Module 7
Electric Circuits

What this module is about

The benefits that we derive from electricity are brought about not by the fundamental charge alone but also by the control of the flow of electrons through different materials or media. Almost, if not all, appliances involve the control of the flow of electrons. This tells us that for electricity to be useful, there needs to be a proper path for electrons to move. This module shall discuss the concept of circuits and how it is being used in different applications. Because of the hazards electricity poses, this module shall also tackle precautionary measures in dealing with electricity. This module contains the following lessons:

- **Lesson 1 - Circuit Basics**
- **Lesson 2 - Series and Parallel Circuits**
- **Lesson 3 - Household Electrical Wirings**
- **Lesson 4 - Computing Electrical Energy Consumption**
- **Lesson 5 - Dealing with Electricity Safely**

What you are expected to learn

After going through this module, you are expected to:

1. identify the basic parts of electrical circuits;
2. distinguish series from parallel circuit connection;
3. relate voltage and current in a given resistor;
4. compute the equivalent resistance of series-parallel circuits;
5. estimate the electrical energy consumption cost of different appliances at home; and
6. practice safety precautions in dealing with electricity.

How to learn from this module

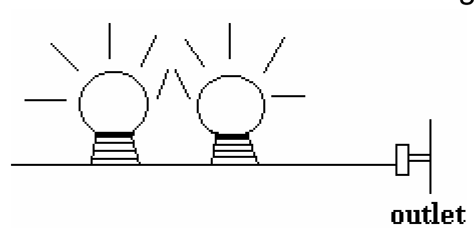
Going through this module can be both a fun and a meaningful learning experience. All you need to do is make use of your time and resources efficiently. To do this, here are some tips for you:

1. Take time in reading and understanding each lesson. It is better to be slow but sure than to hurry finishing the module only to find out that you missed the concepts you are supposed to learn.
2. Do not jump from one chapter to another. Usually, the lessons are arranged such that one is built upon another, hence an understanding of the first lesson is essential in comprehending the succeeding lessons.
3. Be honest. When answering the test items, do not turn to the key to correction page unless you are done. Likewise, when performing experiments, record only what you have really observed.
4. Safety first. Perform the experiments with extra precaution. Wear safety gears whenever necessary.
5. Don't hesitate to ask. If you need to clarify something, approach your teacher or any knowledgeable person.

What to do before (Pretest)

Directions: Select the letter of the option that correctly answers the questions. Write your answer in a separate sheet of paper.

1. Two bulbs are connected and plugged to the outlet as shown in the figure. Both bulbs have the same
   a. current
   b. voltage
   c. resistance
   d. voltage and current



2. When a third bulb is added to the connection in no.1, what happens to the intensity and brightness of the bulbs?
   a. remains the same
   b. increases
   c. decreases
   d. some may increase and others may decrease

3. To find out the electrical consumption at home, we should look at the
    a. generator
    b. transformer
    c. meter
    d. circuit breaker

4. Our electricity in the Philippines is 220 V. V is a unit of what quantity?
    a. velocity
    b. voltage
    c. current
    d. resistance

5. When the fuse in a circuit "blows up", the circuit is said to be
    a. short
    b. open
    c. overloaded
    d. both b and c

The table shows the power ratings and length of use of a toaster, CD player, refrigerator and washing machine.

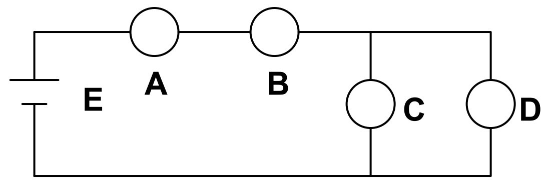
	Power Rating (Watts)	Length of Use (Hours)
Toaster	800	2
CD player	15	12
Refrigerator	800	10
Washing Machine	500	3

6. Which one consumes the greatest electrical energy?
    a. toaster
    b. CD player
    c. refrigerator
    d. washing machine

7. If all are plugged to a 220-V outlet, which appliance will draw the greatest amount of current?
    a. toaster
    b. CD player
    c. refrigerator
    d. washing machine

8. In the circuit below, which two elements are connected parallel to each other?

   a. A and B
   b. B and C
   c. C and D
   d. A and D



9. The circuit element labeled **E** in no. 8 is a schematic diagram of
   a. voltage source
   b. bulb
   c. resistor
   d. switch

10. Why is it NOT advisable to touch electric appliances when our hands are wet?
    a. The appliances may have rust when they get wet
    b. We may get a shock because water conducts electricity
    c. Water may cause the appliance to over heat
    d. All of the above

Key to answers on page 26

Lesson 1   Circuit Basics

In conductive materials, the outer electrons in each atom can easily come and go. That is why they are called free electrons. For electrons to flow continuously and indefinitely through a conductor, there must be a complete, unbroken path for them to move into and out of that conductor. This means that there is a need for an electron source and destination which are able to supply and collect infinite number of electrons so that continuous flow of current is sustained. However, it would be quite impractical to provide such infinite sources and destinations? How do we give electrons a path such that we can create a continuous flow without having to resort to infinite sources and destinations?

The answer to this question is **circuit.** Let us consider an experiment that can provide us with ideas in discovering the concept of a circuit.

What you will do
Activity 1.1 What is a circuit?

What you will need
Small marbles or perfectly rounded and smooth stones
Transparent hose, with hole size big enough to accommodate the marbles or stones.

What to do

Try stretching the hose over a flat surface. Initially, insert the marbles inside the hose and label the positions of the marbles. Now place an additional marble on one end of the hose. What do you notice? The marble on the other end moved, right? In other words, the marbles “flowed”. This flow of marbles is analogous to the flow of electrons. Before an electron moves from one place to another in a conductor, it needs to be displaced by another electron. Later, we shall learn how electrons can be initially moved to create movements in other electrons.

Now, what should you do if you want a continous flow of the marbles? One way is to catch the marble that exits on one end and insert it again in the other end of the hose. Surely, this is very laborious! There is another more practical way. Try creating a loop using the hose, that is, connect the two ends of the hose. Create a movement of the marbles. What do you notice now? Have you created a never-ending loop?

This is the concept of electrical circuit: if we take a wire, or many wires joined end to end, and loop them around so that they form a continuous pathway, we have the means to support a uniform flow of electrons without having to resort to infinite sources and destinations. Each electron advancing in a certain direction in a circuit pushes on the one in front of it, which pushes on the one in front of it and so on. All we need to do is maintain this flow by continuous means of motivation of these electrons.

Before a continuous flow of electrons occurs, we need a force to push these electrons around the circuit. With electrons, this force is the same as the force at work in static electricity.

When two objects are rubbed, an imbalance of charges may happen, which is manifested as attractive or repulsive force between them and other objects near them.

Let us consider two objects that become positively and negatively charged after being rubbed. What kind of force exists between them? Attractive force, right? With no path for electrons to flow from the negatively charged to the positively charged object, all this force can do is to attract the objects together. But what if we bridge the two objects by means of a conductor? The force now provokes the electron to flow in a uniform direction through the conductor until the charge in that area neutralizes the force between the charged objects. This indicates that the electric charge formed by rubbing two materials serves to store a certain amount of energy.

To understand this better, let us consider again an analogy. Have you seen and experienced using a water tank? First, the tank needs to be filled with water. This is done by pumping water into it. This requires an amount of energy equivalent to the work done in storing water in the tank. If the tank's faucet is kept closed over a period of time, then the tank stores that energy. Because of the imbalance of water content in the faucet and tank, the water begins flowing out as soon as the faucet is opened.


Fig. 1.1 Water Tank

We can represent the electrons as water in this analogy. The imbalance of water content represents the imbalance of electric charges. The force attracting the electrons back to their original position is analogous to the force gravity exerts in water in the tank, trying to draw it down to its former position.

Just as pumping water to higher level results in energy being stored, opening the faucet for water to flow represents a release in stored energy. The potential energy stored in the form of electric charge imbalance which is capable of provoking electrons to flow through a conductor can be expressed as a term called **voltage**, which technically is the potential energy per unit charge of the electron. In the concept of static electricity, **voltage** is the work required to move a unit charge from one location to another, against the force which tries to keep the charges balanced.

However, it should be noted that voltage can also be generated by means other than by rubbing certain types of materials against each other. Chemical reactions, radiant energy and the influence of magnetism on a conductor are few of the other means.

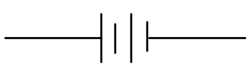
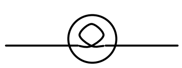
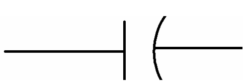
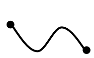
What about current? Following the analogy we used about the water running on a pipeline, this continuous, uniform flow of electrons through a conductor or circuit is called

current. The flow of electrons in one direction results to **direct current**. When the flow of electrons constantly reverses, then **alternating current** is produced.

Having defined voltage and current, we are now ready to build a simple circuit. What is a circuit made of? A circuit is basically composed of three things: sources, loads and connectors. The **source** can be a current or voltage source such as batteries and power supplies. **Loads** are those that consume the energy provided by the source such as household appliances and bulbs. What connects the source and the loads are the **connecting wires**.

Before constructing a real circuit, it is first necessary to represent the circuit parts using schematic diagrams. Here are some of the most commonly used electrical elements and their respective schematic diagrams

Schematic diagrams of elements commonly used in circuits

Schematic Diagram	Element	How to interpret
	Voltage Source (Battery)	The longer vertical lines represent the positive terminal of the battery
	Switch	When the lines are not joined, the switch is open and no current flows through the wire
	Bulb	
	Resistor	Resistors do not have polarities
	Capacitor	The curved line represents the negative terminal of the capacitor
	Fuse	

What you will do

Activity 1.2 – Assembling a simple circuit

What you will need

Bulb, Battery and Connecting Wires

What to do

1. Build the circuit shown in the schematic diagram. What happens to the lamp when you turned the switch open? What if it is closed?

2. Try leaving the set-up for 10 minutes with the switch closed. Now, touch the lamp with your hands. What do you feel?

In the experiment, why did the lamp turn warm? As the electrons work their way to the lamp, they encounter more opposition to the motion than they typically would in the connecting wires. This opposition to electric current is called **resistance**. This opposition generates heat similar to the generation of heat by friction when we rub our hands together.

Georg Simon Ohm found something interesting while investigating on different conductors. He found that electrons do not pass at the same rate through conductors of different materials. Further, he found out that the current passing through a conductor is directly proportional to the potential difference or voltage across the conductor, and their ratio is expressed as **resistance**. He then formulated this into a law, called **Coulomb's Law**, which in equation form yields

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

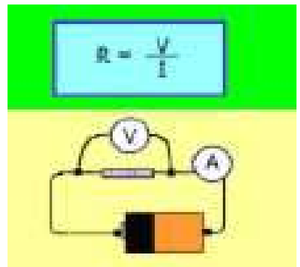
where **R** is the resistance in ohms (Ω)
V is the voltage in volts (V), and
I is the current in amperes (A)

We will now verify Ohm's Law in a simple experiment and apply it later in solving sample problems. However, the experiment will be very good only if you have materials such as ammeter and voltmeter at home. An **ammeter** measures the current flowing through an element and must be connected in series. A **voltmeter** measures voltage across and element and must be connected in parallel with the element. Digital ammeters and voltmeters display the current and voltage values on a screen. However, the analog ones need to be read using pointers, just like the way we read weighing scales.

If the materials are available, you may perform the experiment. If not, you may skip this part and proceed analyzing a set of sample data derived from such experiment.

What you will do
Activity 1.3 – Ohm's law

Experiment – Ohm's Law



What you will need

Variable dc power supply
120, 270- Ω resistors
ammeter and voltmeter

What you will do

1. Assemble the circuit shown in the figure. A digital voltmeter is preferred over the analog one. In the absence of a variable dc power supply, batteries may be used. To vary voltage, you just keep adding batteries in series. You may see your teacher and ask for specific instruction how to go about this experiment.
2. Using the 120 Ω resistor first, vary the power supply eight times and record the current and voltage readings for each trial.
3. For each trial, compute the value of the resistance by dividing voltage by current. At the end of the eight trials, get the average value of the resistance. How do you compare the computed value of resistance to the resistance of the resistor?
4. Repeat steps 2 and 3 for the other resistor.
5. Plot the graph of voltage versus current for both resistors. What kinds of graphs are produced?

Analyzing sample data

Here's a set of data for you to analyze. A 120 Ω resistor was connected to a power source with varying voltage values and the following current values were obtained

Value of the resistor used = 120 Ω

Voltage (V)	Current (A)
3	0.024
6	0.06

9	0.075
12	0.99
15	0.130
18	0.15
21	0.175

You may want to review your notes in the experiment before proceeding to answer the following guide questions:

Guide Questions:

1. In step 3, how does the computed value of the resistance compare to the marked resistance in the element?

   ____
   ____
   ____

2. What kinds of graphs of voltage versus current were you able to obtain for the two resistors?

   ____
   ____
   ____

3. What do these kinds of graphs tell you about the resistors you have just used?

   ____
   ____
   ____

After answering the guide questions, you may have noted that the linear graph produced when the values of voltage and current were plotted indicates a direct proportionality between voltage and current for a typical resistor. This means that as current through the resistor increases, the voltage across it increases proportionally.

Sample Problem on Ohm's Law

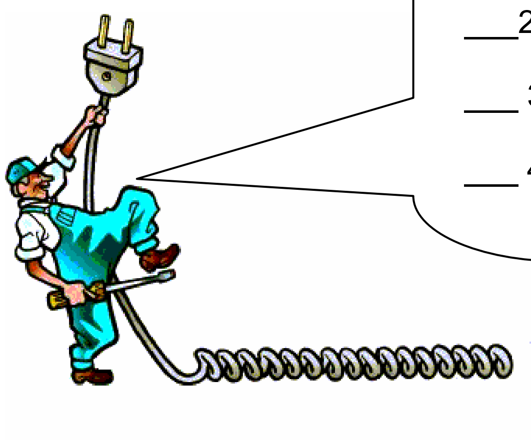
What is the voltage across a bulb with a resistance of 115 Ω when the current flowing through it is 1.5 A?

To solve this problem, we will use the equation V = IR derived from manipulating the equation of ohm's law.

$V = (1.5\ A)\ (115\ \Omega) = 172.5\ V$

What you will do

Self-Test 1.1 State which of these ideas are correct and which are not correct.



___1. Ohm's law tells us that across a resistor, the voltage increases when the current through it also increases.

___2. Voltage is the opposition offered to the flow of electrical charges.

___ 3. Circuits provide pathways for electricity to travel.

___ 4. When the switch is closed, the sources and the loads are not connected.

Key to answers on page 26

Lesson 2 Series and parallel circuits

We shall now explore the two types of circuit connections. At this point, it is again important to recall that conductors provide a path for electrons to flow. This path can be in single direction or it can be a branched path. If like an electron, you are given a single path, you do not have another option but to proceed and take that path. If you are given more paths to take, then you can choose from among these paths. If there were many of you, you may divide yourselves among the paths. Does electron or electricity behave in the same manner? Let us do the next activity to answer this question.

What you will do

Activity 2.1 – Series and Parallel Circuits

In this experiment, you will need the same equipment you used in activity 1.1, but this time a bulb replaces the resistors. In a way, the filament in the bulb serves as resistor. Be sure to get a bulb that has a power rating within the variable dc power supply and the bulbs should be provided with appropriate sockets when necessary. Before preparing this experiment, it is advisable to ask your teacher for assistance on precautionary measures.

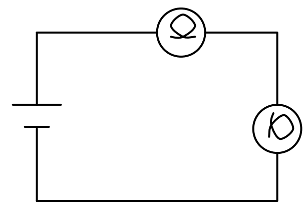


Figure 2.1

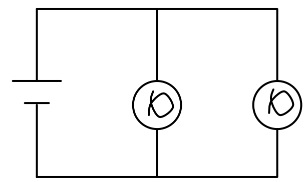


Figure 2.2

What to do

1. Assemble the circuit shown in figure 2.1. Set the dc voltage to 3 V. Observe the intensity of the light emanating from the bulb.
2. Insert one or more bulbs in the circuit. What do you notice about the intensity or brightness of the bulb as you add more and more bulbs?
3. Try to unscrew one of the bulbs from the socket. What happens to the other bulbs? What does your observation indicate?
4. Modify the circuit in step 1 by adding another branch of wire with a bulb as shown in figure 2.2. How do you compare the circuit produced with that in step 1? Which of them is series circuit and which one is parallel circuit?
5. Again, switch on the power supply and observe the brightness of the bulbs. Try adding more branches of wires with a bulb as shown in the figure. Does the brightness of each bulb change?
6. Unscrew one of the bulbs in any branch. Are the other bulbs affected? Try unscrewing one more bulb. Do you observe the same? How does your observation compare to that in step 3?

The circuits you just assembled show series and parallel connections. The circuit in step 1 is a series circuit and the circuit in step 4 is a parallel circuit.

Remember this:

In the series connection, there is only a single path for electric current because there is but a single loop of connecting wire. With this connection, for each part of the circuit, the amount of current remains constant. That is why elements connected in series have the same current. As you added more bulbs in the loop, each bulb turned dimmer because the voltage was divided among the bulbs. Also, the resistance of the circuit increased because the resistance of each bulb added up. Remember that earlier we have discussed that elements that consume energy opposes the flow of electrons because they have resistance.

To compute for the equivalent resistance of resistors connected in series to a source, all we need to do is add the individual resistances. In equation:

$$R_T = R_1 + R_2 + R_3 + \dots + R_n$$

where R_T is the equivalent resistance of the combinations of **n** number of resistors.

On the other hand, parallel circuit connection was shown in step 4 of the experiment. If you try to inspect the circuit, there are many possible paths for the electricity because each element is independently connected to the voltage source. Since current takes many paths, it is divided among the elements or bulbs. But since each bulb is connected independently to the source, each element has the same potential as the source, that is, technically speaking, they are of the same voltage. This is shown by the unchanged brightness of each bulb even when you added more and more circuit branches in step 5. Also, you must have observed that when you unscrewed one of the bulbs, the rest remained lit because current through the glowing bulbs took some alternative paths when there was a break in the circuit.

The total resistance in parallel circuit connection is given by the equation

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

where R_T is the equivalent resistance of the combinations of **n** number of resistors.

Comparing this equation to that in the series connection, we can infer that the equivalent resistance for a parallel circuit connection is always less than any of the individual element's resistance. To produce greater equivalent resistance, elements should be connected in series.

Think about this:

Where are series and parallel connections used? Does connection really matter at all? Have you ever encountered problems with your christmas lights at home like when the bulbs do not glow anymore because of only one busted bulb? But why are Christmas lights connected in series, anyway, if that is a problem? The bulbs are usually very small and have low power and voltage ratings. For bulbs with low voltage ratings, the current drawn must be minimal or small (based on Ohm's law). The increased number of connected bulbs increases the resistance of the circuit but reduces the value of the current drawn from each bulb. By having the bulbs connected this way, the voltage divides among the bulbs, so even high voltage input will not bust the bulbs.

On the contrary, our homes are wired in parallel connections, to provide constant operating voltages for our appliances, which is 220 V in the Philippines. We shall discuss about parallel circuit connection at home in more detail in the next lesson.

Can you think of other situations that make use of series and parallel electrical connections?

Lesson 3 Household Electrical Wiring

Now that we know the difference between series and parallel electrical circuit connections, let us try to see how our homes should be wired.

Figure 3.1 Appliances used at home

During nighttime, when almost all lamps are turned on and you try to switch off one lamp, are the other lamps or appliances in the house affected? How does our observation compare to the results in the experiment on series and parallel circuits when you unscrewed one bulb? Your answer to these questions should already indicate what type of circuit connection is being used at home. Correct, it's parallel!

Our homes are supplied with electricity at a voltage of nearly 220 V. Since most appliances are also designed to operate at this voltage, our appliances should be connected in parallel to the outlets. Recall from our previous experiment that when the bulbs are connected in parallel, they have the same voltage. You may clearly see this when you measure the voltage across each bulb using a multitester.

If one bulb or appliance is turned off, the others remain unaffected because each of these has a separate connection to the source. If one point of the household circuit breaks, there will still be other paths for electricity to flow, unlike in series connection.

By wiring our homes in parallel connection, the total resistance of the elements is also reduced. From the equation of the equivalent resistance of parallel circuits discussed earlier, we can see that the resistance of the combination of electrical elements at home is always less than the resistance of each element.

But how does electricity reach our homes? Electricity is first produced at a very high voltage in a generator. The high voltage electricity is then transmitted through transmission lines to the sub-stations where the voltage is regulated using transformers. The sub-stations then distribute electricity at 220 V by letting it pass through another transformer. These transformers resemble the shape of a tin can and usually hang in posts in our communities.

From the transformers, electricity has to pass through an electric meter that measures our consumption. After the meter, the electricity has to pass through circuit protectors, like circuit breakers and fuses, to protect our appliances just in case there is an abrupt change in current in the circuit.

What you will do

Self-Test 3.1 Analyzing circuit connections

Study the diagram, then answer the questions below on a separate piece of paper.

1. How many different circuits do you see in the household circuits diagram?
2. Are household circuits series circuits or parallel circuits?
3. Explain what would happen if the circuits were the other kind.
4. If the refrigerator in the diagram blew a fuse, what other appliance(s) would be affected?
5. If the coffee maker blew a fuse, what other appliance(s) would be affected?
6. What other appliances would be affected if the living room fan blew a fuse?

Key to answers on page 26

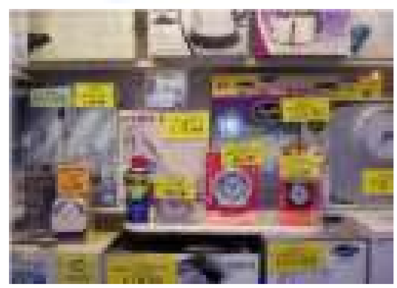
Lesson 4 Computing our electrical energy Consumption

So how do we compute for our electrical energy consumption?

Our appliances have respective power ratings. **Power Ratings** (usually in watts or kilowatts) indicate the amount of energy consumed by each appliance for a period of time. The higher the power rating of an appliance is and the longer the time it is used, the more electrical energy is consumed.

Table 8.2 shows the power ratings of some appliances we usually use at home.

Appliance	**Wattage**
Room airconditioner	1000
Blender	300
Blow dryer	700
CD player	15
Ceiling fan	15
Computer	200
Coffee Maker	800
Freezer	445
Hot plate	1200
Flat iron	1000
Incandescent lamp	40-100
Fluorescent lamp	11-30
Microwave oven	6000-1500
Refrigerator	540-800
Stereo	10-30
Toaster	800-1500
Vacuum Cleaner	1500
Washing Machine	500



When determining how many watts x hours your appliances will use, keep in mind that many of the appliances you might use will only run for an average of a few minutes per day

To compute the cost of electrical energy consumption, multiply the wattage (in kilowatts), the length of time of use (in hours), and the cost of electricity (per kilowatts-hour) set by your electricity distributor.

For example, if the cost of electricity is P 4.77/ kWh (kilowatt-hour) and the refrigerator has been operating for 10 hrs per day, in one month the electrical energy consumption of the refrigerator will be:

Wattage of Refrigerator (kWatts)	=	0.1
x length of use (hours)	=	300
x cost of electricity per kWatts-hour	=	4.77
Total	**=**	**P143.10**

This is only for the refrigerator. How about the other appliances? Try doing the next activity for you to estimate your total monthly consumption, considering the appliances you use. You can read the exact power ratings of your appliances by looking at the manual.

What you will do

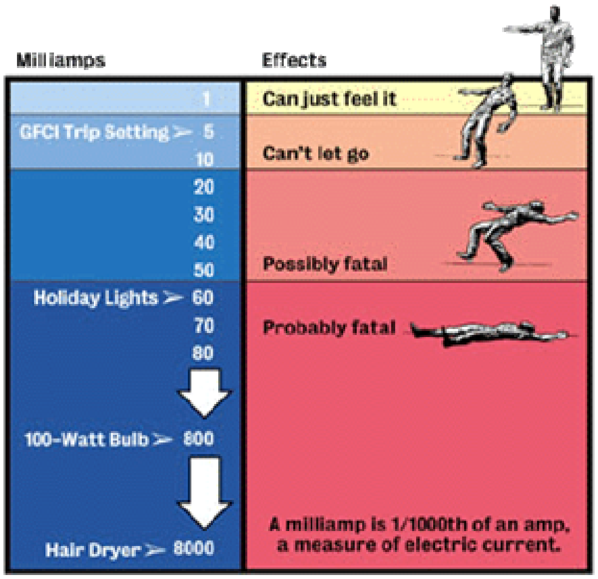
Activity 4.1 Computing electrical consumption.

On the table, list down the appliances you use at home and try to estimate the number of operating hours per month. Then, try to compute your monthly consumption by following the example given.

Appliance	Wattage	Total time of use in one month	Cost of electricity/ kW-hr	Total Cost
			Total Consumption	

Lesson 5 Electrical Hazards and safety

While electricity is very useful, it also poses dangers to our lives. Such hazards may range from simple electrical shocks to fires that result to serious injuries, death and loss of properties.



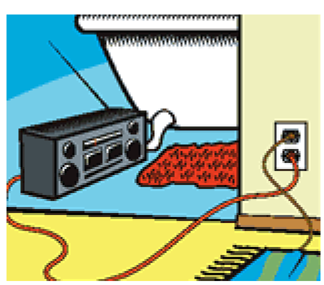
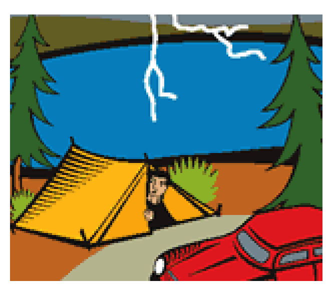
Electricity travels easily through the human body. Your body is 70 percent water, and water is an excellent conductor of electricity. So, when you touch an energized bare electrical wire or a faulty appliance, the electricity will use your body as the shortest path to the ground. If you are grounded, the electricity will instantly pass through you to the ground, causing a harmful and sometimes fatal shock.

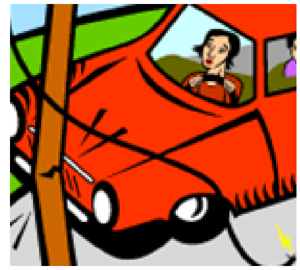
It doesn't take much. You can be killed by the tiny amount of electricity used by one 7.5-watt light if it passes through your chest. If the shock doesn't kill you, it can still badly hurt you by causing serious falls, burns, cuts, or internal bleeding. A shock from a 100-watt bulb or a 1000-watt hair dryer will probably be fatal.

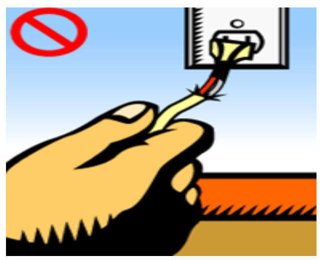
You can avoid harmful or fatal shock by understanding how electricity travels, how to stay out of its way and how to use it properly. What safety precautions should we practice when using electricity?

What you will do

Activity 5.1 In one or two sentences, interpret the pictures shown below to identify the basic precautionary measures we should take when dealing with electricity**.**

Key to answers on page 27

Indeed, electricity is an important part of our lives that cannot be taken for granted. To avoid accidents, it is important that we have basic knowledge on electricity and exercise caution in dealing with it.

As an added protection, some devices may be also placed in our circuit that function as breakers whenever there are faults and problems with the circuit.

Our homes are fed with electricity through lead wires called lines which are connected to outlets inside the house. The voltage impressed on these lines is applied to appliances and other devices that are connected in parallel to these lines.

As more devices are connected to these lines, more pathways are provided for the current. Because of the lowered combined resistance of appliances in parallel, a greater amount of current passes through the wire and heat is generated. If the lines carry more than the safe amount of current, the resulting heat may melt the insulation and start a fire. The lines are said to be overloaded. It is therefore important that our loads (appliances) at home matches the available voltage source. In some case, voltage regulators may be used.

To prevent overloading, fuses are connected in series with the power supply line, making the entire line current pass through it first before reaching the loads. Fuses are made up of metal ribbon that will heat up and melt if the current exceeds the critical value. If the ribbon melts, there is a break in the circuit. Once the fuse is blown out, it must be replaced with a new one once the source of overloading is determined and remedied.

Circuits may also be protected by circuit breakers that use magnets and bimetallic strip to open a switch in cases of overloading. Circuit breakers are often used instead of fuses in modern buildings because they do not have to be replaced each time the circuit is opened.

A diagram of a typical circuit breaker is shown in the figure.

When the live wire carries usual operating current, the electromagnet is not strong enough to separate the contacts. If something goes wrong with the appliance, and large current flows, the electromagnet will pull hard enough to separate the contacts and break the circuit. The spring then keeps the contacts apart. After the fault is repaired, the contacts can then be pushed back together by pressing a button on the outside of the circuit breaker box.

Let's summarize

In this module we have learned that:

1. Circuits provide continuous pathway for electricity to travel. Circuits are composed of sources, loads and connecting wires, which are considered to have negligible resistance.

2. Circuit connections can be series or parallel. In circuit connection, there is only one path of electricity and elements connected in this way have the same current. In parallel connections, there is more than one possible path for electricity to flow. Elements connected in parallel have the same voltage.

3. Ohm's law relates current, voltage and resistance. It states that current is directly proportional to voltage.

4. Power ratings of appliance provide the basis for computing electrical energy consumption. As the power rating and the longer time of use increase, the amount of electrical energy used increases.

5. Electricity can be both useful and harmful as well. It is important that we practice precaution in dealing with it.

6. Electrical sources and loads must be matched correctly to avoid overloading. Fuses and circuit breakers are devices that ensure safety when faults and problems in a circuit arise.

Posttest

Direction: Select the letter of the choice that correctly answers each question.

1. Which of the following quantities do elements connected in series have in common?

   a. Current
   b. Voltage
   c. Resistance
   d. Both a and b

2. Which of the following quantities connected in parallel have in common?

   a. Current
   b. Voltage
   c. Resistance
   d. Both a and b

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

   a. 2 V
   b. 9 V
   c. 18 V
   d. 36 V

4. How do you describe a part of a circuit where no current can pass because of a break or discontinuity?

   a. short
   b. open
   c. overloaded
   d. both a and b

5. What happens to the intensity or the brightness of the lamps connected in series as more and more lamps are added?

   a. increases
   b. decreases
   c. remains the same
   d. cannot be predicted

6. Why should household appliances be connected in parallel with the voltage source?

I. To increase the resistance of the household circuit

II. To impress upon each appliance the same voltage as the power source.

a. I only
b. II only
c. Both I and II
d. Neither I and II

7. Why are fuses and circuit breakers used in circuits?

a. Fuses and circuit breakers open to the circuit when a large amount of current flows through the circuit.
b. Fuses and circuit breakers increase the efficiency of the appliances within the circuit.
c. Fuses and circuit breakers insulate the connection in the circuit.
d. Fuses and circuit breakers can help out the electrical consumption.

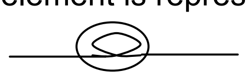
8. An airconditioning unit has a wattage of 900 W and is operating continuously for 1 day. How much is the daily electrical consumption if the cost of electricity is P5.80/kWh?

a. P 5.22
b. P 21.60
c. P 125.28
d. P 522.00

9. Which of the following regulates the voltage of the electricity produced in power plants?

a. Generator
b. Transformer
c. Meters
d. Circuit breakers

10. What electrical element is represented by the schematic diagram in the figure?



a. bulb
b. fuse
c. battery
d. switch

11. What law states that the voltage across an electrical element is proportional to the current flowing through it?

    a. Newton's Law
    b. Faraday's Law
    c. Coulomb's Law
    d. Ohm's Law

12. Which of the following is a unit of current?

    a. kilogram
    b. Ohms
    c. Ampere
    d. Volts

13. Three resistors (20 kΩ, 30 kΩ, 60 kΩ) are connected in series. What is the equivalent resistance of the combination?

    a. 10 kΩ
    b. 60 kΩ
    c. 110 kΩ
    d. 220 kΩ

14. What is the equivalent resistance of the resistors in no. 13, if they were connected in parallel instead?

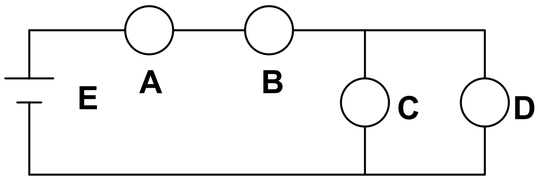
    a. 1 kΩ
    b. 10kΩ
    c. 60 kΩ
    d. 110 kΩ

15. How much current passes through the 20-kΩ resistor when the resistors in no. 13 are connected in series with a 220 V source?

    a. 2 mA
    b. 11 mA
    c. 20 mA
    d. 110 mA

16. According to Ohm's law, across a resistor with constant resistance, what happens to the current across it when the voltage applied is doubled?
    a. remains the same
    b. halved
    c. doubled
    d. quadrupled

17. In the circuit shown, which two bulbs are in series.



a. A and B
b. C and D
c. B and C
d. None of the bulbs are connected in series

18. A kite hangs on the electrical power in your community. Which of the following should you do?

a. Get a long piece of wood and try to remove the kite.
b. Climb the post and try to clear the power line without touching it.
c. Call your barangay electrician and let him do the clearing.
d. Leave the kite, anyway it's just a piece of plastic or paper.

19. Your fuse at home has "blown" up many times. Which of the following will you do to solve this problem and prevent it from happening again?

a. Connect appliances in series instead of parallel.
b. Do not use too many appliances at the same time.
c. Plug two or three appliances in one outlet.
d. Connect an additional fuse to your circuit.

20. To save energy at home, which of the following should you do?

a. Use fluorescent lamp instead of incandescent lamps
b. Iron clothes once a week, not every now and then
c. Clean and defrost you refrigerator regularly
d. All of the above

Key to answers on page 27

Key to Answers

Pretest

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

Lesson 1

Self-Test 1.1

*Statements (1) and (3) are the correct ideas and statements (2) and (4) are incorrect ideas.

Lesson 3

Self-Test 3.1

1. How many different circuits do you see in the household circuits diagram?
   4 circuits

2. Are household circuits series circuits or parallel circuits?
   parallel circuits

3. Explain what would happen if the circuits were the *other* kind.
   All electrical devices would go off each time a light bulb burned out.

4. If the refrigerator in the diagram blew a fuse, what other appliance(s) would be affected?
   the clock

5. If the coffee maker blew a fuse, what other appliance(s) would be affected?
   the electric can opener

6. What other appliances would be affected if the living room fan blew a fuse?
   bedroom lamp; living room lamp; kitchen ceiling light

Lesson 5

Activity 5.1
Possible answers:

- Do not touch appliances with wet hands because water is a good conductor of electricity
- Do not plug too many appliances in one outlet because this may cause overloading
- Do not operate appliances in an open environment especially when the weather is bad.
- Regulate the simultaneous use of appliances to avoid overloading
- Do not destroy electrical posts. Keep away from high-voltage areas
- Do not operate defective appliances because you may accidentally touch live wires
- Do not use electrical appliances while you are in water because water conducts electricity and you may get serious shock.

Post test

1. a	6. b	11. d	16. c
2. b	7. a	12. c	17. a
3. c	8. c	13. c	18. b
4. b	9. b	14. b	19. b
5. b	10. a	15. a	20. d

-End of Module-

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