Oakland Schools Science Scope

Grade 7

Unit 1 – Waves and Energy

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About Our Scope Unit/Lesson Template

This template is designed to serve several teaching and learning principles considered as staples of state of the art science instruction. Here are the key principles in summary:

- It's critical to **elicit prior knowledge** as a unit or lesson begins.
- **Key questions** should drive student explorations and investigations.
- **Activity Before Concept** – Student inquiry-based explorations which give personal experience with phenomena and ideas should precede a presentation of science ideas.
- **Evidence is the heart of the scientific enterprise.** Students generate evidence and analyze patterns in data that help to construct scientific explanations around key questions.
- **Concept Before Vocabulary** – Attaching science vocabulary to concepts developed by student investigations yields more success than beginning a unit or lesson with a list of science vocabulary.
- **Talk, argument and writing** are central to scientific practice and are among the most important activities that develop understanding.
- **Application** of the ideas provides review, extends understanding, and reveals relevance of important ideas.
- **Assessment** of knowledge, skill, and reasoning should involve students throughout the learning process and be well aligned to the main objectives and activities of the unit.

The Scope Science template is designed to put these principles into practice through the design of the ***SCOPE LEARNING CYCLE FOR SCIENCE***. Each unit has at least one cycle. The components are listed below:

The Key Question for the Unit	Each unit has one open-ended Focus Question that relates to all the content and skills of the unit. The Key Question is presented at the opening of the unit and revisited at the unit's conclusion.
Engage and Elicit	Each unit begins with an activity designed to elicit and reveal student understanding and skill prior to instruction. Teachers are to probe students for detailed and specific information while maintaining a non-evaluative stance. They also can record and manage student understanding, which may change as instruction proceeds.
Explore	A sequence of activities provides opportunities to explore phenomena and relationships related to the Key Question of the unit. Students will develop their ideas about the topic of the unit and the Key Question as they proceed through the Explore stage of the learning cycle. Each of the activities may have its own "Focus Question" or central task that will be more focused than the unit question. The heart of these activities will be scientific investigations of various sorts. The results, data and patterns will be the topic of classroom discourse and/or student writing. A key goal of the teacher is to reference the Key Question of the unit, the Engage and Elicit of the students, and to build a consensus especially on the results of the investigations.
Explain	Each unit has at least one activity in the Explain portion of the unit when students reconcile ideas with the consensus ideas of science. Teachers ensure that students have had ample opportunity to fully express their ideas and then to make sure accurate and comprehensible representations of the scientific explanations are presented. A teacher lecture, reading of science text, or video would be appropriate ways to convey the consensus ideas of science. Relevant vocabulary, formal definitions and explanations are provided. It's critical that the activity and supporting assessments develop a consensus around the Key Questions and concepts central to the unit.
Elaborate	Each unit cycle has at least one activity or project where students discover the power of scientific ideas. Knowledge and skill in science are put to use in a variety of types of applications. They can be used to understand other scientific concepts or in societal applications of technology, engineering or problem solving. Some units may have a modest Elaborate stage where students explore the application of ideas by studying a research project over the course of a day or two. Other units may have more robust projects that take a few weeks.
Evaluation	While assessment of student learning occurs throughout the unit as formative assessment, each unit will have a summative assessment. Summative assessments are posted in a separate document.

Grade 7

Unit 1 – Waves and Energy

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Unit 1 – Waves and Energy

Unit Introduction

This unit attends to the Michigan Grade Level Content Expectations as they are gathered in Unit 1 of the Michigan Department of Education Science Companion Document. Topically, the unit addresses concepts within the disciplines of physical science and technology. To organize the content of this unit, the Oakland Schools Science Scope has established two learning cycles:

Cycle 1: The Nature of Mechanical Waves
Cycle 2: The Nature of Electromagnetic Waves

The resources and opportunities to address these topics are of such abundance and quality that the unit has the tremendous potential to be a highly relevant, real-world and investigation-rich experience for students. As teachers look for ways to have students use real-world data, apply interactive technology to real-world questions, and foster meaningful tasks for reading, writing, argumentation and mathematics and framed by the Common Core Curriculum Standards, the issues here provide abundant opportunity. The main limitation is the class time available given other content demands.

On the Common Core State Standards for English Language Arts and Literacy in Science

All science teachers will find the Common Core State Standards of ELA a tremendous asset for reaching learning objectives in science education. Reading, writing, argumentation and discourse are central proficiencies necessary for success in science. All teachers should become fluent with the document and are likely to find it validating.

http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf

These standards are best reached with science instruction that connects content to real-world problems and experiments, complimented with scientific writing, challenging questions, processes for classroom discussion and debate, and use of scientific text.

It is recommended that teachers require students to use an interactive science notebook to support learning in this unit. Here are some features and policies to consider:

- Use a bound notebook – cut and paste or staple some other materials into it (quad-ruled notebooks are nice for the graphing activities).
- The right-facing page is for teacher content; the left is for student reflection.
- Leave four pages for a table of contents.
- Leave the notebooks in the room.

Learning Cycle 1: The Nature of Mechanical Waves

Introduction
In this physical science unit, students conduct investigations to trace the transfer of energy through matter. They begin by exploring mechanical waves such as sound waves, seismic waves and waves in water through a variety of activities. They measure speed, wavelength, frequency and magnitude. Students investigate the properties of sound and its transmission. Students investigate the application of sound waves to the study of echolocation and sonar.

Learning Objectives
Students will be able to:
- Identify examples of mechanical waves, including sound waves, seismic waves and waves on water.
- Describe how mechanical waves are produced by vibrations in matter.
- Demonstrate how mechanical waves transfer energy when they interact with matter.
- Design different instruments that produce and change sounds.
- Construct charts and graphs from data and observations dealing with waves and energy.

Key Question: How does energy travel through matter?

Engage and Elicit

Activity 1 – A Human Wave

Purpose
To elicit student understanding of the transfer of energy through matter.

Activity Description
The class will mimic mechanical waves by passing "push" and "pull" through their arms. This is a very short activity that will begin thought and discussion of how energy moves through matter.

Focus Question
How does energy travel through matter?

Duration
15 minutes

Materials
- Large open space, such as a hallway

Teacher Preparation
1. Obtain access to the open area.
2. Watch for rough pushing and pulling.
3. Have questions prepared for the students to consider and to record in their interactive notebook.

Classroom Procedure
1. Go out in the open hallway. Students will all form a single-file line, facing in the same direction. Give them these directions:
2. Place your hands on, and grasp the shoulders of the person in front of you. Gradually, extend your arms outward until they are straight.
3. When your line has settled down, have someone at the back of the line give the person in front of him/her a **light** shove, followed, a second or two later, a **gentle** backwards pull.
4. Repeat 2-3 times. Remember to keep your arms straight.
5. Try causing a break in the line where energy cannot be transferred. Discuss why the energy could not continue down the line.
6. This would be a good opportunity for an entry in the interactive notebook. Have students record what they noticed about the traveling of energy through their line. What happened when there was a gap or break in the line?

Engage and Elicit

Activity 2 – Can You Hear This?

Purpose
Students will listen to different pitches of sounds and begin to think about how those sounds are made.

Activity Description
Teachers can use a clip from YouTube ("The Ultimate Hearing Test") to show how different pitches sound. Teachers can also find clips of music and use those to begin a discussion on sound differences.

Focus Question
What are some qualities of sound? What causes sound to be so different?

Duration
5-10 minutes

Materials
- YouTube video: "The Ultimate Hearing Test"
  http://www.youtube.com/watch?v=igGroIcga3g&feature=related
- Other videos that show variations in sounds with pitch and amplitude such as sine waves.

Teacher Preparation
1. Preview YouTube clip "The Ultimate Hearing Test," or select other sounds you might want your class to listen to.
2. Select some discussion questions to get the class to begin thinking about sounds and what makes them different from each other.

Classroom Procedure
1. Show clip and have students discuss what they heard.
2. Questions to consider: What were some differences in the sounds you heard? Do you think everyone can hear these sounds? Were they pleasant to your ears?
3. Encourage students to record observations in their interactive journals.
4. Teachers may consider playing music from different instruments or artists and discussing the quality of the sounds in these situations as well.

Engage and Elicit

Activity 3 – Resonance Using a Discrepant Event

Purpose
To provide best explanations for phenomena that demonstrate resonance.

Activity Description
Students will listen to a music box or cell phone and wonder about how sound can be magnified by using a chalkboard. Teachers can use the inside of a music box or a cell phone set to vibrate (or even a ring tone) to demonstrate the idea of resonance. The music box or phone will be touched to a flat pore-less surface (such as a chalkboard) and the sound will be magnified. The combination of the original vibrating object and the forced vibrations of the second object produce sound of greater amplitude in the surrounding air. This results in a louder sound. Another possibility for this Engage and Elicit activity is to have students observe the Collapse of the Tacoma Narrows Bridge, which is a famous video available online. They can discuss what they think could have caused this to happen.

Focus Question
What causes sound (vibrations) to be magnified?

Duration
10 minutes

Materials
- Online video of the Collapse of the Tacoma Narrows Bridge http://www.archive.org/details/SF121
- Inside of a music box or a cell phone that can be set to vibrate or a ring tone
- Flat surface (without pores) such as a chalkboard or table top

Teacher Preparation
1. Gather required materials and preview the online video.

Classroom Procedure
1. Show students the item you will be using (music box or cell phone) and play the music for them.
2. Walk around the classroom so that everyone can hear the music. Solicit responses from students about what they hear, how loud is it and so on. Students may write observations in their interactive notebook.
3. Step over to the board or table top and touch the object making the sound to the flat surface. Solicit responses from students about the difference in sound.
4. Encourage students to discuss what they think causes the sound to increase in such a way. Again, observations and guesses can be recorded in the notebook. You may want to consider writing out student guesses on a large poster board that can be brought out at a later time and revisited.

5. Ask students to suggest other surfaces in the classroom to touch the object to and discuss why or why not the increase in sound could be heard. They may even be able to write a rule at this time for what they are hearing.

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Engage and Elicit

Activity 4 – Let’s Play Ball

Purpose
Students will hear the effects of the changes in sound from a moving object (Doppler Effect).

Activity Description
Using the classroom or an open area, students toss a football with a buzzer inside around the room. Students seated in the middle will experience a change in pitch as the ball with the buzzer moves from place to place.

Focus Question
How does sound change as it emits from a moving object?

Duration
10 minutes

Materials
- Nerf football
- Buzzer (available at Radio Shack)
- Battery to run the buzzer (you may want to purchase battery with the buzzer)
- Sharp knife
- Tape
- Alternative: These balls can be purchased already constructed through Scientific Supply companies

Teacher Preparation
1. Teachers may choose to set up one ball for the class, or may have enough balls for several student groups. To make the footballs “buzz,” make an incision with a sharp blade* in the Nerf football large enough for the students to insert the buzzer and battery. Provide tape to reattach the Nerf that was cut away.
2. *For safety reasons, the students should not have access to the sharp blade. If it is not feasible to construct individual sound sources, one "Doppler Football" may be used as a demonstrator for each group, or for the whole class.

Classroom Procedure
1. Students should obtain a Nerf football, buzzer, and battery from the teacher. Turn on the buzzer and insert it and the battery into the Nerf football. Tape the gap shut. Students have just constructed a movable sound source.
2. Students should try tossing it around a bit and listening to the sound as the football is moving. Have them DESCRIBE the sound produced.
3. Let someone else throw the football. The other student should position him/herself several meters away and note any differences in the pitch of the sound when the buzzer moves away from them as compared to when it is moving toward them.

4. Have the student position him/herself underneath a throw. Any differences?
5. Have students record any patterns they notice in their notebooks. Have them include a drawing of how they think the sound might look if they could see it. Include labels.

Explore

Activity 5 – Slinky Waves

Purpose
To elicit student understanding of the transfer of energy through matter.

Activity Description
Students will use a Slinky to explore the different ways Slinkys move and create patterns.

Focus Question
How does energy travel through matter?

Duration
15 minutes

Materials
- Large open space. **Tip – You may want the students to place Slinkys on a long table. This helps eliminate tangles that seem to happen when Slinkys are placed on the floor.
- Slinkys (they may be cut in half to create more supplies and to eliminate tangles).

Teacher Preparation
1. Obtain Slinkys and cut in half if desired.
2. Determine an area for Slinky use.
3. Prepare to discuss Slinky safety (the students must hold the end of their Slinky tightly to prevent the other student from getting snapped with the Slinky – ouch!!).
4. Prepare discussion questions for class and interactive journal.

Classroom Procedure
1. Students need to work in groups of two. Each student should hold an end of the Slinky.
2. Have students make different shapes with the Slinkys. If they are only making wave shapes, prompt them to use the Slinky coils to send "vibrations" to the student at the other end.
3. Encourage students to experiment with adding more or less energy to their waves.
4. Have them write down any questions or observations they might have about the Slinky in their journal. You may consider having them draw shapes they made with the Slinky and if they did anything to effect the shape.
5. Encourage students to look for patterns in the size and strength of the waves they made. These should also be included in the journal entries and may be shared with the class. Give students time to make any additional notes as they listen to classmates.

Explore

Activity 6 – Penny Activity

Purpose
To elicit student understanding of the transfer of energy through matter, and for students to begin thinking about how they can tell energy has been transferred.

Activity Description
Students will use pennies and explore how energy is added to them and can be transferred through them. Encourage students to explore with different numbers of pennies and different configurations of the pennies to show energy transfer.

Focus Question
How can we tell there has been a transfer of energy?

Duration
15 minutes

Materials
- 4-5 pennies (have more available in case students want to experiment with more pennies)
- Desk top or table top

Teacher Preparation
1. Obtain pennies (putting some in cups for groups to use works well).
2. Prepare discussion questions for class and interactive journal.

Classroom Procedure
1. Set out cups of pennies with at least 4-5 pennies per cup (grouping students in pairs works well for this activity).
2. Students may use the pennies to show that energy is being transferred. Let them explore ways to show this. Students who are having trouble may be prompted to place pennies in a horizontal line and add energy to one end of the line (they can flick the beginning penny at one end of the line, and/or they could try using one penny and "crashing" it into the rest of the line). Students may also choose to stack pennies and try and move the bottom penny by adding energy.
3. Encourage students to address the focus question. How can they tell that energy has been transferred? What needs to happen for energy to be transferred?
4. Give students time to record attempts and observations in their journal. They should also include attempts that didn't work and observations about why those attempts failed.
5. Students may share discoveries with the class.

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Explore

Activity 7 – Wave Shapes

Purpose
Students will begin to think about the parts and shapes of waves.

Activity Description
Students will refer to their interactive notebook and notes from previous experiences to draw what they think a wave would look like if it had to be put into two dimensions.

Focus Question
What are the parts of a wave? Are there different kinds of waves?

Duration
15 minutes (might be useful as a class starter)

Materials
- Paper
- Pen/pencil

Teacher Preparation
No preparation necessary.

Classroom Procedure
1. Ask students how they think the waves they made with the Slinkys might be drawn on paper.
2. What part of the wave seems to be important (enough to have a name)? What parts stand out as being major parts of the wave? Place an X or perhaps a name on that part.
3. Students should be ready to come back to their pictures and label them with correct vocabulary when it is given to them.
4. Ask students "Do you think waves travel in different shapes?"
5. Ask students "What do you think a wave might need to travel?"
6. Prompt the students with: "After the Penny Activity, you might have some ideas for the waves that energy can travel in….Now we are going to put our ideas together and share with the class."
7. Have students get a white board/large sticky notepaper and markers and do the following:
   - Choose/assign the following jobs for your group. Work with people at your table!
     - Writer
     - Artist
     - Presenter
     - Manager
   - Brain storm ideas about the following:
     - What causes waves?
     - How or what carries waves?

- What your group thinks a wave(s) might look like (you may have more than one picture)
- Draw a picture or pictures of your ideas
- Label or star any parts of your wave(s) that you think might be important
- List any types of waves that your group can think of
- Be ready to share with the class
- You will only have 15 minutes to work on your ideas

8. Students should now be ready to put vocabulary to parts of a mechanical wave such as crest, trough, compression, rarefaction, and medium, and understand that mechanical waves need a medium to travel through or their energy cannot be passed on.
9. Given this information, students should be able to go back to their interactive notebooks and add to their previous thoughts and explanations.

Explore

Activity 8 – The Symphony of Sounds

Purpose
Students will investigate different ways that sound is produced and how they might be able to make changes in sound.

Activity Description
Students will begin to apply knowledge of mechanical waves to sounds. They will use a variety of items to make sound and be given opportunities to notice how different lengths of instruments make different pitches.

Focus Question
How is sound produced? Are there any variations to sound?

Duration
One 60-minute class session

Materials
- Wooden meter sticks
- Plastic rulers
- Tuning forks of different sizes
- Rubber bands (different thicknesses and sizes)
- Drinking straws (one per student)
- Scissors
- Rubber stoppers (or the bottom of a gym shoe would work too)
- Teacher-created student guide (content below), printed and copied

Teacher Preparation
1. Decide how you would like to do this activity. Consider the following two approaches. They will depend on materials available, class size, and teacher comfort level. 1) One way to set this up is to have all materials set out at each lab station. Students can use materials as they desire. 2) A second option would be to set up stations and have student groups rotate to the materials. Be prepared for the straw portion of the activity to be a little loud, as students will essentially be constructing kazoos. It might be nice to warn teachers nearby that you will be a little noisy during this activity.
2. You may choose to have the students use a worksheet for this activity. A sample worksheet that guides students is given below under Classroom Procedure. Copies will need to be made.
3. You may also choose to have students record observations for each part in their interactive notebooks.
4. You may also wish to use this activity to help students begin to make claims, use evidence, and supply reasoning for what they discovered (C-E-R method). They will have an opportunity to edit their C-E-R after they have seen some of the "expert" information

about how adding and taking away energy can change amplitude, and how lengthening and shortening the area that waves move through will change pitch.

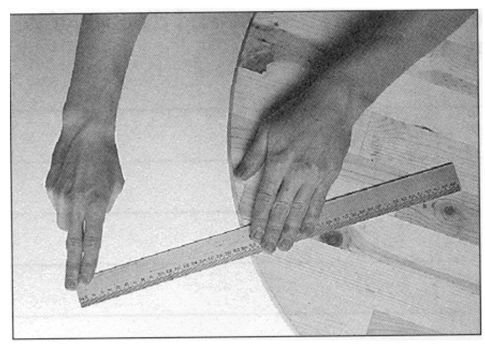
Classroom Procedure

Have students complete the following:

Part 1: Tuning-Fork Sounds.

1. Enter all observations and responses in your interactive notebook.
2. Strike a tuning fork on the edge of a rubber stopper.
3. Hold the tuning fork close to your ear. What do you observe?
4. After striking the fork again, touch the prongs to the surface of a glass container of water and to a loosely held piece of paper. What do you observe?
5. Next, while the tuning fork is sounding, touch its base to the table, to a cup held over your ear, and to other objects.
6. Try some of these experiments with a tuning fork of different sizes.
7. Come up with a pattern that you have noticed after experimenting with the tuning forks in the ways suggested and as many other ways as you can think of.
8. Enter this pattern in your notebook.

Part 2: Ruler Sounds



9. Hold one end of a plastic ruler firmly on the edge of a table.
10. Push down on the other end, and then let it go (do not break the ruler).
11. Try this several times with various lengths of the ruler extending over the end of the table.
12. What patterns do you observe?
13. Substitute the plastic ruler for the wooden one (meter stick), and repeat the activity.
14. What patterns do you observe now?

Part 3: Rubber Band Sounds

15. Stretch a rubber band around a plastic box, and then pluck the rubber band.
16. Listen carefully and describe what happens.
17. Tighten the part of the rubber band that is on the top of the box.
18. Pluck it again.
19. Is there any difference in sound?
20. What patterns can you notice as you tighten or loosen the band?
21. Put a pencil across the top of the box (the short way), under the rubber band, and pluck again.
22. Describe any differences you hear.
23. Experiment with the box and rubber band in as many ways as you can think of.
24. Describe any patterns that you notice. Enter this pattern in your notebook.

Part 4: Straw Sounds

25. Get a drinking straw and flatten it as much as possible (repeat over and over so that your straw will remain almost flat).
26. Cut your straw at the top.
27. Adjust the position of the straw in your mouth (use the part that you cut) and blow through it until a steady sound is produced. The straw should be flat in your mouth.
28. **Be careful:** Use **only your** own straw, and dispose of it after completing the activity.
29. You will be cutting this straw shorter in just a minute. Before you do that, try other ways to make the straw sound different.
30. Record what you tried and your results.
31. Record any patterns that you noticed.
32. While blowing a steady sound, use scissors to cut the straw shorter and shorter. Record any patterns that you notice. Enter this pattern in your notebook.

SUMMARY

	How do I make the object produce sound?	What is the object doing as it produces the sound?	How can I stop the sound?	Can I change any characteristics? If so, how?
Activity 1: Tuning Fork Sounds				
Activity 2: Ruler Sounds				
Activity 3: Rubber Band Sounds				
Activity 4: Straw Sounds				

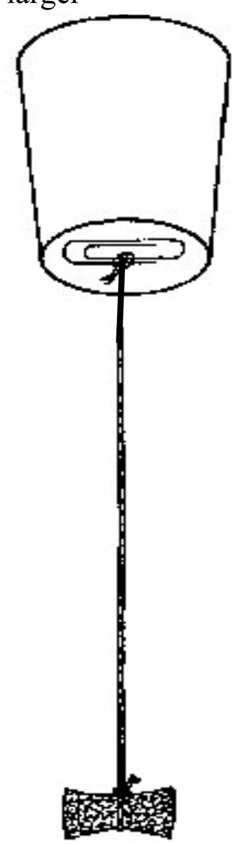
- Develop a general pattern that you observed during this activity. Enter this pattern in your notebook.
- Use the C-E-R method (Claim, Evidence, Reasoning) to make a claim about what you discovered during this lab. You might want to consider what caused sound, and how you changed sound while you were experimenting. Enter this pattern in your notebook.

Explore

Activity 9 – Clucking Chicken

Purpose
Students will continue to experiment with making sounds and variations of sound.

Activity Description
Students will construct a sound-generating instrument and attempt to explain the variations that produce different sounds. Instead of attaching a cotton string to the cup, try various cords, wires and ribbons, or strings from violins or guitars. Instead of a damp sponge, try leather or cloth coated with beeswax or rosin. What if the string is attached to the inside of the cup instead of to the outside? Attach a spring, elastic or chain of rubber bands to the cup, and pluck it. Attach a stretched wire coat hanger and bang it with a hard object. What happens if you use larger containers such as a restaurant-sized food can or a garbage can?



Focus Question
How is sound produced? Are there any variations to sound?

Duration
One class session

Materials
- Metal can or plastic cup
- Paper clip
- Cotton string approximately 70 cm long
- Cellulose sponge
- Variety of strings and wires

Teacher Preparation
1. Gather materials; decide if students will each make their own Clucking Chicken, or if they will have one Clucking Chicken per group.
2. Decide how students will record information discovered: interactive notebook or student worksheet.

Classroom Procedure
Have students complete the following steps:
1. Make a small hole in the bottom of a metal can or plastic cup.
2. Tie a small paper clip on one end of a sturdy cotton string about 70 cm long, and run the other end through the hole in the bottom of the cup (see diagram).
3. Tie a small piece of cellulose sponge at the other end of the string. (The common rectangular sponges sold at supermarkets are made of cellulose.)
4. Dip the sponge in water and squeeze it so it is damp, not soggy.
5. Hold the cup securely in one hand. With the other hand, fold the sponge in half and use it to grasp the upper part of the string tightly.

6. While maintaining a tight grip, slide the sponge down the string with short jerking motions. The sound produced will resemble a loud chicken. By varying the manner in which the sponge is slid down the string, the sound can be made to resemble a frog or what might politely be called "rude noise."
7. Record your observations in your interactive notebook. What did you observe? Was there anything that you did to cause a variation of sound?
8. Make a claim using the Claim-Evidence-Reasoning (C-E-R) strategy.

Explore

Activity 10 – Seeing Sound

Purpose
Students will be able to "see" that sound really travels as a wave.

Activity Description
Students will construct and use a simple oscilloscope to see the waves that their voices make. They should also realize what is required for a sound wave in the physical sense: a series of energy disturbances in a material medium.

Focus Question
How does sound travel?

Duration
If constructing oscilloscopes in class, one class session; if using pre-constructed oscilloscopes, 10-15 minutes

Materials
- Coffee can (both ends removed and smooth) – Can use any steel can like a soup can, if desired.
- Round balloon or drum skin
- String
- Plastic mirror (small)
- Laser pointer
- Laser support
- Double-sided tape

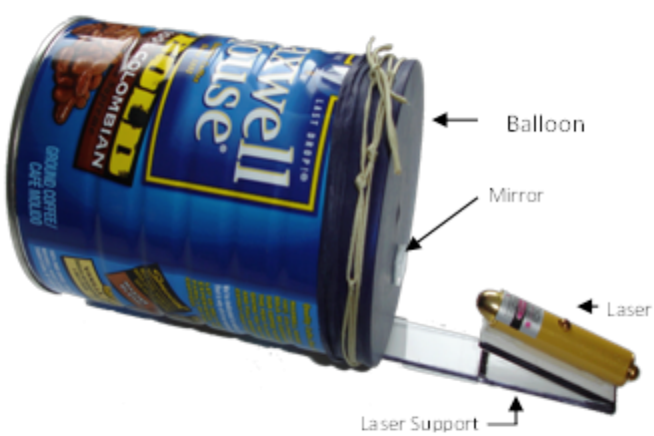
Teacher Preparation
1. Decide if you will have groups construct these oscilloscopes or if you want a class set that you make in advance.
2. Gather materials (especially cans) in advance. Coffee cans work nicely.
3. Decide if you want to use this activity as an Explore or as an Engage activity. If using as an Engage activity, students would just be seeing what their voices look like and wondering why it makes the shape that it does.
4. Decide what you want students to do with the information…journal entry in notebook?

Classroom Procedure
Construction of oscilloscope (see picture below):
1. Remove both ends of a small steel can such as a soup, nut, or single-serving juice can.
2. Cut the bottom two-thirds of a large round balloon.
3. Stretch the bottom of the balloon over one end of the can and attach it securely (see diagram).

4. Use double-sided tape to fasten a small (.5 cm) mirror to the rubber midway between the center and the edge. Plastic mirrors are best; many stores sell plastic mirrors for students to stick up in their lockers. These mirrors can be cut with a hacksaw or broken into small pieces with pliers (**Note:** wear goggles). The advantage of a plastic mirror is that it does not have dangerous sharp edges.
5. Make a support for the laser pointer as shown below (could use a craft stick).
6. Attach laser pointer to support.

Activity:

1. Turn laser pointer on and lights off.
2. Find a blank wall or hang up plain white paper.
3. After oscilloscope construction, have students make different sounds into the open end of the can.
4. Students should notice their voices cause patterns of sound to appear on the wall.
5. Have students change pitch and note the differences in the shape of sound.
6. Have students change amplitude and note the differences in the shape of sound.
7. Record patterns that are noted.
8. Students can also describe how they think this experiment works.



Explore

Activity 11 – Sound Through Different Media

Purpose
To determine if sound travels fastest through liquid, solid, or gas.

Activity Description
Students will use Ziploc baggies filled with different media (solid, liquid, and gas) to learn about how quickly sound travels through matter.

Focus Question
How does changing mediums affect the speed of sound?

Duration
One class session

Materials
- Ziploc bags
- Pencil with an eraser
- Water
- Wood block
- Straw

Teacher Preparation
1. Gather materials.
2. Set up lab stations.
3. Think of some follow-up questions to generate a consensus on the evidence.

Classroom Procedure
Have students complete the following steps:
1. Using the straw, blow air into the Ziploc bag and seal it.
2. Hold the bag next to one ear and make sure to cover the other ear with your hand.
3. Have a partner **lightly** tap the bag with a pencil eraser. How did it sound? Was it loud or quiet?
4. Next, fill the bag with water and seal it.
5. Again, hold the bag up to your ear and cover your other ear with your hand.
6. Have your partner **lightly** tap on the bag with a pencil eraser. Compare this sound with the sound you heard with only air in the bag. Is it louder or quieter?
7. Empty the bag of water and put a block of wood in the bag.
8. Hold the bag up to your ear and cover your other ear with your hand.
9. Have your partner lightly tap the bag with a pencil eraser.
10. Finally, compare all three sounds that you heard. Which sound was the loudest? Quietest? Record your results in the data and observations section.
11. Participate in whole-group discussion lead by teacher follow-up questions.

**Data is to be recorded in your notebook

Mechanical Waves Through Different Media

1. Question: Do mechanical waves (like sound) travel fastest through liquid, solid or a gas?
2. Hypothesis: Write your If / Then / Because for your hypothesis.
3. Background Information: Any solid, liquid, or gas that carries the pattern of sound is called the medium for that sound. For sound, the medium is the matter between the vibrating object and your eardrum. Sound does not travel at the same speed through all forms of media.

Data and Observations

Circle only **<u>one</u>** for each.

Bag of *Air (*Gas*)*	**LOUD**	**LOUDER**	**LOUDEST**
Bag of *Water (*liquid*)*	**LOUD**	**LOUDER**	**LOUDEST**
Bag with *Wood* (Solid)	**LOUD**	**LOUDER**	**LOUDEST**

Analysis

Compare all three sounds that you heard. Answer the following:

1. Do mechanical waves (like sound) travel fastest through solids, liquids or gasses?
2. What is your claim?
3. What is your evidence: (state specific data or observations)?
4. Reasoning: (why does your evidence support your claim)?
5. Conclusion: (sum it all up)

Explore

Activity 12 – Making Music: More Sound Waves

Purpose
Students will use this activity to explore more about sound, amplitude and pitch.

Activity Description
Students will construct a simple horn and explain the fundamental properties of sound.

Focus Question
How is sound produced? How can its quality be changed?

Duration
One class session (if students are constructing); 15-20 minutes if using pre-constructed horns

Materials
- Film canister
- Single-hole paper punch
- 3/4-inch punch
- 1-inch punch (punches can be purchased from a hardware store)
- Thin plastic from a shopping bag
- 4-inch length of 1/2-inch diameter PVC pipe
- 3/8-inch bit and drill

Teacher Preparation
1. Have students bring in film canisters (if possible) or begin to collect them from local stores that develop film.
2. Gather the punches of different sizes (you may be able to find these at a craft or scrapbooking store). You might consider pre-punching the canisters to save time and constructing ten or so horns that can be shared by the class (see Classroom Procedure for directions). These materials should do fine when washed and can be reused for another class.

Possible variations

3. Try different types of plastic instead of the thin plastic grocery bags. Try a piece of Ziplock bag, a 2-mm plastic garbage bag, wax paper, aluminum foil or different types of plastic wrap.
4. Try using a piece of 8-inch PVC pipe and drilling holes approximately 1 inch apart.
5. Consider this: **This might be a great time to introduce some expert information about sound and sound quality (see Explain Activity starting on page 34). Students should start to see connections between adding energy to sound and increasing amplitude, and changing the length the wave can travel through, thus changing pitch. Students with musical backgrounds will have a wealth of knowledge about changing pitch. Teachers might want to consider bringing in musical instruments at this point and involving a band/choir teacher to discuss pitch and amplitude in music.

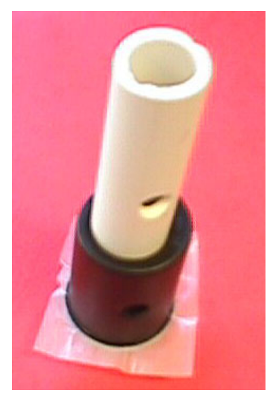
Classroom Procedure

1. Have students use the horns (construction directions below) and try to make sounds with them.
2. Have students try and add variations to their sounds. Can they make them louder, quieter? Higher? Lower?
3. Have students use different materials on top of the film canister. How does this change the sound?
4. Have students record observations in their interactive notebooks. They might be asked to write a rule for this activity using the C-E-R method. They should also record any observations and pictures that will describe what they found in their experiments.

Horn Construction Procedure:

1. Using the 3/4-inch punch, make a hole in the bottom of the 35-mm plastic film canister. To accomplish this, make sure you set the film canister on a cutting board, place the punch on the inside of the canister, and then hit the punch with a hammer.
2. Using a single-hole paper punch, punch a hole in the middle of the side of the film canister. This will become the hole that you blow into.
3. Take the cap of the film canister and punch out the center of the cap, using the 1-inch hole punch. This hole can also be punched out by using a piece of 1-inch metal pipe.
4. Obtain a 4-inch long piece of 1/2-inch PVC pipe. Drill a 3/8-inch hole in the PVC pipe about 1 inch from the end of the pipe.

Assembling the Horn:



1. Insert the 1/2-inch PVC pipe into the 3/4-inch hole from the bottom of the canister. Push the PVC pipe into the film canister so it is approximately halfway into the film canister.
2. Place the cover of the film canister on the table so the cover can be snapped onto the canister containing the PVC pipe.
3. Obtain about a 2-inch square piece of a plastic grocery bag and place it on top of the film canister cover (per photo).
4. Push the canister containing the PVC pipe into the plastic-covered top. Once inserted, the excess plastic can be trimmed off. The plastic goes between the canister and the lid.
5. Slide the PVC pipe forward until it lightly touches the piece of the plastic grocery bag (membrane).

Note: You will know you have done a good job if the plastic looks smooth and tight like a drumhead.

Explore

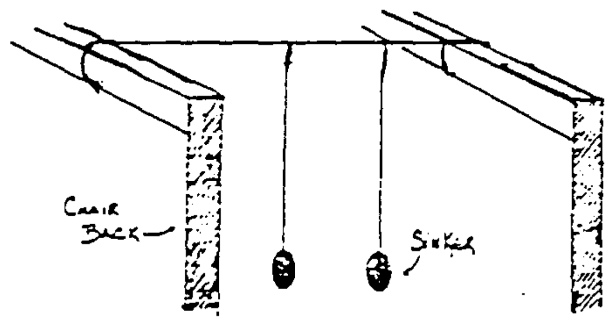
Activity 13 – Resonance-Induced Vibrations

Purpose
Students produce and observe resonance by using pendulums.

Activity Description
Students will use fishing sinkers tied to string to explore the concept of resonance. The two pendulums that are the same length have the same natural frequency. When one swings at its natural frequency, the vibrations produced in the air and the tight string set the other pendulum to swinging at the same natural frequency. This is known as resonance or sympathetic vibrations.

Focus Question
How can vibrating objects affect other objects?

Duration
One 60-minute class session



Materials
- String (three pieces – two should be of equal length for the pendulum, the third should be much longer)
- Large fishing sinkers of different sizes
- Two chairs or a meter stick to tie the string on

Teacher Preparation
1. Pre-cut the string for students for the pendulum (any length will work, but 15-20 cm works well – cutting the long string around a meter in length works well for hanging the pendulums).

Classroom Procedure
1. Give student groups at least two sets of different sized sinkers.
2. Determine how you want students to set up pendulums.
3. Determine how you want students to record information (a chart would work well here).
4. Tie the longest string between two supports, such as two desks. Stretch the string <u>tightly</u>.
5. Take the shorter two strings and tie a fishing lure of the same size to each string (see figure above).
6. Suspend each sinker (same size) from the stretched strings to produce two independent pendulums spaced 6 cm apart as shown.
7. Start one pendulum swinging. While the one pendulum is swinging, OBSERVE what happens to the second pendulum and RECORD observations.
8. Change the length of one pendulum so that it is not the same as the other. Start one pendulum swinging and OBSERVE the other. DESCRIBE any differences you observe.

Describe any patterns you observe.

9. Use sinkers of different sizes. Describe any changes that you see. Look for patterns and record.
10. Make a claim using the C-E-R method.

Explore

Activity 14 – Sound Changes in Moving Objects

Purpose
Students will experience a variety of ways that the sounds of moving objects change as their positions change.

Activity Description
Students will be exposed to hollow tubing (Doppler Tubes), sirens, horns, race cars and anything they can think of that makes noise. They will hear how changing the position of objects affects their sound (the Doppler Effect).

Focus Question
How does changing the position of a moving object change its sound?

Duration
One class session

Materials
- Doppler Tubes (can be purchased from Science Supply companies)
- Whistles
- Horns (you might convince your administrator to get involved; take the class outside to listen as he/she drives past and blows the car horn)
- Sirens (could try local police or school liaison officer for help)
- Cymbals (try your band teacher for other instruments)
- Anything else you can think of that makes noise and would work for this activity
- http://www.youtube.com/watch?v=Kg9F5pN5tlI

Teacher Preparation
1. Gather your noise makers.
2. Watch video of Doppler Effect. http://www.youtube.com/watch?v=Kg9F5pN5tlI
3. Determine how you want students to collect data and where you want them to record it. Drawings with labels might be good to include here. What do students think sound looks like? How do they think sound changes as it travels?

Classroom Procedure
1. Have students prepared to listen to a variety of noises.
2. Demonstrate noises traveling toward students, and away from them.
3. Students should record observations and drawings in their interactive notebooks.
4. Have the noises stationary and have the students move.
5. Do they notice any differences? Patterns? Record and sketch.
6. Students may be ready to make a claim (C-E-R) at this point.

Explore

Activity 15 – Interaction of Sound Waves: Echoes

Purpose
Students will begin to explore what happens when mechanical waves interact with each other**.**

Activity Description
In this activity, the class creates and describes echoes at various locations around the school building. Students set up an investigation to answer the focus question. They plan to collect and organize data in a systematic way.

Focus Question
What happens when sound waves interact with solid materials?

Duration
20 minutes

Materials
- Exterior wall
- Meter stick/measuring tape
- Two large books or cymbals
- Lab sheet to record data

Teacher Preparation
1. Locate an exterior wall without any side walls. Test to make sure there are no other surfaces nearby (like cars) that will distort an echo.
2. This activity works better as a large group activity with only one noise source (as sounds will interfere with each other).
3. You might want to pre-measure the distances to be tested and mark.
4. Decide on how you want the students to record data or consider allowing them to devise a way to organize the results.
5. Obtain cymbals or two large books to make an “echo.”
6. Extensions: take an inter-school field trip to see other locations that make an echo. Discuss what they have in common to cause the echo phenomenon.

Classroom Procedure
1. Present the focus question and ask for some ideas on how we can investigate the nature of echoes as reflections of waves.
2. Take the class outside to the predetermined echo wall.
3. One approach is to have the group start by standing three meters from the wall and make sound (cymbals or books slapping together). Record if class heard an echo.
4. Move group back to six meters. Repeat.
5. Test distances at 9, 12, 15, 18, and 21 meters. Record the findings.
6. Extension: How far away do you have to be before an echo is no longer detected?

7. Connect to web link http://www.falstad.com/ripple/ and explore the various interactions.
8. Observe and record in your notebook:

	Write or draw your observations	Explain what you saw	Expert information (notes, text, etc.)
Reflection			
Refraction			
Diffraction			
Constructive interference			
Destructive Interference			

Explore

Activity 16 – Erosion, Water on the Move: Environmental Tackle Box

Purpose
Students will explore the effects of water wave interaction on beaches.

Activity Description
This is a great opportunity for students to explore the nature of energy in water and to construct an investigation with a physical model. The Classroom Procedure section provides a scripted sequence of steps and questions for students. Another approach could be to have students follow the first part of these procedures, and then require them to propose an investigation that they can design. Here is an effective process for that approach:

1. While students explore the model, have them brainstorm researchable questions.
2. Post the questions on poster paper around the room.
3. Have students look over the questions and decide on one to pursue.
4. Require a "research proposal" from each team, which needs to be teacher approved. The proposals would include the question, required materials, and a procedure.
5. The teacher provides feedback on the investigation design to ensure variables are controlled and it's a "fair test."

Focus Question
How are beaches affected by wave erosion?

Duration
Two class sessions

Materials
- Day 1 - Rectangular aluminum pan, cup, dry sand, and ruler
- Day 2 - Paint tray, plastic cup, dry sand, 2-3 monopoly game houses, water, two transparencies, markers in four different colors, and ruler

Teacher Preparation
1. Gather materials for both days (you can get rectangular pans from the dollar store)
2. Preview video at http://www.lpb.org/education/classroom/itv/envirotacklebox/modules/m4erosion.htm
3. Design lab sheet for student investigation (sample is below). Print and copy.

Classroom Procedure
Have students complete the following steps:

1. Obtain a material bin for your group.
2. Pour one cup of dry sand at one end of the aluminum pan.
3. Find two ways to move sand to the other end of the pan using the following rules:
   a. Don't pick up the pan
   b. Don't move the desk

   c. Don't let any part of your body touch the sand.
4. Now, move sand according to your first method (sand must stay dry):
   a. Draw and describe the location and appearance of the sand after moving it.
   b. Move the sand back to the original position and develop a second way to move the sand.
5. Move sand according to second method:
   a. Draw and describe the location and appearance of the sand after moving it.
   b. What forces in nature move sand?
   c. How did you simulate these forces in your experiment?
   d. Did you do anything to make the sand move faster or farther?
   e. What did you notice about the shape of the sand after the first way you moved it?
   f. What do we call these piles of sand?
   g. What happened to the sand that was "rained on" or got wet?
6. View the video segment about wave action on beaches and determine some of its effects. http://www.lpb.org/education/classroom/itv/envirotacklebox/modules/m4erosion.htm
7. Scroll to the video segment and play.
8. Answer the following questions:
   a. What happened to the sand that was hit with wave action? What are two effects of wave action from the video?
   b. What did you notice about the placement of the homes and buildings on the beaches?
   c. Why is the placement of these buildings creating a problem?
9. Get back into your lab groups and gather materials from the bin.
10. Cover the sloped end of the paint pan with sand about two centimeters deep and gradually decreasing to one centimeter deep at the bottom of the slope. Prop the end with the sand on two or three science books.
11. Stop the sand about one centimeter into the bottom of the pan from the slope. This will be the beach.
12. Place two or three monopoly houses up and down the beach at different distances from the water.
13. Carefully add water to the bottom of the pan until the depth is one centimeter (measure the depth).
14. Take a transparency and lay it on top of the model. Mark it #1.
15. Use a Sharpie to make marks on the transparency that show each corner of the pan. Draw the outline of the beach edge on the transparency.
16. What do you think will happen to the shape of the beach when wave action hits the beach in parallel waves?
17. Use a different colored marker to show your prediction on your transparency. Set the transparency aside.
18. Make waves by lifting the end of the pan opposite the beach about three cm off the table and quickly returning it to the starting position. Repeat this every five seconds for one minute. These waves should be **parallel** to the beach.
19. Observe changes to the beach.
20. Place the transparency back on top of the pan and use a third color to mark the changes made to the beach (include where the houses started and ended up)
21. **Draw** both your **hypothesis** and the **actual beach** in the space below. Use different colors and include a key.

Hypothesis	Actual Beach

22. Rebuild the sloping beach and replace the houses in the same approximate locations along it.
23. Take the second transparency (mark it #2) and repeat the steps.
24. This time your hypothesis should be what you think will happen to the beach and houses when **angular waves** are created.
25. Make waves again. This time, lift one of the corners of the pan opposite the beach about three cm off the table and quickly return it to its starting position.
26. Repeat this action every five seconds for one minute. The waves should hit the beach at an angle.
27. Observe changes to the beach. Place the transparency back on top of the pan and use a third color to mark the changes made to the beach (include where the houses started and ended up).
28. **Draw** both your **hypothesis** and the **actual beach** in the space below. Use different colors and include a key.

Hypothesis	Actual Beach

29. Lay Transparency One on top of Transparency Two.
30. Do both types of waves change the beach in the same way?
31. Why or why not?
32. How do water waves pass their energy on to the beaches they interact with?

Explore

Activity 17 – Making Waves

Purpose
Students will discover what happens below the surface during an ocean wave.

Activity Description
This activity can be a demonstration or a short exploratory activity. Students observe the movement of a cork when wave energy is transferred in water.

Focus Question
How do water waves really move and pass along their energy?

Duration
30 minutes

Materials
- Small aquarium (or clear container of similar size)
- A cork
- A small block of wood
- Masking tape

Teacher Preparation
1. Obtain a tank that will hold water (if possible, obtaining two or three tanks to spread the groups out would work best).
2. Gather materials.
3. Prepare student worksheet or decide how you want information to be recorded.

Classroom Procedure
1. Ask students to predict a result based on the Focus Question.
2. Fill the tank(s) with water.
3. Place the cork in the center (use masking tape to mark the approximate location of the cork on each side of the container).
4. At one end of the tank, gently lower and raise a small wooden block in and out of the water to create waves.
5. Observe what happens to the cork. How does the energy move?

Explain

Activity 18 – Parts of a Wave

Purpose
Students are now ready for some vocabulary and "expert" identification of wave parts.

Activity Description
Students will view and identify wave parts using the following video clip:
http://zonalandeducation.com/mstm/physics/waves/partsOfAWave/waveParts.htm.

Focus Question
How can we describe and name the parts of waves that we have seen in the explorations?

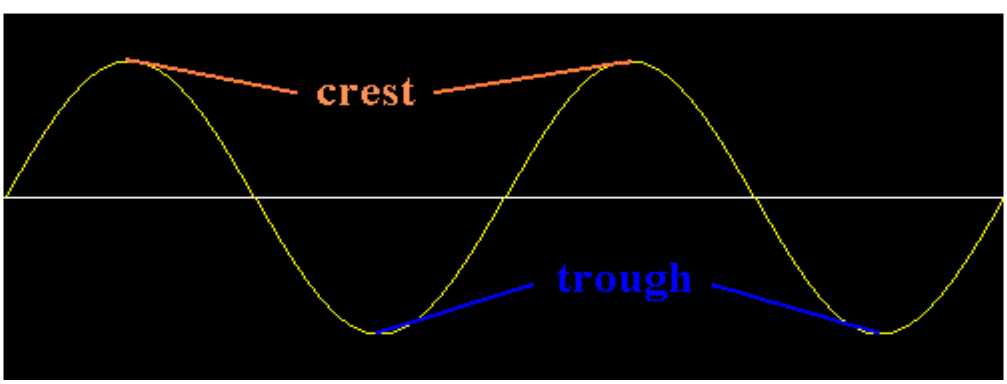
Duration
15-20 minutes

Materials
- Computer and a source to project images
- Prepared paper for notes (or students can use interactive notebook – suggestion would be to use teacher page next to Explore Activity 6 – Shapes of Waves for comparison)

Teacher Preparation
1. View website and links.
2. Prepare worksheet (if needed).

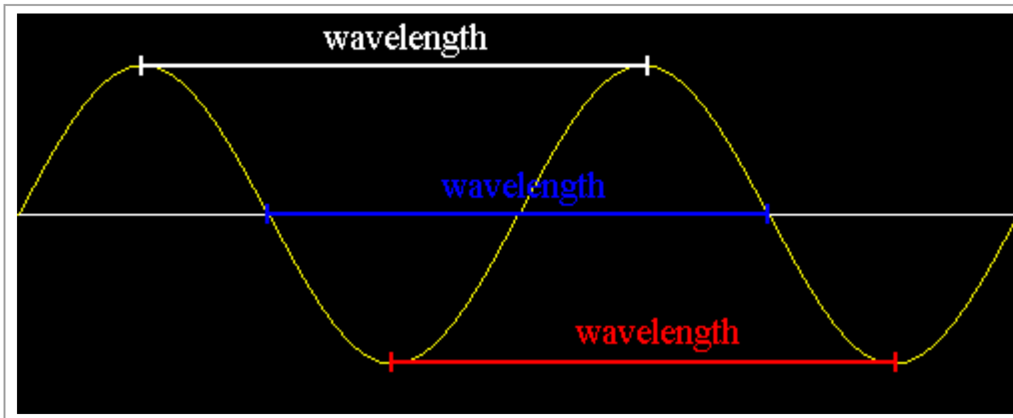
Classroom Procedure
1. Share the following "expert" information with students. Encourage them to look back at notes from Activity 6 – Shapes of Waves to see if they identified the parts of waves that seemed to be important.

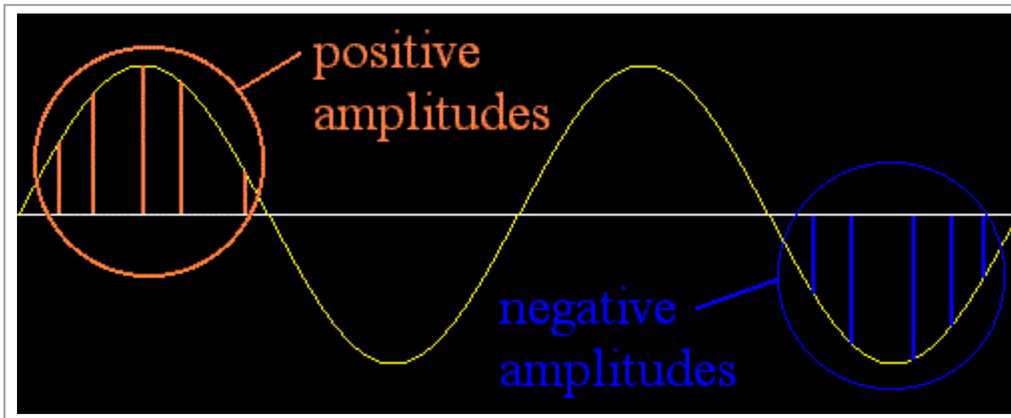
The section of the wave that rises above the undisturbed position is called the **crest**. That section which lies below the undisturbed position is called the **trough**. These sections are labeled in the following diagram:



http://zonalandeducation.com/mstm/physics/waves/partsOfAWave/waveParts.htm

The wavelength of a wave is the distance between any two adjacent corresponding locations on the wave train. This distance is usually measured in one of three ways: crest to crest, trough to next trough, or from the start of a wave cycle to the next starting point. This is shown in the following diagram:





To sum up amplitude, we would say:

- It is the displacement of the medium from its normal position.
- Usually, displacement from a normal position simply means the maximum positive displacement.
- Often, especially in discussions about interference, amplitude means the displacement of the medium from its normal position at certain points, and this displacement can be positive or negative.
- Adding energy or removing energy affects amplitude.

Frequency refers to how many waves are made per time interval. Frequency is usually described as how many waves are made per second, or as cycles per second.
http://zonalandeducation.com/mstm/physics/waves/partsOfAWave/waveParts.htm

The above website contains an interactive clip that shows frequency and how you can adjust it to change the frequency.

Explain

Activity 19 – Wave Speed, Frequency, and Wavelength

Purpose
Students will make observations and collect data to determine the relationship between wave speed, frequency, and wavelength.

Activity Description
Students will use Slinkys and stopwatches to construct waves of different wavelengths and frequencies. There is background information for students to read and compare with previous ideas about waves.

Focus Question
How are speed, frequency, and wavelength related?

Duration
One class session

Materials
- Meter stick
- Stopwatch
- Slinky (a second Slinky is needed for Part 3)
- Calculator

Teacher Preparation
1. Develop student worksheet for copying.
2. Gather materials.
3. Find spaces long enough for Slinkys to be used. Table tops work the best, as using the floor tends to result in tangled Slinkys.
4. Remind students about Slinky safety (don't let go of the end and smack your partner).
5. Groups of four work best for this activity – two Slinky holders, a timer, and a recorder.

Classroom Procedure
1. Have students read the introductory material. Highlighting strategies and any MiClass reading strategies are strongly encouraged here.
2. Reading: Waves are disturbances that transmit energy. Some waves require a medium while others do not. All waves have four properties: amplitude, wavelength, frequency, and speed. **Amplitude** refers to the wave's height. Height needs to be measured from the resting point of the wave. **Wavelength** is the distance between two identical points on a wave. For example, measuring crest to crest on a transverse wave. Longer wavelengths can be made with less energy. **Frequency** shows the number of waves produced per unit of time. It is usually expressed in Hertz, which means one wave per second. Lastly, **wave speed** refers to the speed at which a wave is traveling. On really windy days, you have

probably seen more waves rolling into the beach than on calm days. The windy days would represent a faster wave speed.

Part 1:

1. Stretch the Slinky to a length of 2-4 meters on the floor or on a table.
2. Measure the exact length of the Slinky and record in Figure 1 (in the results section).
3. Pull part of the Slinky sideways with one hand (as shown Picture 1 below) and release the pulled-back portion (causing a wave to travel down the slinky).
4. Using the stopwatch, measure the time it takes for the wave to travel down the length of the Slinky and back. Record this time in Figure 1.
5. Repeat Steps 3-4 two more times.

Picture 1

6. Calculate wave speed for each trial by dividing the length of spring by the time (remember it traveled there and back so **DOUBLE** the length of your Slinky). For example, if your Slinky was four meters long and it took two seconds, then double the length of the slinky 4+4 = 8; therefore 8/2= 4 m/s).
7. Calculate the average Time for Wave and Speed of Wave in the last row of Figure 1.

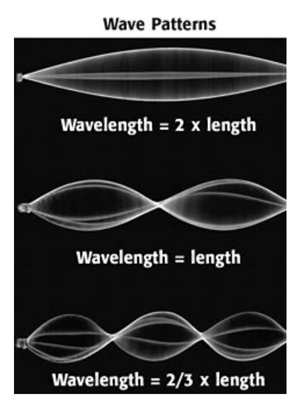
Figure 1:

Wave Speed Data

Trial	Length of Slinky (m)	Time for wave (s)	Speed of wave (m/s)
1			
2			
3			
AVERAGE:	No Calculation		

Part 2:

1. Keep the Slinky the **<u>same length</u>** as used in Part 1. Record in Figure 2 in the results section.
2. One person should start shaking the Slinky from side to side until a wave pattern emerges that resembles one shown in Picture 2 on the right.
3. Using the stopwatch, measure and record in Figure 2 how long it takes for 10 cycles of the wave pattern to occur. (Remember, one back-and-forth shake is one cycle.)
4. Keep the pattern going until the measurements for three trials are made.
5. Calculate the wave frequency for each trial by dividing the number of cycles (10) by the time and record in Figure 2.
6. Calculate the average for each column in Figure 2.



Picture 2

Figure 2:

Trial	Length of Slinky (m)	Time for 10 cycles (s)	Wave Frequency (Hz)
1			
2			
3			
Average	No Calculation		

Part 3:

1. Stretch two Slinkys to the **<u>same length</u>** as used in Parts 1 & 2 (have one person hold the end of each Slinky).
2. Generate a compression wave on one Slinky and a transverse wave on the other Slinky, starting at the same time.
3. Measure the time it takes for each of the waves to travel to the end. Record your results on Figure 3.
4. Repeat for a total of three trials
5. Find the average for the Time of Compression Wave and the Time of Transverse Wave.

Figure 3:

Speed Comparison Data

Trial	Time of Compression Wave	Time of Transverse Wave
1		
2		
3		
AVERAGE:		

Conclusion:

Determine how speed, frequency and wavelength relate to one another. Write this as C-E-R.

Explain

Activity 20 – How Do We Hear?

Purpose
Students will read about and identify the structures of the human ear and differentiate between sound and hearing.

Activity Description
Students will read the following passage and discover how hearing works. MiClass strategies are encouraged here.

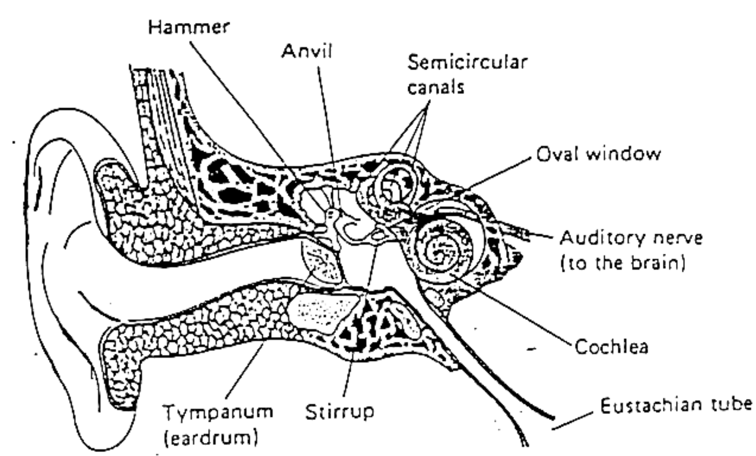
Focus Question
How do sound waves traveling as vibrations allow for hearing to occur?

Duration
One class session

Materials
- Text below

Teacher Preparation
1. Determine how material will be presented and what reading strategies will be used.
2. Copy worksheets if needed.

Classroom Procedure
1. Have the students read the following passage about hearing and use a ‘Talking to the Text” protocol to make student thinking visible. In talking to the text, students write comments and sketches in the margins of the passage. Their comments may be summary statements, questions about content, extension questions, connections they are making, or sketches.
2. Collect the papers and review student comments after class.



How Do We Hear?

The human ear is an extremely good detector of sound. Even the best microphones can barely match the human ear's sensitivity to sound. The function of the ear is to change the vibrational energy of sound waves into electrical signals that are carried to the brain by way of nerves.

The sketch above indicates the structure of the human ear. Sound enters the passageway of the outer ear and strikes the Tympanum, or eardrum, causing it to vibrate. Inside the eardrum, there are three tiny bones, the hammer, the anvil, and the stirrup. These bones conduct the vibrations to the liquid-filled cochlea in the inner ear that transform the sound energy into electrical impulses that are sent to the brain.

At the entrance to the cochlea is the oval window. The amount of energy in the sound wave determines the amount of pressure that is exerted on the oval window, and the intensity of the sound that is heard.

Inside the cochlea is a fluid contained by a membrane that contains over 30,000 nerve endings. This membrane becomes gradually thicker and less taut through the cochlea. The thicker, less taut end is more sensitive to slower vibrations (low frequencies of sound), while the thinner, tighter end is more sensitive to rapid vibrations (higher frequencies of sound). This is analogous to a thick, loose rubber band that would vibrate slowly compared to a thin, tightly stretched rubber band that would vibrate more rapidly. Thus, the rate of vibration, or frequency, of the sound wave determines the part of the membrane and corresponding nerves that will be stimulated. This is the mechanism by which the human ear is able to distinguish sounds that vary in their frequency of vibration. Our perception of the highness or lowness of these frequencies is called pitch.

The human ear cannot hear all frequencies of sound waves. For example, you cannot hear sound from a person waving his hand back and forth, although the person is alternately compressing and rarefying air molecules around his hand. By the scientist's definition, sound is being produced. The range of frequencies of sound that can be detected by the human ear, known as the human range of audibility, varies from individual to individual but is typically between 20 and 20,000 Hertz. This means the lowest pitch sound that humans can hear is produced by a source vibrating about 20 times per second, and the highest pitch sound is produced from a source vibrating at about 20,000 times per second. Sounds produced from sources vibrating more rapidly than 20,000 times per second are known as ultrasounds. As a person ages, the membrane in the cochlea becomes brittle and the range of audibility decreases, especially in the region of higher frequencies.

Explain

Activity 21 – Sound Investigation

Purpose
Students will identify animal hearing ranges and interpret graphs that compare them.

Activity Description
Students will use the chart and information to discover different organisms ranges of hearing.

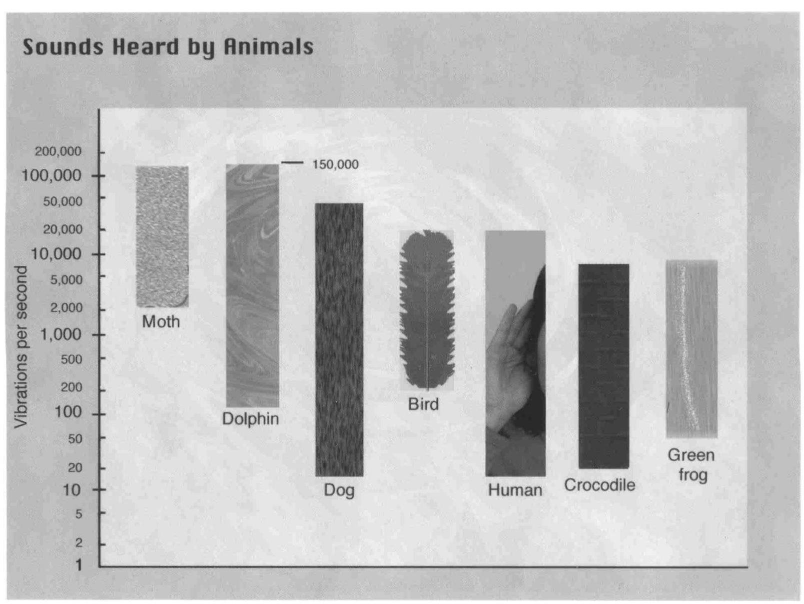
Focus Question
How do sounds heard by animals compare?

Duration
20 minutes

Materials
- "Sounds Heard by Animals" graph and questions

Teacher Preparation
1. Copy worksheet – Note that this is a floating graph. Students need to understand how to use and read a floating graph before doing this activity.
2. Also of note – The increments on the vertical axes are not regular. You might have a discussion about reading graphs carefully and misleading graphs.

Classroom Procedure
1. This graph (see next page) shows the approximate vibration rates required to produce sounds that various kinds of animals can hear. From this graph, find the answers to the questions that follow. In the table, first write the approximate range of vibration heard by each animal. (HINT: Look closely at the scale!)



Student Guide

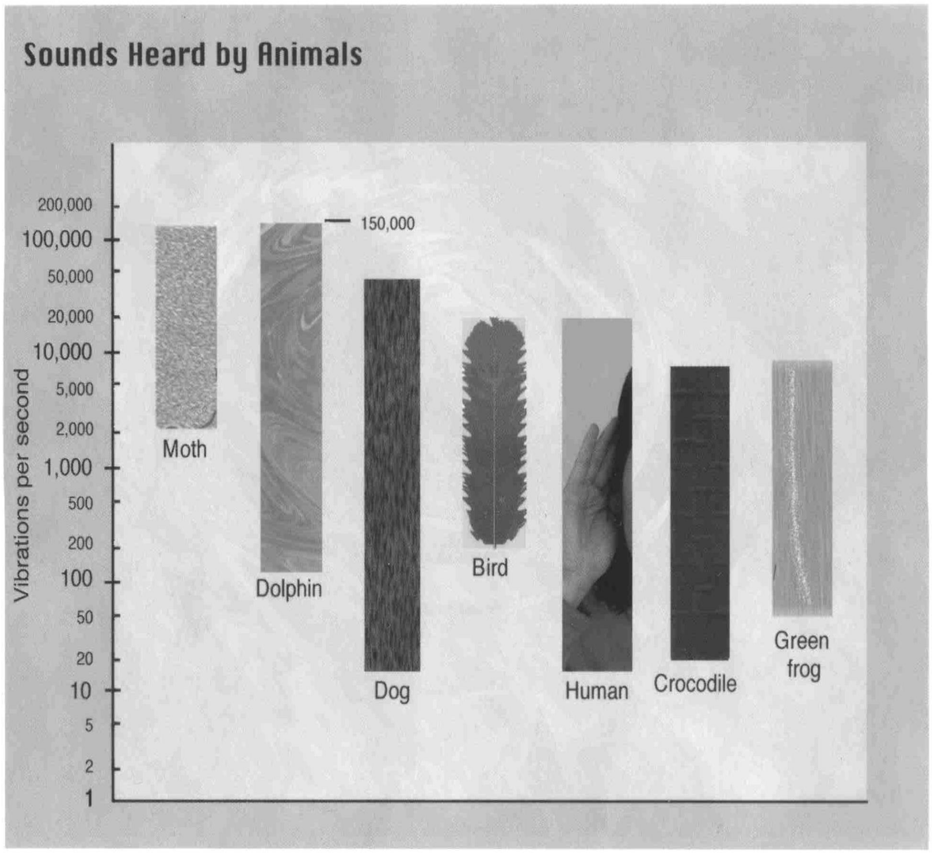
Animal	Vibrations per second
Moth	
Dolphin	
Dog	
Bird	

Human	
Crocodile	
Green Frog	

2. Note that a vibrating object must move back and forth at least 20 times per second to produce a sound that humans can hear. Above what rate of vibration are sounds inaudible to humans?
3. Which animal(s) can hear **higher** sounds that aren't audible to people?
4. Which animal(s) can hear **lower** sounds that aren't audible to people?
5. Which animal can hear the widest range of vibration rates?
6. If you blow a dog whistle, you won't hear anything (I hope!). But a nearby dog may begin to howl. Why?

Sound Investigation Key

This graph shows the approximate vibration rates required to produce sounds that various kinds of animals can hear. From this graph, find the answers to the questions that follow.
In the table, first write the approximate range of vibration heard by each animal. (HINT: Look closely at the scale!)



Animal	Vibrations per second
Moth	2,000 - 150,000
Dolphin	150 - 150,000
Dog	15 - 50,000
Bird	250 - 21,000
Human	20 - 20,000
Crocodile	30 - 6,000
Green Frog	50 - 8,000

Note that a vibrating object must move back and forth at least 20 times per second to produce a sound that humans can hear. Above what rate of vibration are sounds inaudible to humans?
ABOVE 20,000 VIBRATIONS/SECOND

Which animal(s) can hear **higher** sounds that aren't audible to people?

DOGS, MOTHS, BIRDS, DOLPHINS

Which animal(s) can hear **lower** sounds that aren't audible to people? **DOG**

Which animal can hear the widest range of vibration rates? **DOLPHINS**

If you blow a dog whistle, you won't hear anything (I hope!). But a nearby dog may begin to howl. Why? **THE RATE OF VIBRATION IS TOO HIGH TO BE AUDIBLE BY HUMANS BUT NOT DOGS**

Explain

Activity 22 – How Does the Pitch Change as a Moving Sound Source? (Doppler Effect)

Purpose
Students will experience the Doppler Effect.

Activity Description
Students will read the worksheet and answer the questions about the Doppler Effect. They will view video clips of sirens and other vehicles demonstrating the Doppler Effect.

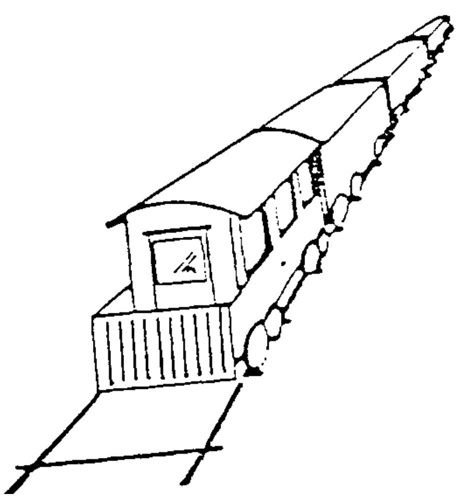
Focus Question
What causes the Doppler Effect, and why does it occur?

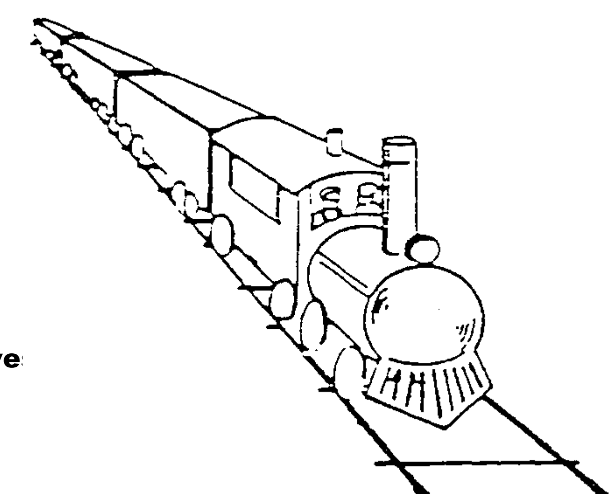
Duration
One class session

Materials
- Copy of student worksheet

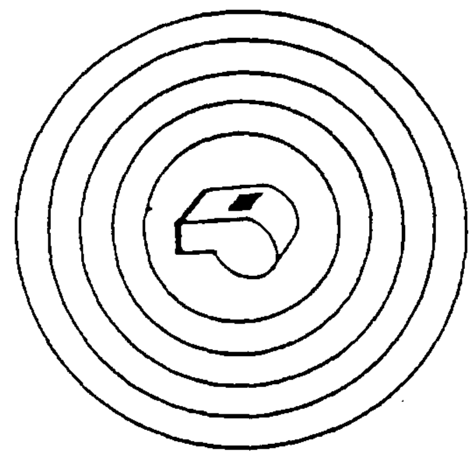
Teacher Preparation
1. Take information below and prepare a student worksheet.
2. Decide on what reading strategies will be used to interact with the text.
3. View and load the following video clips illustrating the Doppler Effect.

Classroom Procedure
Have students complete the following steps:
1. Have you ever noticed the change in pitch that occurs as a moving train whistles or a fire engine siren passes you? The higher pitch produced by an approaching sound-maker is the result of sound vibrations crowding together in front of the sound-maker. Vibrations reach your ear closer together and you hear a higher pitch. The lower pitch produced by a sound-maker is the result of sound vibrations spreading out behind the sound-maker. Vibrations reach your ear farther apart and you hear a lower pitch. If a vibrating object is moving, sound waves crowd together in front to produce a high pitch and spread apart behind to produce a low pitch.

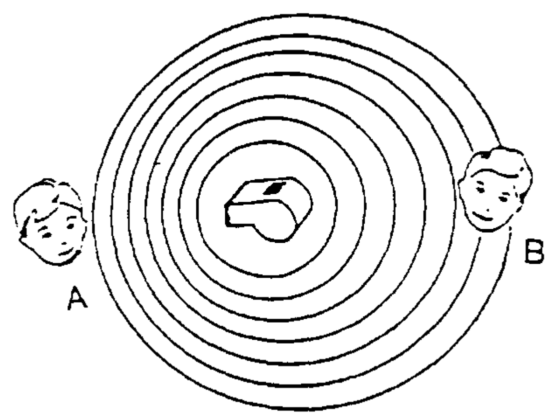




2. Let's use circles to represent vibrations from a whistle. The circles get bigger and bigger as the vibrations move out from the whistle. How many vibrations are shown for this whistle?



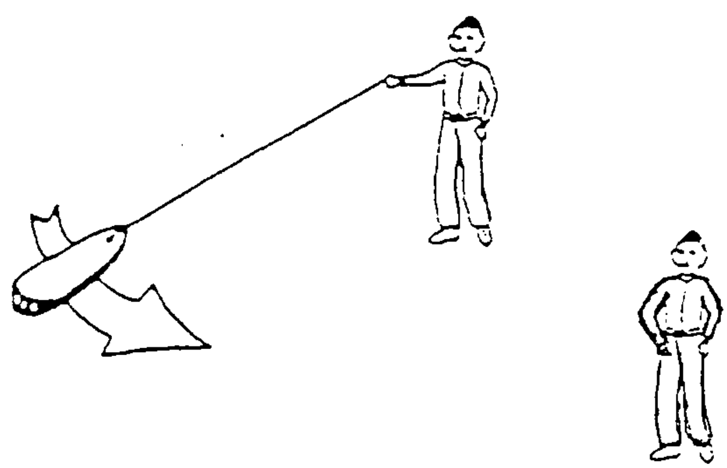
3. Suppose the whistle is not moving. Observers on all sides of the whistle hear the same pitch because the same numbers of vibrations reach each observer in a given period of time.



4. Now let's suppose the whistle is moving. The diagram shows waves crowding together in front of the moving whistle and spreading out behind the whistle.

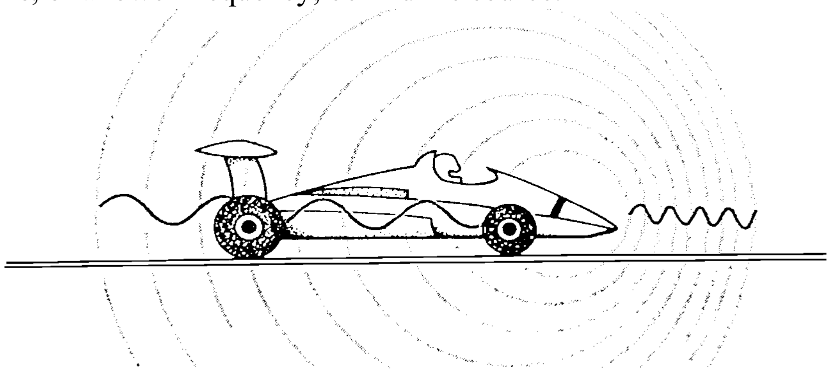
5. In which direction is the whistle moving? Place an arrow on the diagram to show direction.

6. Which observer will hear the higher pitch? Circle that person on the diagram.



7. Draw sound vibrations around the moving buzzer that is moving in the direction of the arrow. Write "HIGH" on the side of the whistle where an observer would hear a high-pitched sound and "LOW" on the side where an observer would hear a low-pitched sound.

8. Doppler Effect: When a sound is moving with respect to the observer, the sound's pitch appears to change. Because of the motion of the source, illustrated here as a racing car, the sound waves appear to be bunched up in front and spread out in back. This results in shorter wavelengths, or an increased frequency, in the front of the source and longer wavelengths, or a lower frequency, behind the source.



Explain

Activity 23 – Mapping the Ocean Floor

Purpose
Students will use their understanding of sound and sonar to solve a problem requiring mapping a region of ocean floor.

Activity Description
Students assume the role of a sonar technician who is creating a map of the ocean floor using data from sonar. As students embark on the process, teachers have a great opportunity to promote more awareness of "indirect measurement" as a tool in science research, which in this case is a "proxy measurement." Proxy measurement means we aren't measuring depth directly. We are measuring time (the time it takes a sound wave to travel from its source—the boat—to the ocean floor and back). Through a mathematical model (an equation), we are converting our time measurement to an assumed depth. Another model is involved: the map of the ocean floor.

Focus Question
How is sonar used to "see" under the water?

Duration
Two class sessions

Materials
- The student handout that explains the problem scenario and procedure for investigation.

Teacher Preparation
1. Copy student worksheet.

Classroom Procedure
1. Explain to the students that our understanding of wave theory allows us to use sound as a tool. Convey that when it is difficult, impractical, or impossible to make direct measurements in nature, we routinely use tools that generate sound or light (e.g., LASER) waves as a "proxy." This is an example of indirect measurement. Our equations and maps are types of scientific models that depict the nature of the features we are exploring.
2. Provide students with the problem scenario statement and instructions for the investigation.

Student Guide

Problem Scenario
Imagine you just were hired by an oceanographer to make a detailed map of a small section of the ocean floor. It seems a large hotel franchise wants to open an underwater hotel for scuba divers, so they need a wide, flat spot on which to build. After arriving at the site, you check your sonar instruments to discover they are sending and receiving perfectly. The only problem is that the computer that converts the speed of sound into meters is not working! In this activity, you will help the oceanographer make the map by converting the speed of sound into meters, and then mapping the ocean floor.

1. Divide each of the sonar times by two.
2. Use this new number to calculate the depth of the ocean floor at each location. To calculate the depth, multiply the number by the speed of sound in salt water (1490 m/s).
3. Plot the ocean floor depths on the chart below, and then connect the points (this is a line graph).

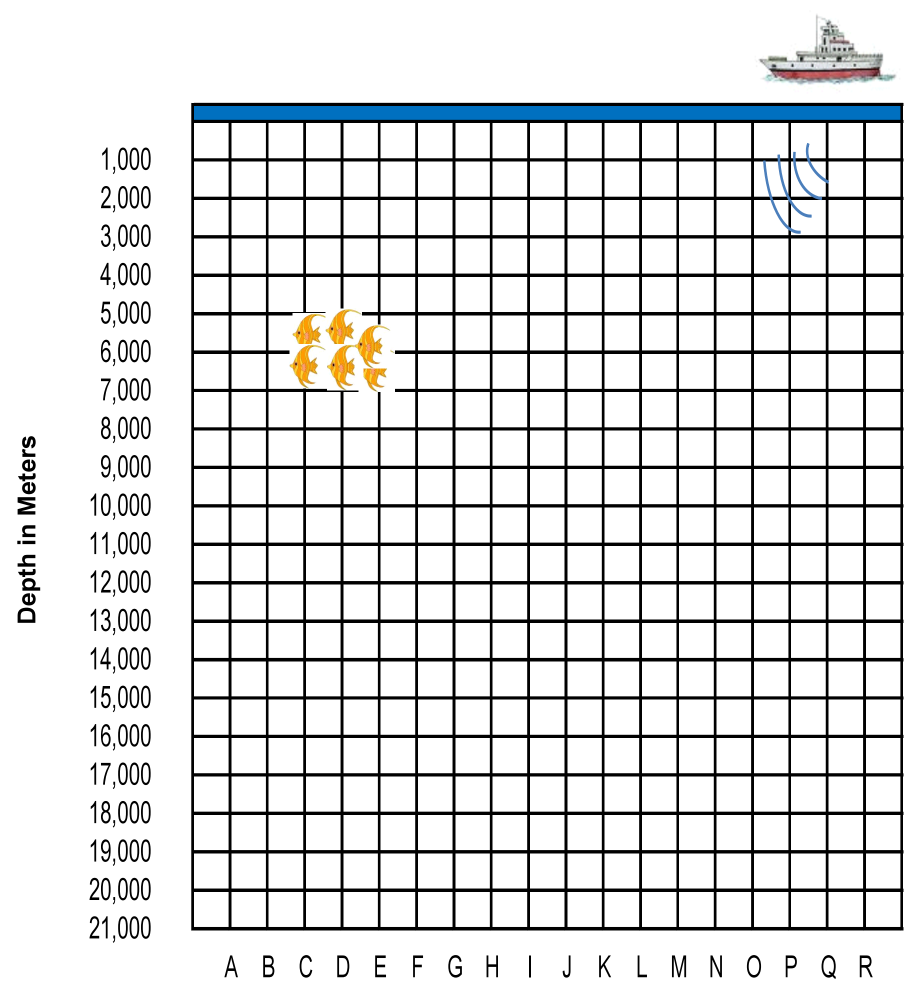
The first one is done for you!

Letter on Graph	SONAR /2	X1490 m/s (ocean floor depths – plot this number)
A	27 s/2 = 13.5	13.5x1490=20,115
B	23 s	
C	19 s	
D	9 s	
E	19 s	
F	19 s	
G	24 s	
H	25 s	
I	24 s	
J	19 s	
K	8 s	
L	25 s	
M	26 s	
N	4 s	
O	24 s	
P	27 s	
Q	26 s	
R	18 s	

Answer the following questions:

1. Why is it important to divide the initial time by two?
2. Why is the speed of sound in saltwater faster than in freshwater?
3. Why are the lowest numbers at the top of the chart rather than at the bottom?
4. At which location is the ocean floor the lowest?
5. At which location is the ocean floor the highest?
6. What would lead you to think that point D is not an accurate reading of the ocean depth?
7. What three locations are valleys in the ocean floor? (Circle them with a colored marker/pencil on the graph).
8. At what location do you recommend they build the Scuba Hotel? (Draw a small version of a hotel at this location on the graph.)

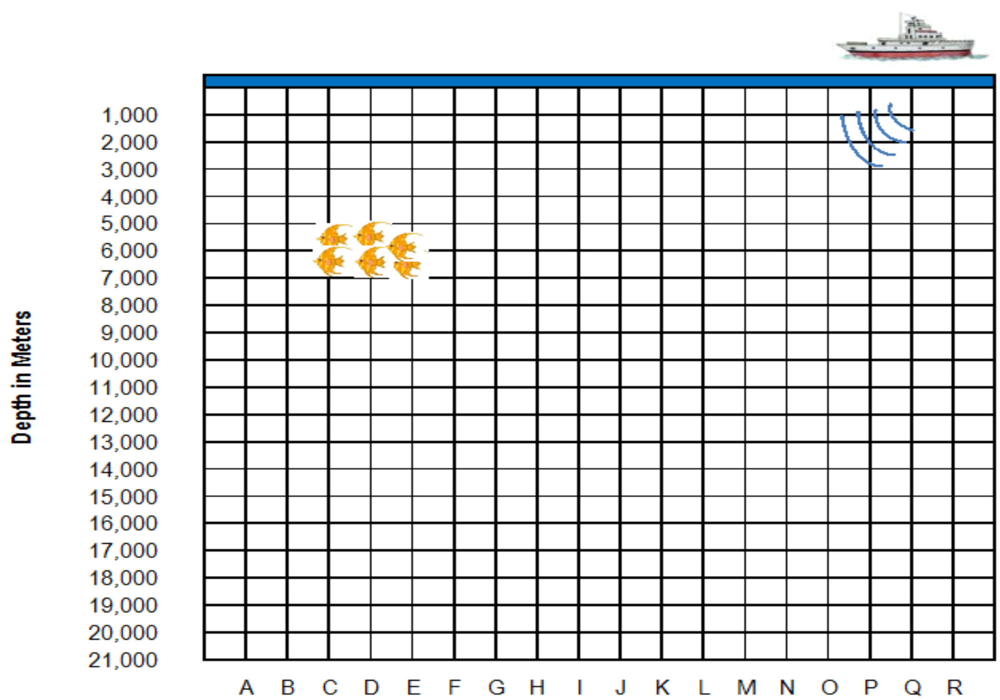
Sonar Map



A	27	seconds
B	23	seconds
C	19	seconds
D	9	seconds
E	19	seconds
F	19	seconds
G	24	seconds
H	25	seconds
I	24	seconds
J	19	seconds
K	8	seconds
L	25	seconds
M	26	seconds
N	4	seconds
O	24	seconds
P	27	seconds
Q	26	seconds
R	18	seconds

Speed of sound in salt water = 1,490 meters per second

Sonar Map



A	27	seconds
B	23	seconds
C	19	seconds
D	9	seconds
E	19	seconds
F	19	seconds
G	24	seconds
H	25	seconds
I	24	seconds
J	19	seconds
K	8	seconds
L	25	seconds
M	26	seconds
N	4	seconds
O	24	seconds
P	27	seconds
Q	26	seconds
R	18	seconds

Speed of sound in salt water = 1,490 meters per second

Answer Key

Letter on Graph	SONAR /2	X1490 m/s (ocean floor depths – plot this number)
A	27 s/2 = 13.5	13.5x1490=20,115
B	23 s	**17135**
C	19 s	**14155**
D	9 s	**6705**
E	19 s	**14155**
F	19 s	**14155**
G	24 s	**17880**
H	25 s	**18625**
I	24 s	**17880**
J	19 s	**14155**
K	8 s	**5960**
L	25 s	**18625**
M	26 s	**19370**
N	4 s	**2980**
O	24 s	**17880**
P	27 s	**20115**
Q	26 s	**19370**
R	18 s	**13410**

Questions: Answer the following questions.

1. Why is it important to divide the initial time by two? **THE TIME TO GET TO THE BOTTOM IS THE ONLY NUMBER NEEDED (NOT THERE AND BACK)**
2. Why is the speed of sound in saltwater faster than in freshwater? **IT IS MORE DENSE THAN REGULAR WATER SO SOUND TRAVELS FASTER**
3. Why are the lowest numbers at the top of the chart rather than at the bottom? **THE TOP OF THE CHART IS SEA LEVEL AND THE FURTHER YOU GO DOWN, THE DEEPTER IT IS**
4. At which location is the ocean floor the lowest? **POINTS A AND P**
5. At which location is the ocean floor the highest? **POINT N**
6. What would lead you to think that point D is not an accurate reading of the ocean depth? **THERE IS A SCHOOL OF FISH IN THE WAY THAT IS PROVIDING A FALSE READING ON THE SONAR**
7. What three locations are valleys in the ocean floor? (Circle them with a colored marker/pencil on the graph). **POINTS H, M, P**

8. At what location do you recommend they build the Scuba Hotel? (Draw a small version of a hotel at this location on the graph) **POINTS C-F**

Explain

Activity 24 – Water Wave Energy

Purpose
Students will discover how water wave energy transfers through water but not to material floating on top of the water. They will also gain a clear picture of how energy is transferred to the bottom of the sea or ocean and creation of wave crests occurs.

Activity Description
Students will view the YouTube clip and understand how water waves transfer energy through a medium. The viewing may be done as a large group or, if computers are available, students may watch and take notes using individual computers.

Focus Question
How do water waves transfer energy?

Duration
30 minutes

Materials
- Student worksheet if desired.

Teacher Preparation
1. Preview the video clip at the web address below.
2. Decide how student information will be recorded.

Classroom Procedure
Web address: http://www.youtube.com/watch?v=7yPTa8qi5X8
1. After viewing the physics animation, have students draw the motion of the red ball as it travels up and down the crest and trough of the wave.
2. How are most waves formed in deep water?
3. During large storms, wind transfers energy to the water, creating large waves as shown in the movie clip from *The Perfect Storm*. Draw the path the boat takes as it tries to crest the last wave.
4. The transfer of energy from water to land that wears away coastlines is called what?

Elaborate

Activity 25 – Measuring Waves and Calculating Frequency

Purpose
Students will measure wavelength and calculate the frequency of a variety of waves.

Activity Description
Students will demonstrate knowledge of how to measure wavelength and amplitude.

Focus Question
Can you measure the amplitude and wavelength of a wave?

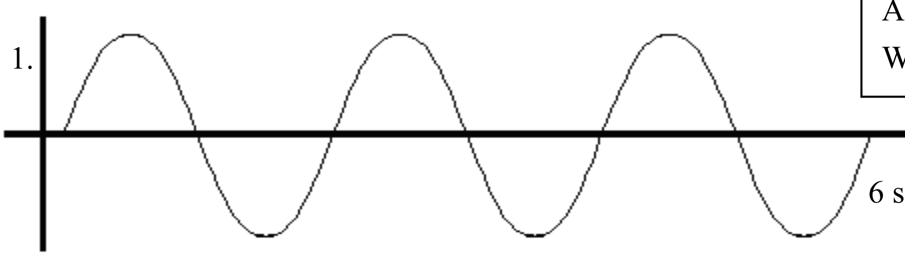
Duration
30 minutes

Materials
- Centimeter ruler
- Student worksheet

Teacher Preparation
1. Copy student worksheet.

Classroom Procedure
Have students use a ruler to measure the amplitude and wavelength of the waves below in centimeters. Have them look up the definitions of the terms if they don't remember them.

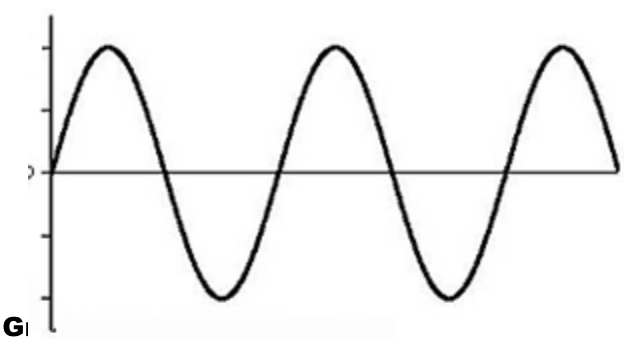
1.



6 seconds

Amplitude_________
Wavelength________

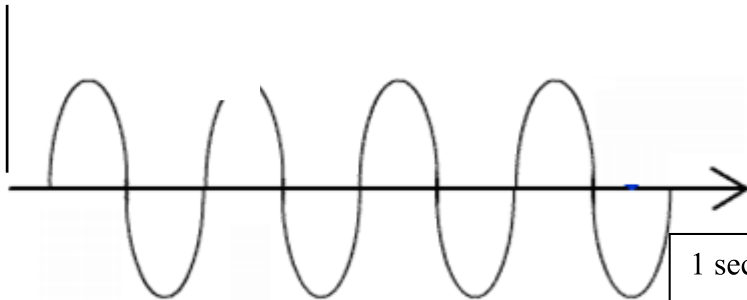
2. 10 seconds



Amplitude_________
Wavelength________

3.

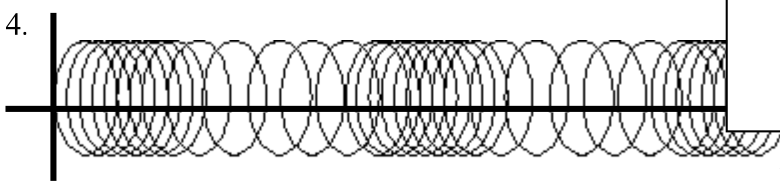
Amplitude_________
Wavelength________



1 second

Amplitude_________
Wavelength________

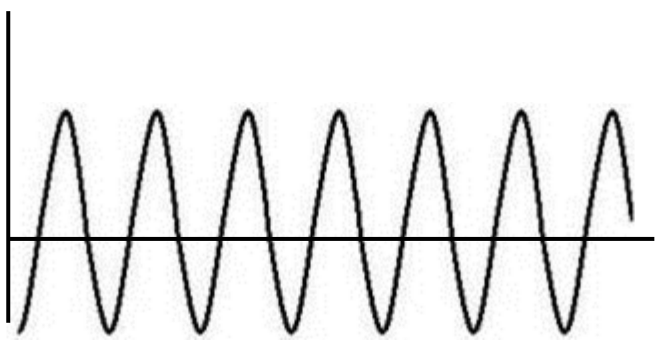
4.



2 seconds

5.

Amplitude_________
Wavelength________



5 seconds

6. Draw your own wave below and determine the amplitude, wavelength, and frequency.

Amplitude_________
Wavelength ________

Remember that frequency, which is expressed in Hertz (Hz), is the number of waves produced in a given amount of time. $Frequency = \frac{number.of.waves}{time}$

If you were watching this wave go by and counted five crests passing a certain point in five seconds, what would the frequency of the wave be?

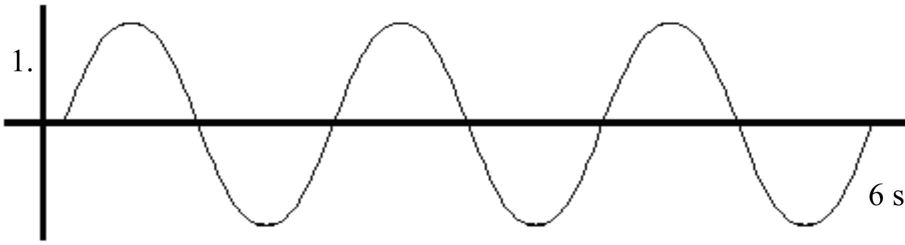
What would the frequency of the wave be if you counted ten crests in five seconds?

If the wavelength became 12 m but the wave speed remained the same, would the frequency increase, decrease, or stay the same? ___________________________________

Answer Key

Directions: Using a ruler, measure the amplitude and wavelength of the waves below in centimeters. Be sure to look up the definitions of the terms if you don't remember them.

1.



6 seconds

Amplitude **1.2 cm**

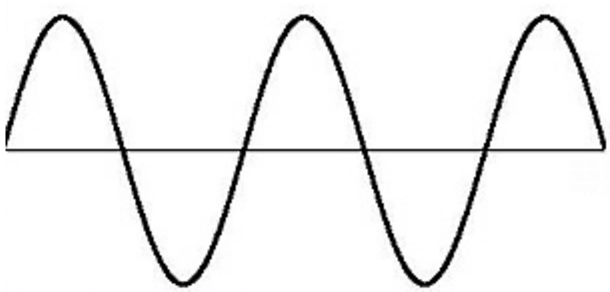
Wavelength **3.5 cm**

Amplitude **1.5 cm**

Wavelength **3.2 cm**

2.

10 seconds

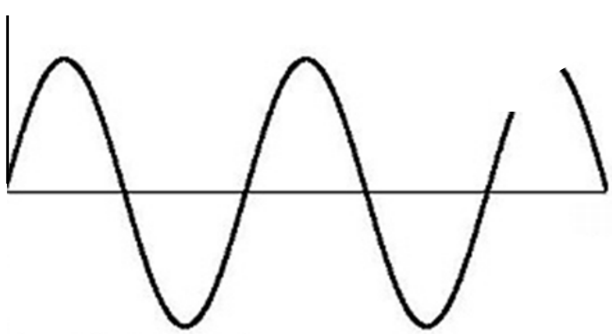


Amplitude **1.4 cm**

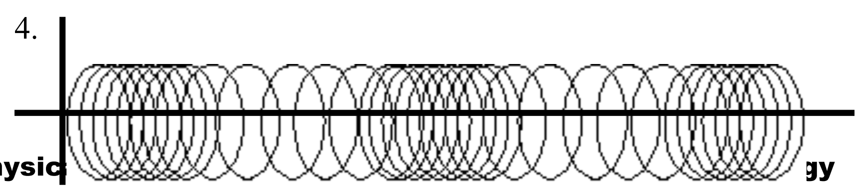
Wavelength **2 cm**

3.

1 second



4.

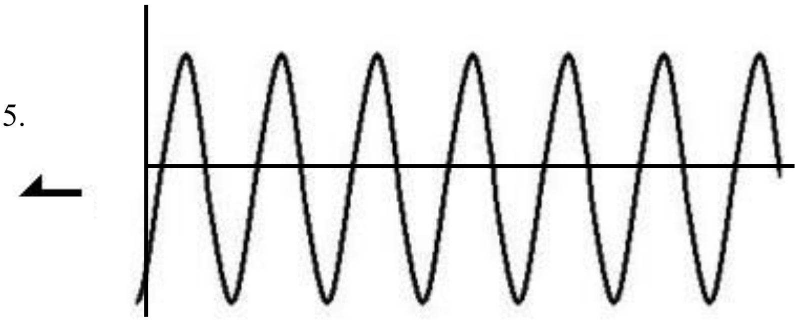


Amplitude **N/A**

Wavelength **4 cm**

2 seconds

5.



Amplitude **1.4 cm**
Wavelength **1.2 cm**

5 seconds

Draw your own wave below and determine the amplitude, wavelength, and frequency.

Amplitude________
Wavelength _______

Remember that frequency, which is expressed in hertz (Hz), is the number of waves produced in a given amount of time. $Frequency = \frac{number.of.waves}{time}$

If you were watching this wave go by and counted five crests passing a certain point in five seconds, what would the frequency of the wave be?

$\frac{5}{5}$ **= 1 Hz**

What would the frequency of the wave be if you counted ten crests in five seconds?

$\frac{10}{5}$ **= 2 Hz**

If the wavelength became 12 m but the wave speed remained the same, would the frequency increase, decrease or stay the same? **FREQUENCY WOULD DECREASE**

Elaborate

Activity 26 – Wave Construction

Purpose
Students will demonstrate knowledge of the parts of a transverse wave and how to measure correctly.

Activity Description
Students will use the directions and construct waves of specific measurements.

Focus Question
Can you construct and label correctly the following transverse waves?

Duration
One class session

Materials
- Construction paper (or some large paper)
- Rulers

Teacher Preparation
1. Gather materials needed for lab.
2. Consider making a rubric for easy correction.

Classroom Procedure
1. Get a piece of construction paper and fold into six equal boxes.
2. Number boxes 1-6.
3. In Box 1, make a wave with a small amplitude. Label the square "Wave with a Small Amplitude."
    a. Measure (in centimeters) the amplitude and record in Box 1. Label where the amplitude is in your wave.
4. In Box 2, make a wave with a large amplitude. Label the square "Wave with a Large Amplitude."
    a. Measure (in centimeters) the amplitude and record in Box 2. Label where the amplitude is in your wave.
5. In Box 3, make a wave with a low frequency for one second. Label the square "Wave with a low frequency."
    a. Measure (in centimeters) the wavelength and record. Mark where the wavelength can be found on your wave.
6. In Box 4, make a wave with a higher frequency. Label the square "Wave with a High Frequency."
    a. Measure (in centimeters) the wavelength and record. Mark where the wavelength can be found on your wave.

7. In Box 5, make a wave with a wavelength of 7 centimeters. Label the square "Wavelength of 7 cm."
   a. Show the wavelength distance of 7 cm and label on your wave.
8. In Box 6, make a wave with a wavelength of 4 centimeters. Label the square "Wavelength of 4 cm."
   a. Show the wavelength distance of 4 cm and label on your wave.

Student Worksheet

Constructing Transverse Waves

Key Idea: Demonstrate understanding of the parts of a transverse wave.

Materials: Ruler, construction paper (with six numbered boxes), pencil

Directions:

1. Divide construction paper into six equal boxes
2. Construct transverse waves for each box using the criteria given.
   a. Box 1 – Label Box 1 “Waves with Small Amplitude.” Construct waves with small amplitude (be sure to include the resting line). Show where the amplitude is on the waves by using a line. Label as “amplitude.” Measure it and write the value (in centimeters).
   b. Box 2 – Label Box 2 “Waves with Large Amplitude.” Construct waves with large amplitude (be sure to include the resting line). Show where the amplitude is on the waves by using a line. Label this. Measure it and write the value (in centimeters). It should be larger than the amplitude from Box 1.
   c. Box 3 – Label Box 3 “Waves with Low Frequency.” Construct waves with low frequency (be sure to include the resting line). The time that has passed to measure the number of waves is one second. That should be indicated next to the resting line.
   d. Box 4 – Label Box 4 “Waves with High Frequency.” Construct waves with high frequency (be sure to include the resting line). The time that has passed to measure the number of waves is one second. That should be indicated next to the resting line.
   e. Box 5 – Label Box 5 “Waves with a 7 cm Wavelength.” Construct a series of waves with a 7 cm wavelength (be sure to include the resting line). Show where the wave length can be measured using a line. Label this. The measurement must be 7 cm.
   f. Box 6 – Label Box 6 “Waves with a 4 cm Wavelength.” Construct a series of waves with a 4 cm wavelength (be sure to include the resting line). Show where the wave length can be measured using a line. Label this. The measurement must be 4 cm.
3. Answer the following questions based on your work and information we have discussed in class.
   a. What types of waves do you think carry energy this way (be specific)?
   b. Which types of waves (give the box number) do you think carry the **most** energy?
   c. What evidence do you have that might support your answer?

Elaborate

Activity 27 – Seeing Without Sight

Purpose
Students will see how echolocation can be used by people to "see."

Activity Description
Students will view clips about Ben Underwood and Daniel Kish, who use echolocation to see. This might be a good activity with which to use journals, blogs or Moodle forum set-ups to elicit student responses.

Focus Question
How can humans use echolocation to overcome challenges such as blindness?

Duration
One or two class periods (depending on method of student response)

Materials
- Video clips, articles
- Method for student discussion

Teacher Preparation
1. Preview video clips and decide format for student discussion.
2. If student blogging is involved, check to see level of understanding for this informal writing task. A day may be needed to show examples of blogs and how to write one to elicit responses.

Classroom Procedure
1. Direct class in viewing the following video clips and articles:

   http://www.cbsnews.com/stories/2006/07/19/earlyshow/main1817689.shtml
   Blind teen "sees" using echolocation. *The Early Show*

   http://www.youtube.com/watch?v=uobuBc2GO0o
   Daniel Kish and Juan Ruiz showing how to use echolocation

   http://en.wikipedia.org/wiki/Human_echolocation#Ben_Underwood
   Article about Ben Underwood

   http://en.wikipedia.org/wiki/Human_echolocation#Daniel_Kish
   Article about Daniel Kish

2. Have students respond to these suggested written response questions:
   a. Discuss some of the obstacles that the man in the movie had to overcome. Include his challenges and what he did about them. How does he affect others?

b. Discuss a challenge you have had to overcome in your life (could be physical, social, or something you may have to face in the future). How will you turn a possible hardship into something positive? How can you use this to help others?

Elaborate

Activity 28 – Sound Waves in Action: Making Some Music

Purpose
Students will demonstrate knowledge about how waves can be used to make sound.

Activity Description
Students will be designing their own musical instruments. Each group/team will produce instruments of the following types:

- Reed (wood wind)
- Percussion
- Wind
- String
- Brass.

Focus Question
Can you demonstrate what you know about pitch, amplitude, and sound by making some music?

Duration
Two to three class sessions

Materials
- Determined by students. Suggestion: instruments must be handmade (using recycled and art materials brought in by students).

Teacher Preparation
1. Decide if and how much class time will be given for the instrument construction (an option would be for construction to occur at home).
2. Consider these suggested parameters: instrument must be able to produce sounds of at least three different pitches and two clearly different amplitudes.
3. Decide what type of written explanation you would like students to produce.
4. Create a rubric (or check bric) for students and distribute before the project gets underway.
5. Determine a time for the "concert"— perform a "song" for the class.

Class Procedure
1. Explain the project and parameters to the students.
2. Provide resources and support as they embark on the project.

Learning Cycle 2: The Nature of Electromagnetic Waves

Introduction
Students investigate light as a form of electromagnetic energy, and relate it to light from the sun which produces light and heat for the earth. Through the use of models, students discover that only a fraction of light produced by the sun is transformed to heat energy on Earth.

Learning Objectives
Students will be able to:
- Describe how electromagnetic waves have and transfer energy.
- Explain that electromagnetic waves consist of radio, infrared, visible, ultraviolet, x-rays, and gamma rays of any wavelength.
- Identify that nuclear reactions take place in the sun, producing heat and light.
- Relate electromagnetic waves to current technology.
- Evaluate data, claims, and personal knowledge through collaborative science discourse on waves and energy.

Key Questions: How are electromagnetic waves transmitted and how are they described? How do they pass along their energy? How are they used for technology and social reasons?

Engage and Elicit

Activity 1 – The Electromagnetic Spectrum

Purpose
Students begin to connect different electromagnetic (EM) waves to the electromagnetic spectrum.

Activity Description
Students reflect on past activities with electromagnetic waves to place different kinds of waves where they think the waves belong in the spectrum.

Focus Question
What are different types of EM Waves? How are they different?

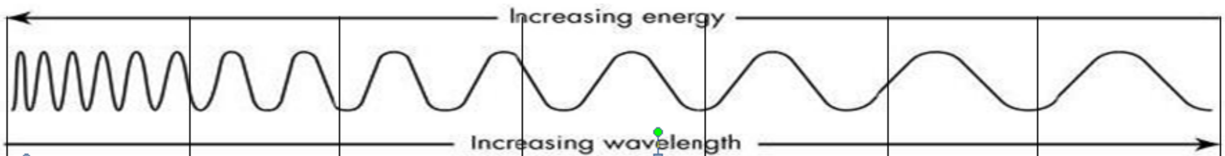
Duration
One class period

Materials
- Student journals

Teacher Preparation
1. Make copy of student worksheet.

Classroom Procedure
1. Brainstorm the different types of EM waves in your journal.
2. Write where you think they go on the chart below.
3. When completing the chart, consider wavelength and amount of energy.
4. After filling out the chart, students will have a chance to work with a partner to share ideas.

Student Worksheet



Own Ideas							
Group Ideas							
Teacher Notes							

Engage and Elicit

Activity 2 – How Is a Radiometer Affected By Light?

Purpose
Students will observe that light is an energy source and can move objects.

Activity Description
The purpose of this demonstration is to provide evidence that light is a form of energy that travels.

Focus Question
Does light cause movement?

Duration
One class session

Materials
- Radiometer (air-filled)
- Bright lamp (100 W frosted bulb mounted in a socket works well)
- Piece of cardboard to block lamp

Teacher Preparation
1. Obtain a radiometer (science supply companies usually carry these).
2. Gather materials.
3. Determine how students will record information (journal or turn-and-talk are two options).

Classroom Procedure
1. Place the radiometer on a level surface in clear view of all the students.
2. Turn on the lamp and bring it close to the radiometer. (The lamp should be placed either to the left or to the right of the radiometer.)
3. Have the class observe that the radiometer has begun rotating, and note in what direction the blades are rotating. Do the light-colored sides of the blades lead the way?
4. Ask students to try to think of some explanations for why the radiometer turns. At this point, the teacher should only try to clarify the comments of the students, if necessary, but not change or correct their comments.
5. Ask the students to predict what will happen if the cardboard were to be inserted between the bulb and the radiometer. Elicit some explanations for their predictions.
6. Now place the cardboard between the bulb and the radiometer. The radiometer should slow down and stop rotating.
7. Remove the card and again have the students note in what direction the radiometer is turning. Ask the students to predict what would happen if the lamp were moved to the opposite side of the radiometer, i.e., would the radiometer continue rotating in the same

direction, or would its direction of rotation change? Have some students provide a rationale for their prediction.

8. Now move the lamp to the opposite side. The radiometer should continue rotating in the same direction.
9. Ask students to predict what will happen if the lamp were held directly above the radiometer.
10. Hold the lamp above the radiometer. The radiometer should continue rotating in the same direction as before (although perhaps a little slower).
11. Ask students if the explanations they proposed earlier for why the radiometer rotates should be changed, in view of their observations.
12. Consider this possible extension: After the radiometer blades are turning, place the radiometer under a stream of cold water. Because the black surfaces will cool faster than the light colored surfaces, the direction of rotation will be reversed.

Engage and Elicit

Activity 3 – Light, Heat and Color

Purpose
To determine relationships between light, heat and color.

Activity Description
The activities are a series of demonstrations to encourage students to think about how light, heat and color are related.

Focus Question
What is the relationship between light, heat and color?

Duration
One class session

Materials
- Two batteries
- Wire
- Lightbulb
- Bunsen burner (or other flame source)
- Copper wire
- Heat resistant glove
- Clothes pin
- Hot plate
- Construction paper
- Flashlight
- Triple Beam Balance Scale

Teacher Preparation
1. Gather materials for demonstrations.
2. Consider how you want students to record information and do activities (this could be done as a demonstration or as a lab).
3. Decide if you will do activities all at once or break them up to use as separate Engage activities.

Classroom Procedure
Conduct the following demonstrations for students and initiate small-group and whole-group discussions and note taking. Have students record their responses in their notebooks.

Demonstration 1: Circuits
1. Observe the completed circuits and record your results below. Be sure to include the color and temperature of the lightbulb**.**
2. Describe observations when one battery was used to complete the circuit.

3. Describe observations when two batteries were used.

Demonstration 2: Wire

1. Using a Bunsen burner, heat a copper wire until light is given off. Record results below.
2. What color is the wire?
3. If you were to place your hand close to the wire, what would you feel?

Demonstration 3: Stove Burner

1. Using a hot plate, observe the burner and the heat given off.
2. As it heated up, what happened to the color of the burner?

Demonstration 4: Light and Paper

1. Situation: Compare the appearance of newspaper exposed to sunlight to newspaper that has not been exposed to sunlight.
2. What does this change tell you about light?

Demonstration 5: Light, Color and Temperature

1. Situation: If pieces of black and white paper were placed in the sun, would the temperatures of the two different colored papers differ. If so, how?
2. What does this tell us about white paper and light?
3. What does this tell us about black paper and light?
4. What effect do you think light has on the temperature of different-colored paper?

Demonstration 6: Flashlight and Mass

1. Situation: Determine the mass of a flashlight. Turn it on for a while and take the mass again. Is there any change?
2. What does flashlight mass tell you about light?
3. Do you think that light occupies space? Explain your thinking.

Student Worksheet
What is the relationship between light, heat and color?

Prior Knowledge: Think about the following questions and discuss with your partner. Record some of your ideas.

1. List several things that produce light.
2. What are some general observations about the temperature of these items?

Color and Temperature
Situation: If a piece of black and white paper were placed in the sun, would the temperatures differ? If so, how?

1. What does this tell us about white paper and light?
2. What does this tell us about black paper and light?
3. What effect do you think light has on the temperature of different colored paper?

Stove Burner: Using a hot plate, observe the burner and the heat given off.

1. As it heated up, what color changes did the hot plate go through?

Energy and Brightness
Situation: Observe the completed circuits and record your results below. Be sure to include the color and temperature of the light bulb.

1. Describe observations of color and brightness when one battery was used to complete the circuit.
2. Describe observations of color and brightness when two batteries were used.

Flashlights and Mass
Situation: Is light matter (does it have mass and occupy space)?

1. What does flashlight mass tell you about light?
2. Do you think that light occupies space? Explain your thinking.

Light, Color and Movement

1. How does the presence of light create movement?
2. How are light, color and movement related?

Light Summary
Directions: Answer either yes or no to the following statements about light and provide evidence for your observations.

1. Can light make things move?
2. Provide evidence from your observations.
3. Can light have mass?
4. Provide evidence from your observations.
5. Can light take up space?
6. Provide evidence from your observations.
7. Can light cause different-colored items to heat at a different rate?
8. Provide evidence from your observations.

Consider what you learned in this exploration. Complete the following statements by selecting the correct word or phrase from the choices provided.

1. Heat and light (rarely, often) occur together.
2. When a small amount of electrical energy passes through a lightbulb, (yellowish, reddish) light is produced.
3. When a large amount of electrical energy passes through a lightbulb, (white, reddish-orange) light is produced.
4. When a small amount of electrical energy passes through an electric stove element, the element gets hot and (gives off, does not give off) light.
5. When a large amount of electrical energy passes through an electric stove element, the element gets hot and (gives off a reddish light, gives off a white light, does not give off light).
6. As an electric stove element becomes hotter, it gives off light that gets (brighter—turning from red to orange; darker—turning from white to red).
7. The color of light given off by a substance often indicates (how large, how hot, what shape) the substance is.

Explore

Activity 4 – Absorption of Light Energy, Photosynthesis and the Greenhouse Effect

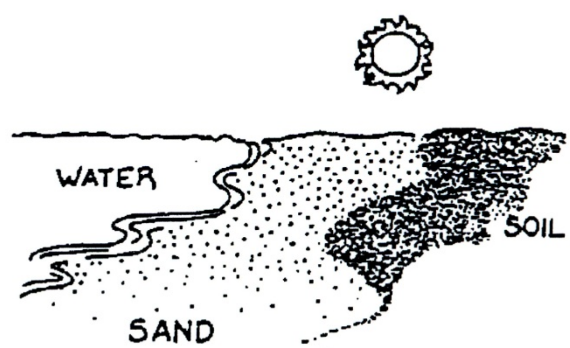
Purpose
Students will explore the concepts of heat absorption and heat capacity as they are compared in a variety of substances.

Activity Description
Students will use water and sand to explore how light energy reaches the earth's surface and transfers its energy.

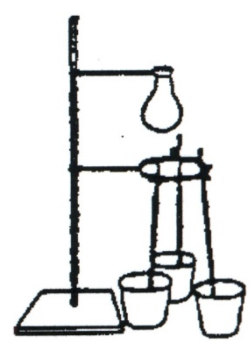
Focus Question
How is the energy from the sun absorbed on Earth?

Duration
One to two class sessions. Day two will be mainly for discussion of the concepts.

Materials
- Two small beakers or metal cups (75-100 ml)
- Two thermometers
- Heat lamp
- Watch or clock with a second hand
- Stirring rod
- Water
- Sand



Teacher Preparation
1. If you use laboratory thermometers, an easy way to conduct this activity is to suspend the thermometers by tying them onto a ring and suspending them from a ring stand.
2. If you use "backed" thermometers, cut down Styrofoam cups to hold a shallow amount of material. Turn over the top section, place it over the base, and use it to support the thermometer in each substance.



3. If you feel that students will be confused because two concepts (absorption and heat capacity) are involved here, you may want to use just two materials at a time. This is a good activity to do outdoors on a sunny day. Be sure that the containers are arranged so that all receive as nearly as possible the same amount of radiation from the lamp.
4. **Possible extensions:** Try placing a thermometer in a cup of grass and a cup of cement to contrast heating of parks versus parking lots, or Wall Street versus Central Park.
5. Continue measuring the temperature after the lamp has been turned off. This can show

that the materials that heated up the quickest also cool off the quickest.

6. Graph the results of the experiment.

Classroom Procedure

Have student complete the following steps:

1. Place equal masses (about 50 g) of sand in one container and water in the other container.
2. In each container, place a thermometer with the base in the middle of the material.
3. Measure the temperatures of the sand and water. If they are not the same temperature, dump out a little water and add hot or cold water until the temperatures are the same.
4. Record the temperature of each material. Shine a light (heat lamp) on the containers and record the temperature in 3-minute intervals. Continually stir the each container with the stirring rod as you read the temperature.
5. Predict which material will absorb the most light energy as indicated by the highest temperature. Explain your prediction.
6. Time how long it takes for the water to warm up to 60°C and record the time. Was your prediction correct?
7. Explain what happened.
8. Which do you think will take longer to cool down to room temperature? Why?

Object	Time (min)							
	3	6	9	12	15	18	21	24
Sand								
Water								
Other #1 (grass)								
Other #2 (cement)								

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Explore

Activity 5 – Seeing Objects in an Aquarium

Purpose
Students will examine refraction and develop the skills needed to locate an object in a transparent medium.

Activity Description
Using a sighting tube and large aquarium, students try and grab a penny. Students will see how light slows down as it enters water from the air. They should notice the penny was not where they thought it was when they looked from above the tank and into the water.

Focus Questions
How does the medium through which light travels affect its speed? How can we tell?
How should you aim a long rod so that when it is shot into the water it will hit a target?

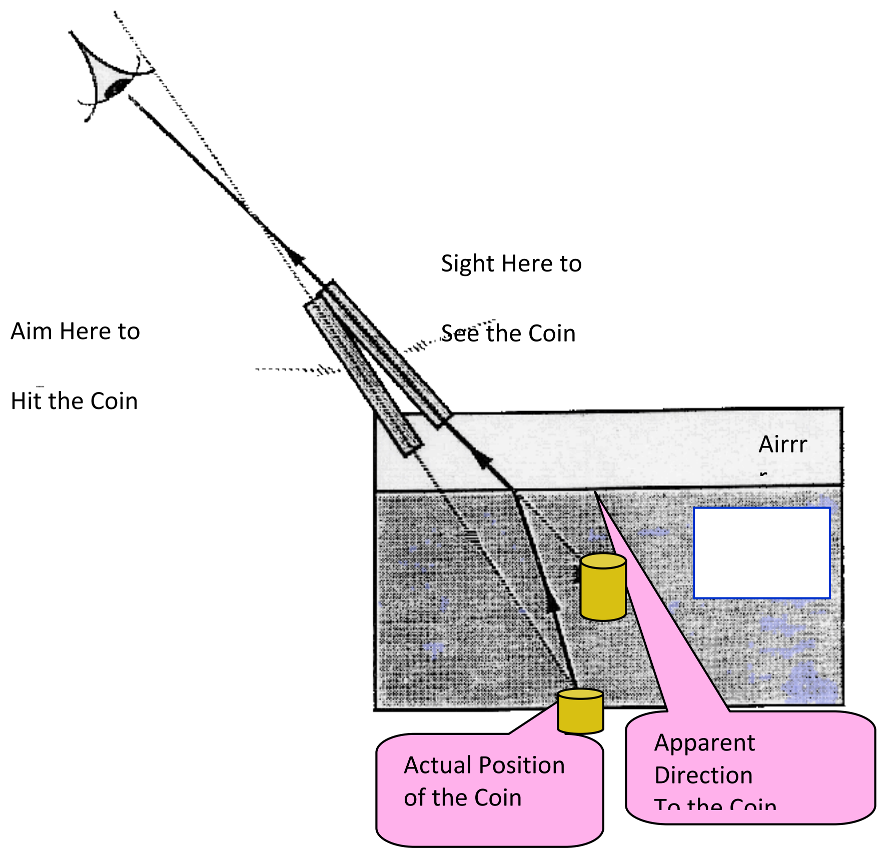
Duration
One class session

Materials
- Large, rectangular aquarium
- Sighting tube
- Long, thin dowel rod
- Stand
- Rod and clamp to hold sighting tube
- Coin
- Water

Teacher Preparation
1. This experiment works best with a large apparatus. The approximate dimensions of the apparatus we have used are as follows:
   - Aquarium: 11" x 11" x 21"
   - Sighting Tube: 7/8" diameter x 15" dowel rod: 1/4" diameter x 36" dowel rod.
2. Since the apparatus is so large, you may only have one set-up. In that case, you should plan to have another experiment going on simultaneously that will keep everybody busy. One group at a time can then work with the apparatus.
3. Make sure the clamp holding the sighting tube is high enough above the edge of the aquarium so students have a lot of maneuverability in aiming the tube. Also make sure the whole apparatus is low enough that even shorter students can look through the tube without climbing on furniture.
4. When the students let the rod go into the water, they may also observe the "apparent" bending of the rod, which is caused by refraction.

Classroom Procedure

1. The set-up consists of a large rectangular tank two-thirds full of water, a sighting tube, and a long thin rod. See sketch below.
2. The "target" is a coin sitting on the bottom at the far end of the tank. The idea is to aim through the sighting tube, clamp it rigidly into place, then insert the rod into the tube and let it slide down into the water. If students aimed correctly, the rod will hit the coin.



3. Have students discuss with their partner(s) their strategy for aiming the sighting tube.
4. Have students set up the equipment as shown in the Figure.
5. Have them look through the sighting tube and aim it according to their strategy written above, then clamp it into place. All partners in the group should have the opportunity to look through the sighting tube before students insert the rod into the tube.
6. Have students insert the rod into the tube, and then release it.
7. What happened? If they were successful, great! If not, have them re-think their strategy and try again.

Explore

Activity 6 – What Happens To Light As It Moves Further From Its Source?

Purpose
Students will explore the diffusion of light as it travels from its source.

Activity Description
Students will use light bulbs and holes in paper to explore the behavior of light as it leaves its source. They will also discover that only a small fraction of the sun's light reaches the surface of the earth due to the distance that light travels to reach us.

Focus Questions
How much of the light energy from the sun reaches the earth? How does light travel from a source to an object?

Duration
One class period, including class discussion

Materials
- Frosted bulb (at least 10 watts) mounted in socket, with electrical cord
- Piece of dark cardboard, 25-cm square
- Letter-size piece of white paper
- Scissors
- Ruler
- Manila file folder

Teacher Preparation
1. A 10-watt soft white frosted light bulb would be best to use in this activity, although a somewhat lower wattage bulb would be okay. The "soft white" type of frosted bulb should be used because it presents a more uniform emitting surface than the standard frosted bulb.
2. The cardboard in which the students cut out a small, square window should be entirely opaque. Heavy dark or black cardboard would be best.
3. The room lights should be dimmed or turned off during this activity. With many light bulbs turned on in the room, students might have some difficulty making the necessary observations. To block light, have students stand a file folder in a "V" behind their bulb. The folder should be arranged to block light on three sides, and should reduce interference from other students' bulbs.
4. An alternative method is to cut the 1.5-cm square hole in a can for potato chips or other snacks. The hole must be at a distance from the bottom of the can equal to the height of the middle of the bulb. Place the can upside-down over the bulb. Note: The can could get too hot if left over the bulb too long.

Classroom Procedure

Have students complete the following steps:

1. Stand the piece of cardboard against the bulb.
2. Cut a 1.5-cm square hole in the center of the cardboard so the opening is touching the middle of the bulb.
3. Turn on the lamp. Stand the file folder behind the bulb in a "V" to block its light from interfering with other students' observations.
4. Hold the piece of white paper against the cardboard and note the illuminated patch of light on the paper.
5. Slowly move the paper away from the cardboard and describe how the size and brightness of the illuminated patch of light on the paper changes.
4. Explain why the size of the patch of light on the paper changed.
5. Explain why the brightness of the patch of light on the paper changed.
6. Suppose the paper were moved much further away from the cardboard (several meters). In that case, you would probably not observe any perceptible illumination on the paper. Does that mean the light only traveled out a certain distance and then just stopped (disappeared)? Explain your answer.

Explore

Activity 7 – Star Light, Star Bright

Purpose
To explore the electromagnetic spectrum using an interactive online tool at the Amazing Space website.

Activity Description
The Amazing Space website offers students a chance to discover information about the electromagnetic spectrum, including the size of different wavelengths and how size affects wave characteristics, the relation of heat and color, and how stars give off light that is not what we see here on Earth.

Focus Question
What is the nature of light and electromagnetic waves?

Duration
One class session

Materials
- Computers
- Student worksheet
- Astronomy website: http://amazing-space.stsci.edu/resources/explorations/

Teacher Preparation
1. Sign out computers (you could have students work in pairs if needed).
2. Review the website and make sure all directions are clear.
3. Consider doing this activity as a teacher-directed activity if computers are not available.
4. Consider the questions below as a suggestion to help students navigate through the site and obtain information.

Classroom Procedure
1. Provide an introduction and the directions to students.
   Directions for website use:
   This web activity is designed to help students understand the nature of light.
   To begin, go to the following **astronomy website**. Then click on Star Light, Star Bright. Complete the following tasks and record the information requested.

Catching The Waves (Click "Next" in the upper right corner until you reach the spectrum picture)

1. Label the electromagnetic spectrum below. Include the approximate size of each type of wave. Then feel free to add any other notes regarding the electromagnetic spectrum. (You will need to click each type of wave to obtain the proper information.)

Making Waves (Click "Next" twice, and then click on Making Waves)

2. The wavelength of light is related to its_______________.
3. After adjusting the energy level, describe how the waves change.
4. Low frequency and low energy are associated with which color of light?
   Click on "Light Facts" in the upper right corner:
5. Higher frequencies and high energy are associated with which color of light?
6. Ultraviolet light penetrates our skin and gets stopped (absorbed) by the tissues just beneath it. X-rays penetrate all the way through skin and muscle and are finally stopped by bones and denser objects. Why does X-ray light get farther into our bodies than ultraviolet?

Heating Up (Click "Next," then Heating Up)

7. What happens to the robot's color as the temperature is increased?
8. As the temperature of the robot increases, its color becomes__________?
   Click "Next":
9. What can you conclude about the peak wavelength from the graph, as the temperature increases?
   Click "Next" (Stellar Personalities):
10. Choose four stars from the list and describe their color. (You will need to click "Next" to see their color.)
    a. ____
    b. ____
    c. ____
    d. ____
    Click "Next":
11. After plotting the measurements on the graph, what connection can you make between star temperatures and colors?
    Click "Next":
12. Hot stars put out their peak radiation at_____________?
13. What is the color of a star that has a temperature of 30,000 degrees?
14. Why does a star appear blue when it also emits green and red light? The star appears blue because its peak wavelength is in the portion of the spectrum that is_________________

Stellar Encounters (Click "Next," then Stellar Encounters)

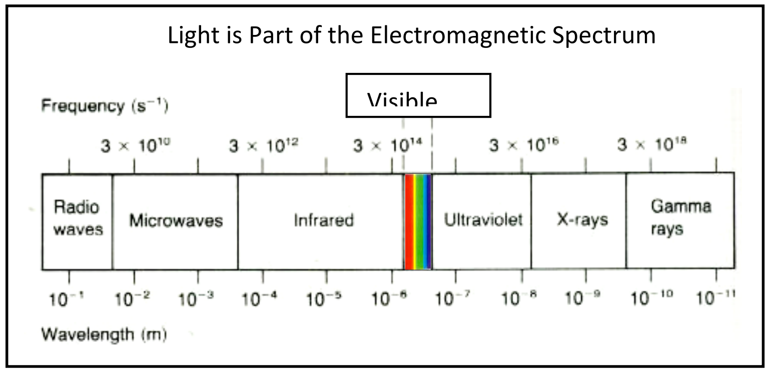
15. List the highlighted stars in order, based on color from hottest to coolest:
16. Which side of the galaxy is hotter? Why?

Explore

Activity 8 – Using a Prism to Reveal the Primary Colors of the Spectrum

Purpose
Students will separate visible light into its various colors.

Activity Description
Students will use a light source and diffraction grating card to observe the parts of visible light.



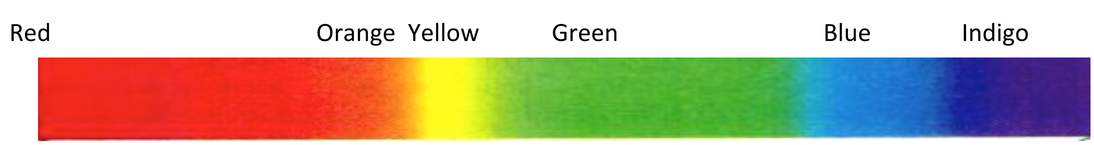
Focus Question
How is the visible portion of the electromagnetic spectrum broken down into colors that we see?

Duration
One class session

Materials
- Diffraction grating card (a tool for separating light)
- Aquarium light bulb
- Colored filters (designed to make one color of light)

Teacher Preparation
1. Obtain diffraction grating cards (science supply store) or something else that will separate visible light into its parts.
2. Decide on how students will record information.

Classroom Procedure
1. Students will obtain the diffraction grating card.
2. Have them look at the single filament light source (aquarium light bulb) provided at the front of the room.
3. While looking through the diffraction grating card, they should see the following image.



Primary colors of light cannot be broken down into other colors.

Identify the three primary colors of light:
1. ________________ 2. ____________________ 3. ____________________

Identify the Components of Individual Colors *(Note: students need a dark area.)*

4. Using the diffraction grating card, have students look at the aquarium bulb that has had a filter placed over it to produce a specific color. View each of the colors of light presented, and identify their component colors.
5. Have students record each of the main colors observed using the diffraction grating card.

Light	Aquarium Bulb
Red	
Blue	
Green	
Cyan	
Magenta	
Yellow	

Explore

Activity 9 – Frisbee Science

Purpose
Students examine the use of sunscreens to determine their effectiveness in blocking ultraviolet waves.

Activity Description
Students use a UV-sensitive Frisbee to test the effectiveness of different sunscreen creams, fabrics and sunglasses to block UV waves.

Focus Question
Do sunscreen lotions, sunglasses and fabrics really block ultraviolet waves?

Duration
One class period

Materials
- Three pieces of UV-sensitive Frisbee for each team
- At least three SPF levels of sunscreen
- Two pairs sunglasses, one with UV protective coating on lenses and one without per team
- Two cloth swatches (cotton and UV blocking) per team
- Stopwatch
- Newspaper
- Masking tape
- Marker
- Plastic wrap

Teacher Preparation
1. Order UV-sensitive Frisbees online. Cost approximately $10 each.
2. Cut Frisbee into several pieces to reduce cost.
3. Have sunscreen and sunglasses available.

Classroom Procedure
Directions:

Part 1 – Sunscreen

1. Cover a piece of Frisbee tightly with plastic wrap. Tape the edges (if needed) of the wrap so it stays in place.
2. Apply small circles of sunscreen (each SPF level) to the wrapped surface of the Frisbee.
3. Use masking tape and a marker to identify each SPF level.
4. Cover the Frisbee with paper and take outside.

5. Uncover the Frisbee and begin timing. Record the time it takes for each SPF area to change color. Add notes or drawings to further record your observations in the chart provided.

Part 2 – Sunglasses and Fabric

1. Using the procedure for sunscreen, set up one Frisbee with UV protected lenses and unprotected glasses. Record observations in the chart provided.
2. Set up another Frisbee with swatches of UV blocking cloth and cotton. Observe the two Frisbees that are set up with different swatches of fabric. Record your findings in the chart provided.

Test Material	Time for change to occur (if any change occurred)	Description of change or additional notes
Unprotected exposed to normal room light		
Unprotected exposed to sunlight		
SPF _____		
SPF _____		
SPF _____		
Plain Sunglasses		
UV Blocking Glasses		
Cotton Fabric		
UV Blocking Fabric		

Questions:

1. Did the UV Frisbee change color when exposed to normal room light?
2. Why did this occur or not occur?
3. Describe the effects that the different sunscreens had on the UV Frisbee.
4. What might you conclude from your observations of the two highest SPF-rated sunscreens; was there a difference?
5. What was the effect of the UV blocking sunglasses?
6. Why is UV blocking important?

Explain

Activity 10 – The Electromagnetic Spectrum: Waves of Energy

Purpose
Students will:
- Understand that the sun's energy is transferred to Earth by electromagnetic waves, which are transverse waves.
- Understand there are eight main types of electromagnetic waves, classified on the electromagnetic spectrum according to their wavelengths.
- Understand how each of the types of electromagnetic radiation is used or found in our everyday lives.

Activity Description
Students will learn facts about each area of the spectrum, including where areas of the spectrum are found in the natural world and how areas are used in science, space exploration, communications, and medicine. Using the "Experts Group" protocol, where student teams develop their own expertise, the teams will present content to one another.

Focus Question
How is the electromagnetic spectrum used by today's society?

Duration
Two or three class sessions

Materials
- Computer with Internet access
- Research materials on the electromagnetic spectrum (articles, books, textbook readings)
- Poster/picture of the electromagnetic spectrum
- Overhead projector, transparencies, and markers
- Chart paper
- Construction paper
- Magazines
- Scissors
- Bulletin board space in the classroom
- The www.sophia.org/electromagnetic-spectrum

Teacher Preparation
1. Divide the class into eight groups.
2. Each group will focus on a portion of the electromagnetic spectrum assigned to them.
3. Students should use traditional forms of research, such as reference books or class texts, as well as Internet links and the Electromagnetic Spectrum Tutorial.

Classroom Procedure

1. Groups must work together to research the following information about their form of radiation.
   - What are the characteristics of this type of radiation (wavelength, frequency, key facts)?
   - Where is this type of radiation located on the electromagnetic spectrum in relation to other kinds of radiation?
   - What properties of the wave define why it is found within this area of the spectrum?
   - How is it used or found in our everyday lives or in certain industries? Identify and explain at least two uses.
2. Each member of the expert group must have the necessary information and materials to make a class presentation on their area of the spectrum. Encourage students to be creative in their presentations. A gallery walk might be a great technique for presentations.
3. Have a variety of materials for students to use for their presentations, including construction paper, chart paper, markers, overheads, chalkboard, colored chalk, and magazines.
4. Tell students that the key to a successful and interesting presentation is to use visuals, such as labeled diagrams.
5. As students watch the class presentations, have them complete a learning chart with important facts and questions about each type of radiation. Student Learning Charts may look like this:

Type of Radiation	Characteristic (wavelength, energy, frequency)	Example of where it's found or used	My own question

Elaborate

Activity 11 – Who's in Control?

Purpose
Students will explore how bandwidths are used and controlled in the United States.

Activity Description
Students will use a debate format to express opinions about government allotment and control of bandwidths for communication in the US.

Focus Question
How should electromagnetic spectra be allocated for commercial use in the United States?

Duration
Three class sessions

Materials
- http://www.ntia.doc.gov/osmhome/allochrt.html
- http://www.fcc.gov/
- Computer access
- Materials for debate (such as note sheet to organize information)

Teacher Preparation
1. Decide on format for debate (could be a live class debate or could be presented as a blog or Moodle assignment).
2. Make computer or research materials available.

Classroom Procedure
1. Have students debate whether the federal government should be allowed to control the frequency bandwidths for communication. In the United States, radio and television stations emit two types of frequencies. For people to hear broadcasts, radio and television stations need to transmit along an audio frequency (AF) within the range of human hearing, which is 20-20,000 Hz. This audio frequency is transmitted along with a radio frequency that has been designated by the government. Radio frequencies distinguish each station. Some of the radio ranges designated by the Federal Communications Committee (FCC)are:
2. AM radio: 530-1600 kHz
FM radio: 88-108 MHz
TV: 54-88 MHz (channels 2-6)
TV: 174-216 MHz (channels 7-13)
TV: ultra-high frequency (UHF), 470-890 MHz
Cellular telephones: 824-894 MHz.
3. The FCC also assigns ranges within radio and TV waves for use by airplanes, ships, police, military, cellular phone and amateur ham radio users. The federal government

restricts usage of specific bandwidths within radio frequency for military use only. Before the teacher begin the debate, have students familiarize themselves with frequency ranges currently in use.

4. Students can access the US Frequency Allocation Chart, http://www.ntia.doc.gov/osmhome/allochrt.html, and the FCC Website Chart, http://www.fcc.gov/, to aid in their research. They should also research how other countries divide their "air wave" space. Students should consider any international implications of these designated ranges and find out what happens at the border between two different countries where the signals emitted by radio and television stations overlap.
5. Once all students have completed this preliminary work, divide the class into two debate groups. It is nice to let students choose their "side." However, if the numbers are uneven, it may be necessary to split students evenly between both sides of the debate. Debate teams should present salient points to support their opinions. After the debate, ask the class as a whole to come to an agreement on whether it is better for the government or for private industry to "divvy up" the frequency ranges within the electromagnetic spectrum.

Elaborate

Activity 12 – Our Electromagnetic Lives

Purpose
Students will reflect on the many ways that electromagnetic waves are used in their everyday lives.

Activity Description
Students explore how their lives are affected by electromagnetic radiation by keeping an "electromagnetic journal" for one week.

Focus Question
How much are our lives are impacted by electromagnetic waves?

Duration
One class session

Materials
None

Teacher Preparation
No preparation necessary.

Classroom Procedure
1. Ask students to record each time they observe or come in contact with electromagnetic radiation each day, such as listening to the radio, talking on their cordless phone, going through security at the airport, or getting a sunburn.
2. Students should record the date, time, and a one-sentence explanation of the incident, including what type of electromagnetic radiation they observed.
3. Have students share their encounters with electromagnetic radiation with the class and create a class tally to find out the most popular daily activity involving exposure to electromagnetic radiation.

Elaborate

Activity 13 – Waves and Technology

Purpose
To develop a more complete understanding of how electromagnetic radiation is used in technology.

Activity Description
In this activity, students work together to brainstorm and present their ideas on how electromagnetic waves are used in technology. They will present their thinking on posters.

Focus Question
How is technology using electromagnetic waves to solve human problems or make life easier?

Duration
One class session

Materials
- Construction paper
- Colored pencils/markers/crayons

Teacher Preparation
Decide how detailed you want this project to be. It is presented here as a very brief look at technology and electromagnetic waves.

Classroom Procedure
1. Identify six ways in which light and technology interact with one another.
2. Follow the procedure below to complete your project. You may work with one partner to complete this project if you prefer (you will only turn in ONE project).
3. Divide your construction paper into six squares.
4. In each square, draw one example of electromagnetic waves being used in or for technology.
5. Label each picture with a name or title.
6. Briefly explain how the object uses electromagnetic waves.
7. Be sure that project is completed in color.

SCoPE Curriculum:

http://oaklandk12.rubiconatlas.org/c/ public

Oakland Schools

http://www.oakland.k12.mi.us/