Lesson Plan: SPH3U Echolocation and Mini Lab

Subject and Grade Level: SPH3U
Date of Lesson: Click here to enter text.
Total Lesson Time: 75 Minutes

Description/goal of the lesson: By the end of this lesson, students will be able to explain the mechanism behind echolocation and explain how echolocation is used in technology and animals.

Success Criteria

1. I can explain the way echolocation is used by animals like bats and dolphins and what these animals use echolocation for.
2. I can explain how the principles behind echolocation are used in a variety of technology like ultrasound devices, SONAR (depth finders), or in devices for the visually impaired.
3. I can calculate the time it takes for a wave to return to a source and solve problems related to echolocation.

Ontario Curricular Expectations

1. **Overall Expectation**:

   A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);
   E3. demonstrate an understanding of the properties of mechanical waves and sound and of the principles underlying their production, transmission, interaction, and reception.

2. **Specific Expectation(s):**

   A1.6 compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables, flow charts, graphs, and/or diagrams
   E3.6 explain selected natural phenomena (e.g., echo location, or organisms that produce or receive infrasonic, audible, or ultrasonic sound) with reference to the characteristics and properties of waves

Materials

Stopwatches (one or more, if you want a variety of measurements), Thermometers (one or more), two wooden planks (or anything to make a quick, loud sound with), Lab Handouts for each student ("Speed of Sound Lab Activity" (attached)

Lab Safety Precautions

1. Be wary of weather conditions, as this lab does have an outdoor component. Ensure students are prepared for the weather.
2. It would also be wise to inform your admin that your class may be outdoors this lesson.
3. This lab may have a field trip aspect for your class. If so, fulfill all field trip requirements as needed. If you stay on the school property, you may not need to prepare a field trip form. In my class, we stood near the school's sports field and the school building to be the surface for the sound to reflect from. Ensure that your students can follow you to your destination without straying.
4. The next hazard would be the wooden boards themselves. In the case of wooden boards, it may be wise for the teacher to perform the clapping, as it is not unlikely for fingers to be pinched between the wood if operated without caution.
5. Additionally, the noise from the wood is rather loud. Hearing protection, or, distance, is wise for those standing near the clapping wood.

Open (Time: 10 minutes)

Introduce the topic of echolocation by asking a thinking question—Why is sound so important to some animals for their livelihood?
Can you think of some technology that uses this? (In Medical Imaging, we use an Ultrasound device to track fetal development in the womb. Waves are sent into the body and they reflect off of the soft tissues inside and we can map these reflections to an image. (Nelson Physics 11, Figure 1 on page 392)

Body (Time: 50 minutes)

Echolocation

A sound wave can reflect off a surface. The wave will not change speed, wavelength, or frequency.
Draw a picture to represent the Angle of incidence = Angle of Reflection. Can talk about how different surfaces affect the reflection of a wave. (Sound cancelling foam vs an empty flat wall)
The time between a sound wave sent out and the detection of a reflection can be used to locate objects.
Weather permitting, go outdoors to the sidewalk or sports field and clap two wooden boards together (Try to find a spot ~100m away, where you can make this noise to reflect off the school surface, or the surface of another building).

Speed of Sound Lab Activity: Review Lab Safety Precautions!

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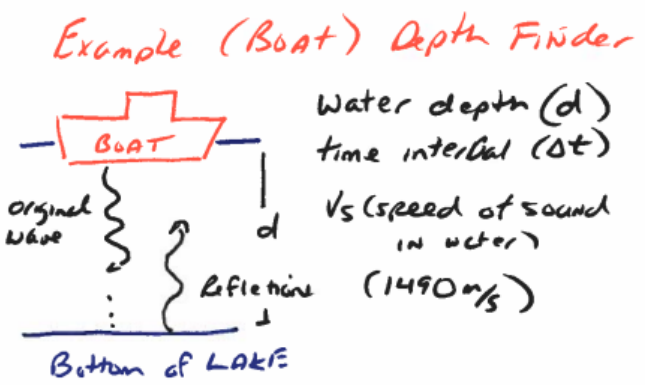
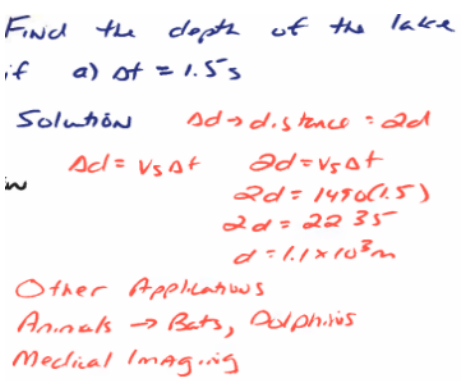
Heading outside, bring the thermometer(s), timer(s), and the two wooden planks.
Demonstrate to the students how to clap the boards without pinching your fingers.
Explain that the goal is to clap at a constant rate so that each time you clap the planks together, the echo returns to you at the same time. This gives you a rhythm to clap at. This is so that we escape some of the human reaction time error that occurs when trying to time a single clap and echo's timing.
We will measure the time it takes for 20 claps to occur.
We will also measure the distance from the source to the object we are reflecting off of, and the thermometer will be used to measure the air temperature.
After collecting this data, return back inside to complete the mini-lab (Attached below. Calculate the speed of sound using $v = 331.4 + 0.606T$. This will be your "theoretical" value. Then using the fact that the school was d meters away and it took t seconds for the sound to return 19 times (the 20th clap means there are 19 echoes), we can use $v=19d/t$ to solve for the speed of sound! (19d is because t = the duration of 19 echoes).
Calculate the percent difference (or if you wish, the percent yield), and have the students discuss possible errors and uncertainties.

Close (Time: 15 minutes)
Students who have completed may work on the following sample problem about a depth finder.





Students who complete that as well may want to attempt a "coin dropped in a well makes a sound" problem (example) that utilizes kinematics and ideas from the sound unit. If the kinematics unit and sound unit have been completed, they should have all the necessary skills to complete this if they want the challenge 😊. Otherwise, use Nelson Science 11 Pg. 474 #2 for another echolocation problem.

Assessment and Differentiation
Formative Practice Problems. Will be taken up the following day in class.
Mini-Lab for Participation. Should be completed by the end of class.
Differentiation is provided by allowing students to choose the level of problem they think they might be ready for.
Additionally, students may want to complete the lab using a virtual copy of the lab (attached below).

Speed of Sound Lab Activity

Purpose - Determine the speed of sound experimentally then compare it to the speed of sound calculated based on the air temperature.

Hypothesis – The percent difference between the two speed of sound calculations will be less than 10%.

Procedure - We will go to the far side of the track and bang 2 boards together to make a loud clapping noise. The sound will travel to the school, reflect off the wall and travel back to us. At that instant we will hear an echo. **We will establish a rhythm by clapping so that the time between the echo and the next clap is the same as the time between the clap and the echo.** C E C E C E C Once the rhythm is established we will measure the time for 20 claps. We

will also measure the distance, d, between our location and the school, and record the outside air temperature.

Data Collection - T = (outside temperature)
d = (distance from school to our location)
t = (time for 20 claps)

Data Analysis -

1. Using the temperature, calculate the speed of sound.

2. Using a different method and the above information, calculate the speed of sound. Describe your logic.

3. Calculate the percentage difference between the two calculations

$$\% \text{ difference} = \frac{\text{difference}}{\text{Average}} \times 100\%$$

Evaluation

Based on your results, briefly describe the success level of the lab.

Conclusion

Write a brief conclusion for this lab. (What did you learn?). Make sure to mention a potential source of error in the lab and how to correct that error (how could you improve the lab?).

More on Speed of Sound Lab

Sir Isaac Newton first tried to determine the speed of sound experimentally at Trinity College at Cambridge around 1680. He used a long hall. He made a noise which travelled down the hall, reflected off the end wall and returned to him as an echo. He used a pendulum which was released at the same time as the noise. He adjusted the length of the pendulum to make the period, the time for 1 cycle, the same as the time it took for the echo to return.
If the length of Newton's corridor is 64 m and he measured a time of 0.37 seconds, determine the speed of sound for Newton.

References

DiGiuseppe, M. (2011). *Nelson Physics 11: Study Guide: University Preparation*. Nelson Education.

Institute of Physics and Math. (2019, October 2). Dropping a coin to find out the depth of a well. *https://institute.hirophysics.com/2019/10/02/dropping-a-coin-to-find-out-the-depth-of-a-well/*

Ontario Ministry of Education. (2008). *The Ontario Curriculum, Grades 11 and 12: Science*. Queen's Printer for Ontario. Retrieved from https://www.edu.gov.on.ca/eng/curriculum/secondary/2009science11_12.pdf.

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