



A TEACHING UNIT ON

ELECTRICITY

FEATURING

THE HISTORIC FOLSOM POWER HOUSE

CALIFORNIA SCIENCE STANDARDS COMPATIBLE FOR GRADE 4

Teacher's Guide

written by
Steve Gregorich
in cooperation with
California State Parks and
The Gold Fields State Park District

This instructional package is composed of two files: an electricity unit and this teacher's guide. Teachers who plan to use the unit should download both files.

Credits

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How to Use the Package

The package is composed of two files: the electricity unit and this teacher’s guide. Teachers who plan to use the unit should download both files.

Document 1: The Electricity Unit

Part A: Lesson Plans provides a sequence of 14 instructional lessons that will prepare children for a field trip to the Folsom Powerhouse and, at the same time, help to meet the California standards for fourth grade science instruction.

Part B: Models provides 4 additional construction activities. Pages may be used as handouts.

Part C: Investigations gives guidance for 4 investigations related to the previous lessons and model construction activities. Pages may be used as handouts

Part D: Handouts

Document 2: This Teacher’s Guide

How to Use the Instructional Package. Describes three sections of the instructional package.

Addressing California Science Standards. Standards are keyed to specific lessons and activities.

The Lesson-By-Lesson Guide. Explains the science, gives suggestions about materials, advice on teaching techniques, and occasional follow up lesson ideas.

Arranging a Field Trip. Provides contact, reservation and travel directions for the Historic Folsom Powerhouse.

Addressing Science Standards

These lessons are designed to help children meet all the “Physical Science” and “Investigation and Experimentation” standards for fourth grade adopted by the California State Board of Education. (See *Science Content Standards for California Public Schools: Kindergarten Through Grade Twelve*, published by the California Department of Education, 2000.) Charts on the next two pages identify the unit activities in which each standard element can be met.

Meeting Fourth Grade Physical Science Standards

Standard	Activities that Address the Standard
1. Electricity and magnetism are related effects that have many useful applications in everyday life. As a basis for understanding this concept:	
a. <i>Students know</i> how to design and build simple series and parallel circuits by using components such as wires, batteries, and bulbs.	Part A. Lesson 1: A Circuit; Lesson 2: Switch in a Circuit; Lesson 3: Switches at the Folsom Powerhouse Lesson 4: Exploring Circuits, Series and Parallel Lesson 5: Predicting Circuits, Series and Parallel
b. <i>Students know</i> how to build a simple compass and use it to detect magnetic effects, including Earth's magnetic field.	Part B. Construct Your Own Magnet and Compass
c. <i>Students know</i> electric currents produce magnetic fields and know how to build a simple electromagnet.	Part A. Lesson 6: Electromagnets; Lesson 7: Electromagnets Pull, Push, and Spin
d. <i>Students know</i> the role of electromagnets in the construction of electric motors, electric generators, and simple devices, such as doorbells and earphones.	Part A. Lesson 8: Electromagnets in Our Lives; Lesson 9: Electromagnets at Folsom Powerhouse Lesson 10: Moving Water Can Push Things Lesson 11: Moving Water at Folsom Powerhouse Lesson 12: Features of the Folsom Powerhouse Lesson 13: Energy Changes at Folsom Powerhouse Lesson 14: Electric Generation at Folsom Powerhouse Field Trip to Historic Folsom Powerhouse
e. <i>Students know</i> electrically charged objects attract or repel each other.	Part A. Lesson 6: Electromagnets Lesson 7: Electromagnets Pull, Push, and Spin Lesson 8: Electromagnets in Our Lives Part B. Construct Your Own Magnet and Compass Part C. How Do Electromagnets Affect a Compass? Field Trip to Historic Folsom Powerhouse
f. <i>Students know</i> that magnets have two poles (north and south) and that like poles repel each other while unlike poles attract each other.	Part A. Lesson 6: Electromagnets Lesson 7: Electromagnets Pull, Push, and Spin Lesson 8: Electromagnets in Our Lives Part B. Construct Your Own Magnet and Compass Part C. How Do Electromagnets Affect a Compass? Field Trip to Historic Folsom Powerhouse
g. <i>Students know</i> electrical energy can be converted to heat, light, and motion.”	Part A. Lesson 7: Electromagnets Pull, Push, and Spin Lesson 8: Electromagnets in Our Lives; Lesson 9: Electromagnets at Folsom Powerhouse Lesson 13: Electric Generation at Folsom Powerhouse Field Trip to Historic Folsom Powerhouse

Meeting Fourth Grade Investigation and Experimentation Standards

Standard	Activities that Address the Standard
<p>6. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:</p> <ul style="list-style-type: none">a. Differentiate observation from inference (interpretation) and know scientists' explanations come partly from what they observe and partly from how they interpret their observations.b. Measure and estimate the weight, length, or volume of objects.c. Formulate and justify predictions based on cause-and-effect relationships.d. Conduct multiple trials to test a prediction and draw conclusions about the relationships between predictions and results.e. Construct and interpret graphs from measurements.f. Follow a set of written instructions for a scientific investigation."	<p>Part A. Lesson 4: Exploring Circuits, Series and Parallel Lesson 5: Predicting Circuits, Series and Parallel</p> <p>Part C. Investigations What Affects the Brightness of Lights in a Circuit? What Affects the Power of an Electromagnet? How Do Electromagnets Affect a Compass? What Affects the Speed of a Water Turbine? Carrying Out Your Own Investigation Part 1: The Question Part 2: The Investigation Part 3: Reporting Your Results</p>

The Lesson-by-Lesson Guide

Introduction

The lesson-by-lesson guides that follow expand upon the lesson plans. They contain:

1. explanations of the science for each lesson,
2. suggestions for preparing materials, and
3. teaching techniques appropriate for each lesson.

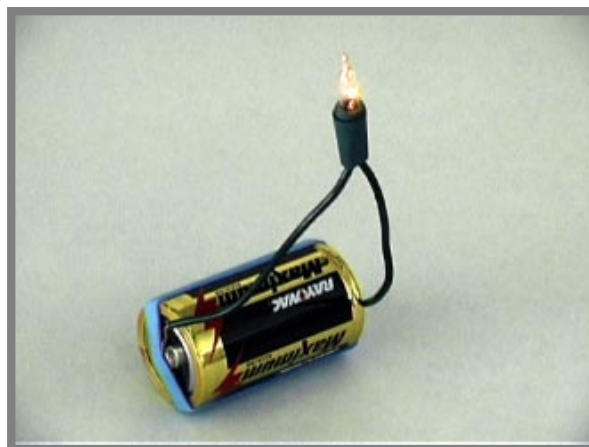
Part A: Lesson Plans

Lesson 1. A Circuit.

The Science

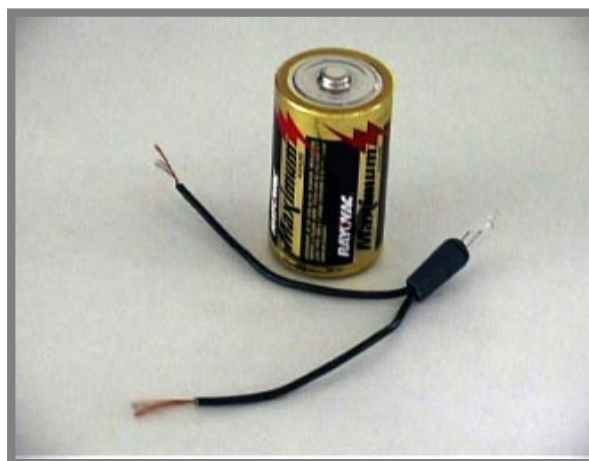
In this lesson children use the simplest-possible materials to create an electrical circuit. The word “circuit” comes from the word “circle.” Electricity flows through a circuit in a circular path. Look at the photo on the right.

Negatively charged particles (electrons) leave from the negative side of the battery, through the wire, through the bulb and then back into the battery on the other (positive) side. The flow of electrons takes a circular path – thus the term “circuit.”



The Materials.

- light bulb and socket. You probably already have more than enough of these at home in your garage or attic. If you have some strings of old holiday lights that no longer light up; you can give them a second life in your classroom. Just cut up the string so that the 2 wires going to each bulb are 2 to 6 inches long. Strip about 1/2” of the rubber coating from the end of each wire. You can get a pair of wire strippers at the hardware store. Test each bulb with a battery to make sure it lights up. There will be one or two bulbs that don’t work – they caused the string to go bad – but the rest of the bulbs will be just fine. If you have no old strings, send a note home to ask parents if they have some. You’ll probably get enough to last you the rest of your teaching career!
- D cell battery (standard-sized flashlight battery). If your school does not provide them, you can get large quantities inexpensively at a warehouse store. Alkaline batteries will give you the best service. Some may become completely discharged during the unit, but I often find they will last for several years. You can test them each year by hooking them up as shown to see if they light a bulb sufficiently. If convenient, you may substitute C or AA cell batteries.
- A thick rubber band that will fit tightly around the battery. This type rubber band is often used in the vegetable section of the grocery store. The kind that work best for me are the ones wrapped around broccoli. My wife drops them in the silverware drawer whenever she gets one. It is amazing how quickly they accumulate. Of course, you can find other rubber bands that will substitute. They should fit tightly to hold the ends of the wires securely against the ends of the battery. If the rubber bands you have are too loose, try doubling them to make them tighter.



Teaching Techniques

Since a simple circuit will only work one way, this is a natural lesson for guided discovery. Given the materials and asked to get the light bulb to light up, the children soon discover that the only way to do that is to touch the bare ends of the wires to each side of the battery – thus producing a circular path for the flow of the electrons.

To get the kids to draw the correct generalization, you can ask them questions like: “What did you do to get the light bulb to light up?” and “What ways did not work?” and finally, “To get the light bulb to light up, what things were ALWAYS the same?” Give them plenty of time to try different things and don’t be surprised if they do not state the generalization right away. For some kids, even very bright ones, this generalization may finally click only after it has been reviewed and experienced several times – that’s normal.

Have the children make a drawing of how they arranged the materials to get the light bulb to light up. Kids have an easier time visualizing and explaining their experiences when they can make a drawing and label it.

Explain to the children how “electrons” flow from the battery, through the wire and bulb, and back again to the battery. Explain the relationship between the word “circuit” and “circle.” Remember that kids never *discover* things like vocabulary – which is learned through direct instruction. Direct instruction from you about these terms is very important to formalize the learning that occurred in the earlier, discovery part of the lesson.

Follow Up Lesson Ideas

When this lesson is over, you may feel that many of the kids had a good time, but probably still don’t quite get the idea of a circuit. You will probably be right. That is why it is important to review the new terms at the beginning of science lessons over the next several days and apply them in many ways. When working with these lessons, frequently ask kids to show you the path the electricity takes through the circuit by tracing it with their finger. When they make drawings, have them label the parts of the drawings using the terms “wire conductor,” “bulb,” “battery,” “circuit,” and “electrons.”

You can let the kids take their circuit materials home and encourage them to explain the circuits to their parents. If you get good parent/child discussions going on at home, they will help keep the children involved, interested, and learning.

If you do acquire a large quantity of old holiday lights, you could send the kids home with a set of 5-10 lights to come up with different arrangements of circuits. The kids bring their arrangements to class to demonstrate and discuss.

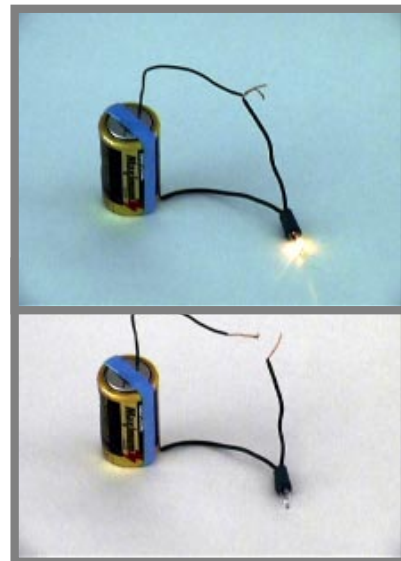
Lesson 2: Switch in a Circuit.

The Science

The children take the next step in understanding a simple circuit by making a “switch” for the circuit. A switch opens and closes the circuit so that the electrical flow is stopped and then started again. The flow of electrons cannot continue through the circuit if the circuit is “broken” or “open” at any point. When the circuit is broken, the light goes out. When the circuit is reconnected or “closed,” the electrons can flow through the circuit again and the bulb lights up.

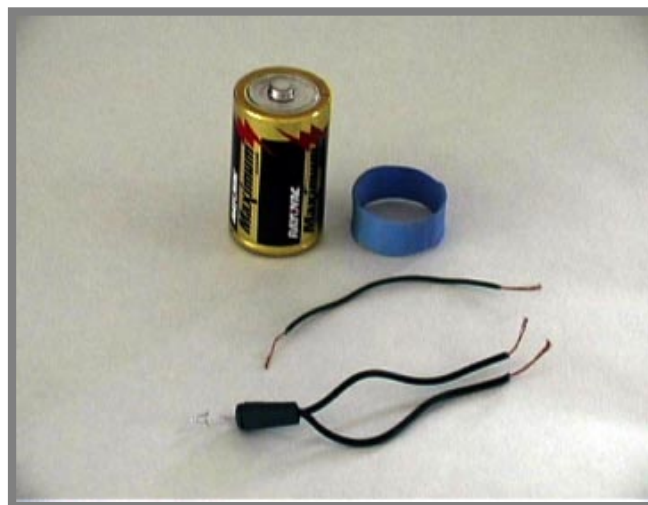
Actually, when the kids worked on the previous lesson, they turned the light bulb off and on many times just by touching the wires to the battery – each time they did that, they were witnessing a switch in action. In this lesson, we make the “switching” more obvious by adding another length of wire to the circuit so we can twist and untwist the ends.

In the top picture on the right, the ends of the wire are twisted together so that we get a complete, “closed” circuit. The light bulb will light up. In the next picture the wires have been separated – the circuit is now “open” so electrons cannot make a complete circuit through it. The light bulb does not light up.



The Materials

- light bulb and socket (see materials suggestions in previous lesson)
- a thick rubber band (see materials suggestions in previous lesson)
- a D cell battery (see materials suggestions in previous lesson)
- a piece of wire about 6” long. You will find that there are extra lengths of wire left over when you cut up an old holiday light set. There will probably be enough of it to make all the 6” long pieces you need. Of course, you will need to peel away the rubber insulation from both ends of the wire or have the children do it.



Teaching Techniques

Always begin with review of the important ideas and terminology from the previous lesson so they will be fresh in the children’s minds. Ask some children to show how to get the light bulb to light up in the circuit. Review the term “circuit.” You could draw several different configurations of the battery, bulb and wires on the board and ask the class “Which of the drawings shows a circuit that would light the bulb?”

The children will not spend as long adding the extra wire to the circuit – this should be pretty easy for them. When they cause the light to go off and on several times and you think they understand that twisting the wires together and untwisting them is a model for a switch, have them draw a circuit with a switch and label all the parts.

Follow Up Lesson Ideas

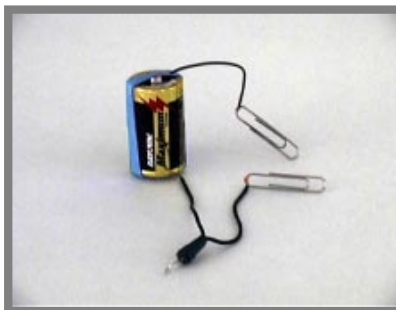
There are several examples of switches in our lives that are easy to see. For instance, a doorbell switch is a plastic button that pushes two wires together to complete the circuit. You may send a note home to parents asking them to donate any old, simple electrical switches like doorbell buttons. In class, children could make large, blowup drawings of the doorbell button, label the parts, and explain how it works. More importantly, they could wire the doorbell button into their simple circuits and flash the light off and on by pressing it. Doing several applications of switches like this should get the idea firmly and permanently across.

Lesson 3: Old Switches at the Folsom Powerhouse

The Science

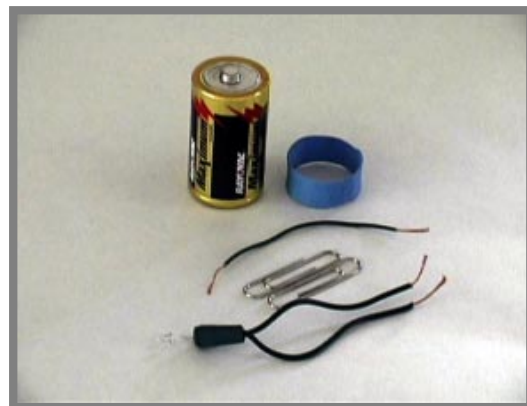
Children make a model of a “knife” switch using paperclips. The knife switch works better than their previous switches in several ways: it is easy to open and close and it stays closed without holding it. It can be used many times without wearing out. It is also the type of switch that children will see at the Folsom Powerhouse during the field trip.

At the Folsom Powerhouse, switches were needed that could handle a very large flow of electrons. If you want to put a switch into a circuit that has a lot of electricity flowing through it, the switch will need to make contact over a large surface area in order for a lot of electrons to flow through at once. A “knife” switch gets its name from its shape – similar to a knife blade. It closes a circuit when the blade is pressed between two tight-fitting pieces of metal. A lot of electricity can flow through it because a lot of metal is pressed into contact.



The Materials.

- handout “Switches at the Folsom Powerhouse.” It would be easy to take a group of 9-year-olds to the Folsom Powerhouse and have them understand very little of what they see. The activities of the last three lessons and the photo of switches at the Folsom Powerhouse will almost guarantee that children will recognize the switches when they see them and have some understanding for what they were for and why this type of switch was used there. This handout is important in helping the children make the connection. (I just made a joke!)
- circuit and switch materials from previous lesson
- 2 large paper clips. You probably have all these you need at your school. The larger ones, about 2 inches long, work best with little fingers. I’ve used paperclips for 30 years to make all sorts of switches for classroom instruction. In this application, the children will need to wrap the bare ends of wire around one end of each paper clip. Most teachers have children do it in class, but occasionally a wire will prick fingers. To avoid that, I often fasten the wires to the paperclips myself before I do the lesson. I even take out my solder gun and solder the ends on so they are firmly and permanently fixed and there are no sharp pieces of wire sticking out. If you want to do that too, you can get an



inexpensive solder gun at an electrical supply store. At first, it will go slow, but in no time at all you will be soldering connections in a matter of seconds and you will have acquired a new skill! Eventually, you will become famous as a wire-sculptor artist making massive paperclip mobiles that swing overhead in airplane terminals.

Teaching Techniques

Don't forget to review past ideas and vocabulary before beginning this lesson: circuit, flow of electrons, switch.

Comparing their model to a picture of switches at the Folsom Powerhouse provides a powerful extension of the idea. It also begins to get the children ready to understand what they will see on the field trip. The lesson makes such a big deal about knife switches because it is a type of switch children can easily see and understand. The switch you use at home to turn on lights, for instance, has plastic covering all its movable parts because the electricity used in our homes is dangerous. With the knife switch, all the parts are exposed and we can see how it works.

Secondly, the knife switch is a logical extension of the simple switches the children made and it shows them how the switch must be different in order to pass a lot of electricity through it. And finally, it makes a strong connection between their unit of study and the upcoming field trip.

When kids are finished with this handout, you might have them take it home so they can discuss it with their parents. Some of the kids will be interested in the knife switch and some won't -- that's OK for now. When the kids go on the field trip and are able to identify parts of the control board at the Folsom Powerhouse and impress the heck out of themselves and their parents, that is when you might expect to see more interest blossom. Let's see what happens then.

Follow Up Lesson Ideas

This would be a neat time to look for other types of switches. Again, you could ask parents for donations of old, small electrical appliances that feature simple switches (i.e. lamp, toaster, flashlight, etc. You could put a collection of these old appliances in a cardboard box in the back of the room and have groups select one, take it to their table, and try to work out the circuit and switch. They could make a drawing of the appliance showing the circuit that runs through it and the switch.

A table lamp would be a really good example because it has a simple circuit that is easily traced and a simple switch and bulb – very similar to what the kids have been working with. A flashlight would be even better because it uses a battery as a power source.

Sometimes teachers will collect a bunch of cheap flashlights and let the kids take them apart as they develop drawings that label the parts and circuit. After their experiences in your class with switches, they will be able to figure out how the slightly different switch in the flashlight works – when they do, you can tell they really like the feeling.

Lesson 4: Exploring Circuits: Series and Parallel

The Science

There are two basic kinds of simple circuits. They are called “series” circuits and “parallel” circuits. Light bulbs are arranged in a series circuit when they are strung one after another within one simple circuit like the picture on the right. Each light bulb in the series adds resistance, so the more light bulbs that are added, the dimmer the string of lights glows.

In a parallel circuit, there is a path of wire for each light bulb – so each light bulb actually has its own circuit like the one shown in the next picture on the right. Since electrical energy flows through only one bulb in each of the circuits, all three bulbs glow brightly – there is no dimming effect caused by adding bulbs as long as you provide each bulb with its own wire path.

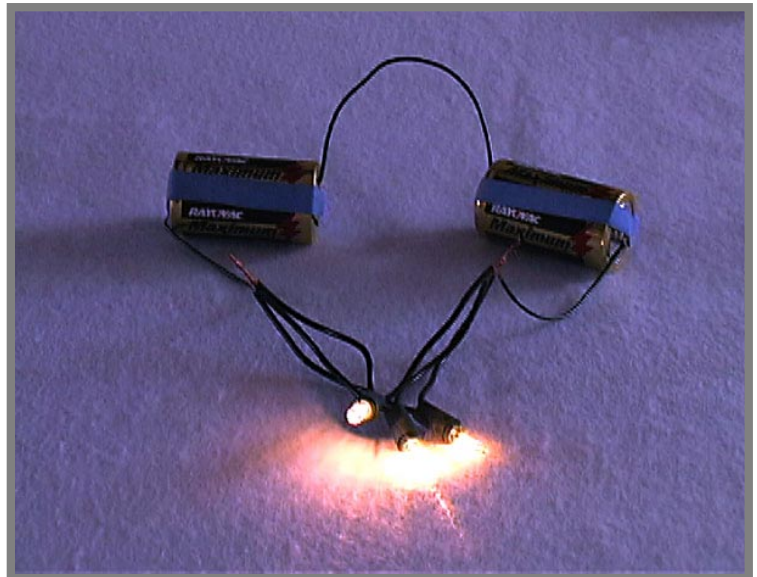
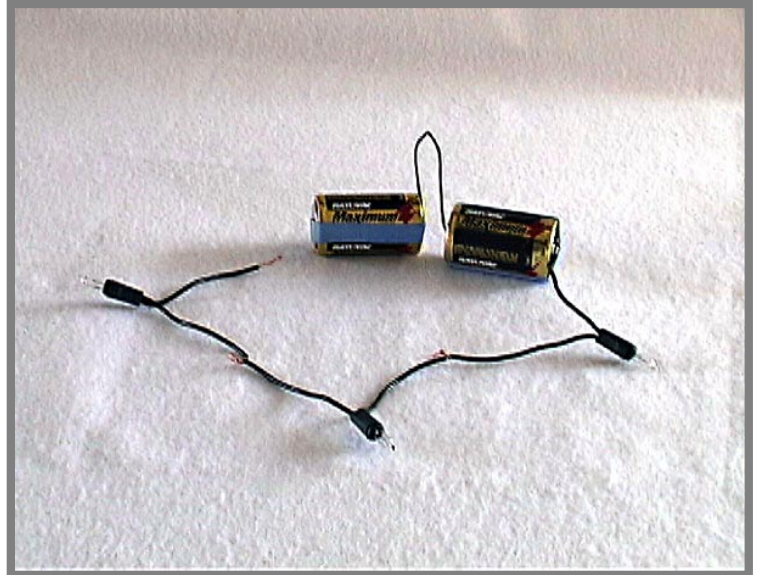
Batteries and other electrical devices may also be wired together in series or in parallel. During the lessons, children may comment on the effects they get when they arrange batteries different ways, but these beginning lessons, for the sake of clarity, will primarily focus on the effects obtained with the arrangements of the bulbs.

The Materials

It is good to have a lot of bulbs, strips of wire, rubber bands and batteries available for these activities so that children can arrange whatever circuits they think of. There should be at least 3 batteries, 3 bulbs, 3 rubber bands and 4 hookup wires for each group.

Teaching Techniques

Children can quickly discover how arranging bulbs in series and parallel circuits affects the flow of electricity in the circuit. The teacher needs to be ready with a few good questions to ask as the children explore and especially when they seem to get stuck.



For instance, when the children are constructing a series circuit (like the one at the top of the previous page) the teacher might ask: “What happens when you add another bulb?” or “What happens when you take a bulb out of the circuit?” Both of these questions will tend to get the kids looking at the cause and effect of changing one variable at a time. Each time they add a bulb, the bulbs grow dimmer. Each time they take away a bulb, the remaining bulbs glow brighter. With patience, it won’t be long before the children are able to correctly draw generalizations about a series circuit and predict what will happen as they change it.

When children are constructing a parallel circuit like the second picture on the previous page, ask the same questions. Keeping the questions the same is important because it helps children to make a clear comparison. Soon, children will see that there is a wire path for each individual bulb. They will realize that just as much electrical force must flow through each of the paths. The bulbs always stay just as bright no matter how many bulbs are added or taken away – so long as each bulb has its own wire path.

It is a good idea to frequently ask children to trace the flow of electricity through their circuits. This way you can determine if they understand that the electric force goes **THROUGH** the wire, **THROUGH** the bulb and **THROUGH** the battery in a continuous flow. Some children may perceive that the electrical force goes out of both sides of the battery and “runs together” inside the light bulb – that is a common misconception. It is easily rectified by having the children trace the **CIRCULAR** flow several times and in several different kinds of circuits.

Follow Up Lesson Ideas

Children can be encouraged to cut their own light bulbs from old holiday light sets so they can experiment at home creating more and more elaborate circuits. They can be encouraged to mount their circuits on a cardboard to display and explain to the other children. With enthusiasm displayed by you and a little encouragement, many children will become quite enthralled with wiring things together and will carry their explorations to surprising levels.

If you have a sufficient number, the children can use the circuits to create electrical art.

Remember to remind the children that exploring electricity using flash light batteries is safe – but they should never experiment with the electricity that comes from wall plugs in their homes.

Lesson 5: Predicting Circuits: Series and Parallel

The Science

In this lesson the science remains the same as the children apply and clarify what they learned in the previous lesson.

The Materials

The two handouts carry the lesson. Miniatures of the handouts are shown on the right. Circuit materials are needed when the handouts are complete.

Teaching Techniques

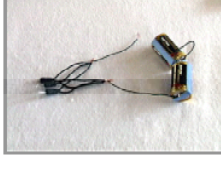
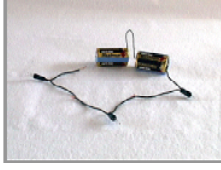

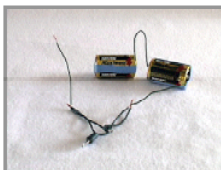
Spend plenty of time reviewing what was learned yesterday. Many children need to use the words and explain what they mean. Remember that new vocabulary does not become fixed until it is used in context about 25 times – so give as much opportunity as possible for children to review and discuss what is meant by a circuit, a parallel circuit, a series circuit, and a switch in a circuit.

The handouts are meant to be self-explanatory, but you know how that goes! It would be a good idea if you had a sample item on the board and solved it with the children. For that matter, you could use the first item of each handout to do together to make sure everyone understands what is expected.

When the handouts are complete the children get their circuit materials and construct each circuit to see if their answers were right or wrong. Remember, if you tell children they are “right” or “wrong,” you may or may not accomplish something. But if you teach children how to correct themselves, you have given them the tools of learning.

Predicting Circuits #1
Handout for Lesson 5

Predict what will happen when the last wire is connected to the battery. Circle your answer. Also, circle “series” or “parallel” to tell what kind of circuit you see in the picture.



PICTURE 1.
All bulbs will be bright.
Some will be bright and some dim.
All bulbs will be dim.
This is a (series) (parallel) circuit.

PICTURE 2.
All bulbs will be bright.
Some will be bright and some dim.
All bulbs will be dim.
This is a (series) (parallel) circuit.

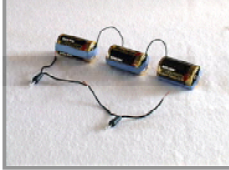
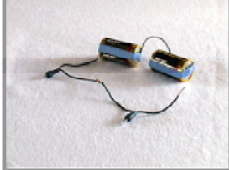
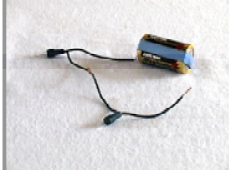

PICTURE 3.
All bulbs will be bright.
Some will be bright and some dim.
All bulbs will be dim.
This is a (series) (parallel) circuit.

PICTURE 4.
All bulbs will be bright.
Some will be bright and some dim.
All bulbs will be dim.
This is a (series) (parallel) circuit.

5

Predicting Circuits #2
Handout for Lesson 5

Predict what will happen when the last wire is connected to the battery. Circle your answer. Also, circle “series” or “parallel” to tell what kind of circuit you see in the picture.



PICTURE 1.
All bulbs will be bright.
Some will be bright and some dim.
All bulbs will be dim.
This is a (series) (parallel) (series and parallel) circuit.

PICTURE 2.
All bulbs will be bright.
Some will be bright and some dim.
All bulbs will be dim.
This is a (series) (parallel) (series and parallel) circuit.

PICTURE 3.
All bulbs will be bright.
Some will be bright and some dim.
All bulbs will be dim.
This is a (series) (parallel) circuit.

PICTURE 4.
All bulbs will be bright.
Some will be bright and some dim.
All bulbs will be dim.
This is a (series) (parallel) circuit.

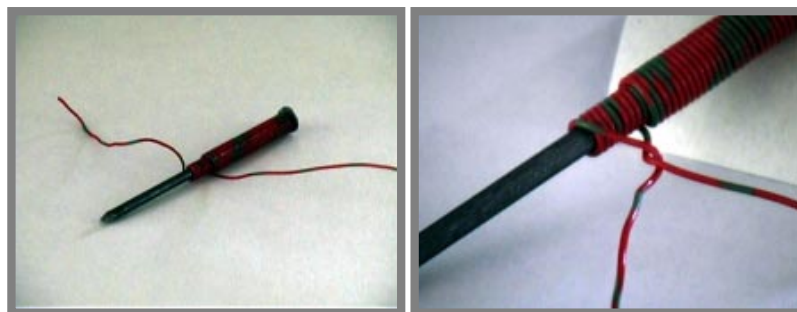
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Lesson 6: Electromagnets

The Science

When electrical force flows through a wire it produces a small amount of magnetism around the wire. If you tightly wrap a wire around an iron nail, the magnetic force will focus in the nail when an electrical current is passed through the wire. That is how one makes an electromagnet.

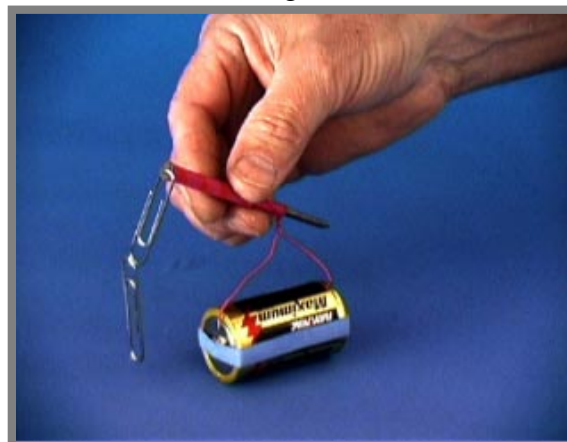
If you move a small compass around an electromagnet, you will find that there is a North Pole on one end of the nail and a South Pole on the other. When you switch the direction of the electrical flow by switching the wires from one side of the battery to another, the poles are reversed.



There are probably THOUSANDS of electromagnets in your classroom. Electromagnets make electric motors spin, ring the chimes on your doorbell, power microphones and radio speakers, move the light waves around inside the TV tube to make pictures, start your car, etc. There is an electromagnet involved every time an electric machine pushes, pulls, or spins something.

The Materials

Several types of wire will work very well for this activity. Telephone hookup wire is very good and is shown in the illustrations. You can also use a wire coated with enamel that is called “bell” wire or you can use strands of wire that are left over after you cut up the string of miniature holiday lights.



Most hardware stores sell nails inexpensively by the pound. If your hardware store does not have the 8d size, a nail close to that size will work just fine.

Teaching Techniques

Children don't usually have much trouble making electromagnets. Keep the materials simple and the directions clear. After having worked with the light bulb circuits and traced the flow of electrical current through a circuit many times, they should be able to map out the flow of electrical current through the electromagnet circuit. As you walk around, have children show you how the electrical force flows from the battery, through the wire, around the nail and then back through the battery again.

Lesson 7: Electromagnets Pull, Push, and Spin.

The Science

See previous lesson.

The Materials

Round or square magnets can be purchased at an electrical supply or hardware store. Minimally, you will only need about 6 of them if the children work in groups – but more would be better.



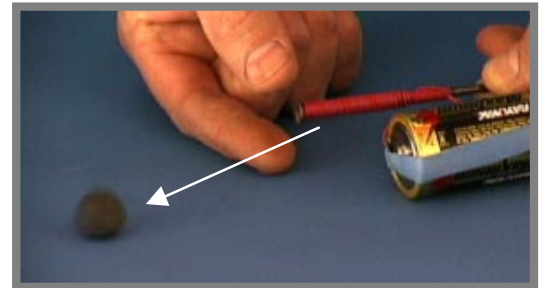
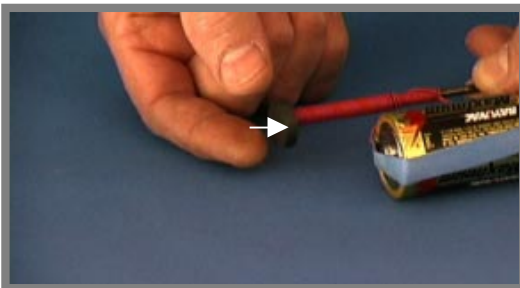
I found a lot of old telephone hookup wire to use for the coil of wire around the nails – so that is what is shown in the pictures. When you cut the light bulbs from the holiday light strings there is a lot of wire left over – that wire will work also. Don't use lamp cord wire – it's too thick.

Teaching Techniques

This lesson and the next lesson center on a simple idea: By observing an electromagnet, you see that it can push, pull and spin things. This lesson gives children the opportunity to observe an electromagnet pushing, pulling and spinning something. In the next lesson, children are asked to identify many electrical things that push, pull and spin something. So it is important that the teacher help the children to make the connections again and again during the two lessons.

The following sequence of pictures that illustrate how an electromagnet can push, pull and spin something, are taken from the optional handout for this lesson. I have designated the handout as "optional" because it simply shows what the children should see anyway when they do the activity. Also, it would have to be color copied and that would be prohibitive. However, if you think it would be useful, you might print out a few copies of it with a color printer so that the detail of the photos will be clear.

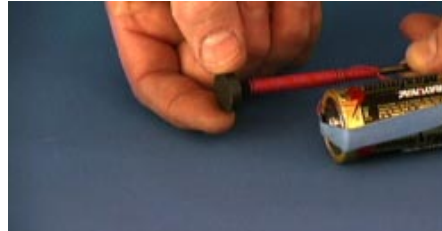
The pictures below show what happens when a small magnet is pulled toward or pushed away by the electromagnet.



The electromagnet attracts one side of the small magnet, and repels the other side.

The sequence of pictures below shows the small magnet first being pushed away (pictures 1 & 2), then spinning around (picture 3), and then pulled back to the electromagnet (pictures 4 & 5). This shows how an electromagnet can “spin” something.

1.



2.



3.



4.



5.



It is this observation that caused Nicola Tesla to conclude that an electric motor could be made using electromagnets. His teacher called the idea “impossible” and referred to it as “a continuous motion scheme.”

Lesson 8: Electromagnets in Our Lives

The Science

Because children and adults are often not aware of the electromagnets around them, it may be necessary for the teacher to give the children some ideas. Here are some examples you can share with the children:

- Electromagnets are placed around the tube of TV sets and computer monitors to “pull” light into the shape of pictures. (You can demonstrate this by placing a magnet against the screen of a TV or monitor in the classroom that is turned on – the picture on the screen will be distorted as it is drawn toward the magnet – wow, neat, do it again, let me do it!)
- An electromagnet is activated when you press the button of a doorbell. When you press the button, the electromagnet pulls an iron rod into contact with a piece of metal creating the “ding” and when you let go of the button, a spring pulls the iron rod back against another piece of metal creating the “dong.” (This would be a great time to take the cover off a doorbell to observe this in action.)
- Electromagnets pull and push on parts of an electric motor to make it spin.
- In an electric generator, electromagnets pull and push electrons to make electricity flow in a wire. That is how we get electricity in our homes.
- In a printer, electromagnets push tiny drops of ink onto the paper to make print.
- In a microphone, sound waves move an electromagnet back and forth to generate electrical pulses. In a speaker, the electrical pulses move an electromagnet to vibrate the speaker and make sound.

The Materials

None

Teaching Techniques

Before giving the children too many ideas, first let them struggle with the idea that all things electric that push pull and spin things use electromagnets. They will need time to think about it, so don't worry if they are quiet for a long time. Get as many ideas from them as you can before throwing some in yourself.

Follow Up Lesson Ideas

Send the children home with the following task: Find 5 things in your home that use electromagnets. Draw a picture of each that shows the electromagnet. Label the drawings.

Lesson 9: Electromagnets at the Folsom Powerhouse

The Science

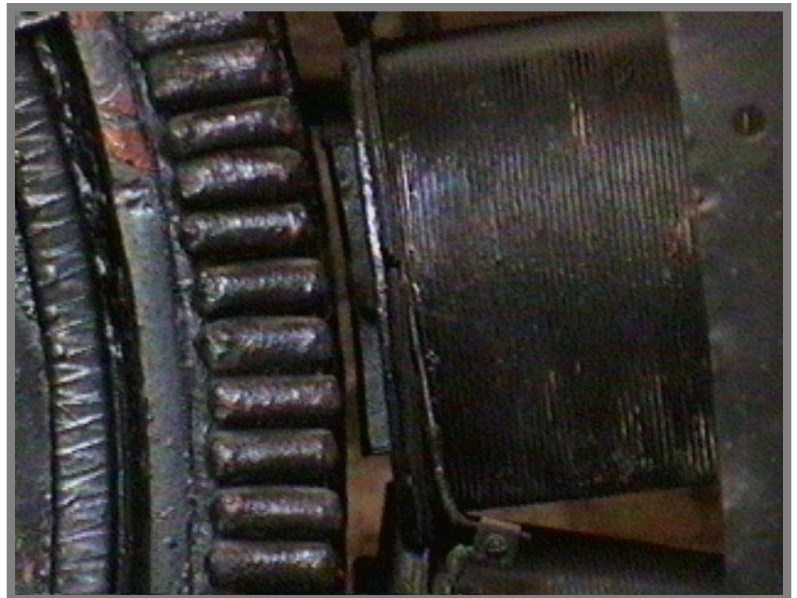
Almost all electromagnets have two things in common: they have a metal core, and they have a wire coil around it. In the photo on the right, there is a ring of electromagnets that make up the field coils of one of the generators at the Historic Folsom Power House.



The Materials

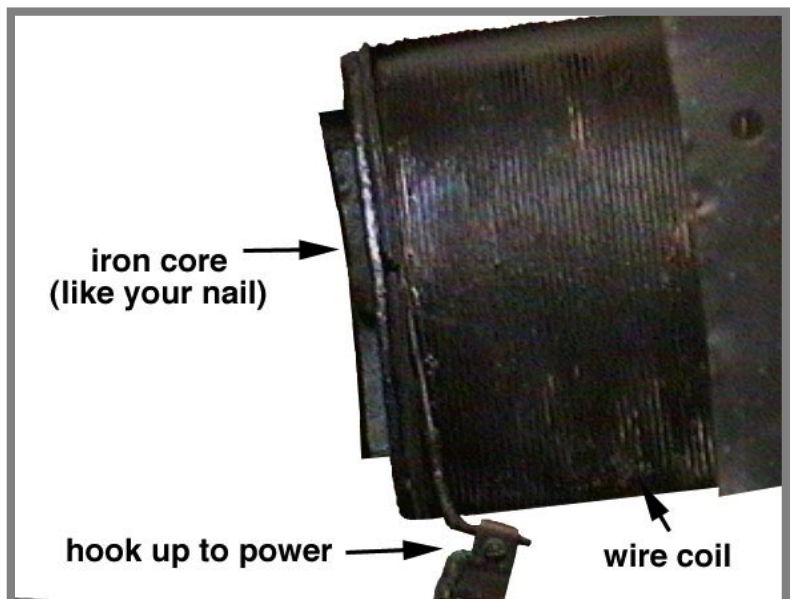
It may be difficult for children to make out the electromagnets that are part of the generator in the top picture. To make them clear, I made a blow-up of one of the electromagnets on the generator. The blow up is directly to the right of this paragraph.

Then I cut away everything in the blowup that was not part of the electromagnet to make it more clear. The cut-away photo is directly below. I then labeled the cut-away to point out the metal core and the wire coil. You can also see one of the hook up wires leading into the wire coil (the other one is on the other side.) These photos are used on the handout you give to the kids and I think they will be helpful.



Teaching Techniques

The object of the lesson is for children to perceive that the coil of wire and metal core of the electromagnets on the generator are similar to the coil of wire and nail they used to make an electromagnet. The children are asked to discuss this in a group, list similarities, and draw lines between similar parts in the cut-away and in their drawing of their own electromagnet. The three activities focus continually on the same



basic idea – strengthening their ability to identify electromagnets when they see them. If your kids visit the Powerhouse and run up to the generator and identify its electromagnets, you will impress the dickens out of the docents. It should be a kick in the pants for the kids too. THAT is a teaching technique.

Lesson 10: Moving Water Can Push Things

The Science

When water is lifted, it is given “potential” energy that is released as “energy of motion” when the water falls back down. For example, the sun gives water potential energy by lifting it high into the sky. When it falls as rain its energy of motion wears away the earth. Water resting in a lake in the mountains has the potential energy imparted to it by the sun that did the lifting. As the water flows from the lake to the valley, its energy of motion moves soil and stones.

Very long ago people used the moving energy of water to make mechanical energy. The moving water turned wheels for grinding wheat and operating early machines. More recently, the energy of moving water is turned into mechanical energy and then electrical energy -- the water turns a water wheel that turns an electrical generator.



In the activity for this lesson, children can direct squirting water to push things – thus observing the energy of motion directly. They may also discover, in this activity or in future investigations, that it is the height of the water that directly affects the force of the water stream, not the total weight of the water in the container.

The Materials

These simple materials will allow the children to observe the “potential” energy of water as it rests in a container, and then observe the “energy of motion” as the water squirts out of the soda straw.

You may find it helpful to start the hole in the bottom of each milk jug with a sharp object like a nail – you could do this ahead of time. You may also find it helpful to caution the children to poke the pencil into the jug almost completely, but not quite, so that the hole will fit tightly over the straw. Good idea to have a few extra milk jugs handy!

Teaching Techniques

It is a good idea to do this activity just before recess. Then collect materials and send the children out. When they return from recess, it will be easier to get them settled and have the closing discussion. In general, I almost always plan to do the most active work with children just before recess, lunch, or the end of the school day. That way, I do not have to struggle trying to get the kids calmed down for a “sit down” lesson. Sure makes life easier.

Lesson 11: Moving Water at the Folsom Powerhouse

The Science

At an electric power plant, water is captured in a holding area. To generate electricity, water is released through a gate to flow down a large pipe. At the bottom of the pipe, the water spins a water wheel. Through an axle, the water wheel spins an electrical generator.

After going through the electric generating plant, the water flows out of the building.

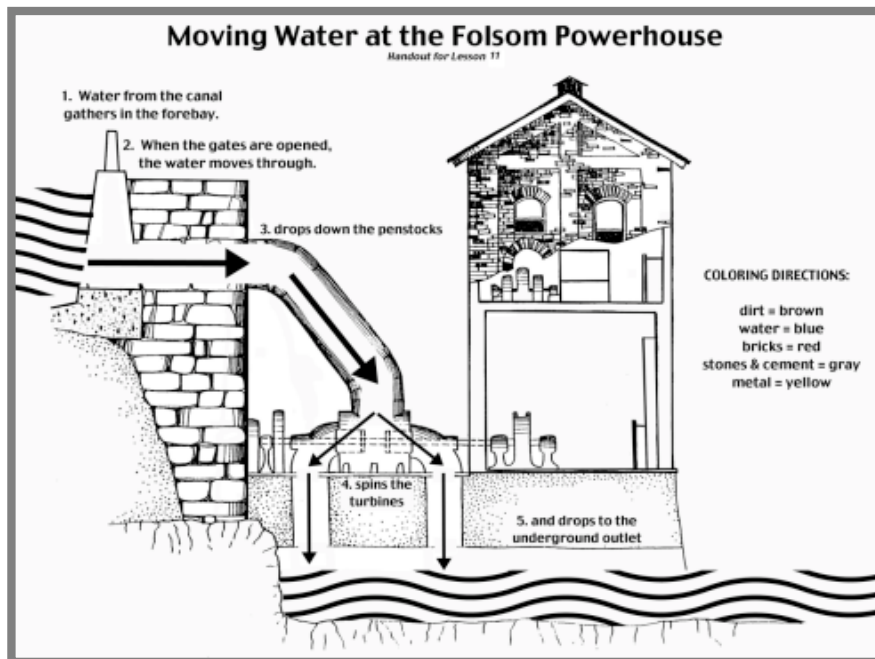
The Materials

A handout is provided for this lesson. A miniature of the handout is shown above. Children color each part of the drawing according to the key.

Teaching Techniques

This handout is intended to provide the teacher with a clear way to determine if children are correctly locating the parts of the powerhouse. It is an opportunity to correct misperceptions by discussing their ideas with other children and with the teacher. It is also an activity through which the children will prepare to understand what they see when they visit the Folsom Powerhouse.

In this lesson, keep the focus on what the water is doing as it passes through the powerhouse. Don't be too concerned about the acquisition of terminology, such as "penstock," since the next lesson will focus on that. This lesson's goal is for the children to understand what is happening.



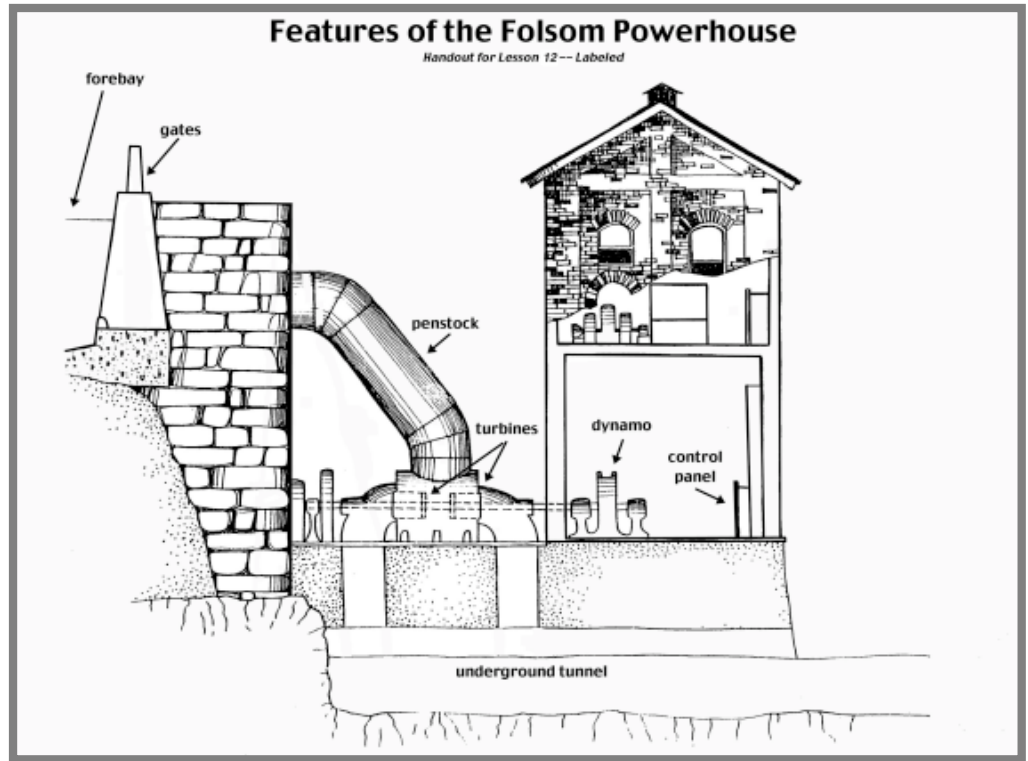
Lesson 12: Features of the Folsom Powerhouse

The Science

There are no additional science concepts presented in this lesson.

The Materials

Two handouts carry this lesson. Each handout shows the same drawing of the Folsom Powerhouse. One handout is labeled and the other is not. One handout is meant to accurately convey terms and definitions to the children in a form they can study and take home with them as a reference. The other is an assessment tool to check for mastery of the terms.



Teaching Techniques

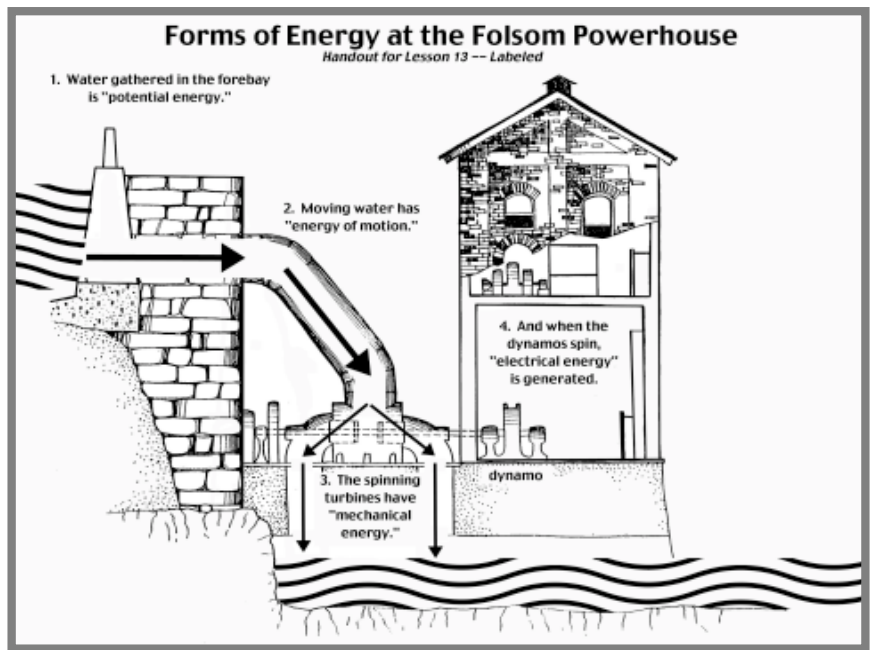
This lesson introduces terms, explains them, reviews them, drills them and finally assesses them. You may want to carry out these activities over several days – perhaps even mix them in with the activities of other lessons.

I suggest that you use the unlabeled handout twice: once while introducing the terms on the board so that the children can copy the terms off the board and label the drawing. Then, give the children the labeled drawing so they can refer to it for spelling, learning the definitions, and checking their understanding. Finally, you can use the unlabeled handout again as a formal or informal assessment.

Lesson 13: Energy Changes Form at the Folsom Powerhouse

The Science

At an electric power plant, the potential energy of water is captured in a holding area called a forebay. Water from the forebay acquires energy of motion when it is released through a gate to flow down the penstock – a large pipe. At the bottom of the penstock, the moving water exerts mechanical energy by spinning a turbine (waterwheels designed for high speed). Through an axle, the turbines spin an electrical generator to make electricity. (The term dynamo is another, old fashioned, name for an electrical generator.)



The Materials

Two handouts carry this lesson – one labeled and the other unlabeled.

Teaching Techniques

Again, it may be best to use the unlabeled handout twice: once while introducing the lesson as the children take notes on the handout, then again at the end of the lesson or on another day when you are ready to assess their mastery of the ideas.

During the discussions about forms of energy, it is a good idea to be prepared to give several examples of the forms of energy under discussion to help children understand. Here are some examples:

Potential energy	rock on the edge of a cliff; soap box derby car at the top of a ramp
Energy of motion	moving car, rolling train, flying airplane; person walking; deer running
Mechanical energy	gears spinning; an axle turning; a pulley belt rotating
Electrical energy	lightning; static electricity; electrical energy in a battery

Ask children to come up with examples.

Lesson 14: Quiz – Generating Electricity at the Folsom Powerhouse

The Materials

A variety of handouts are provided for you to use. It is not intended that you use them all but that the range of items provided will allow you to make choices to suit yourself.

Teaching Techniques

Quiz items A, B, and C are traditional in their approach. Quiz item D and the “Check-Off List for Scientific Problem-Solving” are examples of authentic assessment techniques.

There are other alternatives for assessing the children’s learning. The products of the model construction and investigation activities are also good assessment tools. In addition, children can carry out research projects using online and library references – the subsequent reports they turn in can serve very well as forms of academic assessment.

Final assessment activities for this unit should serve as a preparation for a field trip to the Powerhouse. The assessment can provide a review of terms, definitions, and understandings. Used correctly, assessment activities provide the teacher with information about what things need more explanation, review, or discussion.

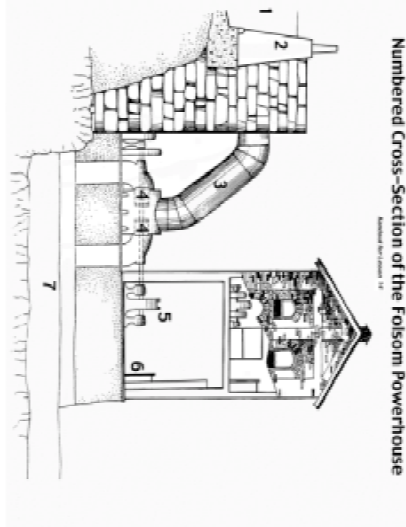
Miniatures of the assessment handouts are shown on the following page.

Quiz Question A
Handout for Lesson 14

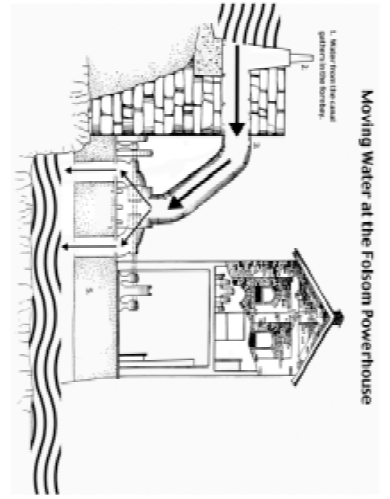
Directions: Choose at least 3 parts of the Folsom Powerhouse shown in the handout on the next page. Give its part number, its name and explain what it does.

PART NO.	NAME	EXPLANATION
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

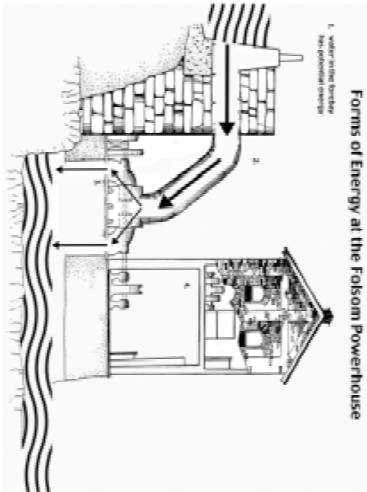
If you run out of room here, write about them on the back of this page.



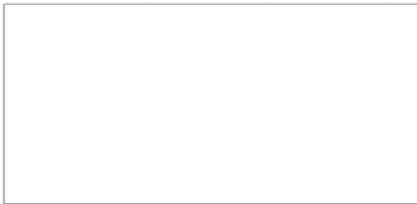
Quiz Question B -- *Handout for Lesson 14*
 In the drawing below, explain how water moves through the Folsom Powerhouse. Number 1 is completed as an example.



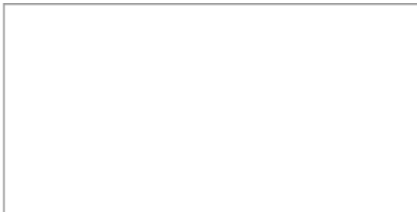
Quiz Question C -- *Handout for Lesson 14*
 In the drawing below, identify each part and what form energy takes in that part. Part 1 is completed as an example.



Quiz Question D -- *Handout for Lesson 14*
 Make a drawing of a light bulb in a circuit with a battery and a switch. Use arrows to show the path of electricity traveling through the circuit. Label these parts: battery, electromagnetic, switch.



Make a drawing of an electric fan in a circuit with a battery and a switch. Use arrows to show the path of electricity traveling through the circuit. Label these parts: battery, electromagnetic, switch.



Check-Off List for Scientific Problem-Solving Skills
Teacher Check-Off Form

_____ is able to

check name _____

1. Differentiate an observation from an inference	<input type="checkbox"/>
2. Measure weight of objects	<input type="checkbox"/>
3. Measure length of objects	<input type="checkbox"/>
4. Measure volume of objects	<input type="checkbox"/>
5. Estimate weight of objects	<input type="checkbox"/>
6. Estimate length of objects	<input type="checkbox"/>
7. Estimate volume of objects	<input type="checkbox"/>
8. Differentiate an observation from an inference	<input type="checkbox"/>
9. Formulate predictions based on cause and effect	<input type="checkbox"/>
10. Justify predictions based on cause and effect	<input type="checkbox"/>
11. Conduct multiple trials to justify a prediction	<input type="checkbox"/>
12. Draw conclusions about relationships between predictions and results	<input type="checkbox"/>
13. Construct graphs from measurements	<input type="checkbox"/>
14. Interpret graphs made from measurements	<input type="checkbox"/>
15. Follow instructions for a scientific investigation	<input type="checkbox"/>

Part B: Models

Construct Your Own Magnet and Compass

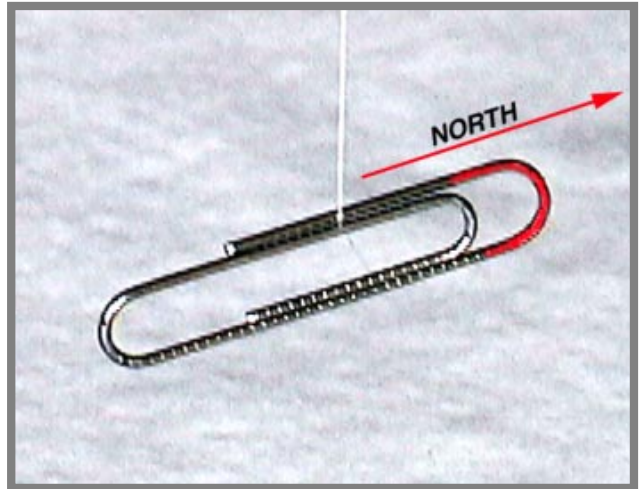
The Science

A piece of metal becomes a magnet when many of its atoms are pointed the same way. You can get many atoms in a piece of iron to point the same way by stroking it with something that is already magnetized.



The Materials:

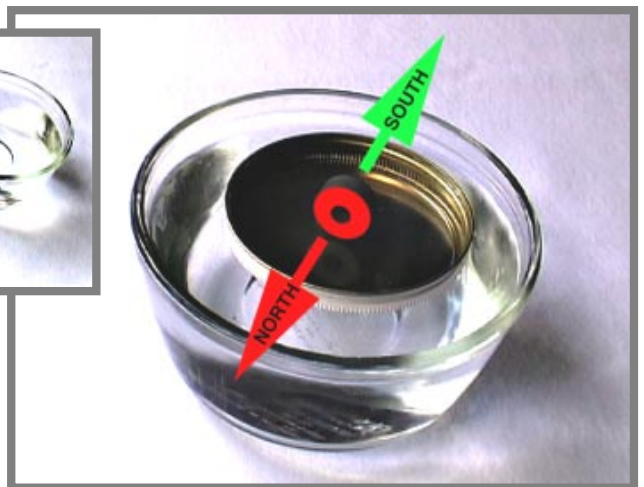
(See directions in lesson plan.) It is a good idea to demonstrate for the children how to stroke the paper clip with the magnet. Holding the clip with one finger, stroke the clip with the magnet in one direction, (See series of 3 photos at top of page.) It is also a good idea to have several blue and red colored markers handy so that children can mark the end of the paper clip that points North with the red marker and mark the end pointing South with the blue marker. The colors make it easy for children to remember which end is which. *COLOR Note that the children have colored the end of the paper clip that points North, red.*



Teaching Techniques:

The lesson plan for this activity may be used as a handout that can help guide the children. Once children have made a magnet successfully, they will want to experiment with other metals. It is a good idea to let them make several.

The alternative method of making a compass is even easier, but it does require water. (See directions in lesson plan.) The magnets you got from the store will quickly rotate the jar lid into a North-South orientation. If you get round magnets similar to those shown here, be sure children stand the magnet on its edge. Using colored markers to mark the North and South parts of the magnet will be helpful here too. With these round, flat magnets, the North and South poles are the flat sides.



Part C: Investigations provides a handout that can help to guide children through an experiment using a compass.

Construct a Model of the Historic Folsom Dam

The Science.

There are many things to be learned by building a model of a dam. Children may learn about where to site a dam, how the gates are constructed, the affects of building a dam on migrating fish.

Children can research these things before and during their construction project.

The Materials:

(See lesson plans for list of materials.) The lesson plan may be distributed to help guide the children. Several materials may be used for this project:

Pottery Clay. Ceramic pottery clay is suggested in the lesson plan because it can be obtained in large amounts at a reasonable cost, and it will harden to a rock-like surface. If you use ceramic clay, it will usually come hard and dry. You need to remove it from its packaging and soak it overnight in a waste can filled with water. In the morning, it can be removed, allowed to dry out in the open just a little while, and it will be ready for shaping. Children like working with the large quantities of ceramic clay to fashion and fire their own cups, flower pots, etc.

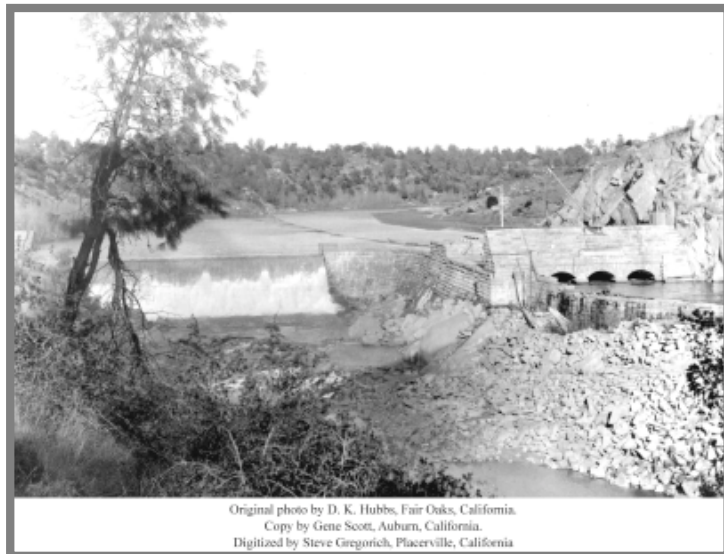
Modeling Clay. If you use the plastic modeling clay usually found in classrooms, there is less of a mess. A child will need at least 4 sticks of the clay to make a model.

Sugar Cubes. Children could stack and glue sugar cubes to construct the model.

Other Materials. Children might use stones, mud, or wet sand.

Teaching Techniques.

It is a good idea to have children find information from other sources to guide the construction. The engineering drawings on the second page of the lesson plan are one example. Depending on their ability and motivation, some children will make basic, simple dam models like the one shown above and some will make highly detailed models.



Construct a Model of the Folsom Powerhouse

The Science.

Children can research how different materials are used in construction. There are many interesting historical uses of materials in the construction of the Historic Folsom Powerhouse. Here are a few examples:

Local stones were quarried by Folsom Prison inmates. The stones were cut and placed in the forebay walls and the foundation of the Powerhouse.

Portland Cement was shipped from England because of its superior strength and durability.

Tin sheets were placed on the roof structures.

Local lumber was milled and used where lighter weight was essential – such as in the moveable water gates and sliding entryway doors.

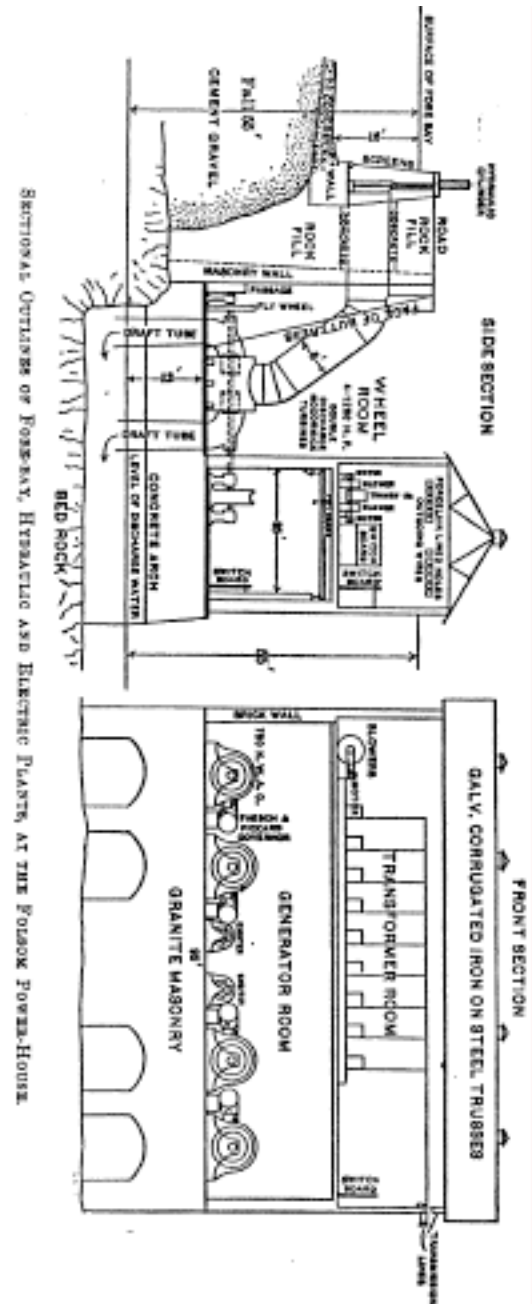
Generators were shipped around Cape Horn from manufacturing plant in the East. The generators were designed by Nicola Tesla. Tesla was a famous European immigrant who patented all the basic components used in alternating current today.

The Materials.

Children can use a variety of materials to make their models – cardboard tubes from paper rolls; sheets of cardboard from corrugated boxes; clay; etc.

Teaching Techniques.

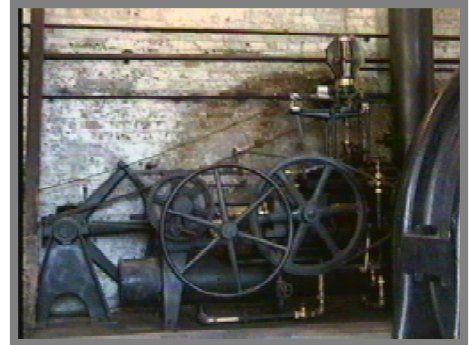
While creating a model, children clarify what they have read in books and seen in pictures. They may disagree, redesign, start over, or even get frustrated for awhile. All along, each problem or question represents the beginning of a new understanding. It is important that the teacher encourage questioning, continued research, and even arguments about how the model should look or the purpose of different parts of the model. If mom and dad get involved in the project – that’s wonderful. Of course, a final demonstration/explanation of the model focuses children on learning vocabulary, doing meaningful research, and developing communication skills.



Construct a Speed Controller

The Science.

The speed regulators at the Folsom Powerhouse are very complex-appearing machines. But their function was simple – to keep the generators spinning at the same speed so the electrical power would be consistent. If the water turbines were to spin the generators at varying speeds, the electricity would sometimes not be powerful enough to illuminate light bulbs and run machines. At other times it would burn them out.



The speed controller children construct in this activity regulates the speed of a spinning thread spool in the simplest way. Fins are attached to a spool so that, when it spins, the friction of the vanes moving through the air slows it down. Speed can be regulated by adding more or less paper clips and by changing the size of the fins.

The Materials:

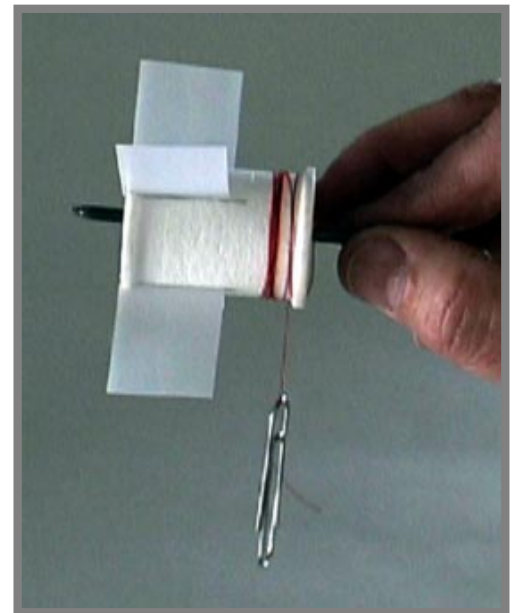
(See lesson plan for construction directions.) The lesson plan may be distributed to children to help guide them in the construction project.



Teaching Techniques.

It is important to be ready with a few questions to guide the children's inquiry about the speed controller. After children have constructed the controller and used it a few times, you might ask them: "How could you make the spool spin faster?" "How could you make the spool spin slower?" These kinds of questions focus the children on the qualities of the speed controller that allow it to control speed.

Children can carry out experiments to see what changes actually cause the spool to spin faster and slower. *Part C: Investigations* provides a handout to guide children through this investigation.

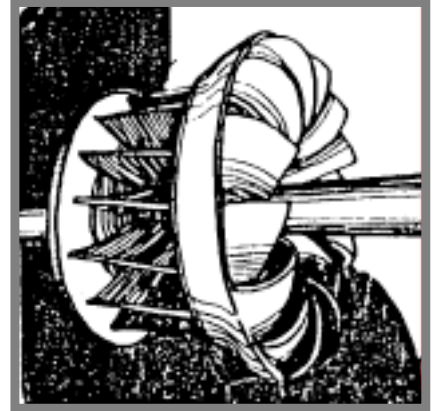


Construct a Water Turbine

The Science.

Water dropping from a height can move things. We can use the force of water to spin a turbine. The height from which the water is dropped determines its force.

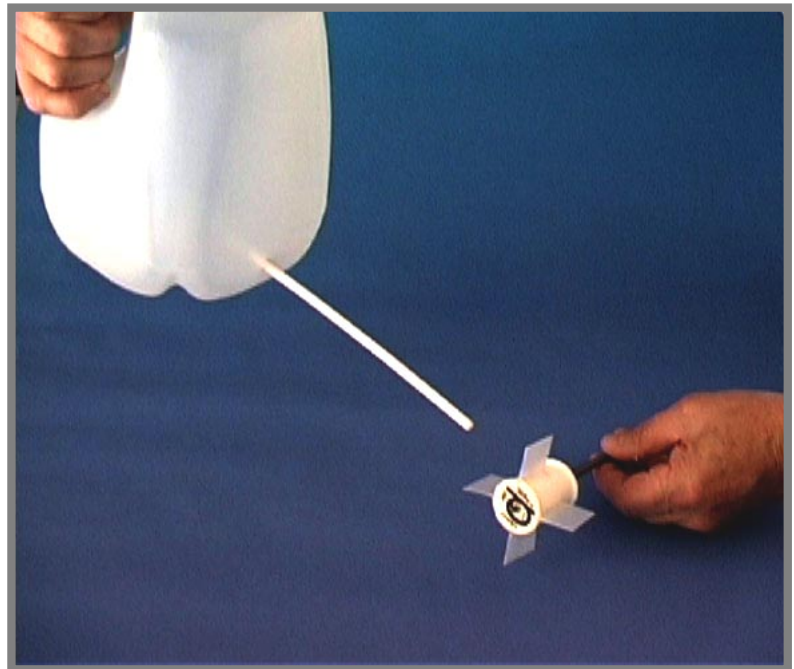
On the right is a drawing of one of the water turbines in the Folsom Powerhouse. The turbine turns an axle that spins the generator to create electricity.



The Materials:

(See lesson plan for list of materials.)
The lesson plan may be distributed to children to help guide them in the activity.

Since the children use the spool and vanes from a previous lesson, this construction project is an easy one. The only problem you might run into is that children might poke too large a hole in the milk jug. Even so, the plastic the jug is made of will tend to return to its original shape. If allowed to sit for a few minutes, the hole will get smaller and the soda straw should then fit snugly. Just in case, it is a good idea to have a few extra jugs available.



Another precaution: If the milk jugs are not rinsed out thoroughly, the remaining milk in them will sour. So if you don't want a very smelly classroom, have one of the children test the jugs by quickly removing the lid, smelling it, and then putting it back on. Offending jugs may be taken to a faucet and rinsed several times before they are used in the lesson.

Teaching Techniques.

Like the compass and speed controller lessons, there is a handout provided in *Part C: Investigations* that can help you guide the investigations children carry out following this activity.

Part C: Investigations

Children can use research or experimentation to answer the questions posed in the investigations described in Part C of the unit plans. Through these kinds of activities, children develop the skills necessary to carry out scientific inquiry.

The investigations are based on previous lessons and models constructed in the unit:		
Investigations	Lessons	Construction Models
What Affects the Brightness of Lights in a Circuit?	Lessons 1-5	Magnet & Compass
What Affects the Power of an Electromagnet?	Lessons 6-9	(in the lesson plan)
How Do Electromagnets Affect a Compass?	Lessons 6-9	Magnet & Compass
What Affects the Speed of a Water Turbine?	Lessons 10-13	Speed Controller

Teachers may choose to use one or more of these investigations to guide the entire class in using online research tools or in carrying out a scientific study. The questions may also be assigned to groups or individuals as part of their class work or they may be used as a take-off point for an entry in a science fair.

The description of each investigation is written as if it were speaking directly to the student to help him/her get started on an investigation. The pages may be copied and distributed.

Teachers should keep in mind the California Science Standards for “Investigation and Experimentation” as they guide children through these activities to ensure that children have opportunities to problem-solving skills. As a convenience, the relevant standards are repeated below:

“Investigation and Experimentation

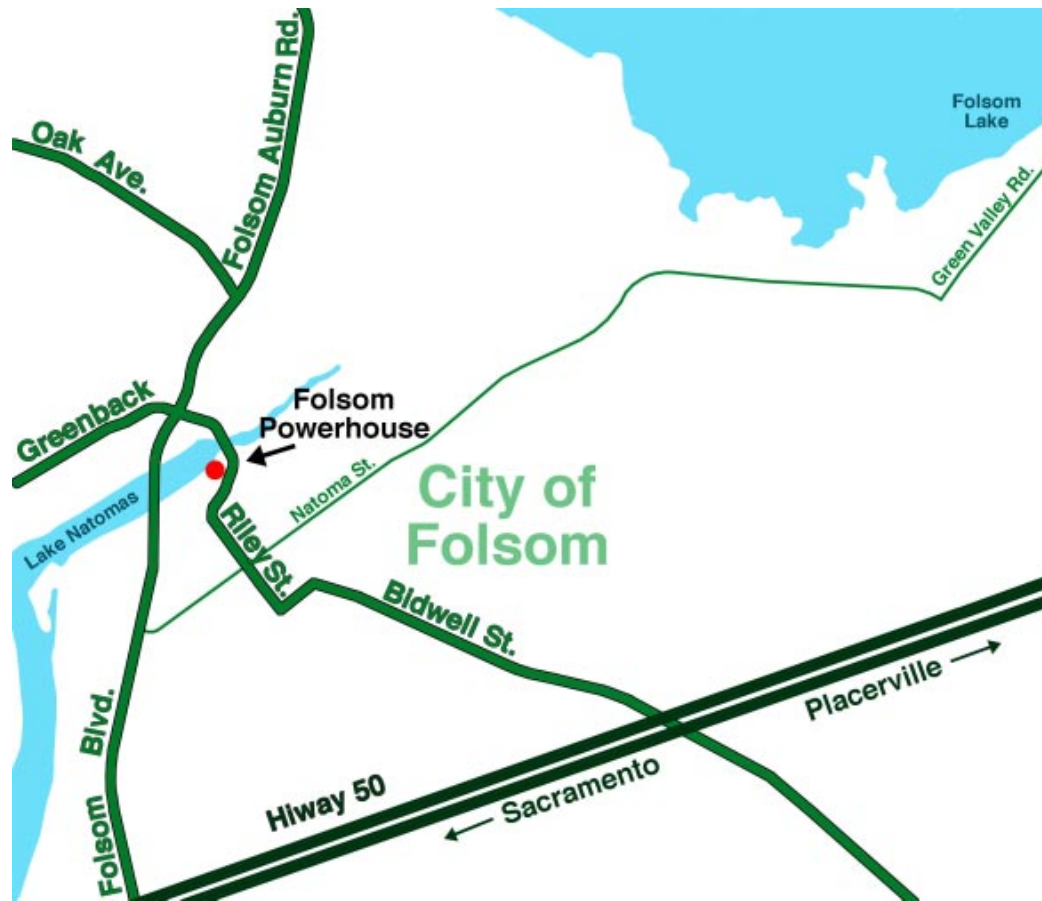
6. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:
 - a. Differentiate observation from inference (interpretation) and know scientists’ explanations come partly from what they observe and partly from how they interpret their observations.
 - b. Measure and estimate the weight, length, or volume of objects.
 - c. Formulate and justify predictions based on cause-and-effect relationships.
 - d. Conduct multiple trials to test a prediction and draw conclusions about the relationships between predictions and results.
 - e. Construct and interpret graphs from measurements.
 - f. Follow a set of written instructions for a scientific investigation.”

Arranging a Field Trip

Information. Telephone 916-988-0205. Address: 7806 Folsom Auburn Road, Folsom, California 95630

Internet site: http://parks.ca.gov/default.asp?page_id=501

Making a Reservation. Group tours are available throughout the week by special arrangement. Call 916-985-4843 for more information. If you are calling to arrange a field trip for a class after using this unit, make sure to mention it.



Directions to the Park.

From Sacramento take Hiway 50 East to the Folsom Boulevard exit. Drive North of Folsom Boulevard until you cross the new Lake Natomas Bridge. At Greenback Lane, turn right and cross the Lake again on the old bridge. The Folsom Powerhouse will be on your right.

From Shingle Springs and Placerville take Hiway 50 West to the East Bidwell St. turnoff. Drive North on East Bidwell. After East Bidwell makes a 90-degree turn to the left, turn right onto Riley St. Pass Natomas and Sutter streets. The park will appear on your left.

Park Operating Hours. Wednesday through Sunday from noon to 4:00pm