MiSP LIGHT AND SOUND
Teacher Guide

Introduction

Light and sound can seem mysterious. It is easy to know when light and sound are present and absent, and students may think that the two are similar because of this and because they know that light and sound travel as waves. But it is difficult to describe what light and sound really are. This unit is designed to demonstrate some differences between electromagnetic radiation (which includes light) and sound. Students should be introduced to the general nature of waves, including wavelength and frequency, and to the different types of waves either before or interspersed with this lesson. General information on these topics is summarized here, and useful links for more information are provided with each section.

Standards

ILST Core Curriculum – Major Understandings:

Standard 4 Physical Setting 4.1d, 4.4b, 4.4c

Physical Setting/Earth Science Core Curriculum – Major Understandings:

Standard 4 Physical Setting 2.2b

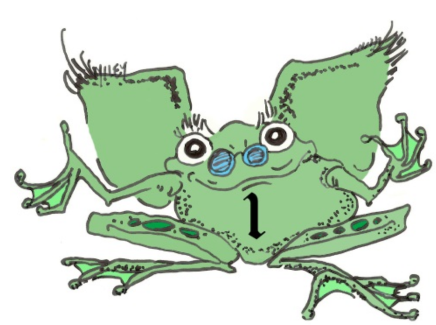
Lesson Objectives: After completing this unit, students will be able to

- Describe the differences and similarities between light (and other electromagnetic radiation) and sound
- Perform an experiment that measures the speed of sound
- Graph and interpret data that demonstrate the speed of radio frequency waves, a form of electromagnetic radiation
- Graph and interpret data that demonstrate the difference between light and sound when they travel through different media

Before These Lessons:

Students must understand the nature of waves and the differences between electromagnetic and mechanical waves in order to understand this unit. The website that follows contains the necessary information and some excellent animations for teaching this material:

http://www.physicsclassroom.com/Class/waves/



Students should understand these important concepts before doing the activities in this unit:

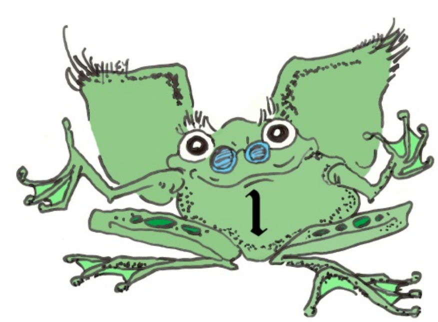
- Waves are everywhere in nature.
- A wave can be described as a disturbance that travels through a medium from one location to another location.
- Waves carry energy, not matter, from one location to another. The particles of the medium (air molecules, water molecules) simply vibrate about a fixed position as the pattern of the disturbance moves from one location to another location.
- Two kinds of waves exist in nature: longitudinal and transverse.
- A **transverse wave** is a wave in which particles of the medium vibrate in a direction perpendicular to the direction in which the wave moves.
- A **longitudinal wave** is a wave in which particles of the medium vibrate in a direction parallel to the direction in which the wave moves.
- Waves can also be categorized on the basis of their ability or inability to transmit energy through a vacuum (i.e., empty space). Categorizing waves in this way leads to two notable categories: electromagnetic waves and mechanical waves.
- An **electromagnetic wave** is a wave that is capable of transmitting its energy through a vacuum (i.e., empty space). Electromagnetic waves, such as light and radio frequency waves, are created by the vibration of charged particles.
- A **mechanical wave** is a wave that is not capable of transmitting its energy through a vacuum. Mechanical waves require a medium in order to transport their energy from one location to another. A sound wave is an example of a mechanical wave.

The emphasis in this unit is on other differences between electromagnetic and mechanical waves:

- Both types of waves are initiated by something that vibrates, but mechanical waves travel slower than electromagnetic waves.
- Electromagnetic waves slow down when they travel through a dense medium.
- Sound waves speed up when they travel through a dense medium.

Other concepts you may want to teach that are not included in this unit:

- The frequency and wavelength of a wave determine how much energy a wave has.
- Frequency is the number of wave crests that pass a point during one second.
- Wavelength is the distance between two identical points on two adjacent waves.
- The shorter the wavelength, the more energy the wave has. But as wavelength increases, frequency decreases.



Day 1 – Sound Waves and the Speed of Sound

Review background information about the differences between electromagnetic and mechanical waves. Introduce sound as a type of mechanical wave. Useful materials for teaching about sound can be found at these websites:

http://phet.colorado.edu/simulations/sims.php?sim=Sound

http://www.physicsclassroom.com/Class/sound/u11l1b.cfm

http://www.physicsclassroom.com/Class/sound/u11l2a.cfm

On day 1 use the instructions found in "Calculating the Speed of Sound," *Activities Linking Science with Math*, NSTA Press, 2009, pp. 99-109. (Note: Use the MiSP worksheets rather than the worksheets in the book.) This activity requires a "field trip" to the schoolyard or other large space for data collection. Speed of sound is calculated but there is no graphing. Students follow Worksheet #1. Student results may be inaccurate due to experimental errors.

Day 2 – Light and Other Electromagnetic Waves

Review background information about the differences between electromagnetic and mechanical waves. Introduce light and radio frequency waves as types of electromagnetic waves. While the basic properties and behaviors of light and other electromagnetic energy should be discussed, the detailed nature of an electromagnetic wave is beyond the scope of this unit.

The following websites will provide useful materials for teaching about electromagnetic waves:

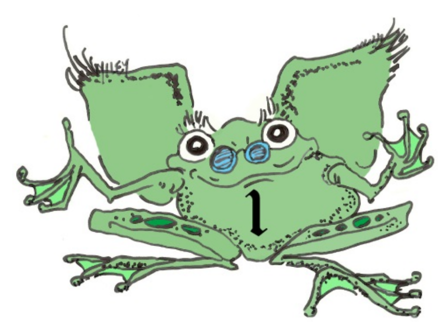
http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html

http://school.discoveryeducation.com/lessonplans/activities/electromagneticspectrum/

http://science.hq.nasa.gov/kids/imagers/ems/ems.html

http://www.compadre.org/Precollege/items/detail.cfm?ID=8092

http://csep10.phys.utk.edu/astr162/lect/light/spectrum.html



Day 2 Activity:

The idea for this activity was adapted from "How Long Does It Take to Say Hello?" in *Out of This World*, AIMS Education Foundation, 2007, p. 122.

All waves in the electromagnetic spectrum travel at the same speed. Determine that speed by graphing the data given below.

Table showing distance of representative planets from Earth and the time it would take for a radio frequency wave transmission to reach that planet

Planet	Distance from Earth in km	Seconds needed for radio frequency waves to travel between the planet and Earth
Mercury	92,000,000	306
Jupiter	629,000,000	2096
Saturn	1,277,000,000	4256
Uranus	2,721,000,000	9070

Graph distance on the *y*-axis and the time needed for radio frequency waves to travel between the planets on the *x*-axis. Students will first convert the data in the table to millions of km (instead of km) and minutes (instead of seconds). For example, 92,000,000 km becomes 92 millions of km and 306 seconds is 5.1 minutes. This change produces numbers that are easier to graph.

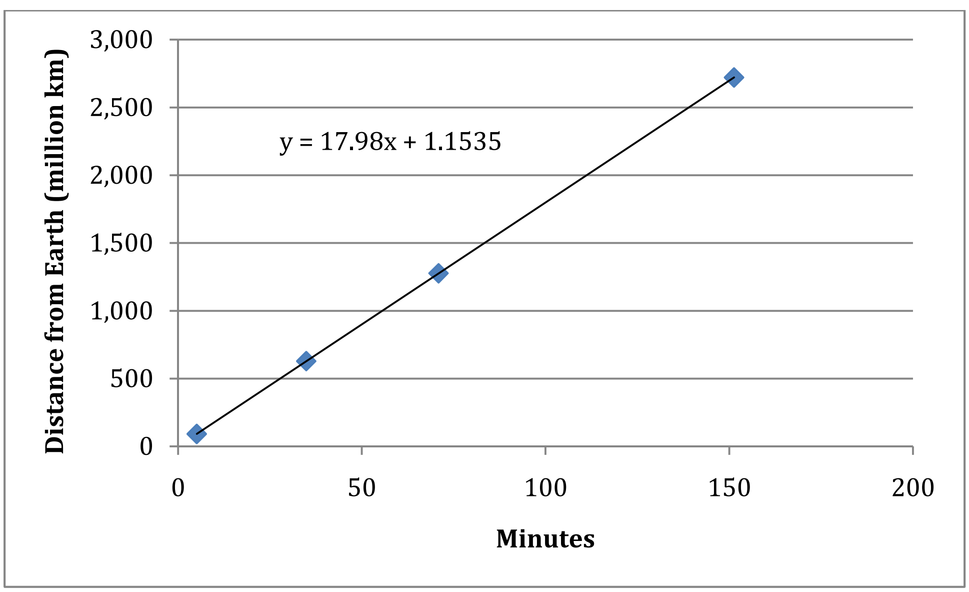
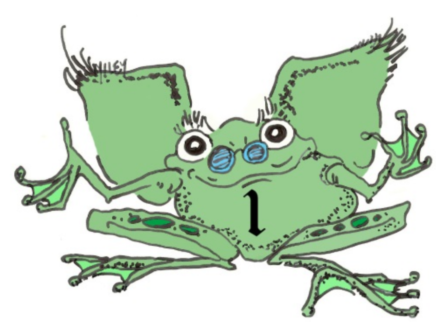


Figure 1. Graph showing data points with distance in millions of km and time in minutes needed for a radio frequency wave to reach the planet. Note that the slope must be divided by 60 and multiplied by 1,000,000 to get the speed of light in km/second.



Students should follow the directions in Worksheet #2 to graph and analyze the data.

What is the speed of the radio frequency waves?

All electromagnetic waves travel at the same speed.

What is the speed of light?

Question of the Day:

Why is it that you see lightning before you hear the thunder associated with it?

Day 3 – Comparing the Speed of Sound and the Speed of Light in Air and Water

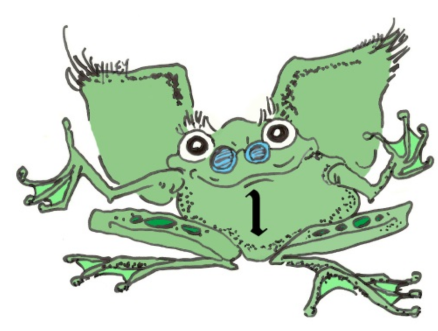
Another difference between light (and other electromagnetic waves) and sound is the effect that traveling through different media has on their speed.

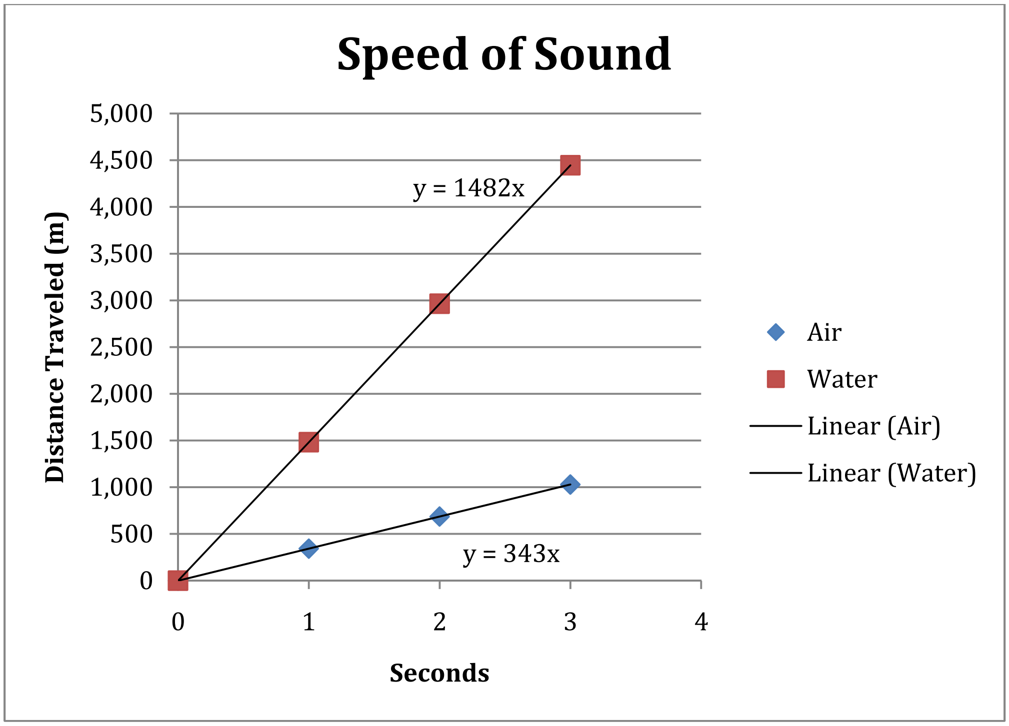
In empty space, the speed of light is about 300,000 km per second. The speed is almost the same in air. In water, however, it slows down to approximately 225,500 km per second. The speed of sound also depends on the medium through which the waves are passing. In this case, the denser the medium, the faster the wave travels. For example, in air at 20°C, the speed of sound is approximately 343 m/s. In fresh water, also at 20°C, the speed of sound is approximately 1,482 m/s. In steel, the speed of sound is about 5,960 m/s.

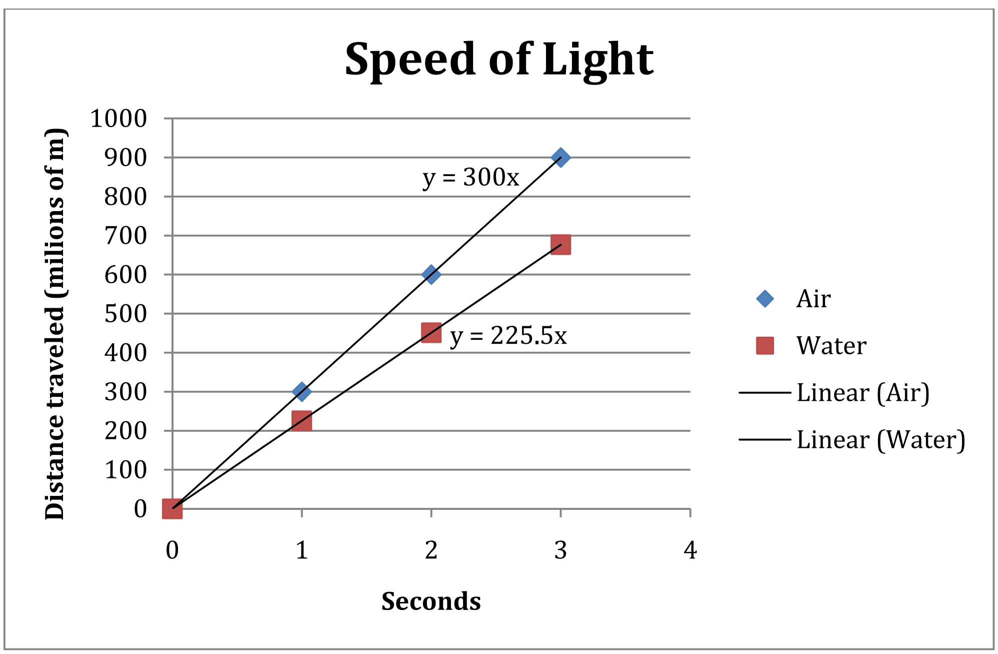
Day 3 Activity

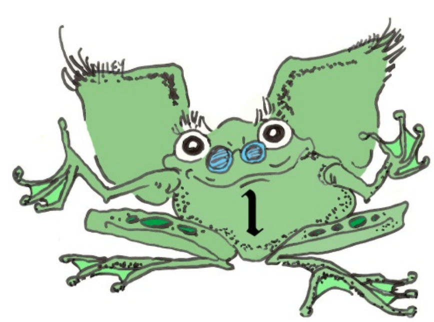
Complete the table and graph the data. Make one graph for sound and one for light. Convert the distance data for light into millions of m before graphing.

Time traveled	Distance (m) traveled			
	Sound in air	Sound in water	Light in air	Light in water
0 seconds	0	0	0	0
1 second	343	1482	300,000,000	225,500,000
2 seconds				
3 seconds				




Speed of Sound
Distance Traveled (m)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
y = 1482x
y = 343x
0
1
2
3
4
Seconds
Air
Water
Linear (Air)
Linear (Water)


Speed of Light
Distance traveled (milions of m)
1000
900
800
700
600
500
400
300
200
100
0
y = 300x
y = 225.5x
0
1
2
3
4
Seconds
Air
Water
Linear (Air)
Linear (Water)



Day 4

Complete calculations and discuss graphs.

Day 5

Administer the assessment: *MiSP Light and Sound Assessment L1*.