

**THEME: Relating the characteristics of sound and light wave to the observable characteristics of ocean waves.**

**TIME:** This lesson will take approximately 5 block classes or 2 weeks in science and should take 3-5 STEM classes. All block classes are 90 minutes.

### **Mississippi College and Career Readiness Standards**

**Standard P.8.6:** Students will demonstrate an understanding of the properties, behaviors, and application of waves.

**Objective P.8.6.4:** Use scientific processes to plan and conduct controlled investigations to conclude sound is a wave phenomenon that is characterized by amplitude and frequency.

### **Mississippi Business and Technology Framework**

4. Use content-specific tools, software, and simulations (e.g., environmental probes, graphing calculators, exploratory environments, web tools) to support learning and research.
5. Apply productivity/multimedia tools and peripherals to support personal productivity, group collaboration, and learning throughout the curriculum

### **Mississippi College and Career Readiness Standards for Mathematics**

**A-REI.10** Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).

**A-REI.11** Explain why the x-coordinates of the points where the graphs of the equations  $y = f(x)$  and  $y = g(x)$  intersect are the solutions of the equation  $f(x) = g(x)$ ; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where  $f(x)$  and/or  $g(x)$  are linear, quadratic, absolute value, and exponential functions. \*

**A-REI.12** Graph the solutions to a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality), and graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes.

**Guiding question:** Why is sound called a wave? How do amplitude and frequency affect the behaviors and performance of waves?

**Objectives:**

Students will:

1. Analyze amplitude and frequency and how they affect the properties of sound
2. Calculate and communicate the relationship between wavelength and frequency
3. Discover that sound is a form of energy that travels in waves called longitudinal waves
4. Observe how sound waves interact with the environment
5. Participate in lab activities to observe these properties
6. Use engineering design to create an instrument that will play a specific note

After observing data on ocean waves, a phenomenon they can see and are familiar with, students will conclude that waves are characterized by frequency and amplitude. This real-world base will be applied to sound and light waves. This part focuses on sound waves.

**Prior Knowledge:** Students have no prior knowledge of waves as a phenomenon characterized by amplitude, frequency and wavelength. Students do have prior knowledge of ocean waves. Students will collect and record data on waves from <http://www.ndbc.noaa.gov/> using the tsunami filter. Students will collect data from three different buoys (one off the coast of a country of their choosing, one mid ocean buoy, and one off the coast of the Gulf of Mexico) for 5 days. Students will record their data on a word document (included). I will not instruct them on what they are recording but allow them to discover amplitude, wavelength, and frequency through data analysis and their prior knowledge about waves. Followed by the question: Why do you think they call sound and light “waves?”

**Justification:** Living only 150 miles north of the Gulf of Mexico and next to a large reservoir, all my students are familiar with and have observed the properties of waves; they just don't know what they are observing. I believe that if I activate their prior knowledge and use Socratic Questioning, I can lead students to fully understand amplitude, frequency, and wavelength before I introduce the “fancy” science words. I believe this will prevent students from shutting down when they hear the “big” words. After I pair their observations with amplitude, frequency, and wavelength, students will find it easier to transfer their prior knowledge to the study of sound and light waves. Providing a base this solid will allow students to go deeper into the properties of waves and how they interact with matter and energy. Students will then be able to use and apply their knowledge to create an instrument that will play a certain note. Using engineering design process, mathematics, and technology, students will adjust their design to play a note within 100 Hz of an assigned note. Students will also be able to apply their knowledge to better understand parabola in math; apply observable phenomenon to mathematical theory. This is the first part of several lessons to understand both light and sound waves. The main purpose of this lesson is to understand that waves are characterized by amplitude frequency and wavelength and that these characteristics are observable. Future lessons will

**Interdisciplinary:** Providing a real-world example and investigating the properties of waves in science should make visualization of the mathematical properties of parabolas become more than a line on a graph. As well, some of my students will relate better to the calculations than the observations. I believe both classes would benefit greatly as we explore this unit together. This unit would also help students in choir or music to better understand pitch, resonance, volume, how string instruments work...etc. And finally, in STEM class students will build a musical

instrument from materials of their choosing. Using engineering design and the scientific method, students will create an instrument that will play a note at different amplitudes and within 100 Hz of an assigned frequency.

**Vocabulary:**

- Acoustic
- Amplitude
- Longitudinal/Compressional wave
- Echo
- Energy
- Frequency
- Medium
- Oscilloscope
- Pitch
- Resonance
- Sound
- Vibrate
- Wave
- Wavelength

**Materials needed:**

- Multiple copies of document(included) to record wave observations
- Drum
- A few small pebbles
- Tuning Fork
- Glass of water (see through glass)
- Rubber band strung over an empty tissue box
- Chromebooks
- Steel Ruler
- Sound stick
- Slinkys
- KWL (included)
- Paper
- Pencils
- Oscilloscopes
- Various materials provided by students to create instruments
- Scientist's Questionnaire (included)
- Rubric for instrument(included)
- Various objects for summative assessment (glass cup, metal cup, plastic cup, cardboard box and piece of wood)
- Drumstick
- Group work accountability sheet (included)

**Engage:** Students will collect and record data on waves from <http://www.ndbc.noaa.gov/> using the tsunami filter. Students will collect data from three different buoys (one off the coast of a country of their choosing, one mid ocean buoy, and one off the coast of the Gulf of Mexico) for 5 days. Students will record their data on a word document that is included at the end of this lesson plan (wave height along with a drawing of their wave). This will only take a few moments at the beginning of these classes. After day 5, we will begin the lesson on sound.

Day 1: Bell work: Think back to a time you were at the beach or at the reservoir and describe the water. Discussion will follow.

I will then ask students to analyze their data and tell me what they are measuring.

Sample questions:

- How would you describe this wave?
- How are these two waves different?
- Describe in your own words some waves you have seen in person. Draw the wave you just described.
- Can you have a big and fast wave?
- Can you have a tall fast wave?

Teacher will continue discussion looking for tall, fast, small, and big to describe the waves.

When students have sufficiently described waves in their own terms then I will have them draw waves from a description I give, i.e. tall and fast, slow and short on whiteboards and hold them up (formative assessment if students cannot differentiate properties pause and illustrate again). I will now introduce frequency (fast or slow), amplitude (tall or short), and wavelength (big or small) (use this key to guide student discussion). I will explain that **all** waves have these characteristics.

Students will then go outside and our resource officer will drive to and from with his siren going. Students will write down observations and questions.

I will then show <https://www.youtube.com/watch?v=Q3oItpVa9fs> and have students record observations.

Discuss as a class and leave students with the question, “Why is sound called a wave?”

Students will then use “Think-Pair Share” (Lyman, 1981) to fill out the K and W on their KWL, followed by a class discussion. Some questions that the teacher should make sure get on lists are but not limited to:

- What does a sound wave look like?
- How do sound waves travel?
- What is a medium?
- Can sound waves travel in space?
- What is the difference between sounds that are different?

Teacher should be prepared for:

- Why does thunder come after lightening?
- What is a sonic boom?

Day 2: Bell work: teacher will play the song ‘Good Vibrations’ and ask students, “What do you think this song is talking about?” Objective is to get the class to agree that they are talking about sound and sound can be classified as a vibration (do not go into description of vibrations).

<https://www.youtube.com/watch?v=OnmFn7bvIrA>

**Explore:** Teacher will begin experiments with reminder of group work and lab safety. Students will have 10-15 mins at each station in groups of 3-5. Hand out Scientists Questionnaire and Experiments sheet (could have experiments blown up and placed at each station).

#### Experiment 1: Steel Ruler

The student will hold one end of the steel ruler to the top of a table, with the other end sitting off the edge of the table. The student will snap the end of the ruler that is not on the table.

Questions to think about:

What happened to the ruler?

What did you hear?

What did you feel?

#### Experiment 2: Your Throat

Have the student touch the side of their throat with two fingers and quietly say ahhh. Do the same thing again, but say ahh a little bit louder. Do it again, but use your whole hand instead of just two finger. Do it again, but feel the front of your throat instead of the side of your throat.

Questions to think about:

Does it feel different with just using two fingers?

Does it feel different on the front of your throat versus the side of your throat?

#### Experiment 3 Drums and Rocks or Paper Clips

Have the student place a few of the small pebbles or paper clips on top of the drum. Give the drum a light tap and see what happens to the pebbles.

Questions to think about:

What do you think is going to happen to the pebbles?

What would happen if you hit the drum harder?

#### Experiment 4: Rubber band and tissue box

Have the student wrap a rubber band around an empty tissue box the long way (<-->) and snap the rubber band. Next wrap the rubber band around the tissue box the other way, snap the rubber band again.

Question to think about:

Did the rubber band make different sounds?

What did the rubber band do when you snapped it?

#### Experiment 5: Tuning Fork in Water

Have the student gently tap the tuning fork on the side of the table and put it in the glass of water right away. Repeat but give it a slightly harder tap.

Questions to think about:

What does the tuning fork do when you tap it?

What does the water do when you put the tuning fork in the glass?

What does the water look like from the top of the glass?  
What does the water look like from the side of the glass?

When complete, gather the class and replay, "Good Vibrations." Discuss until class describes vibrations as back and forth. Continue to discuss until class concludes that sound is a back and forth wave that moves through mediums. Have students discuss these questions.

- What were the variety of mediums through which the waves traveled (solids, liquids, and gases)?
- Can sound exist in space outside of the space shuttle?
- Which waves could you hear in the lab and which could you not?
- Where did the waves travel?
- What do you think a sound wave would look like if we could see it?

**Elaborate:** Day3: Bell work: How do you describe different sounds? Be prepared with either recorded samples or items to demonstrate pitch and loudness.

Discuss until students define in their own words: high and low pitch and loudness or volume. I will use sound stick to create sound waves with different pitches by grabbing the stick at different heights. Leave students pondering the question, "What changed?"

Have students go to [http://www.physics-chemistry-interactive-flash-animation.com/electricity\\_electromagnetism\\_interactive/oscilloscope\\_description\\_tutorial\\_sounds\\_frequency.htm](http://www.physics-chemistry-interactive-flash-animation.com/electricity_electromagnetism_interactive/oscilloscope_description_tutorial_sounds_frequency.htm).

Set V and ms to 1. Turn volume all the way up. Set keyboard to square. Have students, in groups of 2, play 5 different notes and record observations on the same sheet as earlier wave observations.

Turn volume down to half and repeat experiment with the same 5 notes.

Class room discussion/notes exploring the link between amplitude/volume and wavelength/frequency/pitch.

Ask class, "How do we break things?"

Discuss until energy is the class consensus.

Show video of glass breaking with voice. <https://www.youtube.com/watch?v=rRZT7xO5KN4> and ask, "How did the glass break?" Discuss until students conclude that it takes energy to break things and sound waves must have energy.

End of Day 3 and Day 4

**Explain:** Students will take notes on sound waves power point using the Cornell Method prior to class.

Bell work: Write two questions you still have about sound waves.

Discuss: formative assessment to see what questions still need to be addressed.

Teacher and students will explore power point on sound waves and then go back to questions (formative assessment): I cannot include my ppt. (it is long and I don't know how...) but here is a link to a good ppt. <https://peer.tamu.edu/VBB/ScienceTeacherResources.asp>

- What were the variety of mediums through which the waves traveled (solids, liquids, and gases)? Explain to students that mediums are required to carry sound waves.
- Can sound exist in space outside of the space shuttle? Explain that sound needs a medium, but space is a vacuum with no solids, liquids, or gases for sound waves to travel through or vibrate in.
- Which waves could you hear in the lab and which could you not?
- Where did the waves travel? Explain that all the waves continued to move outward and would have continued in this manner unless they hit an object of a different density, especially a solid. The water in the glass hit the edges of the glass and bounced back. Elicit students' ideas about real-world examples of this—for example, echoes.
- What do you think a sound wave would look like if we could see it? Have student volunteers come up to the board to illustrate. Then demonstrate that a sound wave looks like a Slinky being pushed back and forth. Explain to students that sound waves are also called longitudinal waves because they have compressional sections and sections that are more spread out. Use Slinkys to model (have students label a worksheet of a longitudinal wave).
- What would happen if you changed the frequency/wavelength or amplitude of a sound wave?
- Students will also define vocabulary and give real world examples.
- Why is sound classified as a wave? Students should be able to answer with energy, frequency, amplitude, and wavelength.
- How does sound break glass? Explain that sound is energy that resonated with the glass causing the glass to vibrate past structural integrity (there will still be questions but for a later date).
- For my standards, I will leave students with the question, “Why can sound travel through the door but light cannot?” and, “How does light travel through space but sound cannot?” This will be the next lesson.

### **Expand:**

In science class, we will potentially discuss some or all of the following as time allows:

- What are amphitheaters?
- Why do singers wear headsets in large venues?
- Hypothesize what happens to sound waves when they reach a wall or other solid.
- If sound can't travel in space, hypothesize what other modes of communication astronauts can use when they are outside the space shuttle?
- Explain why, based on the behavior of sound waves, a classroom with a tile floor is louder than a library that is carpeted.

- Does the shape of an object affect how sound travels?
- How does sound travel when you have a conversation with your friends?
- Think about what it is like to hear things under water. Debate whether sound travels better in liquids (like water), gases (air), or solids (like putting your head down on a desk and having someone slam a book down on the surface)?
- Discuss why you see lightning before you hear thunder during storms.

In STEM class, using engineering design method, students will:

- create a musical instrument that must play a specific note.
- demonstrate their understanding of sound waves by adjusting their instrument to change the properties of the wave (wavelength and frequency) to meet the criteria.
- use any material that can be reasonably manipulated in class, i.e. string, wire, rubber bands, PVC...
- be asked to play their instrument at different amplitudes.

### **Evaluate:**

In science class, students will have two assessments.

- The teacher will manipulate (with a drum stick) various objects to produce sound. Students will describe this sound in terms of frequency and amplitude. (glass cup, plastic cup, metal cup, cardboard box, and a piece of wood) TTW play 2 sounds at a time and student will respond with which sounds had the highest and the lowest frequency and which sounds had the highest and lowest amplitude. 10 points for each correct answer total of 100 points.
- Students will also receive a district assessment (I do not have access to this document).
- In STEM class, students will receive: Rubric for instrument (rubric is on following pages)
  - Benchmark 1: research and design on time
  - Benchmark 2: materials collected
  - Benchmark 3: instrument constructed
  - Benchmark 4: trials conducted and adjustments made
  - Benchmark 5: Final assessment note played for oscilloscope

### References

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I did not cite experiments because they were given to me some time ago at a workshop. I googled them and found them in multiple places without citation.

Name \_\_\_\_\_

Block \_\_\_\_\_

Experiments- you will have 10 mins at each station.

#### Experiment 1: Steel Ruler

The student will hold one end of the steel ruler to the top of a table, with the other end sitting off the edge of the table. The student will snap the end of the ruler that is not on the table.

Questions to think about:

What happened to the ruler?

What did you hear?

What did you feel?

#### Experiment 2: Your Throat

Have the student touch the side of their throat with two fingers and quietly say ahhh. Do the same thing again, but say ahh a little bit louder. Do it again, but use your whole hand instead of just two finger. Do it again, but feel the front of your throat instead of the side of your throat.

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What does the water look like from the side of the glass?

Name \_\_\_\_\_

Block \_\_\_\_\_

Data Collection

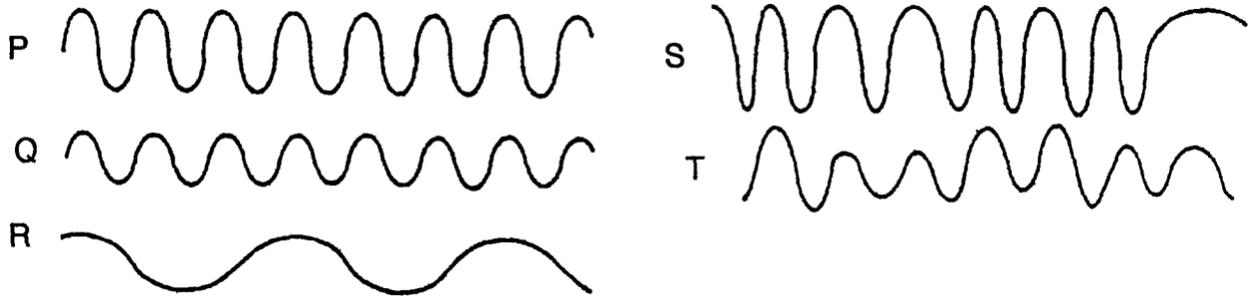
Record data. Draw and describe your wave in column 4. Reflections on back.

Buoy #	Line height	Line width (one U)	Draw (4 U's)

Name \_\_\_\_\_

Block \_\_\_\_\_

Use the five illustrations of waves drawn below to answer the following questions:



Waves P and Q have the same \_\_\_\_\_, but wave P has twice the \_\_\_\_\_ of wave Q.

Waves Q and R have the same \_\_\_\_\_, but wave R has twice the \_\_\_\_\_ of wave Q.

Wave \_\_\_\_\_ shows a steady frequency but changing amplitude.

Wave \_\_\_\_\_ shows steady amplitude but a changing frequency.

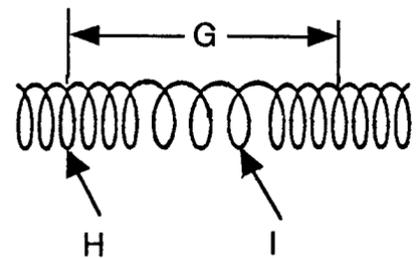
Waves \_\_\_\_\_ and \_\_\_\_\_ have a low amplitude and a steady frequency.

The following questions refer to the diagram to the right:

What type of wave is this?  
\_\_\_\_\_

Letter H represents a \_\_\_\_\_ and  
letter I represents a \_\_\_\_\_.

Letter G represents a \_\_\_\_\_.



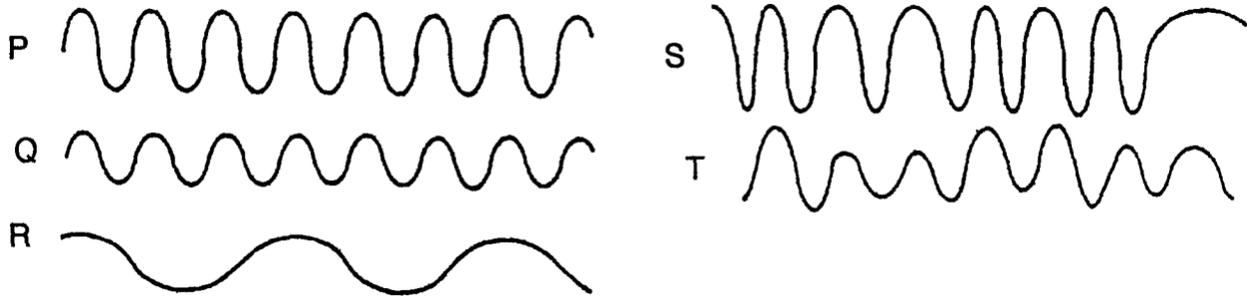
Sound waves are the movement

of \_\_\_\_\_ through substances as \_\_\_\_\_ waves.

Name \_\_\_\_\_

Block \_\_\_\_\_

Use the five illustrations of waves drawn below to answer the following questions:



Waves P and Q have the same wavelength, but wave P has twice the amplitude of wave Q.

Waves Q and R have the same amplitude, but wave R has twice the wavelength of wave Q.

Wave T shows a steady frequency but changing amplitude.

Wave S shows steady amplitude but a changing frequency.

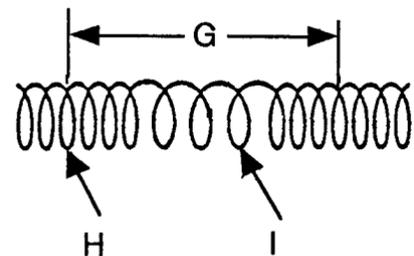
Waves Q and R have a low amplitude and a steady frequency.

The following questions refer to the diagram to the right:

What type of wave is this? Longitudinal

Letter H represents a compression and letter I represents a rarefaction.

Letter G represents wavelength or one wave.



Sound waves are the movement of energy through substances as longitudinal waves.

Name \_\_\_\_\_

Block \_\_\_\_\_

## Scientists Questionnaire

1. What do you see when you conduct the experiment?
2. What do you hear when you conduct the experiment?
3. Where are the vibrations coming from?
4. What is the vibration traveling through?
5. What direction is the vibration going?

6. What happens to the surrounding objects when contacted by the vibrations?

7. Use this space to record answers to the questions in the experiment as well as any other observations.

## Group Talk Feedback

Please answer each question honestly. There are no right answers. Your feedback will help me support your learning.

PART A- Put an X next to the answer that best matches your experience

1. How interesting was your group's discussion?

Very interesting       Interesting       Somewhat interesting  
 Not at all interesting

2. How well did you understand what your group was supposed to do?

I knew what to do       At first I wasn't sure, but then I knew what to do  
 It was never clear to me what I was supposed to do

3. How easy was it for you to discuss the topic?

Very easy       Easy       Somewhat easy       Difficult  
 Very difficult

4. About how many times did you have a chance to talk in your group?

10 or more times       6-9 times       3-5 times       2 times  
 only 1 time       I never had a chance to talk

5. If you talked less than you wanted to, what were the reasons? (Check off all that apply)

I talked as much as I wanted to       I was afraid to share my ideas  
 Somebody was rude to me       Somebody kept cutting me off  
 Nobody paid attention to what I said       I wasn't interested in the topic  
 I didn't know enough about the topic       Some people talked too long  
 I didn't understand what others were saying

Share any other reasons here:

6. How well did you get along with your group?

I got along very well with everyone       I got along well with everyone  
 I got along well with almost everyone       I did not get along well with the group

7. How many students in your group listened to each other's' ideas?

\_\_\_\_\_ All of them    \_\_\_\_\_ Most of them    \_\_\_\_\_ A few of them    \_\_\_\_\_ None of them

SECTION B- Write a response that describes your experience with your group

8. Who did the most talking in your group today?

9. Who did the least talking in your group today?

10. Who had the best idea in your group today?

11. What was your best contribution to the group?

12. Who did the most to encourage and support group discussion today?

13. Would you like to work in this same group again? \_\_\_\_\_ Explain:

14. What could be done to improve the quality of discussion in your group?

### Project Rubric

	<b>10</b>	<b>15</b>	<b>20</b>	<b>25</b>
<b>Teamwork</b>	Only one of the team members did the planning and design	_____ team members worked together on the planning but only one worked on the design	___ members participated in planning and design but they did not work equally	All members of the team participated and worked equally in planning and the designing and worked well together.
<b>Comprehension</b>	Students did not comprehend the goal of the activity.	With guidance students began to comprehend how to build an instrument to make a sound	Students comprehended the goal of the activity and were able to plan and design an instrument	Students met the goal of the activity and went beyond expectations in planning and designing an instrument
<b>Planning</b>	No benchmarks were met.	Some benchmarks were met.	All benchmarks were met but some were not on time.	All benchmarks were met and on time.
<b>Beautiful Music</b>	Instrument produced no sound	Instrument played a sound with 2 amplitudes but not within 200 Hz.	Instrument played 2 amplitudes and was over 100 Hz of target but less than 200 Hz.	Instrument played 2 amplitudes and was within 100 Hz of target.

Name \_\_\_\_\_

Block \_\_\_\_\_

### K-W-L Chart

<b>What I <u>K</u>now</b>	<b>What I <u>W</u>onder (or <u>w</u>ant to know)</b>	<b>What I have <u>L</u>earned</b>