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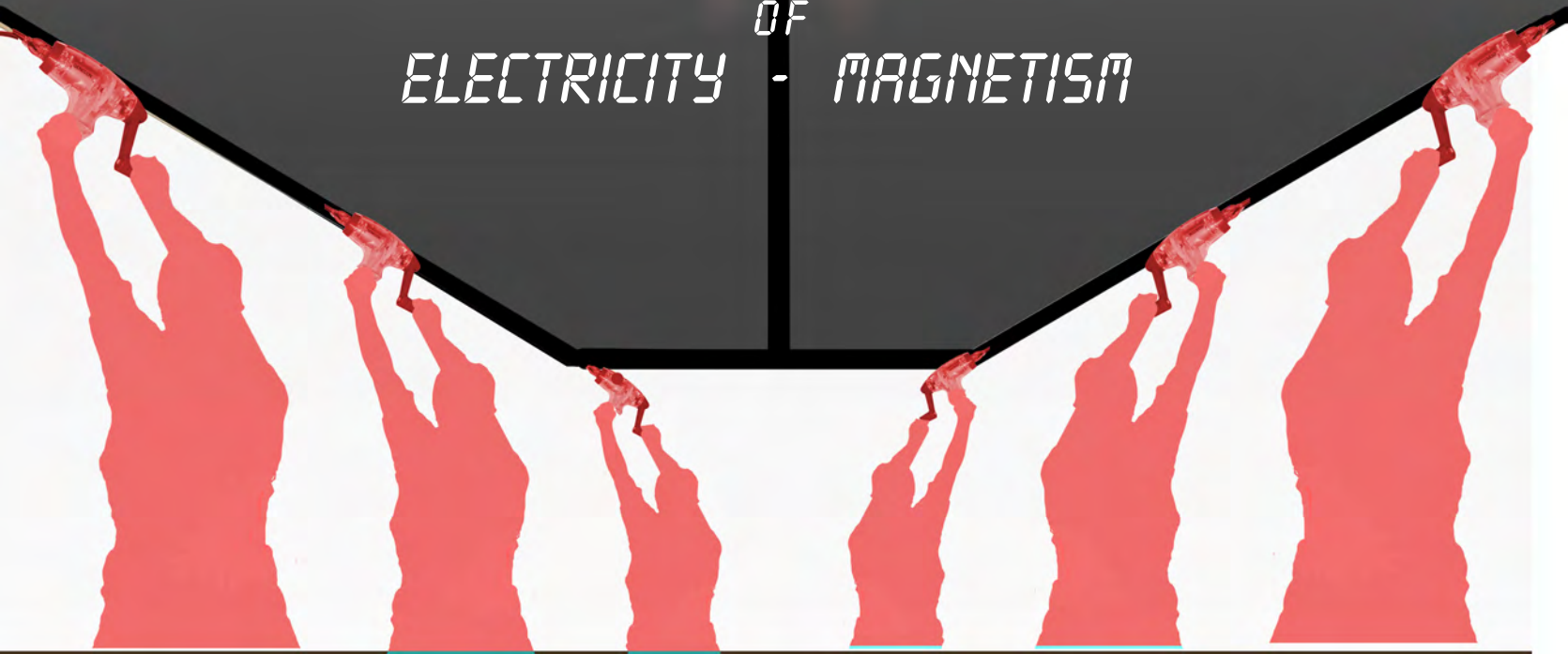
ADVENTURES WITH THE GENECON

22 Hands-on Experiments and Investigation of ELECTRICITY - MAGNETISM



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Letter to the Science Teacher

The activities described in this manual have been designed specifically for use in conjunction with the GENECON Kit. None of these experiments should ever be performed with alternating current.

While the selection of activities was made with grades 4-9 as the curricular focus, quite a few of them are very much on target for high school level physics demonstrations.

The activities are fully detailed to ensure optimum success and are designed to be conducted by the students. Teachers are urged to allow students to arrive at their own interpretations of these investigations, providing only such guidance and clarification as proven necessary to ensure comprehension. The sequence of the activities is intended to lead logically from one concept to the next, but feel free to experiment with the order in which you introduce them.

"Key Concepts" and "Teaching Tips" are provided for each activity, but creative and knowledgeable teachers will surely expand upon these basic ideas. Indeed, the resourcefulness of my colleagues in the classroom has provided the major impetus for the preparation of this Manual. They are the ones who demonstrate daily their professional commitment by seeking out opportunities for involving their students directly in investigating the world around them.

With admiration and respect,

Gary W. Nahrstedt
Professor, Science Education
University of Missouri-Kansas City

Activities

**The New GENECON Kit contents are located on the inside back cover of this manual*

NADA SCIENTIFIC

Getting To Know Your GENECON

Activity 1

Key Concepts

1. A generator converts mechanical energy (the energy of moving parts) into electrical energy (the flow of electrons through a conductor).

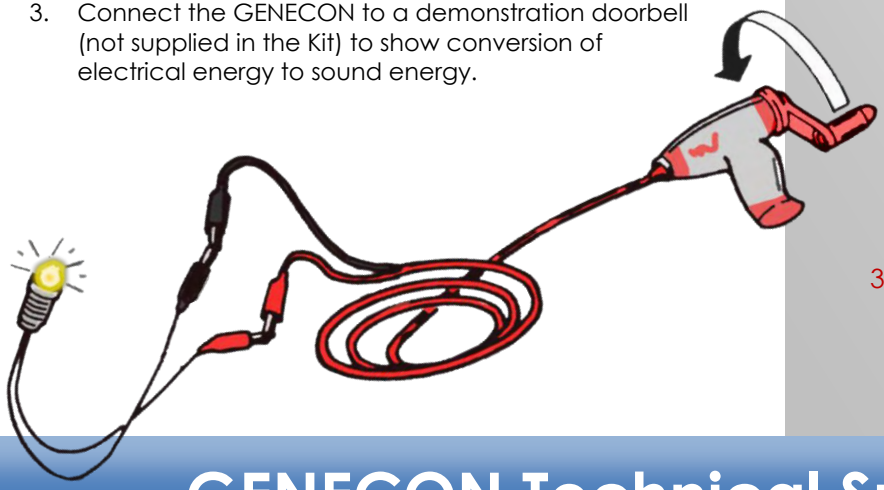
2. The brightness of the bulb is directly related to the voltage of the current passing through it.

Teaching Tips

1. Discuss proper operation of the GENECON with the students.

2. Discuss how lighting the bulb demonstrates a whole series of energy conversions: Chemical energy in the cells of your body was converted into the mechanical energy of your muscles, which the GENECON changed into the electrical energy. The electricity passing through the filament of the bulb got it so hot (thermal energy) that it radiated light energy.

3. Connect the GENECON to a demonstration doorbell (not supplied in the Kit) to show conversion of electrical energy to sound energy.



Materials

1 GENECON with output cord
1 bulb (3.8 V, .3A) in socket with leads

Procedure

1. The output cord should be plugged into the back of the GENECON. Connect the leads of the GENECON to one of the miniature bulb sockets, with leads, supplied in the Kit. Slowly turn the rotary handle of the GENECON with the increasing vigor until the bulb lights. You should notice that the bulb becomes brighter as the handle is turned more rapidly. In general, the brighter the bulb, the more voltage the GENECON is producing.

Caution: The GENECON produces up to 12 volts of pulsating DC current. Overly rapid rotation of the handle may burn out the bulbs supplied in the Kit.

2. SPECIAL CAUTION: While the GENECON is sturdily constructed, excessive speed in rotating the handle can result in stripped gears and damage to the unit. If while rotating the handle in any of the activities which follow, you should experience a sudden "slippage" or decrease in effort required, check your circuit to see if it overloaded (e.g., too many bulbs connected) or shorted out. Continuing to turn the handle when there is no resistance in counterproductive.

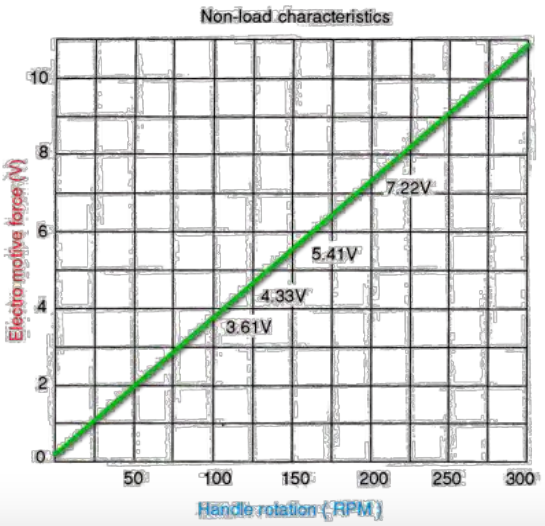
3. Now try turning the handle of the GENECON in the opposite direction. Once again, the bulb lights as before.

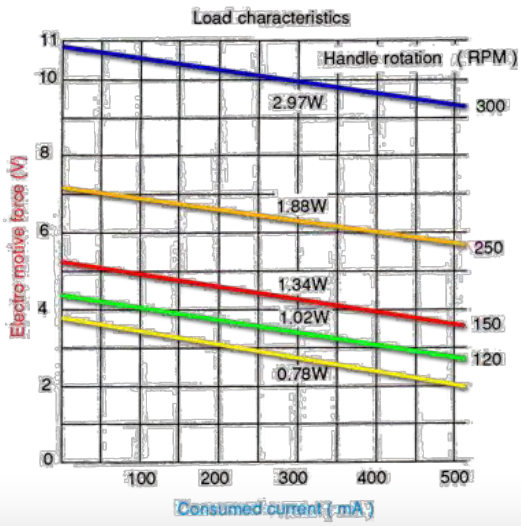
GENECON Technical Specifications

This portable direct current generator is small and convenient. It can be used for experiments involving energy changes or electrolysis. It is capable of generating up to DC 12V with the polarity determined by the position of the handle. The generator body is constructed of transparent acrylic resin allowing the inside structures and mechanisms to be clearly seen and understood. Students can gain direct, hands-on experience in the generation of electricity.

Construction: Transparent ABS resin with red plastic accents
Dimensions: 140 x 114 x 39 mm
Weight: 115 g

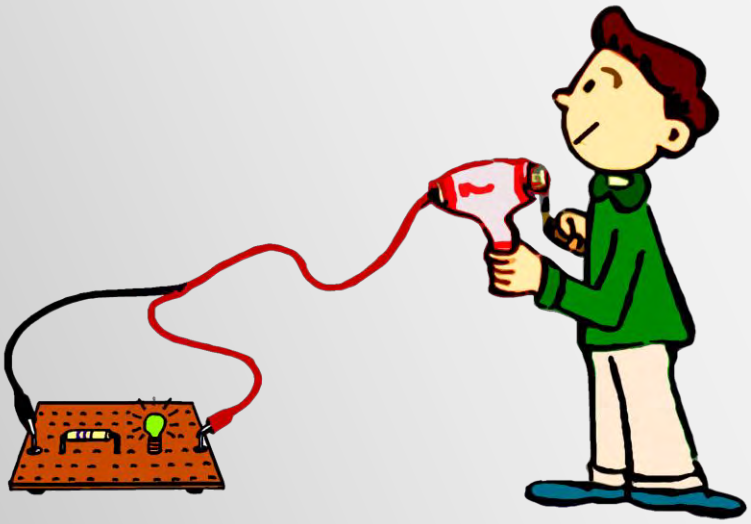
Unit is supplied with special output cord with alligator clips at both ends





NADA SCIENTIFIC

Testing for Polarity



Materials

1 GENECON with output cord
1 Polarity Tester
- *Raw Potato*

Procedure

1. Connect the leads of the GENECON to the two terminals of the Polarity Tester. Turn the handle of the GENECON in a clockwise direction. The diode will glow either red or green. If it emits a red light, the lead closest to the diode is of positive polarity. If the light is green, that same lead is negatively charged.

2. Reconnect the leads of the GENECON (if necessary) so that the red lead is at the terminal closest to the diode. Turn the handle of the GENECON (again, clockwise). The diode should glow red. If it does not, the output cord from the GENECON has been plugged in upside down. The red lead should be on top. This standard arrangement for using the GENECON (clockwise rotation, with red lead on top) will ensure that the red lead always has the positive polarity. Polarity is of little concern in many of the activities in this Manual, but some of them will not work if the prescribed polarity is reversed.

3. With the GENECON connected to the Polarity Tester, rock the handle back and forth. The alternating colors of the diode clearly show that by reversing the direction of the GENECON's handle, you are reversing the direction of the current.

Key Concepts

1. Electricity is the flow of the negatively charged particles, called electrons, through a conductor.

2. Electricity flows from the negative electrode (where there is a surplus of electrons) to the positive electrode (where there is a shortage of electrons).

3. The polarity of and electrical source refers to the location of the positive and negative electrodes.

4. The direction of the rotation of the GENECONs handle determines the polarity of its leads (connectors).

5. Whichever color (red or green) the diode glows, the positive lead is at the terminal of the same color as the diode.

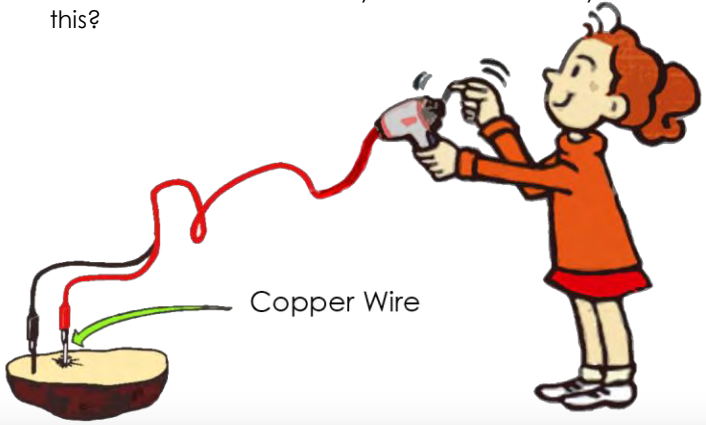
6. Incorrect polarity may cause certain appliances to work improperly or become damaged.

Teaching Tips

1. Another less elegant but fascinating way of determining the polarity of the leads from a DC energy source (e.g. the GENECON, the capacitor, and electric cell) is to use a **raw potato**! Cut the potato in half, and then prepare two copper wires, each about 5 cm in length. With sandpaper, brighten up the ends of the wires and insert them into the potato about 5 mm apart and 5mm deep into the flesh of the potato. Be sure they do not touch each other. Then connect the wires of the GENECON and turn the handle vigorously. Within about 30 seconds you will note the formation of a blue-green color on the potato around one wire, but not the other. This color forms only on the positive wire. (It is copper chloride and is produced by the **electrolysis of natural salt** in the potato.)

2. Ask students to consider what happens when batteries are not installed properly in flashlights or radios. What does "properly" really mean?

3. Discuss the wider blade on one side of the plugs of typical electrical appliances. Such plugs will go into electrical outlets in only one direction. Why is this?



Energy "Loss"

Activity 3

Key Concepts

1. According to the **Second Law of Thermodynamics**, in all energy conversions some energy is "lost" (not recoverable) into the environment.

2. The ratio of input energy to output energy is a measure of the efficiency of the energy conversion system.

3. In mechanical systems (like the GENECON) much of the "lost" energy is in the form of heat due to friction.

Teaching Tips

1. Have the students calculate the apparent efficiency of the "motor" GENECON using data they collected. Express the result as a percentage.

2. Call attention to the fact that both generators and motors produce a lot of noise (a form of sound energy).

3. Make sure students realize that "lost" energy refers to energy which dissipates uselessly into our surroundings-not that we don't know what happened to it or that it "disappeared".

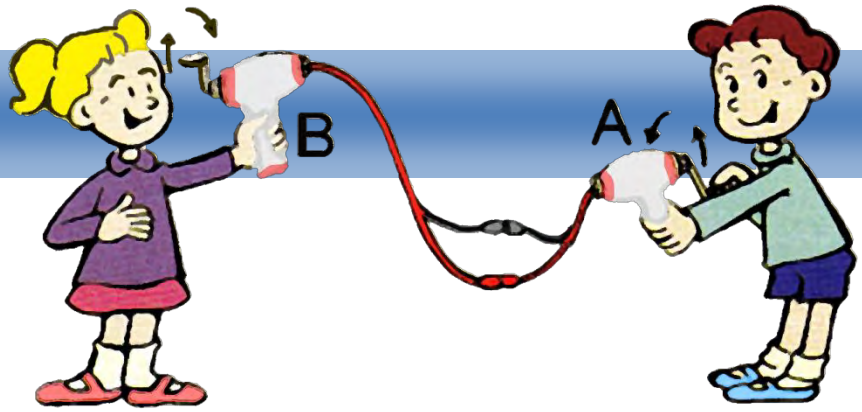
Materials

2 GENECONs with output cord

Procedure

1. Connect the leads of the two GENECONs together (as in Activity #4 and the illustration below)

2. Have one student turn the handle of one GENECON exactly 10 times, while the class counts the number of rotations of the "motor" GENECON. Repeat, using different numbers of rotations. Why does the "output" GENECON always rotate less than the "input" one? Where does the "missing" energy go?



Activity 4

Generator or Motor?

Key Concepts

1. A generator changes mechanical energy into electrical energy; a motor changes electrical energy into mechanical energy.

2. The GENECON can function as either a generator or a motor depending upon the form of energy supplied.

3. The polarity of the electricity supplied determines the direction of rotation of the "motor" GENECON.

Teaching Tips

1. Careful observation of the interior mechanisms of a GENECON will reveal the presence of a small DC motor!

2. Review the instructions on a polarity in Activity #2. Note that when the color-coded leads of the two GENECONs are connected, both handles will rotate in the same direction.

3. Do not allow the metal alligator clip connectors from the same GENECON to accidentally touch each other or both units will be shorted out.

Materials

2 GENECONs with output cords

Procedure

1. Label one GENECON "A" and the other "B". Attach the leads of "A" directly to the leads of "B". Have one student turn the handle of GENECON "A" while another students holds "B" by the grip only. Most students will be surprised by the result: the handle of "B" will begin to rotate just like a motor! Note the direction in which the handle of "B" is turning: Is it clockwise or counterclockwise?

2. What happens to "B" when the students operating GENECON "A" reverses its direction of rotation?

3. What happens when GENECON "B" is operated while "A" is held passively by the grip? Which one is the "motor" GENECON now?

Activity 5

Conductor or Insulator?

Materials

1 GENECON with output cord
1 bulb (3.8 V,0 .3A) in socket with leads
- *Variety of objects made of metal, wood, plastic, rubber, glass etc.*

Procedures

1. Prepare a "circuit tester" by connecting one lead of the GENECON. With one student operating the GENECON, have another touch the two loose leads together closing the circuit and lighting the bulb. Now separate the leads, thereby breaking the circuit. If conductive material is placed between these leads, the bulb will light.

2. Have the students test the conductivity of a variety of objects with the GENECON circuit tester.

Key Concepts

1. Materials which allow an electric current to pass through them easily are called conductors.

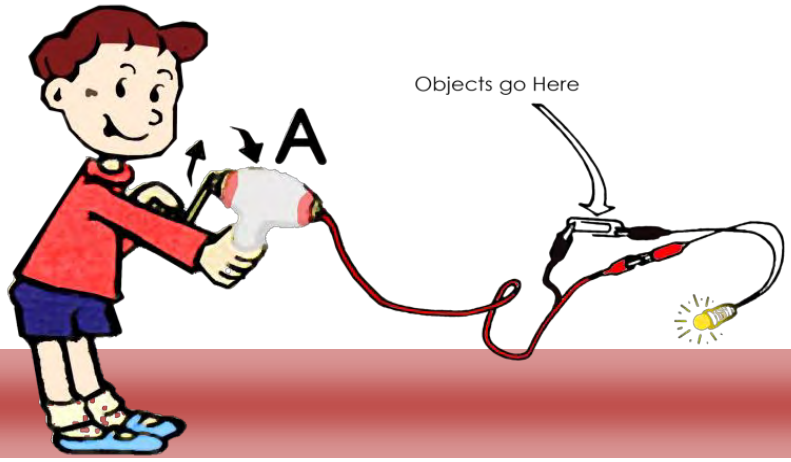
2. Materials typically are excellent **conductors.**

3. Materials which do not conduct electricity very well are called **insulators.**

Teaching Tips

1. Compare the results of this activity to materials which are purposely used as conductors and insulators in our environment

2. Include among the items to be tested some "tricky" materials, like pipe cleaners and metal-coated wrapping paper.



Activity 6

Mystery Circuit Boxes

Materials

GENECONs with output cord
1 Bulb (3.8V, .3A) in socket with leads
- *Several small, sturdy cardboard boxes*
- *Brass brads*
- *Bell wire*

Procedure

1. Construct several "mystery circuit boxes" by sticking 8 brass brads through the box lids in a pattern similar to the sketch below. Number each brad on the lid.

2. Turn the lid over and connect short lengths of bell wire between selected brads. Make sure there is good electrical, metal-to-metal contact between the bell wire and the selected brad tabs. Wrap the wire around the tabs, and then bend the tabs back firmly to the cardboard lid. Close the boxes and secure with a rubber band.

3. Provide the students with a GENECON circuit tester (consult Activity #5) and challenge them to locate the mystery circuits.

Key Concepts

1. Brads which are connected by bell wire will complete a circuit and light the bulb.

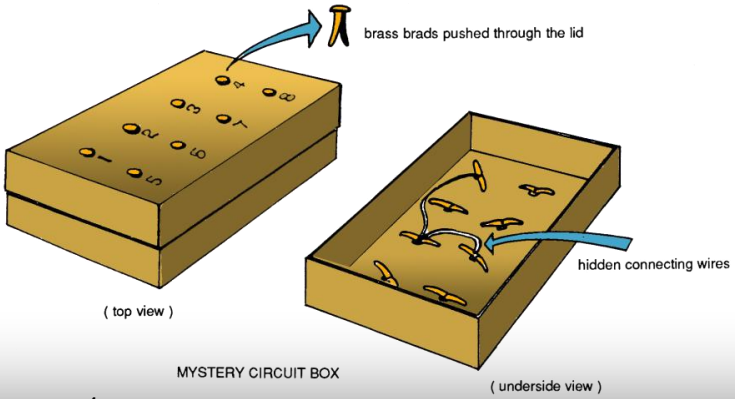
2. Deciding on a systematic strategy for checking all possible circuit combinations will be more effective and efficient than hit-or-miss testing.

Teaching Tips

1. Set up different circuits in each of the several boxes.

2. Select at least one box with a metal-coated top. The results may be quite surprising!

3. Have the students record the results of their investigation in the following format. "1,7";"6,7" etc. If students had reported those particular successful combinations, would they be able to predict that brads 1 and 6 would have to work also?

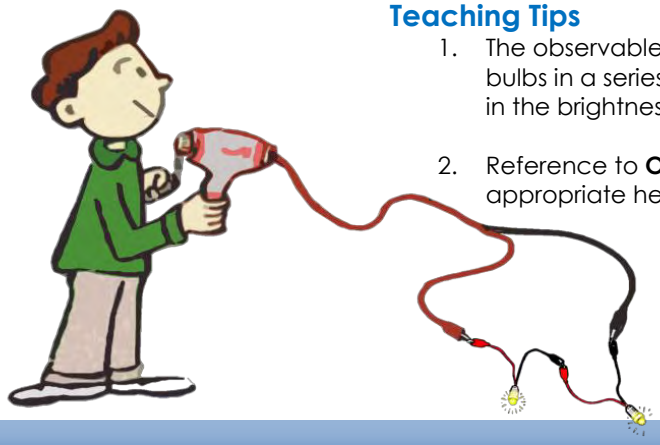


Bulbs in Series

Activity 7

Key Concepts

1. The bulbs in this circuit are wired **in series** (one after the other), providing only one path for the current.
2. When a bulb burns out or is removed from the circuit, the flow of electricity stops.
3. As bulbs are added to a series circuit, there is an increase in resistance and a corresponding decrease in current.
4. Bulbs and other electrical devices are considered as **loads** on the circuit in that they convert electricity into some other form of energy while altering the characteristics of the circuit itself.



Teaching Tips

1. The observable result of adding bulbs in a series circuit is a decrease in the brightness of the bulbs.
2. Reference to **Ohm's Law (I=V/R)** is appropriate here.

Materials

1 GENECON with output cord
4 Bulbs (3.8V,.3A) in sockets with leads

Procedure

1. Connect one of the bulbs to the GENECONs and light it up to moderate brightness. (Caution! Excessive rotation may burn out the bulb.)
2. Add another bulb to the circuit by inserting it between the first bulb and the GENECON (as in the sketch). Light up both bulbs by rotating the handle **at the same rate** as before. Note any change in brightness.
3. Add a third and then fourth bulb in a similar manner, noting any changes in brightness.
4. While one student is operating the GENECON to illuminate the four bulbs wired in series, another student should unscrew any bulb in that circuit. What happened to the other bulbs?

Bulbs in Parallel

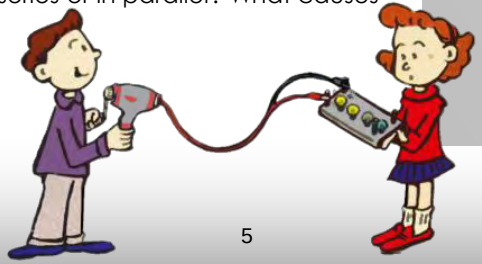
Activity 8

Key Concepts

1. The Parallel Bulb Base consists of 4 bulbs wired in parallel, which provides more than one path for the electricity.
2. When one of the bulbs in a parallel circuit burns out or is removed from the circuit, the other bulbs remain lit. The current does not have to pass through one bulb to get to the next one.
3. As bulbs (or other loads) are added to a parallel circuit, there is a decrease in resistance and a corresponding increase in current.
4. As the load (more bulbs) increases, the mechanical energy to operate the GENECON must also be increased.

Teaching tips

1. Additional bulbs, and even another GENECON, can be added as loads in parallel using the terminal at the opposite end of the Bulb Base. However, the circuit can easily become overloaded.
2. Relate the results of this activity and the preceding one to **Ohm's Law (I=V/R)**
3. Compare the results of these two activities to familiar experiences. What are two different ways to wire up Christmas strings of lights? Are the circuits in most homes wired in series or in parallel? What causes overloaded circuits?



Materials

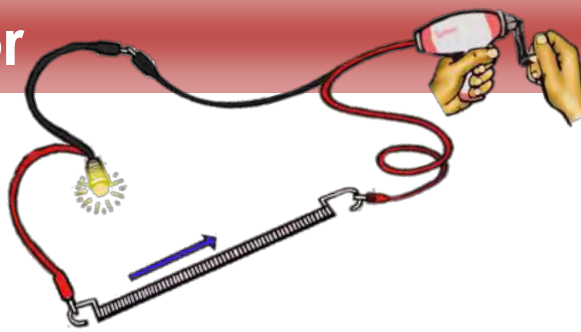
GENECON with output cord
Parallel Bulb Base
4 Bulbs (3.8V, 0 .3A)

Procedure

1. Connect the alligator clips on the output cord of the GENECON to either pair of terminals on the Parallel Bulb Base.
2. Put a bulb in the socket nearest the terminals being used. Light the bulb by rotating the handle of the GENECON briskly, but not excessively.
3. Place bulbs loosely in each of the three remaining sockets. As one student continues to operate the GENECON at constant speed, another student should screw in these bulbs one at a time. As the bulbs light one after the other, what effect is felt by the GENECON operator?
4. This effect can be experienced again as each of the bulbs is taken out of the circuit one-by-one in reverse order.

Activity 9

Variable Resistor



Materials

GENECON with output cord
1 Bulb (3.8V, .3A) in socket with leads
Nichrome coil
- *Pencil*

Procedure

1. Connect one lead from the GENECON to one end of the nichrome coil. The other lead should be attached to one of the leads from the bulb. The remaining lead from the bulb can then be connected to the opposite end of the nichrome coil (see sketch below).

2. Rotate the handle of the GENECON at a constant speed and observe the brightness of the bulb.

3. While continuing to operate the GENECON at a constant speed, have another student **slide** the lead from the bulb back and forth along the length of the nichrome coil. Observe the effect on the brightness of the bulb.

Key Concepts

1. Resistance to the flow of the electricity by a conductor increases with the length of the conductor; i.e., resistance is directly proportional to the length.

2. Observed changes in the brightness of the bulb reflect corresponding changes in the voltage supplied to the bulb.

3. The nichrome wire in the activity serves as a variable resistor or **rheostat** (a device for adjusting the current supplied to an appliance).

Teaching Tips

1. For an interesting variation of this activity, you will need a pencil. The teacher should expose the entire length of graphite core by cutting away the top layer of wood.

2. The length of graphite may then be substituted for the nichrome coil in the procedure described above, with similar results.

3. Pencil "lead" is really made of graphite, a form of carbon which is a conductor of electricity.

Activity 10

The Thermal Effect

Materials

GENECON with output cord
Exoergic Experiment Device
Thermometer
Nichrome wire

Procedure

1. Connect the leads on the GENECON to the Exoergic Device (a resistor combined with a liquid crystal thermometer).

2. Note the temperature in degrees Celsius on the liquid crystal scale. The correct temperature is the green number. If two numbers are equally vivid, the temperature is the odd number in between.

3. Rotate the handle of the GENECON at a steady rate for about 60 seconds. Read the temperature again.

4. For another simple variation of this activity, tightly wrap a 25 cm length of nichrome wire. Have a student record the initial temperature and then turn the handle of the GENECON briskly for about 20 seconds. Note the change in temperature.

Key Concepts

1. The mechanical energy required to operate the GENECON is converted into electrical energy which in turn is changed into thermal (heat) energy by the resistor in the Exoergic Device.

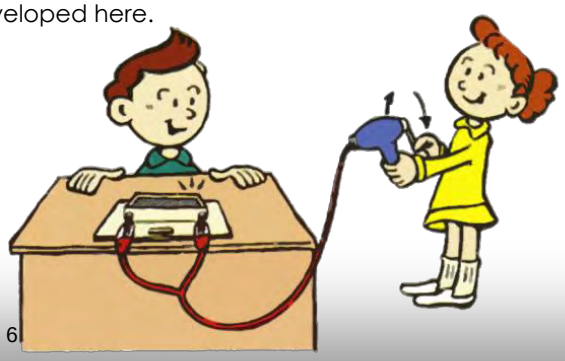
2. In the case of the nichrome wire, the heat from the internal resistance of the wires causes the liquid in the thermometer bulb to expand and move upward resulting in a higher reading on the thermometer scale.

Teaching Tips

1. The "thermal effect" which is observed and measured in this investigation is useful in explaining the operation of electric toasters and other electrical heating appliances.

2. This is a good place to remind students that much of the energy "lost" (see Activity #3) in energy transformations is in the form of heat.

3. The next activity (Short Circuits and Fuses) builds upon the concepts developed here.



Short Circuits and Fuses

Activity 11

Key Concepts

1. A short circuit is created when accidental contact occurs between wires of opposite polarity in a circuit before the electricity reaches the intended appliance (load).

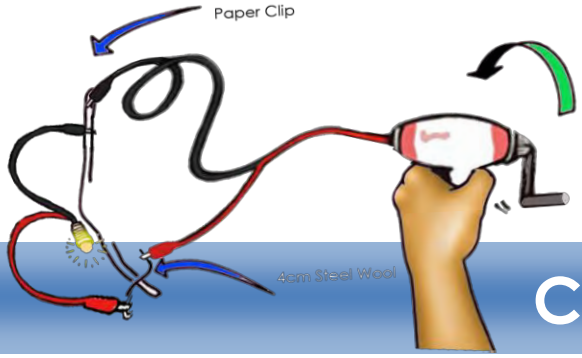
2. Short circuits offer very little resistance to the flow of electricity (Ohm's Law again), so wires will get hot and could start a fire.

3. Fuses are designed to melt when they get hot, thereby shutting down the dangerously overheated circuits.

Teaching Tips

1. Demonstrate how broken or worn insulation in electric cords can cause short circuits.

2. Explain why replacing blown fuses with copper pennies is a very dangerous practice.



Materials

GENECON with output cord
1 Bulb (3.8V, .3A) in socket with leads
- *1 Paper clip*
- *4 cm strand of steel wool, medium grade*

Procedures

1. Connect the bulb to the output cord of the GENECON in the usual manner. Disconnect **one** of the leads connecting the bulb and insert a 4 cm strand of medium steel wool, completing the circuit again. Have one student generate enough current to light the bulb brightly. Then have another student lay a straightened out paper clip across the two leads from the bulb for a few seconds (see sketch). What happened to the brightness of the bulb? (Caution: You are creating a **short circuit**. Do not touch the steel wool wire as it will get quite hot.) Remove the paper clip. The bulb should return to a normal brightness.)

2. Repeat the shorting-out process, as above, but continue it for a few more seconds. The steel wool wire should get red hot and then burn through, breaking the circuit. By turning off the circuit, the steel wool wire is functioning similar to a **fuse** which protects appliances and wiring in overheated circuits.

Current Detector

Activity 12

Key Concepts

1. The flow of electricity through a wire conductor produces a magnetic field around the wire. **(Oersted's Law)**

2. The needle of a compass is a permanent magnet. The deflection of the needle in this activity is a result of an interaction between its own magnetic field and the field created by the flow of electricity through the copper wire.

3. The polarity of the magnetic field reverses when the direction of the current changes.

Teaching Tips

1. Do not operate the GENECON for more than a few seconds at a time, since the circuit in this case is essentially shorted out.

2. The compass wrapped with copper wire is functioning much like an electric meter or current detector. One such meter which can detect and measure weak electric currents is called a **galvanometer.**

3. Discuss the Earth's magnetic field in a relationship to the operation of a magnetic compass. Would such a compass be useful on the moon?

Materials

GENECON with output cord
Magnetic compass
- *#24 Enameled copper wire*

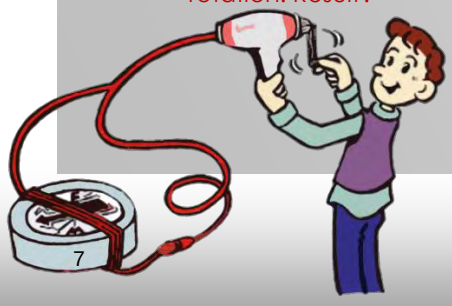
Procedure

1. Wrap a length of the copper wire around the magnetic compass. The rim of the case is grooved to facilitate wrapping the wire. About 6 or 7 wraps should be adequate. Scrape the clear insulation off the ends of the wires before connecting them to the leads of the GENECON.

2. Move the compass so that the needle aligns itself in the same direction as the wraps of wire.

3. Have a student turn the handle of the GENECON **slowly.** Even the slightest rotation will cause the needle to be deflected from its resting position, indicating the presence of the electric current.

4. Now reverse the direction of the GENECONs handle rotation. Result?



Magnetism

Materials

2 Rubber magnets
1 U-shaped magnet
Magnetic compass
"Mag Chips" (Iron filings do same work)
- *Small sheet of glass or plastic*
- *Meter stick, string*
- *Variety of objects made of metal, wood, plastic, rubber, etc.*

Procedure

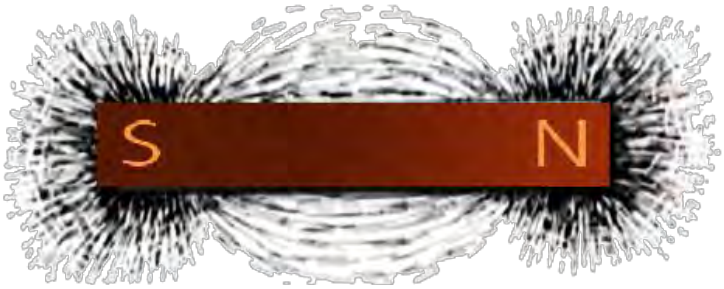
1. Use a rubber magnet to determine what kinds of objects have magnetic properties; i.e., are attracted to a magnet.

2. Place a rubber magnet under a piece of cardboard or a paper plate and some metal paper clips on top. Move the magnet around. What other materials can magnetism penetrate?

3. Tie a string around the middle of one of the rubber magnets and suspend it from a horizontally mounted meter stick. Adjust the string so that the magnet is balanced horizontally and can turn freely. In what geographic direction does its north pole point? Bring the north pole of one rubber magnet close to the north pole of the suspended magnet. What happens? Now approach the north pole of the suspended magnet with the south pole of the magnet in your hand. Result?

4. Place a rubber bar magnet under a clear sheet of glass or plastic. Sprinkle Mag Chips on the glass sheet while tapping it lightly with your finger. The pattern which emerges indicated the presence of a magnetic field surrounding the magnet. Place the two rubber magnets end-to-end with "unlike" poles facing each other (but separated by about 2 cm). What pattern results from this alignment? Change one of the magnets so that "like" poles are facing. What is the pattern of the magnetic field now? Replace the bar-shaped magnets with the U-shaped magnet. How does its field differ from the previous one?

5. The pointer of a compass is designed to point to the earth's magnetic North Pole. Place the magnetic compass within the field of one of the rubber bar magnets. Which pole of the bar magnet attracts the pointer of the compass? Is there a contradiction here?



Key Concepts

1. Most of the ordinary objects which are attracted by a magnet contain iron. However, certain other metals, like nickel and cobalt and alloys, may also be responsive. Copper, aluminum, zinc, silver, and gold are examples of metals which are not magnetic.

2. Magnets can be made in many different shapes.

3. Magnets always have two poles: the one which points north (when suspended freely) is called its north pole; the other pole is called its south pole.

4. Like poles attract each other; unlike poles repel.

5. Magnetism is a force and can produce motion.

6. Magnetic force is strongest at the poles.

7. Magnetism can occur through some intervening materials.

8. The north pole of a magnet is more correctly called the "north-seeking" pole.

9. A magnetic field surrounds each pole of a magnet.

Teaching Tips

1. The demonstrations of magnetic fields (with Mag Chips) can be performed on an overhead projector for easy visibility by the entire class.

2. The rubber bar magnets can be cut in half to demonstrate that magnets are always **bipolar.**

3. Do not store magnets in close proximity to a compass.

4. **Challenge Question:** Given two steel bars which are identical in every way, except only one is a magnet, is there a quick and simple way to identify the magnet without using any other objects except your hands?

Electromagnetism

Activity 14

Iron Core

	1	2	3	AVG.
100 turn coil				
200 turn coil				

Key Concepts

1. An electromagnet consists of a coil of wire, and iron core, and an electric current going through the coil.
2. When the current in the coils stops, the electromagnet loses its magnetism.
3. The strength of an electromagnet is directly proportional to the number of turns in the coil and the strength of the current.
4. Cores made of materials other than iron tend to be ineffective.
5. The polarity of an electromagnet depends upon the direction of the current flowing through the coil.

Teaching Tips

1. Call attention to those instances when one or two paper clips remain attached to the electromagnet even after the GENECON operation stops. This is called residual magnetism: it is temporary. Quickly reversing the rotation of the GENECONs handle will change the polarity of the electromagnet, and the paper clips will fall off.
2. Conceptually, the most important understanding here is that electricity and magnetism are interrelated phenomena; thus the term **"electromagnetism"** is appropriate.

Materials

GENECON with output cord
Electromagnet Set, consisting of
- *2 coils (100 turns; 200 turns)*
- *4 Core rods (iron, copper, aluminum, glass)*
- *4Rubber "donut" retainers*
- *Steel paper clips*

Procedure

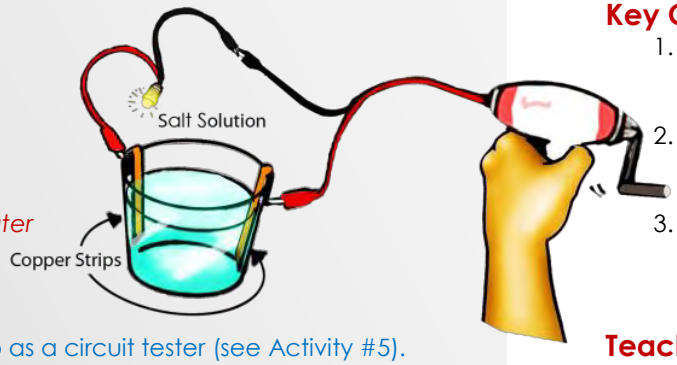
1. Connect the leads of the GENECON to the tabs of the 100-turn coil (the skinnier one). While one student operates the GENECON briskly, another student should attempt to attract the steel paper clips by touching them with the opposite end of the coil. Result?
2. Next, put up a rubber "donut" retainer on the very end of each of the four core rods. (The "donut" retainer will prevent the cores from falling out of the coils after they are inserted.) Start by inserting the **iron** core in the **100**-turn coil which is still connected to the GENECON. Touch the protruding end of the core to a pile of paper clips while the GENECON is being operated. How many paper clips can it pick up? Repeat this activity two more times, report the date in the table below, and calculate and average number of paper clips lifted with this coil.
3. Now change over to the **200**-turn coil and repeat the above procedures. Record the data in the table as before. Which coil produces the greater magnetism?
4. Try each of the other cores (copper, aluminum, glass) in the 200-turn coil. Results?
5. Use the 200-turn coil, the iron core, some paper clips, and the GENECON to determine how changing the **current** produced (by rotation speed of the GENECONs handle) affects the strength of the electromagnet.
6. Finally, approach the magnetic compass with the protruding end of the electromagnet. What effect does it have? Quickly reverse the direction of the current through the coil (by rotating the handle of the GENECON in the opposite direction). Result?

Activity 15

Salt Water Electrolyte

Materials

GENECON with output cord
1 bulb (3.8V, .3A) in socket
2 Coppers strips
- *Small clear plastic cup*
- *Table salt*
- *Stir stick*
- *Distilled and/or tap water*
- *Sandpaper*



Procedure

1. Set up the GENECON and bulb as a circuit tester (see Activity #5). Pour a small mound of table salt on to a piece of paper. Test the dry salt with the two open leads to determine if it is a conductor of electricity. (Since the bulb does not light, apparently salt is a non-conductor.)

2. Lightly use the sandpaper on the copper strips to remove corrosion. Bend the tops of each strip so that they can be suspended from the plastic cup. Fill the cup with tap water. Connect the open leads of the GENECON circuit tester to the copper strips as in the sketch above. Operate the GENECON to see if the water will conduct electricity and light the bulb. (Water is a poor conductor so this is not likely).

3. Now add about one teaspoonful of the table salt to the cup and stir it to facilitate its going into solution. Test the conductivity of the salt water. (If the bulb does not light, add a little more salt.)

Key Concepts

1. Dry table salt is not a good conductor of electricity.

2. Pure water is not a good conductor of electricity

3. An electrolyte is a solution which will conduct electricity. Salt is an electrolyte.

Teaching Tips

1. Students must understand that while pure water is not a good conductor of electricity, most water contains impurities which allow it to conduct current. If the current is large, as it is in houses and elsewhere, the combination of water and electricity can be dangerous, even fatal.

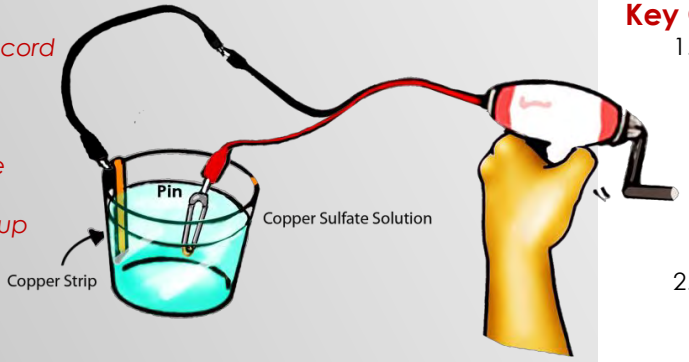
2. The roles of **ions** in forming electrolytes should be discussed here.

Activity 16

Electroplating

Materials

GENECON with output cord
Polarity tester
1 Copper strip
- *28 Grams of Copper Sulfate*
- *Safety pin*
- *Clear plastic cup*
- *Warm water*
- *Tissue paper*



Procedure

1. Dissolve 28 of copper sulfate in a clear plastic cup about ¾ full of warm water.

2. Lightly sand the copper strip prior to attaching it to the **positive** lead of the GENECON. Check the polarity with the tester provided if necessary (see Activity #2 for details). Attach the other GENECON lead to the safety pin. Immerse the copper strip and the safety pin in the copper sulfate solution at opposite sides of the cup. (You may wish to tape the leads to the lip of the cup to prevent slippage.)

3. Rotate the handle of the GENECON **slowly** in a **clockwise** direction for about 15-30 seconds. Almost immediately a dark deposit will form on the safety pin. Remove the red and gently wipe off the deposit. Note that the pin is already acquiring a light copper coating. Continue this same procedure, being sure to wipe off the dark deposits every 30 seconds or so. In a few minutes the safety pin should have a uniform copper appearance.

Key Concepts

1. Electroplating is the process of coating one metal with another metal by means of passing an electric current (DC) through an electrolyte. The "donor" metal becomes the positive electrode, and the "receiver" metal is the negative electrode.

2. The process of electroplating is essentially a special kind of electrolysis reaction.

3. Electroplating is commonly used to deposit a thin layer of a valuable metal (silver, nickel, copper) on the surface of a less valuable metal (iron or steel).

Teaching Tips

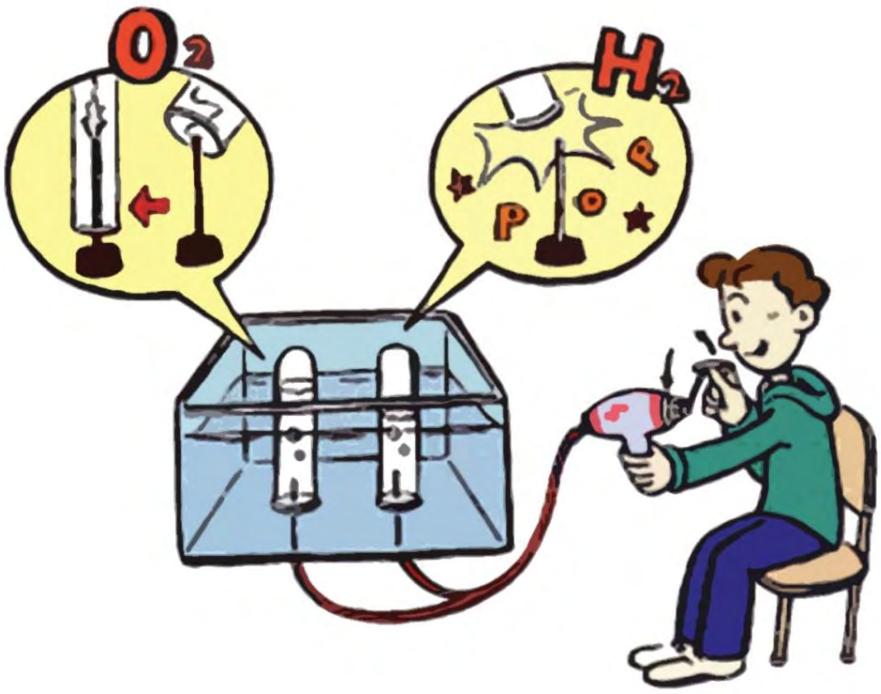
1. **Caution! Copper sulfate is poisonous. The solution should be prepared in advance by the teacher.**

2. The deposition of oxides on the safety pin will interfere with the planting process if not wiped off periodically.

3. Metals can be unplated by reversing the direction of the current.

Electrolysis of Water

Activity 17



Key Concepts

1. Water molecules can be decomposed by strong electric current into the elements which make them up **hydrogen** and **oxygen**.

2. The observed ratio of hydrogen or oxygen gas produced by electrolysis is in direct proportion to the number of atoms of each in a water molecule: 2 to 1.

3. Hydrogen is an excellent fuel and will burn in the presence of atmospheric oxygen.

4. Oxygen is not a fuel but does support combustion. Fuels burn quite vigorously in the presence of pure oxygen.

5. An electrolyte is necessary to conduct the electricity in the above process. Electrolytes ionize when they dissolve.

Teaching Tips

1. Caution: Sodium hydroxide is caustic, so use plenty of water to rinse off any solution you may get on your hands.

2. Be sure **safety goggles** are worn during the testing of the gases.

3. Discuss possibility of obtaining large quantities of hydrogen (an excellent fuel) by means of the electrolysis of abundant ocean water.

Materials

GENECON with output cord
Electrolysis Apparatus
- *2% sodium hydroxide solution, 500 ml*
- *Matches*
- *Wood splints*
- ***Safety goggles***

Procedure

1. Fill the tank with the sodium hydroxide solution which will serve as an electrolyte. Using the plastic test tube holder provided, fill up the two test tubes with the solution and invert them over the electrodes. There should be no air in the tubes.

2. Connect the leads of the GENECON to the electrodes underneath the tank, as in the sketch to the right. The positively charged, color-coded electrode (see Activity #2) will become the site for the collection of oxygen gas. The hydrogen gas will collect at the negative electrode. Rotate the handle of the GENECON in a clockwise direction only. If reversed, both gases may collect in the same tube, creating a potentially dangerous mixture.

3. Prepare your students for some real work. They can take turns operating the GENECON for about a 20 – 25 minute period until both tubes are filled with gas.

4. Observe the formation of the gas bubbles at each electrode. Note that when the GENECON stops, so do the bubbles. Compare the rate at which each tube fills with gas by displacing the electrolyte solution. What is the apparent ratio?

5. When the tubes are full, put on safety goggles. Remove the tube above the negative electrodes using the test tube holder. Keep it upside down while testing the mouth of the tube with a match. Result?

6. Now test the tube above the positive electrode by thrusting a glowing wood splint in the neck of the inverted tube. Result?

Motor Manipulations

Materials

GENECON with output cord
Test leads with alligator clips
Capacitor
- *DC motor (constructed in Activity #19)*

Procedure

1. Connect the leads of the GENECON to the lead-in wires of the motor you are about to make on the next page. Rotate the handle of the GENECON at a moderate rate. If the armature does not spin, give it a gentle push with your finger. When the motor is operating smoothly, notice the direction the armature is spinning.

2. Try rotating the handle of the GENECON in the opposite direction. Result? Reverse the leads of the GENECON. Result?

3. What happens when the stack of 3 magnets is turned upside down?

4. Connect two or more motors together in **series** with the GENECON. Compare and contrast the results with Activity #7. (Bulbs in Series).

5. Connect two or more motors together in **parallel** with the GENECON. Compare and contrast the results with Activity #8 (Bulbs in Parallel).

Key Concepts

1. A current passing through a wire produces a magnetic field. (see Activity #17.)

2. A magnetic field exerts a force on a movable wire carrying an electric current (the motor effect). See Activity #18.

3. When a wire carrying a current is formed into a coil (in this case, an armature), the strength of the motor effect is greatly increased.

4. Changing the polarity of either the magnet or the electric current moving through the armatures results in changing the direction of rotation of the armature.

5. An electric motor converts electrical energy into mechanical energy.

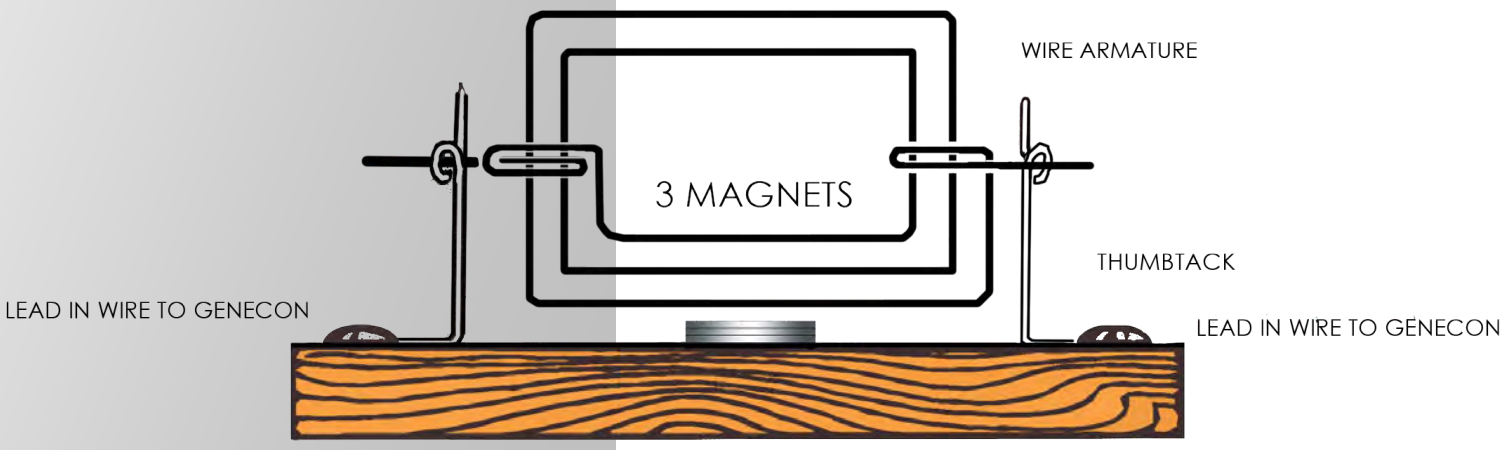
Teaching tips

1. Allow students to try out most of the suggested activities at **their** initiative. They will surely think up some very good ideas on their own.

2. Make the capacitor available to be used in conjunction with the above explorations.

3. Encourage some students to build another armature which has "6 turns" of wire and compare its operation to the "3 turn" armature.

4. Remind the students that the GENECON they are using also functions as a motor when an electric current is fed into it. Would the little DC motor function as a generator if the armature were given a spin? If you have a **galvanometer** (a sensitive current detector), connect the leads on the DC motor to it and give it a try.

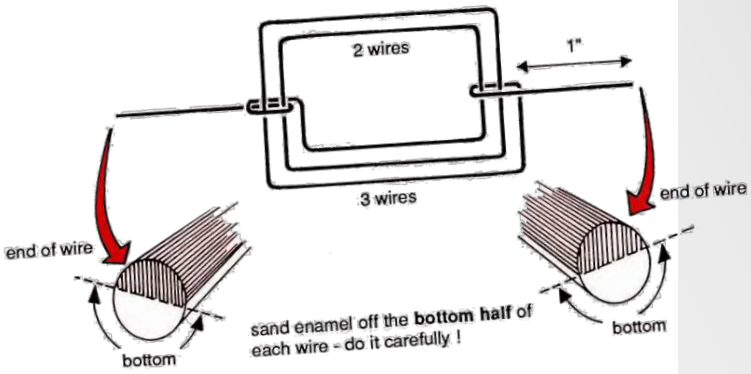


SIDE VIEW

Let's Make a Motor!

Activity 19

This small DC motor has been built quite successfully by hundreds of students (grade 4 and up) and their teachers. It is very inexpensive, and the necessary materials can be easily acquired. Younger children will require teacher assistance. The completed motor may require some minor adjustments to get it going: that's quite "normal". The GENECON will provide ample voltage to spin the armature at high rate.



Materials

- *45 cm, #24 enameled copper wire*
- *(3) 1 in. rectangular ceramic magnets*
- *(2) 10 cm lengths of bell wire*
- *1 Small block of wood (4 in. long furring strip)*
- *Paper clips, thumb tacks, fine sandpaper*

Procedure (Motor Assembly)

1. **Making the Armature**
   Wind the enameled copper wire into a rectangular coil using the end of the wood block as a mold. Neatness counts! Form the side loops tightly and make sure they are in the center of the sides of the armature coil. See sketch below. It is important that the clear enamel be removed from **only the underside** of the "arms" of the armature coil.

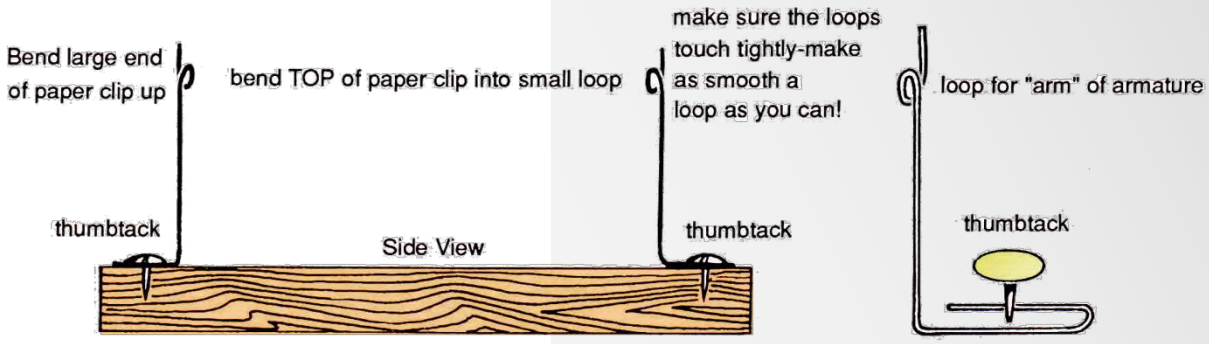
2. **Making the Motor Base and Support**
   Bend two regular paper clips to form the **motor supports.** Thumbtacks hold the motor supports (paper clips) to the wood base. The bell wires should be stripped at each end; wrap one end of each wire around and under the thumbtacks.

3. **Putting it All Together**
   The assembled motor should look like this. The 3 ceramic magnets should be stacked on top of each other. The armature should spin smoothly and just barely pass over the magnets. The motor supports (paper clips) must not wiggle around!

4. **Trying it Out!**
   Connect the GENECONs leads to the motor's lead-in wires. Generate a current. If the armature does not start spinning, or if it seems to just "tremble", give it a tap with your finger. Most motors will not self-start. Do not keep supplying current if the armature doe not spin!

5. **Troubleshooting**
   Most motors require some adjusting! Check to see that the underside of both "arms" has had all the clear insulation removed. You should see bright shining metal along its entire under-surface. Make sure armature "arms" are not binding against the motor support loops. There should be 1/8 inch clearance on each side for free movement. Check all metal-to-metal connections.

For Clever things to do with your motor, see activity #18.



The Motor Effect

Materials

GENECON with output cord
Electric Swing Apparatus
- *Ring-stand with clamp*

Procedure

1. Set up the apparatus as in the sketch below. The height of the clamp should be adjusted so that the bottom of the swing is exactly between the poles of the U-shaped magnet.

2. Make sure that the swing can move freely. Connect the leads of the GENECON to the terminals on the wooden swing mount.

3. Rotate the handle of the GENECON rapidly but only about ¼ to ½ turn. What direction did the swing move?

4. Now reverse the handle rotation-again only about ¼ to ½ turn. Result?

5. Change the polarity of the electric current going through the swing by reversing the GENECON connections on the wooden swing mount. Result?

6. Finally, rotate the horseshoe magnet so that the opposite pole is within the swing. Result?

Key Concepts

1. A current passing through a wire produces a magnetic field around the wire **(Oersted's Law).**

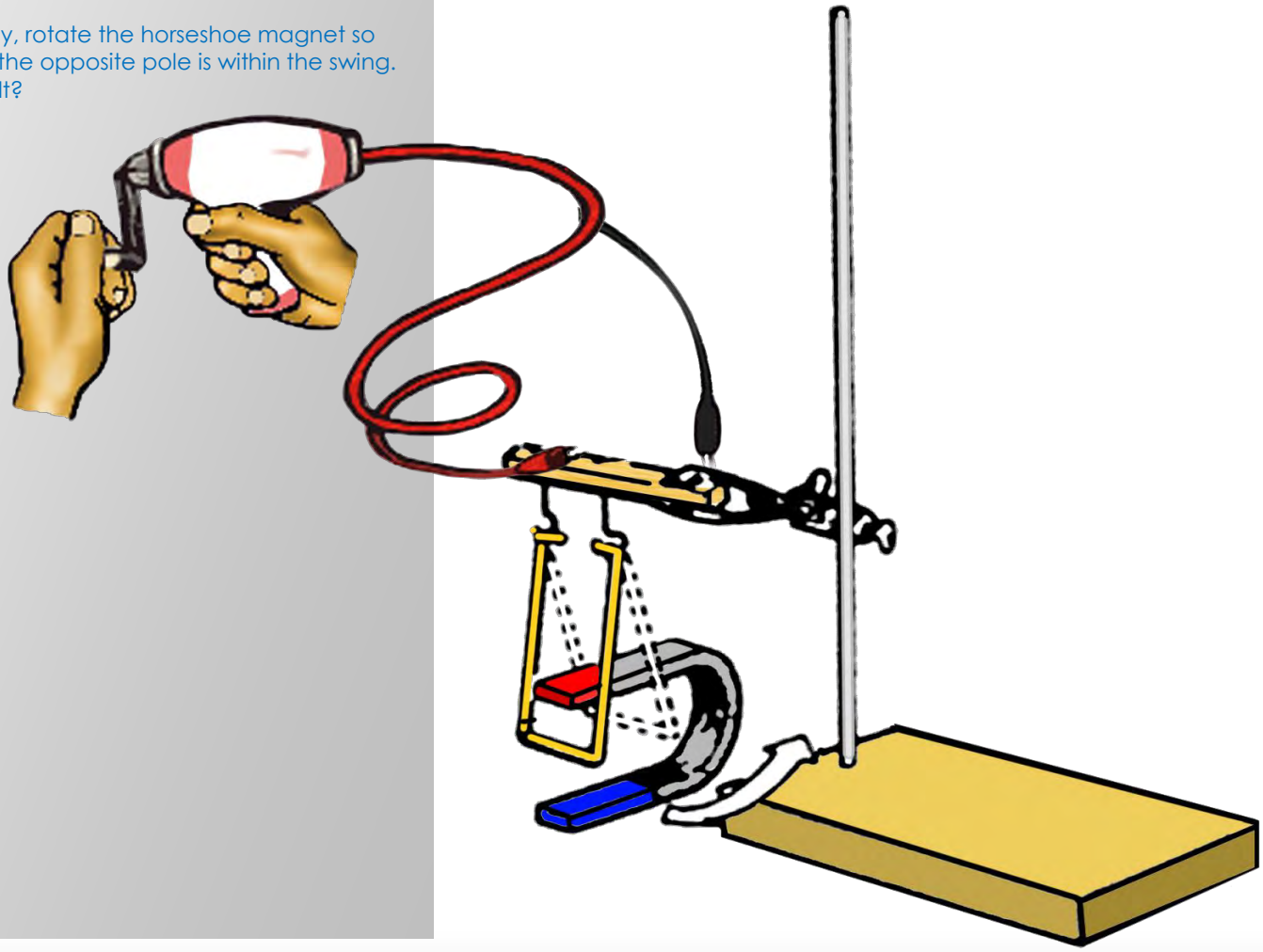
2. A magnetic field exerts a force on a movable wire carrying an electric current (the motor effect).

3. Changing the polarity of either the magnet or the electric current moving through the wire (the swing) results in changing the direction of the motion of the wire.

Teaching Tips

1. Depending on the sophistication of the students, you may wish to discuss the "**left-hand rule**" which relates the direction of the current and the magnetic field to the direction of the resulting force.

2. The best rocking action of the swing can be obtained by alternating ¼ rotations of the GENECON.

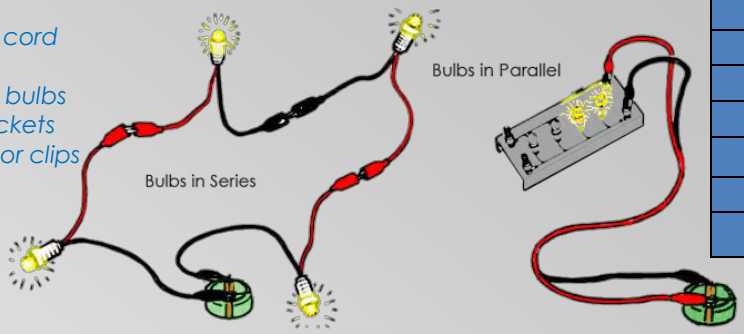


Energy Storage

Activity 21

Materials

GENECON with output cord
Capacitor
Parallel Bulb Base, with bulbs
4 Bulbs (3.8B, .3A) in sockets
2 Test leads with alligator clips
- *Stopwatch*



Turns	Seconds
10	
20	
30	
40	
50	
60	

Procedure

Part 1

1. Attach the leads of the GENECON to the terminals of the capacitor (a device for storing electrical energy). Charge-up the capacitor by rotating the handle of the GENECON clockwise about 10 times. Release the handle of the GENECON; it will begin to turn as the stored electricity feeds back into the GENECON. Allow the capacitor to discharge until the handle no longer turns.

2. Recharge the capacitor by once again turning the handle of the GENECON in a clockwise direction about **60 times.** You will notice that at the beginning, much more effort is required to charge the capacitor than at the end. Continuing to turn the handle when the capacitor is fully charged accomplishes nothing. But at what point does it reach full charge? Let's find out!

3. The table above is helpful in determining the approximate number of handle rotations required to fully recharge the capacitor. The control variable will be the number of seconds the recharged capacitor will light a single bulb. Attach the fully charged capacitor to the leads of a bulb and, using a stopwatch. Carefully determine how long it remains lit. Enter the result in the space opposite "60 turns" in the data table.

4. Allow the capacitor to remain connected to the bulb for about 30 seconds after the bulb goes out to assure that it discharges completely. This should be done after each subsequent test. Also, have a student disconnect one of the leads from the GENECON to the capacitor **immediately** after the requisite number of recharging turns has been reached.

5. Complete the remaining tests, enter the data in the table, and reach a reasonable conclusion as to the optimum number of turns required to fully recharge the capacitor.

Part 2

1. Now the optimum number of handle rotations for full charge has been determined, let us extend our investigations into the effects of placing additional bulbs (up to four) in the circuit. In these tests, always allow the capacitor to discharge completely prior to recharging and always use the same optimum number of turns for recharging.

2. First, conduct some tests on adding bulbs to **series** (end-to-end). Use a stopwatch to measure the time the bulbs stay lit. Also note any changes in apparent brightness as additional bulbs are added. Record results in Table "S" below.

3. Now let's see what happens when the same tests are conducted on bulbs in the **parallel** bulb base. Start with one bulb and proceed to the test two, three and then all four. Note any changes in brightness. Record results in table "P".

Key Concepts

1. A capacitor is a device for storing electrical energy.

2. There are significant differences in the manner in which series circuits and parallel circuits consume electricity from a finite energy source.

3. In comparison testing, certain variables must be carefully held constant (i.e. "controlled").

Table "S"				
Bulbs in Series				
1	Trial #1	Trial #2	Trial #3	Average
2				
3				
4				
	Second Bulbs Lit			
Comments on Brightness				

Table "P"				
Bulbs in Parallel				
1	Trial #1	Trial #2	Trial #3	Average
2				
3				
4				
	Second Bulbs Lit			
Comments on Brightness				

Teaching Tips

1. The black double-stripe on the capacitor represents the negative terminal. If the capacitor is completely discharged, polarity is of little concern. However, maintaining a consistent polarity between tests is highly desirable.

2. When recharged, the capacitor may be used as another electrical energy source for many of the activities described in the manual.

Activity 22

An Unexpected Storage Cell

Materials

GENECON with output cord
Polarity Tester
1 Copper strip
1 Zinc strip
- *Aluminum foil or strip*
- *Clear plastic cup*
- *table salt*
- *Stir stick and sandpaper*
- *Test lead wire*

Procedure

1. Prepare the electrolytic solution by filling the cup about ¾ full of water. Add salt and stir until it will no longer dissolve, creating a saturated solution.

2. Make a strip of aluminum (comparable in size to the copper and zinc strips) by folding aluminum foil several layers thick. Lightly sand the copper and zinc strips to remove oxidation. Connect the **positive** lead from the GENECON (check with Polarity Tester; see Activity #2) to the copper strip and the negative lead to the zinc strip.

3. Insert each metal strip into the solution. Do not let the two strips touch each other. Keep the leads from the GENECON above the solution. You may wish to clip them to the lip of the cup to keep them from moving around.

4. Rotate the handle of the GENECON **clockwise** vigorously for about 30 seconds. Note the bubbles rising from the zinc strip Release the handle. After a very short pause, the handle will begin turning very slowly on its own! In most instances, the handle will rotate spontaneously for about 1 minute.

5. This charging-discharging sequence can be repeated many times. Note any color changes in the solution.

6. Prepare a fresh salt solution. Substitute the aluminum strip for the Zinc strip and repeat the activity. Result?

Key Concepts

1. Electrical energy can be stored in chemical systems.

2. The GENECON is putting electrical energy into the copper-zinc (or aluminum)-salt water system. This **electrochemical** system thus has a higher energy state. The discharge of electrical current back into the GENECON, causing it to behave like a motor, is a restoration of energy equilibrium.

3. While the electrochemistry of this system is more complex than it may appear, it is probable that a difference in concentration at the two electrodes results in a reversal of the reaction.

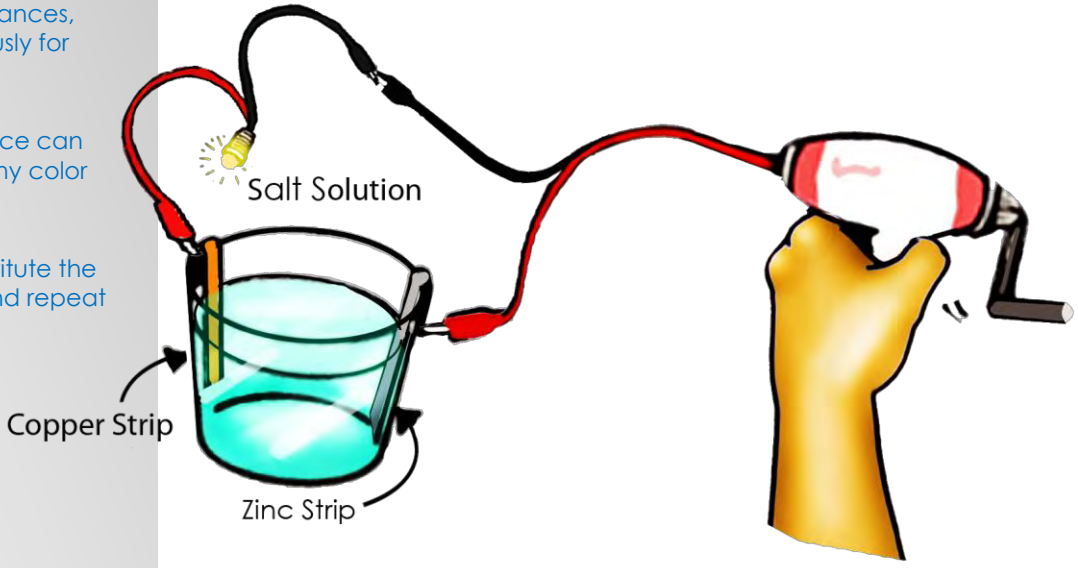
Teaching Tips

1. Polarity is especially important in this activity.

2. Try a strip made of iron or steel at the negative electrode. How does it compare with the other metal strips?

3. The metal strips which serve as electrodes should be sanded lightly between each use. The aluminum strip will not require sanding, however.

4. You may wish to have more advanced students investigate several variables which would shed light on the properties of this system: (1) what is the relationship between the charging time and the number of handle rotations during discharge? Is there an optimum charging time? (2) Which metal, aluminum or zinc, provides the greater discharge capacity? (3) What is the effect of stirring the solution immediately after charging the system? (4) How long will the electrochemical system retain its charge?



New GENECON Kit Inventory of Equipment

Quantity	Product Code	Product Description
1	N99-B-2637-002	GENECON Manual: "Adventures with the GENECON"
2	N99-B10-2632	GENECON with output cords
1	N99-B-2637-015	Exoergic Experiment Device (5Ω)
1	N99-B-2637-020	Parallel Bulb Base, Simple form (with 4 bulbs-3.8V, 0.3A)
1	N99-B-2637-025	Electric Swing apparatus (Incl. U-shaped magnet, wire swing; wood swing mount)
1	N99-B-2637-035	Capacitor (5.5V, 1.0F). FS TYPE
1	N99-B-2637-040	Electrolysis Apparatus (incl. acrylic tank + 2 test tubes + tongs)
1	N99-B-2637-045	Magnetic Compass, OG-40
1	N99-B-2637-050	Electromagnet Set (2 solenoid coils–x100, x200; one each copper, aluminum, glass and iron; 4 rubber "donut" retainers)
1	N99-B-2637-055	Polarity Tester (diode)
1	N99-B-2637-060	Nichrome coil (solenoid type), 500W (100V) with hooks
4	N99-B-2637-065	Bulbs in sockets with leads (3.8V, 0.3A)
2	N99-B-2637-070	Rubber Bar Magnet
4	N99-B-2637-075	Copper Strips, Length: 10 cm
2	N99-B-2637-080	Zinc strips Length: 10 cm
2	N99-B-2637-085	Test leads with alligator clips (36cm long)
1	N99-B-2637-095	Metal backed Thermometer
1	N99-B-2637-100	Nichrome wire 0.4mm in diameter (8.6ohm/m), approx. 1 meter
10	N99-B-2637-105	Extra bulbs (3.2V, 0.3A)
2	N99-B-2637-110	Bulbs #112 (1.5V) for storage battery activity
1	N99-B-2637-115	"Mag Chips" Jar, 25g

* In the "materials" section of the 22 Activities, items which are marked with a bullet (○) are to be provided by the teacher

* All componets of the GENECON Kit can be purchased separately

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