Beyond the Slinky®, Part 2

Quantitative Characteristics of Waves

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Grade Level	9th – 12th Grade	**Time Frame**	150 minutes
Subject	Science	**Duration**	2-3 class periods
Course	Physical Science, Physics		

Essential Question

How do you measure a wave?

Summary

Students will use springs to investigate the quantitative characteristics of waves. Then, they will use their data to derive the formula connecting frequency, wavelength, and velocity. Later, students will connect those math ideas to an example from nature. This lesson is Part 2 of "Beyond the Slinky®," a three-part lesson series on waves and their properties.

Snapshot

Engage

Students listen to a spectrum of tones and speculate why the tones sound different.

Explore

Using a long, skinny spring, a Slinky® toy, and a rope, students create different properties of waves and make drawings in their notebooks.

Explain

As a class, students discuss the characteristics of waves using the proper terminology.

Extend

Students calculate the characteristics of waves using math problems in a real-world survival scenario.

Evaluate

Students revisit the spectrum of tones from the beginning of the lesson and add academic language to their written explanations of why the tones sound different.

Standards

ACT College and Career Readiness Standards - Science (6-12)

IOD202: Identify basic features of a table, graph, or diagram (e.g., units of measurement)
IOD304: Determine how the values of variables change as the value of another variable changes in a simple data presentation
IOD404: Perform a simple interpolation or simple extrapolation using data in a table or graph
SIN301: Understand the methods used in a simple experiment
EMI601: Determine which complex hypothesis, prediction, or conclusion is, or is not, consistent with a data presentation, model, or piece of information in text
EMI603: Use new information to make a prediction based on a model

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Oklahoma Academic Standards (Chemistry)

CH.PS4.1.1: 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.

Oklahoma Academic Standards (Chemistry)

PH.PS4.1 : Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
PH.PS4.1.DCI.1: 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.

Attachments

- Bat Cards—Beyond the Slinky® Part 2 - Spanish.docx
- Bat Cards—Beyond the Slinky® Part 2 - Spanish.pdf
- Bat Cards—Beyond the Slinky® Part 2.docx
- Bat Cards—Beyond the Slinky® Part 2.pdf
- Lesson Slides—Beyond the Slinky® Part 2.pptx
- Outsmart the Bat—Beyond the Slinky® Part 2 - Spanish.docx
- Outsmart the Bat—Beyond the Slinky® Part 2 - Spanish.pdf
- Outsmart the Bat—Beyond the Slinky® Part 2.docx
- Outsmart the Bat—Beyond the Slinky® Part 2.pdf
- Wave Activities—Beyond the Slinky® Part 2 - Spanish.docx
- Wave Activities—Beyond the Slinky® Part 2 - Spanish.pdf
- Wave Activities—Beyond the Slinky® Part 2.docx
- Wave Activities—Beyond the Slinky® Part 2.pdf
- Why Do the Tones Sound Different—Beyond the Slinky® Part 2 - Spanish.docx
- Why Do the Tones Sound Different—Beyond the Slinky® Part 2 - Spanish.pdf
- Why Do the Tones Sound Different—Beyond the Slinky® Part 2.docx
- Why Do the Tones Sound Different—Beyond the Slinky® Part 2.pdf

Materials

- Lesson Slides (attached)
- Why Do the Tones Sound Different? handout (attached; one per student)
- Wave Activities handout (attached; one per student)
- Outsmart the Bat handout (attached; one per student)
- Bat Cards (attached; one card per student)
- Long, skinny springs (one per group)
- Slinky® toys (one per group)

- Meter sticks (two per group)
- Stopwatches or timers (one per group)

Engage

Teacher's Note: Lesson Preparation

Before the lesson, prepare the lab materials, print the handouts, and print and cut out the attached **Bat Cards**. Print the cards double-sided so that the bats appear on the front side and the frequencies appear on the back side. Prepare enough cards to provide one per student.

Introduce the lesson using the attached **Lesson Slides**. Display **slide 3** to share the essential question and go to **slide 4** to review the lesson objectives with students.

Go to **slide 5** and pass out the attached **Why Do the Tones Sound Different?** handout. Inform students they will listen to audio and then use the Bell Ringer portion of the handout to answer the question.

Teacher's Note: Bell Ringer

Usually, bell work involves a task that students can complete independently as they enter the classroom and get settled. In this lesson, students cannot answer the question until you have played the following video for them. However, the activity is still a “Bell Ringer” for this lesson because it is at the beginning.

Teacher's Note: Join in!

Generational differences in ability to hear are interesting to explore. Most students will start hearing the sound at around the same time, but adults will take longer to hear the noise. Age-related hearing loss starts with higher pitches and works its way lower.

Invite students to stand up, and let them know they should sit down when they start hearing a high-pitched noise. Then, play the video “How Old Is Your Hearing?” starting at the 1-minute mark. Even after everyone sits down, let the video play until 1:31 so that students can hear the full range of sound.

Embedded video
https://youtube.com/watch?v=iN3PBpInNJM

Give students a few minutes to write their responses to the question "Why do the tones sound different?" in the Bell Ringer box. When time is up, ask students to hold on to their handouts for use later in the lesson.

Explore

Organize students into groups of three or four. Pass out the following materials to each group:

1. Long, skinny spring (often referred to as a snaky or helical spring)
2. Slinky® toy
3. Two meter sticks
4. Stopwatch/timer

Go to **slide 6**. Pass out the attached **Wave Activities** handout either to each student or to each group, depending on how you want students to collect data.

Have students explore only the concepts of amplitude, frequency, and wavelength in these activities—the next portion of the lesson is when they will learn the academic terminology to discuss these concepts further.

Teacher's Note: Danger Zone

The goal of the activity is for students to discover that *frequency increases as wavelength decreases*. To arrive at this understanding, students need to make the springs move quickly. With this in mind, warn students to beware of swinging springs, and be ready to positively reinforce appropriate classroom behavior and to deliver consequences to those who do not take the activity seriously.

Have students follow the directions on the handout to complete the activities. Provide additional guidance as needed.

Explain

After students have completed the Explore activity, bring the whole class back together. Inform students they will use academic language to describe what happened with their springs.

Display **slide 7** to show students what happened when they moved their springs up and down—use the diagram to explain how this movement created a transverse wave. Next, go to **slide 8** and give students time to draw a picture of the wave on the slide.

Go to **slide 9** to introduce the academic language used to describe and study waves. Give students time to label their drawings correctly and add definitions of the terms on the slide.

Then, go to **slide 10** and ask students to answer the following questions based on their findings from the Explore activity:

1. What is the relationship between wavelength and frequency—is it proportional or inversely proportional?
2. What is the relationship between frequency and velocity—is it proportional or inversely proportional?
3. Based on this information, can you write a formula connecting wavelength, frequency, and velocity?

The first two questions should lead students to derive the formula that connects wavelength, frequency, and velocity. Though it may be tempting to “help” students by giving them the formula, ask for student volunteers to share their ideas instead and make refinements to reach the answer through student input.

Answers

1. Wavelength is inversely proportional to frequency.
2. Frequency is proportional to velocity.
3. Wavelength times frequency equals velocity.

Extend

Display **slide 11** to introduce a problem that students need to solve using their knowledge of waves. Play the "Moth jamming bat" video.

Embedded video

https://www.youtube.com/watch?v=GZxK_0OSoFk

Pass out the attached **Outsmart the Bat** handout to each student. Once students have read through it, inform them you are the "bat" who will "fly around" and give each student a frequency. With the **Bat Cards** in hand, move around the room and give one card to each student.

Go to **slide 12**. On the handout, have students attempt to figure out the life-saving wavelength they need to produce to throw off the bat and avoid being eaten.

Teacher's Note: Providing Guidance

Resist the urge to provide too much guidance to students as they work on this problem. It is okay for them to struggle. Students have the correct formula by this point in the lesson, so allow them time to solve the problem in a way that works for them.

Once students have arrived at their answers, have them work in groups and try to replicate the wavelength with their springs.

Teacher's Note: Challenging Activity

This activity includes the use of the spring because application math problems don't end with a circled answer. Due to the nature of waves, students may find this activity difficult, if not impossible, at first.

After a few minutes, ask students if they struggled to replicate the wavelength. (The answer should be yes.) This is your chance to guide them through the scaling process. After they scale, have them try to replicate the wavelength again.

Teacher's Note: Scaling

Scaling reduces or enlarges numbers (usually by powers of 10) to make the numbers manageable. For example, if the wavelength were 16 nanometers, you could scale that up to 16 cm to make it replicable.

Evaluate

Display **slide 13** and have students get out their handouts from the beginning of the lesson. Have students first look over their Bell Ringer answers, then ask students to respond to the following prompt in the Exit Ticket box:

Based on what you've learned, describe the relationship between wavelength, frequency, and velocity and explain how that relationship reveals why the tones sound different.

When students have finished writing their answers, you may collect their handouts to assess what they have learned.

Resources

- Barracuda1983. (2006, June 3). Pipistrellus pipistrellus in flight [Image]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Pipistrellus_flight2.jpg
- Corcoran, A. (2013, September 23). Moth jamming bat - National Geographic untamed Americas [Video]. YouTube. https://www.youtube.com/watch?v=GZxK_0OSoFk
- Joe N Tell. (2019, February 4). How Old is Your Hearing? - Interactive Test for Your Ears [Video]. YouTube. https://www.youtube.com/watch?v=iN3PBpInNJM
- K20 Center. (n.d.). Bell ringers and exit tickets. Strategies. https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f505d6f2