Mechanical Waves

Level	
High School	

Time Required	Lesson Summary
100 min (2-50 min. class periods)	This lesson reviews the fundamentals of mechanical waves. First, teachers will instruct students in the parts and movement of waves. Then students will work in small groups on several short inquiry activities that will allow them to understand the characteristics of waves.

Standards

NGSS

PH4 Wave properties – The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

Vocabulary	Objectives
crest trough amplitude wavelength period frequency doppler effect transverse wave compressional wave	• Students will be able to describe the movement of the two types of mechanical waves. • Students will determine how the components of a wave affect other components.

Materials

- Slinky
- Student computers
- Access to the internet
- The activity can be done without computers if necessary. Please see the accommodations section at the bottom of this document.

Pre-Requisites
None.

Safety Considerations
None

Pacing Notes
This lesson contains a pre-homework assignment. See the *Before the Lesson* section for details. This lesson will take two – 50-minute class periods. Day 1: Wave discussion, direct instruction, begin the wave on a String Activity or slinky wave lab. Day 2: Start with the activity described in the *Culturally Inclusive/Responsive* section, finish the wave on a String Activity (or slinky wave lab) and class discussion.

Before the Lesson
Reserve student computers if your school uses computer carts. Otherwise, make sure the simulation https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html (last accessed 6/24/23) runs on student computers a few days before the activity. Be aware that you may need your school's IT department to allow this program's use. If student computers are not available, use the slinky wave lab instead of the wave on a string activity. The day before you teach this lesson, identify students' previous knowledge of mechanical waves. You could use the previous day's starter quiz or create your own method for determining what your students know about this topic. This is an essential part of this lesson as it will determine what you need to include in your instruction. It would help if you also gave students the homework assignment the day before the lesson.

Assessments	**Classroom Instructions**
Pre-Activity Assessments	**Introduction**
Walk around the room after completing administrative tasks and look at students' labeling. Do most students seem to have the labels in the right	When students come into the classroom, please give them a copy of the wave sheet. Ask them to label the wave parts as you take attendance and take care of administrative tasks.

places? This information should be a review from middle school. However, if students seem confused, you may want to spend additional time on this part of the lesson.	
Activity Embedded Assessments	**Activities**
To assess the knowledge of as many students as possible, try to call on a different individual each time. If students aren't volunteering to give answers, it may indicate they are uncomfortable with the information. If necessary, spend additional time going over the basics of waves. While talking about transverse and compressional waves, frequently stop to check for understanding. An effective way to do this is to stop and ask students to explain half of what you just talked about to their neighbor. Then the students switch roles,	1. Class Discussion **Ask**: Where have you seen a wave? or What kinds of waves are you familiar with from day-to-day living? Allow students to share with the class. Let as many as possible share. However, you may need to limit the number to allow time for the other activities. 2. Direct Instruction a. Project the wave sheet on the board (or draw it if no projector is available). b. Ask students to identify the term for each part of the wave, then have another student give the definition. Once you have finished the definitions for the features of the wave, continue with the explanation for frequency, period, and the Doppler effect. Finally, discuss the two types of waves, compression and transverse. c. For compression or longitudinal waves, mention that they are started by a vibration and move through matter. Some examples include sound waves, and the primary or P earthquake wave. If you have a slinky, demonstrate a longitudinal wave's movement with the spring toy. d. For transverse waves mention that a vibration starts them, and most move through matter. Some examples include water waves and secondary or S earthquake waves. If you have a slinky, demonstrate a transverse wave's movement with the spring toy. e. If you don't have a slinky, you should show the following video so students can see these waves. https://www.youtube.com/watch?v=0Anh9HthWgQ (last accessed 6/24/23) f. The above information can be presented to students in the manner that best fits your teaching style. For example, you can lead a discussion, show a video or lecture. However, make sure you include the above content in your teaching. In addition, research has found that allowing students to talk about the content helps them develop a deep understanding.

and the other person explains half of the content. Students should be told it is okay to correct their partner if they say something wrong. Spend some time explaining how to do that without insulting the other person.	
As students are working, walk around and ask groups the following: How did you design this experiment? Why did you design it that way? Is there something else you could have done to learn more about the situation? What did you learn from that portion of the activity? Do you think these findings are transferable to all waves? Why or why not? Collect the pages at the end of the activity and grade them.	3. Wave on a string a. This inquiry activity allows students to determine the relationship between wave components. If student computers are available, assign students to work in pairs. Be flexible. If a student wants to work alone, please allow it. If student computers are not available, use the slinky lab instead. There are teacher instructions for that activity on the webpage. b. Students should go to this web page https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html (last accessed 6/24/23) c. The instructions on the wave on a string sheet guide students through three inquiry activities and two observation activities. These are short activities and should not take too long if students are on task. Establish a time limit and periodically remind students of your expectation as they work.

Post Activity Assessments	Closure
As you conduct the discussion, call on various students to provide answers. Including as many individuals as possible can check the understanding of a more significant percentage of the class. As one student answers, pay attention to the reactions of the remaining students. Are they engaged in the discussion? If you spot an individual who is not paying attention, ask them the next question. This will allow you to determine if they are bored or if they don't understand. If several of the class don't seem to be following along with the discussion, break the class into several large groups. (Large enough to have a meaningful conversation but not so large that some students can opt not to participate.) Walk around the class monitoring the discussions. Pay attention to the answers given by groups and to the participation levels.	1. After students have finished the wave on a String Simulation, conduct a discussion with your students. The questions listed below should be used to start the conversation on each activity. Follow up with the questions you feel are appropriate. If students don't provide a reason for their answers, please ask for one. It is vital that students can back up their statements with evidence. **Ask**: Does a wave's frequency affect the wavelength? How? **Ask**: Does a wave's amplitude affect the wavelength? How? **Ask**: Does a wave's frequency affect the amplitude? How? **Ask**: Why did the wave amplitude change over distance? (Omit if you used the slinky wave lab) The answers should include the initial energy of the wave and losing energy to the medium it travels through. **Ask**: Is there anywhere where the amplitude would not decrease over distance? (Omit if you used the slinky wave lab) The answer is no. However, in a vacuum, no energy would be lost to the medium. **Ask**: What happened to the wave when it reached the clamp at the end? Why do you think that happened? (Omit if you used the slinky wave lab) This would be a good time to talk about wave reflection and refraction. You can decide how you would like to include this topic in your class.

Intercede in a group if incorrect information is being shared or if there are students not participating.	

Culturally Inclusive/Responsive Components
Both compression or longitudinal and transverse waves are associated with Earthquakes. Before scientists could explain how these natural disasters occur, people created stories to explain them. Start the second class by having students investigate some Earthquake myths from around the world. Each myth could be investigated by a small group of students who could use their knowledge of waves to explain why the local people created this story. The USGS has a nice collection of these stories but lacks background information on myths. https://www.usgs.gov/natural-hazards/earthquake-hazards/science/earthquake-legends?qt-science_center_objects=0#qt-science_center_objects (last accessed 6/24/23) The Milford library uses the same list of stories but has some background information on myths. https://milford.lib.de.us/2020/07/25/fantastic-folklore-earthquake-myths/ (last accessed 6/24/23) Alternatively, you could collaborate with an English/Language arts colleague during this lesson. For example, the ELA teacher could instruct students in mythos, and you could teach students on waves. Then you and the ELA teacher could connect to the other discipline to help students understand how the subjects are related.

Accommodations
Please alter the above activities to meet the needs of your students. Some suggestions to make all students enjoy the learning activities: - Give students a choice between working in a group or with a partner on the wave simulation. - Reduce the number of activities students with IEPs must complete. Let them share their information with another group and get information from that group. - It may help ELL students to work in groups with native-speaking peers.

Educator Resources

Background information on mechanical waves:

1. A tutorial can be found here https://www.khanacademy.org/science/physics/mechanical-waves-and-sound (last accessed 6/24/23)

Optional Extension Activities

- If you wish to include some calculations in this inquiry lesson, there is a wave equation page. This could be assigned as homework at the end of day two. If students completed the Phet simulation work early, they could start work on this page while others finished. DO NOT USE if you plan on using lesson two – *Electromagnetic Waves* in your classroom. That lesson includes very similar calculations as part of the station activities.

It is important that you assign this after the students have completed the inquiry activity, or it will undermine the effectiveness of self-discovery.

Acknowledgments

This is the first lesson in a nine-lesson series intended to increase student understanding of radio frequencies. You are welcome to just use this lesson but if you are interested in this topic consider checking out the others in the series.

Lesson One: Mechanical Waves
Lesson Two: Electromagnetic Waves
Lesson Three: Electromagnetic Spectrum
Lesson Four: Argumentation and Radio Waves
Lesson Five: Investigating Spectrum Users
Lesson Six: Aircraft and Newton's Second Law of Motion
Lesson Seven: Weather Forecasting and Radio Waves
Lesson Eight: Satellites and Society
Lesson Nine: Spectrum Management

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