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Science
Quarter 1 - Module 7:
Basic Electricity

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Science

Quarter 1 - Module 7:
Basic Electricity

DEPARTMENT OF EDUCATION

Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using them.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

What I Need to Know

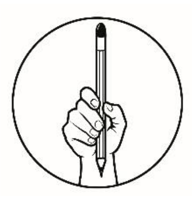
This module was designed and written with you in mind. It is here to help you master basic electricity. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the textbook you are now using.

This module contains:

- **Lesson 1** – Ohm's Law

After going through this module, you are expected to:

1. Infer the relationship between current and voltage *(MELC Week 5-6)*



What I Know

Directions: Choose the letter of the correct answer. Write your answers on a separate sheet of paper.

1. It is a difference in electric potential energy in joule/coulomb.

   A. Circuit
   B. Current
   C. Resistance
   D. Voltage

2. What is the SI unit of voltage?

   A. ampere
   B. ohm
   C. volt
   D. watt

3. It is the number of charges passing through a wire per unit time.

   A. Current
   B. Power
   C. Resistance
   D. Voltage

4. What is the SI unit of current?

   A. ampere
   B. ohm
   C. volt
   D. watt

5. It is the opposition to the flow of electric charges as they travel through a conducting wire.

   A. Circuit
   B. Current
   C. Resistance
   D. Voltage

6. What is the SI unit of resistance?

A. ampere
B. ohm
C. volt
D. watt

7. Which of the following is the correct statement of Ohm's Law?

A. When current increases in a circuit, voltage increases and resistance increases.
B. When current increases in a circuit, voltage decreases and resistance increases.
C. When current decreases in a circuit, voltage decreases and resistance increases.
D. When current increases in a circuit, voltage increases while resistance remains constant.

8. It supplies energy in an electric circuit.

A. Load
B. Switch
C. Voltage source
D. Conducting wire

9. It converts electrical energy into different forms of energy such as light, heat, or sound in an electric circuit.

A. Load
B. Switch
C. Voltage source
D. Conducting wire

10. According to Ohm's law, across a resistor with constant resistance, what happens to the current across it when the voltage applied is halved?

A. halved
B. doubled
C. quadrupled
D. remains the same

11. Consider a simple electric circuit with a voltage source of 20.0 V which has a current of 0.500 A. What is the resistance of the load?

A. 20.0 ohms
B. 30.0 ohms
C. 40.0 ohms
D. 50.0 ohms

12. A laptop power charger has an output of 5.00 volts and has a resistance of 800 ohms. What is the current output of the charger?

    A. 6.25 mA
    B. 50.0 mA
    C. 75.0 mA
    D. 80.0 mA

13. A LED TV power adaptor has a 2-mA output and resistance of 900 ohms. What is the voltage output of the adaptor?

    A. 2 volts
    B. 4 volts
    C. 6 volts
    D. 8 volts

14. A motorcycle starter motor needs 40.0 A to operate with a resistance of 0.150 ohms. What is the needed voltage to start the motor?

    A. 5.00 V
    B. 6.00 V
    C. 7.00 V
    D. 8.00 V

15. A water heater has a resistance of 22 Ω connected to a 220-V voltage source. What is the needed current to operate the heater?

    A. 5 A
    B. 7 A
    C. 8 A
    D. 10 A

Lesson 1 Ohm's Law

Recall that when you studied heat and temperature, you learned that heat energy flows from a body of higher temperature to a lower temperature. The flow ceases when both bodies reach the same temperature. Similarly, when an electrical conductor is connected to different electric potentials, charge flows from one end to the other end of the conductor. Without potential difference, no charge flows as well.

What's In

To attain a sustained flow of charge in a conductor, an electrical set up must maintain a difference in potential while charge flows from one end to the other. The situation is analogous to a flow of water from a higher reservoir to a lower one. Water will flow in a pipe that connects the reservoirs only as long as a difference in water level exists. Like the flow of water molecules in a pipe, electric current also is simply the flow of electric charges in a conducting wire. These charges are free electrons that would only flow in conducting wires, usually made of metals, connected to a voltage source. When there is flow of electric charges, an electric current is present.

Electric current (I) is the rate of flow of electric charges from one point to another in a circuit. It is measured in Amperes (A). One ampere is a rate of flow equal to 1 coulomb of charge per second. Mathematically, electrical current is given by

$$I = \frac{q}{t}$$

where: I = current in Amperes (A)
q = charge in coulombs (C)
t = time in seconds (s)

The standard unit of charge is coulomb. One coulomb is the electric charge of 6.25 billion electrons. So, if a wire carries 5 amperes, 5 coulombs of charges flow through the wire each second. This means that there are 31.25 billion electrons flowing from one point of a circuit to another. That is a lot of electrons! How much more if a wire carries 10 amperes, twice as many electrons would pass at any cross-section each second.

A sustained current in conducting wire requires a suitable pumping device; meaning, charges will flow only when they are pushed or driven. The work needed per unit charge to move between two points is called voltage (V), expressed in unit volt (V).

Voltage (V) is what makes a current move. Mathematically voltage is given by,

$$V = \frac{W}{q}$$

where: V = voltage in volts (V)

W = work in Joule (J)

q = charge in coulomb (C)

A common automobile battery, as shown in figure 1, will provide a voltage of 12 volts to a circuit connected across its terminals. Then 12 joules of energy are supplied to each coulomb of charge that is made to flow in the circuit. Remember, voltage does not go anywhere, it only drives the charges to move. Figure 2 shows the equivalent electrical symbol of 12-volt automobile battery. You notice that it has 6 pairs of short and long lines that represent negative and positive terminals respectively. Each pair corresponds to 2 volts.

Fig. 1 12 V automobile battery

Illustrated by: Angelo Zaldy C. Francia

Fig. 2 Electrical symbol of a 12 V battery

Illustrated by: Angelo Zaldy C. Francia

We know that batteries and generators are the primary sources of voltage in an electric circuit. How much current exists in a circuit depends not only on the voltage but also on the electrical resistance of the conductor.

Electrical resistance (**R**) is the opposition to the flow of current by the conducting wire. The electrical resistance of the wire depends on its thickness, length, and conductivity. Thick wires have less resistance than thin wires because thick wires have greater cross-sectional area for the electron to flow than thin wires. Moreover, longer wires have more resistance than shorter wires because longer wires have longer path for the current to flow. Copper wires have less resistance than steel wires of the same size because copper has higher conductivity than steel. Conductivity is the property of matter that allows current to flow. The higher the conductivity of material the more current can freely flow. Electrical resistance also depends on temperature. At higher temperature, atoms are violently vibrating that can result to greater collision, creating more resistance against the flow of current. Electrical resistance is measured in ohms (Ω), named after Georg Simon Ohm.

An electronic device that is designed to resist the flow of current is known as a resistor, shown in figure 3 with its equivalent electrical symbol in figure 4.

Fig. 3 Resistor

Illustrated by: Angelo Zaldy C. Francia

Fig. 4 Electrical symbol of Resistor

Illustrated by: Angelo Zaldy C. Francia

A resistor can also be a light bulb, as shown in figure 5 with its equivalent electrical symbol in figure 6, that will convert the energy that was moving the electrons into heat and light.

Fig. 5 Light Bulb

Illustrated by: Angelo Zaldy C. Francia

Fig. 6 Electrical symbol of light bulb

Illustrated by: Angelo Zaldy C. Francia

What's New

The relationship among voltage, current, and resistance is summarized by Ohm's law. Ohm discovered that at constant resistance, current in a circuit is directly proportional to the voltage established across the circuit as graphically represented in Figure 7.

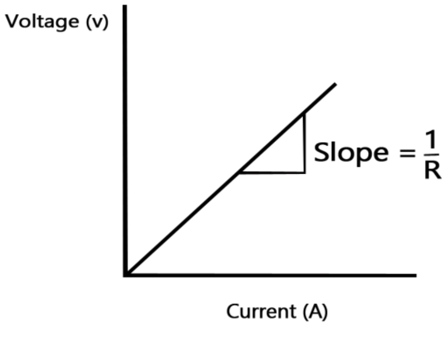


Fig. 7. Graphical Representation of Ohm's Law.

Illustrated by Rey R. Angel

For given values of resistance, current and voltage in Figure 8, current will double if voltage is doubled at constant resistance as shown in Figure 9. This means that the greater the voltage, the greater the current. If the resistance of a circuit is doubled, the current would be reduced to one-half when voltage is held constant. This means that the greater the resistance, the smaller the current (Figure 10).

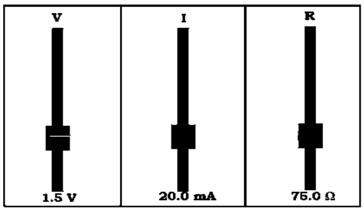


Fig. 8. Initial values of voltage, current, and resistance.

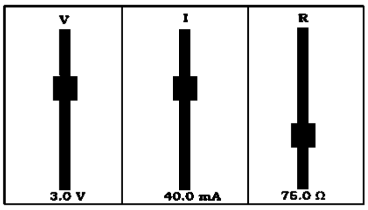


Fig. 9. Increasing current and voltage at constant. resistance.

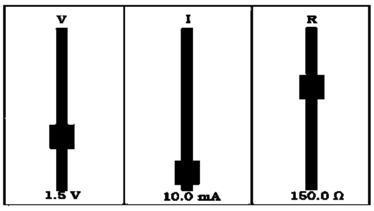


Fig. 10. Inverse relationship of resistance and current at constant voltage.

Illustrated by Rosa Mia L. Pontillo

What is It

Ohm's Law

In a simple circuit, voltage is directly proportional to current. Its proportionality constant is R = Resistance.

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

Where: V = voltage expressed in volt (V)

I = Current expressed in Ampere (A)

R = Resistance expressed in ohm (Ω)

Example 1

Find the resistance in kΩ of a single motor horn if it has a voltage of 6 V and current of 2 mA.

Given: Voltage (V) = 6 V;

Current (I) = 2 mA x (1A/1000mA) = 0.002A

Required: Resistance (R)

Solution: Ohm's Law: V = I R

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

$$= \frac{6}{0.002}$$

$$= 3000\ \Omega\ \left(\frac{1\ K\Omega}{1000\Omega} \right)$$

$$= 3\ k\ \Omega$$

Example 2

If a circuit has a resistance of 44 Ω and a current of 5 A, what is its voltage?

Given: Resistance (R) = 44 Ω

Current (I) = 5 A

Required: Voltage (V)

Solution: Ohm's Law V = I R

V = 44 Ω x 5

= 220 V

Example 3

What will happen to the current if the resistance is tripled? State the relationship of current and resistance based on your answer.

V = I R

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

If R is tripled then, $I = \frac{V}{3R} = \frac{1}{3}\frac{V}{R}$

Therefore, when resistance is tripled, the current is reduced by one third. The result shows that when resistance is increased at constant voltage, the current is reduced.

Activity 1. Voltage, Current and Resistance Relationship

Directions: Provide what is asked. Write your answers on a separate sheet of paper.

1. What will happen to the current if the voltage is decreased by one half while the resistance is held constant? State the relationship of voltage and current based on your answer.

____

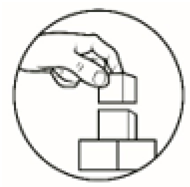
____

2. What will happen to the current if resistance is doubled while voltage is kept constant? State the relationship of current and resistance based on your answer.

____

____

Rubric for Scoring	
2 points	Relationship is completely explained using Ohm's Law.
1 point	Incomplete explanation of relationship using Ohm's Law.
0 point	No explanation.



What's More

Activity 2. Ohm's Law Application

Directions: Complete the solutions of the problems. Write your answers on a separate sheet of paper.

1. A multi-cab starter motor has a current of 60.0 A and a voltage of 12 V. What is the resistance of the starter motor?

Given: Current (I) = _______ A

Voltage (V) = _______ V

Required: Resistance (Ω)

Formula: $R = \frac{voltage}{curent} =$ ______

Solution: V = IR

Answer: Resistance = ______Ω, the resistance of the electric motor.

2. An electric fan has a resistance of 3.0 kΩ and a voltage rating of 220 volts. What is the current needed to operate the electric fan?

Given: Resistance (R) = ______ kΩ ($\frac{1000\ \Omega}{1\ k\Omega}$) = _____

Voltage (V) = ______ volts

Required: Current (I)

Formula: $I = \frac{voltage}{resistance} =$ ________

Solution: V = IR

Answer: Current = ______ A, the current needed

3. A traffic light has a total resistance of 22 kΩ and requires 10 mA of current to operate. What is the voltage required to operate the traffic light?

Given: Resistance (R) = ______ kΩ ($\frac{1000\ \Omega}{1\ k\Omega}$) = ______ Ω

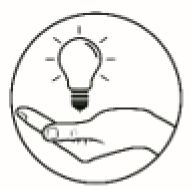
Current (I) = ______ mA ($\frac{1\ A}{1000\ mA}$) = ______ A

Required: Voltage(V)

Solution: V = I R

V = (_______ A) (_______ Ω)

Answer: Voltage = ________ volts, the voltage required



What I Have Learned

Directions: Provide what is asked. Write your answers on a separate sheet of paper.

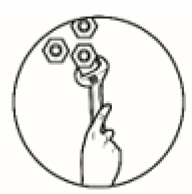
1. State the relationship of current, voltage, and resistance.

Rubric for Scoring	
2 points	The relationship is completely stated.
1 point	The relationship is partially stated.
0	No answer.

2. What is the product of resistance and current in Ohm's Law? ___________

3. In Ohm's Law, what is the electrical quantity if the voltage is divided by its current? ___________

4. In Ohm's Law, what is the electrical quantity if the voltage is divided by its resistance? ___________



What I Can Do

Activity 3. Ohm's Law at Home

Directions: Read and understand the situation below. Write your answers on a separate sheet of paper.

In the Philippines, an electric energy distributor supplies each household 220 volts of voltage and 60 A of current. Applying your knowledge on Ohm's Law, in what way your appliances be used at home to maintain a safe amount of current?

Rubric for Scoring	
2 points	The answer is consistent with the concept of Ohm's Law.
1 point	The answer is not consistent with concept of Ohm's Law.
0	No answer.

Assessment

Directions: Choose the letter of the correct answer. Write your answers on a separate sheet of paper.

1. What is the electric current if a circuit has a resistance of 100 Ω and voltage of 12.0 V?

   A. 0.120 A
   B. 9.00 A
   C. 12.0 A
   D. 25.0 A

2. What is the electric current if a circuit has a resistance of 100 Ω and a voltage of 6.00 V?

   A. 0.0600 A
   B. 4.50 A
   C. 6.00 A
   D. 12.5 A

3. What is the voltage of a circuit that has a resistance of 6 kΩ and a current of 2 mA?

   A. 9 V
   B. 10 V
   C. 11 V
   D. 12 V

4. What will happen to the current if the voltage is reduced to one half?

   A. tripled
   B. doubled
   C. decreased by one half
   D. decreased by one fourth

5. Calculate the voltage if the current passing through the wire is 3 A, and has a resistance of 10 Ω.

   A. 6 V
   B. 30 V
   C. 75 V
   D. 150 V

6. What is the voltage across a 6 Ω load when 3 A of current passes through it?

   A. 2 V
   B. 9 V
   C. 18 V
   D. 36 V

7. Which of the following properties of materials does NOT affect resistance?

   A. Length
   B. Thickness
   C. Temperature
   D. Strength of the material

8. Ampere is a unit of what electrical quantity?

   A. Current
   B. Load
   C. Resistance
   D. Voltage

9. What happens to the current across a circuit when the voltage is doubled while the resistance is held constant?

   A. Tripled
   B. Halved
   C. Doubled
   D. Remains the same

10. Which of the following statements is correct about the relationship of voltage and current?

    A. Current varies directly with voltage and resistance is changing.
    B. Current varies indirectly with voltage and resistance is changing.
    C. Current varies directly with voltage when resistance remains constant.
    D. Current varies indirectly with voltage when resistance remains constant.

11. What type of conducting wire has the greatest resistance to the flow of current?

    A. thin, long wire
    B. thick, long wire
    C. thin, short wire
    D. thick, short wire

12. Which of the following conducting wires has the least resistance?

    A. Steel wire at room temperature
    B. Steel wire at higher temperature
    C. Copper wire at room temperature
    D. Copper wire at higher temperature

13. How many coulombs does a 3-A current have in one second?

    A. 3 C
    B. 4 C
    C. 5 C
    D. 6 C

14. How many billions of electrons are there in a 3.000-A current?

A. 6.250
B. 12.50
C. 18.75
D. 25.00

15. What is the amount of current when 60 coulombs of charges pass through a circuit in 10 seconds?

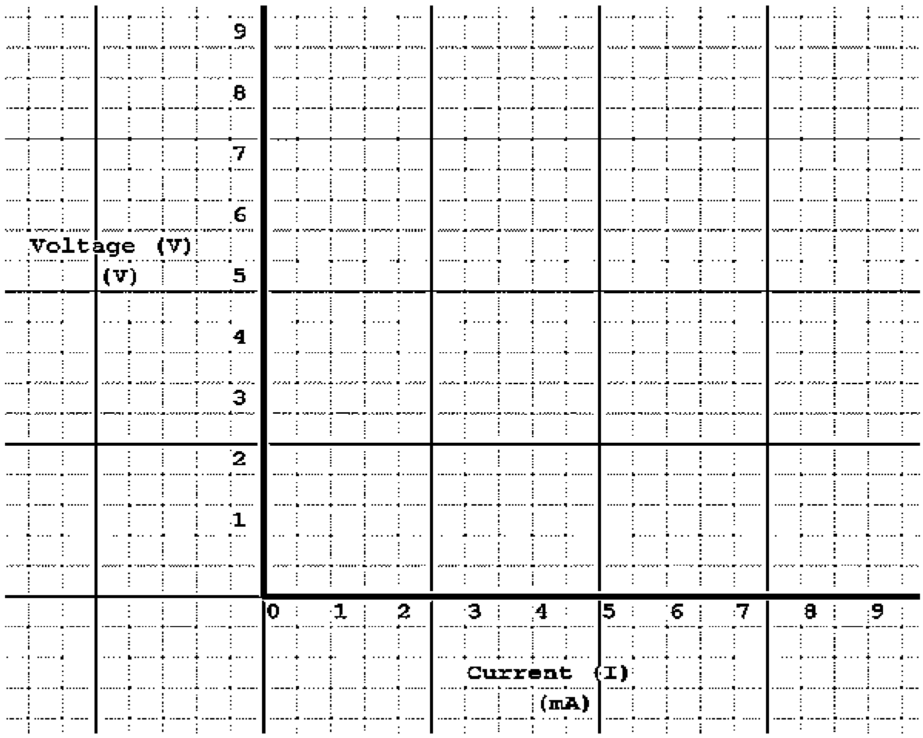
A. 3 A
B. 4 A
C. 5 A
D. 6 A

Additional Activities

Activity 4. Graphing Current vs Voltage

Directions: Calculate the current and complete the table below. Using the values of voltage and current on the table, plot the V versus I graph. Write your answers on a separate sheet of paper.

Voltage (V)	Current (mA)	Resistance kΩ
0.0		1.0
1.0		1.0
2.0		1.0
3.0		1.0
4.0		1.0
5.0		1.0
6.0		1.0
7.0		1.0
8.0		1.0
9.0		1.0



Notes to the Teacher

Provide extra copies of this activity for students' use.

Answer Key

What I know

1. D
2. C
3. A
4. A
5. C
6. B
7. D
8. C
9. A
10. A
11. C
12. A
13. A
14. B
15. D

What is It

Activity 1

1. $V = IR$

When: $V = V/2$

R is constant

$V/2 = IR$

$I = V/2R$

Therefore, current is decreases by one half if voltage is decreased by one half while resistance is held constant.

2. $V = IR$

When: $R = 2R$

V is constant

$V = I(2R)$

$I = V/2R$

Therefore, when resistance is doubled while Voltage is held constant, Current is halved.

What's More

Activity 2

1. Given: current = <u>60.0</u> A

voltage = <u>12</u> volts

Required: resistance (R)

Solution: $V = I R$

Formula: Resistance $= \frac{voltage}{curent} = \frac{12\ volts}{60.0\ A}\ \Omega$

Answer: Resistance = 0.200 Ω, the resistance of electric motor.

2. Given: Resistance (R) = 3.0 kΩ x 1000 Ω/1 kΩ = <u>3000 Ω</u>

Voltage (V) = <u>220</u> volts

Asked: current (I)

Solution: $V = I R$

$$I = \frac{voltage}{resistance} = \frac{220\ volt}{3000\ \Omega}$$

Answer: current = 0.073 A, the current needed to operate the electric fan

Assessment

1. A
2. A
3. D
4. C
5. B
6. C
7. D`
8. A
9. C
10. C
11. C
12. C
13. A
14. C
15. D

What I Can Do

Activity 3

The following are possible answers:

a. The conducting wire has maximum current capacity to operate safely. To prevent consumption more than the safe amount of current, the appliances should be used when necessary.

b. Turn off television if no one is watching.

c. Unplug all appliances from the outlet when these are not used. Even if the appliance is turned off, it is still consuming current especially if it is operated using a remote-control switch.

What I Have Learned

1. The relationship among current, voltage and, resistance is stated in Ohm's law: Current is directly proportional to voltage when resistance is held constant; however, at a constant voltage, current decreases when resistance is increased.
2. Voltage
3. Resistance
4. Current

What's More

Continuation of **Activity 2**

3. **Given**: Resistance (R) = 22 k Ω x (1 000 Ω/1 k Ω) = <u>22000</u> Ω

Current (I) = <u>10</u> mA x (1 A/1000 mA) = <u>0.01 A</u>

Required: Voltage(V)

Solution: V = I R

V = (<u>0.01</u> A) (<u>22000</u> Ω)

V = <u>220</u> volts

Answer: V = 220 volts is needed to operate the traffic lights.

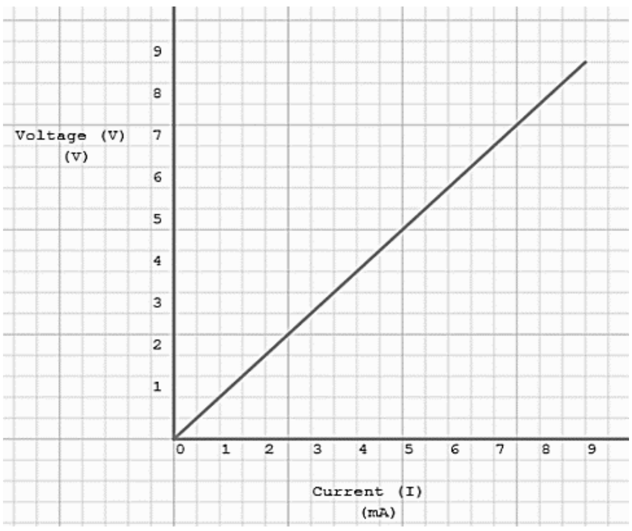
Additional Activities

Activity 5

Current (mA)

0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0

Additional Activities



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