DEPARTMENT OF EDUCATION
SCHOOLS DIVISION OF NEGROS ORIENTAL
REGION VII
Kagawasan Ave., Daro, Dumaguete City, Negros Oriental

# OHM'S LAW: ENERGY AND POWER IN ELECTRIC CIRCUIT

## for GENERAL PHYSICS 2/ Grade 12/ Quarter 3/ Week 5


# SELF-LEARNING KIT

NegOr_Q3_GenPhysics2_SLKWeek5_v2

# FOREWORD

This Self-Learning Kit will serve as a guide in identifying the concepts of energy and power in an electric circuit.

This Kit focuses on the devices for measuring current and voltage in circuit diagrams. You will learn various ways of describing electric circuits through the use of words, drawings, or with the use of conventional circuit diagrams and symbols. Problems involving current, resistivity, resistance and Ohm's law are also emphasized in context such as, but not limited to, batteries and bulbs, household wiring and selection of fuses. Thus, you can show appreciation on the importance of electric fuses in maintaining electrical safety.

Explore and be ready to be equipped with it.

## OBJECTIVES

At the end of this Self-Learning Kit, you will be able to:

**K:** explain the difference between ohmic and non-ohmic materials; potential difference from electromotive force and the total power dissipated in an electric circuit;
**S:** illustrate circuit diagrams with power sources and calculate current, voltage and resistance;
**:** solve problems involving Ohm's Law; and
**A:** give importance of making circuit diagrams and knowing the different devices in operating and measuring current and voltages for electrical safety.

## LEARNING COMPETENCIES

Differentiate ohmic and non-ohmic materials in terms of their I-V curves **(STEM_GP12EMIIIe-38).**

Differentiate emf of a source and potential difference (PD) across a circuit **(STEM_GP12EMIIIe-40).**

Given an emf source connected to a resistor, determine the power supplied or dissipated by each element in a circuit **(STEM_GP12EMIIIe-42).**

Solve problems involving current, resistivity, resistance, and Ohm's law in contexts such as, but not limited to, batteries and bulbs, household wiring, and selection of fuses **(STEM_GP12EMIIIe-44).**

Operate devices for measuring currents and voltages **(STEM_GP12EMIIIe-45).**

Draw circuit diagrams with power sources (cell or battery), switches, lamps, resistors (fixed and variable) fuses, ammeters, and voltmeters **(STEM_GP12EMIIIf-47).**

## I. WHAT HAPPENED

Ancient people did not know about the power of electric current. They only knew about creating small sparks through friction. However as time passes by and civilization comes in, electric current then enters the world, where a big bang of change occurs. Can you imagine water flowing from the mountains to a lowland area? It is the same as electrons flowing through a circuit. To understand things in a better perspective, let's try to go with the flow!

## PRE-TEST:

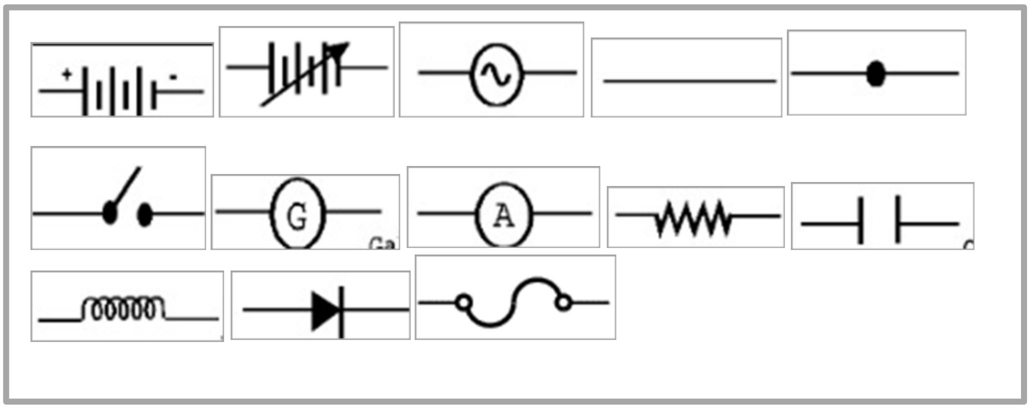
**A. Identify to Simplify!**

**Directions:** Identify whether the following materials is ohmnic or non-ohmic. Write ***O*** if it's Ohmic and ***NO*** if it's not.

_____1. Copper wire
_____2. Silver
_____3. Steel
_____4. Iron
_____5.Concrete
_____6. Dirty water
_____7. Breast implant (Silicon gel)
_____8. Tin cans
_____9. CD and DVD
_____10. Gold ring

**B. Drawtify! (Draw to identify)**

**Directions:** Draw the electrical components/symbols on the space provided after each number. Choose your answer from the symbols found inside the box. Do this in your notebook/Answer Sheet.




*Source: Electrical Circuit Symbols And Meanings - Circuit Diagram Images | Electrical circuit*

1. Resistor -___________________
2. Galvanometer -___________________
3. Ammeter -___________________
4. Cell/Battery -___________________
5. Fuse -___________________
6. Wire -___________________
7. Variable DC supply -___________________
8. Switch -___________________
9. Wire connection -___________________
10. Diode -___________________
11. Capacitor -___________________
12. Inductor -___________________
13. AC voltage supply -___________________

## II. WHAT I NEED TO KNOW
## DISCUSSION

### DIFFERENCES BETWEEN OHMIC AND NON-OHMIC MATERIALS IN TERMS OF I-V CURVES

- An electric conductor could be ohmic or non-ohmic. The main difference between an ohmic and non-ohmic conductor is that ohmic follows Ohm's law whereas non-ohmic does not. For Ohmic conductor they follow a linear relationship between current and voltage and for the non-ohmic it is not linear.

- Ohmic materials are usually good conductors of electricity example of which are metals like copper, gold, silver, etc. and non-ohmic are semiconductors. Examples of semiconductors are germanium and silicon.

- An ohmic material works at a constant temperature while a non-ohmic material does not.

- Remember that Ohm's law is represented by:

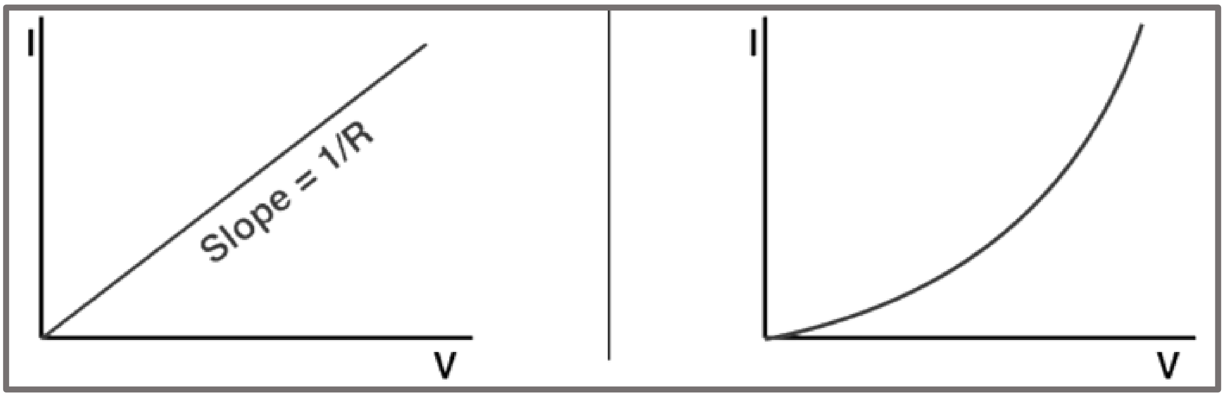
$$V = IR$$

where: V =voltage

I = current

R = resistance

(Note that I-V curves represents Current, resistance to voltage)




(A) Ohmic (B) Non-ohmic

*Source: (4) Ohmic vs. Non Ohmic Resistors - IB Physics - YouTube*

***Figure 1***. Difference in I-V curves of Ohmic and Non-ohmic materials

## ELECTROMOTIVE FORCE AND ELECTRIC POTENTIAL DIFFERENCE

Electromotive force and electric potential difference are two closely related concepts under electric circuits, but in this part of the lesson you will clearly see their difference in terms of their role and uses.

- Electromotive force is the driving force of a device that keeps the constant flow of charges ***across circuit.***
  - **Example:** The chemical energy inside a battery produces ***emf*** that drives the **electrons** throughout the circuit.

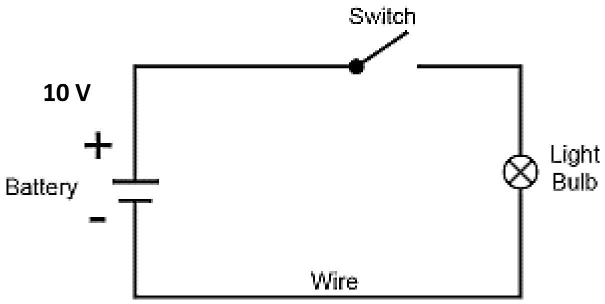



*Image Source: Mammoth memory*

**10 volts** is equivalent of 10 joules of energy needed to move 1 coulumb across the circuit.

- It is represented using the formula:

$$\varepsilon = \frac{W}{Q}$$

where: $\mathcal{E}$ = Electromotive force (V or volts)
W = work done (J or joules)
Q = charge (measured in coulumb)

***If,***

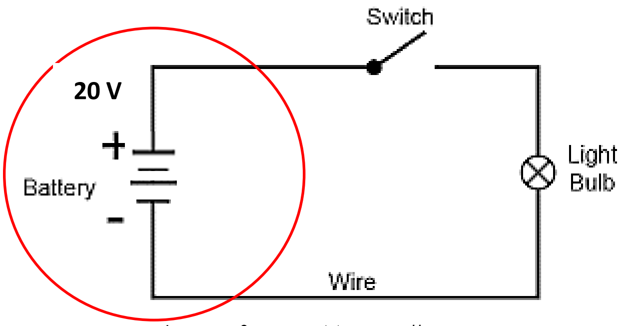



*Image Source: Mammoth memory*

**Therefore,**

$$v = \frac{W}{Q}$$

$$20v = \frac{W}{1}$$

***W= 20 J*** *is the amount of work done to drive across a circuit.*

- Electric potential difference is a work done to drive per unit charge ***across two points.***

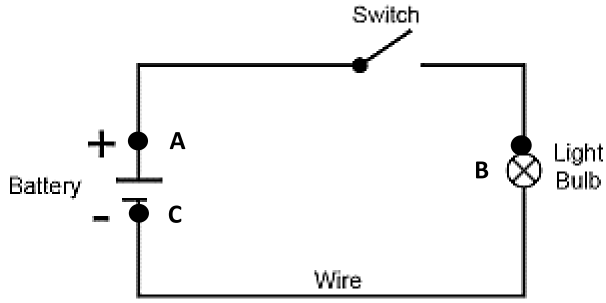



*Image Source: Mammoth memory*

- Given the diagram on the previous page, both **electromotive force** and **potential difference** follows the same formula, where **E = W/Q.**

  Now how do we look for the potential difference between two points?

  *Given that the total energy across the circuit is **10 v,*** or the emf.

$$\boldsymbol{PD}_{ab} = 5\ volts$$

  *This means that the energy from point **a to b is 5 volts.***

  To get the **PD** (Potential difference from point C to B) do the following:

$$\boldsymbol{PD}_{cb} = 10\ volts - 5\ volts$$

**= 5 volts**

You now have the **potential difference or p.d.** from the different points. If you add them together, you will get the **electromotive force or emf.**

*Based on the discussion mentioned above, what is the main difference between these two?*

Below is a table summarizing the difference between the two.

| | **EMF OF A CELL** | **POTENTIAL DIFFERENCE** |
|---|---|---|
| 1 | The emf of a cell is the maximum potential difference between the two electrodes of a cell when the cell is in the open circuit. | The potential difference between the two points is the difference of potential between the two points in a closed circuit. |
| 2 | EMF is independent of resistance of circuit and depends upon the nature of electrodes and electrolyte. | This depends upon the resistance between two points of the circuit and current flowing through the circuit. |
| 3 | The term emf is used for source of current. | Potential differences can be measured between any two points of circuit. |
| 4 | This is a cause. | It is an effect. |

## THE POWER SUPPLIED OR DISSIPATED BY EACH ELEMENT IN A CIRCUIT

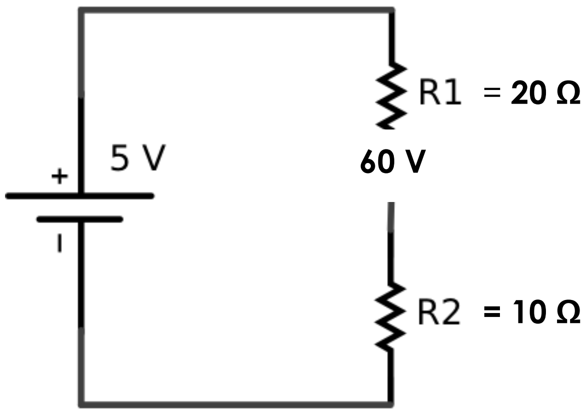
An ever-present challenge in electronic circuit design is selecting suitable components that not only perform their intended task but also will survive under foreseeable operating conditions. A big part of that process is making sure that your components will stay within their safe operating limits in terms of current, voltage, and power. Of those three, the "power" portion is often the most difficult because the safe operating area can depend so strongly on the particulars of the situation, that's why identifying the dissipated power by each element is vital in electric circuits.

***Example 1:***

Find the power dissipated on each resistor. (Series circuit)

Remember the following before going through the problem.

P = power (W, watts)
V = voltage (V)
R = Resistors/resistance (Ω ohms)
I = current (A, amps/ampere)




***Given:***

V = 60 V
$R_1$ = 20 Ω
$R_2$ = 10 Ω

**First**, calculate the **total resistance ($R_T$).** To calculate the total resistance, use the formula below:

$$R_T = R_1 + R_2$$

Substitute the given value:

$$R_T = 20\,\Omega + 10\,\Omega$$
$$= 30\,\Omega$$

**Second,** calculate the current flowing in the circuit using Ohm's law.

$$I = \frac{V}{R_T}$$
$$I = \frac{60\ V}{30\ \Omega}$$
$$I = 2\ A$$

**Third,** calculate the **power** of each resistors using the formula:

$P_1 = I^2R_1$ and $P_1 = I^2R_2$

$$P_1 = I^2R_1$$
$$P_1 = 2^2\ x\ 20$$
$$P_1 = 4\ x\ 20$$
$$P_1 = 80\ W$$

**80 watts** is the power dissipated by the first resistor.

$$P_1 = 2^2\ x\ 10$$
$$P_1 = 4\ x\ 10$$
$$P_1 = 40\ W$$

**40 watts** is the power dissipated by the second resistor.

**Power** is the rate at which energy is delivered to a device. A power of **1 watt** means that **1 joule** of energy is delivered each second, so in 10 seconds 10 joules of energy is being delivered. Based on the example, the first resistor is converting 80 joules of electrical energy into heat every second while the second resistor is converting 40 joules of electrical energy into heat every second.

*How much joules of electrical energy do the circuit converts into thermal energy every 10 seconds?*

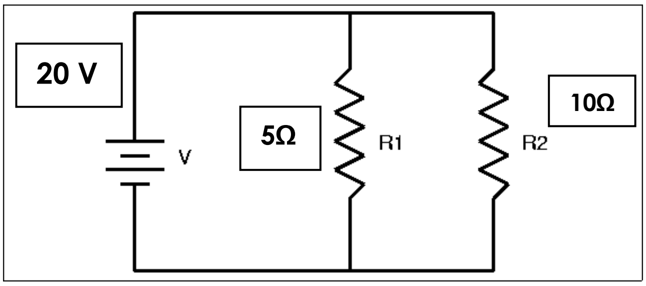
Let us now try to calculate the power delivered by the battery using the formula:

$$P_B = VI$$
$$P_B = 60\ V\ x\ 2\ A$$
$$P_B = 120\ W$$

**Notice that the power delivered by the battery is equal to the sum of the power delivered by each resistor.** This is according to the law of conservation of energy wherein the energy that the battery delivers to the circuit should be equal to what the elements of the circuit is consuming.

***Example 2:***

Find the power dissipated on each resistor and the power delivered by the battery. (Parallel circuit)




**Given:**

Voltage = 20 V
Resistor 1 = 5 Ω
Resistor 2 = 10 Ω

First, calculate the power by each resistor because it's not the same. Whenever you have two resistors connected in parallel circuit the voltage across them is the same. ***So, the voltage across the first and second resistor is the same as the voltage of the battery which is 20 V.***

***REMEMBER:***

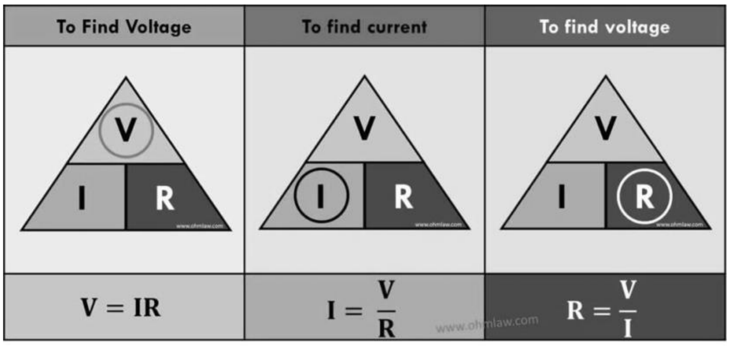
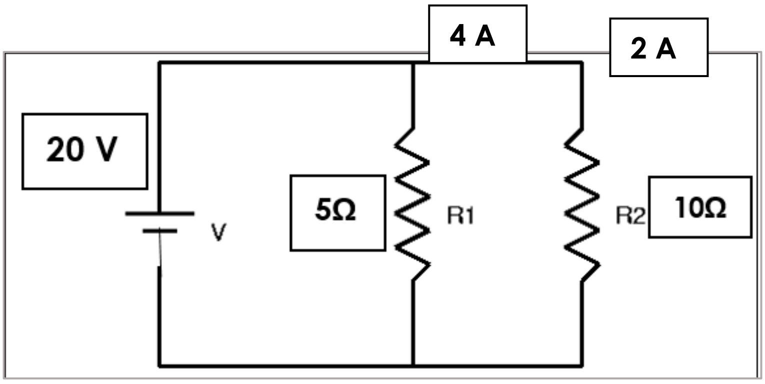



*IMAGE SOURCE: Voltage Current Resistance Triangle [VIR Triangle] • Ohm Law*

To calculate the current flowing through each resistor, use Ohm's law.

$$V = IR$$
$$I_1 = \frac{V}{R_1}$$
$$I_1 = \frac{20\ V}{5\ \Omega}$$
$$I_1 = 4\ A$$




V = IR

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

$$I_2 = \frac{20\ V}{10\ \Omega}$$

$$I_2 = 2\ A$$

The current leaving the battery is the sum of the currents flowing on each resistor. Therefore, the battery is delivering **6 A** of current to the circuit.

Calculate the power dissipated by each resistor:

$$P_1 = {I_1}^2 R_1$$

$$P_1 = 16\ x\ 5$$

$$P_1 = 80\ W$$

$$P_2 = {I_2}^2 R_2$$

$$P_2 = 4\ x\ 10$$

$$P_2 = 40\ W$$

Calculate the power delivered by the battery:

$$P_B = VI$$

$$P_B = 20\ V\ x\ 6\ A$$

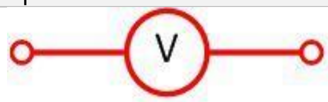
$$P_B = 120\ W$$

## DEVICES FOR MEASURING CURRENT AND VOLTAGE

Electricity is measured in two ways: either through **current** or v**oltage**. The current and voltage of the circuit are measured through **ammeter** and **voltmeter** respectively. The working principle of the ammeter and voltmeter are same as that of the galvanometer.

The **galvanometer** uses a coil which is placed between the magnet. When the current flows through the coils, it becomes deflected. The deflection of the coils depends on the charge passing through it. This deflection is used for measuring the current or voltage. The galvanometer works as a voltmeter when the resistor is placed in series with the galvanometer.

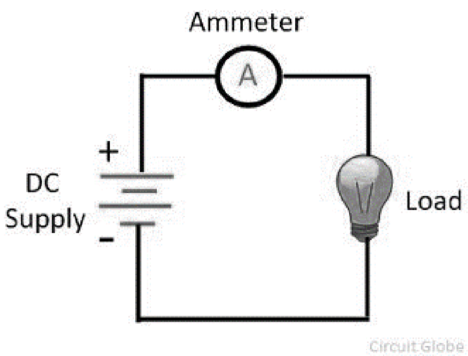
**COMPARISON CHART**

| Basis For Comparison | Ammeter | Voltmeter |
|---|---|---|
| **Definition** | The instruments used for measuring the current. | It measures the voltage between any two points of the circuit. |
| **Symbolic Representation** |   |   |
| **Resistance** | Low | High |
| **Connection** | It is connected in series with the circuit. | It is connected in parallel with the circuit. |
| **Accuracy** | More | Less |
| **Changing of Range** | Not possible | Possible |

*Source: Difference Between Ammeter & Voltmeter (with Comparison Chart) - Circuit Globe*

### Definition of Ammeter

The **ammeter** is the measuring instrument which is used to measure the current in the circuit. It measures the small amount of current in milliamperes or micro-amperes. The ammeter is placed in series with the measuring circuit so that the whole current of the circuit passes through it.

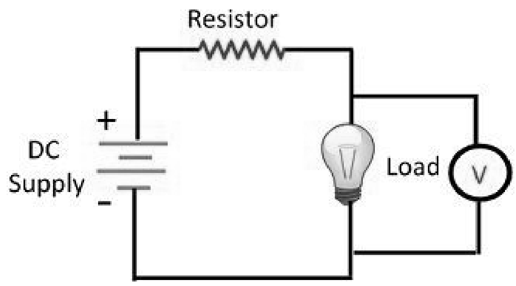



The resistance of the ammeter is very small as compared voltmeter. For ideal ammeter, the value of resistance is equal to zero. The small resistance does not obstruct the flow of current, and thus the ammeter measures the true value.

### Definition of Voltmeter

The voltmeter is the voltage measuring devices. It is connected in parallel with the electrical circuit whose potential is to be measured. The connection polarity of the voltmeter is same as that of the ammeter i.e. the positive terminal is connected to the positive polarity of the supply and the negative potential is connected to the negative polarity.

The resistance across the voltmeter is very large as compared to the ammeter. This resistance does not allow the current to flow through the voltmeter and thus the exact value of the voltage across the measuring point is measured. The value of resistance in ideal voltmeter is approximately equal to infinity.




*Source: Difference Between Ammeter & Voltmeter (with Comparison Chart) - Circuit Globe*

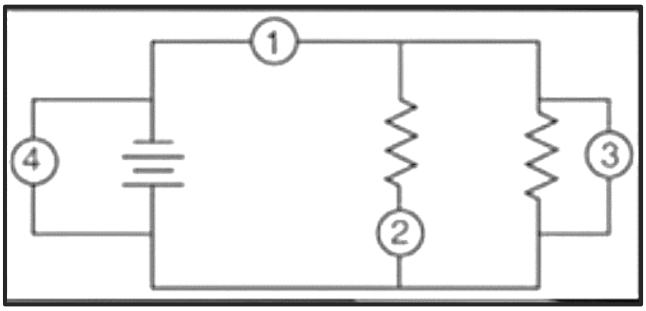
**Key Differences between Ammeter and Voltmeter**

The following are the key difference between Ammeter and Voltmeter:

| AMMETER | VOLTMETER |
|---|---|
| Measures the small value current flows in the circuit | Measures the potential difference between any two points of the electrical circuit. |
| The resistance of the ammeter is low. So that, the whole current of the circuit will pass through it. | The internal resistance of the voltmeter is very low so that the current from the circuit does not disturb the measuring of the voltmeter. |
| Connected in series with the circuit for measuring the complete current | Connected in parallel with the circuit. The potential difference of the parallel circuit remains same at all points. |
| Accuracy is High | Accuracy is Low |
| Measuring range of cannot be changed. | The measuring range can be increased or decreased by changing the value of resistance |

*Source: Difference Between Ammeter & Voltmeter (with Comparison Chart) - Circuit Globe*

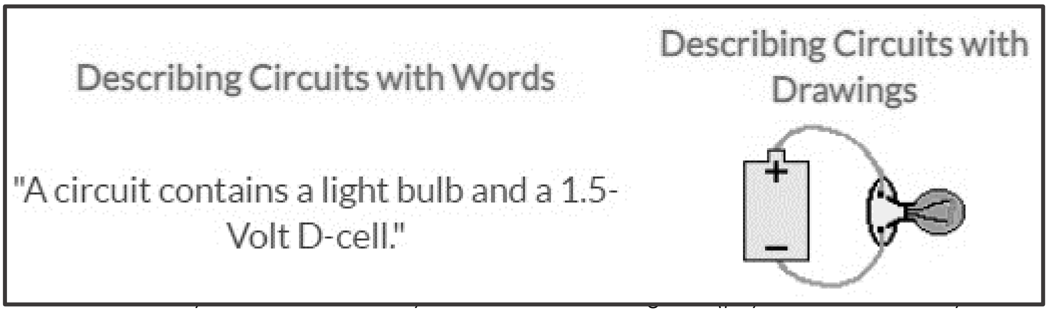
**Let's practice!**




In the diagram, possible locations of an ammeter and voltmeter are indicated by circles 1, 2, 3 and 4. Where should an ammeter be located to correctly measure the total current and where should a voltmeter be located to correctly measure the total voltage? Explain your answers and write it in your notebook.

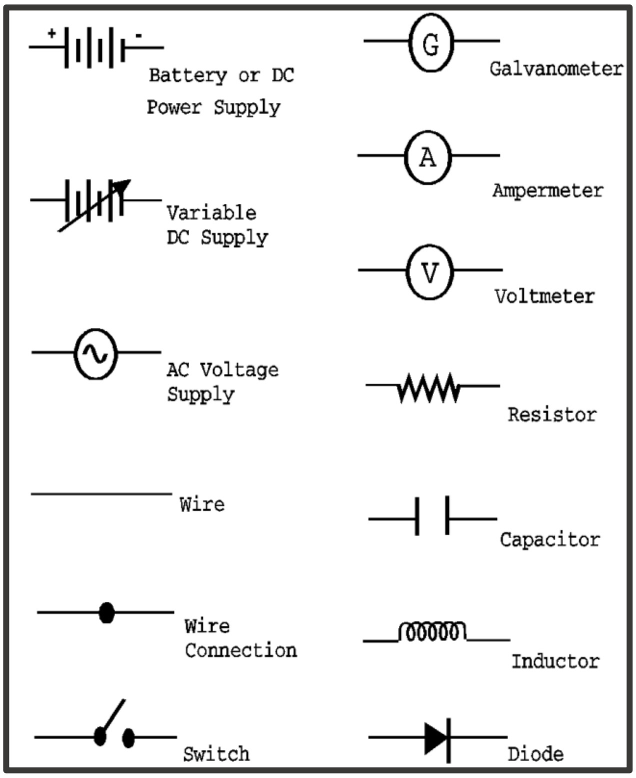
## CIRCUIT DIAGRAM AND CIRCUIT SYMBOLS

Electric circuits, whether simple or complex, can be described in a variety of ways. An electric circuit is commonly described with mere words. Saying something like "A light bulb is connected to a D-cell" is enough words to describe a simple circuit. On many occasions, a person grows accustomed to quickly picturing the circuit in their mind, but another means of describing a circuit is to simply draw it. Such drawings provide a quicker mental picture of the actual circuit.




A final means of describing an electric circuit is by use of conventional circuit symbols to provide a schematic diagram of the circuit and its components. Some circuit symbols used in schematic diagrams are shown below.

Here are some circuit diagrams and symbols.

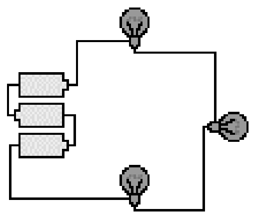



*Source: Electrical Circuit Symbols And Meanings - Circuit Diagram Images | Electrical circuit*

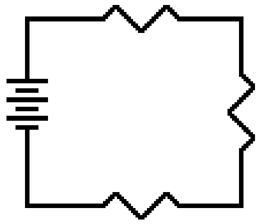
*Example 1:*

**Description with Words:** Three D-cells are placed in a battery pack to power a circuit containing three light bulbs.

**Drawing of Circuit**



**Schematic Diagram of Circuit**

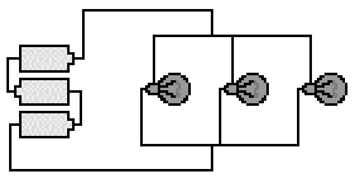


Using the verbal description, one can acquire a mental picture of the circuit being described. This verbal description can then be represented by a drawing of three cells and three light bulbs connected by wires. Finally, the circuit symbols presented above can be used to represent the same circuit. Note that three sets of long and short parallel lines have been used to represent the battery pack with its three D-cells. And note that each light bulb is represented by its own individual resistor symbol. Straight lines have been used to connect the two terminals of the battery to the resistors and the resistors to each other.

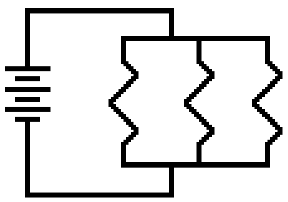
*Example 2:*

**Description with Words**: Three D-cells are placed in a battery pack to power a circuit containing three light bulbs.

**Drawing of Circuit**

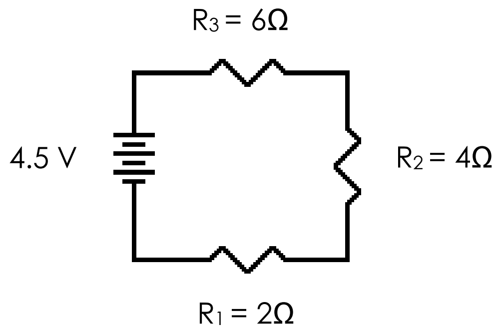


**Schematic Diagram of Circuit**



Using the verbal description, one can acquire a mental picture of the circuit being described. But this time, the connections of light bulbs is done in a manner such that there is a point on the circuit where the wires branch off from each other. The branching location is referred to as a **node**. Each light bulb is placed in its own separate branch. These branch wires eventually connect to each other to form a second node. A single wire is used to connect this second node to the negative terminal of the battery.

To give meaning to the diagram of a series circuit in Example 1, we will place value for the resistors connected in series.



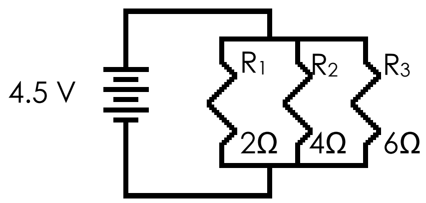

The total resistance in the circuit is:

$R_T = R_1 + R_2 + R_3$
$= 2\Omega + 4\Omega + 6\Omega$
$= 12\Omega$

The current flowing in the circuit is:

$$I = \frac{V}{R_T} = \frac{4.5\,V}{12\,\Omega} = \mathbf{0.375\,A}$$

In example 2, the resistors are connected in parallel with each other.




The total resistance in the circuit is:

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

$$= \frac{1}{2\Omega} + \frac{1}{4\Omega} + \frac{1}{6\Omega}$$

$$= \frac{6+3+2}{12}$$

$$\frac{1}{R_T} = \frac{11}{12}$$

$$R_T = \frac{12}{11} = 1.09\,\Omega$$

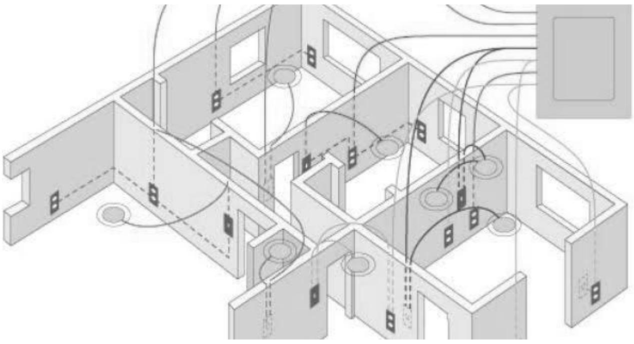
The current flowing in the parallel circuit is:

$$I = \frac{V}{R_T} = \frac{4.5\,V}{1.09\,\Omega} = \mathbf{4.12\,A}$$

According to Ohm's Law, current is directly proportional to the voltage and inversely proportional to the resistance in the circuit. This can be seen in the two examples of circuits where values of resistance are added. Connecting resistors in series will create high resistance to the circuit. High resistance will create low current flow. Connecting resistors in parallel offers low resistance to the circuit and allows much current flow.

## HOUSEHOLD WIRING

Your household provides you with the best visualization of how electric circuits work in delivering electrical energy. You know which appliances are included in the circuit and how the use of electricity can be optimized.



*Adapted from https://www.google.com/amp/s/www.pinterest.com/amp/pin/528821181216596550/*

***Figure 2.*** An example of a household electric circuitry

## SELECTION OF FUSES

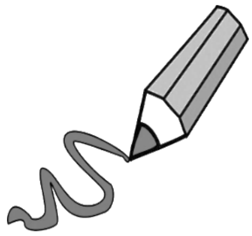
The flow of current in a conductor generates heat along its path. Too much heat, however, can be dangerous to the overall circuit and may cause fire. **Electrical fuses** provide a solution to this concern. Fuses are designed to have very thin pieces of wire. They only allow a certain amount of current to pass through them; otherwise, a fuse burns out if there is an excessive amount of current. If the fuse burns out, it will shut down the entire circuitry, thus preventing damage. It is always safer to use a small fuse than a large one. By selecting the proper fuse to be used in your circuitry, you can be protected from electrical accidents due to faulty wiring.

*Adapted from https://www.amazon.com/Bussmann-AGC-1-8-GLASS-FUSE/dp/B009IXMLB6*

***Figure 3.*** An electric fuse installed at home minimizes the risk of accidents

## PERFORMANCE TASK:

**Electromotive Force and Potential Difference**



***Objective:*** Distinguish between electromotive forces and potential differences.

***Material:*** A Circuit Diagram

***Procedure:***

1. Draw a circuit diagram with two batteries, 1 light bulb and switch. You can apply your creativity provided that the appropriate symbols are used.
2. Label the electromotive force and the potential difference.

***Question:*** How does an electromotive force differ from potential difference? Write your answers on your notebook/Answer Sheet.

***Rubric:***

| | |
|---|---|
| Organization of components | – 20 points |
| Complete circuit | – 10 points |
| Creativity | – 10 points |
| **TOTAL** | **– 40 points** |

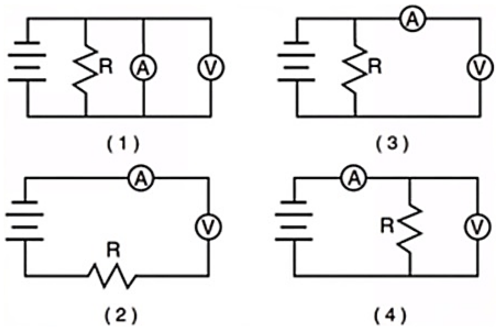
## III. WHAT I HAVE LEARNED EVALUATION/POST-TEST

### I. MULTIPLE CHOICE

**Directions:** Choose the letter/number of the correct answer. Write it on your notebook/Answer Sheet.

1. Which of the following follows a linear relationship between current and voltage?
   a. emf b. P.d. c. ohmic d. non-ohmic
2. Which of the following is an ohmic material?
   a. dirty water b. breast implant c. tin cans d. CD and DVD
3. The following are non-ohmic materials, EXCEPT:
   a. Silicon b. tin c. diode d. copper
4. It is the driving force across two different points.
   a. Potential difference c. ohmic materials
   b. Electromotive force d. non-ohmic materials
5. Is voltage across two resistors in a parallel circuit the same?
   a. Yes b. No c. Maybe d. Neither yes or no

6. Which circuit diagram correctly shows the connection of Ammeter A and voltmeter V to measure the current through and potential difference across resistor R?




7. A student uses a voltmeter to measure the potential difference across a resistor. To obtain a correct reading, the student must connect the voltmeter _______.
    a. After connecting the other circuit components.
    b. Before connection the other circuit components.
    c. in series with the resistor.
    d. in parallel with the resistor.
8. Which statement about ammeters and voltmeters is correct?
    a. The internal resistance of both meters should be low.
    b. Both meters should have a negligible effect on the circuit being measured.
    c. The potential drop across both meters should be made as large as possible.
    d. The scale range on both meters must be the same.
9. The **galvanometer** uses a coil which is placed between the magnet. When the current flows through the coils, what will happen to the current?
    a. It will be reflected.
    b. It will be deflected.
    c. It will be refracted.
    d. All of the above
10. The resistance across the voltmeter is very large as compared to the ammeter. This statement is _______.
    a. True
    b. False
    c. Neither True nor False
    d. Undecided

## II. PROBLEM SOLVING

**Directions:** Solve the given problems below. Show your solution on your notebook/Answer Sheet.

1. Find the voltage drop in an extension cord having a $0.0600\Omega$ resistance and through which 5.00 A is flowing.
2. A cheaper cord utilizes thinner wire and has a resistance of $0.300\Omega$. What is the voltage drop in it when 5.00 A flows?
3. A coil receives an electric power of 4500 W from a supplied voltage of 240 V. What is the resistance of the coil?

# REFERENCES


Basics: Power dissipation and electronic components, Windell Oskay. Retrieved from

circuitglobe.com/difference-between-ammeter-and-voltmeter.html

David, Oliver M. *General Physics* 2. Makati City, Philippines: DIWA Learning Systems Inc., 2017.

https://webstockreview.net/

Evilmadscientist.com/2012/basics-power-dissipation-and-electronic-components/

Ohmlaw.com/voltage-current-resistance-triangle-vir-triangle/

Terminal Potential Difference – eSaral. Retrieved from www.esaral.com/emf-internal-resistance-of-a-cell-terminal-potential-difference-types-of-cells/

www.youtube.com/watch?app=desktop&v=Ciasa_SH0cI

www.pinterest.ph/pin/542965298808561001/

**DEPARTMENT OF EDUCATION**
**SCHOOLS DIVISION OF NEGROS ORIENTAL**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Schools Division Superintendent

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Education Program Supervisor – (LRMDS)

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PSDS-Division Science Coordinator

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Librarian II (LRMDS)

**ELMAR L. CABRERA**
PDO II (LRMDS)

**LANIE MAE C. DE LA TORRE**
Writer

**STEPHEN C. BALDADO**
Lay-out Artist

---

**ALPHA QA TEAM**
JOSE MARI B. ACABAL
MA. MICHELROSE G. BALDADO
ROWENA R. DINOKOT
GENEVA FAYE L. MENDOZA

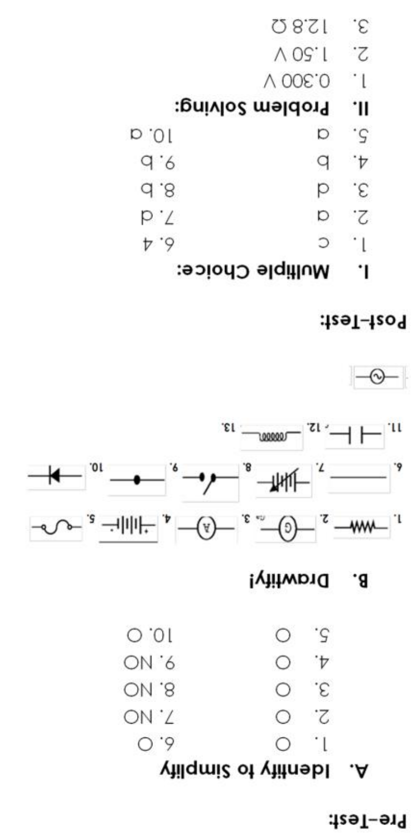
**BETA QA TEAM**
ZENAIDA A. ACADEMIA
ALLAN Z. ALBERTO
EUFRATES G. ANSOK JR.
ROWENA R. DINOKOT
LESTER C. PABALINAS

## SYNOPSIS AND ABOUT THE AUTHOR

An electric conductor could be ohmic or non-ohmic. The main difference between the two is that ohmic follows Ohm's law whereas non-ohmic does not. Ohmic materials are usually good conductors of electricity, example of which are metals like copper, gold, silver, etc. and non-ohmic are semiconductors. Examples of semiconductors are germanium and silicon.

Electricity is measured in two ways: either through **current** or v**oltage**. The current and voltage of the circuit are measured through **ammeter** and **voltmeter** respectively. The working principle of the ammeter and voltmeter are same as that of the galvanometer. The **ammeter** is the measuring instrument which is used to measure the current in the circuit. The voltmeter is the voltage measuring devices. It is connected in parallel with the electrical circuit whose potential is to be measured.

## ANSWER KEY



**Pre–Test:**

**A. Identify to Simplify**

1. O    6. O
2. O    7. NO
3. O    8. NO
4. O    9. NO
5. O    10. O

**B. Drawtify!**

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13.

**Post–Test:**

**I. Multiple Choice:**

1. c    6. 4
2. a    7. d
3. d    8. b
4. b    9. b
5. a    10. a

**II. Problem Solving:**

1. 0.300 V
2. 1.50 V
3. 12.8 Ω

**LANIE MAE C. DE LA TORRE** is currently teaching at Jimalalud National High School – Main Campus, Jimalalud Negros Oriental.

She is a Graduate of Bachelor of Secondary Education major in Biological Sciences at Negros Oriental State University, Bais Campus II and is currently pursuing her Masters in Educational Management in the same university.