4HEGM 30

The Power Of ELECTRICITY

WORKBOOK

Florida 4-H Energy Education Program

UNIVERSITY OF FLORIDA
IFAS EXTENSION

OUR NATURAL WORLD

Table of Contents

UNDERSTANDING ELECTRICITY

Nearly everyone is familiar with the word ENERGY, yet few people know what it really is. Energy, simply put, is the rate at which work is done. Work is the effort to produce or accomplish something.

Scientists have concluded that the world is made up of atoms. Atoms which have the same number of protons combine together to form unique substances called elements which can be found on the periodic table. We also know that atoms are made up of sub-components or subatomic particles called protons, neutrons, and electrons. Protons which have a positive (+) charge and neutrons which do not have a charge, make up the core of the atom called the **nucleus.** Electrons, on the other hand, have a negative (-) charge and are constantly moving around the outer layers ofthe atom.

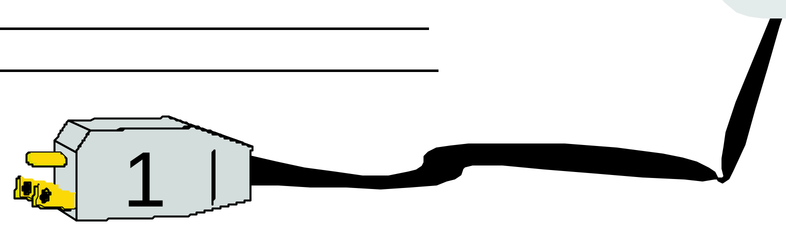
Electrical energy is created when electrons are being exchanged from one atom to another. The steady movement of electrons is the **key** to electricity. Electricity is called a secondary source of energy because it is produced frommany forms of energy.

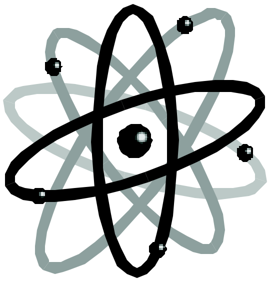
There are six forms of energy: Mechanical, Chemical, Electrical, Radiant, Thermal, and Nuclear.

Our dependency on chemical energy is evident from all the batteries that we use. A battery or "cell" consists of two plates of unlike metals known as electrodes and a chemical called an electrolyte. When a battery is "connected",the energy stored in the cell (in the form of electrons) is allowed to flow.

Give an example of each form of energy:

Mechanical ___________________________________
Electrical _____________________________________
Radiant (light) _______________________________
Thermal (heat) _______________________________
Nuclear ______________________________________
Chemical _____________________________________





ATOMS

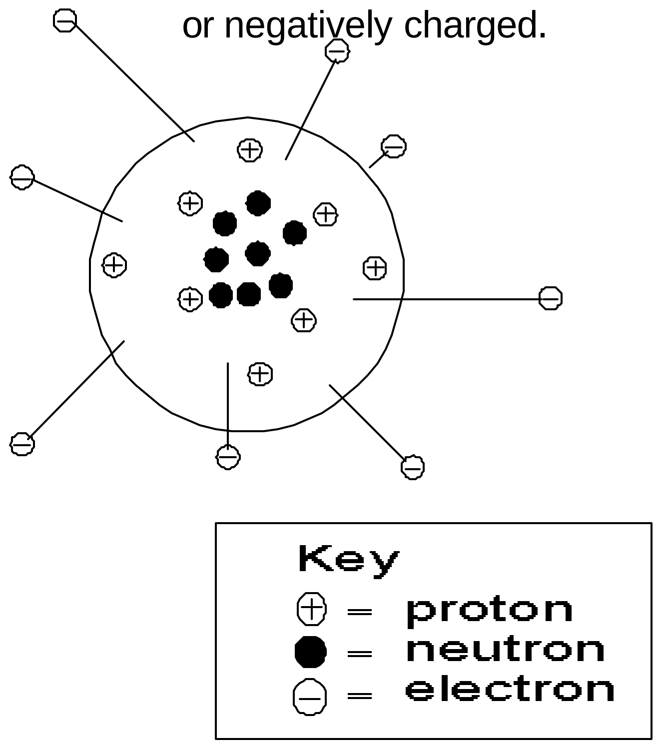
Let's findouthowATOMSwork!

What You Need:

- 3 8 black beads(neutrons)
- 3 8 greenbeads (protons)
- 3 8 red beads (electrons)
- 3 Styrofoam ball
- 3 Toothpicks
- 3 Glue

What You Do:

- Glue 8 black beads close together on the surfaceofeach styrofoam ball. Thenglue 8 green beads evenly on the surfaceofeachstyrofoam ball around theblackbeads. This makes upthenucleus ofthe ATOM.
- Insert 8 red beaded toothpicks of varying length intoeach styrofoam ball.
- The movement of electronscan be demonstratedbymovingthe beadedtoothpicks from one atom toanother, creating an imbalanceofelectrons. The atoms thenbecomepositively or negatively charged.



- Pushsomeelectrons closer to the nucleus, othersstay further away. The electrons circle the protons andneutronsin layers making some electrons easier topull away from oneatom to another.
- Create a positivelycharged atom.
- Create a negatively charged atom.

Electron Action

ELECTRIC HAIR

What You Need:

3 Plasticcomb

3 1/2 inch cut-out paper squares

What You Do:

- Using the plasticcomb,comb your hair for about 1 minute.
- Put theteethof the comb on the pieces of paper and lift carefully.

BALLOON MAGIC

What You Need:

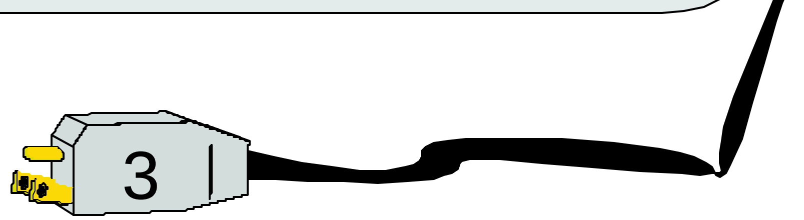
3 Balloon

What You Do:

- Inflate andknot the endofthe balloon.
- Rubtheballoon in your hairfor about 1 minute.
- Place the rubbedside of the balloonagainst the wall.

Try this with a friend!

- **Tie two balloons together with a long piece of thread.**
- **“Charge” each balloon by rubbing them with nylon,woolor on your clothing for 1 minute.**
- **Hold thread in the middle with your arm stretched out so that the balloons are equal distance from the middle of the thread.**
- **Let the balloons hang freely.**
- **What happened?**

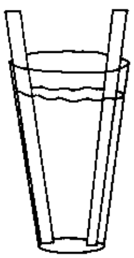


Chemical energy

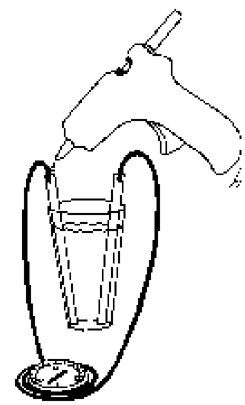
What You Need:

3 8oz.glass
3 plasticspoon
3 4 tablespoons of salt
3 30 inchesterminalwire
3 6inchstrip of copper
3 6inchstrip of zinc
3 6oz.warmdistilledwater
3 compass

What You Do:



- Add a copper andzinc strip to either sideof the glass. Fill the glass within 1/2 inchofthe top with warm water. Addthesaltandstir with a spoon.
- Wrap the terminal wirearound the compass and note the compass reading.
- Using the gluegun, connect one end of the terminal wire tothezincstripandtheother end to the copper strip.

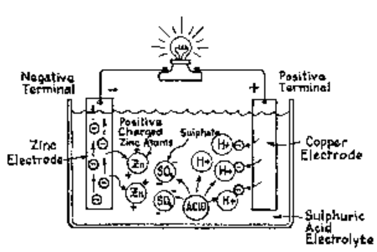


What directiondoesthecompasspoint:

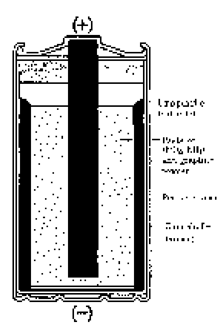
1. whenthewireiswrappedaroundit?___________________________
2. whenthewireisattachedtothecopper and zinc? ______________

What happened?____

Thecopper has a _______chargeand the zinc has a _______ charge.



Wet Cell



DRYCELL

Look at thetwotypesofbatteries on the left. How are these similar or different fromyourbattery?

____

____

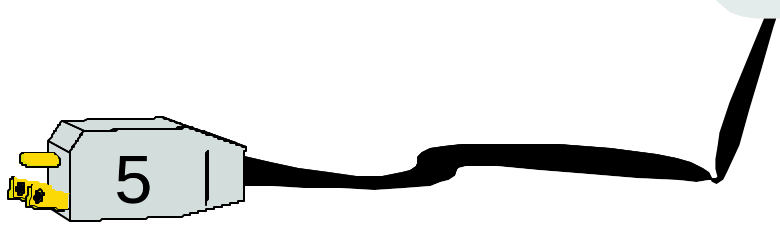
How electricity Travels

We know that everything is made up of atoms and that atoms are made up in part, of electrons. Electrical Energy comes from the movement of electrons. These moving or “traveling” electrons behave in certain ways. They travel through some substances much more easily than others. Substances that allow for electron flow are called **conductors,** those that don't are called **insulators**. In order for electron flow to be beneficial for "electricity", a "circuit" or circle of electron flow has to be complete.

A *closed circuit* allows the electrons to flow completely through the system uninterrupted. An *open circuit* prevents electrons from flowing through the system.

Electrons travel at different speeds and can be controlled by the size of the conductor and the force behind the electron movement. Different size wiring is required to safely allow for different amounts of electrons to flow. **Circuits** are the paths that electrons are allowed to take and can be designed to do different things. An electron path that flows through all parts of a circuit is called a *Series* circuit. An electron path that flows to each part of a circuit is called a *Parallel* circuit.

In many ways, electricity can be compared to water. Both water and electricity need pressure to force them to flow. Voltage is a measure of the force behind the motion of electricity. Voltage is measured in units called **volts.** We constantly have voltage running through our electrical outlets unless there is a power outage. Amperes (Amps) are a measure of the amount of flow of electric current. Volts and amperes together give us electricity. This electric power is measured in **watts**. We find watts by multiplying the voltage and amperes.



E l e c t r o n F l o w

Using a D cell battery, asmalllight socket and three 24"pieces of bell wire, test various materials to see ifthey allow for electron flow.

Definethefollowing:

CONDUCTORS ____

INSULATORS ____

WIRES CONNECTED TO:	DID THE LIGHTbulb work? **(yes or No)**	CONDuctor of electricity ✔	Insulator of electricity ✔
Other wire			
Nail			
Paper			
Rubber			
Plastic			
Pencil			
Other:			
Other:			

List materials that are:

Insulators

____

____

____

____

____

Conductors

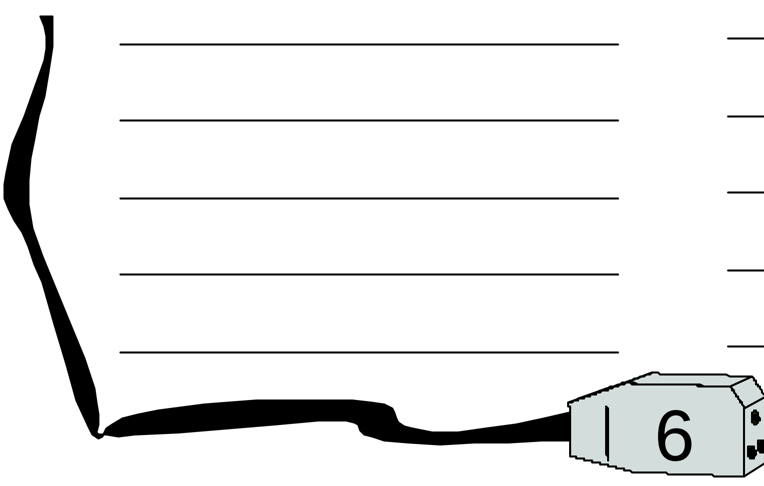
____

____

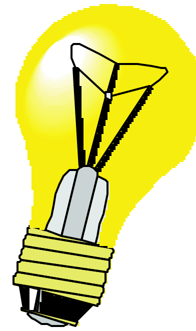
____

____

____



A Current Discovery



What You Need:

- 3 "D" battery
- 3 1 inch X 5 inchstrip of aluminum foil
- 3 Flashlight bulb

What You Do:

N Using ONLY the materials listed above, make the light bulb "light-up".

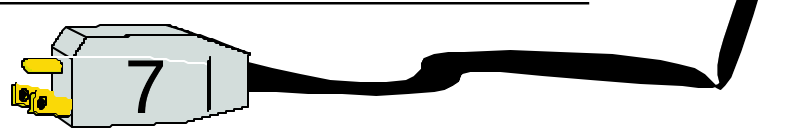
Recordeach attempt by drawing and labeling a detailed picture below.

1.	2.
3.	4.

What hadtotakeplaceforthelightbulbto"light"?

____

____



Electric

What You Need:

3/4" wide board about 4" x 6"
A 6 volt dry-cell battery
1 piece of 24" black bell wire
2 pieces of 12" white bell wire
Two 10-penny box nails (3 in.)
Three 3-penny box nails (1 in.)
2 small screws or carpet tacks
Two 2" rubber bands
Two miniature sockets with solder terminals
Two 1½ volt flashlight bulbs
TOOLS: ruler, pencil, hammer, pliers or vise

What You Do:

- Lay out the board with a pencil and ruler as indicated in *figure 1*.
- Measure points A, B, C, and D first. Point A needs to be 3" from the long end and approximately 2" from the short end. (Point A needs to be near the center of the board.) Point B is measured 2" from the end in the same line as point A.
- Measure 1½" from one of the long ends of the board and draw a line across the board.
- Place points E and F in the corners at the opposite end of the board as the line you've just drawn.
- Bend the 3" nail as shown in *figure 2* using pliers or vise and hammer. This is the crank nail or "switch"

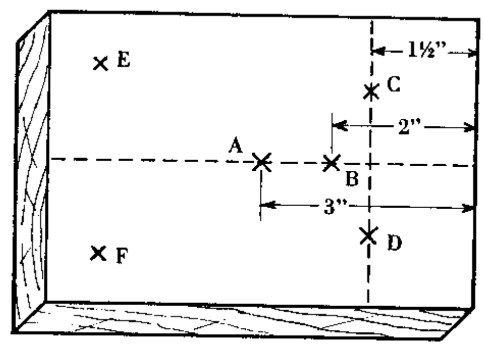


Figure 1

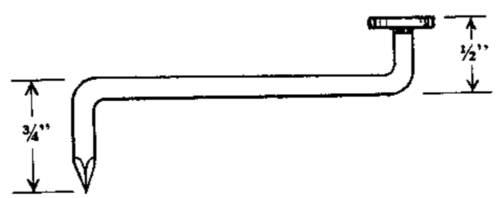


Figure 2

Circuit

- Pound the 1" nails ½ inch into the board at points A, C, and D (*figure 3*.) Use the 3" nail to make a hole ½" deep at point B. Put the crank nail in this hole and pound it in a little farther (*figure 4*.) Attach the lamp socket brackets at points E and F. Stretch the rubber band as shown in *figure 5.*

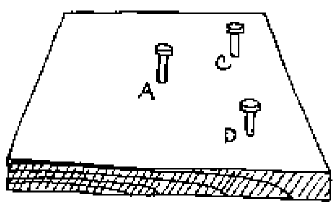


Figure 3

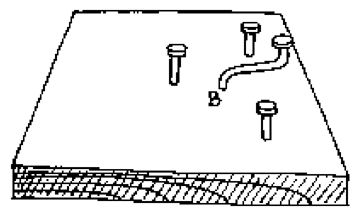


Figure 4

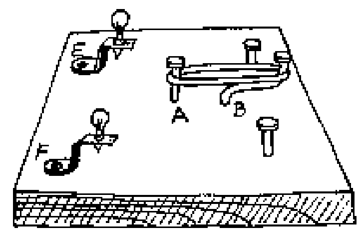


Figure 5

- Lay out the electricity path and the circuit as shown in *figure 6*. Use the black wire for the positive side of the circuit (the center "POLE" of the battery). Twist it around the switch crank at point B and the center pole of the battery. Run another piece to the outside terminal of bulb socket at E from point (nail) C. Run the white wire to the negative pole of the battery from the other terminal at E.

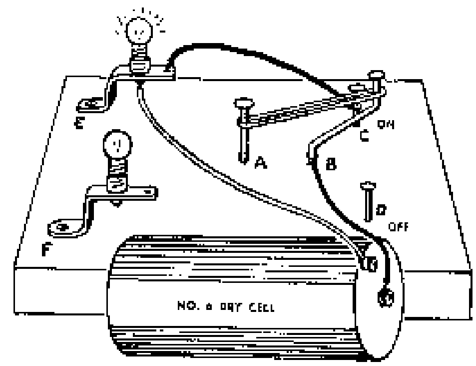


Figure 6

- Your electric circuit is complete!
- Close the circuit (turn switch to On - point C). The rubber band should hold the switch nail tightly against nail C. Open the circuit (turn switch to OFF - point D).

Try this

- Remove the wire that goes from socket E to the negative pole and reattach to socket F.
- Run a wire from socket F to socket E and turn circuit on.
- Wire each socket with a white wire directly to the negative pole of the battery and to Point C. Close the circuit.

ELECTRICITY'S SILENT PARTNER

The flowofelectrons (electricity) is only part of the "story" in producing electricity. Weknowthat electricity is theflow of electrons from atom toatom.

The important fact that electric chargesthat are alike, repel one another, andunlikechargesattract oneanother is similar tothe importance of magnetismand magnetic fields in theuseofelectricity.

The ends of magnets have poles whichiswherethestrength of the magnet is the strongest. The areaaroundthe "north" and "south" pole are called magnetic fields. Poles that are alike (N&N or S&S) repel each other, whereas, unlike poles (N&S) attract eachother, a concept similar to electriccharges. The earth itself is a large natural magnet having a northpole andsouthpole!

Modern scientists believe that magnets are madeofmillions of small particles called molecules, whichareinturnmadeofatoms. Each molecule is itself a tiny magnet. In an unmagnetizedbarofiron, the molecules have noarrangement, and produce no magnetic field outside of the bar. However, under the influence of a magnet, the molecules arrange themselves so that their magneticfieldsarealigned in thesamedirection. Now the bar of ironhasbecomeatemporary magnet! Only certain kinds of metal can be made into magnets, for example:iron,steel, nickel, cobalt, andspecial combinations of metals (alloys). Magnets made of steel or special metals hold their magnetism for a long time. These are called "permanent" magnets.

Therearemagnetsthat are much moreuseful than permanent magnetscalled **electromagnets**. Theycanbemademuchstronger than permanent magnets and can be controlled by changing the current or flow of electrons. Oneofthemostsimpleuses of electromagnetscomesfrom their abilitytoswitchmagneticfields on and off very quickly.

The **Silent** Partner

What objects are attracted to a magnet:

Magnetic Attraction	**No Magnetic Attraction**
____________________________	____________________________
____________________________	____________________________
____________________________	____________________________
____________________________	____________________________

Using magnets suspended by the middle, determine the north “poles” of the magnets. Use the magnets to determine if “like” poles attract or repel each other. What about opposite poles?

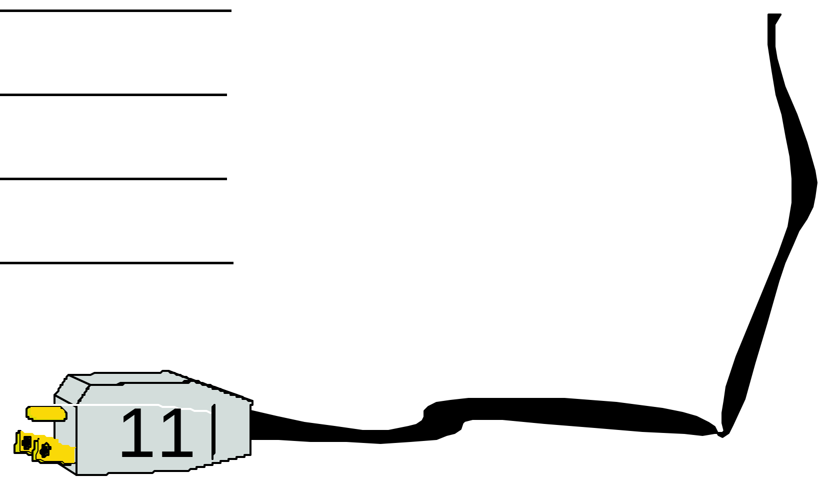
Do these attract or repel?

North & North ___________________

North & South___________________

South & North___________________

South & South ___________________



M a k i n g a n ELe c t r o m a g n e t

What You Need:

3 magnet

3 6volt lantern battery

3 24"pieceofbellwire

3 penknife

3 one iron 3-4"nail or screw

3 scotch tape

What You Do:

- Using the wire strippers, remove ½" of theplastic covering from both ends of a 24" piece of bell wire.
- Wind thewiretightlyaround a 3-4" nail or screw about 20timesandleaveabout3"ofwirefreeon each endofthenail.
- Use a piece oftapetoholdthestripped ends of thewireagainstthetwoterminals ofthebattery, asshown in *figures1and2.*

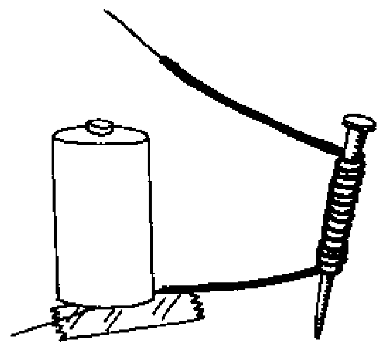


Figure 1

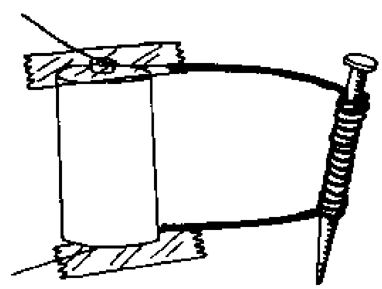


Figure 2

Trytopickuppaperclips,smallnails,oranytiny metal object thatamagnetwouldnormallypickup.

“Disconnect”one oftheendsofthewirefromthe battery and notewhathappens.

- Placethenorthpole of thepermanent magnet next tothesouth pole oftheelectromagnet.
- Switch the ends orleadstothebattery. Whathappens?
- Switch theendsorleadsasecondtime. Whathappens?

Construct a SIMple motor

What You Need:

3 One roll of No.24enameled wire

3 One roll of electric tape

3 Three 4 inch (20-penny) nails

3 Four 2½ inch (8-penny) nails

3 Four 3 inch brads (10-penny)

3 Boardformotorbase, 4 in. X 6 in. X 3/4 in.

3 Two staples or 4 small brads

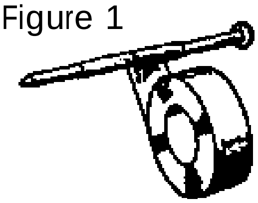
3 Two tacks

3 Two 3-volt dry-cell batteries (or a 6-volt transformer)

What You Do:

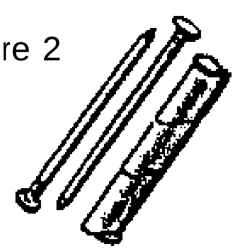
Step 1: Making an armature(thespinningpartofthemotor)

Figure 1



- Wrapabout1½inchesofa4inchnailwithtwolayersof electrical tapeasshownin *figure 1*. Thiswillbethe SHAFT of yourmotor.
- Usingtwopairsof2½inchnailswiththeheadsandpoints inopposite directions, wraptapearoundthemasshownin *figure2*. Wrap tapearoundeach pair with heads and pointsalternated. When complete,therewillbe2setsof2 nails, tapedtogetherheadtoend.
- Centera set on each side of the shaft. Place the sets about1 inch from the head of the shaftnail. Wrap them together withtwolayers oftapefromtiptotipasshownin *figure 3*.
- Start at the shaft andwindNo.24enameled wiretoone endandtack. Then dothe sameontheotherend.Always windinthesamedirection. Leave 6 inchesofsparewire at the start andfinishasshownin *figure 4*.

Figure 2



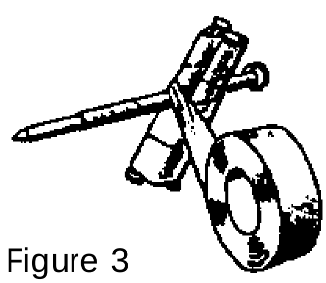
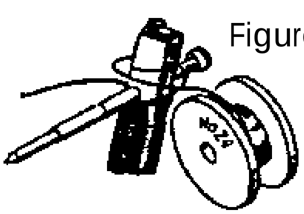


Figure 3

Figure 4



Continue

Simple motor

Step 2: Making a Commutator (reverses the current automatically and keeps the electromagnet spinning.)

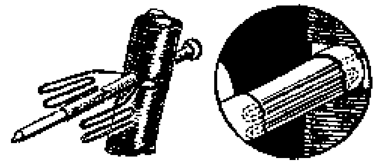


Figure 5

- Scrape all insulation off the ends of the 6 inch wire coming from the Armature. Bend the bare ends back and forth like a "Z" as shown in *figure 5.* Lay them flat over the taped shaft, one on each side of the shaft.
- Hold the commutator down with narrow strips of tape as shown in *figure 6*. Wrap the tape tightly near the armature or core and at the opposite end.

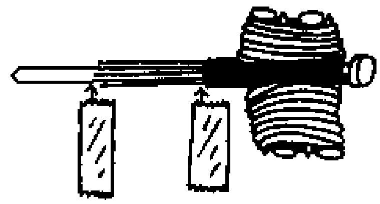


Figure 6

Step 3: Making the Stator or Field (the magnet that stays in one position and whose poles do not change. This could be a U-shaped permanent magnet or electromagnet.

- Make the core by bending two 4 inch nails in the middle at right angles. Space the heads about 3 inches apart to form a horseshoe. Wrap together with two layers of electrical tape as shown in *figure 7.*
- Wind about 400 turns of wire around the center. Leave 4 inches of spare wire at start and finish as shown in *figure 8.* Remember to wind in the same direction.
- Attach the stator or "Field" to the wood base at each end of the wire with staples or small brads bent over as shown in *figure 9*. The **field** poles are now in place.

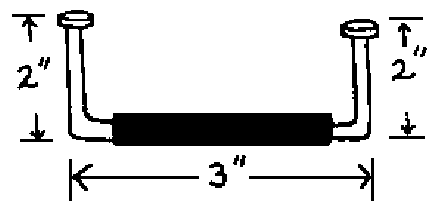


Figure 7

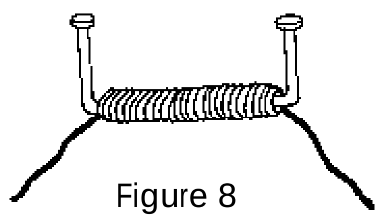


Figure 8

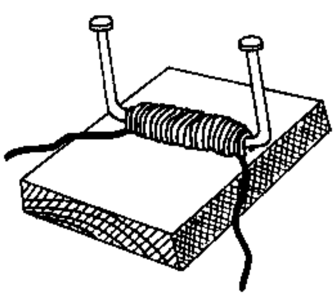


Figure 9

Step 4: Making the Armature Support and Brushes (wires that transmit electricity to the commutators. Since the commutator is spinning with the rotor, it cannot be directly connected to a source of current. The current-carrying wires must "brush" against the commutator to transfer the current.)

Continue ☞

CONtinued

- Scrapetheinsulationfromtheendsoftwo 6 inchpiecesofwire. Tack them to the baseandbendthemasshownin *figure10* tomake **BRUSHES.**
- Drivetwopairs of 3 inchfinishing nails sidebysideintothebaseabout31/4inch apartfromtoptobottomandinline midwaybetweenthe fieldpoles.
- Wrap wirearound the supportstoform armature bearings or supports, as shown in *figure 11*.
- Scrapeinsulationofftheendsofthe wire from the **FIELD** poles andconnectone endtoa **BRUSH**.

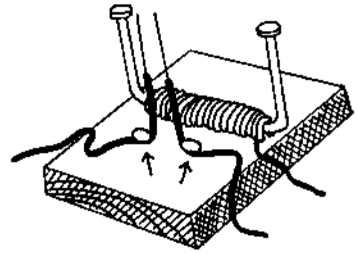


Figure 10

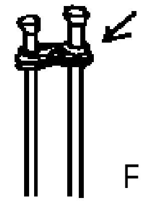


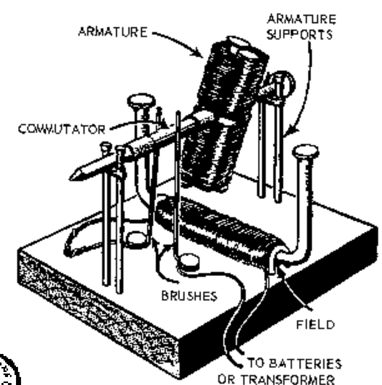
Figure11

Step 5: ConnecttheMotor

Thefollowingare parts of your assembled simplemotoras shownassembled in *figure12*.

- Armature
- Armature Supports
- Commutator
- Brushes
- Field

Figure12



- Place the commutator andarmaturein the armature supportsasshownintheassembled motor. Adjusttheposition of **Commutator** and tensionof **Brushes** so that the brushestouch thecommutator whenitisturningforbest operation.
- Takethearmature off themotorand connectthe commutator towires from a dry-cell battery.
- To test thepolarityofeachend ofthearmature, placeacompass ateach end (*figure 13*) and note theneedlecompassdirection.
- Switch the connectionson the commutator and testagain.Note what happens.
- With thearmature still off, connectthefieldcoil directlytothe dry-cell asshown in *figure14*.
- Test the polarity ofeach end of thefieldwiththe compass.
- Reassemble themotoragainandstartitby attaching thefieldcoiland thebrush wire.
- Push **Field** poles slightly out ofalignment with theturning **Armature** (*figure 15*) andobserve.

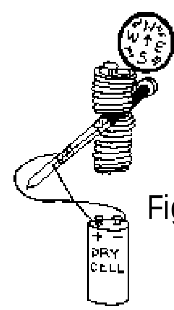


Figure 13

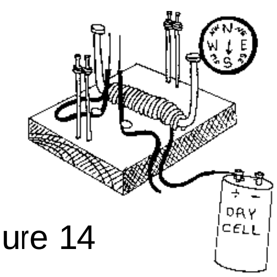


Figure 14

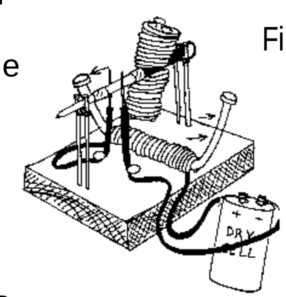


Figure 15

ENERGY IN ACTION

Electric energy is the work done or the energy expended in a circuit or part of a circuit in a given time. Remember that electricity is measured in watts and that a watt is equal to volts (force of electricity) times ampere (flow of electricity). A unit of energy is the **watt-hour** that can be determined by multiplying watts by the hours, or the length of time the energy is used. A **kilowatt** is simply 1000 watts.

The Underwriters' Laboratory sets minimum safety standards (Codes) for electrical items. The UL seal does not mean that the item is the best that can be bought. It does mean, however, when the item is new, it is safe to use under the conditions for which it was designed. The familiar label UL is the registered trademark of Underwriters' Laboratories, Inc., a nationwide, independent, not-for-profit organization. UL has been testing products for safety since 1894.

RULES TO REMEMBER

List "Rules to Remember" to remain safe when around electricity.

1. ____

2. ____

3. ____

4. ____

Can You Find?

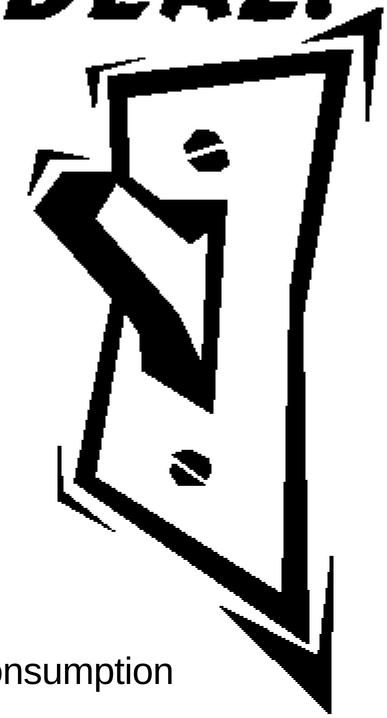
Where is the fuse box or breaker switch in you home?___________

Where do electrical lines come into your home? _______________

Does your family keep appliance "USE and CARE" information in your home?

Where?_____________________.

WATTS THE BIG DEAL!



A unit of energy is measured in WATT-HOURS and can be calculated by multiplying watts by the time (hours) that electrical energy is used.

If a 100 watt lamp is left on for one hour, what is the watt-hour? for 30 minutes?

List below electrical appliances you and your family use and estimate the hours per day used, days per week, and the daily watt-hours.

To calculate watt-hours:

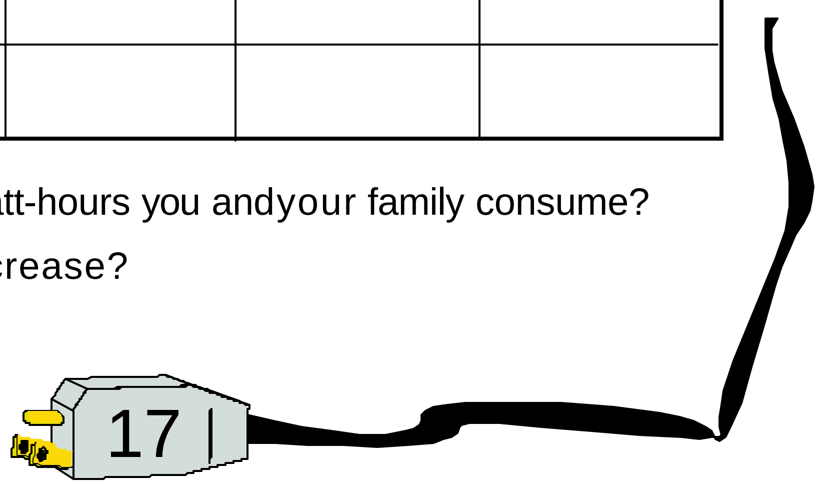
> Watts x hours x days used per week
> divided by 7 (days in a week) = watt-hours per day consumption

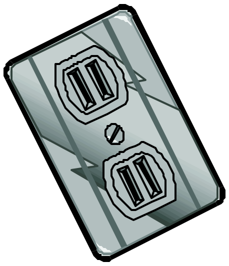
For Example: $\frac{\text{8 watts x 10 hrs/day x 4 days/week}}{\text{7 days/week}} = \frac{\text{320 watt-hours/week}}{\text{7 days/week}} = 45.7\ \frac{\text{watt-hours}}{\text{day}}$

Appliance	Watts Required	Hours per day used	Days per week used	Daily watt-hours
Portable Radio	8	10	4	45.7

What is the TOTAL per day watt-hours you and your family consume?

How might that increase or decrease?





Is it worth it?

Given: 1 Kilowatt = 1,000 watts
Formula: Kw x hr x KwH cost

- What is the electric cost of a 1,000 watt toaster operated for 5 minutes with a kilowatt-hour costing .08 cents?

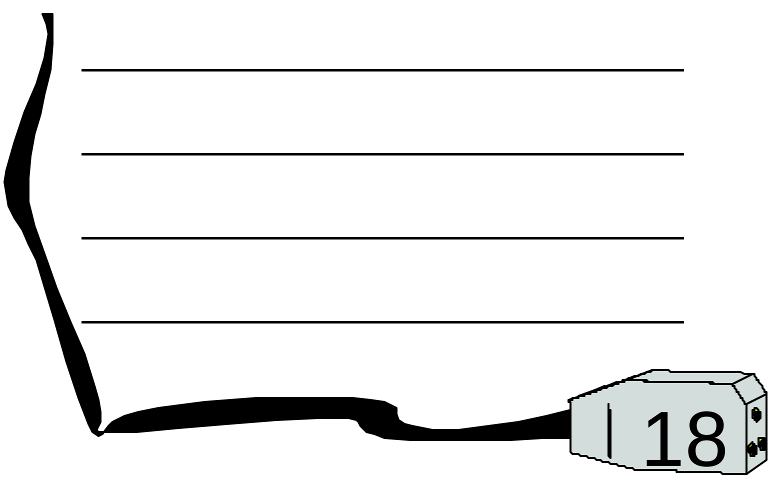
- What is the electric cost of a 5,000 watt appliance that runs 24 hours a day?

List some appliances and the watt use required for them to "run".

Appliance:	**Watt Needed:**
______________________________	________________________
______________________________	________________________
______________________________	________________________
______________________________	________________________

If a kilowatt-hour costs .08 cents, how much does it cost to run each of the appliances above for 3 hours?

Appliance	**Cost to run 3 hours**
______________________________	________________________
______________________________	________________________
______________________________	________________________
______________________________	________________________



ENERGY AND THE ENVIRONMENT

We have becomevery dependent onelectricity. Justimagine what it wouldbelikenot tohave the POWER of electricity! When your "power"goesoff at home, it canberatherannoying. The costfor electricity varies from placetoplace but we really payvery little for each KwHofelectricityweuse. It's notfree,butit's a necessity that wearewillingtopayfor. However, thereareadditional "costs" of using energy and natural resources for the productionofelectricity.

Electricity is generatedatpowerplants andcanbeproduced from a number of different resources. Power plantstypically use coal, natural gas or nuclear fission to generate electricity. Otherresources such as solar panels, wind mills, andbiomass canalso be used, but at a higher cost.

There are effects of using these resources in the natural environment. How do you think the following effect theenvironment when used togenerateelectricity:

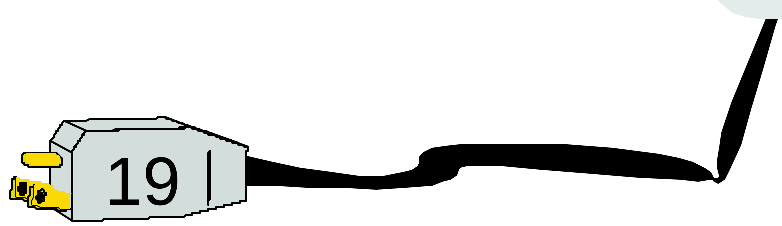
Coal ________________________________
____

Natural gas ____________________________
____

Nuclear fission _________________________
____

Water(hydropower) ______________________
____

Regardless of the resources usedtogenerateelectricity, there areeffectsto the environment as a result. How wediscard used energyresources also has effects on theenvironment.



Rechargeable = recyclable

- How much does a D-cell battery weigh? Weigh several batteries.
- Below, identify thebatteries being used inyoureveryday life and complete the chart.

Measurement 1gram = .035 ounces
1ounce=28.4grams

Battery Type	Weight	#	Where Found	Total Weight	Total weight of toxic substances

1. Assume that weareusingonly Dcell batteries, calculatethetotal weight of solid waste generated by total number of disposable D cell batteries weused above if each battery weighs _______grams. Calculatethetotalsolid wastegenerated fromusing thebatteries above. (Total weight)

2. Assume that weareusingonly D cell batteries. Calculate the toxic chemicals that are disposed of if each D cell disposablebattery produced.12grams.

3. Now estimate how often batteries "die-out" and new ones are needed for each itemthey're used in andcalculatethewasteofsolid and toxic wastedisposedof.

How Did You Do?

Understanding Electricity

_____Do you know the six forms of energy?

_____________________________________ ____________________________

_____________________________________ ____________________________

_____________________________________ ____________________________

How Electricity Travels

_____What is a closed circuit? _____________________________________

____

_____What is an open circuit?_______________________________________

____

Electricity's Silent Partner

_____Poles that are alike __________________ each other.

_____Unlike poles ________________ each other.

Energy In Action

_____Electricity is measured in____________.

Electricity And The Environment

What resources do power plants typically use to produce electricity?

____

____

____

1. This document is 4HEGM30 of the Florida 4-H Youth Development Program, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Reviewed June 2002. Please visit the EDIS website at http://edis.ifas.ufl.edu.

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