Battle of the Waves

Sound vs Light

By: Vaneesha Persad, Katelyn Johnson, and Heather Miller

Focus on Inquiry

The student will collect, analyze, and interpret data to develop an understanding of how the speeds of sound and electromagnetic waves change through different mediums.

Lesson Content Overview

Students will simulate and construct and explanation relating to how sound and electromagnetic waves move at different speeds through different mediums.

Duration	Setting	Grouping	PTI Inquiry Subskills
85 minutes	Classroom	Small groups of 5-6 and whole class	2.6, 3.1, 3.2, 3.3, 3.5, 4.2, 4.3, 4.4, 5.2, 5.3, 5.4, 5.7, 5.8, 5.9, 7.2, 7.3

Lesson Components	Estimated Time	Inquiry Subskills Used	Technology Used	Level of Student Engagement	Brief Description
Engage	10	5.2	Projector, computer, and video	2	Students are given a video to watch pertaining to the speeds of sound and EM waves.
Explore	20	2.6, 3.1, 3.2, 3.5, 4.2, 4.4, 5.8	None	3	Students work in small and large groups to simulate how the speeds of sound and EM waves change through solids, liquids, gasses, and a vacuum.
Explain	30	4.3,5.3, 5.4, 5.7, 5.9, 7.2, 7.3	None	3	Students will graph and analyze their data. They will construct an explanation about how the speed of sound and EM waves change as particles get closer together and farther apart.
Expand/Elaborate	15	3.3, 5.3, 5.4	None	3	Students will analyze data of an unknown type of wave, classify it as either a light or sound wave, and support their claim.
Evaluate	10	7.2	None	1	Students will take an exit ticket addressing the learning targets.

Level of Student Engagement

1	Low	Listen to lecture, observe the teacher, individual reading, teacher demonstration, teacher-centered instruction
2	Moderate	Raise questions, lecture with discussion, record data, make predictions, technology interaction with assistance
3	High	Hands-on activity or inquiry; critique others, draw conclusions, make connections, problem-solve, student-centered

Next Generation Science Standards – Inquiry

NGSS Practice 2:Developing and Using Models
NGSS Practice 3: Planning and Carrying Out Investigations
NGSS Practice 4: Analyzing and Interpreting Data
NGSS Practice 5: Using Mathematics
NGSS Practice 6: Constructing explanations
NGSS Practice 8: Obtaining, Evaluating and Communicating Information

Next Generation Science Standards – Physical Science

MS-PS4-2- Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Florida Science Standards – Nature of Science

SC.7.N.1.1- Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

Florida Science Standards – Content

SC.7.P.10.3- Recognize that light waves, sound waves, and other waves move at different speeds in different materials.

Materials and Advance Preparation

Materials List

Class Set:

- 1 projector
- 1 computer

Student Materials

- Student lab sheet: **Blackline Master #2** (1 per student)
- Exit ticket: **Blackline Master #3** (1 per student)

Part I Small Group Materials:

- 1 timer per group

Part II Whole Class/Small Group Materials:

- 1 timer per group

Blackline Masters

1. **Blackline Master #1** Modeling Each State of Matter
2. **Blackline Master #2** Student Lab Sheet
3. **Blackline Master #3** Exit Ticket
4. **Blackline Master #4** Answer Keys

Advance Preparation

1. Print Blackline Masters #2 and #3.
2. Pull up YouTube video on laptop: **http://tinyurl.com/howsoundtravels**
3. Gather 1 timer per group.

Lesson Information

Learning Objectives

1. The student will be able to differentiate between the speeds of sound and electromagnetic waves through solids, liquids, gases, and a vacuum.
2. The student will be able to collect, analyze, and interpret data to develop an understanding of how the speeds of sound and electromagnetic waves change through different mediums

Prior Knowledge Needed by the Students

- Students will need to know that sound and electromagnetic energy travel in waves.
- Students will need to know that electromagnetic waves are light waves.

Background Information

Properties of Sound: Sound is produced when particles vibrate. The vibrating object pushes the particles of matter next to it and causes them to compress (or squeeze together) and the waves travel as more particles begin to vibrate. Consequently, sound waves cannot travel in the absence of particles (a vacuum or empty space) and travel faster when particles are closer together. So, the speed of sound waves changes through different mediums as follows: **(fastest) solid > liquids > gasses (slowest) and they cannot travel through space or in a vacuum.**

Properties of Light: Light spreads out in all directions from its source and travels in waves. Light travels at "the speed of light" (about 299,792,458 meters per second). Light can travel through a vacuum (empty space) as well as through all types of matter. Light slows down when it travels through different mediums. Light waves travel the fastest when there are no particles in its path (in a vacuum) and slow down when there are more particles in its path. So, the speed of light waves changes through different mediums as follows: **(fastest) vacuum > gasses > liquids > solids (slowest).**

Lesson Procedure

Engage

1. Play the video "How Sound Travels" **http://tinyurl.com/howsoundtravels**.
   NOTE: *If there is an advertisement at the beginning of the video, please fast forward or "Skip" through the ad if available. Make sure to display the video full screen (arrows to the right of video time bar at the bottom of the screen) so that the web page advertisements and other suggested videos are not seen. Watch for and close any pop-up ads that may occur during the video.*
2. When the first question pops up on the video, have students write down their predictions on **Blackline Master #2**. *Question: On your worksheet, predict who would be the first, second, and third to detect the explosion. Explain your thinking!*
3. Keep the video up but **do not play the remainder of the video until students have completed Parts 1 and 2 of the lab.**

Explore

Part 1: Sound Waves

1. Students will form groups of a minimum of 5-6 people.
2. Ensure that each group has 1 stopwatch/timer.
3. Instruct/guide students to brainstorm with their groups how to arrange themselves so that they are modelling particles in a solid, liquid, gas, or vacuum. Refer to **Blackline Master #1.**
4. Students will use a stopwatch to simulate a sound wave traveling through the medium by passing it from one particle (person) to another. They will time how long it takes for the sound to travel through each state of matter.
5. Emphasize that the timer should start as the first person (particle) passes it and should stop when the last person (particle) receives it.
6. Allow students about 5-10 minutes of data collection.
7. Circulate around the room to make sure that students are properly recording their data.

Part 2: Electromagnetic Waves

1. Students will still collaborate with their group from Part 1.
2. As a whole class discussion, have students brainstorm how to model the particles in a solid, liquid, gas, or vacuum in a large group setting. Refer to **Blackline Master #1.**
3. One person from each group will act as the light wave. Ensure that this student has a stopwatch/timer.
4. They will time how long it takes for the light wave (student) to travel from one side to the next through the particles in each state of matter which is modeled by the other students.
5. Emphasize that the timer should start as the light wave student starts moving and should stop when he/she reaches the other side.
6. Allow students about 5-10 minutes of data collection.
7. Circulate around the room to make sure that students are properly recording their data.
8. Once students have completed part 1 and part 2, have them graph their results in a double bar graph on page 3 of **Blackline Master #2**.

Some questions you might ask students while circulating the room during parts 1 and 2 include:

- *How might particles in a solid be arranged? Possible student response: close together and touching.*

- *How might particles in a liquid be arranged? Possible student response: closer than in gasses but more spread out than in solids.*
- *How might particles in a gas be arranged? Possible student response: very far apart and moving around a lot more when compared to liquids and solids.*
- *Why would the arrangement of particles affect the speed that sound waves travel? Student responses will vary and should be used to identify misconceptions.*
- *Why would the arrangement of particles affect the speed that light waves travel? Student responses will vary and should be used to identify misconceptions.*

Explain

1. Play the remainder of "How Sound Travels" **http://tinyurl.com/howsoundtravels**.
   NOTE: *If there is an advertisement at the beginning of the video, please fast forward or "Skip" through the ad if available. Make sure to display the video full screen (arrows to the right of video time bar at the bottom of the screen) so that the web page advertisements and other suggested videos are not seen. Watch for and close any pop-up ads that may occur during the video.*
2. In their groups, have students answer the conclusion questions on their lab papers. Refer to **Blackline Master #4** for an answer key.
3. Some additional questions you might ask students at the conclusion of parts 1 and 2 include:
   - *How does the speed of light waves change through different mediums? Possible student response: the speed of light waves changes through different mediums as follows: (fastest) vacuum > gasses > liquids > solids (slowest).*
   - *How does the speed of sound waves change through different mediums? Possible student response: the speed of sound waves changes through different mediums as follows: (fastest) solid > liquids > gasses (slowest) and they cannot travel through space or in a vacuum.*
   - *Compare and contrast your graphs. Student responses will vary based on their data.*
   - *Why aren't sound waves able to travel in a vacuum? Possible student response: sound waves require a medium to travel.*

Expand

1. Students will complete the "Identifying Wave X" section in **Blackline Master #2.**
2. Students will be given data on an unknown type of wave.
3. They will analyze the data to classify the wave as either a sound wave or a light wave, make a claim, and then use the evidence in the data table to support their claim. Refer to **Blackline Master #4** for an answer key.

Evaluate

FORMAL EVALUTION

1. Battle of the Waves Assessment: **Blackline Master #3.**

INFORMAL or OPTIONAL EVALUTIONS

1. Student questioning (refer to Explore and Explain sections)
2. Conclusion questions in **Blackline Master #2.**

WRAP UP.

Bring the lesson to a conclusion by having the students discuss the following questions with their shoulder partner:

1. *How are light waves different than sound waves? Possible student response: they travel at different speeds through different mediums; sound waves require a medium and light waves do not; light travels the fastest in a vacuum and sound travels the fastest in solids.*
2. *If a bomb exploded in space, what might you observe related to sound and light? Possible student response: you would see the explosion but you wouldn't hear it because sound waves require a medium.*
3. *In a string telephone, what is the function of the string that connects the cups? Possible student response: the string provides a medium for the sound wave to travel from one cup to the other.*

CITATION OF SOURCES.

Mr. Riddz Science. (2015, January 15) *How sound travels through different media.* Retrieved from https://www.youtube.com/watch?v=q9ezMbDpIHI

✓ Yes, I cited all materials and resources used in this lesson.

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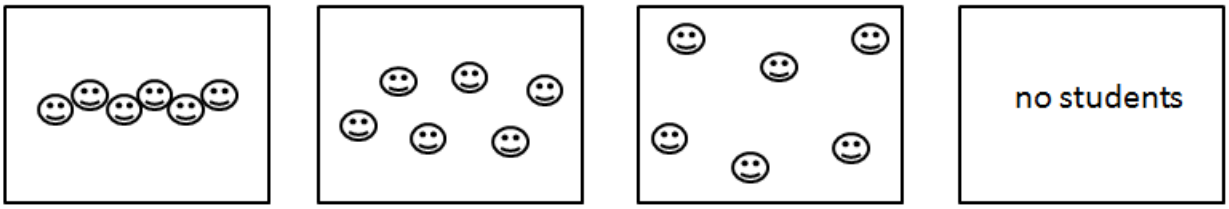
Lesson authors' signatures

Blackline Master #1

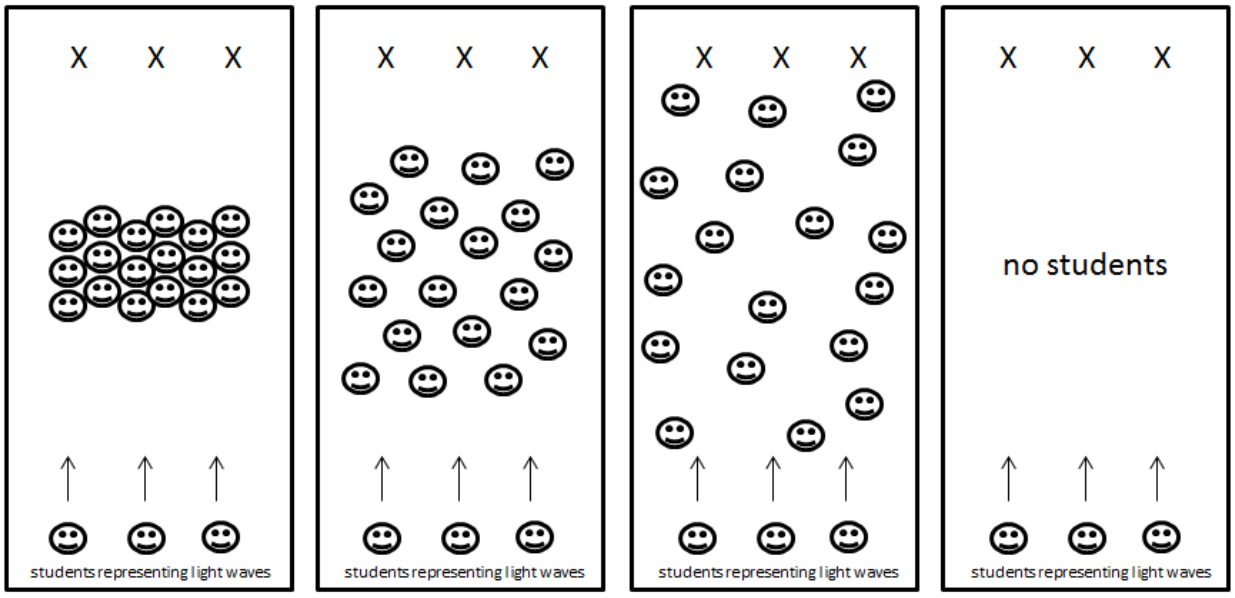
Modeling Each State of Matter

Part 1 Sound Waves-Small Groups



Solid | Liquid | Gas | Vacuum

Part 2 Light Waves-Whole Class



Solid | Liquid | Gas | Vacuum

Blackline Master #2

Battle of the Waves

Purpose: How does the speed of sound and electromagnetic waves change through different mediums?

Materials

- Stopwatch
- Paper
- Pencil

Prediction

_____

_____

_____.

Part 1: Speed of Sound Waves

Procedures

1. Students will form groups of a *minimum* of 5-6 people.
2. Discuss and brainstorm with your group how to model the particles in a solid, liquid, gas, or vacuum. You will each be a particle in these three states of matter.
3. Use the stopwatch to simulate a sound wave traveling through the medium by passing it from one particle (person) to another.
4. Your goal is to TIME how long it takes for the sound to travel through each state of matter.
5. Collect and record your data within *Data Table #1*.

Data Table #1

State of Matter	Trial 1	Trial 2	Trial 3	Average
Solid				
Liquid				
Gas				
Vacuum (space)				

Blackline Master #2

Part 2: Speed of Electromagnetic/Light Waves

Procedures

1. Students will still collaborate with their previous group from Part 1.
2. As a class, brainstorm how to model the particles in a solid, liquid, gas, or vacuum in a large group setting. You will each be a particle in these three states of matter.
3. One person from each group will act as the light wave.
4. Use the stopwatch to simulate a light wave traveling through the medium by timing how long it takes for the light wave person to get from one side of the particles to the other.
5. Your goal is to TIME how long it takes for the light to travel through each state of matter.
6. Collect and record your data within *Data Table #2*.

Data Table #2

State of Matter	Trial 1	Trial 2	Trial 3	Average
Solid				
Liquid				
Gas				
Vacuum (space)				

Blackline Master #2

Graph

Directions: Graph your averages from Data Table 1 and Data Table 2. REMEMBER to follow all graphing rules by including titles and units.

Blackline Master #2

Conclusion:

1) Was your prediction from the video correct? Explain.

_____

_____

_____.

2) Compare and contrast the data results from both graphs.

_____

_____

_____.

3) Which medium does sound travel the fastest in? Which medium does sound travel the slowest in? Explain and cite evidence.

_____

_____

_____.

4) Which medium does light travel the fastest in? Which medium does light travel the slowest in? Explain and cite evidence.

_____

_____

_____.

5) Explain any sources of error that may have occurred during your data acquisition.

_____

_____

_____

_____.

Blackline Master #2

Identifying Wave X:

Directions: Students collected data on Wave X as it traveled through a variety of materials. Analyze the data table below.

Materials	Speed of Wave X
Wood	3960 m/s
Water	1486 m/s
Air 40˚C	355 m/s
Aluminum	6320 m/s
Copper	4600 m/s
Air 20˚C	343 m/s
Glass	6320 m/s
Vacuum	

Using your knowledge from the Battle of the Waves experiment and information from the data table above, determine if the wave the students observed is a sound or light wave. Cite data from the table above when you explain and justify your answer.

Wave X is a _____ wave.

Justification and explanation:

_____

_____

_____

_____

Fill in the missing value in the table with the speed of Wave X in a vacuum. Explain your answer.

_____

_____

_____.

Blackline Master #3

Name _____ Date _____

Battle of the Waves Assessment

____ 1. Light travels fastest in which type of medium?
A. Vacuum (space) B. Gas
C. Liquid D. Solid

____ 2. Sound travels fastest in what type of medium?
A. Vacuum (space) B. Gas
C. Liquid D. Solid

____ 3. A medium is NOT required for sound to travel.
A. True C. False

Explain your answer: _____

_____

_____.

4. Read the statements below and determine if each one is a characteristic of sound waves, light waves, or both. On the line, put either an **S** for sound waves, **L** for light waves, or **B** for both.

_____These types of waves travel the slowest in solids.

_____These types of waves travel the slowest in gases.

_____These types of waves can travel in a vacuum (space).

_____These types of waves do not require a medium to travel.

_____These types of waves can travel through water.

_____These types of waves require particles to vibrate.

5. During a thunderstorm, lightning and thunder actually occur at the same time. Using what you have learned, explain why we observe the sound of thunder after we observe the flash the lightning.

_____

_____

_____.

Blackline Master #4 – ANSWER KEY

Conclusion:

1) Was your prediction from the video correct? Explain.

Student answers will vary.

2) Compare and contrast the data results from both graphs.

Student responses will vary but should include that the speed of sound and light are opposite through the different mediums.

3) Which medium does sound travel the fastest in? Which medium does sound travel the slowest in? Explain and cite evidence.

Sound travels the fastest in solids and the slowest in gasses. The closer the particles are, the quicker they can vibrate, and the faster the wave will travel. Sound waves also cannot travel through a vacuum because they require a medium to travel.

4) Which medium does light travel the fastest in? Which medium does light travel the slowest in? Explain and cite evidence.

Light travels the fastest in a vacuum and the slowest in solids. Light waves travel faster when there are less particles in its path.

5) Explain any sources of error that may have occurred during your data acquisition.

Student responses will vary but might include that when modelling the light wave, the student representing the wave might be moving at different rates for each trial. Another source of error might be the delayed reaction time in stopping the timer.

Blackline Master #4 – ANSWER KEY

Identifying Wave X:

Directions: Students collected data on Wave X as it traveled through a variety of materials. Analyze the data table below.

Materials	Speed of Wave X
Wood	3960 m/s
Water	1486 m/s
Air 40˚C	355 m/s
Aluminum	6320 m/s
Copper	4600 m/s
Air 20˚C	343 m/s
Glass	6320 m/s
Vacuum	0 m/s

Using your knowledge from the Battle of the Waves experiment and information from the data table above, determine if the wave the students observed is a sound or light wave. Cite data from the table above when you explain and justify your answer.

Wave X is a ___sound___ **wave**.

Justification and explanation:

Student answers should incorporate the following:

- In the data table above, the speed of the wave is the slowest when traveling through the materials Air 20˚C at 343 m/s and Air 40˚C at 355 m/s which are both gases. The wave is the fastest within the wood at 3960 m/s, copper at 4600 m/s, glass at 6230 m/s, and aluminum at 6320 m/s, all of which are solids.
- Based on the Battle of the Waves experiment, we know that light waves do not require a medium to travel and travel the fastest when fewer particles are in the way. Sound waves require medium and travel when particles vibrate and move. The closer the molecules in that particular medium are to each other, the faster the sound wave will travel

Fill in the missing value in the table with the speed of Wave X in a vacuum. Explain your answer.

Student answers should incorporate the following:

- Sound waves **require medium and travel when particles vibrate and move.** The closer the molecules in that particular medium are to each other, the faster the sound wave will travel. Sound waves cannot travel through the vacuum (empty space) since there is no particles that can vibrate. Thus, the speed of Wave X through a vacuum would be 0 m/s.

Blackline Master #4 – ANSWER KEY

Battle of the Waves Assessment: ANSWER KEY

____ 1. Light travels fastest in which type of medium?

A. Vacuum (space) B. Gas
C. Liquid D. Solid

____ 2. Sound travels fastest in which type of medium?

A. Vacuum (space) B. Gas
C. Liquid D. Solid

____ 3. A medium is NOT required for sound to travel.

A. True C. False

Explain your answer: Possible student response: sound requires a medium in which to travel, such as a gas, liquid, or solid. The sound waves cause the particles within the medium to vibrate and move. The closer the molecules in that medium are to each other the faster the sound will travel.

4. Read the statements below and determine if each one is a characteristic of sound waves, light waves, or both. On the line, put either an **S** for sound waves, **L** for light waves, or **B** for both.

___L___These types of waves travel the slowest in solids.

___S___These types of waves travel the slowest in gases.

___L___These types of waves can travel in a vacuum (space).

___L___These types of waves do not require a medium to travel.

___B___These types of waves can travel through water.

___S___These types of waves require particles to vibrate.

5. During a thunderstorm, lightning and thunder actually occur at the same time. Using what you have learned, explain why we observe the sound of thunder after we observe the flash the lightning.

Student responses should include the following components:

- Within a thunderstorm, the lightening is observed first since it will travel faster than sound waves through the air (gas). The sound of thunder can be heard shortly after since it travels the slowest within gases.
- Light waves do not require a medium to travel and travel the fastest when fewer particles are in the way.
- Sound waves require medium and travel when particles vibrate and move. The closer the molecules in that particular medium are to each other, the faster the sound wave will travel.