Science Nine

Module Four:

Electrical Principles and Technologies

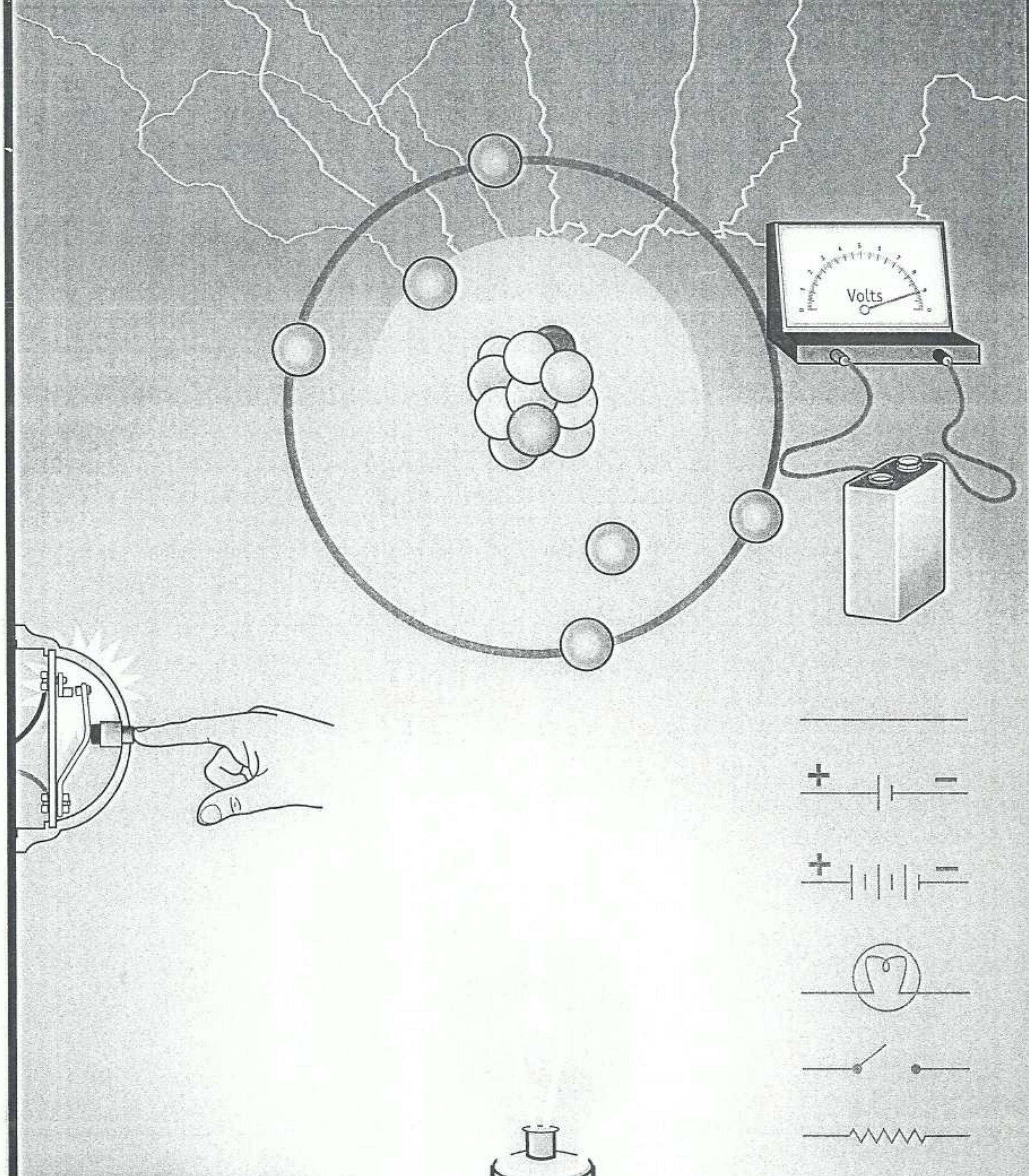
Name:

Date Received:

Date In:

Grade:

ELECTRICAL PRINCIPLES AND TECHNOLOGIES



GRADE 9
TOPIC FOUR

NAME

Lacombe Outreach School

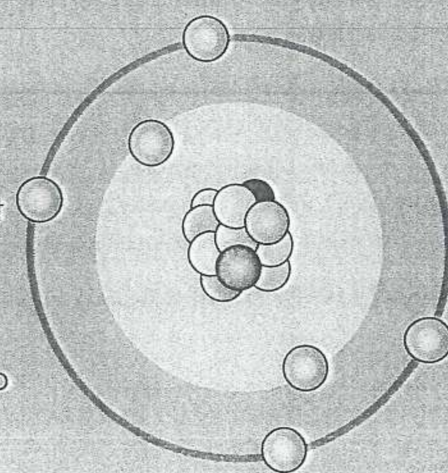
Part A: What is electricity?

Electricity is a type of energy.

Do you remember learning that all matter is made up of atoms and that each atom has a center (nucleus) that contains positively-charged particles (protons) and uncharged particles (neutrons)?

Outside the nucleus of an atom are the negatively-charged particles called electrons. Most of the time, the negatively-charged electrons and the positively-charged protons in an atom are equal. They balance each other out to make the atom stable.

When the balance of positive and negative charges in an atom is changed by an outside force, electrons can break free and then join onto other atoms and make them negatively charged. The flow of electrons is electricity.



Use the words in the passage above to help you fill in the blanks in these sentences.

1. Electricity is a type of _ _ _ _ _ _.

2. Electricity starts as the charged particles in _ _ _ _ _ (the particles that make up all matter).

3. When something happens to an atom that affects the balance of its charged particles, the _ _ _ _ _ _ _ _ _ can break free.

4. Negatively-charged particles are the basic part of _ _ _ _ _ _ _ _ _ _ _ (a type of energy).

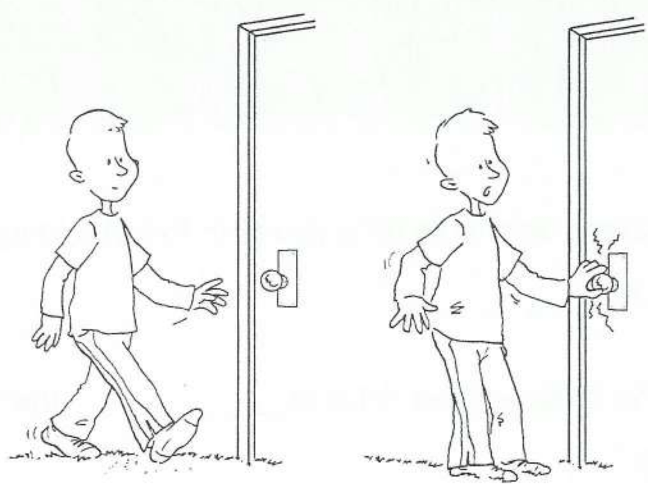
More about electrical charges . . .

You learned on the previous page that electricity begins as the electrical charges that break away from atoms that "lose their balance." Did you wonder what causes the atoms to become unbalanced?

Atoms often become imbalanced or "charged" when the object that they make up is rubbed or touched. You know that an object has become charged when it attracts (pulls) or repels (pushes) objects that get close to it (think about how a magnet works).

When you shuffle across a carpet, the atoms in you and the atoms in the carpet get rubbed together and some of your electrons are transferred to the carpet (leaving your atoms unbalanced). If you touch a doorknob you will likely get a shock because the atoms in your body want to become balanced again so they pull electrons from the doorknob and they jump across like a spark.

There are "rules" that electrical charges follow when they move.



1. **Opposite charges attract each other.**

   Positively-charged objects (made of atoms with missing electrons) and negatively-charges objects (made of atoms with extra electrons) are naturally pulled together.

2. **Like charges repel each other.**

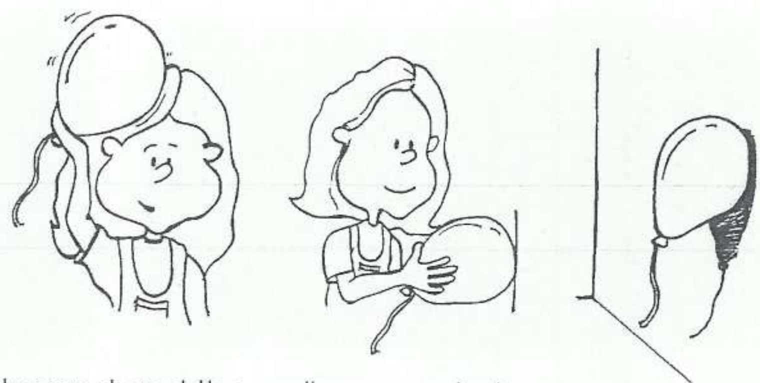
   Objects with positively-charged particles will "push" other objects with positively-charged particles away and the same is true of objects with negatively-charged particles.

3. **Charged objects are attracted to neutral objects.**

   Objects that have an imbalance (uneven number) of electrons and protons are automatically pulled towards objects that have a balance (equal number) of electrons and protons and are uncharged.

Use the information you have learned so far to help you to identify what is happening in each of the scenes below. Put a check mark beside the correct answer to each example.

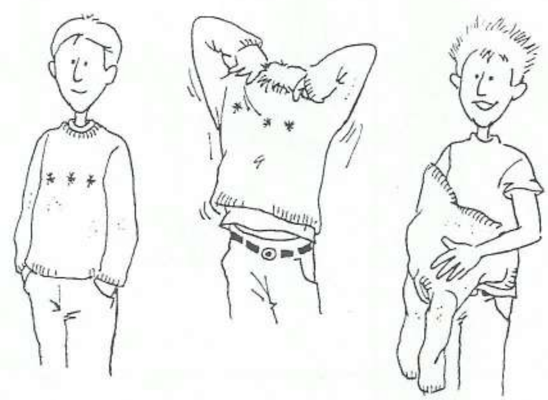
1. The girl on the right rubbed a balloon against her hair and then held it against the wall and it stayed there. Why do you think this happened?



- ☐ The balloon had become charged and the wall was neutral.
- ☐ The balloon was negatively-charged and so was the wall.
- ☐ The balloon was transferring protons to the wall.

2. The boy on the right pulled his sweater off and his hair stood on end. Why do you think this happened?

- ☐ The atoms in the boy's hair all became positively and negatively-charged and, since atoms with different charges are attracted to each other, they are sticking together.
- ☐ The atoms in the boy's hair all became negatively-charged and, since "like" atoms repel one another, they are all pushing away from each other and the boy's head.



3. Use one of the rules of electrical charges on the previous page to explain what happened when the boy touched a doorknob.

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Part B: What's the difference between static electricity and current electricity?

Static Electricity

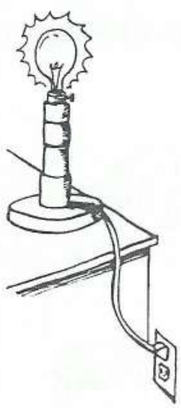
Static electricity is an electrical charge that builds up when atoms become unbalanced and then is discharged all at once (e.g., flies out like a spark).

Current Electricity

Current electricity is the constant (non-stop) flow (movement) of electrical charge from one place to another. In order to create electrical current, you need to have an energy source and a complete circuit (unbroken pathway) for the charged particles to travel.

Use the information you have learned so far to help you to identify what type of electricity is present in each of the scenes below. Write the word **Static** or **Current** below each example.

1.



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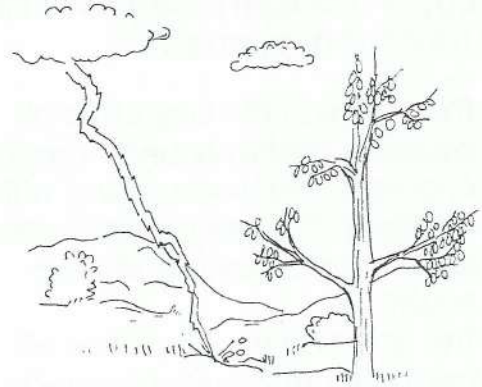
2.



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More about current electricity . . .

You learned on the previous page that current electricity is a constant flow of electrical charge that comes from a power source and flows along a pathway called a **circuit**. A circuit usually includes a source, a conductor and a load.

Source

Where the electrical charge is produced so it flows constantly.

Conductor

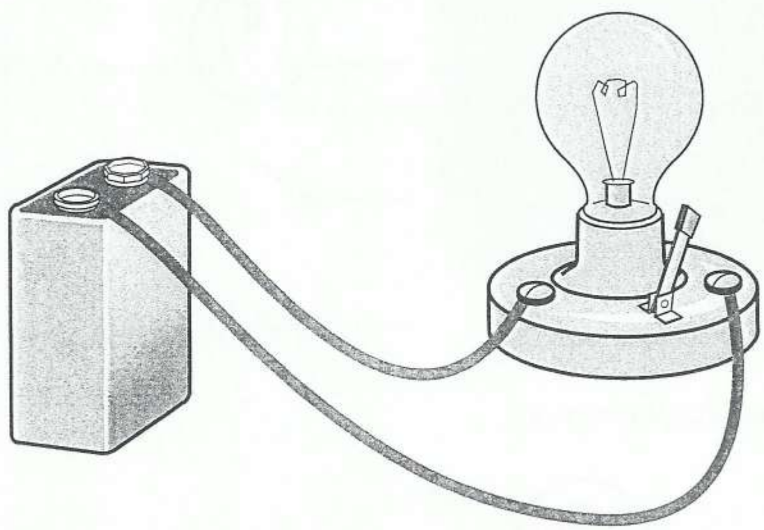
The material that forms the pathway along which the electrical current flows (e.g., wires).

Load

The device that converts (changes) electrical energy to another kind of energy (e.g., light). The load can also be called the **resistor**.

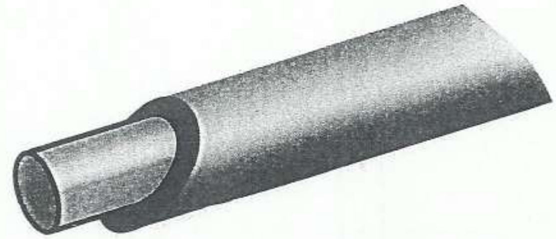
Control

The switch that can turn the circuit or devices attached to it on and off.



Conductors vs. Insulators

You have probably already learned about conductors and insulators, but it's important to keep that information in mind when you are studying electricity. In order to keep the electric current flowing, it must be on a circuit made of a metal that conducts (passes along) the electrical charge well and that is wrapped or covered in an insulator that traps the electrical charge inside.



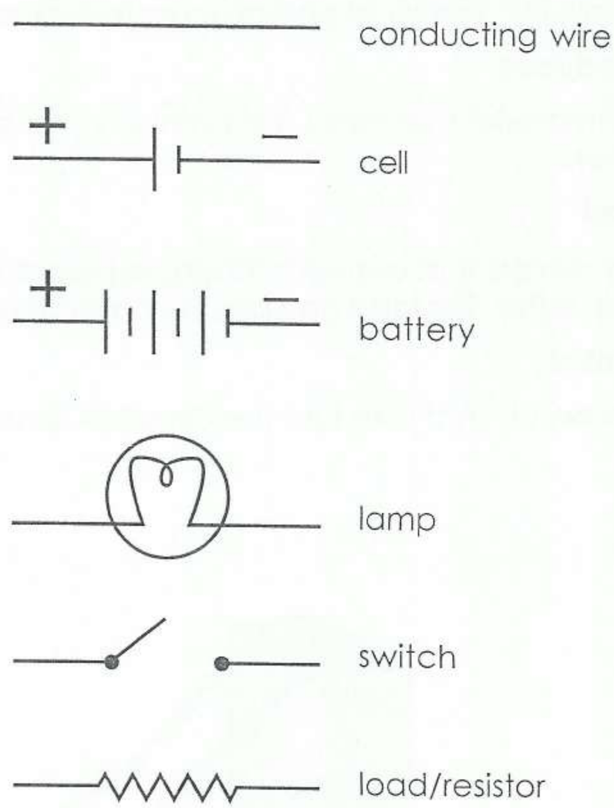
Superconductors are metals that pass electrical current along very quickly and can handle very high charges.

The following symbols are used by scientists and electrical engineers when they draw circuit diagrams. Using the same symbols makes circuit diagrams like a "universal language."

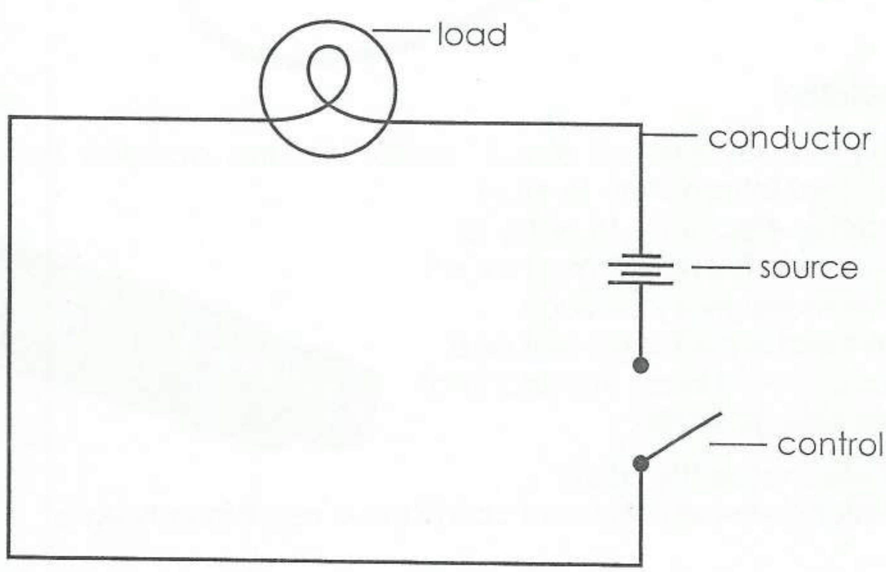
Note: A **cell** is a simple power source. When two or more cells work together it's called a **battery**.

Rules for drawing circuit diagrams.

1. Draw with a pencil on graph paper and use a ruler!
2. Always make the diagram in the shape of a square or rectangle.
3. Conductors must be straight lines with right-angled corners (e.g., **L**)
4. Conductor lines should not cross over each other.

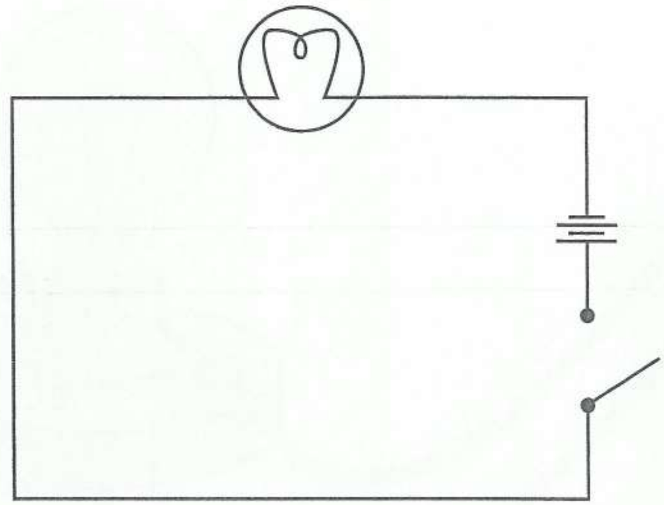


This is an example of a circuit diagram.

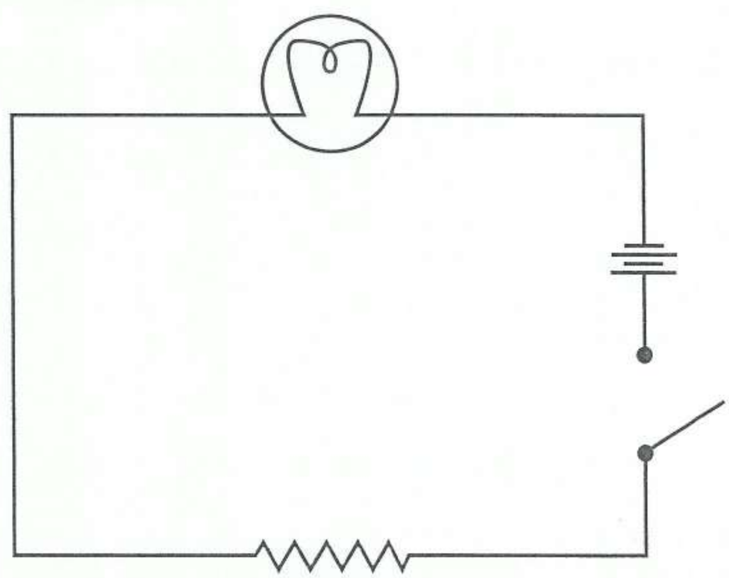


Label the parts of these circuit diagrams.

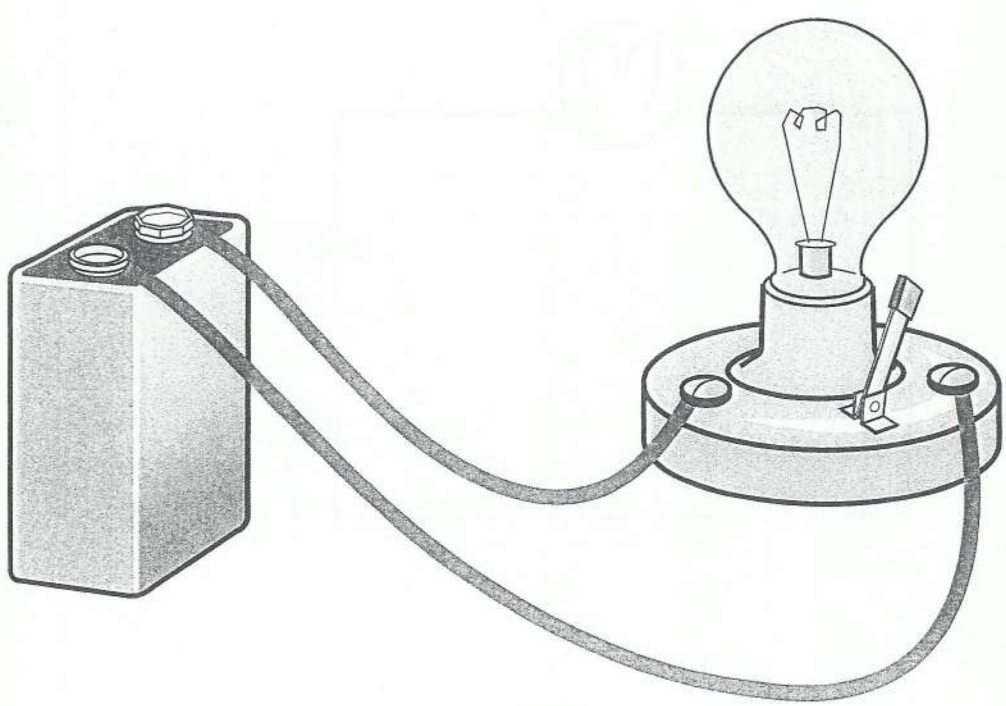
1.



2.



Draw a circuit diagram that reflects the parts of this device.



3.

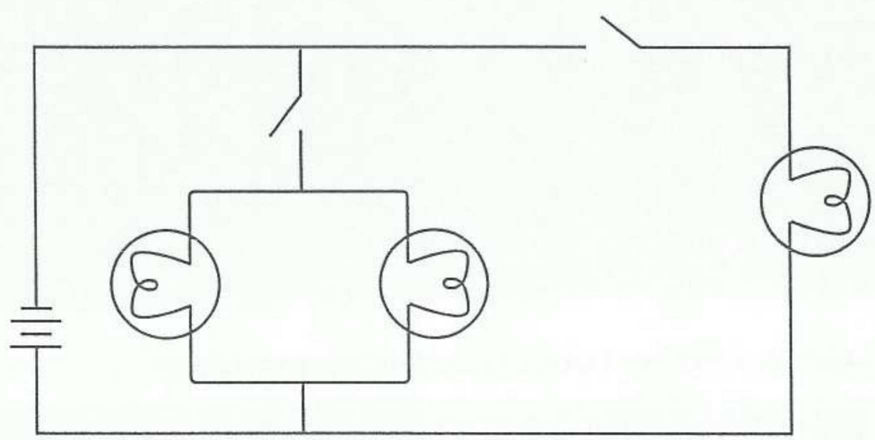
Simple vs. Complex

Simple circuits, like the ones you have already studied, only need one source, conductor, load and control (resistor).

Complex circuits, on the other hand, often have multiple loads and/or controls.

Label the parts of this complex circuit diagram.

1.



2. Explain how this circuit works and what each part does.

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Part C: How is electricity measured?

Measuring Current

Current is the amount of electrical charge that moves through a device every second. Current is written in Amperes (A) or Milliamperes (mA). Have you ever heard of someone refer to the power of a device as its "Amps?"

There are four main things that affect the amperage (number of Amperes) of a device:

1. The amount of charge coming from the power source.
2. The "speed" of the conductors (e.g., faster metals, etc.).
3. The insulator that stops charge or energy from escaping.
4. The efficiency of the load or resistor that takes the charge from the electrons and uses it in the device.

Study the information in this chart about household appliances.

Appliance	Current in Amperes
Clock Radio	0.4 A
60 W Light	0.5 A
20'' Television	3.0 A
37'' Television	4.7 A
Toaster	8 A
Toaster Oven	11 A
Oven	35 A

Using the information you have learned so far, answer the following true or false questions about the appliances on the previous page. Write **T** for True or **F** for False on each line.

1. ____ The electrical charge moving through the circuit that powers a 60 W light is greater than the electrical charge moving through the circuit that powers the clock radio.

2. ____ The 37'' television probably has a "stronger" resistor than a 20" television.

3. ____ The toaster probably has better insulated wiring than the toaster oven but the same resistor.

4. ____ The oven's circuit allows 35 A of electrical charge to pass through every second.

5. What do you think would be a reasonable guess of the Amperes of a microwave? Explain why you think so.

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6. Why do you think it is important to take care of your electrical cords to avoid them getting cut or damaged?

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Measuring Voltage

As you have learned, electrical energy is carried by charged particles. **Voltage** is the amount of electrical charge that each charged particle carries. In this way, the total energy of an electrical current is calculated by multiplying the voltage by the total charge of the electrons.

Think about voltage as the power of the charge and Amperage as the amount of current.

Type of Device	Current Voltage
Small Electronics	6 V
Cars' Electrical Systems	12 V
North American Power Outlets	120 V
European Power Outlets	240 V
Industrial Machinery	600 V

1. In Europe, every power outlet has a "safety" switch that turns the plug sockets on and off. In North America, it is usually only bathroom power outlets that have this kind of "breaker." Why do you think this is the case? Explain your answer.

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2. Why do you think safety regulations (rules) are so strict in industrial work sites? What might happen if they weren't?

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Calculating Watts $W = IV$

Most devices are described by the number of watts they run on. Watts are calculated by multiplying amperes by volts.

E.g., If a clock radio has an amperage of 0.4 A and a voltage of 6 V, it runs on 2.4 watts of power.

$$0.4\ A \times 6\ V = \mathbf{2.4\ W}$$

Calculating Energy in Joules $J = Wt$

Devices are described according to the amount of electrical energy they convert (change) into another kind of energy (e.g., heat and light).

E.g., If a desk lamp has an amperage of 0.5 A and a voltage of 6 V, it runs on 3 watts of power. The amount of electrical energy (in joules) that it converts to light energy every minute is 180 joules.

$$0.5\ A \times 6\ V = 3\ W$$

$$3\ W \times 60\ \text{Seconds} = \mathbf{180\ Joules}$$

Calculating Resistance in Ohms $V = IR$

Resistance is a measure of how hard it is for the electric current to pass through or along the circuit. The more resistance a substance has, the more energy it can "take" from each electron as it passes.

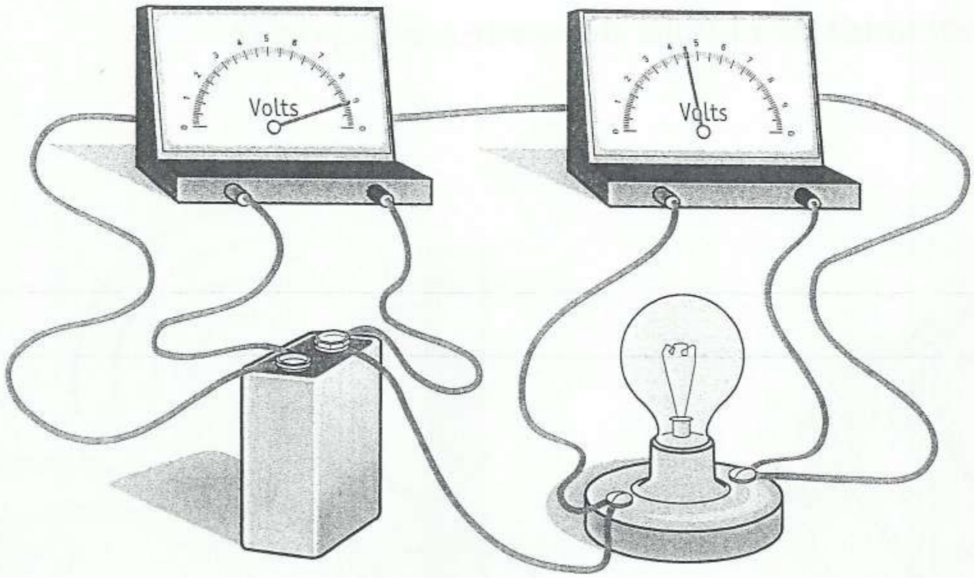
E.g., If an electric stove is connected to a 240 V outlet and the current runs at 20 A, the resistance of the heating element inside the stove is 12 Ohms.

$$240\ V / 20\ A = \mathbf{12} \qquad \mathbf{R = \frac{V}{I}}$$

W = Watts
A = Amps
I = Current
V = Volts
J = Joules
T = Time

Using the information you have learned so far, answer the following true or false questions about electrical energy. Write **T** for True or **F** for False on each line.

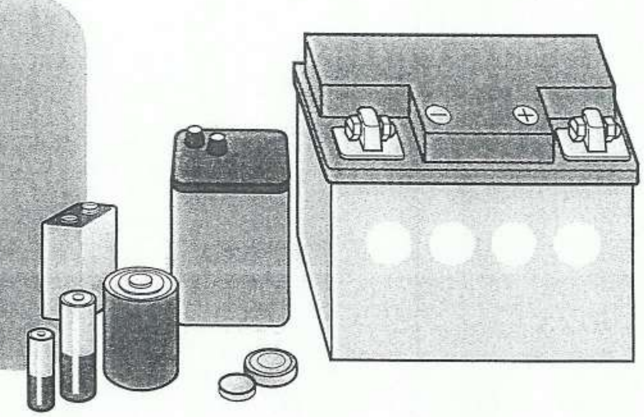
1. ____ Watts are calculated by multiplying amps by volts.
2. ____ Voltage is the amount of electrical charge each particle carries.
3. ____ Amperage (current) is the amount of electrical charge that moves through a circuit.
4. ____ Watts and joules are the same.
5. ____ Resistance is a measure of how hard it is for electrons to pass through or along a substance.
6. ____ The greater the resistance, the less electrical charge is picked up by a device.
7. ____ If a device uses 7 A and 14 V, its wattage (number of watts) is 2 W.
8. ____ If a device uses 7 A and 14 V, its wattage (number of watts) is 98 W.
9. ____ If a device has a wattage of 98 W, it converts 5880 J of energy every minute.
10. ____ If a device has a wattage of 98 W, it converts 1.6 J of energy every minute.
11. ____ If a 12 A hair dryer is plugged into a standard power outlet in North America, the resistance is 10 Ohms.
12. ____ If a 12 A hair dryer is plugged into a standard power outlet in North America, the resistance is 20 Ohms.
13. ____ The formula for calculating wattage is amperage multiplied by voltage.
14. ____ The formula for calculating energy converted is watts multiplied by time.
15. ____ The formula for calculating resistance is volts divided by amperes.



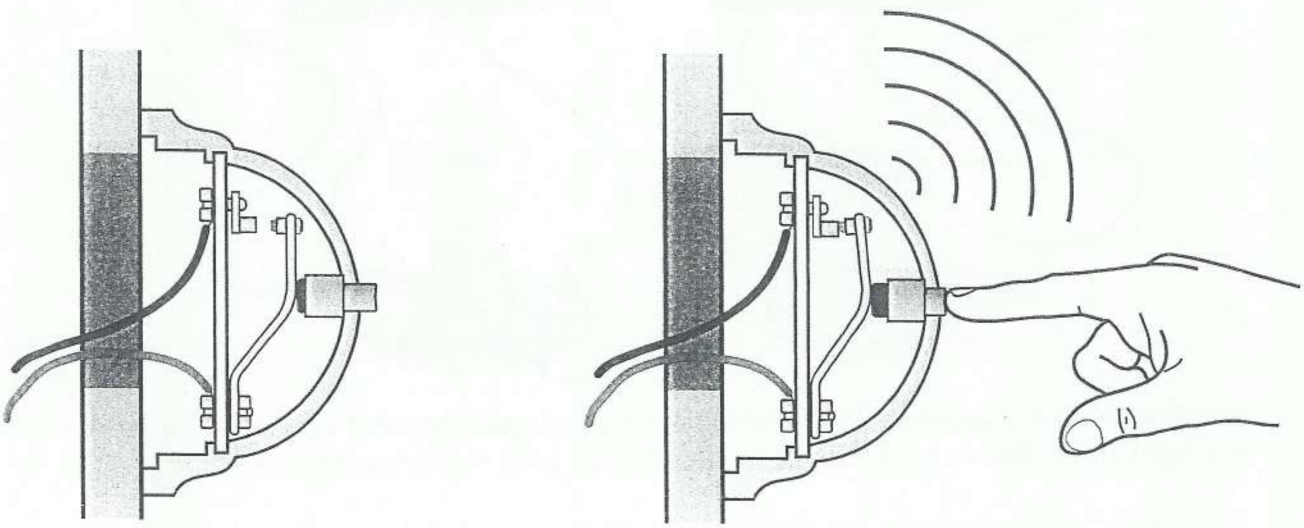
1. Identify and/or calculate the voltage, amperage (current) and wattage of the light bulb. Remember to write each one with the correct units!

Voltage	Amperage	Wattage

Did you know?
Batteries have positive and negative ends because chemical reactions inside the battery mix up the atoms and push the negative charges to one end and the positive charges to the other. That way, the negative charges can flow out of one end of the battery, forming an electric current that can then be used by devices on a circuit.



Part D: What kinds of circuits do we use everyday?



1. What is one "rule" about circuits that the doorbell teaches you?

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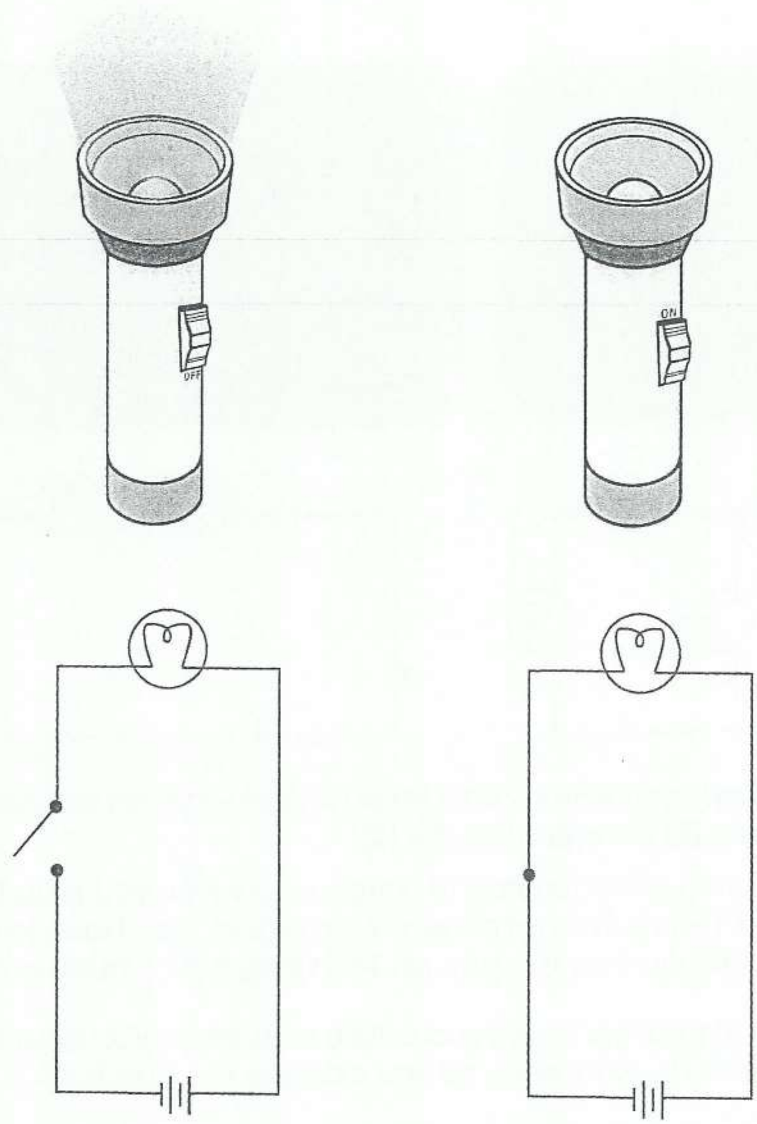


2. Draw lines to connect the flashlights with the correct circuit diagrams.

> **Hint:** Each pair of diagrams shows that the device is *on* or *off*.

3. How is a flashlight like a doorbell?

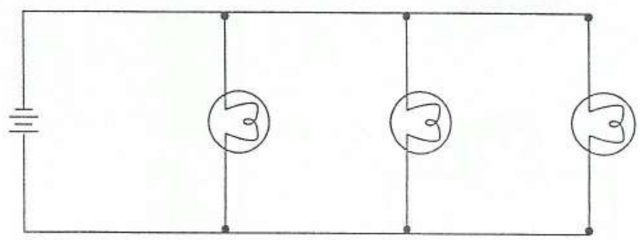
Houses are wired with many *parallel* circuits, some *series* circuits, and combinations of both.

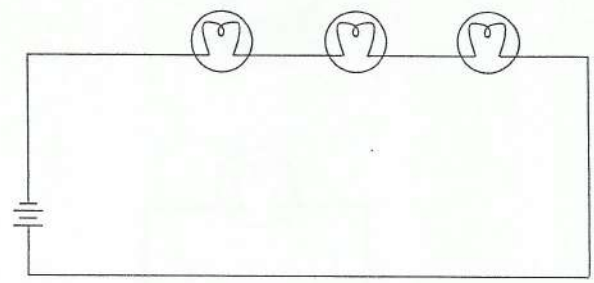
Parallel Circuits

Parallel circuits have a separate current path (wire) for each section of the circuit. This means that each device has its own connection to the power source. One problem with parallel circuits is that you have to turn each device off in turn; there isn't "one main switch."

Series Circuits

Series circuits share a wire that follows one pathway and passes through all of the devices. The main problem with series circuits, is that if there is a break anywhere in the circuit; none of the devices along the path will work. Also, series circuits all share the same load of power, so more devices means less power each.





Consider each of the following situations and then decide whether each is an example of parallel circuitry (**P**) or series circuitry (**S**).

1. ____ You wrap a string of lights around a tree and when you plug them in, the lights don't work. To make them work again, you have to check every bulb until you find the one on the string that is burnt out.

2. ____ You wrap a string of lights around a tree and when you plug them in, one of the lights doesn't work, so you change the one bulb.

3. ____ You have a toaster, kettle and microwave on one counter in your kitchen. They are all plugged into different plug sockets but, if you turn on all three appliances at once, the fuse blows because there isn't enough power to run all three at the same time.

4. ____ You have two lights in your kitchen and to turn them off, you have to flip two switches (one for each light).

Did you know?

Large switches are fine in houses, but in small electronic equipment, tiny circuits called *transistors* are used instead. They are made of three layers of silicon. The current runs through the middle and activates the top and bottom layers like on/off switches.

Part E: What happens to all of the electricity?

Energy Transfer and Transformation

As you have learned, electrical energy is **transferred** (moved from place to place) through circuit wires. At the "end of the line" when the current reaches the device it is powering, the electrical energy is usually **transformed** (changed) into another form of energy. It's important to remember, though, that before the energy became an electrical current in the first place, it was another kind of energy.

For example, hydropower is converted to electricity that is supplied to a toaster and the toaster changes it to heat energy to toast the bread.

Electrical energy—current
Chemical energy—reactions
Light energy—light
Thermal energy—heat
Mechanical energy—movement

Use the types of energy listed above to fill in the blanks in the following sentences:

1. Inside batteries, __ __ __ __ __ __ __ __ (1) reactions take place that separate the positive and negative charges. The negatively-charged particles flow out of one end of the battery as __ __ __ __ __ __ __ __ __ __ (2) energy and power a flashlight that gives off __ __ __ __ __ (3) energy and (after a while) __ __ __ __ __ __ __ (4) energy.
2. Wind spins a windmill creating __ __ __ __ __ __ __ __ __ __ (5) energy which is then transformed and stored as __ __ __ __ __ __ __ __ __ __ (6) energy that will later travel in currents.
3. A blender is powered by __ __ __ __ __ __ __ __ __ __ (7) energy and it produces __ __ __ __ __ __ __ __ __ __ (8) energy to mix liquids, etc.

Energy Input and Output

Input is how much energy is **put into** a device; output energy is how much energy it **puts out** (gives). The more efficient a device is, the closer the input and output energy amounts are.

According to the **Law of Conservation of Energy**, energy can't be created or destroyed, only changed from one form to another. When devices give out less energy than they take in, it is usually because some of the energy escapes into the environment as heat or light energy.

Use the information in the following chart to help you answer the questions on the next page.

Device	Input	Output	Energy Lost	Efficiency
100 W Light Bulb	100 Joules of Electrical Energy	5 Joules of Light Energy	95 Joules of Heat Energy	5% Efficient
Small Space Heater	10 Kilojoules of Chemical Energy	8 Kilojoules of Heat Energy	2 Kilojoules of Light Energy	80% Efficient
Sport Utility Vehicle	650 Kilojoules of Chemical Energy	182 Kilojoules of Mechanical Energy	468 Kilojoules of Heat Energy	28% Efficient

1. How much more energy is put into a light bulb than a light bulb puts out for its intended purpose (to provide light)? ______________________________

2. If a light bulb was used in a situation where its intended purpose was to provide heat, how much energy would be lost as light? ______________________

3. The small space heater lost most of its energy as heat. How could it possibly be considered 80% efficient?

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4. Do you think a small car would be more or less efficient than a sport utility vehicle? Why do you think so?

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5. Which of the devices on the previous page was the least efficient?

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6. Based on the numbers in the chart on the previous page, which of the following formulas is correct for figuring out the efficiency of a device?

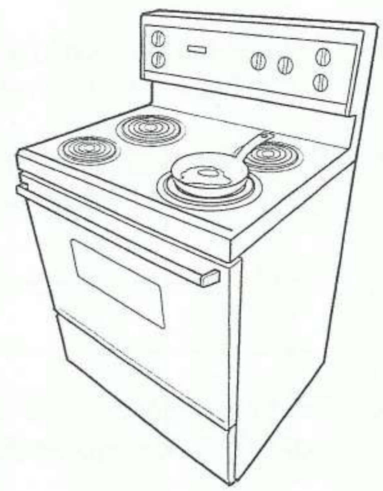
a. $\text{Efficiency} = \dfrac{\text{input energy}}{\text{output energy}} \times 100$

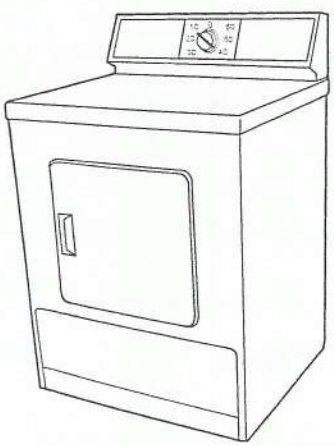
b. $\text{Efficiency} = \dfrac{\text{output energy}}{\text{input energy}} \times 100$

c. $\text{Efficiency} = \dfrac{\text{input energy}}{\text{output energy}} \ / \ 100$

Part F: How does our electricity use affect the environment?

Stoves have different-sized elements because people use different-sized pans depending on what they are cooking and how much they are cooking. If a small pan is put on a larger element, more heat escapes because the heat around the edges (where there is no pot) escapes into the air.





Dryer timers usually go up to 60 minutes. Most people let their clothes stay in the dryer for the whole cycle, even though the clothes may be dry after 30 minutes or less. Any heat that the dryer produces after the clothes are dry is wasted.

1. What can people do to make stove-top cooking more energy efficient?

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2. What can people do to make drying clothes in machines more environmentally friendly?

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3. Can you think of any other household appliances that could be used more efficiently? Which ones? How?

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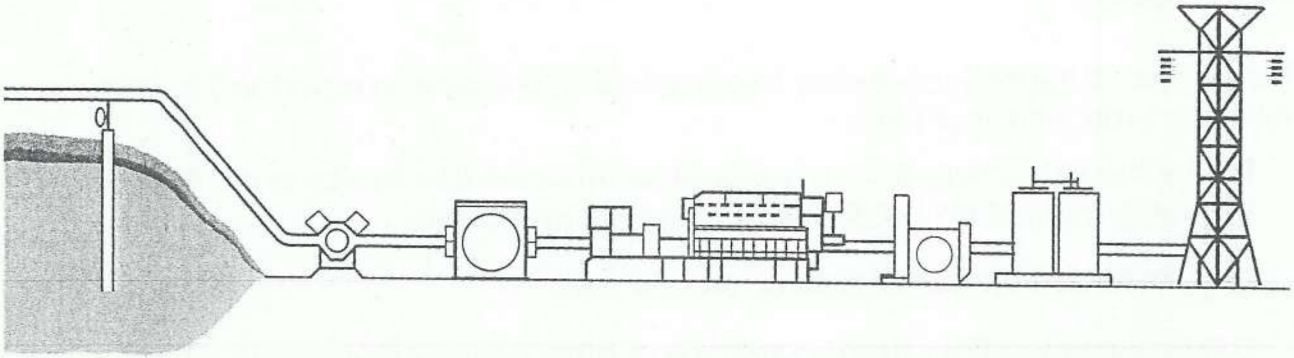

One of the most recently discovered sources of energy that can be transformed into electricity is biomass—the energy that comes from the breakdown of waste. Biomass is considered a "green" energy source because it is less harmful to the environment than other sources. Biomass relies on waste that the world is producing anyway and stops the depletion (using up) of the world's non-renewable resources (e.g., coal and oil). The transformation of biomass gases to electrical energy does not produce the same air pollutants as other forms of energy conversion, so the environment is further saved from damage.

What is your opinion of biomass as an energy source? Explain your answer.

Final Project

Choose one of the projects below to complete (alone or with a partner) and then share your work with your class.

1. Follow the instructions from a textbook or other reliable source and under the supervision of an adult, construct your own battery.

   Hint: Research on the Internet under *wet cell.*

2. Follow the instructions from a textbook or other reliable source and under the supervision of an adult, construct a device for converting mechanical energy (the energy of movement) into electrical energy.

3. Ask your teacher for electrical kits/supplies available at the school and under the supervision of an adult, create and test a small electrical device, making improvements over time.

4. Conduct research into the pros and cons (good things and bad things) about each of the following sources of electrical energy: oil, gas, coal, biomass, wind, waves, batteries. Present your information in a chart.

5. Research and write a short oral presentation that describes how electrical technologies have improved the world's ability to communicate, share and store information.

6. Create a poster to teach people about conserving energy. Use words and graphics to make your poster both informative and visually appealing.