ENERGY 1

PARENT/TEACHER'S GUIDE

A comprehensive course that teaches the fundamental principles in work, energy, and power. Students will build several different kinds of batteries, learn how solar, wind, and water can be used to generate electricity, construct simple machines, race bobsleds, zoom roller coasters, build hydraulic-pneumatic machines and so much more.

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This curriculum is aligned with the National State Standards and STEM for Science.

Introduction

Greetings, and welcome to the unit on Energy. I hope you will find this helpful in preparing to teach your students, exhaustively thorough in content and a whole lot of fun, because that's when students and teachers do their best work.

This curriculum course has been prepared to be completed over several weeks, completing 1-2 lessons per week. You will find that there are 26 lessons outlined to take you from an introduction of Energy on through several advanced alternative energy lessons complex enough to win a prize at the science fair. If you complete this course and send your kids off, you'll find their high school teachers entirely blown away by their mastery of the subject, and then will really be able to fly with them. Each lesson has a Teacher Page and a Student Worksheet.

The following features on each set of the Teacher Pages:

- Overview: This is the main goal of the lesson.
- Suggested Time: Make sure you have enough for completing this lesson.
- Objectives : These are the core principles covered with this lesson.
- Materials: Gather these before you start.
- Lab Preparation: This outlines any preparation you need to do ahead of time.
- Lesson: This outlines how to present the topic to the students, stirs up interest and gets the students motivated to learn the topic.
- Lab Time & Worksheets: This includes activities, experiments, and projects that reinforce the concepts and really brings them to life. You'll also find worksheets that make up their Scientific Journal.
- Background Lesson Reading: This is optional additional reading material you can utilize ahead of time to help you feel confident when the students ask questions during the Lab Time. I don't recommend giving this reading to the kids beforehand. If you must share it with them, then do so *after* the students have gotten a chance to roll around with the activities. By doing this, it teaches kids to ask their own questions by getting curious about the concepts through the experiments, the way real scientists do in the real world.
- Exercises & Answer Key: How well did you teach? How well did they learn? Time to find out.
- Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Immediately following the Teacher Pages are "Student Worksheets" for each of the activities. Each set of student worksheets has the following sections:

- Overview
- What to Learn
- Materials
- Lab Time & Worksheets
- Exercises

In addition to the lessons, we have also prepared the following items you'll find useful:

- Scientific Method Guide
- Master Materials and Equipment List
- Lab Safety Sheet
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- Written Quiz (with Answer Key)
- Lab Practical Test (with Answer Key)

Master Materials List for All Labs

This is a brief list of the materials that you will need to do *all* of the activities, experiments and projects in each section. The set of materials listed below is just for one lab group. If you have a class of ten lab groups, you'll need to get ten sets of the materials listed below. For ten lab groups, an easy way to keep track of your materials is to give each group a number from one to ten, and make up ten separate lab kits using small plastic tubs or baskets. Put one number on each item and fill each tub with the materials listed below. Label the tubs with the section name, like *Energy Study Kit* and you will have an easy way to keep track of the materials and build accountability into the program for the kids. Copy these lists and stick them in the bin for easy tracking. Feel free to reuse items between lessons and unit sections. Most materials are reusable year after year. (RS = Radio Shack)

- AA-size battery
- alligator clip leads (RS#278-1156)
- aluminum foil
- aluminum soda can
- balloon
- black paint or spray paint (flat)
- bleach
- can with a lid
- digital multimeter
- earphones
- electrodes
- foam block (about 6" long)
- glass container
- graphite from inside a pencil (use a mechanical pencil refill)
- hot glue gun with glue sticks
- index cards
- long cardboard tube
- marbles
- masking tape
- milk jug lids or film can tops (4)
- nail (galvanized)
- newspaper
- paint brush
- paper
- paper clip
- pennies minted before 1982 (or a short section of copper pipe)
- pennies, quarters, or washers
- penny
- pipe foam insulation (3/4-inch)
- plastic cups (3)
- plate
- popsicle stick
- propeller
- pulley
- radio or music player
- razor or scissors
- real silverware (not stainless)
- rubber band
- salt
- set of magnets (at least 6)
- solar cell
- Solar Project Kit (Radio Shack #277-1201) or other solar cell with motor (usually sold in hobby stores)
- spoon
- stopwatch
- straws
- string
- string or yarn
- tape
- tea bags (2)
- thermometer
- tomato juice
- toy cars
- vinegar (distilled white)
- washer or a weight
- water or violin rosin
- wood screws (brass)
- wooden skewers

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Unit Prep

This is a short list of things that you may want to consider as you prepare for this unit.

Student Lab Books: If you're the kind of teacher who likes to prepare lab books for your kids, now is a good time to do this. You can copy the *Introduction for Kids* and the *Student Worksheets* for each of the experiments, 3-hole punch them, and stick it in a binder. You'll want one binder per student.

Science Journals: One of the best things you can do with your students is to teach them how to take notes in a journal as you go along. This is the same way scientists document their own findings, and it's a lot of fun to look back at the splattered pages later on and see how far you've come. I always jot down my questions that didn't get answered with the experiment across the top of the page so I can research these topics more.

Master Set of Materials: If you plan on doing all the labs in this unit, you'll want to start gathering your materials together. There's a master materials list so you'll have everything you need when you need it.

Test Copies: Students will take two tests at the end of each section. There are quizzes and lab practical tests you can copy and stash away for when you need them.

Classroom Design: As you progress through the units, you'll be making demos of the experiments and kids will be making posters. You can hang these up on your bulletin boards, string them from the ceiling, or display them in a unique way. I always like to snap photos of the kids doing their experiments and hang those up along with their best labs so they can see their progress as we go along.

Lab Safety

Goggles: These should be worn when working with chemicals, heat, fire, or projectiles. These protect your eyes from chemical splatter, explosions, and tiny fast-moving objects aimed at the eyes. If you wear glasses, you can find goggles that fit over them. Don't substitute eyeglasses for goggles, because of the lack of side protection. Eyeglasses don't provide this important side eye protection.

Clean up Messes: Your lab area should be neat, organized, and spotless before you start, during your experiment, and when you leave. Scientists waste more time hunting for lost papers, pieces of an experiment, and trying to reposition sensitive equipment… all of which could have easily been avoided had they been taught organizational skills from the start.

Dispose of Poisons: If a poisonous substance was used, created, or produced during your experiment, you must follow the proper handling procedures for disposal. You'll find details for this in the experiments as needed.

Special Notes on Batteries: Do not use alkaline batteries with your experiments. Find the super-cheap kind of batteries (usually labeled "Heavy Duty" or "Super Heavy Duty") because these types of batteries have a carbon-zinc core, which does not contain the acid that alkaline batteries have. This means when you wire up circuits incorrectly (which you should expect to do because you are learning), the circuits will not overheat or leak. If you use alkaline batteries (like Energizer and Duracell) and your students short a circuit, their wires and components will get super-hot and leak acid, which is very dangerous.

No Eating or Drinking in the Lab: All foods and drinks are banned from your classroom during science experimentation. When you eat or drink, you run the very real risk of ingesting part of your experiment. For electricity and magnetism labs, always wash your hands after the lab is over to rinse off the lead from the electrical components.

No Horse Play: When you goof around, accidents happen, which means chemicals spill, circuits short, and all kinds of hazards can occur that you weren't expecting. Never throw anything to another person and be careful where you put your hands – it could be in the middle of a sensitive experiment, especially with magnetism and electricity. You don't want to run the risk of getting shocked or electrified when it's not part of your experiment.

Fire: If you think there's a fire in the room (even if you're not sure), let your teacher know right away. If they are not around (they always should be), smother the fire with a fire blanket or use a fire extinguisher and send someone to find an adult. Stop, drop, and roll!

Questions: If you're not sure about something stop and ask, no matter what it's about. If you don't know how to properly handle a chemical, do part of an experiment, ask! If you're not comfortable doing part of the experiment, then don't do it.

Teaching Science Right

These activities and experiments will give you a taste of how science can be totally cool AND educational. But teaching science isn't always easy. There's a lot more to it than most traditional science books and programs accomplish. If your students don't remember the science they learned last year, you have a problem.

What do kids really need to know when it comes to science? Kids who have a solid science and technology background are better equipped to go to college, and will have many more choices once they get out into the real world.

Learning science isn't just a matter of memorizing facts and theories. On the contrary, it's developing a deep curiosity about the world around us, AND having a set of tools that lets kids explore that curiosity to answer their questions. Teaching science in this kind of way isn't just a matter of putting together a textbook with a few science experiments and kits.

Science education is a three-step process (and I mean teaching science in a way that your students will really understand and remember).

Here are the steps:

1. Get kids genuinely interested and excited about a topic.

2. Give them hands-on activities and experiments to make the topic meaningful.

3. Teach the supporting academics and theory.

Most science books and curriculum just focus on the third step and may throw in an experiment or two as an afterthought. This just isn't how students learn. When you provide your students with these three keys (in order), you can give your students the kind of science education that not only excites them, but that they remember for many years to come.

So what do you do? First, don't worry. It's not something that takes years and years to do. It just takes commitment.

What if you don't have time? What I'm about to describe can take a bit of time as a teacher, but it doesn't have to. There is a way to shortcut the process and get the same results! But I'll tell you more about that in a minute. First, let me tell you how to do it the right way:

Putting It into Action

Step one: Get students genuinely interested and excited about a topic. Start by deciding what topic you want your students to learn. Then, you're going to get them really interested in it. For example, suppose I want my fifth-grade students to learn about aerodynamics. I'll arrange for them to watch a video of what it's like to go up in a small plane, or even find someone who is a pilot and can come talk with the kids. This is the kind of experience that will really excite them.

Step two: Give your students hands-on activities and experiments to make the topic meaningful. This is where I take that excitement and let them explore it. I have flying lesson videos, airplane books, and real pilots interact with my students. I'll also show videos on how pilots plan for a flight. My students will learn about navigation, figuring out how much fuel is needed for the flight, how the weight the plane carries affects the aerodynamics of it, and so much more. (And did I just see a spot for a future math lesson also?) I'll use pilot training videos to help us figure this out (short of a live demo, a video is incredibly powerful for learning when used correctly).

My students are incredibly excited at this point about anything that has to do with airplanes and flying. They are all positive they want to be pilots someday and are already wanting flying lessons (remember - they are only fifth-graders!).

Step three: Teach the supporting academics and theory. Now, it's time to introduce academics. Honestly, I have my pick of so many topics, because flying includes so many different fields. I mean my students use angles and math in flight planning, mechanics and energy in how the engine works, electricity in all the equipment on board the plane, and of course, aerodynamics in keeping the plane in the air (to name just a few).

I'm going to use this as the foundation to teach the academic side of all the topics that are appropriate. We start with aerodynamics. They learn about lift and drag, make paper and balsa-wood gliders and experiment by changing different parts. They calculate how big the wings need to be to carry more weight (jelly beans) and then try their models with bigger wings. Then we move on to the geometry used in navigation. Instead of drawing angles on a blank sheet of paper, our workspace is made of airplane maps (free from the airport). We're actually planning part of the next flight my students will "take" during their geography lesson. Suddenly, angles are a lot more interesting. In fact, it turns out that we need a bit of trigonometry to figure out some things.

Of course, a 10-year old can't do trigonometry, right? Wrong! They have no idea that it's usually for high school and learn about cosines and tangents. Throughout this, I'm giving them chances to talk with the pilot in class, share what they've learned with each other, and even plan a real flight. How cool is that to a kid?

The key is to focus on building interest and excitement first, and then the academics are easy to get students to learn. Try starting with the academics and...well, we've all had the experience of trying to get kids do something they don't really want to do.

The Shortcut: Okay, so this might sound like it's time-intensive. If you're thinking "I just don't have the time to do this!" Or maybe "I just don't understand science well enough myself to teach it to my students at that level." If this is you, you're not alone.

The good news is, you don't have to. The shortcut is to find someone who already specializes in the area you want your students to learn about and expose them to the excitement that the person gets from the field. Then, instead of you being the one to invent an entirely new curriculum of hands-on activities and academics, use a solid science program or curriculum (live videos, not cartoons). This will provide them with both the hands-on experiments and the academic background they need.

If you use a program that is self-guided (that is, it guides you and your students through it step-by-step), you don't need to be hassled with the preparation. That's what this unit is intended to do for you and your students. This program uses these components and matches your educational goals set by state standards.

This unit implements the three key steps we just talked about and does this all for you. My hope is that you now have some new tools in your teaching toolbox to give your students the best start you can. I know it's like a wild roller coaster ride some days, but I also know it's worth it. Have no doubt that that the caring and attention you give to your students' education today will pay off manifold in the future.

Educational Goals for Energy 1

Energy is the ability to do work…but what is work? We're heading back in time to the "Golden Age" when Galileo, Newton, and other geniuses were figuring out all kinds of amazing things about the world around us. We'll start our discoveries in the field of energy by checking out how energy is stored through batteries, and how to convert it into usable forms, like kinetic energy, electric energy, chemical energy, and more. We have many innovative ways to harness energy. All the energy on the planet originally came from the sun (including wind energy because weather is driven by the sun), but it might have been transformed into a different form, like chemical or electrical energy, along the way.

We're also going to study the dynamics behind sound waves and the energy that allows a bobsled or roller coaster to slide down a hill as we play with kinetic and potential energy. You'll soon discover how energy is converted into one form or another, and that energy is not created or destroyed, but rather changes forms.

We'll also investigate simple machines and how they help convert this energy into something useable, including screws, levers, pulleys, and a complicated hydraulic-pneumatic earthmover that you will build totally from scratch.

All this will give us a great grasp on energy and how it moves through everything we do! Are you ready?

Here are the scientific concepts:

Part 1

- Energy comes from the sun to the Earth in the form of light.
- Sources of stored energy take many forms, such as food, fuel, and batteries.
- Machines and living things convert stored energy to motion and heat.
- Energy can be carried from one place to another by waves, such as water waves and sound, by electric current, and by moving objects.

By the end of the labs in this unit, students will be able to:

- Design and build experiments that demonstrate that sources of stored energy take many forms, such as food, fuel, and batteries.
- Know how to demonstrate how solar energy reaches Earth through radiation, mostly in the form of visible light.
- Understand how to determine that energy can be carried from one place to another by waves, such as water waves and sound, by electric current, and by moving objects.
- Differentiate observation from inference (interpretation) and know scientists' explanations come partly from what they observe and partly from how they interpret their observations.
- Measure and estimate the weight, length and volume of objects.
- Formulate and justify predictions based on cause-and-effect relationships.
- Conduct multiple trials to test a prediction and draw conclusions about the relationships between predictions and results.
- Construct and interpret graphs from measurements.
- Follow a set of written instructions for a scientific investigation.

Lesson #1: Can a Battery be Used to Store Energy?

Teacher Section

Overview: The students will learn about the properties of batteries and their capabilities by creating a chemical reaction.

Suggested Time: 30-45 minutes

Objectives: This experiment allows the students to learn how energy is transmitted in batteries through electrical current.

Materials (per lab group)

- Earphone or headset for a portable radio
- Small piece of aluminum foil
- Tomato juice
- New, shiny penny
- Two wires with alligator clips on each end of the wires
- Plate
- AA-size battery
- Spoon

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

In this experiment you made a simple battery with a penny, aluminum foil, and tomato juice. You completed a circuit with your battery by touching one of the wires attached to the earphone or headset to the penny, while touching the other wire to the aluminum foil. When you completed the circuit, a flow of electrons was produced by your battery. The crackling sound you heard was caused by the earphone or headset converting electrical energy from your battery into sound energy.

In your battery, the aluminum in the aluminum foil loses electrons. The other part of the reaction is more complex. Either the acid in the tomato juice or copper ions (that form when the copper metal in the penny reacts with the acid in the tomato juice) gain the electrons lost by the aluminum.

The main types of batteries are known as primary and secondary batteries. Dry cell batteries, like the ones used in flashlights and portable radios, are primary batteries. Another important primary battery is the mercury battery.

Mercury batteries are typically small and flat. They are used to power cameras, watches, hearing aids, and calculators.

An advantage of primary batteries is that they are generally inexpensive. One disadvantage is that they cannot be recharged. When the chemical substances in the primary batteries are used up, the battery is dead.

Lead storage batteries and nickel-cadmium (NiCad) batteries are examples of secondary batteries. Car batteries are lead storage batteries. Flashlight batteries that are rechargeable are NiCad batteries. Secondary batteries are more expensive than primary batteries. However, unlike primary batteries, lead storage batteries and NiCad batteries can be recharged repeatedly.

Lesson

A battery is a device that produces electrical energy from a chemical reaction. Another name for a battery is voltaic cell. Voltaic means to make electricity.

Most batteries contain two or more different chemical substances. The different chemical substances are usually separated from each other by a barrier. One side of the barrier is the positive terminal of the battery and the other side of the barrier is the negative terminal. When the positive and negative terminals of a battery are connected to a circuit, a chemical reaction takes place between the two different chemical substances that produces a flow of electrons (electricity).

When a battery is producing electricity, one of the chemical substances in the battery loses electrons. These electrons are then gained by the other chemical substance.

A battery is designed so that the electrons lost by one chemical substance are made to flow through a circuit, such as a flashlight lamp, before being gained by the other chemical substance. A battery will produce a flow of electrons until all of the chemical substances involved in the chemical reaction are completely used.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Examine the metal shaft of the part of the earphone or headset that is inserted into a portable radio. You will notice that just below the tip of the shaft there is a plastic spacer. Clip on one of the wires below this spacer. Then clip on the other wire above this spacer.
4. To test that the wires are properly connected to the earphone or headset, take the unconnected ends of the two wires and touch them to an AA-size battery. One wire should touch the positive end of the battery, while the other is touching the negative end of the battery. Place the earphone or headset to your ear. If your connections are made correctly, you should hear a crackling sound in the earphone or headset. If you do not hear a crackling sound, check your connections carefully.
5. Place a small piece of aluminum foil, about five inches (13 centimeters) square, on a small plate. Using a spoon, make a puddle of tomato juice on the aluminum foil. The puddle of tomato juice should be slightly larger than a penny. Next, place a new, shiny penny face down in the puddle of tomato juice.
6. Using the alligator clip, attach one of the wires connected to the earphone to one of the edges of the aluminum foil. Take the end of the other wire and touch the alligator clip to the penny. Move the alligator clip over the penny.

7. Have the students record their observations on their worksheets and discuss your results

Alternative Experiments:

- Repeat this experiment using other coins such as a dime, nickel, or quarter. Do any of these coins cause a louder crackling sound in the earphone or headset?
- Repeat this experiment using a nail instead of a coin. Can you make a battery with other juices? To find out, repeat this experiment with other juices such as lemon and orange juice. What do you observe?

Exercises

1. Fill in the blank: A battery produces ________________ energy from ______________________ energy. (electrical, chemical).
2. Another name for a battery is: (voltaic cell)
3. As one chemical loses electrons, what happens to the other chemical? (gains electrons)
4. When will a battery run out? (when one of the chemicals is used up)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #1: Can a Battery be Used to Store Energy?

Student Worksheet

Name____

Overview: We start our unit on energy with some of the most common sources of energy in our lives: batteries! We'll learn the basics of what makes them special.

What to Learn: Ask yourself how the energy is moved in this battery. What causes the electricity to flow?

Materials

- Earphone or headset for a portable radio
- Small piece of aluminum foil
- Tomato juice
- New, shiny penny
- Two wires with alligator clips on each end of the wires
- Plate
- AA-size battery
- Spoon

Lab Time

1. Examine the metal shaft of the part of the earphone or headset that is inserted into a portable radio. You will notice that just below the tip of the shaft there is a plastic spacer. Clip on one of the wires below this spacer. Then clip on the other wire above this spacer.
2. To test that the wires are properly connected to the earphone or headset, take the unconnected ends of the two wires and touch them to an AA-size battery. One wire should touch the positive end of the battery, while the other is touching the negative end of the battery. Place the earphone or headset to your ear. If your connections are made correctly, you should hear a crackling sound in the earphone or headset. If you do not hear a crackling sound, check your connections carefully.
3. Place a small piece of aluminum foil, about five inches (13 centimeters) square, on a small plate. Using a spoon, make a puddle of tomato juice on the aluminum foil. The puddle of tomato juice should be slightly larger than a penny. Next, place a new, shiny penny face down in the puddle of tomato juice.
4. Using the alligator clip, attach one of the wires connected to the earphone to one of the edges of the aluminum foil. Take the end of the other wire and touch the alligator clip to the penny. Move the alligator clip over the penny.
5. Record your observations on the worksheet below.

Battery Observations

1. Do you hear a crackling sound when you touch the alligator clips to the penny in the puddle of tomato juice? What do you hear when you move the alligator clip over the penny?

2. What do you hear when you stop touching the penny with the alligator clip?

Exercises Answer the questions below:

1. Fill in the blank: A battery produces _________________ energy from ______________________ energy.
2. Another name for a battery is:
    a. Solar array
    b. Voltaic cell
    c. Nuclear reactor
    d. Fusion cell
3. As one chemical loses electrons, what happens to the other chemical?
    a. It loses electrons
    b. It gains electrons
    c. Nothing
    d. It decomposes
4. When will a battery run out?
    a. When its batteries run out
    b. When its chemicals are used up
    c. When all the electrons are gone
    d. When the bunny stops drumming

Lesson #2: Salty Battery

Teacher Section

Overview: Today we'll see how ocean water can power a simple LED light.

Suggested Time: 30-45 minutes

Objectives: This lab teaches the kids how energy can be moved through batteries and electrical currents.

Materials (per lab group)

- water
- salt
- vinegar (distilled white)
- bleach **(IMPORTANT: WEAR GOGGLES!)**
- glass container (like a cleaned-out jam jar)
- electrodes
- real silverware (not stainless)
- shiny nail (galvanized)
- large paper clip
- dull nail (iron)
- wood screws (brass)
- copper pennies minted before 1982 (or a short section of copper pipe)
- graphite from inside a pencil (use a mechanical pencil refill)
- 2 alligator wires
- digital multimeter

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Electrochemistry studies chemical reactions that generate a voltage and vice versa (when a voltage drives a chemical reaction) are called "oxidation and reduction reactions," or redox for short. When electrons are transferred between molecules, it's a redox process.

Fruit batteries use electrolytes (solution containing free ions, like salt water or lemon juice) to generate a voltage. Think of electrolytes as a material that dissolves in water to make a solution that conducts electricity. Fruit batteries also need electrodes made of conductive material, like metal. Metals are conductors not because electricity passes through them, but because they contain electrons that can move. Think of the metal wire like a hose full of water. The water can move through the hose. An insulator would be like a hose full of cement – no charge can move through it.

You need two different metals in this experiment that are close, but not touching inside the solution. If the two metals are the same, the chemical reaction doesn't start and no ions flow and no voltage is generated – nothing happens.

Lesson

We can learn a lot about energy from chemistry and the ways that they interact with each other. A basic way that batteries operate can be explained by electrochemistry: the study of these electrical properties of chemical elements and compounds.

The basic idea of electrochemistry is that charged atoms (ions) can be electrically directed from one place to the other. If we have a glass of water and dump in a handful of salt, the NaCl (salt) molecule dissociates into the ions Na+ and Cl-.

When we plunk in one positive electrode and one negative electrode and crank up the power, we find that opposites attract: Na+ zooms over to the negative electrode and Cl- zips over to the positive. The ions are attracted (directed) to the opposite electrode and there is current in the solution.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Fill a cup with water, adding a teaspoon of salt, a teaspoon of distilled white vinegar, and a few drops of bleach. **NOTE: BE very careful with bleach! Cap it and store as soon as you've added it to the cup.**
4. Find two of the following materials: copper*, aluminum*, brass, iron, silver, zinc, graphite (* indicates the ones that are easiest to start with – use a copper penny and a piece of aluminum foil). Attach an alligator clip lead to each one and dunk into your cup. Make sure these two metals DO NOT TOUCH in the solution.
5. You've just made a battery! Test it with your digital volt meter and make a note of the voltage reading. Connect the multimeter in series to read the current (remove a clip from the metal and clip it to one test probe, and attach the other test probe to the metal. Make sure you're reading AMPS, not VOLTS when you note the reading for current. Current is measured in amps).
6. Test out different combinations of materials and note which gives the highest voltage reading for you. Is it enough to light an LED? Buzzer? Motor? What if you made two of these and connected them in series? Three? Four?

Exercises

1. Which measurement refers to the flow of electrical current? (amps)
2. What is another name for a battery? (voltaic cell)
3. Which direction are ions going to flow if a current becomes available? (to the opposite electrode)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #2: Salty Battery

Student Worksheet

Name____

Overview: Did you know that you can make electricity using a few common materials and even sea salt? We'll find out how, and why chemicals have so much to teach us when it comes to energy.

What to Learn: How is the electricity being generated? Where does this current come from?

Materials

- water
- salt
- vinegar (distilled white)
- bleach IMPORTANT: WEAR GOGGLES!
- glass container (like a cleaned out jam jar)
- electrodes
- real silverware (not stainless)
- shiny nail (galvanized)
- large paper clip
- dull nail (iron)
- wood screws (brass)
- copper pennies minted before 1982 (or a short section of copper pipe)
- graphite from inside a pencil (use a mechanical pencil refill)
- 2 alligator wires
- digital multimeter

Lab Time

1. Make sure to use safety goggles for this experiment. Do not handle any harmful chemicals without adult supervision.
2. Fill a cup with water, adding a teaspoon of salt, a teaspoon of distilled white vinegar, and a few drops of bleach. **NOTE: BE very careful with bleach! Cap it and store as soon as you've added it to the cup.**
3. Find two of the following materials: copper*, aluminum*, brass, iron, silver, zinc, graphite (* indicates the ones that are easiest to start with – use a copper penny and a piece of aluminum foil). Attach an alligator clip lead to each one and dunk into your cup. Make sure these two metals DO NOT TOUCH in the solution.
4. You've just made a battery! Test it with your digital volt meter and make a note of the voltage reading. Connect the multimeter in series to read the current (remove a clip from the metal and clip it to one test probe, and attach the other test probe to the metal. Make sure you're reading AMPS, not VOLTS when you note the reading for current. Current is measured in amps).
5. Test out different combinations of materials and note which gives the highest voltage reading for you. Is it enough to light an LED? Buzzer? Motor? What if you made two of these and connected them in series? Three? Four?

Salt Battery Data Table

Material	Voltage Reading

Exercises Answer the questions below:

1. Which measurement refers to the flow of electrical current?
    a. Volts
    b. Ions
    c. Amps
    d. Watts
2. What is another name for a battery?
    a. Chemitrode
    b. Voltaic cell
    c. Nuclear reactor
    d. Fusion cell
3. Which direction are ions going to flow if a current becomes available?
    a. Towards the same-charged electrode
    b. Towards the opposite-charged electrode
    c. Towards no electrode, they float out into space

Lesson #3: Do Plants Store Energy?

Teacher Section

Overview: This is a simple experiment where kids have the chance to see the energy that a plain old peanut contains in its shell. They will observe the nature and length of its burning, and will get a real picture of the energy that gets stored in living plants underground.

Suggested Time: 30-45 minutes

Objectives: This lesson will introduce that the earth contains energy that can be used for our benefit from the natural sources all around us, even in the ordinary shell of a peanut! This shows how the soils, rocks, and minerals provide for conditions that allow us to meet our energy needs.

Materials (per lab group)

- Goggles
- 2 shelled raw peanuts
- Small pair of pliers
- Match or lighter
- Sink
- Timer

Lab Preparation

1. Take some thought about the easiest and safest way to manage the peanut ignition in your classroom for this lab. Peanuts can vary in the duration and intensity of their combustion, so the students will need to do this lab under direct adult supervision.
2. Print out copies of the student worksheets.
3. Read over the Background Lesson Reading before teaching this class.
4. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

A peanut is not a nut, but actually a seed. In addition to containing protein, a peanut is rich in fats and carbohydrates. Fats and carbohydrates are the major sources of energy for plants and animals.

The energy contained in the peanut actually came from the sun. Green plants absorb solar energy and use it in photosynthesis. During photosynthesis, carbon dioxide and water are combined to make glucose. Glucose is a simple sugar that is a type of carbohydrate. Oxygen gas is also made during photosynthesis.

The glucose made during photosynthesis is used by plants to make other important chemical substances needed for living and growing. Some of the chemical substances made from glucose include fats, carbohydrates (such as various sugars, starch, and cellulose), and proteins.

Photosynthesis is the way in which green plants make their food, and ultimately all the food available on earth. All animals and non-green plants (such as fungi and bacteria) depend on the stored energy of green plants to live. Photosynthesis is the most important way animals obtain energy from the sun.

Oil squeezed from nuts and seeds is a potential source of fuel. In some parts of the world, oil squeezed from seeds--particularly sunflower seeds--is burned as a motor fuel in some farm equipment. In the United States and elsewhere, some people have modified diesel cars and trucks to run on vegetable oils.

Fuels from vegetable oils are particularly attractive because, unlike fossil fuels, these fuels are renewable. They come from plants that can be grown in a reasonable amount of time. Fossil fuels are nonrenewable fuels because they are formed over a long period of time.

Lesson

1. Plants get their energy from the sun, but also from the soils that they are planted in. What is the main way that plants get their energy, and what is it called? Yes, hopefully the kids will know about photosynthesis. When the sun reacts with the tiny packets of cells in the plant leaves, carbon dioxide and water combine to make a simple sugar called glucose. This sugar is the plant's food, and as a byproduct, the plant will give off oxygen.
2. What's important about photosynthesis is that all life on earth gets its food from plants in one way or another. Since plants get their food from the sun, we really owe our food needs to the ability that plants have to feed themselves!
3. Ask the kids to think about what they had for breakfast. Anybody have cereal? Well, they ate from a plant like wheat, corn, or rice that grew from the soil. OK, what about another level up? Who had eggs, or bacon? Well, where did that chicken or pig get its food from? Now we can really see the circle of life at work here.
4. Plants and animals also store energy in the forms of fats and oils. These can be sources of energy that are renewable, just like the corn products that we worked with in last lesson! These are pretty great sources of fuel because they can be substituted for gasoline and are renewable. So what are we going to test today? One pretty modest renewable source of fuel: a peanut!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Safety review: Clearly outline the rules regarding the handling of fire in the lab area. If there is a specific sink where the kids will need to do their experiment, make sure to designate it beforehand.
4. Close the drain with a sink stopper, and fill the sink with around an inch of water.
5. Put on safety goggles. Using a small pair of pliers, hold the peanut over the sink and ask your adult helper to light the peanut with the lighter until it catches fire. Have your data recorder ready with the timer.
6. Upon ignition (when the peanut is burning by itself and doesn't need the lighter), start the timer and run it until the peanut stops burning. Record the time on the worksheet. The adult remains present for the entire duration that the peanut is one fire.
7. Drop the peanut into the sink once finished to ensure all flames are out. Allow it to cool and record additional observations in the worksheet.

Exercises

1. What is the process called in which plants get food from the sun? (photosynthesis)
2. Where does all life on the planet get its food? (plants, and the sun)
3. What can people use a peanut's energy for? (fuel for cars, food)

Other things to try: If time allows, students can compare the peanut's combustion with that of a piece of dry spaghetti. The procedure for burning the spaghetti will be the same as for the peanut.

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #3: Do Plants Store Energy?

Student Worksheet

Name____

Overview: Put your safety goggles on for today's lab, because we're working with fire! You'll be measuring how much energy a peanut holds by setting it aflame.

What to Learn: All our energy needs on earth come from somewhere. We cannot make our own food, but plants can. We are all connected to the plants and soils that they grow in because they provide our very basic needs, as well as some of our more modern needs.

Materials

- Goggles
- 2 shelled peanuts
- Small pair of pliers
- Match or lighter
- Sink
- Timer

Lab Time

1. Today we're working with fire, so follow all special instructions about working with flames today.
2. Close the drain with a sink stopper, and fill the sink with around an inch of water.
3. Put on safety goggles. Using a small pair of pliers, hold the peanut over the sink and ask your adult helper to light the peanut with the lighter until it catches fire. Have your data recorder ready with the timer.
4. Upon ignition (when the peanut is burning by itself and doesn't need the lighter), start the timer and run it until the peanut stops burning. Record the time on the worksheet. The adult remains present for the entire duration that the peanut is one fire.
5. Drop the peanut into the sink once finished to ensure all flames are out. Allow it to cool as you record additional observations in the worksheet and complete the exercises.

Do Plants Store Energy? Data and Observations

Peanut	**Time burned (write in seconds):**
1 2	

Observations:

Does the peanut burn with a clean flame or a sooty flame?

What color is the flame? What color does the peanut turn when it burns?

Did the size of the peanut change after it had burned for several minutes?

Exercises Answer the questions below:

1. What is the process called where plants get food from the sun?
    a. Osteoporosis
    b. Photosynthesis
    c. Chlorophyll
    d. Metamorphosis
2. Where does all life on the planet get its food?

3. List two ways that we could use the energy in a peanut:
    a.

    b.

Lesson #4: Can Electricity be Made from Sunlight?

Teacher Section

Overview: Your students will learn about alternative energy up close as they handle a real solar photovoltaic cell in lab today.

Suggested Time: 30-45 minutes

Objectives: This lab helps the students learn how the sun transmits energy, accounting for the vast proportion of energy used on our planet.

Materials (per lab group)

- Silicon solar cell
- Two wires with alligator clips on each end of the wires
- Earphone or headset for a portable radio
- AA-size battery

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

The solar cell you are using for this experiment is made from the element silicon. Silicon solar cells consist of two thin wafers of treated silicon that are sandwiched together. The treated silicon is made by first melting extremely pure silicon in a special furnace. Tiny amounts of other elements are added which produce either a small positive or negative electrical charge.

Usually, boron is added to produce a positive charge and phosphorus is added to produce a negative charge. The addition of these other elements to pure silicon to produce an electrical charge is called doping.

After being doped, the molten silicon is allowed to cool. As it cools, the doped silicon grows into a large crystal from which very thin wafers are cut. A wafer cut from a large crystal of silicon doped with boron is called the positive or P-layer because it has a positive charge. A wafer cut from a large crystal of silicon doped with phosphorous is called the negative or N-layer.

Note: For this experiment you will need a silicon solar cell. Small silicon solar cells are inexpensive and can be purchased at many electronic supply stores. This experiment should be done on a bright, sunny day.

Lesson

To make a solar cell, a positive wafer (called the P-layer) and a negative wafer (called the N-layer) are sandwiched together. This causes the P-layer to develop a slight positive charge, and the N-layer to develop a slight negative charge. The solar cell is connected to a circuit by wires leading from the P-layer and the N-layer. When light falls on the surface of the cell, electrons are made to move from one layer to the other. Thus, a current of electricity flows through the circuit.

The first solar cells provided electrical power for space satellites and vehicles. Satellites and space vehicles are still big users of solar cells. Solar cells are now being used to provide electrical power for calculators and similar devices, weather stations in remote areas, oil-drilling platforms, and remote communication relay stations.

The best silicon cells convert only a small portion of the sunlight striking the cells into electricity. The efficiency of solar cells is about 15 percent. This means that 15 percent of the sunlight that strikes the cell is converted into electrical energy. The sunlight that is not converted into electricity either reflects off the surface of the cell or is converted into heat energy.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Examine the metal shaft on the part of the earphone or headset that is inserted into a portable radio. You will notice that just above the tip of the shaft there is a plastic spacer. Clip on one of the wires below this spacer. Then clip on the other wire above this spacer.
4. To test that the wires are properly connected to the earphone or headset, take the unconnected ends of the two wires and touch them to an AA-size battery. One wire should touch the positive end of the battery, while the other should touch the negative end of the battery. Place the earphone or headset to your ear. If your connections are made correctly, you should hear a crackling sound in the earphone or headset. If you do not hear a crackling sound, check your connections carefully.
5. Take the earphone or headset, with wires attached, and the solar cell outside into the sunshine. Ask a friend to join you. Your friend can help you hold the solar cell.
6. Place the earphone or headset to your ear. Ask your friend to hold one of the flat sides of the solar cell facing the sun. The two flat sides of the solar cell are different. In this experiment, you will determine which flat side must face the sun for the cell to generate electricity.
7. While your friend holds one of the flat sides of the solar cell facing· the sun, you hold one of the alligator clips on the side of the cell facing the sun. At the same time, touch the other alligator clip to the opposite side of the cell. As you hold the alligator clips to the cell, avoid blocking the sunlight striking the solar cell.
8. Ask your friend to turn the solar cell over so that the side that was not facing the sun before now does. Touch a clip to the two sides of the solar cell.
9. After determining which side of the solar cell needs to face the sun to make a crackling sound in your earphone or headset, ask your friend to hold that side toward the sun. Touch the two alligator clips to each side of the solar cell. Move the alligator clip touching the bottom of the solar cell around the bottom side to keep making the crackling sound in your earphone or headset. Next, block the sunlight striking the solar cell.

Alternative experiments:

- Repeat this experiment on a cloudy day. Do you still hear a crackling sound in the earphone or headset? If you do hear a crackling sound, is it quieter than on a bright, sunny day?
- Is there enough light in a room to cause the solar cell to make electricity? Try it yourself and see.

Exercises

1. If two electrodes become activated by a current, which way will the ions flow? (to the opposite-charged electrode)
2. What type of energy source is the solar panel most closely related to? (battery)
3. The solar cell's efficiency is not very good. How much of its energy is converted into electricity? (15 percent)
4. Name one common use for solar cells: (satellites, home power, power plants, road signs, monitoring stations, calculators, etc.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #4: Can Electricity be Made from Sunlight?

Student Worksheet

Name____

Overview: We'll get some hands-on experience with a real solar cell to answer the question of today's lab.

What to Learn: This lab will help you learn how and where most of our energy comes from - the sun!

Materials

- Silicon solar cell
- Two wires with alligator clips on each end of the wires
- Earphone or headset for a portable radio
- AA-size battery

Lab Time

1. Examine the metal shaft on the part of the earphone or headset that is inserted into a portable radio. You will notice that just above the tip of the shaft there is a plastic spacer. Clip on one of the wires below this spacer. Then clip on the other wire above this spacer.
2. To test that the wires are properly connected to the earphone or headset, take the unconnected ends of the two wires and touch them to an AA-size battery. One wire should touch the positive end of the battery, while the other should touch the negative end of the battery. Place the earphone or headset to your ear. If your connections are made correctly, you should hear a crackling sound in the earphone or headset. If you do not hear a crackling sound, check your connections carefully.
3. Take the earphone or headset, with wires attached, and the solar cell outside into the sunshine. Ask a friend to join you. Your friend can help you hold the solar cell.
4. Place the earphone or headset to your ear. Ask your friend to hold one of the flat sides of the solar cell facing the sun. The two flat sides of the solar cell are different. In this experiment, you will determine which flat side must face the sun for the cell to generate electricity.
5. While your friend holds one of the flat sides of the solar cell facing· the sun, you hold one of the alligator clips on the side of the cell facing the sun. At the same time, touch the other alligator clip to the opposite side of the cell. As you hold the alligator clips to the cell, avoid blocking the sunlight striking the solar cell.
6. Ask your friend to turn the solar cell over so that the side that was not facing the sun before now does. Touch a clip to the two sides of the solar cell.
7. After determining which side of the solar cell needs to face the sun to make a crackling sound in your earphone or headset, ask your friend to hold that side toward the sun. Touch the two alligator clips to each side of the solar cell. Move the alligator clip touching the bottom of the solar cell around the bottom side to keep making the crackling sound in your earphone or headset. Next, block the sunlight striking the solar cell.
8. Record your observations on the worksheet below.

Sun Energy Observations

1. Describe the difference between the two sides of the solar cell. Which side must be facing the sun to cause crackling in the earphone or headset when you touch the clips to the solar cell? What happens to the crackling sound when you block the sunlight from striking the solar cell?

2. When you examine your silicon solar cell, you will notice that the two flat sides of the cell are different. One side should have a silvery color, while the other side should appear dark. You should determine in this experiment that one side of the solar cell needs to face the sun for you to hear a strong crackling sound in the earphone or headset. The crackling sound is electricity, generated by the solar cell, passing through the earphone or headset. Can you hear it?

Exercises Answer the questions below:

1. If two electrodes become activated by a current, which way will the ions flow?
    a. To the electrode of the same charge
    b. To the electrode of the opposite charge
    c. None of the above
2. What type of energy source is the solar panel most closely related to?
    a. Biofuel
    b. Chemical battery
    c. Nuclear reactor
    d. Plant energy
3. The solar cell's efficiency is not very good. How much of its energy is converted into electricity?
    a. 50 %
    b. 80%
    c. 30%
    d. Less than all of these
4. Name one common use for solar cells:

Lesson #5: Solar Boat

Teacher Section

Overview: This clever experiment uses a boat to help us learn which angles are most helpful for solar arrays to collect and convert energy from the sun.

Suggested Time: 30-45 minutes

Objectives: This lab reinforces the ideas of last week's lab: how the sun transmits energy that is used all over our planet in a variety of ways.

Materials (per lab group)

- Solar Project Kit (Radio Shack #277-1201) or other solar cell with motor (usually sold in hobby stores)
- Foam block (about 6" long)
- Alligator clip leads (RS#278-1156)
- Propeller (if your kit doesn't come with one) – you can rip one off an old small personal fan or old toy

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Lesson

Does it really matter what angle the solar cell makes with the incoming sunlight? If so, does it matter much? When the sun moves across the sky, solar cells on a house receive different amounts of sunlight. You're going to find out exactly how much this varies by building your own solar boat.

Many solar companies advise people on how to position their solar panels depending on where in the world they live. Of course you would want to think about this if you live in a place where the sun is blocked for part of the year. Surprisingly, some of the world's fastest growing solar power markets are in cold, northern climates like Canada and Russia!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Attach the wires of the solar cell to the motor (one to each motor terminal).
4. Attach the propeller to your motor. If the shaft won't fit, drill out the center hole. If the hole is too large, use a tiny dab of hot glue on the shaft tip to secure the propeller into place.
5. Stand out in the sun. How do you need to hold your solar cell to make the propeller spin the fastest?

6. Position the motor on a block of foam so that the propeller hangs off the edge and is free to rotate. Hot glue the motor into place, being careful not to get any hot glue near any vents in your motor.
7. Hot glue your solar cell to the foam block. You might want to check the final position in sunlight before attaching it.

Exercises

1. What kind of electricity comes from a battery and photovoltaic cell? (electrochemical)
2. Electricity is another name for the free flow of (electrons)
3. True or false: Ions are attracted to the same charge. (false)
4. Do solar panels work in cloudy climates? (yes)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #5: Solar Boat

Student Worksheet

Name____

Overview: Does it matter at what angle a solar panel receives incoming sunlight? If so, does it matter enough to make a difference? We'll find out today in this clever experiment.

What to Learn: Sunlight is very important for all life on earth. Without it, we would not be able to survive. Thankfully we can use its energy in all kinds of ways, like we will today!

Materials

- Solar Project Kit (Radio Shack #277-1201) or other solar cell with motor (usually sold in hobby stores)
- Foam block (about 6" long)
- Alligator clip leads (RS#278-1156)
- Propeller (if your kit doesn't come with one) – you can rip one off an old small personal fan or old toy

Lab Time

1. Attach the wires of the solar cell to the motor (one to each motor terminal).
2. Attach the propeller to your motor. If the shaft won't fit, drill out the center hole. If the hole is too large, use a tiny dab of hot glue on the shaft tip to secure the propeller into place.
3. Stand out in the sun. How do you need to hold your solar cell to make the propeller spin the fastest?
4. Position the motor on a block of foam so that the propeller hangs off the edge and is free to rotate. Hot glue the motor into place, being careful not to get any hot glue near any vents in your motor.
5. Hot glue your solar cell to the foam block. You might want to check the final position in sunlight before attaching it.

Solar Boat Observation

Draw a picture of the angle at which your solar boat performs the best. Why do you think this is?

Exercises Answer the questions below:

1. What kind of electricity comes from a battery and photovoltaic cell?
    a. Nuclear
    b. Voltaic
    c. Electrochemical
    d. Ionized
2. Electricity is another name for the free flow of:
    a. Protons
    b. Quarks
    c. Electrodes
    d. Electrons
3. True or false: Ions are attracted to the same charge.
    a. True
    b. False
4. Do solar panels work in cloudy climates?
    a. Yes
    b. No

Lesson #6: Solar Car

Teacher Section

Overview: The students should have a blast creating their very own solar-powered race car in this fun, hands-on experiment.

Suggested Time: 30-45 minutes

Objectives: This lesson reinforces the ideas from previous experiments: how sunlight provides energy for our use in a variety of ways.

Materials (per lab group)

- Solar Project Kit (Radio Shack #277-1201) or other solar cell with motor (usually sold in hobby stores)
- Foam block (about 6" long)
- Alligator clip leads (RS#278-1156)
- 2 straws (optional)
- 2 wooden skewers (optional)
- 4 milk jug lids or film can tops
- Set of gears, one of which fits onto your motor shaft (most solar motor kits come with a set), or rip a set out of an old toy
- Hot glue gun
- Scissors or razor
- Stopwatch

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Electrons orbit the nucleus of an atom in specific layers called shells, and which shell they are in depends on the amount of energy they have. When sunlight hits a solar cell, it knocks an electron free of its shell. Once an electron is knocked out of its shell, it's called a *free electron.* The free electrons start flowing through the silicon to create electricity. The solar cells are structured is such a way as to keep the electricity flowing only in one direction. The electron flow created is DC (direct current).

The solar cells you can buy from stores require huge amounts of energy in creating the solar cell, which is the primary downside. You need high temperatures, big vacuum pumps, and lots of people to make a set of solar cells. However, if we focus just on the physics of the solar cell, then we can easily create our own solar battery and other solar cell projects using household items. While these cells won't look as spiffy as the ones from the store, they still produce electricity from sunlight.

Lesson

Solar energy (power) refers to collecting this energy and storing it for another use, like driving a car. The sun blasts 174 x 1015 watts (which is 174,000,000,000,000,000 watts) of energy through radiation to the earth, but only 70% of that amount actually makes it to the surface. And since the surface of the earth is mostly water, both in ocean and cloud form, only a small fraction of the total amount makes it to land.

A solar cell converts sunlight straight into electricity. Most satellites are powered by large solar panel arrays in space, as sunlight is cheap and readily available out there. While solar cells seem ”new” and modern today, the first ones were created in the 1880s, but were a mere 1% efficient. (Today, they get as high as 35%.) A solar cell’s efficiency is a measure of how much sunlight the cell converts into electrical energy.

Solar cells are usually made of silicon. Sunlight is made of packets of energy called photons. When photons hit the silicon, one of three things can happen: the photons can pass straight through the silicon if they have a low enough energy; they can get reflected off the surface; or (and this is the fun part) they get absorbed and the electrons in the silicon get knocked out of their shell. Once they get knocked out, they start flowing. Once this happens, voila! We have electricity!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Measure four inches from the end of your piece of balsa wood and cut in a straight line with the scissors or razor. Take the remaining piece and measure it so that you divide it in half lengthwise. Cut it with the razor. *Note: Adult supervision is needed for this step!*
4. Use the hot glue gun to join the two pieces, one on top of another.
5. Next, cut the straw into three pieces, each measuring as follows: 1 x 1 and 5/8”, 1 x 1 and 7/8”, and one extra leftover piece.
6. Now to attach the wheels to the body of the car. Take the second largest gear (it should be about the same size as the wheel), setting aside the other gears. Press the metal rod axle into the wheel, then thread the small washer in the car kit into the axle. Place the straw over the axle, and then attach the washer and wheel to the other side to complete the wheel and axle assembly. Check to make sure the axle spins freely by holding onto the straw. Attach the wheel to the base of the balsa wood with hot glue.
7. Start assembling the remaining wheels in the same manner, but after you add the shorter of the straws and washer, add the gear before closing the axle with the final wheel. Check to make sure that both the wheel and the gear spin freely when you hold the straw. Attach this axle to the body of the car with hot glue.
8. Attach the smallest of the gears to the shaft of the motor, and then align the motor so that the small gear meshes with the gear on the wheel and axle. Hot glue the motor in place when you’ve found the sweet spot.
9. Attach the solar cell to the body of the car with a small dab of hot glue. Take care to make sure the wires are facing away from the gears so that we don’t have the wires flying all over the place.
10. Attach the wires by twisting them together according to their color.
11. Go outside on a nice sunny day and mark out a set distance for your cars to travel. Use a stopwatch to record how quickly they travel the distance. Compare these results to different weather patterns. Do you notice anything? Record all your data on the worksheet.

Exercises

1. Most solar cells are made of what material? (silicon)
2. Name one benefit of solar cells and one drawback of using them for electricity. (Benefit=renewable, clean, less pollution, etc., Drawback=expensive, takes a lot of energy, have to mine for minerals)
3. Electrical current begins flowing when (electrons are knocked out of orbiting atoms)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #6: Solar Car

Student Worksheet

Name____

Overview: We're making our very own solar-powered cars as you discover important concepts about the sun's energy and how to capture it.

What to Learn This lesson reinforces the ideas from previous experiments: how sunlight provides energy for our use in a variety of ways.

Materials

- Solar Project Kit (Radio Shack #277-1201) or other solar cell with motor (usually sold in hobby stores)
- Foam block (about 6" long)
- Alligator clip leads (RS#278-1156)
- 2 straws (optional)
- 2 wooden skewers (optional)
- 4 milk jug lids or film can tops
- Set of gears, one of which fits onto your motor shaft (most solar motor kits come with a set), or rip a set out of an old toy
- Razor or scissors
- Stopwatch

Lab Time

1. Measure four inches from the end of your piece of balsa wood and cut in a straight line with the scissors or razor. Take the remaining piece and measure it so that you divide it in half lengthwise. Cut it with the razor. *Note: Adult supervision is needed for this step!*
2. Use the hot glue gun to join the two pieces, one on top of another.
3. Next, cut the straw into three pieces, each measuring as follows: 1 x 1 and 5/8", 1 x 1 and 7/8", and one extra leftover piece.
4. Now to attach the wheels to the body of the car. Take the second largest gear (it should be about the same size as the wheel), setting aside the other gears. Press the metal rod axle into the wheel, then thread the small washer in the car kit into the axle. Place the straw over the axle, and then attach the washer and wheel to the other side to complete the wheel and axle assembly. Check to make sure the axle spins freely by holding onto the straw. Attach the wheel to the base of the balsa wood with hot glue.
5. Start assembling the remaining wheels in the same manner, but after you add the shorter of the straws and washer, add the gear before closing the axle with the final wheel. Check to make sure that both the wheel and the gear spin freely when you hold the straw. Attach this axle to the body of the car with hot glue.
6. Attach the smallest of the gears to the shaft of the motor, and then align the motor so that the small gear meshes with the gear on the wheel and axle. Hot glue the motor in place when you've found the sweet spot.
7. Attach the solar cell to the body of the car with a small dab of hot glue. Take care to make sure the wires are facing away from the gears so that we don't have the wires flying all over the place.
8. Attach the wires by twisting them together according to their color.

9. Go outside on a nice sunny day and mark out a set distance for your cars to travel. Use a stopwatch to record how quickly they travel the distance. Compare these results to different weather patterns. Do you notice anything? Record all your data on the worksheet.

Solar Car Data Table

Date	Weather	Time

Total distance traveled:

Exercises Answer the questions below:

1. Most solar cells are made of what material?
    a. Hydrogen
    b. Aluminum
    c. Silicon
    d. Titanium
2. Name one benefit of solar cells and one drawback of using them for electricity.
    a. Benefit:

b. Drawback:

3. Electrical current begins flowing when:
    a. Sunlight hits an atom
    b. Electrons are knocked out of orbiting atoms
    c. Protons get charged
    d. An atom’s nucleus splits

Lesson #7: Can the Sun be used to heat water?

Teacher Section

Overview: The students will use some more advanced experimentation techniques to answer today's lab question.

Suggested Time: 30-45 minutes

Objectives: This lab helps students understand how the sun affects the energy we use daily.

Materials (per lab group)

- Paint brush
- Thermometer (outdoor type)
- Newspaper
- Aluminum foil
- Water
- Large, plastic glass
- Empty aluminum 12-ounce (355 milliliter) soft drink can
- Black paint or spray paint (flat, not shiny)

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

When the sun is overhead, about 1,000 watts of solar power strike 1 square meter (10.8 square feet) of the earth's surface. Using solar cells, this solar energy can be converted to electricity. However, because sunlight cannot be converted completely to electricity, it takes at least a square meter of area to gather enough sunlight to run a 100-watt light bulb.

Solar energy is still more expensive than other methods of generating electricity. However, the cost of solar electricity has greatly decreased since the first solar cells were developed in 1954.

It has been proposed that panels of solar cells on satellites in orbit above the earth could convert solar energy to electricity twenty-four hours a day. These huge solar power satellites could convert electrical energy to microwaves and then beam these microwaves to Earth. At the earth's surface, tremendous fields covered with antennas could convert the microwave energy back to electricity.

It would take thousands of astronauts many years to build such a complicated system. However, there are many practical uses of solar energy in use today. These uses include heating water, heating and cooling buildings, producing electricity from solar cells, and using rain and snow from the water cycle to power electrical generators at dams.

In this experiment, you should find a significant increase in the temperature of the water that was left in the black can during the day. The tap water initially may be about 21°C (70°F), but after the water has been heated inside the can, the temperature should rise to more than 38°C (100°F). The exact temperature you achieve in your miniature, solar water heater (black can) will depend on your location and the time of year. However, you should find that the water temperature will go much higher than the temperature of the outside air.

Lesson

The energy of sunlight powers our biosphere (air, water, land, and life on the earth's surface). About 50 percent of the solar energy striking the earth is converted to heat that warms our planet and drives the winds. About 30 percent of the solar energy is reflected directly back into space. The water cycle (evaporation of water followed by rain or snow) is powered by about 20 percent of the solar energy.

Some of the sunlight that reaches the earth is used by plants in photosynthesis. Plants containing chlorophyll use photosynthesis to change sunlight to energy. Since these green plants form the base of the food chain, all plants and animals depend on solar energy for their survival.

The electromagnetic radiation from the sun includes ultraviolet, visible, and infrared radiation. Ultraviolet radiation is the type of sunlight that causes tanning of skin. Visible radiation is the type of sunlight we see with our eyes. Infrared radiation is the type of sunlight that we feel as heat when the sun is shining on our skin. All these forms of solar radiation have energy associated with them.

When solar energy from the sun's electromagnetic radiation strikes a black surface, solar energy is converted to heat energy and the surface is warmed. Other colors will absorb solar energy, but lightly colored surfaces tend to reflect the light, while darker colors absorb the solar energy. You may have noticed this difference if you ever walked barefoot on a dark road on a hot summer day.

Direct solar energy is not hot enough for cooking. The higher temperatures required for cooking or for changing water to steam require concentrating the energy of sunlight with mirrors or lenses. However, directly absorbed solar energy is hot enough for heating homes and producing hot water with little or no energy costs.

When we turn on a hot water faucet at a sink, water is taken from a hot water tank. In industrialized countries, we usually heat water using electricity or natural gas and store the hot water in this insulated tank. However, around the world, there are millions of solar heaters used for heating water.

Solar water heaters use a black metal plate covered with insulated glass. These solar heaters are usually placed on rooftops to receive the maximum amount of sunlight. Water flows through tubes beneath the black metal plates. Solar energy heats the black metal plates and the water passing in tubes underneath the plates. The heated water is piped to a storage tank, where it is kept until needed. If the location of the solar heater is not consistently sunny, then an auxiliary heater--using electricity or natural gas--is sometimes used to heat the water.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Go outside and spread a sheet of newspaper on the ground. Place an empty aluminum soft drink can on the newspaper. Have an adult help you paint the outside of the aluminum can. You can use a brush and can of

paint or spray paint. Be sure to use paint that is suitable for a metal surface. The paint should give you a flat (not shiny) surface. Be sure not to get the paint on anything but the can and newspaper. After painting, set the can where the paint can dry overnight.

4. You will need to do the rest of this experiment on a warm, sunny day. Partially fill a large, plastic glass with cool tap water. Check the temperature of the water with a thermometer. Pour the water from the plastic glass into the painted black can, completely filling the can. Pour out any extra water remaining in the plastic glass. Cover the can's opening with a small piece of aluminum foil about the size of a quarter.
5. Set the black can outside in a sunny spot. Pick a place where the sun will shine on the can all day. (You do not want the can to be in the shade.)
6. After the can of water has been in the sunshine for about four hours, pour the water into the large, plastic glass. Check the temperature of the water with the thermometer. Feel the outside of the can.

Exercises

1. The solar energy that hits the earth is responsible for what proportion of the energy on our planet? (Nearly 100%)
2. Name one way that the physical earth uses the earth's energy: (Photosynthesis, the water cycle)
3. True or false: Solar power is generally less expensive than other forms of power. (false)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #7: Can the sun be used to heat water?

Student Worksheet

Name____

Overview: Although you won't need any lab coats, we are getting serious with our scientific skills here. We're going to explore the sun's energy potential in our experiment today.

What to Learn: You'll explore how the sun affects what we see as energy every day.

Materials

- Paint brush
- Thermometer (outdoor type)
- Newspaper
- Aluminum foil
- Water
- Large plastic glass
- Empty aluminum 12-ounce (355 milliliter) soft drink can
- Black paint or spray paint (flat, not shiny)

Lab Time

1. Go outside and spread a sheet of newspaper on the ground. Place an empty aluminum soft drink can on the newspaper. Have an adult help you paint the outside of the aluminum can. You can use a brush and can of paint or spray paint. Be sure to use paint that is suitable for a metal surface. The paint should give you a flat (not shiny) surface. Be sure not to get the paint on anything but the can and newspaper. After painting, set the can where the paint can dry overnight.
2. You will need to do the rest of this experiment on a warm, sunny day. Partially fill a large plastic glass with cool tap water. Check the temperature of the water with a thermometer. Pour the water from the plastic glass into the painted black can, completely filling the can. Pour out any extra water remaining in the plastic glass. Cover the can's opening with a small piece of aluminum foil about the size of a quarter.
3. Set the black can outside in a sunny spot. Pick a place where the sun will shine on the can all day. (You do not want the can to be in the shade.)
4. After the can of water has been in the sunshine for about four hours, pour the water into the large, plastic glass. Check the temperature of the water with the thermometer. Feel the outside of the can.
5. Record your observations on the worksheet below, and continue to discuss what's going on in this experiment.

Heating Water Data Table

Time	**Temperature**
Beginning of experiment	
After 2 hours	
After 4 hours	

Total difference in temperature: (+/-)

Exercises Answer the questions below:

1. The solar energy that hits the earth is responsible for what proportion of the energy on our planet?
    a. Nearly all of it
    b. About 50%
    c. 25%
    d. None of these
2. Name one way that the physical earth uses the earth's energy:

3. True or false: Solar power is generally less expensive than other forms of power.
    a. True
    b. False

Lesson #8: Marshmallow roaster

Teacher Section

Overview: This experiment allows the students to make some more delicious (and often burned) treats using the power of the sun.

Suggested Time: 30-45 minutes

Objectives: This lab will focus on the infrared section of the electromagnetic spectrum, and learn about the different areas that the sun's energy influences our earth.

Materials (per lab group)

- 7×10" page magnifier (Fresnel lens)
- Cardboard box, about a 10" cube
- Aluminum foil
- Hot glue, razor, scissors, tape
- Wooden skewers (BBQ-style)
- Chocolate, marshmallows, & graham cracker
- Thermometer

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

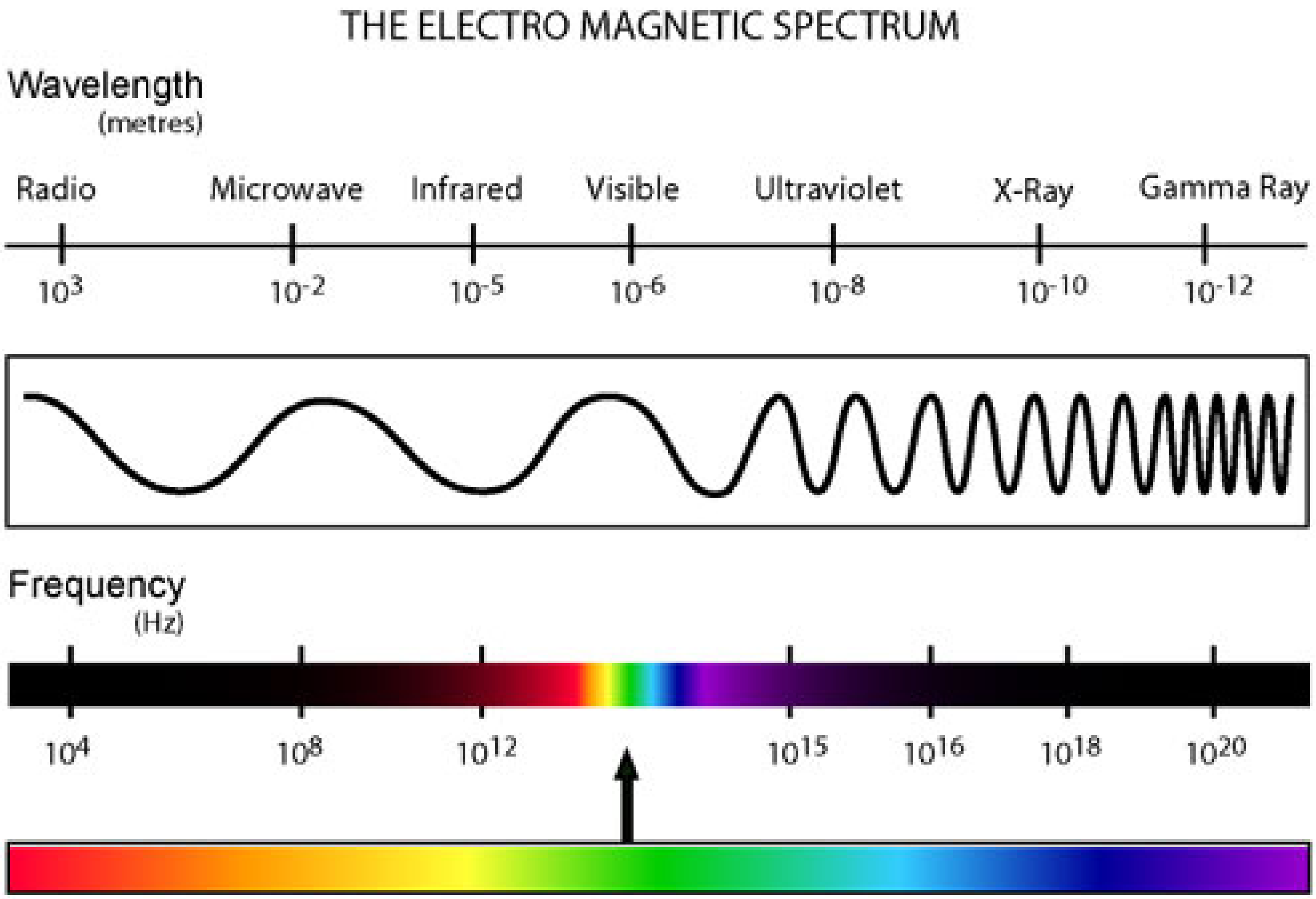
The Fresnel lens is a lot like a magnifying glass. A Fresnel lens (first used in the 1800s to focus the beam in a lighthouse) has lots of ridges you can feel with your fingers. It's basically a series of magnifying lenses stacked together in rings (like in a tree trunk) to magnify an image.

The best thing about Fresnel lenses is that they are lightweight, so they can be very large, which is why you'll find them in lighthouses. Fresnel lenses curve to keep the focus at the same point, no matter close your light source is.

The Fresnel lens in this project is focusing the incoming sunlight much more powerfully than a regular handheld magnifier. But focusing the light is only part of the story with your roaster. The other part is how your food cooks as the light hits it. If your food is light-colored, it's going to cook slower than darker (or charred) food. Notice how the burnt spots on your food heat up more quickly!

Lesson

This lesson will focus on the different parts of the **electromagnetic spectrum**. You can use the diagram below to illustrate each of the important divisions we make. Do you notice how energetic light is, and how different the uses are for each type? Infra-red is the one most directly responsible for cooking our food, while the visible spectrum is what we see in the sky all around us.



Use a helpful mnemonic device to help you remember the spectrum and its parts: RMIVUXG, such as "Red Monkeys In Violet Underwear X-ray Good"… even though it's not proper English, it might do the trick to help remember the different parts of the spectrum.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Take a razor and cut out a hole from the cardboard box slightly smaller than the Fresnel lens. Make sure the lens will fit.
4. Find the side of the lens that has grooves and place that side facing outwards. Secure the lens with hot glue. Use adult help if needed.
5. Cover each side of the inside of the box with aluminum foil. The lens will collect incoming light, but we don't want the box itself to catch on fire! This is what the foil is for. Don't worry about making the foil perfectly arranged. It just needs to cover every exposed part of the box.
6. Close the flaps of your box and seal it shut.
7. Cut a small window (maybe twice the size of the marshmallow) in the side of the box. Use your skewer to poke a hole through one door and out of the other. This is where the marshmallow goes.

8. Put a marshmallow in place on the skewer, and place your oven in the sun to get cooking! Record your observations and data on the worksheet.

Exercises

1. Label the electromagnetic spectrum. (Refer to diagram.)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #8: Marshmallow Roaster

Student Worksheet

Name____

Overview: Do you like marshmallows cooked over a campfire? I sure do. What if you don't have a campfire? We'll solve that problem by building our own food roaster that you can use to roast hot dogs, marshmallows, or anything you want. And it's battery-free since this device is powered by the sun.

What to Learn: Again, you'll see how the sun can directly meet our energy needs!

Materials

- 7×10" page magnifier (Fresnel lens)
- Cardboard box, about a 10" cube
- Aluminum foil
- Hot glue, razor, scissors, tape
- Wooden skewers (BBQ-style)
- Chocolate, marshmallows, & graham cracker
- Thermometer

Lab Time

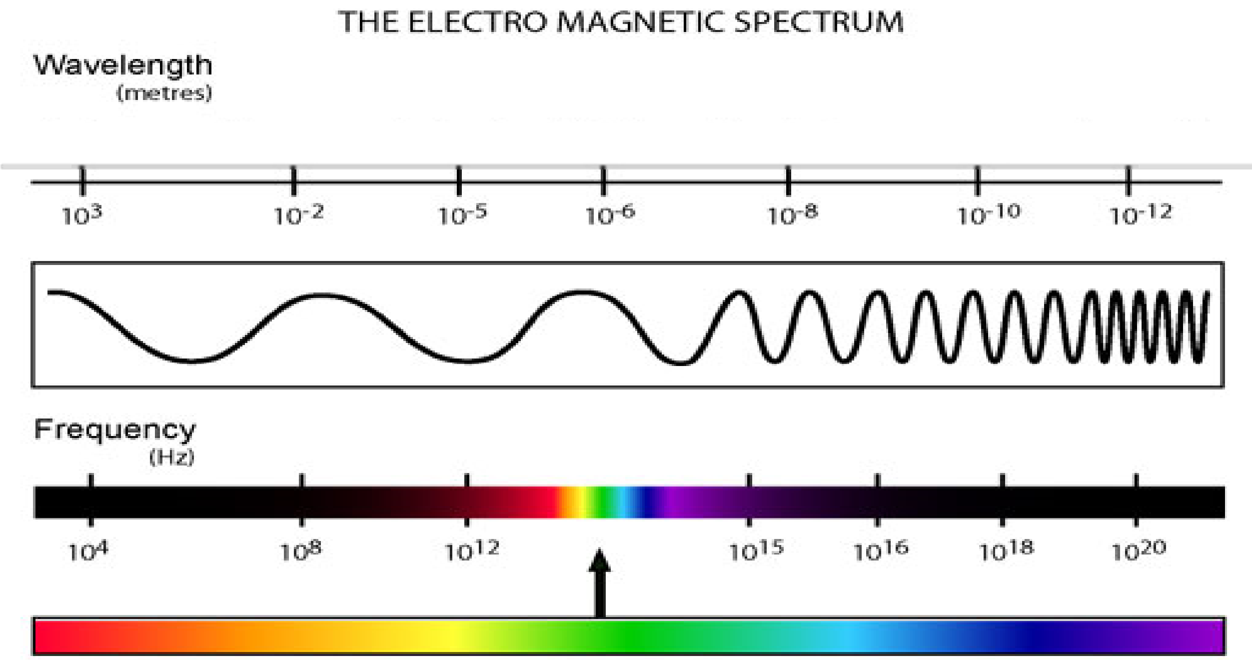
1. Take a razor and cut out a hole from the cardboard box slightly smaller than the Fresnel lens. Make sure the lens will fit.
2. Find the side of the lens that has grooves and place that side facing outwards. Secure the lens with hot glue. Use adult help if needed.
3. Cover each side of the inside of the box with aluminum foil. The lens will collect incoming light, but we don't want the box itself to catch on fire! This is what the foil is for. Don't worry about making the foil perfectly arranged. It just needs to cover every exposed part of the box.
4. Close the flaps of your box and seal it shut.
5. Cut a small window (maybe twice the size of the marshmallow) in the side of the box. Use your skewer to poke a hole through one door and out of the other. This is where the marshmallow goes.
6. Put a marshmallow in place on the skewer, and place your oven in the sun to get cooking! Record your observations and data on the worksheet. Use a thermometer to get your temperature readings in degrees Celsius.

Marshmallow Roaster Data Table

Time	Is it cooked?	Temperature (C)
2 hours		
3 hours		
3.5 hours		
4 hours		
4.5 hours		
5 hours		
5.5 hours		
6 hours		

Exercises Answer the questions below:

1. Label the parts of the electromagnetic spectrum below:



Lesson #9: Can the sun be used for cooking?

Teacher Section

Overview: Your students will harness the power of the sun to heat water and create enough energy to supply a commonplace culinary need.

Suggested Time: 30-45 minutes

Objectives: This lab teaches how energy comes from the sun, which arrived at planet Earth through radiation. As we use this energy, we convert it into other forms. This is particularly relevant as we talk about food and our own energy usage needs.

Materials (per lab group)

- Three clear, clean plastic cups
- Two small tea bags
- Aluminum foil
- Watch or clock
- Measuring cup
- Water
- Two spoons
- White sheet of paper
- Plastic pan (4 inches deep and 12 inches across is a convenient size but other sizes can be used)

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

The first large-scale application of solar power generation involves the basic principle of what we'll be using to heat our food. This type of energy collection, called solar thermal power, uses the heat energy from the sun to concentrate and convert sunlight into electricity. Usually this involves heating water into steam that turns a turbine. You may have seen these types of power plants as they involve collection towers with an array of mirrors arranged in a circle around the tower.

The largest solar power plants in the world are solar thermal arrays, notably the Agua Caliente plant in the Mojave Desert, which generates up to 350 megawatts of power, enough to power thousands of homes.

Lesson

Cooking involves heating food to bring about chemical changes. Sometimes foods are heated simply because the food tastes better warm than cold. In making tea, we sometimes heat water to help dissolve instant tea or help dissolve sugar if the tea is sweetened.

Normally the water used to make tea is heated on a range top or in a microwave oven. Using a range or microwave oven requires buying energy in the form of electricity or natural gas. Using a solar cooker does not require any energy costs because it uses a freely available renewable energy source: the sun.

A curved mirror in a bowl-like shape can focus reflected sunlight at a spot for cooking. A mirror about 1.5 meters (5 feet) across can generate a temperature of 177°C (350°F) and boil a liter of water in about fifteen minutes. In sunny areas of the world, solar cookers can be used instead of burning firewood for cooking.

Another way reflected and focused sunlight is used is to generate electricity. In southern California in 1982, a solar-thermal plant was built that can generate ten million watts of electrical power. This plant consists of 1,818 mirrored heliostats. A heliostat is a device that moves to track the sun across the sky and to reflect the sunlight at the same point. Each heliostat has twelve mirrors, and all the heliostats reflect sunlight to the same spot. The reflected light is directed at the top of a 90-meter (295-foot) tall tower. The concentrated sunlight is used to boil water and heat the steam up to 560° C (1,040 ° F). The steam turns a turbine that powers a generator to produce electricity.

One obvious disadvantage of solar-thermal plants is that they only operate when the sun is shining. The heat energy can be stored for a time by heating up a liquid or melting salt. Or the energy can be used to break water into hydrogen and oxygen. The hydrogen can then be stored and burned later to produce water and release energy.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Use two sheets of aluminum foil and place them crosswise to completely cover the bottom and sides of a plastic pan. Try to arrange the aluminum foil so that it is smooth and curved like a bowl. The aluminum foil will help to reflect the solar energy and concentrate the light and heat toward the center of the pan. Place this aluminum-covered pan outside in a warm, sunny spot where the sunlight will shine directly on it.
4. Add one cup of water to each of two plastic cups. The water you add to the cups should be neither hot nor cold, but about room temperature. Place one cup of water in the middle of the pan. Turn the empty plastic cup upside down and place it on top of this cup. Leave this “solar cooker” undisturbed for one hour. The other cup of water should remain inside.
5. After one hour, gently place one tea bag in each of the water-filled cups. Wait ten minutes and then lift the tea bag out of each cup. Using a spoon, stir each cup of tea. Place both cups of tea on a white piece of paper and look down on the two cups to compare their darkness. Put your finger in each cup of tea to compare their temperatures.

Exercises

1. What type of solar energy are we seeing in this experiment? (solar thermal)
2. Name two ways that the earth's systems depend on the sun (the water cycle, photosynthesis)
3. What is one advantage of solar thermal energy? What is one disadvantage?

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #9: Can the sun be used for cooking?

Student Worksheet

Name____

Overview: We need the sun for many things, but can it cook your food? We'll harness the power of the sun in today's experiment and find out!

What to Learn: This will help you understand how the sun's energy is converted to meet our needs.

Materials

- Three clear, clean plastic cups
- Two small tea bags
- Aluminum foil
- Watch or clock
- Measuring cup
- Water
- Two spoons
- White sheet of paper
- Plastic pan (4 inches deep and 12 inches across is a convenient size but other sizes can be used)

Lab Time

1. Use two sheets of aluminum foil and place them crosswise to completely cover the bottom and sides of a plastic pan. Try to arrange the aluminum foil so that it is smooth and curved like a bowl. The aluminum foil will help to reflect the solar energy and concentrate the light and heat toward the center of the pan. Place this aluminum-covered pan outside in a warm, sunny spot where the sunlight will shine directly on it.
2. Add one cup of water to each of two plastic cups. The water you add to the cups should be neither hot nor cold, but about room temperature. Place one cup of water in the middle of the pan. Turn the empty plastic cup upside down and place it on top of this cup. Leave this "solar cooker" undisturbed for one hour. The other cup of water should remain inside.
3. After one hour, gently place one tea bag in each of the water-filled cups. Wait ten minutes and then lift the tea bag out of each cup. Using a spoon, stir each cup of tea. Place both cups of tea on a white piece of paper and look down on the two cups to compare their darkness. Put your finger in each cup of tea to compare their temperatures.

Solar Cooking Data Table

	Cup 1	Cup 2
Temperature at start		
Temperature after 1 hour		

Exercises Answer the questions below:

1. What type of solar energy are we seeing in this experiment?
   a. Solar fusion
   b. Solar voltaic
   c. Solar thermal
   d. Radiation potential
2. Name two ways that the earth's systems depend on the sun:
   a.
   b.
3. What is one advantage of solar thermal energy? What is one disadvantage?
   a. Advantage:
   b. Disadvantage:

Lesson #10: Solar cookies

Teacher Section

Overview: By now we know that we can use solar cells to harness the sun's rays to meet our energy needs. Today, however, we'll see how light can be used to cook food without a direct conversion of this energy into some other electrical form.

Suggested Time: 30-45 minutes

Objectives: This experiment will show student how the sun influences phenomena on Earth, as well as how we can use this energy for our needs.

Materials (per lab group)

- Two large sheets of poster board (black is best)
- Aluminum foil
- Plastic wrap
- Black construction paper
- Cardboard box
- Pizza box (clean!)
- Tape & scissors
- Reusable plastic baggies
- Cookie dough (your favorite)
- Thermometer (preferably with a needle point reader)

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

The solar cookie oven uses the light from the sun, specifically the UV and IR parts of the spectrum, to bake the dough into some delicious treats. The UV rays are energetic and are responsible for damaging our skin if we don't shield it. The atmosphere of our earth does a lot to dissipate this energy so we aren't subject to some of the more harmful parts of the energy that the sun emits. In fact, the sun can eject enormous, energetic bursts of radiation far into space in the form of solar flares. We experience these flares as scrambles in our satellite signals, as well as see their effects visually in the atmosphere as aurorae.

The solar cookie oven operates on the basic principle that the electromagnetic radiation can be concentrated to be directly useful for our energy needs. Instead of converting the energy into electricity to power an oven, for example, the sun's rays are now directly heating the surfaces that the cookies rest on. A few ingredients are necessary for this oven to operate properly, which is what this experiment explores.

Lesson

Sunlight at the Earth's surface is mostly in the visible and near-infrared (IR) part of the spectrum, with a small part in the near-ultraviolet (UV). The UV light has more energy than the IR, although it's the IR that you feel as heat.

We're going to use both to bake cookies in our homemade solar oven. There are two different designs – one uses a pizza box and the other is more like a light funnel. Which one works best for you?

Your solar cooker does a few different things. First, it concentrates the sunlight into a smaller space using aluminum foil. This makes the energy from the sun more potent. If you used mirrors, it would work even better!

You're also converting light into heat by using the black construction paper. If you've ever gotten into car with dark seats, you know that those seats can get *HOT* on summer days! The black color absorbs most of the sunlight and transforms it into heat (which boosts the efficiency of your solar oven).

By strapping on a plastic sheet over the top of the pizza-box cooker, you're preventing the heat from escaping and cooling the oven off. Keeping the cover clear allows sunlight to enter and the heat to stay in. (Remember the black stuff converted your light into heat?) If you live in an area that's cold or windy, you'll find this part essential to cooking with your oven!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Measure an inch from each of three sides of the pizza box. Use the scissors/razor to cut a door out of the pizza box. Bend the door open if necessary. Cover the inside of the door with aluminum foil.
4. The heat needs to get trapped inside the box. Take your plastic wrap and tape it over the opening between the door and the inside of the pizza box. It doesn't matter which side you tape it on.
5. To help the heat stay inside the box, line the inside with aluminum foil. You can also add an insulation layer with some cotton balls, shredded paper, or similar to create a layer that will help trap the heat. On top, place your foil. On top of this, put down the black construction paper. Use tape to secure it all in place.
6. Check to make sure the box still closes. Take your cookie dough and place it in balls onto the surface of the paper. If you want, you can place a piece of parchment between the cookie and the sheet of paper, but make sure the parchment is only under the cookie.
7. Record your observations and data on the table below. Measure the temperature with a thermometer as well.
8. Enjoy your cookies! Be sure to share!

Exercises

1. Name the type of heat energy that the sun provides: (radiation)
2. What are some ways that the sun's energy can be directly harnessed? (cooking, heating/cooling)
3. Name three parts of the electromagnetic spectrum: (gamma, IR, X-ray, radio, microwave, UV, visible)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #10: Solar Cookies

Student Worksheet

Name____

Overview: By now you know how the sun's energy can be converted to meet our energy needs. But can it be used to directly provide us with energy? Today we'll find out how and make some treats along the way.

What to Learn: Ask how the sun can be used to provide energy directly, without being converted into electricity or other forms of energy first. Also, you'll be able to name different parts of the electromagnetic spectrum.

Materials

- Two large sheets of poster board (black is best)
- Aluminum foil
- Plastic wrap
- Black construction paper
- Cardboard box
- Pizza box (clean!)
- Tape & scissors
- Reusable plastic baggies
- Cookie dough (your favorite)
- Thermometer (preferably with a needle point reader)

Lab Time

Note: There's a real food safety concern here, as the cookie dough stays in the "danger thermal zone" for more than four hours. Do not eat the cookies until they register 165 on an instant-read thermometer, or omit the eggs in your recipe.

1. Measure an inch from each of three sides of the pizza box. Use the scissors/razor to cut a door out of the pizza box. Bend the door open if necessary. Cover the inside of the door with aluminum foil.
2. The heat needs to get trapped inside the box. Take your plastic wrap and tape it over the opening between the door and the inside of the pizza box. It doesn't matter which side you tape it on.
3. To help the heat stay inside the box, line the inside with aluminum foil. You can also add an insulation layer with some cotton balls, shredded paper, or fine shavings. On top, place your foil. On top of this, put down the black construction paper. Use tape to secure it all in place.
4. Check to make sure the box still closes. Take your cookie dough and place it in balls onto the surface of the paper.
5. Record your observations and data on the table below. Measure the temperature with a thermometer as well.
6. Enjoy your cookies! Be sure to share!

Solar Cookie Data Table

Time	Is it cooked?	Temperature (C)
3 hours		
4 hours		
4.5 hours		
5 hours		
5.5 hours		
6 hours		
6.5 hours		
7 hours		

Exercises Answer the questions below:

1. Name the type of heat energy that the sun provides:
    a. Convection
    b. Conduction
    c. Radiation
    d. Invection
2. What are some ways that the sun's energy can be directly harnessed?

3. Name three of the different parts of the electromagnetic spectrum:
    a.
    b.
    c.

Lesson #11: Buzzing hornets

Teacher Section

Overview: We'll look at the dynamics of sound today by constructing a box to illustrate how the sound waves travel through a medium.

Suggested Time: 30-45 minutes

Objectives: This lesson introduces a new concept: how different materials can transmit energy. An easy way to see this is through sound, which travels as vibrations through a substance.

Materials (per lab group)

- 2 index cards
- Popsicle stick (larger, like a tongue-depressor size)
- Rubber band
- Scissors
- String or yarn
- Hot glue gun

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Here is the principle at work behind the buzzing hornet:

When you sling the hornet around, wind zips over the rubber band and causes it to vibrate like a guitar string, and the sound is focused (slightly) by the card. The card really helps keep the contraption at the correct angle to the wind so it continues to make the sound.

Troubleshooting: Most kids forget to put on the rubber band, as they get so excited about finishing this project that they grab the string and start slinging it around, and then they wonder why it's so quiet. Make sure they have a large rubber band (about 3.5" x ¼ "– or larger) or you won't get a sound.

Lesson

Sound is everywhere. It can travel through solids, liquids, and gases, but it does so at different speeds. It can rustle through trees at 770 mph (miles per hour), echo through the ocean at 3,270 mph, and resonate through solid rock at 8,600 mph.

Sound is made by things vibrating back and forth, whether it's a guitar string, drum head, or clarinet. The back and forth motion of an object (like the drum head) creates a sound wave in the air that looks a lot like a ripple in a pond after you throw a rock in. It radiates outward, vibrating its neighboring air molecules until they are moving around, too. This chain reaction keeps happening until it reaches your ears, where your "sound detectors" pick up the vibration and works with your brain to turn it into sound.

This is one example of energy being transferred through matter. Just as electricity and sunlight also transfer energy (as ions and radiation, respectively) so too does sound. Although sound does it more indirectly, because the sound waves communicate the rippling or vibration of the molecules in space! Instead of electrons flowing or photons blasting at you, you're on the other end of a slinky from whatever made the sound! *Tip: Use a slinky to show compression waves as a demonstration. This is the type of wave that forms when you snap one side and allow the bunched coils to travel to the other side.*

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Cut two of the corners off the popsicle stick. Use hot glue to attach the index card to the stick quickly along the uncut side. If the index card is longer than your popsicle stick, trim it with the scissors.
4. Cut the second index card in half along its width (hamburger style). Now fold each piece of the index card in half a total of three times, so that you are left with a small, folded rectangle.
5. Use hot glue to sandwich the folded paper over one of the sides of the popsicle stick.
6. Take the remaining folded index card half and tie the string around it, making one tie on its opposite side. Your result should look something like a string-tied package, but looser. Attach the card to the other side of the popsicle stick, sandwiching it with hot glue.
7. Allow the glue to dry. Take the large rubber band and wrap it around the index card so that it covers both sides and both index card sandwiches.
8. Test your hornet by whipping it around your head quickly until it makes a sound.

Exercises

1. Which of the following best describes how sound gets to us? (vibrations in molecules)
2. Name two ways energy is transferred: (radiation, electricity)
3. True or false: A loud noise represents molecules that vibrate violently. (true)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #11: Buzzing hornets

Student Worksheet

Name____

Overview: Energy isn't just found in the sunlight or power plants that provide us with electricity, but in the molecules that vibrate as sound waves.

What to Learn: This lesson will show us how different materials transfer energy.

Materials

- 2 index cards
- Popsicle stick (larger, like a tongue-depressor size)
- Rubber band
- Scissors
- String or yarn
- Hot glue gun

Lab Time

1. Cut two of the corners off the popsicle stick. Use hot glue to attach the index card to the stick quickly along the uncut side. If the index card is longer than your popsicle stick, trim it with the scissors.
2. Cut the second index card in half along its width (hamburger style). Now fold each piece of the index card in half a total of three times, so that you are left with a small, folded rectangle.
3. Use hot glue to sandwich the folded paper over one of the sides of the popsicle stick.
4. Take the remaining folded index card half and tie the string around it, making one tie on its opposite side. Your result should look something like a string-tied package, but looser. Attach the card to the other side of the popsicle stick, sandwiching it with hot glue.
5. Allow the glue to dry. Take the large rubber band and wrap it around the index card so that it covers both sides and both index card sandwiches.
6. Test your hornet by whipping it around your head quickly until it makes a sound.
7. Try spinning your hornet at different speeds: slow, medium, and fast. Note the sound difference. Record your observations and data on the worksheet below.

Buzzing Hornets Data

Speed of spin	**Sound**
Slow	
Medium	
Fast	

Exercises Answer the questions below:

1. Which of the following best describes how sound gets to us?
    a. Chemical electricity
    b. Solar radiation
    c. Heat conduction
    d. Vibrating molecules
2. Name two ways energy is transferred:
    a.
    b.
3. True or false: A loud noise represents molecules that vibrate violently.
    a. True
    b. False

Lesson #12: Harmonica

Teacher Section

Overview: This time the kids use their breath the recreate the Buzzing Hornets experiment with a different twist. They'll love creating this and taking it home to share with parents and siblings.

Suggested Time: 30-45 minutes

Objectives: This lab explains how sound travels and is transmitted, introducing key concepts about how different things on our earth can transmit energy.

Materials (per lab group)

- two tongue depressor popsicle sticks
- three rubber bands, one at least 1/4″ wide
- paper
- tape

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Musical instruments harness the energy of the vibrating molecules in their materials to great effect. They are usually classified into the method by which sound is created or transmitted. Many instruments, including guitars, banjos, mandolins, and even pianos use strings that vibrate at a pitch determined by its length or width. Materials like nylon, steel, or bone explain why a classical guitar sounds different from a dobro, popular in bluegrass music.

The harmonica is a simple reed-type instrument, where the musician's breath forces the molecules in a reed-like material to vibrate, creating a sweet, high pitch. Other famous examples include the flute, oboe, and bassoon.

Here's what is going on in this experiment:

The rubber band vibrates as you blow across it and you get a great sound. You can change the pitch by sliding the cuffs (this does take practice).

Troubleshooting: This project is really a variation on the Buzzing Hornets, but instead of using wind to vibrate the string, you use your breath. The rubber band still vibrates, and you can change the vibration (pitch) by moving the cuffs closer together or further apart. If the cuffs don't slide easily, just loosen the rubber bands on the ends. You can also make additional harmonicas with different sizes of rubber bands, or even stack three harmonicas on top of each other to get unusual sounds.

If you can't get a sound, you may have clamped down too hard on the ends. Release some of the pressure by untwisting the rubber bands on the ends and try again. Also – this one doesn't work well if you spit too much – wet surfaces keep the rubber band from vibrating.

Lesson

Your voice is a vibration, and you can feel it when you place a hand on your throat when you speak. As long as there are molecules around, sound will be traveling though them by smacking into each other.

That's why if you put an alarm clock inside a glass jar and remove the air, there's no sound from the clock. There's nothing to transfer the vibrational energy to – nothing to smack into to transfer the sound. It's like trying to grab hold of fog – you can't, because there's nothing to hold on to.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Rip the paper in half. Stack the popsicle sticks on top of each other, and wrap the paper around them. Secure the whole thing with tape. Make sure you can slide the paper off easily. We'll call this a cuff.
4. Create another cuff with the other paper and popsicle sticks.
5. Take a fat rubber band and put it on a popsicle stick lengthwise.
6. Slide a cuff onto each end, leaving a bit of room at the end.
7. Lay the second popsicle stick on top, and wrap the second rubber band around and around to secure the ends and ensure they stay in place. Do this at both ends.
8. Play the harmonica by putting the thing up to your lips. Kids have to touch your lips to make this effective. To change the pitch, slide the cuffs closer together or farther apart. Is there a difference in sound?

Exercises

1. A battery creates electricity out of chemical energy, while sound is transmitted through: (a molecule's motion)
2. Your harmonica is most like which of the following instruments: (Clarinet)
3. Explain how this experiment is similar to the Buzzing Hornets. How is it different?

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #12: Harmonica

Student Worksheet

Name____

Overview: Move over Mozart! We'll create our own musical instruments today and explore more about the world of sound.

What to Learn: Ask yourself how this experiment is similar to the Buzzing Hornets lesson we did last week. How is it different?

Materials

- two tongue depressor popsicle sticks
- three rubber bands, one at least 1/4″ wide
- paper
- tape

Lab Time

1. Rip the paper in half. Stack the popsicle sticks on top of each other, and wrap the paper around them. Secure the whole thing with tape. Make sure you can slide the paper off easily. We'll call this a cuff.
2. Create another cuff with the other paper and popsicle sticks.
3. Take a fat rubber band and put it on a popsicle stick lengthwise.
4. Slide a cuff onto each end, leaving a bit of room at the end.
5. Lay the second popsicle stick on top, and wrap the second rubber band around and around to secure the ends and ensure they stay in place. Do this at both ends.
6. Play the harmonica by putting the thing up to your lips. Kids have to touch your lips to make this effective. To change the pitch, slide the cuffs closer together or farther apart. Is there a difference in sound?
7. Note how the pitch changes when you change the cuffs along the length of the harmonica. Record your data in the worksheet.

Harmonica Data Table

Position	**Pitch: Higher/Lower?**
Middle 1/4th	N/A
Close to the ends of the stick	
Close to the middle of the stick	

Exercises Answer the questions below:

1. A battery creates electricity out of chemical energy, while sound is transmitted through:
    a. Heat movement
    b. Rotating atoms
    c. Molecule movement
    d. Solar radiation
2. Your harmonica is most like which of the following instruments:
    a. Guitar
    b. Piano
    c. Clarinet
    d. Timpani
3. Explain how this experiment is similar to the Buzzing Hornets. How is it different?
    a. Similar

    b. Different

Lesson #13: Air Horn

Teacher Section

Overview: We can see sound at work dynamically through sonic booms. This is one example of a sound wave's vibration power to affect the matter around it in dramatic fashion.

Suggested Time: 30-45 minutes

Objectives: Students will understand how energy is transmitted through different mediums, observable especially through sound waves.

Materials (per lab group)

- 7-9" balloon
- straw
- film canister
- drill and drill bits

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Sound is a form of energy. Energy is the ability to move something over a distance against a force, remember? What is moving to make sound energy? Molecules. Molecules are vibrating back and forth at fairly high rates of speed, creating waves. Energy moves from place to place by waves. Sound energy moves by longitudinal waves (the waves that are like a slinky). The molecules vibrate back and forth, crashing into the molecules next to them, causing them to vibrate, and so on and so forth. All sounds come from vibrations.

Frequency describes how fast something is vibrating. Hertz is a measurement of frequency and one Hertz is one vibration per second.

Our ears are our sound antennas. When something vibrates, it causes energy to move by longitudinal waves, from the object vibrating to our ears. If that something is vibrating between about 60 Hz and 20,000 Hz it will cause your eardrum to vibrate. This is sound.

When something vibrates, it pushes particles. These pushed particles create a longitudinal wave. If the longitudinal wave has the right frequency and enough energy, your eardrum antennas will pick it up and your brain will turn the energy into what we call sound.

Sound is caused by something vibrating. If you can hear it, you can bet that somewhere, something is vibrating molecules and those molecules are vibrating your eardrums. The sound may be coming from a car, thunder, a balloon popping, clapping hands, or your gold fish blowing bubbles in her tank. However, no matter where it's coming from, what you are hearing is vibrating particles, usually vibrating air molecules.

Troubleshooting: Instead of a rubber band vibrating to make sound, a rubber sheet (in the form of a cut-up balloon) vibrates, and the vibration (sound) shoots out the straw. This is one of the pickiest experiments – meaning that it will take practice for your child to make a sound using this device. The straw needs to barely touch the inside surface of the balloon at just the right angle in order for the balloon to vibrate. Make sure you're blowing through the hole in the side, not through the straw (although you will be able to make sounds out of both attempts).

Lesson

Sound can change according to the speed at which it travels. Another word for sound speed is pitch. When the sound speed slows, the pitch lowers. With clarinet reeds, it's high. Guitar strings can do both, as they are adjustable. If you look carefully, you can actually see the low-pitch strings vibrate back and forth, but the high-pitch strings move so quickly it's hard to see. But you can detect the effects of both with your ears.

The range of your ears is about 20 – 20,000 Hz (cycles per second). Bats and dogs can hear a lot higher than we can. The image (right) is a real picture of an aircraft as it breaks the sound barrier – meaning that the aircraft is passing the speed that sounds travels at (about 700 mph). The white cloud you see in the photo is related to the shock waves that are forming around the craft as it moves into supersonic speeds. You can think of a shock wave as big pressure front, which creates clouds. In this photo, the pressure from the shock waves is condensing the water vapor in the air.

There are lots of things on earth that break the sound barrier – bullets and bullwhips, for example. The loud crack from a whip is the tip zipping faster than the speed of sound.

So why do we hear a boom at all? Sonic booms are created by air pressure (think of how the water collects at the bow of a boat as it travels through the water). The vehicle pushes air molecules aside in such a way they are compressed to the point where shock waves are formed. These shock waves form two cones, at the nose and tail of the plane. The shock waves move outward and rearward in all directions and usually extend to the ground.

As the shock cones spread across the landscape along the flightpath, they create a continuous sonic boom. The sharp release of pressure, after the buildup by the shock wave, is heard as the sonic boom.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Grab an un-inflated balloon and place it on your table. See how there are two layers of rubber (the top surface and the bottom surface)? Cut the neck off the balloon and slice it along one of the folded edges (still un-inflated!) so that it now lays in a flat, rubber sheet on your table.
4. Drape the balloon sheet over the open end of the film canister and snap the lid on top, making sure there's a good seal (meaning that the balloon is stretched over the entire opening - no gaps).
5. Insert the straw through the bottom end, and blow through the middle hole (in the side of the canister).

6. You'll need to play with this a bit to get it right, but it's worth it! The straw needs to *just* touch the balloon surface inside the canister and at the right angle, so take a deep breath and gently wiggle the straw around until you get a BIG sound. If you're good enough, you should be able to get two or three harmonics!
7. Record all observations in the worksheet.

Exercises

1. What is another word for the speed at which sound travels? (pitch)
2. Sonic booms are caused by: (shock waves as air molecules compress)
3. True or False: The unit used to measure pitch is Hertz. (yrue)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #13: Air Horn

Student Worksheet

Name____

Overview: We'll be able to detect sound waves as you amplify a squeak into a really annoying sound loud enough to make the cat cringe.

What to Learn: Energy is transmitted through a variety of matter forms, and can be observed as the sound waves cause matter to vibrate.

Materials

- 7-9" balloon
- straw
- film canister
- drill and drill bits

Lab Time

1. Grab an un-inflated balloon and place it on your table. See how there are two layers of rubber (the top surface and the bottom surface)? Cut the neck off the balloon and slice it along one of the folded edges (still un-inflated!) so that it now lays in a flat, rubber sheet on your table.
2. Drape the balloon sheet over the open end of the film canister and snap the lid on top, making sure there's a good seal (meaning that the balloon is stretched over the entire opening - no gaps).
3. Insert the straw through the bottom end, and blow through the middle hole (in the side of the canister).
4. You'll need to play with this a bit to get it right, but it's worth it! The straw needs to *just* touch the balloon surface inside the canister and at the right angle, so take a deep breath and gently wiggle the straw around until you get a BIG sound. If you're good enough, you should be able to get two or three harmonics!
5. Record all observations in the worksheet.

Air Horn Observations

1. How would you describe the pitch of the Air Horn? Is it high, medium, or low?

2. Why does the Air Horn sound like this? What is going on at the molecular level?

Exercises Answer the questions below:

1. What is another word for the speed at which sound travels?
    a. Longitude
    b. Dynamic
    c. Resonance
    d. Pitch
2. Sonic booms are caused by:
    a. Flash boil of water molecules in the air
    b. Shock waves created as air molecules compress
    c. Air molecules that vibrate so quickly they get torn apart
    d. None of the above
3. True or False: The unit used to measure pitch is Hertz.
    a. True
    b. False

Lesson #14: Seeing sound waves

Teacher Section

Overview: Vibrating molecules are the key to sound waves, and how we receive them in different forms.

Suggested Time: 30-45 minutes

Objectives: This experiment helps convey how different forms of matter produce energy in different ways, specifically how molecules transmit vibration energy through sound waves.

Materials (per lab group)

- Radio or music player
- Balloon
- Water
- Mixing bowl

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

This experiment builds on itself and can be reconfigured in a variety of ways. Review the Lab Time progression to see which of these can suit your class needs.

Lesson

Remember that sound is nothing more than vibrating molecules. The speaker from your stereo gets molecules of air to vibrate by creating longitudinal waves that push air. Your eardrums vibrate just like the speakers do when the longitudinal waves of sound energy hit your ears.

In this experiment, you'll see that the sound is coming from vibration. As long as a guitar string, rubber band, or drum head vibrates, you hear a sound. If you stop the object from vibrating, you will stop the sound. Sound is vibration.

The second thing I'd like you to notice is that the guitar string, rubber band, or drum heads can make sounds with different pitches. The tighter you stretch the material, the faster it vibrates. Another way to say "vibrating faster" is to say higher frequency. In sound, the higher the frequency of vibration, the higher the pitch of the note. The lower the frequency, the lower the pitch of the note. The average human ear can hear sound at as high a frequency as 20,000 Hz, and as low as 20 Hz. Pianos, guitars, violins and other instruments have strings of various sizes so that they can vibrate at different frequencies and make different pitched sounds. When you talk or sing, you change the tension of your vocal cords to make different pitches.

One last thing to notice here is what happens when you pluck a guitar string or a rubber band both hard and then softly. The string makes a louder noise the harder you plucked it, right? Since sound is energy, when you pluck that string hard, you put more energy into it than when you pluck it softly. You gave energy (moved it a distance against a force) to the guitar string. When you released it, it moved the air against a force which created sound energy.

For sound, the more energy it has, the louder it is. Amplitude is the size of the wave. The more energy a wave has the bigger it is. When it comes to sound, the larger the wave (the more energy it has) the louder it is. So when you plucked the guitar string hard (gave it lots of energy), you made a louder sound.

I said this in the beginning but I'll repeat it here, hoping that now it makes more sense. When something vibrates, it pushes particles against a force (creates energy). These pushed particles create longitudinal waves. If the longitudinal waves have the right frequency and enough energy (loudness), your eardrum antennas will pick it up and your brain will translate the energy into what we call sound.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Turn on your music player and turn it up fairly loud. (Tell your parents that it's for science!)
4. Take a look at your speaker. You should be able to see it vibrating. If there's a song with a lot of bass, you should really be able to see it moving.
5. Put your hand on the speaker. Can you feel the vibrations?
6. *With adult supervision,* put a half-filled bowl of water on top of your speaker. You should be able to see the water vibrate.
7. Remember that sound is nothing more than vibrating molecules. All speakers do is get molecules of air to vibrate, creating longitudinal waves. They push air. Your eardrums vibrate just like the speakers do when the longitudinal waves of sound energy hit your ears.

Part II:

8. Inflate the balloon. Get it fairly large. Turn the music on loud (the more bass the better).
9. Put both hands lightly on the balloon.
10. Walk around the room holding the balloon lightly between your hands. Try to feel the balloon vibrating.

Part III: Without speakers.

11. Here's another version of the same idea – I'll bet you did this experiment when you were a small baby! You need: a mixing bowl (one of those metal bowls), something to hit it with (a wooden spoon works well), and water.
12. Take the mixing bowl and put it on the table.
13. Smack it with the wooden spoon. Listen to the sound.
14. Put your ear next to the bowl and try to hear how long the sound continues.
15. Now hit the bowl again. Touch the bowl with your hand a second or two after you hit it. You should hear the sound stop. This is called dampening.
16. Now, for fun, fill the bowl with water up to an inch or so from the top.

17. Smack the bowl again and look very carefully at where the bowl touches the water. When you first hit the bowl, you should see very small waves in the water. I want you to notice two things here. Sound is vibration. When the bowl is vibrating, it's making a sound. When you stop it from vibrating, it stops making sound. Any sound you ever hear comes from something that is vibrating. It may have vibrated once, like a balloon popping. Or it may be vibrating consistently, like a guitar string. **The other thing I want you to notice is that you can actually see the vibrations.** If you put water in the bowl, the tiny waves that are formed when you first hit the bowl are caused by the vibrating sides of the bowl. Those same vibrations are causing the sound that you hear.

Part IV: No Water

18. Stretch a few rubber bands around the box or the bowl. If possible, use different thicknesses of rubber bands. Strum the rubber bands.
19. Feel free to adjust how stretched the bands are. The more stretched, the higher the note.
20. Try plucking a rubber band softly.
21. Now pluck it fairly hard. The hard pluck should be louder.

Exercises

1. Fill in the blank: A louder sound means that there is _______________ energy. (greater, more, etc.)
2. Explain how sound travels through a medium like water. (Water molecules vibrate from a source of vibration.)
3. True or False: A faster vibrating string will have a lower frequency. (false)
4. True or False" Sound waves are also known as longitudinal waves. (true)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #14: Seeing sound waves

Student Worksheet

Name____

Overview: You'll quickly see a variety of ways that sound waves interact with different materials in our lab today.

What to Learn: Since we're learning about energy in this unit, ask yourself where the energy is being created and transferred in each part of lab today.

Materials

- Radio or music player
- Balloon
- Water
- Mixing bowl

Lab Time

1. Turn on your music player and turn it up fairly loud. (Tell your parents that it's for science!)
2. Take a look at your speaker. You should be able to see it vibrating. If there's a song with a lot of bass, you should really be able to see it moving.
3. Put your hand on the speaker. Can you feel the vibrations?
4. *With adult supervision,* put a half-filled bowl of water on top of your speaker. You should be able to see the water vibrate.
5. Remember that sound is nothing more than vibrating molecules. All speakers do is get molecules of air to vibrate, creating longitudinal waves. They push air. Your eardrums vibrate just like the speakers do when the longitudinal waves of sound energy hit your ears.

Part II:

6. Inflate the balloon. Get it fairly large. Turn the music on loud (the more bass the better).
7. Put both hands lightly on the balloon.
8. Walk around the room holding the balloon lightly between your hands. Try to feel the balloon vibrating.

Part III: Without speakers.

9. Here's another version of the same idea – I'll bet you did this experiment when you were a small baby! You need: a mixing bowl (one of those metal bowls), something to hit it with (a wooden spoon works well), and water.
10. Take the mixing bowl and put it on the table.
11. Smack it with the wooden spoon. Listen to the sound.
12. Put your ear next to the bowl and try to hear how long the sound continues.
13. Now hit the bowl again. Touch the bowl with your hand a second or two after you hit it. You should hear the sound stop. This is called dampening.
14. Now, for fun, fill the bowl with water up to an inch or so from the top.

15. Smack the bowl again and look very carefully at where the bowl touches the water. When you first hit the bowl, you should see very small waves in the water. I want you to notice two things here. Sound is vibration. When the bowl is vibrating, it's making a sound. When you stop it from vibrating, it stops making sound. Any sound you ever hearcomes from something that is vibrating. It may have vibrated once, like a balloon popping. Or it may be vibrating consistently, like a guitar string. **The other thing I want you to notice is that you can actually see the vibrations.** If you put water in the bowl, the tiny waves that are formed when you first hit the bowl are caused by the vibrating sides of the bowl. Those same vibrations are causing the sound that you hear.

Part IV: No Water

16. Stretch a few rubber bands around the box or the bowl. If possible, use different thicknesses of rubber bands. Strum the rubber bands.
17. Feel free to adjust how stretched the bands are. The more stretched, the higher the note.
18. Try plucking a rubber band softly.
19. Now pluck it fairly hard. The hard pluck should be louder.

Observations:

1. What do you observe about the sound interacting with the water? What is going on at the molecular level, that is, if we zoomed in to see the atoms?

2. Does the balloon vibrate more for low sounds or high sounds?

3. How does the sound change when you hit the bowl with the wooden spoon through the procedure?

4. What do you notice about the placement of rubber bands and the sound it produces over the bowl?

Exercises Answer the questions below:

1. Fill in the blank: A louder sound means that there is ______________ energy.

2. Explain how sound travels through a medium like water.

3. True or False: A faster vibrating string will have a lower frequency.
    a. True
    b. False
4. True or False: Sound waves are also known as longitudinal waves.
    a. True
    b. False

Lesson #15: Best Parent-Annoyer

Teacher Section

Overview: We wrap up our section on sound energy with this fun and totally easy sound experiment in sonic vibrations, guaranteed to make hairs stand on end.

Suggested Time: 30-45 minutes

Objectives: This experiment teaches the kids how energy travels and changes form.

Materials (per lab group)

- water or violin rosin
- string
- disposable plastic cup of different sizes
- pokey-thing to make a hole in the cup

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.
4. Hand cups out to each lab group of different sizes. The kids will compare the sounds at the end of lab.

Background Lesson Reading

Violin rosin is a material made from pine sap that creates a friction surface between the horsehair strings of a bow and the nylon of the violin strings. While this configuration creates a sweet sound worthy of a concert hall, we'll be making some unorthodox music today (if you can call it that).

This is one of my absolute favorites, because it's so unexpected and unusual. The experiment setup looks quite harmless, but it makes a sound worse than scratching your nails on a chalkboard. If you can't find the weird ingredient, just use water and you'll get nearly the same result (it just takes more practice to get it right). Ready?

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Poke a hole in the bottom of the cup large enough to thread the string through. Put the string through, and then tie off one end with a small knot. This will make sure the string stays put in the cup. Make sure you have a few feet of string.

4. If you’re using water, soak the string in water for several minutes. If you use rosin, prepare the rosin by scratching it up until it becomes flaky and powdery to the touch. Then run the length of the rosin along the string, being careful to cover all sides.
5. Hold the cup in one hand, and take two fingers from your other hand and carefully apply pressure so that they stick and slip down the length of the string. Experiment to see which may make the loudest noise.

Exercises

1. As your string vibrates loudly, with a high pitch, what is going on? How would you explain this in terms of the molecules of the string? (The molecules are vibrating violently, releasing a greater amount of energy,)
2. Where and how is the energy traveling? (down the length of the string, as a longitudinal wave)
3. The speed at which a molecule vibrates is called its: (frequency)
4. What type of wave does sound travel as? (longitudinal)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #15: Best Parent-Annoyer

Student Worksheet

Name____

Overview: Adults probably won't appreciate this one, but we'll end this part of our studies on sound waves by creating a one-of-a-kind, all purpose parent annoyer!

What to Learn: Try to imagine what is going on at the molecular level, and what all of this talk about sound has to do with our larger theme of energy.

Materials

- water or violin rosin
- string
- disposable plastic cup of different sizes
- pokey-thing to make a hole in the cup

Lab Time

1. Poke a hole in the bottom of the cup large enough to thread the string through. Put the string through, and then tie off one end with a small knot. This will make sure the string stays put in the cup. Make sure you have a few feet of string.
2. If you're using water, soak the string in water for several minutes. If you use rosin, prepare the rosin by scratching it up until it becomes flaky and powdery to the touch. Then run the length of the rosin along the string, being careful to cover all sides.
3. Hold the cup in one hand, and take two fingers and carefully apply pressure so that they stick and slip down the length of the string. Experiment to see which may make the loudest noise.
4. Record your observations in the worksheet below

Parent-Annoyer Observations

Draw a diagram of the sound waves traveling down the string. You can include a few molecules in there for good measure.

Exercises Answer the questions below:

1. As your string vibrates loudly, with a high pitch, what is going on? How would you explain this in terms of the molecules of the string?

2. Where and how is the energy traveling?

3. The speed at which a molecule vibrates is called its:
    a. Frequency
    b. Wavelength
    c. Lambda
    d. Energy
4. What type of wave does sound travel as?
    a. Sine
    b. Sonic
    c. Longitudinal
    d. Compression

Lesson #16: Inclined Plane

Teacher Section

Overview: The kids will learn about the ability that energy gives us to do work through simple machines. The machine in the spotlight today is the inclined plane.

Suggested Time: 30-45 minutes

Objectives: This experiment helps the kids understand how machines convert energy into motion and heat.

Materials (per lab group)

- Sheet of paper
- Short dowel or cardboard tube from a coat hanger
- Tape

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Inclined planes have played important roles throughout history. Many of the wonders of the world were built using the aid of ramps and other inclined planes (not to mention handy pulleys and levers) to help laborers host the stones that built the pyramids, Great Wall of China, and other feats of engineering. The Assyrians used these ramps to allow their siege engines to tear down an enemy city's walls, and the Romans copied suit. Screws were used by the Greeks and Romans alike, creating fanciful ways to transfer energy, pump water, and even attack enemy troops. Leonardo da Vinci even used a creative screw shape to devise the earliest design for a helicopter!

Lesson

Energy is the ability to do work. Simple machines enable us to do work over distance. Work happens when something moves a distance against a force. Although it seems a little hard to comprehend, this is truly one of the most useful concepts in physics. I'm willing to bet you spend a lot of your time moving things a distance against a force. Do you ever climb stairs, walk, ride a bicycle, or lift a fork to your mouth to eat? Of course you do. Each one of those things requires you to move something a distance against a force. You're using energy and you're doing work. Work is not that hard … it's force that can be difficult. Imagine getting up a 10-step flight of stairs without a set of stairs. Your legs don't have the strength/force for you to jump up, you'd have to climb up or find a ladder or a rope. The stairs allow you to, slowly but surely, lift yourself from the bottom to the top.

Now imagine you are riding your bike and a friend of yours is running beside you. Who's got the tougher job? Your friend, right? You could go for many miles on your bike but your friend will tire out after only a few miles. The bike is easier (requires less force) to do as much work as the runner has to do.

Now here's an important point, you and your friend do about the same amount of work. You also do the same amount of work when you go up the stairs versus climbing up the rope. The work is the same, but the force needed to make it happen is much different. Don't worry if that doesn't make sense now. As we move forward, it will become clearer.

This "making the force less" thing is where simple machines come in. Way back when, folks needed to move stuff. Long before there were cranes and bulldozers. They needed to move heavy stuff, rocks, boulders, logs, boats, etc. These clever folks discovered machines. A machine, in science language, is any device that transmits or modifies energy. In other words, energy is put into the machine and comes out of the machine, but along the way the energy does work, changes direction, changes form or all of the above.

We're going to focus on the fact that machines can allow you to use less force to do work. Most folks say that there are six simple machines. These are the inclined plane, the wheel and axle, the lever, the pulley, the wedge, and the screw. Every machine with moving parts, from a tape player to a car, from a computer to a freight train, is made up of simple machines. We are going to spend time with two of the simple machines. By learning how they work you will get a nice picture of all the simple machines and what they do. In this lesson, we will be spending some quality time with levers, and in the next lesson we will spend time with pulleys.

What's an inclined plane? Jar lids, spiral staircases, light bulbs, and key rings are all examples of inclined planes that wind around themselves. Some inclined planes are used to lower and raise things (like a jack or ramp), but they can also used to hold objects together (like jar lids or light bulb threads).

Here's a quick experiment you can do to show yourself how something straight, like a ramp, is really the same as a spiral staircase.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Cut a right triangle out of paper so that the two sides of the right angle are 11" and 5 ½" (the hypotenuse – the side opposite the right angle – will be longer than either of these).
4. Find a short dowel or use a cardboard tube from a coat hanger. Roll the triangular paper around the tube beginning at the short side and roll toward the triangle point, keeping the base even as it rolls.
5. Notice that the inclined plane (hypotenuse) spirals up as a tread as you roll. Remind you of screw threads? Those are inclined planes.

Exercises

1. What is one way to describe energy? (the ability to do work)
2. Work is when something moves…(when force is applied)
3. Name two simple machines: (inclined plane, pulley, lever, wheel, wedge)
4. Name one example of a simple machine:

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #16: Inclined Plane

Student Worksheet

Name____

Overview: Energy allows us to do work. We've had to come up with ways to allow us to do this more easily with things called simple machines. The inclined plane is one example of a simple machine. We'll learn why this is important.

What to Learn: You will learn how simple machines help us to do work, as well as some of the ways that they help us in our everyday life.

Materials

- Sheet of paper
- Short dowel or cardboard tube from a coat hanger
- Tape

Lab Time

1. Cut a right triangle out of paper so that the two sides of the right angle are 11" and 5 ½" (the hypotenuse – the side opposite the right angle – will be longer than either of these).
2. Find a short dowel or use a cardboard tube from a coat hanger. Roll the triangular paper around the tube beginning at the short side and roll toward the triangle point, keeping the base even as it rolls.
3. Notice that the inclined plane (hypotenuse) spirals up as a tread as you roll. Remind you of screw threads? Those are inclined planes.

Observations

1. How does this help you do work?

2. Draw a picture of the inclined plane (left) and then how it is the same as a screw (right).

Exercises Answer the questions below:

1. What is one way to describe energy?
    a. The amount of atoms moving around at any given moment
    b. Electrons flowing from one area to another
    c. The ability to do work
    d. The square root of the speed of an electron
2. Work is when something moves when:
    a. Force is applied
    b. Energy is used
    c. Electrons are lost or gained
    d. A group of atoms vibrate
3. Name two simple machines:
    a.
    b.
4. Name one example of a simple machine:

Lesson #17: Roller coasters

Teacher Section

Overview: Marbles can teach us a lot about energy, especially while they zoom down a custom-made coaster track! Students will learn how energy can be transferred from kinetic energy to potential energy and back again.

Suggested Time: 30-45 minutes

Objectives: Students learn some important concepts about how potential energy is converted into motion energy.

Materials (per lab group)

- Marbles
- Masking tape
- 3/4″ pipe foam insulation (NOT neoprene and NOT the kind with built-in adhesive tape)

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Energy is always conserved. While it may sound like one of Newton's laws, this wasn't actually formulated until the 19th century. This law explains why we can't create a perpetual motion machine to meet all of our energy needs.

To make the roller coasters, you'll need foam pipe insulation, which is sold by the six-foot increments at the hardware store. You'll be slicing them in half lengthwise, so each piece makes twelve feet of track. It comes in all sizes, so bring your marbles when you select the size. The ¾" size fits most marbles, but if you're using ball bearings or shooter marbles, try those out at the store. (At the very least you'll get smiles and interest from the hardware store sales people.) Cut most of the track lengthwise (the hard way) with scissors. You'll find it is already sliced on one side, so this makes your task easier. Leave a few pieces uncut to become "tunnels" for later roller coasters.

Lesson

You might have heard how energy cannot be created or destroyed, but it can be transferred or transformed (if you haven't, that's okay – you'll pick it up while doing this activity). We will observe two types of energy here today: kinetic energy, and potential energy.

Kinetic energy is the energy of motion that an object has when it is pushed, flies, or falls.

Potential energy is the energy that an object has in relation to the system in which it exists. To imagine this, pretend that you are shooting a bow and arrow. When you pull your arm back, the arrow doesn't have kinetic energy, because it isn't moving. Yet the system has given it a lot of energy so that when you release your fingers, the arrow will fly fast and far.

Roller coasters are a prime example of energy transfer: You start at the top of a big hill at low speeds (high gravitational potential energy), then race down a slope at breakneck speed (potential transforming into kinetic) until you bottom out and enter a loop (highest kinetic energy, lowest potential energy). At the top of the loop, your speed slows (increasing your potential energy), but then you speed up again and you zoom near the bottom exit of the loop (increasing your kinetic energy), and you're off again!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Check your insulation tube. One side should be cut, so turn the tubing over and cut the other side, so you have two halves of the tubing.
4. To join the track, put tape on the inside and backside of the tubing.
5. To make a loop or corkscrew, use a third piece of tape to wrap all the way around the tube.
6. Tape one end of the tube as high as you can reach on the wall to start the marble rolling. Once you're ready, release the marble and watch it fly down the track!

Exercises

1. What type of energy does a marble have while flying down the track of a roller coaster? (kinetic)
2. What type of energy does the marble have when you are holding it at the top of the track? (potential)
3. At the top of a camel back hill, which is higher for the marble, kinetic or potential energy? (potential)
4. At the top of an inverted loop, which energy is higher, kinetic or potential energy? (potential)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #17: Roller coasters

Student Worksheet

Name____

Overview: Marbles can teach us a lot about energy, especially while they zoom down a custom-made coaster track! Today you'll learn how energy can be transferred from kinetic energy to potential energy and back again.

What to Learn: You'll discover important concepts about how potential energy is converted into motion energy.

Materials

- Marbles
- Masking tape
- 3/4″ pipe foam insulation (NOT neoprene and NOT the kind with built-in adhesive tape)

Lab Time

1. Check your insulation tube. One side should be cut, so turn the tubing over and cut the other side, so you have two halves of the tubing.
2. To join the track, put tape on the inside and backside of the tubing.
3. To make a loop or corkscrew, use a third piece of tape to wrap all the way around the tube.
4. Tape one end of the tube as high as you can reach on the wall to start the marble rolling. Once you're ready, release the marble and watch it fly down the track!

Observations

Where is the marble going the fastest?

When does the marble seem to slow down?

Why doesn't the marble fly off the track when it goes upside-down?

Exercises Answer the questions below:

1. What type of energy does a marble have while flying down the track of a roller coaster?

2. What type of energy does the marble have when you are holding it at the top of the track?

3. At the top of a camel back hill, which is higher for the marble, kinetic or potential energy?

4. At the top of an inverted loop, which energy is higher, kinetic or potential energy?

Lesson #18: Bobsleds

Teacher Section

Overview: We'll get more kinetic energy practice in this fun lesson where we let our marbles fly again, this time down a handmade bobsled track.

Suggested Time: 30-45 minutes

Objectives: This experiment will help the kids understand how energy converts into different forms.

Materials (per lab group)

- aluminum foil
- marbles (at least four the same size)
- long tube (gift wrapping tube or the clear protective tube that covers fluorescent lighting is great)

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

This is one of those quick-yet-highly-satisfying activities which utilizes ordinary materials and turns it into something highly unusual… for example, taking aluminum foil and marbles and making them into a racecar.

While you can make a tube out of gift wrap tubes, it's much more fun to use clear plastic tubes (such as the ones that protect long overhead fluorescent lights). Find the longest ones you can at your local hardware store. In a pinch, you can slit the gift wrap tubes in half lengthwise and tape the lengths together for a longer run or side-by-side for multiple tracks for races. (Poke a skewer through the rolls horizontally to make a quick-release gate.)

If you're finding that the marbles fall out before the bobsled reaches the bottom of the slide, you need to either crimp the foil more closely around the marbles or decrease your hill height.

Check to be sure the marbles are free to turn in their "slots" before launching into the tube – if you've crimped them in too tightly, they won't move at all. If you oil the bearings with a little olive oil or machine oil, your tube will also get covered with oil and later become sticky and grimy… but they sure go faster those first few times!

Lesson

Energy changes to other forms of energy all the time. The electrical energy coming out of a wall socket transfers to light energy in the lamp. The chemical energy in a battery transfers to electrical energy which transfers to sound energy in your personal stereo. In the case of the ball falling, gravitational potential energy transfers to kinetic energy, the energy of motion.

Here's an example: As Phillip holds the ball at the top of the building, the ball has 100 Joules of potential energy (the number is just an example). When he drops it, the potential energy of the ball drops since the height of the ball gets less and less. At the same time, however, kinetic energy increases because the speed of the ball increases. All the way down, the sum of the two energies equals 100. No energy gets lost, it only gets transferred. Energy is conserved.

Now here's a question you may be asking yourself, "If energy is neither created nor destroyed in a closed system then why doesn't a pendulum swing forever?"

Energy is neither created nor destroyed, but it can be transferred into non-useful energy.

In the case of a pendulum, every swing loses a little bit of energy, which is why each swing goes slightly less high (achieves slightly less PE) than the swing before it. Where does that energy go? To heat. The second law of thermodynamics states basically that eventually all energy ends up as heat. If you could measure it, you'd find that the string, and the weight have a slightly higher temperature than they did when they started due to friction. The energy of your pendulum is lost to heat!

If you could prevent the loss of energy to useless energy, you could create a perpetual motion machine. A machine that works forever! There have been a lot of folks who have spent a lot of time trying to make a perpetual motion machine. So far, they have all failed. A perpetual motion machine is one that is said to be 100% energy efficient. In other words, all the energy that goes into it goes to useful energy.

Your pendulum could be said to be about 90% efficient. Very little energy is converted into useless energy. In most systems, energy is converted to useless heat and sound energy.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Take a piece of aluminum foil, around 12 inches on each side. Scrunch it up and make a torpedo-like shape.
4. Squish one of the marbles onto one side, and then arrange the other three marbles along the length of the aluminum clump so that they resemble peas in a pod. Continue to pinch and form the foil around each one of the marbles.
5. Test your bobsled by turning it over and rolling it on the table a few times. If it doesn't roll, re-pack the marbles so they can move freely.
6. Place the bobsled in the tube with one side elevated, and release!
7. Experiment with different amounts of marbles or marble sizes and record your observations on the worksheet below.

Exercises

1. Potential energy is energy that is related to: (the system that it is in.)
2. If an object's energy is mostly being used to keep that object in motion, we can say it has what type of energy? (kinetic)
3. True or False: Energy is able to remain in one form that is usable over and over again. (false)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #18: Bobsleds

Student Worksheet

Name____

Overview: We'll get more kinetic energy practice in this fun lesson where we let our marbles fly again, this time down a handmade bobsled track.

What to Learn: We continue to explore the means by which energy is transferred and used according to the laws of physics.

Materials

- aluminum foil
- marbles (at least four the same size)
- long tube (gift wrapping tube or the clear protective tube that covers fluorescent lighting is great)

Lab Time

1. Take a piece of aluminum foil, around 12 inches on each side. Scrunch it up and make a torpedo-like shape.
2. Squish one of the marbles onto one side, and then arrange the other three marbles along the length of the aluminum clump so that they resemble peas in a pod. Continue to pinch and form the foil around each one of the marbles.
3. Test your bobsled by turning it over and rolling it on the table a few times. If it doesn't roll, re-pack the marbles so they can move freely.
4. Place the bobsled in the tube with one side elevated, and release!
5. Experiment with different amounts of marbles or marble sizes and record your observations on the worksheet below.

Bobsled Observations

Configuration of Bobsled	Observations:

Exercises Answer the questions below:

1. Potential energy is energy that is related to:
   a. Equilibrium
   b. Kinetic energy
   c. Its system
   d. Its elevation
2. If an object's energy is mostly being used to keep that object in motion, we can say it has what type of energy?
   a. Kinetic energy
   b. Potential energy
   c. Heat energy
   d. Radiation energy
3. True or False: Energy is able to remain in one form that is usable over and over again.
   a. True
   b. False

Lesson #19: Go Go Go!

Teacher Section

Overview: This experiment focuses on the energy transfer of rolling cars. You'll be placing objects and moving them about to gather information about the potential and kinetic energy.

Suggested Time: 30-45 minutes

Objectives: This lab is designed to teach all about energy transfer, as well as provide the kids with some key experience collecting data and interpreting the results.

Materials (per lab group)

- a few toy cars (or anything that rolls like a skate)
- a board, book or car track
- measuring tape

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Lesson

As you lifted the car onto the track in today's lab, you gave the car potential energy. As the car went down the track and reached the floor, it lost potential energy and gained kinetic energy. When the car hit the floor it no longer had any potential energy, only kinetic.

If the car was 100% energy efficient, the car would keep going forever. It would never have any energy transferred to useless energy. Your cars didn't go forever, did they? Nope, they stopped and some stopped before others. The ones that went farther were more energy efficient. Less of their energy was transferred to useless energy than the cars that went less far.

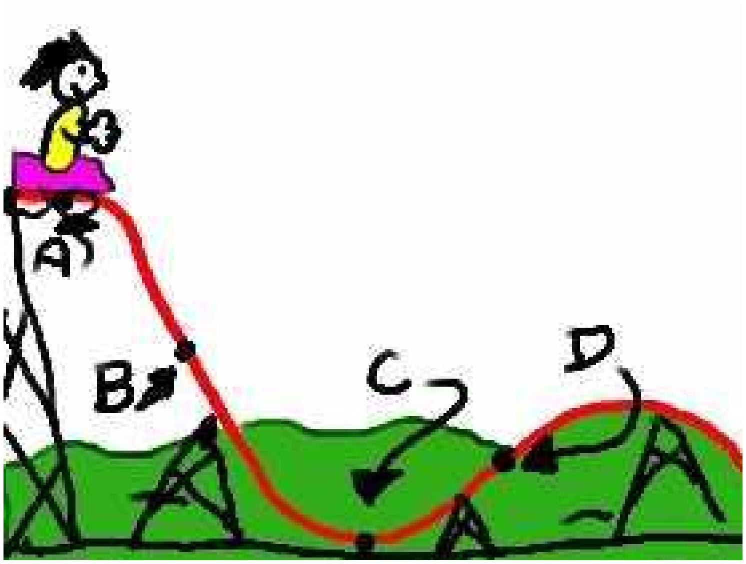
Where did the energy go? It went to heat energy, created by the friction of the wheels, and to sound energy. Was energy lost? No, it was only changed. If you could capture the heat energy and the sound energy and add it to the kinetic energy, the sum would be equal to the original amount of energy the car had when it was sitting on top of the ramp.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Set up the track (board or book so that there's a nice slant to the floor).
4. Put a car on the track.

5. Let the car go.
6. Mark or measure how far it went.
7. Experiment with different track configurations. Does this make a difference? Record your results on the data worksheet below.

Exercises



1. Where is the potential energy greatest? (A)
2. Where is the kinetic energy greatest? (C)
3. Where is potential energy lowest? (C)
4. Where is kinetic energy lowest? (A)
5. Where is KE increasing, and PE is decreasing? (B)
6. Where is PE increasing and KE decreasing? (D)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #19: Go Go Go!

Student Worksheet

Name____

Overview: This experiment focuses on the energy transfer of rolling cars. You'll be placing objects and moving them about to gather information about the potential and kinetic energy.

What to Learn: This will help us get in touch with the fundamentals of energy transfer, specifically how kinetic and potential energy are related to one another.

Materials

- a few toy cars (or anything that rolls like a skate)
- a board, book or car track
- measuring tape

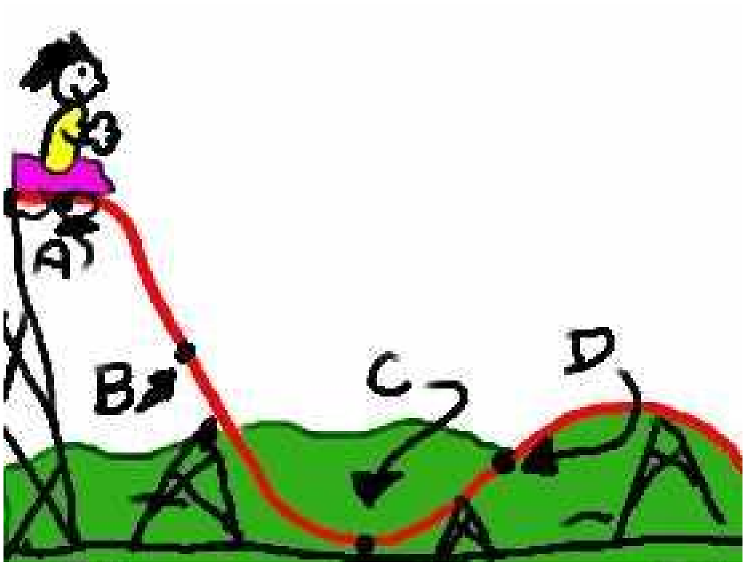
Lab Time

1. Set up the track (board or book so that there's a nice slant to the floor).
2. Put a car on the track.
3. Let the car go.
4. Mark or measure how far it went.
5. Experiment with different track configurations. Does this make a difference? Record your results on the data worksheet below.

Go Go Go! Data Table

Configuration:	Description:	Distance Traveled:
1		
2		
3		
4		

Exercises Answer the questions below:



1. Where is the potential energy greatest?

2. Where is the kinetic energy greatest?

3. Where is potential energy lowest?

4. Where is kinetic energy lowest?

5. Where is KE increasing, and PE is decreasing?

6. Where is PE increasing and KE decreasing?

Lesson #20: Mystery toy

Teacher Section

Overview: This fun experiment shows the kids how kinetic energy is transformed into potential energy through the key ingredient in the toy that sums up the mystery: the elastic rubber band.

Suggested Time: 30-45 minutes

Objectives: We aim to explain how energy is transferred and transmitted in various forms: kinetic, potential, heat.

Materials (per lab group)

- can with a lid
- heavy rock or large nut
- two paper clips
- rubber band

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

The hex nut is a weight that twists up the rubber band as the can rolls around it. The kinetic energy (the rolling motion of the can) transforms into potential (elastic) energy stored in the rubber band the free side twists around. The can stops (this is the point of highest potential energy) and returns to you (potential energy is being transformed into kinetic). The farther the toy is rolled, the more elastic potential energy it stores.

Lesson

Engage the kids in the dynamics of potential and kinetic energy, clearing up any misconceptions they may have about the way that they work. If you have some extra time, you can talk about how other common energy transfers occur, most notably through heat loss in a system. This can tie into simple machines, especially how they use energy and enable work to be done efficiently or inefficiently, depending on the tool!

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. You'll need two holes punched through your container – one in the lid and the bottom. Thread your rubber band through the heavy washer and tie it off (this is important!).
4. Poke the ends of the rubber band through one of the holes and catch it on the other side with a paper clip. (Just push a paper clip partway through so the rubber band doesn't slip back through the

hole.) Do this for both sides, and make sure that your rubber band is a pulled mildly tight inside the can. You want the hex nut to dangle in the center of the can without touching the sides of the container.

5. Now for the fun part … gently roll the can on a smooth floor away from you. The can should roll, slow down, stop, and return to you! If it doesn't, check the rubber band tightness inside the can.

Exercises

1. Explain in your own words two types of energy transfer
2. True or false: All energy in a system is lost to heat. (false)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #20: Mystery Toy

Student Worksheet

Name____

Overview: This mystery toy will help us uncover the dynamics of energy transfer, and how kinetic and potential energy are related.

What to Learn: Ask yourself, "How is the energy moving through this system?" Where is the potential energy stored? Where is the kinetic energy interacting?

Materials

- can with a lid
- heavy rock or large nut
- two paper clips
- rubber band

Lab Time

1. You'll need two holes punched through your container – one in the lid and the bottom. Thread your rubber band through the heavy washer and tie it off (this is important!).
2. Poke the ends of the rubber band through one of the holes and catch it on the other side with a paper clip. (Just push a paper clip partway through so the rubber band doesn't slip back through the hole.) Do this for both sides, and make sure that your rubber band is a pulled mildly tight inside the can. You want the hex nut to dangle in the center of the can without touching the sides of the container.
3. Now for the fun part… gently roll the can on a smooth floor away from you. The can should roll, slow down, stop, and return to you! If it doesn't, check the rubber band tightness inside the can.

Mystery Toy Observations

1. Where is the energy stored in this system at the point when the can stops rolling away from you?

2. What happens to the kinetic energy at this point?

Exercises Answer the questions below:

1. Explain in your own words two types of energy transfer:
    a.
    b.
2. True or false: All energy in a system is lost to heat.
    a. True
    b. False

Lesson #21: Pendulums

Teacher Section

Overview: This is a very simple yet powerful demonstration that shows how potential energy and kinetic energy transfer from one to the other and back again, over and over.

Suggested Time: 30-45 minutes

Objectives: This experiment helps the kids understand dynamics of energy transfer, which can be conveyed through natural phenomena as well as machines and systems, like our pendulum.

Materials (per lab group)

- some string
- a bit of tape
- a washer or a weight of some kind
- set of magnets (at least 6, but more is better)
- metal sheet

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

This two-part experiment helps us understand the dynamics of kinetic and potential energy. The large nut from our last experiment can be used again for this experiment, coincidentally.

The chaos pendulum is more of a curiosity than a lesson in kinetic energy. You can use the pendulum to explain the conservation of energy, and in fact that a "perpetual motion machine" is impossible to build. You don't need to get into the complexities of magnetic fields and electromagnetism.

Lesson

A pendulum is an easy way to see how energy changes forms between kinetic and potential energy. If we look at a swinging pendulum, where is the energy different in this system? Think back to our past experiments with motion.

Remember, potential energy is highest where the weight is the highest. Kinetic energy is highest were the weight is moving the fastest. So potential energy is highest at the ends of the swings. Here's a coincidence: That's also where kinetic energy is the lowest since the weight is moving the least. Where's potential energy the lowest? At the middle or lowest part of the swing.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Make the string into a 2-foot or so length.
4. Tie the string to the washer or weight.
5. Tape the other end of the string to a table.
6. Lift the weight and let go, causing the weight to swing back and forth at the end of the pendulum.
7. Have the kids answer the questions on their worksheet before moving to the second part of the experiment. When everyone has had some time, announce the next part of the experiment.
8. Attach a magnet where the nut or weight was attached.
9. Suspend your pendulum above the metal sheet.
10. Place the rest of the magnets in a circle around the space below the hanging pendulum. Make sure they all face the same direction.
11. Play with the arrangement of the magnets to try and get it to move around. If you do this right, you can get the pendulum to swing pretty much forever! How is this possible? Adjust the height of the pendulum by shortening the string and attaching it with masking tape if you need to.

Exercises

1. Why can we never make a machine that powers itself over and over again? (Because energy is conserved and lost to heat or other forms of energy that aren't kinetic.)
2. In the pendulum, as kinetic energy increases, potential energy ______________. (decreases)
3. As potential energy decreases, kinetic energy ________________. (increases)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #21: Pendulums

Student Worksheet

Name____

Overview: This is a very simple yet powerful demonstration that shows how potential energy and kinetic energy transfer from one to the other and back again, over and over.

What to Learn: Where does the energy go? You should know by now how kinetic and potential energy are related, but this experiment should help us remember well.

Materials

- some string
- a bit of tape
- a washer or a weight of some kind
- set of magnets (at least 6, but more is better)
- metal sheet

Lab Time

1. Make the string into a 2-foot or so length.
2. Tie the string to the washer, or weight.
3. Tape the other end of the string to a table.
4. Lift the weight and let go, causing the weight to swing back and forth at the end of the pendulum.
5. Now stop and go ahead to answer the questions about the pendulum. Record your observations about how the pendulum moves in lab today.
6. Attach a magnet where the nut or weight was attached.
7. Suspend your pendulum above the metal sheet.
8. Place the rest of the magnets in a circle around the space below the hanging pendulum. Make sure they all face the same direction.
9. Play with the arrangement of the magnets to try and get it to move around. If you do this right, you can get the pendulum to swing pretty much forever! How is this possible? Adjust the height of the pendulum by shortening the string and attaching it with masking tape if you need to.

Pendulum Observations:

1. Watch the pendulum for a bit and describe what it's doing as far as energy goes. Where is the potential energy greatest? Where is the kinetic energy greatest? Where is potential energy lowest? Where is kinetic energy lowest? Where is KE increasing, and PE is decreasing? Where is PE increasing and KE decreasing? Where did the energy come from in the first place? Draw a picture of the pendulum and label each part.

2. Lastly, where did the energy come from in the first place? It came from you. You added energy (increased PE) when you lifted the weight. (By the way, you did work on the weight by lifting it the distance you lifted it. You put a certain amount of Joules of energy into the pendulum system. Where did you get that energy?

3. What does this tell us about the energy that gets used by us, by machines, and by pretty much anything in the universe?

Exercises Answer the questions below:

1. Why can we never make a machine that powers itself over and over again?
    a. Energy is mostly lost to heat.
    b. Energy is completely used up.
    c. Energy is unlimited, but is absorbed by neighboring air molecules.
    d. None of these
2. In the pendulum, as kinetic energy increases, potential energy ______________.
    a. Increases
    b. Decreases
3. As potential energy decreases, kinetic energy ________________.
    a. Increases
    b. Decreases

Lesson #22: Catapults

Teacher Section

Overview: This exciting experiment helps us understand energy kinetic energy as only ancient warfare could teach us: as the energy stored in elastic or tensile strength is converted to the kinetic energy powerful enough to tear down a wall!

Suggested Time: 30-45 minutes

Objectives: We'll explore how energy is stored and transformed.

Materials (per lab group)

- 9 tongue-depressor size popsicle sticks
- four rubber bands
- one plastic spoon
- ping pong ball or wadded-up ball of aluminum foil (or something lightweight to toss, like a marshmallow)
- hot glue gun with glue sticks

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Troubleshooting: These simple catapults are quick and easy versions of the real thing, using a fulcrum instead of a spring so kids don't knock their teeth out. After making the first model, encourage kids to make their own "improvements" by handing them additional popsicle sticks, spoons, and glue sticks (for the hot glue guns).

If they get stuck, you can show them how to vary their models: glue a second (or third, fourth or fifth) spoon onto the first spoon for multi-ammunition throws, increase the number of popsicle sticks in the fulcrum from 7 to 13 (or more?), and/or use additional sticks to lengthen the lever arm. Use ping pong balls as ammo and build a fort from sheets, pillows, and the backside of the couch.

What's going on? We're utilizing the "springy-ness" in the popsicle stick to fling the ball around the room. By moving the fulcrum as far from the ball launch pad as possible (on the catapult), you get a greater distance to press down and release the projectile. (The fulcrum is the spot where a lever moves one way or the other – for example, the horizontal bar on which a seesaw "sees" and "saws".)

Lesson

When you drop a ball, it falls 16 feet the first second you release it. If you throw the ball horizontally, it will also fall 16 feet in the first second, even though it is moving horizontally… it moves both away from you and down toward the ground. Think about a bullet shot horizontally. It travels a lot faster than you can throw (about 2,000 feet each second). But it will still fall 16 feet during that first second. Gravity pulls on all objects (like the ball and the bullet) the same way, no matter how fast they go.

What if you shoot the bullet faster and faster? Gravity will still pull it down 16 feet during the first second, but remember that the surface of the Earth is round. Can you imagine how fast we'd need to shoot the bullet so that when the bullet falls 16 feet in one second, the Earth curves away from the bullet at the same rate of 16 feet each second?

Answer: That bullet needs to travel nearly 5 miles per second. (This is also how satellites stay in orbit – going just fast enough to keep from falling inward and not so fast that they fly out of orbit.)

Catapults are a nifty way to fire things both vertically and horizontally, so you can get a better feel for how objects fly through the air. Notice when you launch how the balls always fall at the same rate – about 16 feet in the first second. What about the energy involved?

When you fire a ball through the air, it moves both vertically and horizontally (up and out). When you toss it upwards, you store the (moving) kinetic energy as potential energy, which transfers back to kinetic when it comes whizzing back down. If you throw it only outwards, the energy is completely lost due to friction.

The higher you pitch a ball upwards, the more energy you store in it. Instead of breaking our arms trying to toss balls into the air, let's make a simple machine that will do it for us. This catapult uses elastic kinetic energy stored in the rubber band to launch the ball skyward.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Stack seven popsicle sticks and secure them together with rubber bands. Twist them around a few times so they stay securely. Do this on each end.
4. Grab two more popsicle sticks, stack them, and secure one end with a rubber band. The other end will stay open. We'll slide our fulcrum into the open end.
5. Slide the open end over the seven stacked sticks, and secure the whole thing by crossing a rubber band over the end of the two stacks.
6. Attach the spoon to the end of the upward-facing stick with hot glue or an extra rubber band.
7. Take the aluminum foil and scrunch it into a ball. Place the ball on the spoon, press it down, and release!

Exercises

1. How is gravity related to kinetic energy? (Gravity pulls an object and helps its potential energy convert into kinetic energy.)
2. If you could use your catapult to launch your ball of foil into orbit, how high would it have to go? (high enough so that when it falls back down the earth is already curving away)
3. Where is potential energy the greatest on the catapult? (when the spoon is pressed down all the way)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #22: Catapults

Student Worksheet

Name______________________________

Overview: Turns out the ancient people could teach us a thing or two about energy when they laid siege to an enemy town. Although we won't do this today, we will explore some of the important physics concepts that they have to teach us.

What to Learn: Energy can be found in many forms. Identify what kinds and where each type of energy are working in this experiment, and you'll be ready to move on.

Materials

- 9 tongue-depressor size popsicle sticks
- four rubber bands
- one plastic spoon
- ping pong ball or wadded-up ball of aluminum foil (or something lightweight to toss, like a marshmallow)
- hot glue gun with glue sticks

Lab Time

1. Stack seven popsicle sticks and secure them together with rubber bands. Twist them around a few times so they stay securely. Do this on each end.
2. Grab two more popsicle sticks, stack them, and secure one end with a rubber band. The other end will stay open. We'll slide our fulcrum into the open end.
3. Slide the open end over the seven stacked sticks, and secure the whole thing by crossing a rubber band over the end of the two stacks.
4. Attach the spoon to the end of the upward-facing stick with hot glue or an extra rubber band.
5. Take the aluminum foil and scrunch it into a ball. Place the ball on the spoon, press it down, and release!

Catapult Observations

1. What part of the catapult stores the most potential energy? Why is this?

2. Where is the kinetic energy transferred to in this catapult?

3. How would you make a catapult's projectile travel farther? Explain.

Exercises Answer the questions below:

1. How is gravity related to kinetic energy?
    a. Gravity creates kinetic energy in all systems.
    b. Gravity explains how potential energy is created.
    c. Gravity pulls an object and helps its potential energy convert into kinetic energy.
    d. None of the above
2. If you could use your catapult to launch your ball of foil into orbit, how high would it have to go?
    a. Above the atmosphere
    b. High enough to slingshot around the moon
    c. High enough so that when it falls, the earth curves away from it
    d. High enough so that it is suspended in empty space
3. Where is potential energy the greatest on the catapult?

Lesson #23: Levers

Teacher Section

Overview: We return to simple machines as we explore how energy can be utilized to do work in specific ways.

Suggested Time: 30-45 minutes

Objectives: Students will learn how humans can use machines to convert energy into meaningful, usable forms.

Materials (per lab group)

- A nice strong piece of wood. 3 to 8 feet long would be great if you have it.
- A brick , a thick book or a smaller piece of wood (for the fulcrum)
- Books, gallons of water or anything heavy that's not fragile

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

So what is this lever thing anyway? Well, at its most basic level, it's a stick and a rock … pretty simple machine, huh? Believe it or not, using this very simple machine you can lift hundreds of pounds with your bare hands and very little effort. Let's try it.

Levers, being simple machines, have only three simple parts: the load, the effort, and the fulcrum. Let's start with the load. The load is basically what it is you're trying to lift. The books in the last experiment were the load. Now for the effort. That's you. In the last experiment, you were putting the force on the lever to lift the load. You were the effort. The effort is any kind of force used to lift the load. Last comes the fulcrum. It is the pivot that the lever turns on. The fulcrum, as we'll play with a bit more later, is the key to the effectiveness of the lever.

There are three types of levers. Their names are first-class, second-class and third-class. The only difference between the three different levers is where the effort, load and fulcrum are.

A first-class lever is a lever in which the fulcrum is located in between the effort and the load. This is the lever that you think of whenever you think of levers. Examples of first-class levers are the see-saw, a hammer (when it's used to pull nails), scissors (take a look, it's really a double lever!), and pliers (same as the scissors, a double lever).

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Put your fulcrum on the ground.

4. Put your lever on the fulcrum. Try to get your fulcrum close to the middle of the lever.
5. Put some weight on one end of the lever.
6. Now push down on the other side of the lever. Try to remember how hard (how much force) you needed to press to lift the heavy object.
7. Move the fulcrum under the lever so that it is closer to the heavy object.
8. Push down on the other side of the lever again. Can you tell the difference in the amount of force?
9. Move the fulcrum closer still to the heavy object. Feel a difference now?
10. Feel free to experiment with this. Move the fulcrum farther away and closer to the object. What conclusions can you draw? Write these on the worksheet below.

Exercises

1. What is a simple machine? (a machine that changes the direction or strength of a force)
2. What are the three parts of a lever? (load, fulcrum, and effort)
3. Name two examples of levers that you could find in your house. (scissors, hammer, crowbar, etc.)
4. What are the types of levers called? (first, second, and third class)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #23: Levers

Student Worksheet

Name____

Overview: Simple machines convert energy also, but help us do work. We'll explore the lever, a very common and surprisingly useful tool that helps us direct our energy to specific and helpful applications.

What to Learn: Today you'll discover how we can use machines to convert energy into meaningful, usable forms.

Materials

- A nice strong piece of wood. 3 to 8 feet long would be great if you have it.
- A brick , a thick book or a smaller piece of wood (for the fulcrum)
- Books, gallons of water or anything heavy that's not fragile

Lab Time

1. Put your fulcrum on the ground.
2. Put your lever on the fulcrum. Try to get your fulcrum close to the middle of the lever.
3. Put some weight on one end of the lever.
4. Now push down on the other side of the lever. Try to remember how hard (how much force) you needed to push to lift the heavy object.
5. Move the fulcrum under the lever so that it is closer to the heavy object.
6. Push down on the other side of the lever again. Can you tell the difference in the amount of force?
7. Move the fulcrum closer still to the heavy object. Feel a difference now?
8. Feel free to experiment with this. Move the fulcrum farther away and closer to the object. What conclusions can you draw? Write these on the worksheet below.

Lever Observations

1. What happened when you moved the fulcrum closer to the heavier object? Was it easier or harder to move the weight?

2. What can you say about the distance between the fulcrum and the object as it relates to the force that you must apply?

3. Keeping the answer to the last question in mind, what would theoretically be the most useful design for a lever?

Exercises Answer the questions below:

1. What is the best definition for a simple machine?
    a. A machine with less than three parts
    b. A machine with a simple name
    c. A machine that changes the direction or amount of a force
    d. A machine that helps you do work quickly
2. What are the three parts of a lever? Circle all that apply:
    a. Fulcrum
    b. Weight
    c. Load
    d. Effort
3. Name two examples of levers that you could find in your house:
    a.
    b.
4. What are the types of levers called?
    a. Three tiers
    b. First, second, and third class
    c. Poor, rich, and middle
    d. Forty-five and ninety-nine percenters

Lesson #24: See-saw

Teacher Section

Overview: We're going to use everyday objects to build a simple machine and learn how to take data.

Suggested Time: 30-45 minutes

Objectives: This experiment will help the students learn how energy is transmitted and transformed through machines, which help us do work.

Materials (per lab group)

- A wooden ruler or a paint stick for the lever
- Many pennies, quarters, or washers (many little somethings of the same mass)
- A spool, eraser, pencil (anything that can be your fulcrum)
- A ruler (to be your um….ruler)
- Paper cups
- Optional: A scale that can measure small amounts of mass (a kitchen scale is good)

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Remember that levers have three parts: the work, effort, and the load. In this case, there are two loads, distributed at different points on the effort. The fulcrum and its distance to the load will determine what kind of data we'll get at the end of this experiment.

Lesson

How powerful are simple machines? Do you believe that they can help you do work?

Archimedes (286 to 212 B.C.) said, "Give me a place to stand and I can move the Earth." As you can see, Archimedes was quite fond of simple machines. In fact, he was a master of all the simple machines. He did not invent them, but he did put them to some amazing uses.

For example, a story goes that the Greek king Hiero had a problem. He had had a boat made that was so large no number of men could get it into the water. What good is a boat that is stuck on land? The king told Archimedes his problem, and Archimedes said "Pfffft, I can launch that boat with one hand!" Sure enough, after several days, Archimedes created a system of levers and pulleys that allowed him to move the boat by himself… with one hand.

According to one version of the story, the king did not believe that Archimedes was doing it on his own and that there must be some trick. Archimedes said, "Okay, you do it." The king hesitantly gave it a try and sure enough, in front of a huge crowd, the king moved the ship. At that point, the king shouted out, "From this day forth, Archimedes is to be believed in everything that he may say."

Archimedes was an unbelievable scientist and mathematician. There are many terrific stories surrounding his life and discoveries. I would highly recommend taking the time to look into him a bit further. The most famous thing we attribute to him is the term "Eureka!" which means, "I found it!" and is also the name of a town in northern California.

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Tape one paper cup to each end of the lever. (This allows for an easy way to hold the pennies on the lever.)
4. Set your fulcrum on the table and put your lever (ruler or paint stick) on top of it. Try to get the ruler to balance on the fulcrum.
5. Put five pennies on one side of your lever.
6. Now, put pennies, one at a time, on the other side of your lever, this is your effort. Keep adding pennies until you get your lever to come close to balancing. Try to keep your fulcrum in the same place on your lever. You may even want to tape it there.
7. Count the pennies on the effort side and count the pennies on the load side. If you have a scale, you can weigh them as well. With the fulcrum in the middle, you should see that the pennies/mass on both sides of the lever are close to equal.
8. This part's a little tricky. Measure how high the lever was moved. On the load side, measure how far the lever moved up and on the effort side measure how far the lever moved down. Be sure to do the measuring at the very ends of the lever.
9. Write your results in your worksheet.
10. Remove the pennies and do it all over again, this time moving the fulcrum one inch (two centimeters) closer to the load side.
11. Continue moving the fulcrum closer to the load until it gets too tough to do. You'll probably be able to get it an inch or two (two to four centimeters) from the load.
12. If you didn't use a scale, feel free to stop here. Don't worry about the "work in" and "work out" parts of the table. Take a look at your table and check out your results. Can you draw any conclusions about the distance the load moved, the distance the effort moved, and the amount of force required to move it?

Exercises

1. What is work? (force moved over a distance)
2. What is the unit we use to measure energy? (Joule)
3. Describe a first class lever using one example. (a hammer, crowbar, or scissors works well)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #24: See-saw

Student Worksheet

Name____

Overview: We're going to use everyday objects to build a simple machine and learn how to take data.

What to Learn: A lever is designed to take a force and apply it somewhere else so that we can do work.

Materials

- A wooden ruler or a paint stick for the lever
- Many pennies, quarters, or washers (many little things of about the same mass)
- A spool, eraser, pencil (anything that can be your fulcrum)
- A ruler (to be your um….ruler)
- Paper cups
- Optional: A scale that can measure small amounts of mass (a kitchen scale is good)

Lab Time

1. Tape one paper cup to each end of the lever. (This allows for an easy way to hold the pennies on the lever.)
2. Set your fulcrum on the table and put your lever (ruler or paint stick) on top of it. Try to get the ruler to balance on the fulcrum.
3. Put five pennies on one side of your lever.
4. Now, put pennies, one at a time, on the other side of your lever, this is your effort. Keep adding pennies until you get your lever to come close to balancing. Try to keep your fulcrum in the same place on your lever. You may even want to tape it there.
5. Count the pennies on the effort side and count the pennies on the load side. If you have a scale, you can weigh them as well. With the fulcrum in the middle, you should see that the pennies/mass on both sides of the lever are close to equal.
6. This part's a little tricky. Measure how high the lever was moved. On the load side, measure how far the lever moved up and on the effort side measure how far the lever moved down. Be sure to do the measuring at the very ends of the lever.
7. Write your results in your worksheet.
8. Remove the pennies and do it all over again, this time moving the fulcrum one inch (two centimeters) closer to the load side.
9. Continue moving the fulcrum closer to the load until it gets too tough to do. You'll probably be able to get it an inch or two (two to four centimeters) from the load.
10. If you didn't use a scale, feel free to stop here. Don't worry about the "work in" and "work out" parts of the table. Take a look at your table and check out your results. Can you draw any conclusions about the distance the load moved, the distance the effort moved, and the amount of force required to move it?

See Saw Data Table

Placement of load	How high did the lever move? (inches)
Beginning	
1 inch closer to load	
2 inches closer to load	
3 inches closer to load	

Exercises Answer the questions below:

1. What is work?
    a. Force against an object
    b. Force over distance
    c. 9 hours and sweat
    d. Energy applied to an object
2. What is the unit we use to measure energy?
    a. Newton
    b. Watt
    c. Joule
    d. Horsepower
3. Describe a first class lever using one example.

Lesson #25: Simple pulley experiments

Teacher Section

Overview: This set of experiments will give us a good sense of what pulleys are and how they work to enable us to do work.

Suggested Time: 30-45 minutes

Objectives: We'll take data as we learn how energy is converted into different forms and how machines help us do this.

Materials (per lab group)

- One pulley (from the hardware store … get small ones that spin as freely as possible. You'll need three single pulleys, or if you can find one get a double pulley to make our later experiment easier.)
- About four feet of string
- 2 paper cups
- Many little masses (about 50 marbles, pennies, washers etc.)
- Yardstick or measuring tape
- A scale (optional)
- 2 paper clips
- Nail or some sort of sharp pokey thing
- Table

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

Pulleys are the second of a total of six simple machines. These are very obviously designed to change the direction of a force for the key purpose of the simple machine: to do work.

Lesson

When we played with levers we could see that, by using a simple machine, we were able to use less force to move a heavy object than we would have had to use if we didn't use a simple machine. We also saw that with that lessening of force came an increase in distance.

Obviously, you can only make a lever so long. After a while it gets kind of ridiculous. Imagine lifting a concrete block or a car with a lever. That's a big lever, and you probably still wouldn't be able to lift the car very high. This is where pulleys come in.

By the use of a pulley (otherwise known as a block and tackle), car mechanics lift 600-lb car engines with one hand! Cranes that lift steel girders and thousand-pound air conditioning units are basically pulleys! (By the way, Archimedes is credited for inventing the crane. He actually used a crane as a weapon to defend Syracuse from Rome. When the Roman ships got close to the Syracuse walls, Archimedes' crane would grab them and turn them over! Go science!)

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Use the nail to poke a hole in both sides of the cup. Be careful to poke the cup … not your finger! Thread about 4 inches of string or a pipe cleaner through both holes. Make sure the string is a little loose. Make two of these mass carriers. One is going to be your load (what you lift) and the other is going to be your effort (the force that does the lifting).
4. Dangle the pulley from the table.
5. Bend your two paper clips into hooks.
6. Take about three feet of string and tie your paper clip hooks to both ends.
7. Thread your string through the pulley and let the ends dangle.
8. Put 40 masses (coins or whatever you're using) into one of the mass carriers. Attach it to one of the strings and put it on the floor. This is your load.
9. Attach the other mass carrier to the other end of the string (which should be dangling a foot or less from the pulley). This is your effort.
10. Drop masses into the effort cup. Continue dropping until the effort can lift the load.
11. Once your effort lifts the load, you can collect some data. First, allow the effort to lift the load about one foot (30 cm) into the air. This is best done if you manually pull the effort until the load is one foot off the ground. Measure how far the effort has to move to lift the load one foot.
12. When you have that measurement, you can either count the number of masses in the load and the effort cup or if you have a scale, you can get the mass of the load and the effort.
13. Write your data into your pulley data table in your worksheet.

Exercises

1. What is the load and effort of a pulley? Draw a pulley and label it.
2. What does a simple machine help us do? (direct force in a different direction or magnitude)
3. Name one other type simple machine and an example: (inclined plane or lever)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #25: Simple pulley experiments

Student Worksheet

Name____

Overview: Ever wonder how pulleys work, and how you can use them to lift ten friends with only one hand? We'll explore this today.

What to Learn: Pulleys are like other simple machines in that they help us do work by changing the direction or strength of a force.

Materials

- One pulley (from the hardware store… get small ones that spin as freely as possible. You'll need three single pulleys, or if you can find one get a double pulley to make our later experiment easier.)
- About four feet of string
- 2 paper cups
- Many little masses (about 50 marbles, pennies, washers etc.)
- Yardstick or measuring tape
- A scale (optional)
- 2 paper clips
- Nail or some sort of sharp pokey thing
- Table

Lab Time

1. Use the nail to poke a hole in both sides of the cup. Be careful to poke the cup … not your finger! Thread about 4 inches of string or a pipe cleaner through both holes. Make sure the string is a little loose. Make two of these mass carriers. One is going to be your load (what you lift) and the other is going to be your effort (the force that does the lifting).
2. Dangle the pulley from the table.
3. Bend your two paper clips into hooks.
4. Take about three feet of string and tie your paper clip hooks to both ends.
5. Thread your string through the pulley and let the ends dangle.
6. Put 40 masses (coins or whatever you're using) into one of the mass carriers. Attach it to one of the strings and put it on the floor. This is your load.
7. Attach the other mass carrier to the other end of the string (which should be dangling a foot or less from the pulley). This is your effort.
8. Drop masses into the effort cup. Continue dropping until the effort can lift the load.
9. Once your effort lifts the load, you can collect some data. First, allow the effort to lift the load about one foot (30 cm) into the air. This is best done if you manually pull the effort until the load is one foot off the ground. Measure how far the effort has to move to lift the load one foot.
10. When you have that measurement, you can either count the number of masses in the load and the effort cup or if you have a scale, you can get the mass of the load and the effort.
11. Write your data into your pulley data table in your worksheet below.

Pulleys Data Table

Distance lifted	Amount of coins needed to lift
1 inch	
3 inches	
6 inches	
1 foot	

Exercises Answer the questions below:

1. What is the load and effort of a pulley? Draw a pulley and label it.

2. What is the best way to say what a simple machine helps us do?
    a. Do work without changing force applied
    b. Change the direction or strength of a force
    c. Lift heavy shipping containers
    d. None of these
3. Name one other type simple machine and an example:

Lesson #26: Hydraulic earth mover

Teacher Section

Overview: This experiment seems complicated, but it's really just levers in action, plus a lesson in hydraulics.

Suggested Time: 30-45 minutes

Objectives: This experiment creatively explores the concepts of work, force, and how they relate to energy, as well as how useful this energy is when converted to forms that can do work.

Materials (per lab group)

- plastic cup
- 20 tongue-depressor-size popsicle sticks
- 6 syringes (anything in the 3-10mL size range will work)
- 6 brass fasteners
- 5' of flexible tubing (diameter sized to fit over the nose of your syringes)
- four wheels (use film canister lids, yogurt container lids, milk jug lids, etc.)
- 4 rubber bands
- two naked (unwrapped) straws
- skewers that fit inside your straws
- hot glue gun (with glue sticks)
- sharp scissors or razor (get adult help)
- drill with small drill bits (You'll be drilling a hole large enough to fit the stem of a brass fastener.)

Lab Preparation

1. Print out copies of the student worksheets.
2. Read over the Background Lesson Reading before teaching this class.
3. Watch the video for this experiment to prepare for teaching this class.

Background Lesson Reading

What's going on in this experiment? It's all about air pressure distribution. Because both syringes are open to the atmosphere, they both have equal amounts of air pressure pushing down on the surface of the water. When you raise one syringe higher than the other, you have increased the elevation head of the higher syringe, which works to equalize the water levels in the two syringes (thus shoving water out of the lower syringe). Elevation head is due to the fluid's weight (gravitational force) acting on the fluid and is related to the potential energy of the raised syringe (which increased with elevation). This acts as the force that is applied to the lever, helping us do work in creative ways.

Lesson

When people mention the word "hydraulics," they could be talking about pumps, turbines, hydropower, erosion, or river channel flow. The term "hydraulics" means using fluid power, and deals with machines and devices that use liquids to move, lift, drive, and shove things around. Liquids behave in certain ways: They are incompressible, meaning that you can't pack the liquid into a tighter space than it already is occupying.

If you've ever filled a tube partway with water and moved it around, you've probably noticed that the water level will remain the same on either side of the tube. However, if you add pressure to one end of the tube (by blowing into the tube), the water level will rise on the opposite side. If you decrease the pressure (by blowing across the top of one side), the water level will drop on the other side.

In physics, this is defined through Pascal's law, which tells us how the pressure applied to one surface can be transmitted to the other surface. As liquids can't be squished, whatever happens on one surface affects what occurs on the other. Examples of this effect include siphons, water towers, and dams. Scuba divers know that as they dive 30 feet underwater, the pressure doubles. This effect is also shown in hydraulics – and more importantly, in the project we're about to do!

But first, let's understand what's happening with liquids and pressure:

Here's an example: If you fill a glass full to the brim with water, you reach a point where for every drop you add on top, one drop will fall out. You simply can't squish any more water molecules into the glass without losing at least the same amount. Excavators, jacks, and the brake lines in your car use hydraulics to lift huge amounts of weight, and the liquid used to transfer the force is usually oil at 10,000 psi.

Air, however, is compressible. When car tires are inflated, the hose shoves more and more air inside the tire, increasing the pressure (amount of air molecules in the tire). The more air you stuff into the tire, the higher the pressure rises. When machines use air to lift, move, spin, or drill, it's called "pneumatics." Air tools use compressed air or pure gases for pneumatic power, usually pressurized to 80-100 psi.

Different systems require either hydraulics or pneumatics. The advantage to using hydraulics lies in the fact that liquids are not compressible. Hydraulic systems minimize the "springy-ness" in a system because the liquid doesn't absorb the energy being transferred, and the working fluids can handle much heavier loads than compressible gases. However, oil is flammable, very messy, and requires electricity to power the machines, making pneumatics the best choice for smaller applications, including air tools (to absorb excessive forces without injuring the user).

Lab Time

1. Review the instructions on their worksheets and then break the students into their lab groups.
2. Hand each group their materials and give them time to perform their experiment and write down their observations.
3. Connect two syringes with a piece of flexible tubing. Cut the tubing into three equal-sized pieces and use one to experiment with.
4. Shove the plunger on one syringe to the "empty," and leave the other in the "filled" position before connecting the tubing. What happens when you push or lift one of the plungers? Is it quick to respond, or is there "slop" in the system?
5. Now remove both plungers and, leaving the tubing attached, fill the system with water to the brim on both ends (this is a good bath-time activity!). Keep the open ends of the syringes at the same level as you fill them. What happens if you lower one of the syringes? What happens when you raise it back up? Is there now air in your system?

6. Fill your syringe-tube system up with water again, keeping the plungers at the same height as you work.
7. Insert one of the plungers into one of the syringes and play with the levels of the syringes again, lifting one and lowering the other. Now what happens, or doesn't happen?
8. Now connect your plungers into a fully hydraulic system: Push the plunger all the way down to expel the water from one of the syringes (water should leak all over the place from the open syringe).
9. Now add the second plunger to the open syringe and push the plunger down halfway. What happens? You have just made a hydraulic system!

Exercises

1. Hydraulics refers to the use of what to do work? (fluids)
2. What is it called when we use air to do work? (pneumatics)
3. In general, liquids cannot be squished together. What do we call this? (incompressible)
4. Is the answer to the previous question important to how all hydraulic systems work? (No)

Closure: Before moving on, ask your students if they have any recommendations or unanswered questions that they can work out on their own. Brainstorming extension ideas is a great way to add more science studies to your class time.

Lesson #26: Hydraulic earth mover

Student Worksheet

Name____

Overview: We'll finish this unit on Energy by building a pretty cool hydraulic earth mover. You'll be amazed by the power of liquid to help move the machine and help us to do work!

What to Learn: This lab shows us how fluids can specifically be used to help us to do work. This is a good example of the types of energy conversion that we use every day.

Materials

- plastic cup
- 20 tongue-depressor-size popsicle sticks
- 6 syringes (anything in the 3-10mL size range will work)
- 6 brass fasteners
- 5' of flexible tubing (diameter sized to fit over the nose of your syringes)
- four wheels (use film canister lids, yogurt container lids, milk jug lids, etc.)
- 4 rubber bands
- two naked (unwrapped) straws
- skewers that fit inside your straws
- hot glue gun (with glue sticks)
- sharp scissors or razor (get adult help)
- drill with small drill bits (You'll be drilling a hole large enough to fit the stem of a brass fastener.)

Lab Time

1. Connect two syringes with a piece of flexible tubing. Cut the tubing into three equal-sized pieces and use one to experiment with.
2. Shove the plunger on one syringe to the "empty," and leave the other in the "filled" position before connecting the tubing. What happens when you push or lift one of the plungers? Is it quick to respond, or is there "slop" in the system?
3. Now remove both plungers and, leaving the tubing attached, fill the system with water to the brim on both ends (this is a good bath-time activity!). Keep the open ends of the syringes at the same level as you fill them. What happens if you lower one of the syringes? What happens when you raise it back up? Is there now air in your system?
4. Fill your syringe-tube system up with water again, keeping the plungers at the same height as you work.
5. Insert one of the plungers into one of the syringes and play with the levels of the syringes again, lifting one and lowering the other. Now what happens, or doesn't happen?
6. Now connect your plungers into a fully hydraulic system: Push the plunger all the way down to expel the water from one of the syringes (water should leak all over the place from the open syringe).
7. Now add the second plunger to the open syringe and push the plunger down halfway. What happens? You have just made a hydraulic system!

Hydraulic Earth Mover Observations

1. Look back at the procedure for Lab Time, and at Step number 3. At this point in your experiment, what happens to the syringes when you raise and lower one but not the other?

2. After you've connected the second plunger, what happens?

3. Explain what the fluid is doing in your earth mover.

Exercises Answer the questions below:

1. Hydraulics refers to the use of what to do work?
   a. Solids
   b. Gases
   c. Fluids
   d. Liquids
2. What is it called when we use air to do work?
   a. Aerodynes
   b. Pneumatics
   c. Nitrous
   d. Oxygenation
3. In general, liquids cannot be squished together. What do we call this?
   a. Impressive
   b. Immersive
   c. Inert
   d. Incompressible
4. Is the answer to the previous question important to how all hydraulic systems work?
   a. Yes
   b. No

Part 1 Evaluation

Teacher Section

Overview: Kids will demonstrate how well they understand important key concepts from this section.

Suggested Time: 45-60 minutes

Objectives: Students will be tested on the key concepts:

- Energy and matter have multiple forms and can be changed from one form to another.
- Energy comes from the sun to the Earth in the form of light.
- Sources of stored energy take many forms, such as food, fuel, and batteries.
- Machines and living things convert stored energy to motion and heat.
- Energy can be carried from one place to another by waves, such as water waves and sound, by electric current, and by moving objects.

Students will also demonstrate these principles:

1. Collecting and interpreting data from an experiment
2. Making valid observations based on their actions in lab
3. Energy is not completely used up, but only takes different forms.

Materials (one set for entire class)

- Weight (like a rock)
- Dowel or yardstick
- Tape (to keep the rock on the yardstick)

Lab Preparation

1. Print out copies of the student worksheets, lab practical, and quiz.
2. Have a tub of the materials in front of you at your desk. Kids will come up when called and demonstrate their knowledge using these materials.

Lesson

The students are taking two tests today: the quiz and the lab practical. The quiz takes about 20 minutes, and you'll find the answer key to make it easy to grade.

Lab Practical

Students will demonstrate individually that they know how to create a simple machine that could theoretically help them do work. While other kids are waiting for their turn, they will get started on their homework assignment. You get to decide whether they do their assignment individually or as a group.

Part 1 Evaluation

Student Worksheet

Overview: Today you're going to take two different tests: the quiz and the lab practical. You're going to take the written quiz first, and the lab practical at the end of this lab. The lab practical isn't a paper test – it's where you get to show your teacher that you know how to do something.

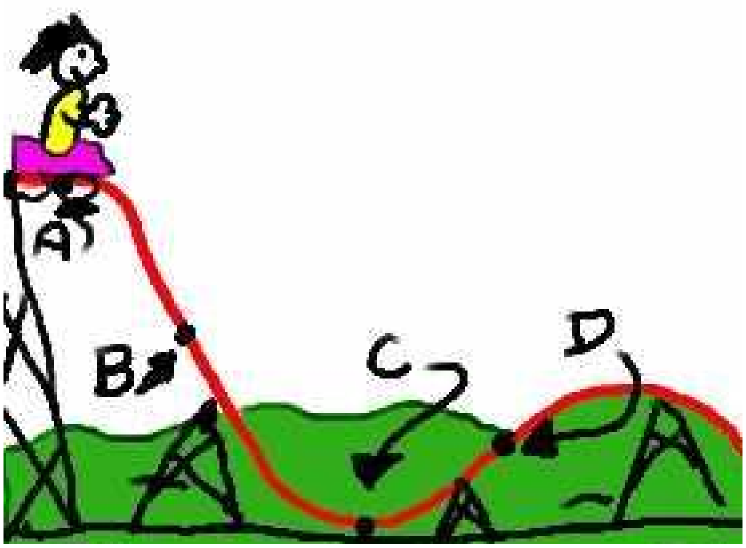
Lab Test & Homework

1. Your teacher will call you up so you can share how much you understand about energy and how it works. Since science is so much more than just reading a book or circling the right answer, this is an important part of the test to find out what you really understand.
2. While you are waiting for your turn to show your teacher how much of this stuff you already know, you get to get started on your homework assignment. The assignment is due next week, and half the credit is for creativity and the other half is for content, so really let your imagination fly as you work through it. Choose one:
    a. Write a short story or skit about inventing a machine that uses simple machines from the perspective of the machine (like a pulley, wedge, screw, ramp, lever, or wheel and axle). You'll read this aloud to your class.
    b. Make a poster that teaches the main concepts of simple machines. When you're finished, you'll use it to teach to a class in the younger grades and demonstrate each of the principles that you've learned, and give examples of a perpetual machine and why it won't work … ever.
    c. Write and perform a poem or song about simple machines. This will be performed for your class.

Part 1 Quiz

Teacher's Answer Key

1. Fill in the blank: A battery produces ________________ energy from _____________________ energy. (electrical, chemical)
2. Another name for a battery is: (voltaic cell)
3. As one chemical in a battery loses electrons, what happens to the other chemical? (gains electrons)
4. What type of energy source is the solar panel most closely related to? (chemical battery)
5. Electricity is another name for the free flow of: (electrons)
6. Which of the following best describes how sound gets to us? (vibrating molecules)
7. Name two ways energy is transferred: (heat, sound, radiation, etc.)
8. True or false: A loud noise represents molecules that vibrate violently. (true)
9. What is one way to describe energy? (the ability to do work)
10. Work is when something moves when: (Energy is used over a distance.)
11. Name two simple machines: (lever, pulley, inclined plane)
12. A lever has three parts. Circle all that apply: (fulcrum, load, effort)



13. Where is the potential energy greatest? (A)

Part 1 Quiz

Name____

1. Fill in the blank: A battery produces _______________ energy from ____________________ energy.

2. Another name for a battery is:
   a. Solar array
   b. Voltaic cell
   c. Nuclear reactor
   d. Fusion cell
3. As one chemical in a battery loses electrons, what happens to the other chemical?
   a. It loses electrons
   b. It gains electrons
   c. Nothing
   d. It decomposes
4. What type of energy source is the solar panel most closely related to?
   a. Biofuel
   b. Chemical battery
   c. Nuclear reactor
   d. Plant energy
5. Electricity is another name for the free flow of:
   a. Protons
   b. Quarks
   c. Electrodes
   d. Electrons
6. Which of the following best describes how sound gets to us?
   a. Chemical electricity
   b. Solar radiation
   c. Heat conduction
   d. Vibrating molecules
7. Name two ways energy is transferred:
   a.

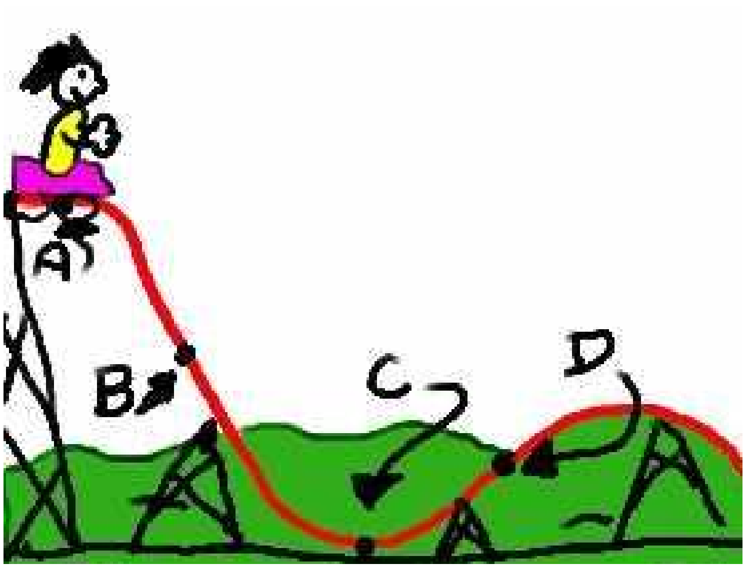
   b.

8. True or false: A loud noise represents molecules that vibrate violently.
   a. True
   b. False
9. What is one way to describe energy?
   a. The amount of atoms moving around at any given moment

b. Electrons flowing from one area to another
c. The ability to do work
d. The square root of the speed of an electron

10. Work is when something moves when:
    a. Force is applied
    b. Energy is used
    c. Electrons are lost or gained
    d. A group of atoms vibrate
11. Name two simple machines:
    a.

    b.
12. A lever has three parts. Circle all that apply:
    a. Fulcrum
    b. Weight
    c. Load
    d. Effort



13. Where is the potential energy greatest?

Part 1 Lab Practical

Teacher's Answer Key

This is your chance to see how well your students have picked up on important key concepts, and if there are any holes. Your students also will be working on their homework assignment as you do this test individually with the students.

Materials:

- Weight (like a rock)
- Dowel or yardstick
- Tape (to keep the rock on the yardstick)

Lab Practical: Ask the student *Note: Answers given in italics!*

- You will make a simple machine out of only these materials. Pretend the boulder weights four times your weight. How can you move the boulder with only a long plank of wood (the yardstick) and you? *The student will place the boulder on the end of the yardstick, and put a fulcrum, like their hand, close to the boulder. They will then push down on the other end of the yardstick and the rock moves up one fourth the distance that their hand pushes down on the yardstick end.*
- Give three examples of simple machines you use every day. *Scissors, screws, jam jar lids, ramps, a wedge in the door to hold it open, pliers, pulleys, and more!*

The Scientific Method

One of the problems kids have is how to experiment with their great ideas without getting lost in the jumble of result data. So often students will not have any clear ideas about what change caused which effect in their results! Students often have trouble communicating their ideas in ways that not only make sense but are also acceptable by science fairs or other technical competitions designed to get kids thinking like a real scientist. Another problem they face is struggling to apply the scientific method to their science project in school, for scout badges, or any other type of report where it's important that other folks know and understand their work.

The scientific method is widely used by formal science academia as well as scientific researchers. For most people, it's a real jump to figure out not only how to do a decent project, but also how to go about formulating a scientific question and investigate answers methodically like a real scientist. Presenting the results in a meaningful way via "exhibit board"… well, that's just more of a stretch that most kids just aren't ready for. There isn't a whole lot of useful information available on how to do it by the people who really know how. That's why I'm going to show you how useful and easy it is.

The scientific method is a series of 5 steps that scientists use to do their work. But, honestly, you use it every day, too! The five steps are Observation, Hypothesis, Test, Collect Data, and Report Results. That sounds pretty complicated, but don't worry, they are just big words. Let me tell you what these words mean and how to play with them.

Step 1: Observation means what do you see, or hear, or smell, or feel? What is it that you're looking at? Is that what it usually does? Is that what it did last time? What would happen if you tried something different with it? Observation is the beginning of scientific research. You have to see or touch or hear something before you can start to do stuff with it, right?

Step 2: Once you observe something, you can then form a hypothesis. All hypothesis really means is "guess." A hypothesis is an educated guess. Tonight at dinner, when someone asks you, "Do you want peas or carrots?" Say, "I hypothesize that I would like the carrots." Everyone will think you're a genius! Basically you're saying "I guess that I would like the carrots." Hypotheses aren't right or wrong, they are just your best guess.

Step 3: To see if your guess is correct, you need to do the next step in the scientific method: test. The test is just what it sounds like: running experiments to see whether or not your hypothesis is correct.

Step 4: As you do your tests, you need to collect data. That means collecting the numbers, the measurements, the times, the data of the experiment. Once you collect your data, you can take a look at it, or in other words, analyze it.

Step 5: Once you analyze your data you can report your results. That basically means tell someone about it. You can put your data in a chart or a graph or just shout it from the rooftops!

Here's a great way to remember the 5 steps. Remember the sentence "Orange Hippos Take Classes Regularly." The first letter in each word of that goofy sentence is the same as the first letter in each step of the scientific method. That's called a mnemonic device. Make up your own mnemonic devices to remember all sorts of stuff.

"OK, so that's what the words mean. How do I use that every day?"

Well, I'm glad you asked that question. If you had cereal for breakfast this morning, you did the scientific method. On the table you had a bowl of cereal with no milk in it. As you looked at your dry cereal, you made an observation, "I need milk!" At that point, you made a hypothesis, "There's milk in the fridge." You can't be sure there's milk in the fridge. Someone might have used it up. It might have gone bad. Aliens may have used it to gas up their milk-powered spaceship. You just don't know! So you have to do a test.

What would be a good test to see if there is milk in the fridge? Open the fridge! Now once you move the week-old spaghetti and the green Jell-O (at least you hope it's Jell-O) out of the way, you can see if there is milk or not. So you collect your data. There is milk or there isn't milk. Now you can finally report your results. If there is milk, you can happily pour it on your cereal. If there isn't any milk, you report your results by shouting, "Hey, Mom...We need milk!" Scientific method, not so hard is it?

You'll get familiar with the scientific method by doing the activities and experiments in your lessons. Most scientists don't use the *full* version of the scientific method, which actually includes several additional steps to the ones I've outlined above. You'll find the full-blown version of the scientific method in the back of this book. I've included a copy of a special project which won first prize at a science fair. You'll find this complete project explains every detail and how it uses the full version of the scientific method so you can see how to do it for yourself on any project you choose.

Vocabulary for the Unit

Alternative energy is energy obtained from non-fossil fuel sources. This is also known as renewable energy.

Conduction is heat energy transferred directly between substances.

Convection is heat energy exchanged through intermediary molecules.

Energy is the ability to do work.

Joule is the standard unit used to measure energy, defined as one Newton of force moved over 1 meter.

Kinetic energy is the energy of motion that an object has when it is pushed, flies, or falls.

Potential energy is the energy that an object has in relation to the system in which it exists.

Power is work done over a period of time.

Specific heat is how much heat energy a mass of a material must absorb before it increases 1°C.

Radiation is energy transmitted through the electromagnetic spectrum, on our planet from the sun.