Classroom Activities

Energy, Vibrations and Waves

Kindergarten and First Grade

A Collaboration of the Pasco (WA) School District and the Laser Interferometer Gravitational-wave Observatory (LIGO)

Version 2
Sept 2014

This version of the kindergarten-first grade packet may not be the most up-to-date version that exists. Please check the following url to download the most current version:

https://dcc.ligo.org/LIGO-T1400520/public

For additional information, including teacher professional development related to the packet materials, contact

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Introduction

This packet contains classroom activities and materials designed to address most of the Disciplinary Core Ideas (DCI's) for standard 1-PS4 in the Next Generation Science Standards (NGSS). The packet also addresses some of K-PS2 standard and could be used to supplement learning about energy and engineering. Middle and elementary teachers in the Pasco School District (PSD) along with personnel at LIGO Hanford Observatory have developed the activities.

Similar packets exist for 4th grade and middle school. These contain a greater number of activities and more in-depth practices. Hopefully this packet will give students a foundation for future learning about energy, waves, light and sound.

Some comments about implementation and safety:

- Use adequate space for the sound tubes so students do not hit each other or items in the classroom.
- If two students stretch the Slinky and one student suddenly lets go, the rapid compression of the Slinky could cause injury. Ask students to avoid letting go of the stretched Slinky.
- If the end caps come off of the Slinky, sharp edges could be exposed.
- When using the optical materials, please beware that they provide no protection from the Sun. Remind students not to look directly at the Sun.
- Use caution when handling magnifying glasses. Under the right conditions, magnifying lenses could cause a burn.

LIGO and PSD welcome feedback regarding the use of this packet and the related standards. Direct feedback to *outreach@ligo-wa.caltech.edu* .

LIGO provides training on the classroom use of these materials. We strongly encourage teachers to request a workshop for this training. Contact LIGO at 509-372-8248 or at *outreach@ligo-wa.caltech.edu* to discuss possibilities for a wave workshop at your school or at LIGO Hanford Observatory.

LIGO welcomes students of any age to visit the Observatory on field trips. At LIGO students can see wave science and scientists in action as LIGO personnel continue their quest to uncover new information about the universe by measuring gravitational waves. LIGO offers enjoyable age-appropriate hands-on experiences for students along with opportunities to rub shoulders with STEM professionals in work locations such as LIGO's control room. Check the LIGO Hanford Web site at *www.ligo-wa.caltech.edu/field_trips.html* for more information on field trips.

Kindergarten standard, Next Generation Science Standards

K-PS2 Motion and Stability: Forces and Interactions

PERFORMANCE EXPECTATIONS

Students who demonstrate understanding can:

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [*Clarification Statement:* Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.] [*Assessment Boundary:* Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.]

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.* [*Clarification Statement:* Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of an object and a structure that would cause an object such as a marble or ball to turn.] [*Assessment Boundary:* Assessment does not include friction as a mechanism for change in speed.]

**This performance expectation integrates traditional science content with engineering through a practice or disciplinary core idea.*

Science and Engineering Practices

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.

- With guidance, plan and conduct an investigation in collaboration with peers. (K-PS2-1)

Analyzing and Interpreting Data

Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.

- Analyze data from tests of an object or tool to determine if it works as intended. (K-PS2-2)

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Connections to Nature of Science

Scientific Investigations Use a Variety of Methods

- Scientists use different ways to study the world. (K-PS2-1)

Disciplinary Core Ideas

PS2.A: Forces and Motion

- Pushes and pulls can have different strengths and directions. (K-PS2-1), (K-PS2-2)
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1), (K-PS2-2)

PS2.B: Types of Interactions

- When objects touch or collide, they push on one another and can change motion. (K-PS2-1)

PS3.C: Relationship Between Energy and Forces

- A bigger push or pull makes things speed up or slow down more quickly. *(secondary to K-PS2-1)*

ETS1.A: Defining Engineering Problems

- A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. *(secondary to K-PS2-2)*

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1), (K-PS2-2)

4 NEXT GENERATION SCIENCE STANDARDS — Arranged by Disciplinary Core Ideas

See connections to K-PS2 on page 1

Next Generation Science Standards, Volume 1. 2013. The National Academies Press. ISBN 13: 978-0-309-27227-8

First grade standard, Next Generation Science Standards

1-PS4 Waves and Their Applications in Technologies for Information Transfer

PERFORMANCE EXPECTATIONS

Students who demonstrate understanding can:

1-PS4-1. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. [*Clarification Statement*: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.]

1-PS4-2. Make observations to construct an evidence-based account that objects can be seen only when illuminated. [*Clarification Statement*: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.]

1-PS4-3. Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. [*Clarification Statement*: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).] [*Assessment Boundary*: Assessment does not include the speed of light.]

1-PS4-4. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.* [*Clarification Statement*: Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drum beats.] [*Assessment Boundary*: Assessment does not include technological details for how communication devices work.]

**This performance expectation integrates traditional science content with engineering through a practice or disciplinary core idea.*

Science and Engineering Practices

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.

- Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence to answer a question. (1-PS4-1), (1-PS4-3)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.

- Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. (1-PS4-2)
- Use tools and materials provided to design a device that solves a specific problem. (1-PS4-4)

Disciplinary Core Ideas

PS4.A: Wave Properties

- Sound can make matter vibrate, and vibrating matter can make sound. (1-PS4-1)

PS4.B: Electromagnetic Radiation

- Objects can be seen if light is available to illuminate them or if they give off their own light. (1-PS4-2)
- Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.) (1-PS4-3)

PS4.C: Information Technologies and Instrumentation

- People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes. (1-PS4-1), (1-PS4-2), (1-PS4-3)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

- People depend on various technologies in their lives; human life would be very different without technology. (1-PS4-4)

10 NEXT GENERATION SCIENCE STANDARDS — Arranged by Disciplinary Core Ideas

See connections to 1-PS4 on page 132.

Next Generation Science Standards, Volume 1. 2013. The National Academies Press. ISBN 13: 978-0-309-27227-8

Overview

Through the use of this packet students and teachers will begin to explore the science of vibrations, waves, sound, light and similar expressions of energy. The packet activities support exploration and inquiry. The packet encourages students and teachers to make meaning of the activities, to connect their ideas to prior learning and to begin to interrogate the universe around them. Additionally, teachers can use the packet activities to introduce kindergarteners and first graders to several of the NGSS science and engineering practices. Asking questions, constructing explanations and engaging in argument from evidence represent the NGSS Science and Engineering Practices that most closely connect to the explorations in this kit.

Teachers can use the packet to involve students in pure exploration or in a more structured mini-unit. To use this packet in an exploratory manner, introduce the activities and ask students to move through the activity stations. Teachers who already possess a plan for wave instruction but who need a high engagement component to supplement their plan will find the packet helpful. As an alternative, the packet and the stations could be used as a mini-unit to address relevant NGSS and Common Core standards as well as the language development needs of students. Specific teacher implementations of the packet will depend on time and other logistics constraints and the teacher's goals for student learning.

This packet does not fully address the information transfer component of the NGSS standard. To more fully meet this component, teachers might add an activity in which students use walkie-talkies for communication (perhaps if such items can be borrowed from the school's office or administration).

The 5E model that appears in this packet relates to the stages of the 5E learning cycle: Engage, explore, explain, elaborate and evaluate. This model encourages and promotes inquiry-based learning and allows students to build personal meaning from the activities. Check the Midwestern State University (MSU) or NASA links below for more 5E information.

- http://faculty.mwsu.edu/west/maryann.coe/coe/inquire/inquiry.htm

- http://www.nasa.gov/audience/foreducators/nasaeclips/5eteachingmodels/

The packet includes some ideas for informal assessments. Teachers should use best practices for assessing student progress against the learning goals for the content that the packet supports.

5E Mini-Unit Sample

Engage (Day 1: 30 minutes): Background knowledge and classroom demonstration

- Create KWL chart about energy, waves, sounds and light
- Demonstrate “Tornado Tube” and “Bottle Fountain” activities
- Classroom discussion about the demonstration
    - Why does the water form a whirlpool?
    - What causes this reaction?
    - What is happening to the water?
    - How are the “Tornado Tube” and the “Bottle Fountain” different?
- Statement of purpose for the remainder of the unit

Explore (Day 2: 45 minutes): Activity station rotations

- Expectations for activities
- Set up the following activities:
    - Sound Tube
    - Groaning Tube
    - Regular Top
    - Top with Arms
    - Upside-Down Top
    - Gyroscope
- Group the students by 3 or 4
- Rotate groups every 5 minutes for 6 rotations
- Classroom discussion: What did you see/learn/experience today?

Explore (Day 3: 30 minutes): Activity station rotations

- Review expectations
- Set up the following activities:
    - Slinky
    - Poppers
    - Kaleidoscopes
    - Rattlebacks
- Group students and rotate every 5 minutes for 4 rotations
- Classroom discussions: What did you see/learn/experience today? Did it relate to any activities we did yesterday? How?

Explore (Day 3: 30 minutes): Activity station rotations

- Review expectations
- Set up the following activities:
    - Colored acetate sheets
    - Polarizing film
    - Prisms
    - Ultraviolet beads
- Group students and rotate every 5 minutes for 4 rotations

- Classroom discussion: What did you see/learn/experience today? Did it relate to any activities we have done the last two days? How?

Explain (Day 4: 30 minutes)

- Showcase each station as a whole group
- Ask the students what they discovered, share scientific principles found in this packet under the “science kit” section

Elaborate (Day 5: 30 minutes)

- Watch Bill Nye the Science Guy video *Sound*** (this will connect and cement the understanding they gained during the “Explain” day).

Evaluate (Day 6: 45 minutes): Build a device to communicate over a distance

- Complete KWL chart
- Read the scenario (at the end of the packet)
- Place students in teams of 3 or 4
- Give them access to a variety of materials such as tin cups. Light sources, paper clips, string, musical instruments, paper towel tubes or anything found in the LIGO kit
- Students work for 30 minutes then present their idea to the their classmates
- Unit checklist assessment (whole class)

** Bill Nye *Sound* video: http://www.dep-store.com/product-p/77a34vl00.htm

Conceptual Background for Teachers

The poppers station represents perhaps the simplest activity in the kit. Students fold the popper inside out and set it on the table (this can be a challenge for kindergarten hands). The popper sits still for a moment – students might notice that the plastic starts bending on its own – and then the popper propels itself into the air. This scenario offers connections to several basic concepts of motion.

A stationary object needs a push or a pull to move. The fancy word for push or pull is **force.** Notice that the popper pushes itself.

The popper flies upward into the air, but then the motion changes. The popper stops moving up and starts moving down. Our observation tells us that a second force must be present, a force that pulls the popper down after the popper pushes itself up. We call the second force **gravity**. Gravity belongs to a class of forces that can cause objects to move without being touched.

After students turn the popper inside out but before the popper pushes itself off the table, the object rests in a somewhat funny or special state. If I merely set a popper on a table, the self-push won't occur. I must turn the device inside out. After doing so, I notice that the popper now possesses "something" that causes it to jump. We call the "something" **energy**.

We can define energy by what it accomplishes. Energy can cause things to move. Imagine a bowling pin that's sitting still. If I hit the pin by rolling a bowling ball at it, the pin will receive a force (a push) from the ball and the pin will fall over. The fact that the pin moved means that the bowling ball possessed energy. As it falls, the pin might hit another pin and knock over the second pin. This means that the first pin possessed energy. Where did this energy come from? The ball. The ball transferred some of its energy to the first pin; the first pin transferred some of this energy to the second pin. Whenever I see a stationary object begin to move, I know that the object must have received energy.

(Bowling photo: Wikipedia)

The popper differs from the bowling pin. The bowling pin was struck by another object (the ball) – this is how the energy transfer occurred. But once we turn the popper inside out, the popper doesn't need energy from a different object to move. Apparently the energy comes from within the folded popper. We conclude that once we turn the popper inside out, the popper contains stored energy. We name stored energy **potential energy**. A stationary bowling pin doesn't knock itself over – it doesn't contain potential energy. The pin receives its energy from a moving object, the bowling ball. The energy that objects possess because they're moving is named **kinetic energy**.

Now imagine that I don't fold the popper but that I merely hold it (or any other object) in the air with my hand. When I let go, the object will begin moving downward. This means that the object received energy. But I didn't fold the popper to give it "inside out" potential energy. What's the source of the energy for a falling object? Gravity. When I hold an object, gravity gives the object potential energy. When I let go (without pushing or pulling – just dropping), the potential energy from gravity causes the popper to move. Now that it's moving, the popper possesses kinetic energy. If the popper falls into a pan of water, the water will move. I'll see a splash and some waves. The popper transferred some of its kinetic energy to the water. Energy is energy; we recognize energy because it can cause stationary objects to move (or, more generally, it can change the motion of objects). Energy finds expression as potential energy (stored energy) or kinetic energy (the energy associated with motion).

To summarize, let's describe the popper experiment using vocabulary. When I turn a popper inside out, I transfer **energy** to the popper. This energy exists as **potential energy** as the popper sits on the table. Finally the popper puts a **force** on itself and moves upward; the popper's **potential energy** turns into **kinetic energy**. **Gravity** puts an opposite **force** on the popper (but not through a touch – **gravity** doesn't require a touch). Eventually the **force** of **gravity** changes the direction of the popper's motion and the popper starts to fall. At the top of its jump, the popper sits still for a tiny fraction of a second. At this point the popper has no more **kinetic energy**, but it has **potential energy** from **gravity**. **Gravity's potential energy** now turns into the popper's **kinetic energy** as the popper falls back to the table.

Now think about the kit's tornado tube experiment. Just like the popper, the water in the tornado tube might be sitting still. I invert the tornado tube and transfer energy to the

water by swirling the device with my hands rapidly. I watch the tornado form inside the bottle. Unlike the popper, which quickly lost its energy and sat still again, the water in the tornado tube just keeps going around and around until all of the water in the top bottle drains into the bottom bottle. Of course gravity supplies the force that makes the water go down. We imagine that if we carried a tornado tube into outer space to a location where gravity was very weak, and we shook the tube in a circle, the water might go around and around for a very long time because it wouldn't fall into the lower bottle. We name the movement of the water in the tornado tube **periodic motion**. Periodic motion occurs over and over again the same way. The popper experiment doesn't illustrate periodic motion. The popper moves up, falls down and then stops. The water in the tornado tube, in contrast, continues moving around and around over and over again. Tornado tubes, tops and gyroscopes all illustrate periodic motion.

If I stretch my arm in front of me and swing my arm back and forth (left to right) I'm doing periodic motion. We could call this type of back-and-forth periodic motion an **oscillation**. Now imagine that someone places the end of a Slinky in my hand. Then the person grabs the other end of the Slinky and backs away from me, so the Slinky stretches out between us as we face each other. This person holds her end still, but my

end constantly moves because I'm moving my hand back and forth. The Slinky follows the movement of my hand, and this movement travels down the Slinky. I see sideways hills and valleys traveling down the Slinky. These are **waves**. When the waves reach the end of the Slinky held by the other person, the waves bounce back – they **reflect** – and travel back toward me. Waves occur when something vibrates or oscillates and the energy of the vibration transfers into a **medium**. In the Slinky experiment, my hand acts as the oscillator and the metal coils of the Slinky act as the medium.

Now imagine the groaning tube experiment. When I hold the tube upright, the little kazoo inside falls through the tube. As the air moves through it, the kazoo vibrates. These vibrations transfer energy into the surrounding air. The energy vibrates as it travels through the air in the same manner that the kazoo was vibrating in the tube. These "traveling vibrations" in the air are **sound waves**. When the sound waves reach our ears, they make our eardrums vibrate and our brain recognizes this pattern of vibrations as the sound of the kazoo. The whirly tube also makes sound waves.

All waves can be characterized be certain measureable properties.

- **Amplitude** describes the height of waves.
- **Frequency** represents the rate at which the medium vibrates.
- **Wavelength** represents the distance between two successive peaks (crests) or two successive valleys (troughs) in a series of waves.

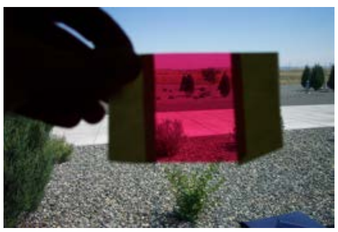
In several respects light waves don't differ significantly from sound waves. Sound waves are produced when objects vibrate (musical instruments, human vocal cords, audio speakers, etc.). Light waves are produced when subatomic particles vibrate (usually electrons). A system must receive energy to vibrate. In the case of sound waves, the energy might come from the expulsion of air from my lungs or from the tap that I give to a piece of metal like a wind chime. In the case of light, electrons can receive energy from several possible sources, such as heat (incandescent lights), electrical voltage (fluorescent lights) or chemicals (glow sticks). Both with sound and light, energy causes vibrations and these vibrations produce waves.

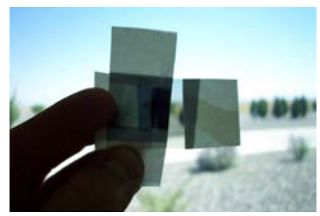
Frequency constitutes one big difference between sound waves and light waves. Sound waves represent hundreds or thousands of vibrations per second. Light waves that cause color arise from trillions of vibrations per second. Electrons have very little mass and can vibrate at very high frequencies.

Because light waves travel with such high frequencies, we don't really experience light as wave behavior; we experience light as color. Several experiments in the kit involve processes that relate to the wave nature of light, even though we don't see the light "waving."

- Kaleidoscopes: **Reflection** of light to make the nice patterns in the scope

- Look-through kit: **Absorption** (colored filters), **diffraction** (rainbows), **polarization** (polarizing filters)





- Magnifying glass, prisms: **Refraction**

- UV Beads: **Absorption** (of non-visible UV light from the Sun).

Kit Stations

Use the items in this kit to explore various aspects of physical science. Instructions with photographs are given below. Some of the items are small and should not be used by younger preschoolers or toddlers.

Sound Tube

Description: Long flexible plastic tube

Instructions: Hold the tube by the small end and whirl the tube around quickly. Listen for the notes that the tube produces.

Science principles: As you whirl the tube, air is forced through the tube. The ripples in the tube create small whirlwinds in the tube as the air passes through. The vibration of the whirlwinds produces sound waves. The more rapidly you whirl the tube, the higher the frequency (pitch) of the sound waves.

Groaning Tube

Description: Rigid plastic tube

Instructions: Hold the tube upright and quickly turn it over. Listen for the sound.

Science principles: There is a small unit that slides back and forth inside the tube. This is the sound emitter. The length of the air column changes as the emitter slides down the tube. The air column vibrates because of the sound waves produced by the emitter. As the length of the air column changes, the pitch of the sound changes slightly.

Regular Top

Description: Disk-shaped top with a stem for spinning.

Instructions: Grab the top by the stem and spin it on a hard surface.

Science principles: When an object starts moving in a certain direction, it will continue to move in that direction unless something applies a push or pull (a force) to the object. The same is true of spinning objects. Once they start spinning, they will continue to spin unless another force, such as friction, reduces the spin. Tops and gyroscopes also wobble as they spin. The wobbling motion is "precession" and comes from the fact that a spinning object produces torques that can oppose the effect of gravity.

Top with Arms

CAUTION: SMALL PIECES

Description: Similar in appearance to the regular top but smaller. Two plastic extensions lie between the two layers of the top.

Instructions: Grab the top by the stem and spin it on a hard surface.

Scientific Principles: Same as the regular top. When the tops spins, the two extension arms are flung outwards and the arms spin at the same rate as the top. The top spins rapidly enough that your eyes can't resolve the motion of the arms. You see a blurred image as the arms spin.

Upside-down Top

Description: Nearly a sphere. One portion of the top is flat. The stem protrudes from the flat portion.

Instructions: Grab the top by the stem and spin it on a hard surface. Watch the top turn upside down as it spins. It should turn all the way over and spin on the stem.

Scientific Principles: The upside-down behavior of the top requires a good bit of mathematics to explain. The behavior basically arises from the top's odd shape.

Gyroscope

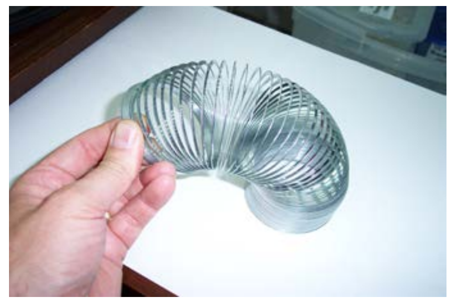
Description: A metal wheel that spins on an axle inside a round metal cage. A piece of string is required. The gyroscope may have a plastic base on which you can place it when it is spinning.

Instructions: The gyroscope is tricky to use. You must feed one end of the string through the tiny hole in the axle. Then you must wind the string onto the axle by turning the wheel without tangling the string. Once the string is wound, pull the free end of the string to make the axle spin. You'll need to be holding the gyroscope by the metal cage so your fingers don't slow the spinning of the wheel. A strong, smooth pull will unwind the string and make the axle spin at a high rate. Then you can set the gyroscope on the plastic base, on the floor or on the palm of your hand to watch it spin.

Scientific Principles: The gyroscope is basically another type of top. If you spin the gyroscope at a high rate then tap the top, you'll see the precession, or wobble, of the device.

<u>Slinky</u>

Description: A loosely coiled spring



Instructions: There are many interesting things to do with a Slinky. Two people can stretch the ends and shake one end, making waves travel up and down the spring. Slinkies can also walk down stairs if given a start down the first step.

Scientific Principles: Slinkies are excellent devices for showing that waves are movements of energy. When shaking the end of a stretched spring, you can see that the wave moves down the length of the Slinky while the coils vibrate back and forth.

<u>Tornado Tube</u>

Description: The Tornado Tube is a short plastic pipe with threads on each end and a reduced-diameter opening through the middle. You will need two empty 2-liter plastic bottles. Fill one of the bottles about 2/3 full of water. Then screw the neck of each bottle into the threads on each end of the Tornado Tube.

Instructions: With the two bottles screwed into the ends of the tube, and with one bottle partially full of water, turn the device upright so that the partially full bottle is on top. Now swirl the device in a circular motion. You should see a whirlpool form in the top bottle as the water falls to the bottom.

Scientific Principles: Gravity causes the water in the top chamber to move to the bottom, but the air in the bottom chamber must leave if the water is to enter from the top. Swirling the device creates a whirlpool with a hole in the center. The air in the bottom chamber will be pushed to the top through the hole as the water falls down to the bottom along the sides.

Bottle Fountain

Description: Nearly identical to the Tornado Tube. There are two long thin tubes that protrude from the connector, one up and one down. Invert the device just like the Tornado Tube. The upward movement of air from the lower bottle to the upper forces a fountain of water to the top of the upper bottle.

Poppers

CAUTION: SMALL PIECES

Description: Small rubbery bowl-shaped objects

Instructions: The poppers are a challenge to operate. Hold a popper by the rim and turn the center portion inside-out by pushing on it with your thumbs. Set it on a flat hard surface, keeping it inside-out. Now let go. If you are quick enough, the popper will throw itself into the air as it turns right-side-out.

Scientific Principles: The popper material is elastic. When you change its shape, it wants to snap back to its original shape. When you turn the popper inside-out it acquires a lot of potential energy through stretching. When you let go, the potential energy of the stretching turns into kinetic energy as the popper flies into the air.

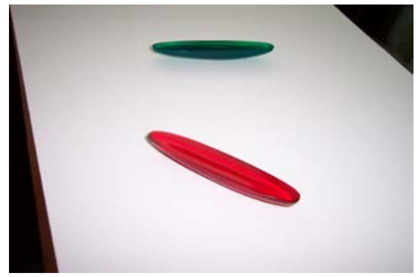
Kaleidoscopes

Description: Black tube with an eye hole at one end

Instructions: The kaleidoscope works best in well-lit conditions. Do not point a kaleidoscope at the sun. Look through the eye hole and turn the rotating piece at the opposite end of the tube. You should see a pattern inside the kaleidoscope that changes as you rotate the end.

Scientific Principles: The kaleidoscope contains a group of small colored pieces that randomly arrange themselves at the end of the tube. The arrangement of the pieces changes as you rotate the end of the tube. The nice pattern that you see on the inside of the tube is produced by a set of mirrors that reflect the incoming light back and forth, causing the arrangement of the pieces to become multiplied in your view. The inside of the kaleidoscope is like a tiny house of mirrors, causing the image of the randomly arranged pieces to be reflected several times, Rattlebacks

Description: Small colored plastic items that are long and thin and shaped like little boats



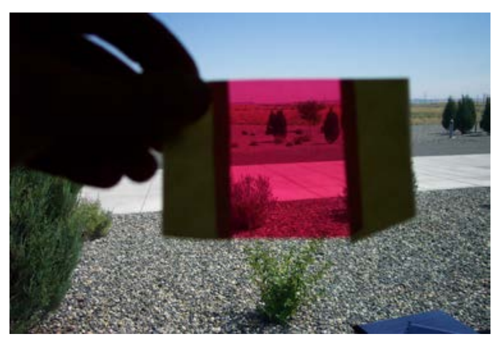
Instructions: Set the rattleback on a hard smooth surface so that it rests on the surface like a little boat. Hit the end of the rattleback with your finger to make it spin horizontally. Try spinning it in the clockwise direction first. You should see it spin clockwise. Then it will stop spinning and bob up and down with a rocking motion. It will then spin in the opposite direction – counterclockwise. Note that if you spin it counterclockwise at the start, it will continue to spin and will not reverse the direction of its spin.

Scientific Principles: Look carefully at the rattleback and you will see that its shape is not symmetric. There is an imbalance in its mass that produces a transfer of energy from the spinning motion to the rocking motion. Once the rattleback starts the rocking motion, the resulting spin will only occur in the counterclockwise direction due to its shape. Try tapping it from the top on one of the ends to make it rock – you should then see it start to spin counterclockwise.

Look-Through Kit

The Look-Through Kit is a small Zip-lock bag that contains six pieces of plastic. The sheet sections are three different activities. Do not use any of these items to look directly at the sun. Make sure that you hold the pieces of plastic by the tape on the edges instead of touching the plastic itself.

Colored Acetate Sheets

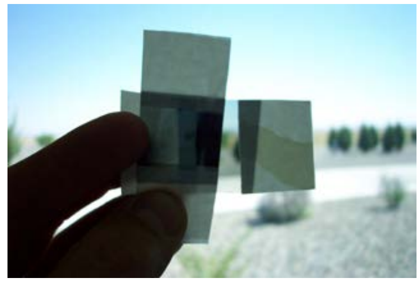


Description: These are the pieces of red, green and blue plastic.

Instructions: Hold the sheets in front of your eyes and the world will appear to change color. You can also combine the colors by holding more than one sheet in front of your eye.

Scientific Principles: The colored sheets act as filters, removing certain colors by absorbing those colors from sunlight or room lights. Other colors are allowed to pass through. When you combine sheets, you see an even smaller slice of color that is allowed to pass through. This slice is a color that is between the two colors of the filters that you are using.

Polarizing Film



Description: These are the two small pieces of dark plastic film.

Instructions: Hold one piece in front of the other in line with your eye and look at a light or a cloud in the sky (do not look directly at the sun). Now rotate one of the pieces while you hold the other still. What you are looking at will almost disappear when you're holding the two pieces at a right angle.

Scientific Principles: Polarizing film absorbs all of the light waves from a light source except those waves that are wiggling along one particular direction. When you hold one sheet in front of the other at a right angle, you are blocking nearly all of the possible orientations of light waves that are coming from your light source, so the source looks very dark. Polarizing sunglasses have lenses that contain polarizing material.

Diffraction Gratings

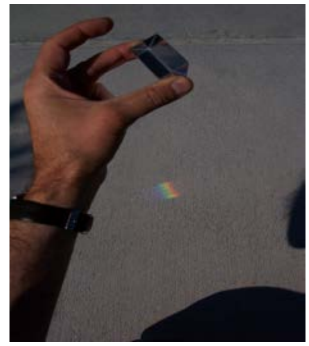
Description: This is the piece of nearly colorless, nearly transparent plastic film.

Instructions: Hold the diffraction grating (by the taped edge) and look at a light source (not the sun). The gratings work best in a dark room. You should see rainbow patterns as you look at lights with the diffraction grating film.

Scientific Principles: The diffraction grating film has thousands of lines etched on its surface, lines that are so thin that your eye cannot distinguish them. The sets of lines acts as a picket fence when light hits it, blocking the light that hits the lines but letting the light pass between the lines. As the broken-up light makes its way through the grating, it undergoes a process called diffraction in which certain wavelengths of light reinforce each other at particular angles. The result is that the original white light sample is split into its component colors. Fluorescent and incandescent lights (household lights) will yield a diffraction pattern that contains nearly all the colors of the rainbow

Prisms

Description: These are solid triangular shaped pieces of colorless transparent plastic.



Instructions: The prisms only work effectively when you pass sunlight through them and look for the resulting rainbow pattern on a nearby smooth surface such as concrete or asphalt. Stand in sunlight and hold a prism by the ends so that the sunlight can pass through it. Rotate the prism around to change the angle at which the sun strikes it. At the correct angle, you should see a rainbow pattern appear on the ground in front of you.

Scientific Principles: When light goes through a prism, the light undergoes refraction, which is the bending of light that is cause by changing the speed of the light as it passes out of one materials and enters another material. Different wavelengths (colors) of light are refracted by different amounts, causing the colors of white light to separate into a rainbow pattern.

Magnifying Glass

Description: These are oval-shaped plastic units. The magnifying glass sits inside its plastic cover.

Instructions: You must swivel the lens out of the cover. It only swivels out in one direction. Use the raised edges on the top of the lens to push it out of the cover.

Scientific Principles: The magnifying glass has curved surfaces. Light rays change speed as they enter the glass from the air. Because the glass is curved, the change in speed results in a change in direction. The path of the light is bent by the lens as the light moves from the object through the lens and to your eye. This makes objects appear larger than their actual size.

Ultraviolet Bead Rings

CAUTION: SMALL PIECES

Description: Small beads that are strung on loops of plastic

Instructions: The beads change color in sunlight. Take them from a room that has reduced lighting into the sunshine and you will see the changes.

Scientific Principles: The sun delivers some ultraviolet light to us in addition to visible light and infrared light (heat). Ultraviolet light is more energetic than visible light and carries enough energy to change the chemical bonds in certain molecules. This type of change in pigment molecules in your skin is what gives you a sun tan (or burn). The beads contain a UV-sensitive chemical. Sunlight stimulates a change the structure of the chemical, changing its color while the sunlight strikes it. Darkness turns off the change.

Materials List

Activity	Item	Source	Part Number	Cost
Sound Tube	Sound tube (whirly)	Educational Innovations**	SS-600	3.50
Groaning Tube	Ridged plastic tube	Arbor Scientific**	P7-7160	1.75
Regular Top	Standard top	Oriental Trading Co**	IN-13602699	5.99 (12)
Top with Arms	Plastic top with extenders	Toy store		1.29
Upside-down Top	Spherical top	Amazon.com**		6.65 (4)
Gyroscope	Gyroscope	Arbor Scientific**	P3-3501	6.50
	Fishing line	Sporting goods**		2.49
Slinky	Metal slinky	Fred Meyer		3.50
Tornado Tube	Tornado tube	Educational Innovations**	SS-1	1.95
Bottle Fountain	Fountain Connection	purefunsupply**	YEP10112	5.36
Poppers	Poppers	Oriental Trading Co**	IN-16/454	4.25 (12)
Kaleidoscope	Basic kaleidoscope	Yoyo.com**	Schylling Classic	7.99
Rattlebacks	Plastic rattlebacks	Educational Innovations**	SS-310	7.95 (5)
Colored Acetate	Red, green, and blue plastic	Craft store		5.99
Polarizing Film	Dark, plastic film	American Science & Surplus**	37640P1	17.50
Diffraction Gratings	Diffraction grating slides	Rainbowsymphony.com **	01602	0.40
Prisms	plastic prisms	stevespanglerscience **	WPSM-700	8.99
Magnifying Glass	Small hand-held magnifying glasses	Toy store		3.99
UV Beads	UV beads	Educational Innovations**	UV-AST	6.95
Storage	Zip-ties	Hardware store		3.99

** Online source

Name: ____

Group Scenario

Pretend that you find a room that's the size of your classroom but the room is completely empty. There's nothing in it at all. On the floor in the middle of the room there's a water bottle standing upright on the floor. Your job is to knock the bottle over. You're not allowed to touch the bottle with your hands. You'll need to figure out another way to knock it over.

See if your group can think of six different ways to knock over the bottle without touching it with your hands.

1.
2.
3.
4.
5.
6.

Which one of your six ideas do you think would work the best? Explain why.

Draw a picture of what your idea would look like if you actually did it.

Scientist Score Sheet

Check how well each of these activities helped you learn about energy, vibrations and waves.

	My favorite	I liked this	I did not like this
Watching demonstrations			
Hands-on stations			
Working with a partner			
Working in small groups			
Presenting your ideas to the class			
Watching “Bill Nye the Science Guy”			
Asking questions in class			
Class discussions			
Engineering (the Scenario)			