "Mark the Text" and highlight KEY DEFINITIONS as you read along.

ALSO, answer the "Reading Check" questions in the side margin as you go! ✔

Before You Read

Do you think electrons can move through all conducting substances equally well? Give your reasons why or why not on the lines below.

no, different substance will have different resistance.

Create an Outline

Make an outline of the information in this section. Use the headings in the reading as a starting point. Include the bold terms and any other terms that you think are important.

What is resistance?

Electrical resistance is the property of a substance that slows down the movement of electrons and converts electrical energy into other forms of energy. For instance, the resistance of the tungsten filament in a light bulb is more than 400 times greater than the resistance of copper connecting wires. When current moves through the high-resistance filament of the light bulb, the filament converts much of the energy carried by the current into light and heat. When the same current moves through the copper wire, the amount of energy converted into heat is much smaller.

The unit used for measuring resistance is the **ohm** (Ω). An ohmmeter can be used to measure resistance.

How is resistance related to voltage and current?

Voltage, current, and resistance are closely related.

- Current is the movement of electrons (charges) through a conductor.
- Voltage is what makes the electrons move through the conductor.
- Resistance works against and slows down the motion of the electrons.

Good conductors have low resistance, which means that electrons flow through them easily. Poor conductors have high resistance, which means electrons are slowed down.

How does Ohm's law relate voltage, current, and resistance?

Ohm's law is a mathematical equation that shows how voltage, current, and resistance are related:

$$\text{resistance} = \frac{\text{voltage}}{\text{current}} \text{ or } R = \frac{V}{I},$$

where R stands for resistance, V stands for voltage, and I stands for current.

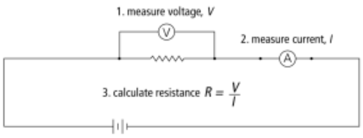
You can rewrite this equation to solve for any of the variables in it. Thus:

$$\text{voltage} = \text{current} \times \text{resistance } (V = IR)\text{; and}$$

$$\text{current} = \frac{\text{voltage}}{\text{resistance}} \left(I = \frac{V}{R}\right)$$

What is a resistor?

A **resistor** is a component in a circuit that has a specific resistance. Resistors are used to control current or voltage to suit the needs of other electric devices in the circuit. The circuit symbol for a resistor looks like this: —ww—



Using Ohm's law, you can calculate resistance from current and voltage measurements.

Reading Check

1. State Ohm's law in words.

Reading Check

2. What is a resistor?

ANSWERS

Reading Checks
Page 123

1. Resistance equals voltage divided by current.
2. a component in an electric circuit that has a specific resistance

HW May 21st

Homework **Assignment #1: Practice Worksheets pages 11-14**
Complete this assignment in the space provided below.

Voltage, current, and resistance
Page 124

1. **(a)** amount of charge passing a point in a conductor every second
   (b) amount of electric potential energy per one coulomb of charge
   (c) opposition to the flow of current through a circuit
   (d) mathematical equation that shows how voltage, current, and resistance are related (resistance equals voltage divided by current)
   (e) a component in a circuit that has a specific resistance, used to control current or voltage

	CURRENT	VOLTAGE	RESISTANCE
Symbol	I	V	R
Unit	amperes (A)	volts (V)	ohms (Ω)
Meter used for measurement	ammeter	voltmeter	ohmmeter
Symbol for Meter	—(A)—	—(V)—	—ww—
Formula	$I = V \div R$	$V = I \times R$	$R = V \div I$

Meter			
Formula	$I = V \div R$	$V = I \times R$	$R = V \div I$

Calculations with Ohm's law

Use Ohm's law to complete the following table. Write the formula you will use and substitute the known values into the formula. Show all your work and include the correct unit with your answer. The first question has been done to help guide you.

	Question	Show your work	Answer
1.	A current through a resistor in a circuit is 1.5 A. If the potential difference across the resistor is 6 V, what is the resistance of the resistor?	$R = V \div I$ $= 6\ V \div 1.5\ A$ $= 4\ \Omega$	$4\ \Omega$
2.	A toaster is plugged into a 120 V outlet. What is the resistance of the toaster if the current in the toaster is 10 A?		
3.	A light bulb with a resistance of 30 Ω is connected to a battery. If the current in the light bulb is 0.2 A, what is the voltage of the battery?		
4.	What is the current in a flashlight bulb with a resistance of 24 Ω if the voltage provided by the flashlight battery is 3 V?		
5.	An electric iron plugged into a wall socket has a resistance of 20 Ω. If the current in the iron is 6 A, what is the voltage provided by the wall socket?		

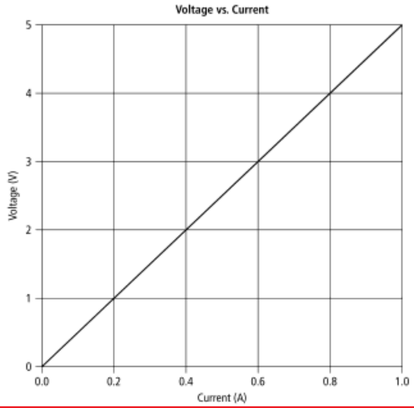
ANSWERS

Calculations with Ohm's law
Page 125

2. $R = V \div I = 120\ V \div 10\ A = 12\ \Omega$
3. $V = I \times R = (0.2\ A)(30\ \Omega) = 6\ V$
4. $I = V \div R = 3\ V \div 24\ \Omega = 0.125\ A$
5. $V = I \times R = (6\ A)(20\ \Omega) = 120\ V$

Relationship between current, voltage, and resistance

Use the graph below to answer the questions that follow.



1. **(a)** As current increases, voltage increases.
   (b) This suggests that there is a positive correlation between voltage and current. It also suggests that there is a direct relationship between voltage and current.
2. The voltage doubles when the current is doubled.

SCIENCE LAB

Ohm's Law Lab

$V = I \cdot R$

voltage (volts)

current (amps)

Resistance (ohms Ω)

Part 1: Measuring Volts and Amps

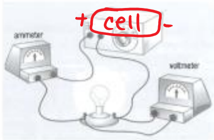
Purpose: To measure the current and voltage in a circuit by using an ammeter and a voltmeter

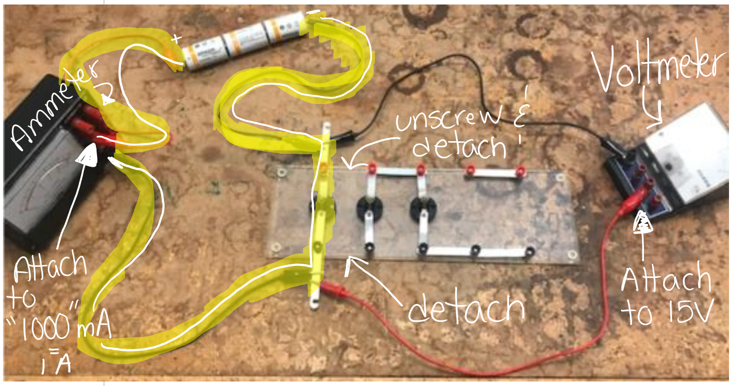
Pre-lab Question:

1. What units are used to measure current and voltage? Current - amps (Ammeter) Voltage - volts (voltmeter)

Materials: Three 1.5 V cells, an ammeter, a voltmeter, a 3.8 V bulb and five pieces of wire.

Method: 1. Place a 1.5 V cell in the cell holder and connect to an ammeter, a bulb and a voltmeter as shown in the diagram below





2. Make sure the voltmeter, which measures the voltage in volts, is connected in **parallel** to the bulb.
3. The ammeter should be connected **in series** and measures the current flowing through the circuit in amps.
4. Start with a single 1.5 V cell and then add cells in series to complete the observations table below. For 1.5 V, 3.0 V and 4.5 V measure the current and the voltage in the system. Record this in your observations table below.
5. Observe the brightness of the bulb as the voltage increases. Record this in your observations table below.
6. **Keep your equipment set up this way for Part 2.**

Observations:

Voltage of Cells/Battery	Current in amps	Voltage in volts	Brightness of globe (describe)
1.5 V 1 cell	0.19A	1.35V	dim
3.0 V 2 cells	↑ increase (0.28A)	↑ increase (2.75V)	medium brightness
4.5 V 3 cells	↑ increase (0.32A)	↑ increased (4.4V)	brightest

* when voltage ↑ current also ↑

indep. variable: voltage (number of batteries)
dep. variable: current (amps)

Discussion Questions:

1. What happens to the brightness of the bulb as the current and voltage increase?

2. Where does the energy needed for the bulb to glow come from?

3. The bulb is an energy converter. It changes ______________ energy into _________________ energy.

4. What happens to the voltage of the bulb as the current increases?

5. What is the relationship between the following:

   a. Volts and amps:

   ____

   b. Volts and brightness:

   ____

Extension:

1. Why are the leads of the voltmeter connected to each side of the bulb, and what does the voltmeter measure?

2. Describe how an ammeter is connected. Why is it connected like this?

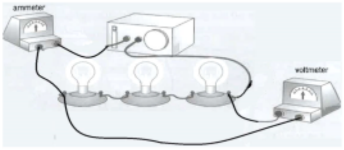
Part 2: Exploring Resistance

Purpose: To investigate what happens to the brightness of bulbs when they are connected in series as more bulbs are added to the system.

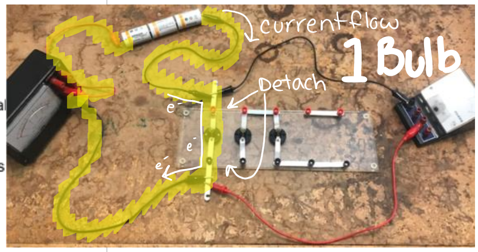
Materials: Cells, three bulbs, six pieces of wire and a switch.

Method:

1. Using your equipment from Part 1 that is already assembled make a series circuit with one bulb, then two bulbs and finally with three bulbs as shown in the figure below



2. Compare the brightness of the bulbs in each case. Measure the voltage and current for each scenario (with 1 bulb, 2 bulbs, 3 bulbs). Record in your observations table 1.
3. Now place a switch near the first bulb, then between the first two bulbs and finally between the second and third globes (when you add the third bulb). Observe what happens.
4. Compare the brightness of the bulbs in each case. Record in your observations table 2.
5. Remove one bulb and see if the others will glow.



Need Help?
Try THIS before you ask your teacher.

$V = I \cdot R$

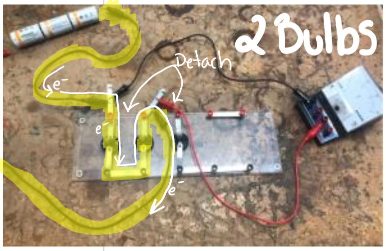
$4.5 = I \cdot R$

Observations:

Table 1:

Number of Bulbs	Measured Voltage	Measured Current (I)	Brightness of Bulb
1	4.5V	0.3 A	bright
2	4.5V	decreased	
3	4.5V	0.2 A	Dim

increasing # of bulbs increases the Resistance in the circuit.



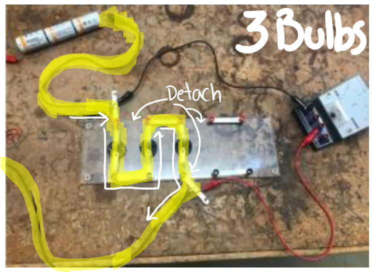


Table 2:

Position of the Switch	Brightness of Bulb
Switch near first bulb	
Switch between first two bulbs	
Switch between second and third bulbs	

I 5

$V = I \cdot R$

Calculations:

Using your measured values for current and voltage from Table 1 above, calculate the resist for each of the following in the table below: **(Show your work!!)**

$R = \frac{V}{I}$

Number of Bulbs	Resistance
1	
2	
3	

Discussion:

1. What happens to the brightness of the bulb as the number of bulbs increases?
2. What happens when a bulb is removed?
3. What happens when the switch is placed in different positions?
4. What happens to resistance as the number of bulbs increases?

electrical device (light, radio, toaster, etc)

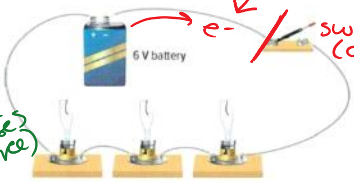
PART B: LOADS CAN BE CONNECTED IN SERIES OR PARALLEL

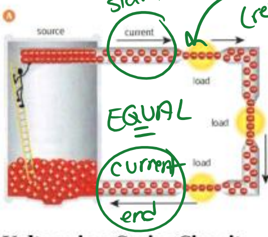
All of the circuits that you have studied so far have a single loop. In such a circuit, current flows along one pathway. Most circuits, however, are much more complex, and current may flow along more than one pathway. (parallel)

When current can flow along just one path in a circuit, the circuit is called a series circuit. The circuit components are connected in series.

The diagram *(right)* shows three light bulbs connected in SERIES.

Trace the path of the current. Notice how there is only one path in which it can flow through the battery, switch, and loads.





If the switch is open all electrons are blocked and the current stops.

In this series circuit, there is just ONE path through which the current can flow.

The current is equal in all parts of the circuit

Voltage in a Series Circuit

If a series circuit is like a waterslide, the people on the waterslide represent the electrons that flow through the circuit.

A person has MORE potential energy at the top of the stairs than at the bottom.

For Example:

If the staircase has 12 steps. A person who slides from the top of the slide to the bottom will "lose" all 12 steps before returning to the bottom of the stairs.

"losing 12 Volts when flow through circuit"

17

In an electric circuit, the charge that leaves a 12 V battery "loses" all 12 V before it returns to the battery.

These losses occur on loads such as light bulbs or resistors, which transform the electrical energy into some other form of energy.

$V_{total} = V_1 + V_2$
$= 4 + 2 = 6$

e^-

bulb requires 4V

bulb requires 2V

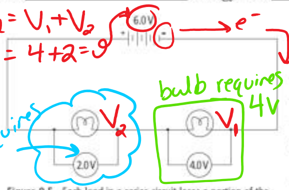


Figure 9.5 Each load in a series circuit loses a portion of the total voltage.

Each load in the series circuit lose a portion of the total voltage supplied to the electrons by the battery (Figure 9.5).

The sum (+) of the voltages lost on the loads equals the total voltage supplied by the battery.

Current in a Series Circuit

In an electric circuit, the electrons repel each other with the same action-at-a-distance force. Therefore, most of the electrons flowing in a circuit will remain fairly evenly spaced apart. Since there is only one path for the electrons to travel in the series circuit, the current in each part of a series circuit is EQUAL (Figure 9.6).

Ammeter measures 1.0A current

... at ANY point in the circuit

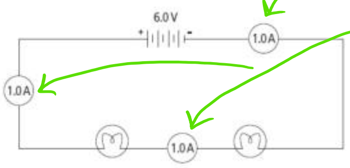


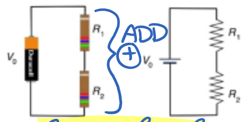
Figure 9.6 The current is the same throughout a series circuit.

For Example: This is similar to a garden hose filled with water. The amount of water entering the garden hose must be the same as the amount of water leaving the same hose. All along the hose, therefore, the "current" of water is the same.

Resistors in Series

Imagine if a waterslide contained a section where the water escaped and you had to slide across dry plastic. This section would have __MORE resistance__ than the other parts of the slide, and therefore you would slow down. (you = current)
If all the people on this slide behaved like __electrons__ and kept almost equal spacing, then everyone would __slow down__ due to this __resistance__.
Suppose there were another dry patch farther down the slide. This resistance would slow down the person sliding across it __MORE__ and cause everyone to slow down __even more__. The total number of people reaching the bottom per minute would be less. The same result occurs in an electric circuit when __resistance is added.__

can be a load.



$R_{Total} = R_1 + R_2$

Resistors placed in __series increase the total resistance__ of the circuit.
When you place resistors in series, you increase the total resistance, and therefore the __current__ throughout the circuit __decreases__.

PRACTICE

1. What do we call a circuit that has only one path?

   series circuit.

2. What happens to the current in a series circuit when a switch is opened?

   current stops flowing.

3. How does the total voltage lost on all loads compare to the total voltage supplied by the battery?

   The total voltage supplied by the battery must equal the total voltage lost on all loads in the circuit.

4. Why is the current at any two locations in a series circuit always the same?

   Because there is only one path, the current in a series circuit is equal.

5. If a resistor is added in series to an existing resistor, what happens to the total resistance?

   The total resistance will increase.

   $\boxed{R_{Total} = \text{the sum of all resistors in the circuit.}}$

Multiple Pathways

When a circuit has at least one branch point where the current splits into 2 or more pathways it is a Parallel circuit.

Light bulb, etc.

The components in these pathways are connected in parallel. Figure 3.25 shows a circuit that has all of the same components as the previous circuit we examined. However, the bulbs are connected in parallel

Trace the path of the current. Notice where it branches and the current splits into 2 pathways.

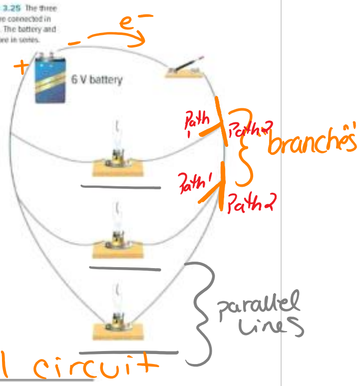
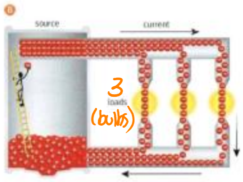


Figure 3.25 The three bulbs are connected in parallel. The battery and switch are in series.



In this parallel circuit the current splits into three paths.

In each path, the current is decreased

A closed pathway that has several different paths is called a parallel circuit. Electrons leaving the battery have 3 possible ways "paths" of returning to the battery in this example.

An electron can travel through bulb 1, bulb 2, or bulb 3 before returning to the battery.

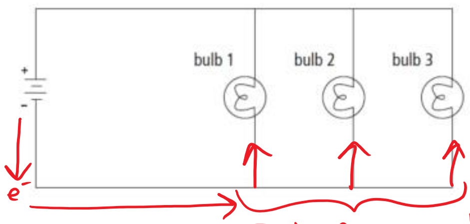


Figure 9.7 Electrons leaving the battery have three possible ways to return to the battery in this circuit.

Total current is divided between the 3 paths.
(not always equal)

A waterslide with _more than 1_ slide gives the rider different experiences than the single pathway waterslide . If someone decides to stop on one of the slides, the _other slides (pathways) still run._. Even though there are different pathways down, everyone climbs the same stairs and everyone ends up in the same pool at the bottom of the slides.

Voltage in a Parallel Circuit

Suppose people climbed 50 stairs (50V) to reach the top of the waterslide. Regardless of which of the three slides the people travel down, they will end up in the _same pool_. They will "_lose_" all the _potential energy_ they gained when they climbed the stairs by the time they reach the bottom.

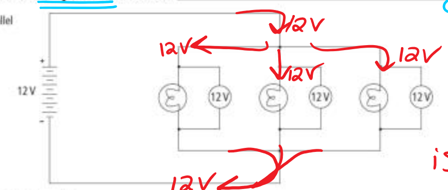
In an _electric circuit_, the battery supplies electric potential (voltage) energy to the electrons through a _potential difference_.

If the _battery_ has a potential difference of 12 V, then the _electrons will lose_ these _12V_ of potential difference by the time they return to the battery.

As you can see in Figure 9.9, the _voltage_ on each of the light bulbs in _parallel_ is the same.

Loads that are in parallel have the _same voltage_ (diff. to a series circuit)

Figure 9.9 Each load in parallel must have the same voltage.



Voltage in Parallel is EQUAL

Current in a Parallel Circuit

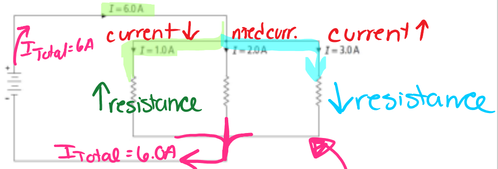
Remember...In a _series_ circuit, the _current is the same_ throughout the circuit. This is because there is only _one path_ for the electrons to travel.

In a _parallel_ circuit, the current branches into _multiple_ pathways that eventually rejoin. A _portion of the e⁻_ travels on each path. (divided)

A pathway with _less resistance_ will be able to have _MORE electrons_ travel on it and therefore will have _MORE current_ than a pathway with more resistance.

Figure 9.10 shows a battery connected to three different resistors connected in ________________.

Figure 9.10 Current entering the junction point divides among the three possible paths.



The total current leaving the battery divides into three possible pathways.

The location where a circuit divides into multiple paths or where multiple paths combine is called a "junction point".

No current is created or destroyed by parallel paths.

The current is only split up to travel different routes.

Loads of different resistance that are connected in parallel will have different currents.

The total current at (start) a junction point must equal the sum(+) of the current leaving the junction point. (end of branch)

Resistors in Parallel

Imagine that you are standing at the end of a long line in a grocery store. There is only one checkout open, and all customers must pass through the one checkout. This is like a series circuit since there is only one path. The cashier in this situation represents a resistance since the cashier slow down the customers. Suppose a second checkout is opened. Customers can now check out their groceries in either line. Even though the second cashier is also a resistor, the customers do not have to wait as long.

The same is true for electric circuits (Figure 9.11). When you place a resistor in parallel with another resistor, you create another pathway.

Resistors placed in parallel will Decrease total resistance of the circuit.

When the total resistance of the circuit decreases, the total current leaving the battery must therefore increase

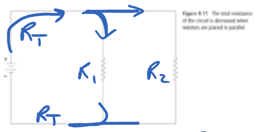


Figure 9.11 The total resistance of the circuit is decreased when resistors are placed in parallel.

$R_{Total} = R_1 + R_2$

22

HW: May 23: Practice Q p.23
Reading p 24-25
Assignment #2 worksheets pg 26-28

PRACTICE

1. What name is given to a circuit that contains more than one pathway?

parallel circuit

2. Two loads are connected in parallel. Compare the voltage across each load.

Loads in parallel have the same (equal) voltage.

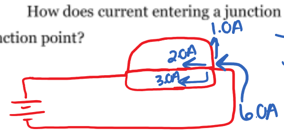
3. Two loads are connected in parallel. Must the current through one load equal the current through the other load?

No, the total current will be split (divided) between the pathways, so the current through one load will be different to the current through the other load.

4. What name is given to a location in a circuit where the circuit branches into more pathways or where pathways rejoin?

junction point.

5. How does current entering a junction point compare to current leaving that same junction point?



The current entering and leaving the SAME junction point is not equal. The current must split between all pathways (will decrease)

6. If you add a resistor in parallel to an existing resistor, what happens to the total resistance in the circuit?

The total resistance of the circuit will increase.

(this will decrease the current).

(this will decrease the current).

Reading About: Series & Parallel Circuits pg 25-26

STOP & READ THIS!

Complete the following reading about series and parallel cirsuits. Be sure to "Mark the Text" and highlight KEY DEFINITIONS as you read along.

ALSO, answer the "Reading Check" questions in the side margin as you go!

Before You Read

A circuit is a complete pathway like an electric circuit or a school running track. What other examples of circuits can you list?

student answers will vary

Mark the Text

Identify Concepts

As you read, highlight each question head in this section. Then use a different colour to highlight the answers to the questions.

Reading Check

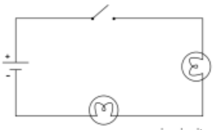
1. What is a series circuit?

Reading Check

2. What is a parallel circuit?

What is a series circuit?

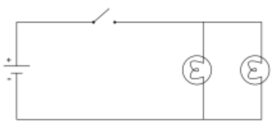
A **series circuit** is an electric circuit that has only one pathway for electric current to take. You can think of a series circuit as a set of parts that are connected end to end. The charges pass through each load before they return to a battery or other energy source. All the moving charges travel through each part of the circuit.



series circuit

What is a parallel circuit?

A **parallel circuit** is an electric circuit that has two or more pathways for electric current to take. Some of the moving charges travel through one pathway of the circuit, and other moving charges travel through other pathways of the circuit. All the charges return to the source after moving through the pathways. The place where pathways separate or join in a parallel circuit is called a **junction point**.



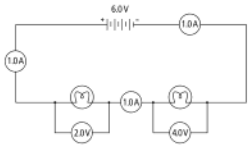
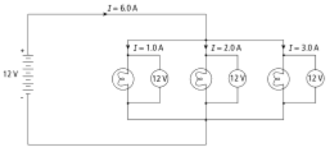
parallel circuit

ANSWERS:

Reading Checks
Page 128
1. an electric circuit with one path for current to take
2. an electric circuit with two or more pathways for electric current to take

What happens to the current, voltage, and resistance in series and parallel circuits?

The table below summarizes the effects that series circuits and parallel circuits have on the current, the voltage, and the resistance of the circuits.

Series circuit	**Parallel circuit**
	
Current The current through the whole circuit is the same throughout and is equal to the total current supplied by the source.	***Current*** The current through each pathway of the circuit adds up to the total current supplied by the source.
Voltage The voltages across each of the loads in the circuit add up to the voltage supplied by the source.	***Voltage*** The voltages across each of the loads in the circuit are equal to each other and to the voltage supplied by the source.
Resistance Resistors placed in series increase the total resistance of the circuit. As a result, the total current throughout the circuit decreases.	***Resistance*** Resistors placed in parallel decrease the total resistance of the circuit. As a result, the total current through the circuit increases.

Homework **Assignment #2: Practice Worksheets pages 26-28**
Complete this assignment in the space provided below.

Series or parallel?

For each of the following statements, identify whether it applies to a series circuit or a parallel circuit.

1. The current is the same throughout the circuit.
____
2. Adding a resistor will decrease the total resistance of the circuit.
____
3. The voltage across each resistor in the circuit is the same.
____
4. There is only one pathway for electrons to flow.
____
5. Adding a resistor will increase the total resistance of the circuit.
____
6. There is more than one pathway for current to flow.
____
7. As more cells are added to the circuit, the brightness of the light bulb increases.
____
8. There are junction points in the circuit.
____
9. If the current through one load in the circuit goes to 0 A, the current through all other loads remains the same.
____
10. The sum of voltages across the loads equals the total voltage supplied by the battery.
____
11. The total current entering a junction point equals the sum of the current leaving the junction point.
____

ANSWERS:

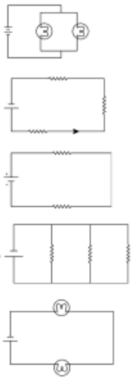
Series or parallel?
Page 130

1. series
2. parallel
3. parallel
4. series
5. series
6. series
8. parallel
9. parallel
10. series
11. parallel

Is it in series or in parallel?

Match each description on the left with the correct circuit on the right.

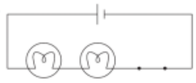
Description	Circuit
1. ______ 3 resistors in series	A.
2. ______ 3 resistors in parallel	B.
3. ______ 2 light bulbs in series	C.
4. ______ 2 light bulbs in parallel	D.
	E.



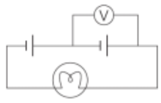
ANSWERS

Is it in series or in parallel?
Page 131

1. B
2. D
3. E
4. A
5.



6.



Draw circuit diagrams as directed below.

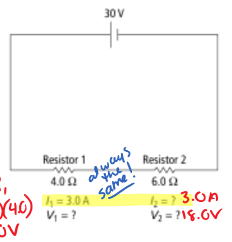
5. Draw a circuit diagram showing one resistor and one light bulb in series.	**6.** Draw a circuit diagram showing one resistor and one light bulb in parallel.

Calculations with series circuits

Ohm's Law
$V = I \cdot R$

$\frac{V}{I \mid R}$

Use the diagrams to answer the questions below.



Step ① $V_1 = I_1 \cdot R_1$
$V_1 = (3.0)(4.0)$
$V_1 = 12.0V$

Step② $V_2 = 30V - 12.0V$
$V_2 = 18.0V$

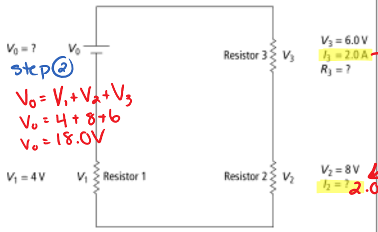
Step③ $I_2 = \frac{V_2}{R_2}$
$I_2 = \frac{18.0V}{6.0\Omega}$
$I_2 = 3.0A$

1. (a) What is the total resistance in the circuit? $R_1 + R_2 = 4.0 + 6.0 = 16.0\Omega$

(b) What is the amount of current flowing through Resistor 2? 3.0A

(c) Using Ohm's Law ($V = IR$), determine the voltage drop across Resistor 2. (see step 2) = 18.0V

(d) What is the voltage drop across Resistor 1? (see step1) = 12.0V



step②
$V_0 = V_1 + V_2 + V_3$
$V_0 = 4 + 8 + 6$
$V_0 = 18.0V$

step ①

current is always the same is a SERIES circuit.

Step③
$R_3 = \frac{V}{I}$
$R_3 = \frac{6.0V}{2.0A}$
$R_3 = 3.0\Omega$

2. (a) What is the total voltage in the circuit? (see step 2) = 18.0V

(b) What is the amount of current flowing through Resistor 2? (see step 1) = 2.0A

(c) Ohm's law is $R = \frac{V}{I}$. Use Ohm's law to determine the resistance of Resistor 3. 3.0Ω

ANSWERS

Calculations with series circuits
Page 132

1. **(a)** 10 Ω
   (b) 3 A
   (c) 18 V
   (d) 12 V
2. **(a)** 18 V
   (b) 2 A
   (c) 3 Ω

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PART C: PARALLEL LOADS ARE PRACTICAL FOR CIRCUITS IN THE HOME.

If one load in a ________________ circuit burns out, the circuit will be open, charges will stop moving, and no loads in that circuit will work.

This makes ____________________________________in homes, where many loads are needed.

Think of a kitchen. Each load must work independent of all others. Otherwise a burned out ceiling lamp would cause a toaster, microwave and radio on the same circuit to stop working. Likewise, if you turned off the radio, all other appliances would stop working as well.

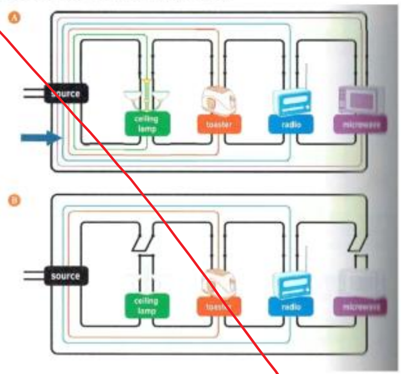


Figure 3.27 Parallel circuits are practical because each appliance is controlled by its own switch.
A All of the appliances are running.
B When the microwave and lamp are turned off, the toaster and radio still run.

In Figure 3.27, all devices are connected in _________________. Each can be controlled by its own ________________ without shutting off the others. The pathways in the diagram represent conductors, and the coloured lines represent current flowing to a specific device.

The arrow in part A shows that, when all appliances are on, a large amount of current is passing through the conductor near the source. When large amounts of current flow through a wire, it can get very hot and it becomes a safety hazard.

Multiple Circuits Within a Building

While parallel circuits are convenient in one room, imagine if all the electrical devices in an entire home were connected to the same parallel circuit. The current flowing to each device also would be flowing through the wire conductors connected to the source. This large amount of current could make the wires ______________________, possibly causing a ________.

Because of this safety concern, many ________________ parallel circuits are installed in buildings, as shown in Figure 3.28. Each colour represents a single ____________________. A very large electrical cable carries electrical energy form a power company to a building. This large cable branches out and is connected to each of the parallel circuits inside a circuit panel. The cables for all circuits leave this circuit panel and carry electrical energy throughout the building.

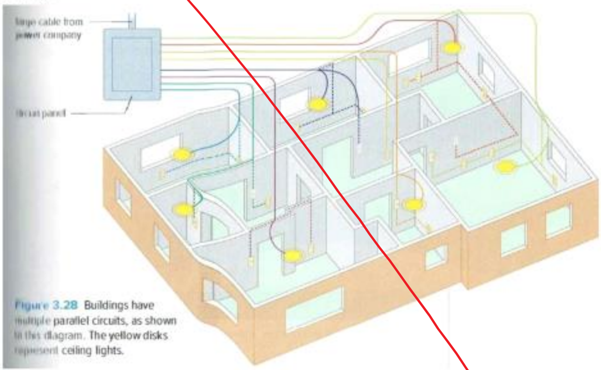


Figure 3.28 Buildings have multiple parallel circuits, as shown in this diagram. The yellow disks represent ceiling lights.

PRACTICE

1. Explain why it would be impractical to wire a home with a circuit in which all loads were connected in series.

2. Explain why a parallel circuit, with too many electrical devices is not safe.

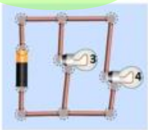
Series and Parallel Circuits Lab

Part 1: Prediction Questions - Comparing Circuits

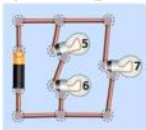
Consider the pictures of each of these circuits, then answer the questions below. Answer the prediction questions before you build these circuits:

Series Circuit

Parallel Circuit



Complex Circuit



1) From the circuits above, predict which bulb (or bulbs) will be the brightest. Why do you think that?

2) Current is the flow of charge (measured in coulombs/sec = amps) in a circuit. Describe how you think current will flow in the different types of circuits above.

Part 2: Building Circuits

"Phet circuit construction"

Open the circuit constructor at the following URL:

http://phet.colorado.edu/sims/circuit-construction-kit/circuit-construction-kit-dc_en.jnlp

or Google " phet circuit construction kit". Create the circuit shown in Figure 1.

Make the following modifications to the component properties by right-clicking on each component:

- Set the resistance of each light bulb to 5 ohms
- Set the battery voltage to 10 volts

$$V = I \cdot R$$

$$I = \frac{V}{R}$$

$$R = \frac{V}{I}$$

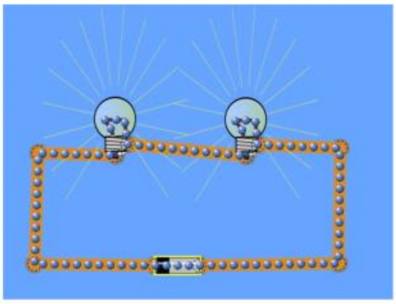


Figure 1

Check in:

What type of circuit is shown in Figure 1?

How many pathways are there for electrons to take in the circuit shown in Figure 1?

32

1. What is the total resistance of these series-connected bulbs?

R =	

2. Use Ohm's law to calculate the circuit current (I):

Formula to calculate current I = ____________ where:

V= voltage in _______ = ____________

R=Resistance in _______ = ____________

I = **Calculate** current in <u>amps</u>

I =

I =	

3. Use the Non-Contact Ammeter to measure the current the circuit. Record the measured current.

I =	

The bulbs in Figure 1 are connected in ____________________.

Now connect another bulb in series with the first two. Change the properties of this bulb to have 5 ohms of resistance.

4. **Calculate** the circuit current for the new modified circuit and record this calculated current.

I =	

5. Use the Non-Contact Ammeter to measure the current in the new modified circuit. Record the measured current.

I =	

Now connect the bulbs in the configuration shown below. Make sure each bulb is set for 5 ohms of resistance and the battery is set for 10 volts.

6. What do you immediately notice about the bulbs and why?

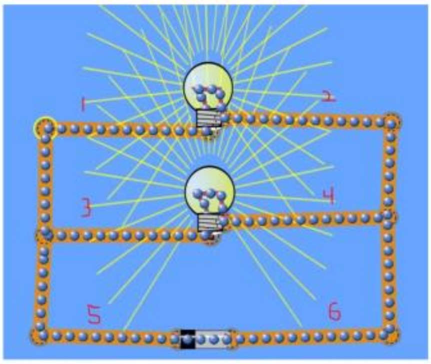


Figure 2

The bulbs in Figure 2 are connected in ______________________________ . How many pathways are there for electrons to take? __________________.

Figure 2

7. What is the total resistance of these _____________ - connected bulbs?

R =	

8. Calculate the currents for this circuit and record these calculated values.

$I_{(\text{point } 1)}$ =	
$I_{(\text{point } 2)}$ =	
$I_{(\text{point } 3)}$ =	
$I_{(\text{point } 4)}$ =	
$I_{(\text{point } 5)}$ =	
$I_{(\text{point } 6)}$ =	

9. Use the Non-Contact Ammeter to measure the currents in the circuit. Record the measured currents.

$I_{(\text{point } 1)}$ =	
$I_{(\text{point } 2)}$ =	
$I_{(\text{point } 3)}$ =	
$I_{(\text{point } 4)}$ =	
$I_{(\text{point } 5)}$ =	
$I_{(\text{point } 6)}$ =	

If the calculated values of current don't match the measured values of current read about parallel circuits in your notes/assignments and recalculate the currents.

10. As you add more bulbs (loads) in a **series** circuit what happens to the current in the series circuit and why?

11. As you add more bulbs (loads) in a **parallel** circuit what happens to the current in the series circuit and why?

12. Which one of these circuits, series or parallel, represents the type of electrical connections found in your home?

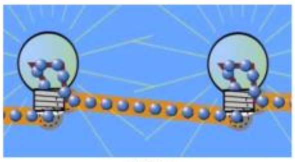


Figure 3

Figure 2

Just as loads like the light bulbs can be connected in series (Figure 3) and parallel (Figure 4) the power sources can also be connected in series and parallel.

13. What is the advantage of connecting power supplies in series?

14. What is the advantage of connecting power supplies in parallel?

Extension:

15. Build a complex circuit using the online simulation. Diagram your circuit below and include the voltage and resistance values and current values at a number of points within your circuit.

16. Use the online simulation to explore. How can you cause a fire to occur in the circuit? Based on what you find out what recommendations can you make for electrical safety to ensure that this doesn't happen within someone's home?

Homework **Assignment #3: Review Worksheets pages 39-41**
Complete this assignment in the space provided below.

Ohm's Law Review

V=IR	V: Voltage (V)
I=V/R	I: Current (A)
R=V/I	R: Resistance (Ω)

4 Steps

1. List your givens and unknown (V, I and R)
2. Write down Ohm's Law
3. Substitute in givens
4. Solve for unknown

1. Find the current through a circuit with a resistance of 24 Ω when 24 V is applied.

$I = \frac{V}{R} = \frac{24V}{24\Omega} = 1.0A$

2. Find the resistance of a circuit that draws 0.06 A with 12 V applied.

$R = \frac{V}{I} = \frac{12V}{0.06A} = 200\Omega$

3. Find the applied voltage of a circuit that draws 0.2 amperes through a 4800-ohm resistance.

$V = I \cdot R = (0.2A)(4800\Omega) = 960V$

4. Find the applied voltage of a telephone circuit that draws 0.017 A through a resistance of 15,000 Ω.

$V = I \cdot R = (0.017A)(15000\Omega) = 255V$

5. If a blender is plugged into a 110 V outlet that supplies 2.7 A of current, what is the resistance of the of the blender?

$R = \frac{V}{I} = \frac{110V}{2.7A} = 40.7\Omega$

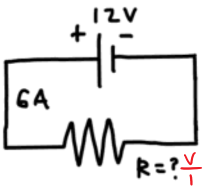
6. A resistive load of 600-ohms is connected to a 24 V power supply. Find the current through the resistor.

$I = \frac{V}{R} = \frac{24V}{600\Omega} = 0.04A$

$V = I \cdot R \qquad I = \frac{V}{R} \qquad R = \frac{V}{I}$

Solve for the unknown quantity.

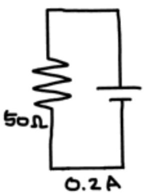
7.



$R = ? \quad \frac{V}{I} = \frac{12V}{6A}$

$R = 2\Omega$

8.

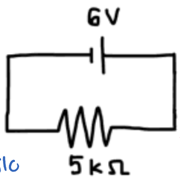


$V = ? = I \cdot R$

$V = (0.2A)(50\Omega)$

$V = 10V$

9.



Ω → kilo ×1000

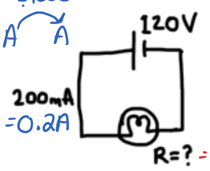
= 5000Ω

$I = ? \frac{V}{R}$

$I = \frac{6V}{5000\Omega}$

$I = 0.0012A$

10.



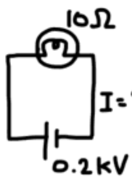
milliA → A ÷1000

200mA = 0.2A

$R = ? = \frac{V}{I} = \frac{120V}{0.2A}$

$R = 600\Omega$

11.

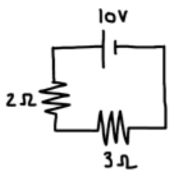


$I = ? = \frac{V}{R} = \frac{200V}{10\Omega}$

$I = 20A$

0.2kV = 200V

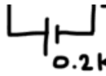
12.



$I = ? \frac{V}{R} = \frac{10V}{5\Omega}$

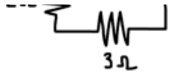
$I = 2A$

$R = 2\Omega + 3\Omega$



$I = 20A$

$V \xleftarrow{\times 1000} \text{KiloV}$



$I = 2A$

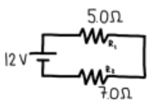
$R = 2\Omega + 3\Omega$

$R = 5\Omega$

Series and Parallel Circuits Review

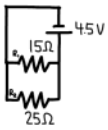
For each circuit, determine the voltage, current and resistance through each resistor and the total voltage, current and resistance of the circuit.

1.



2.

3.



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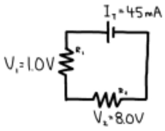

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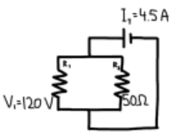
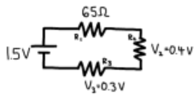
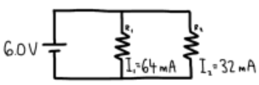


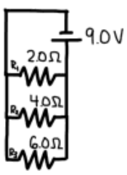
6.



7.



8.



SERIES AND PARALLEL CIRCUITS - SOL'NS

1.

$V_1 = 5.0V$
$I_1 = 1.0A$
$R_1 = 5.0\Omega$

$V_T = 12V$
$I_T = 1.0A$
$R_T = 12.0\Omega$

$V_2 = 7.0V$
$I_2 = 1.0A$
$R_2 = 7.0\Omega$

① $R_T = R_1 + R_2$
$= 5.0 + 7.0$
$= 12.0\Omega$

② $V_T = I_T R_T$
$I_T = \frac{V_T}{R_T}$
$= \frac{12}{12.0}$
$= 1.0A$

③ $I_T = I_1 = I_2$
$I_1 = 1.0A$
$I_2 = 1.0A$

④ $V_1 = I_1 R_1$
$= (1.0)(5.0)$
$= 5.0V$

⑤ $V_2 = I_2 R_2$
$= (1.0)(7.0)$
$= 7.0V$

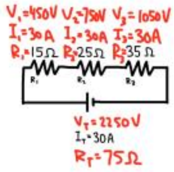
2.

$V_1 = 450V$ $V_2 = 750V$ $V_3 = 1050V$
$I_1 = 30A$ $I_2 = 30A$ $I_3 = 30A$
$R_1 = 15\Omega$ $R_2 = 25\Omega$ $R_3 = 35\Omega$

① $R_T = R_1 + R_2 + R_3$

② $I_T = I_1 = I_2 = I_3$

2.



① $R_T = R_1 + R_2 + R_3$
$= 15 + 25 + 35$
$= 75\Omega$

② $I_T = I_1 = I_2 = I_3$
$I_1 = 30A$
$I_2 = 30A$
$I_3 = 30A$

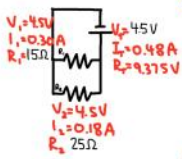
③ $V_T = I_T R_T$
$= (30)(75)$
$= 2250V$

④ $V_1 = I_1 R_1$
$= (30)(15)$
$= 450V$

⑤ $V_2 = I_2 R_2$
$= (30)(25)$
$= 750V$

⑥ $V_3 = I_3 R_3$
$= (30)(35)$
$= 1050V$

3.



① $V_T = V_1 = V_2$
$V_1 = 4.5V$
$V_2 = 4.5V$

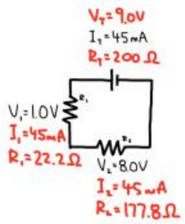
② $V_1 = I_1 R_1$
$I_1 = \frac{V_1}{R_1}$
$= \frac{4.5}{15}$
$= 0.30A$

③ $V_2 = I_2 R_2$
$I_2 = \frac{V_2}{R_2}$
$= \frac{4.5}{25}$
$= 0.18A$

④ $I_T = I_1 + I_2$
$= 0.3 + 0.18$
$= 0.48A$

⑤ $V_T = I_T R_T$
$R_T = \frac{V_T}{I_T}$
$= \frac{4.5}{0.48}$
$= 9.375\Omega$

4.



① $I_T = I_1 = I_2$
$I_1 = 45mA$
$I_2 = 45mA$

② $V_1 = I_1 R_1$
$R_1 = \frac{V_1}{I_1}$
$= \frac{1.0}{0.045}$
$= 22.\overline{2}\Omega$

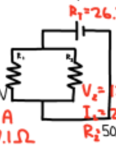
③ $V_2 = I_2 R_2$
$R_2 = \frac{V_2}{I_2}$
$= \frac{8.0}{0.045}$
$= 177.\overline{7}\Omega$

④ $V_T = V_1 + V_2$
$= 1.0 + 8.0$
$= 9.0V$

⑤ $R_T = R_1 + R_2$
$= 22.\overline{2} + 177.\overline{7}$
$= 200\Omega$

5.

$V_T = 120V$
$I_T = 4.5A$
$R_T = 26.7\Omega$



$V_1 = 120V$
$I_1 = 2.1A$
$R_1 = 57.1\Omega$

$V_2 = 120V$
$I_2 = 2.4A$
$R_2 = 50\Omega$

① $V_T = V_1 = V_2$

$V_T = 120V$

$V_2 = 120V$

② $V_2 = I_2 R_2$

$I_2 = \frac{V_2}{R_2}$

$= \frac{120}{50}$

$= 2.4A$

③ $I_T = I_1 + I_2$

$I_1 = I_T - I_2$

$= 4.5 - 2.4$

$= 2.1A$

④ $V_T = I_T R_T$

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

$= \frac{120}{4.5}$

$= 26.\bar{6}\,\Omega$

⑤ $V_1 = I_1 R_1$

$R_1 = \frac{V_1}{I_1}$

$= \frac{120}{2.1}$

$= 57.1\Omega$

6.

$V_1 = 0.8V$
$I_1 = 12.3mA$
$R_1 = 65\Omega$

$V_T = 1.5V$
$I_T = 12.3mA$
$R_T = 121.9\Omega$

$V_2 = 0.4V$
$I_2 = 12.3mA$
$R_2 = 32.5\Omega$

$V_3 = 0.3V$
$I_3 = 12.3mA$
$R_3 = 24.4\Omega$

① $V_T = V_1 + V_2 + V_3$

$V_1 = V_T - V_2 - V_3$

$= 1.5 - 0.4 - 0.3$

$= 0.8V$

② $V_1 = I_1 R_1$

$I_1 = \frac{V_1}{R_1}$

$= \frac{0.8}{65}$

$= 0.0123A$

$= 12.3mA$

③ $V_T = I_T R_T$

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

$= \frac{1.5}{0.0123}$

$= 121.9\Omega$

④ $V_2 = I_2 R_2$

$R_2 = \frac{V_2}{I_2}$

$= \frac{0.4}{0.0123}$

$= 32.5\Omega$

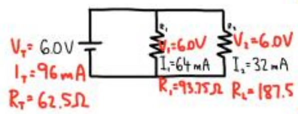
⑤ $V_3 = I_3 R_3$

$R_3 = \frac{V_3}{I_3}$

$= \frac{0.3}{0.0123}$

$= 24.4\Omega$

7.



① $V_T = V_1 = V_2$

$V_1 = 6.0V$

$V_2 = 6.0V$

② $I_T = I_1 + I_2$

$= 0.064 + 0.032$

$= 0.096A$

$= 96 mA$

③ $V_T = I_T R_T$

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

$= \frac{6.0}{0.096}$

$= 62.5\Omega$

④ $V_1 = I_1 R_1$

$R_1 = \frac{V_1}{I_1}$

$= \frac{6.0}{0.064}$

$= 93.75\Omega$

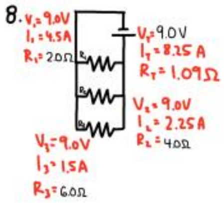
⑤ $V_2 = I_2 R_2$

$R_2 = \frac{V_2}{I_2}$

$= \frac{6.0}{0.032}$

$= 187.5\Omega$

8.



① $V_T = V_1 = V_2 = V_3$

$V_1 = 9.0V$

$V_2 = 9.0V$

$V_3 = 9.0V$

② $V_1 = I_1 R_1$

$I_1 = \frac{V_1}{R_1}$

$= \frac{9.0}{2.0}$

$= 4.5 A$

③ $V_2 = I_2 R_2$

$I_2 = \frac{V_2}{R_2}$

$= \frac{9.0}{4.0}$

$= 2.25 A$

④ $V_3 = I_3 R_3$

$I_3 = \frac{V_3}{R_3}$

$= \frac{9.0}{6.0}$

$= 1.5 A$

⑤ $I_T = I_1 + I_2 + I_3$

$= 4.5 + 2.25 + 1.5$

$= 8.25 A$

⑥ $V_T = I_T R_T$

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

$= \frac{9.0}{8.25}$

$= 1.\overline{09}\ \Omega$