Macduff Integrated Art STEM Lesson Plan FINAL

Topic, Grade Level, Time

This is an 8th grade lesson for a Physical Science Classroom. Having previously introduced harmonic motion and waves, this mini-unit addresses specifically longitudinal waves through the creation of a musical instrument. We also cover the Doppler Effect and a comparison between longitudinal and transverse waves.

Standards

National Core Art Standards

Anchor #5. Develop and refine artistic techniques and work for presentation. (Performance Standard (VA:Pr5.1.7) a. Based on criteria, analyze and evaluate methods for preparing and presenting art.)

Anchor #6. Convey meaning through the presentation of artistic work.

Next Generation Science Standards

1-PS4-1. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

1-PS4-4. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

- Use tools and materials provided to design a device that solves a specific problem. (1-PS4-4)

Art Integration

Students will be using their prior knowledge, lessons learned in class, and research to design a working musical instrument capable of playing an entire octave. This requires knowledge of the musical term octave and creates a distinct medium for communicating through song. Students will also be part of the 'orchestra' in class, requiring them to listen and evaluate other people's instruments to combine the sounds together.

Justification

Sound waves are often a mystery to students. They have seen ocean waves, pond ripples, and even make waves with their jump ropes, but the idea of a wave moving in the same direction as the particles of the medium is not as intuitive. Even musicians can balk at the idea of a longitudinal wave as they see their guitar strings vibrate in a transverse pattern. As such, this can turn into a bit of a dry unit, perhaps made more interesting with Slinkies and springs, but still falling short of activating a response in the affective domain.

Additionally, music is often seen as something for other kids. It's nice, but it's beyond most people, so we just listen to the radio and don't bother playing. By combining the focus on learning about sound AND creating a musical instrument, students are activating their affective domain and producing something that needs to work in harmony with other students.

And extending the lesson, students can use their octave scale to send messages. This is a bit more challenging, but there is a fabulous clip from the Tom Hanks movie, “The Man with One Red Shoe” that sends home the feasibility of using just a few notes to send a complex message. Even simply using the letters in an octave, students can spell various words with a limited alphabet.

Thus their science learning is enhanced by the creation of harmonious music, and their musical skill is applied to the sending of coded messages.

Measurable Objectives

1. Students will be able to identify the parts of a longitudinal wave.
2. Students will be able to compare and contrast the structure of longitudinal and transverse waves.
3. Students will be able to summarize various applications of both types of waves.
4. Students will be able to apply the concepts from lessons about longitudinal waves to their description of their musical instrument.
5. Students will create an instrument that creates specific longitudinal wavelengths equal to (or approximating) an octave.

Lesson Procedure

See 5E Matrix attached.

Assessment Rubric

See Musical Instrument Rubric in Lesson Materials

Lesson Materials

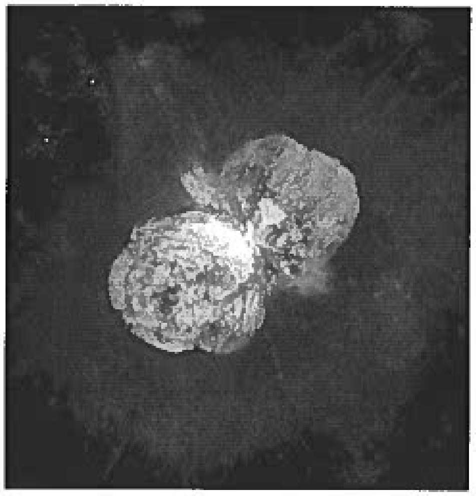
Attached below.

5E Lesson Plan	
Engage The purpose for the ENGAGE stage is to pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.	This mini-unit begins with an online Gizmo at ExploreLearning.com. All the Gizmos are highly engaging, and are easy to manipulate to demonstrate various scientific phenomena. The lesson begins with a 'think now' scenario, which should be discussed before letting students explore the gizmo. This gives a good baseline on where student knowledge of sound waves is at the moment. After progressing through the lesson, students can reflect back on their initial answer to the 'think now' question and see how they have already grown in knowledge. This lesson will be very similar to one later in the week. Assessment will focus on the growth between the two lessons.
Explore The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.	Following the ExploreLearning lesson, students will be introduced to the final project and have a day to explore their options, plan their work time, and begin researching based on their set goals. Teacher will monitor activity to ensure students are on task and making progress. While students have the project as work mostly at home, further lessons will include a demo and discovery about the Doppler Effect as well as a webquest about longitudinal waves. Both of these lessons are to help support the development of the students' understanding of sound waves and their application to creating a musical instrument.
Explain The purpose for the EXPLAIN stage is to provide students with an opportunity to communicate what they have learned so far and figure out what it means.	Throughout all of the lessons, there will be many opportunities for students to explain their learning. The Gizmo starts with a 'think now' and class discussion. Througout the lesson it would be appropriate to stop and have a student demonstrate to the class what they've discovered. By the end of the day when introducing the musical instrument project, students should all be able to complete an exit slip describing how they will make a resonant sound replicating an octave. The Doppler Effect is designed to help students work on understanding the relationship between terms like speed, pitch, and frequency. The final webquest helps students review their lessons from the first day as well as explore the passage of sound vibrations through various phases of matter. All of these lessons are monitored by the teacher and paused for class discussion regularly. Exit slips should be collected daily to ensure all students have the chance to be heard and reflect.
Elaborate/Extend The purpose for the EXTEND stage is to allow students to use their new knowledge and continue to explore its implications.	Beyond simply learning the concepts, the crux of this unit is the application of this knowledge through the engineering design cycle to create a musical instrument. This requires critical thinking, application of knowledge, and creativity, but it's also designed to allow each student to express their individuality however they choose with a wide open end point, so they can create well beyond the parameters of the project.
Evaluate The purpose for the EVALUATION stage is for both students and teachers to determine how much learning and understanding has taken place.	The rubric for the Musical Instrument Project is designed for growth. Students may not necessarily get full credit the first time, but through feedback and review they should be allowed to demonstrate mastery as they grow. The final days of the unit should include a peer review day. Call it a dress rehearsal where everyone brings in their instrument. Students then go around and review several of their peers' instruments using the rubric. They also work to group the instruments into sections, similar to an orchestra. This is usually done based on the source of the sound: string, percussion, wind, etc. This is also a great time to show the clip from Man with One Red Shoe showing how a few short measures of music were seen as a hidden code. Give students the challenge to create a hidden message in their music for tomorrow's performance. The second day is for performance. A good idea is to bring in an actual musician to be the conductor and help kids find their own rhythm or harmony for their instrument. Class can close with students sharing their secret messages and allowing other students to try to guess.

Name: ______________________________ Date: ____________________

Student Exploration: Longitudinal Waves

Vocabulary: antinode, compression, displacement, frequency, interference, longitudinal wave, medium, node, rarefaction, standing wave



Prior Knowledge Question (Do this BEFORE using the Gizmo.)

In many science fiction movies, an evil alien spaceship explodes with an enormous KABOOM!!

Suppose you were floating in space at a safe distance from a large explosion such as the supernova at left. Do you think you would you hear anything? Explain.

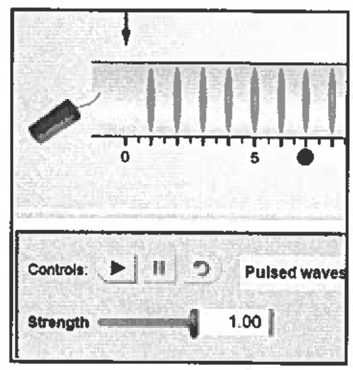
____

____

____

Gizmo Warm-up

No sounds can be heard in outer space because sound waves require a **medium**, such as air, to travel through. Sound waves are examples of **longitudinal waves**, or waves in which particles move back and forth in the same direction as the wave.



You can use the *Longitudinal Waves* Gizmo™ to explore the behavior of sound waves. In the Gizmo, an air-filled tube contains 24 evenly-spaced, airtight dividers. To begin, select the **Pulsed waves** setting and the **Open tube**. Set the **Strength** to 1.00. Deselect the graph options at lower right.

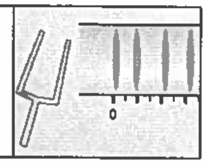
1. Click **Play** (▶) to set off the firecracker by the left end of the tube. What do you see?

   ____

   ____

2. Do any individual air molecules travel the length of the tube? ____________________

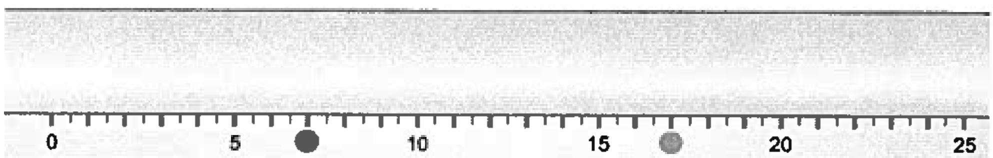
   How do you know? ___________________________________

Activity A: Observing longitudinal waves	Get the Gizmo ready: • Click **Reset** (↺). • Select **Continuous waves**. Check that the **Strength** is 1.00 and **Freq.** is 30 Hz.	

Introduction: When you strike a tuning fork on a hard surface, the tines of the fork start to vibrate back and forth at a certain **frequency**, or number of cycles per second. This motion causes nearby molecules to move back and forth, creating sound waves. The greater the frequency of the sound wave, the higher pitched the sound will be.

Question: What happens to air as a sound wave passes through it?

1. Observe: Click **Play**, and then click **Pause** (⏸) after about 70 simulated milliseconds (does not have to be exact). Sketch the current positions of the dividers below.



2. Identify: Longitudinal waves have two important features. **Compressions** are regions where particles are squished together. **Rarefactions** are regions where particles are spread apart.

   In your diagram above, draw a red rectangle around each compression and a blue oval around each rarefaction. (Note: The dividers were originally spaced one meter apart.)

3. Observe: Turn on the **Displacement** graph. The **displacement** of a divider is equal to the change from its original position. The original positions of the red and green dividers are shown by the red and green dots below the tube.

   In which direction has the red divider moved? __________ The green divider? __________

4. Interpret: Compare the displacement graph to the dividers in the tube.

   A. How does the graph represent movement to the right? ______________________

   ____

   B. How does the graph represent movement to the left? ______________________

   ____

(Activity A continued on next page)

Activity A (continued from previous page)

5. Analyze: Compare the displacement graph to the tube. What do you notice about the displacement near the center of a compression or a rarefaction?

____

____

6. Observe: Click **Play**. How is the progress of the longitudinal waves shown on the displacement graph?

____

____

7. Explore: Click **Reset**. Experiment with different values for the **Strength** and **Freq.** of the tuning fork.

   A. How does changing the strength of the fork's vibration affect the characteristics of the longitudinal wave? ____

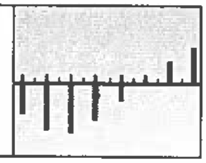
   ____

   ____

   B. How does changing the frequency of the fork's vibration affect the characteristics of the longitudinal wave? ____

   ____

   ____

Activity B: Explaining longitudinal waves	Get the Gizmo ready: • Click **Reset**. • Set the **Strength** to 1.00 and **Freq.** to 30 Hz.	

Question: What causes particles to move back and forth as a wave passes?

1. Observe: Turn off **Displacement** and turn on **Pressure**. Click **Play**, and then click **Pause** after about 100 milliseconds. Identify the compressions and rarefactions in the tube.

   A. What do you notice about the air pressure in the compressions? ______________

   B. What do you notice about the air pressure in the rarefactions? ______________

   C. How does the spacing of dividers in the tube relate to the air pressure? ______________

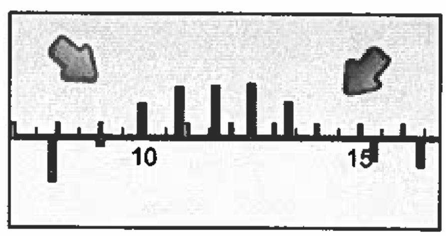
2. Predict: You can predict the motion of a divider by comparing the air pressure on either side.

   A. Look at the bar representing the red divider. Is the air pressure higher in the chamber to the left or to the right of the divider? ______________

   B. In which direction do you think the divider is being pushed right now? ______________

   C. Click **Play**. Were you correct? Explain. ______________

3. Compare: Click **Pause**. Open the **Tools** palette at top right. Drag an arrow to a region of the graph where the pressure increases from left to right and a second arrow to a region where the pressure decreases from left to right. An example is shown at right.



   Turn off **Pressure** and turn on **Acceleration**.

   What do you notice? ______________

(Activity B continued on next page)

Activity B (continued from previous page)

4. Analyze: What can you say about the acceleration of dividers when the pressure increases from left to right? ____________________

   ____

   What can you say about the acceleration when the pressure decreases from left to right?

   ____

5. Make a rule: Based on what you have observed, how can you predict the acceleration of a divider based on the pressure graph? ____________________

   ____

6. Think and discuss: Why do you think a longitudinal wave is also called a *pressure wave*?

   ____

7. Compare: Return the arrows to their tray and turn on the **Displacement** graph. How is the displacement graph related to the acceleration graph? ____________________

   ____

8. Explain: To explain this relationship, imagine a single divider moving back and forth between two stationary walls.

   A. What happens to the air pressure on each side of the divider as it moves to the right?

      ____

   B. What happens to the air pressure on each side of the divider as it moves to the left?

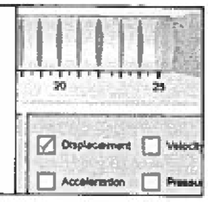
      ____

   C. How does this explain the acceleration of the divider? ____________________

      ____

      ____

The fact that acceleration opposes displacement helps to explain the *harmonic motion*, or back-and-forth motion, of many waves.

Extension: **Standing waves**	Get the Gizmo ready: • Click **Reset**, and select a **Closed tube**. • Set the **Strength** to 0.10 and **Freq.** to 14 Hz. • Check that **Displacement** is on. • Turn off **Velocity, Acceleration**, and **Pressure**.	

Introduction: When waves hit a wall, they often bounce back. The reflected waves can interact with the oncoming waves in a phenomenon called **interference**. Interference can increase or decrease the strength of waves, depending on how the waves are lined up.

Question: What is the result of wave interference?

1. Observe: Click the *zoom in* button (+) on the graph twice. Click **Play**, and watch the simulation for about 500 milliseconds of simulation time.

   A. Over time, do the waves in the graph seem to be changing in size? ______________

   B. If so, are the waves getting bigger or smaller? ______________________________

   C. Are there dividers that seem to move less than the other dividers? ______________

   D. Can you see the path of individual waves from left to right in the tube? ___________

2. Label: What you are watching is a **standing wave**. This occurs when the waves that reflect off the right wall of the tube interact with the waves moving down the tube from left to right.

   A. Locate the three points that do not show much displacement at all, and mark them with arrows from the POINTER tray. These are the **nodes** of the standing wave. Click the camera icon (📷) to take a snapshot of this graph. Right click the image, choose **Copy**, and then paste the image into a blank document. Label this image "Nodes of a standing wave."

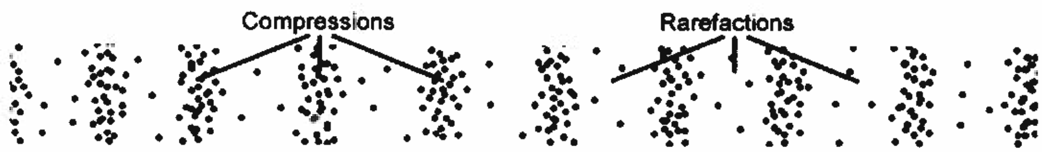
   B. Return the arrows marking the nodes, and now mark the **antinodes** where displacement is maximized. Take a snapshot, paste it into your document, and label this image "Antinodes of a standing wave."

3. Challenge: Experiment with other values of **Strength** and **Freq.** to create other examples of standing waves. What values of **Strength** and **Freq.** lead to a standing wave with four nodes? Five nodes? Describe your results on a separate page.

Vocabulary: Longitudinal Waves

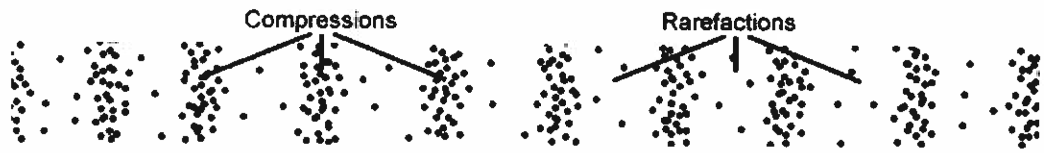
Vocabulary

- Antinode – a point on a *standing wave* where the *displacement* is maximized.
- Compression – a region within a *longitudinal wave* where the density of the *medium* is relatively high.
    - For a sound wave passing through air, compressions are regions where air particles are pushed together. (*Rarefactions* are areas where particles are spread apart, as shown below.)



- Displacement – the difference between an object's current position and its original position.
    - If an object has moved to the right, its displacement is positive. If it has moved to the left, its displacement is negative.
- Frequency – the number of times something occurs in a given period of time.
    - The frequency of a sound wave is equal to the number of waves that pass a point each second.
    - The unit of frequency is the hertz (Hz). One hertz is one event per second.
    - The shorter the wavelength of a wave is, the greater its frequency. Longer wavelengths correspond to lower frequencies.
- Interference – the superposition of two or more waves which results in a new pattern.
- Longitudinal wave – a wave in which the back-and-forth motion of the medium is aligned with the motion of the wave.
- Medium – a substance through which waves can travel.
    - For example, sound waves can pass through a gas such as air, a liquid such as water, or a solid such as glass.
    - Unlike light waves, sound waves require a medium. Light can travel through the vacuum of space, but sound waves cannot.
- Node – a point on a standing wave where the displacement is zero.

- Rarefaction – a region within a longitudinal wave where the density of the medium is relatively low.
    - For a sound wave passing through air, rarefactions are regions where air particles are spread apart.



- Standing wave – a wave that does not appear to travel (propagate) in any direction.
    - Standing waves are often produced by interference between advancing waves and reflected waves.

Musical Instrument Building Project

For this assignment you will spend 1 week going through the engineering design cycle to create a unique musical instrument. This should not be an assignment you complete in a day or two as you are required to document your progress and keep track of things that don't work.

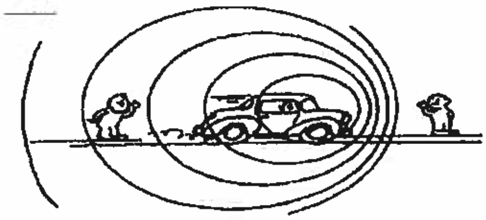
Specifically, you will be evaluated by:

- Creative use of household objects. The less you spend at the store, the better your grade.
- Don't try to recreate an existing instrument. Be creative.
- Being creative means you might hit some walls and bumps. Keep working. Document your errors and failures. This is part of the design cycle.
- Make sure you can bring your instrument to school. Don't make it so large or cumbersome that you can't bring it to share.
- Think about the different ways you can make a sound with an instrument. You can blow, beat, strum, scrape or maybe even something else. Design your instrument with your sound procurement in mind.
- Your instrument should be able to play at least one complete octave.
- Your engineering journal should keep track of each trial. A brief written narrative should accompany each step to document what worked, what didn't and what you expect to try next.
    - This journal could be a combination of text and images, or just text. Your choice.
- Be sure to connect with your parents. They just might enjoy the project AND you won't get in trouble to using household items they aren't ready to part with.

Rubric	3 points	2 points	1 point	Total
Materials	All materials acquired from scrounging around the house.	Minimal pieces needed to be purchased.	All materials purchased for project.	
Perseverance	Project is complete on time!	Project is nearly complete, but extra time needed.	Project was begun, but not finished.	
Ingenuity	A completely unique instrument.	An instrument inspired by a current instrument.	An instrument fully modeled after an existing one.	
Portability	Easily carried and transported to any location for playing.	The instrument requires some assembly to be played after arrival.	The instrument is unwieldy and needs help for transport and/or set up.	
Octave	8 (or more) clear notes!	There is a clear progression of pitch/tone, but not necessarily an octave.	Pitch and tone are varied, but there is no octave.	
Engineering journal	Clear progression of thought from vision to completion, with reflection on errors as opportunities.	Notes and images represent some progression, but lacks clarity of process.	Minimal notes submitted, may or may not represent the EDC.	

Doppler Effect Worksheet Name:____________________

1. When an automobile moves towards a listener, the sound of its horn seems relatively
   a. Low pitched b. High Pitched c. Normal



2. When the automobile moves away from the listener, its horn seems
   a. Low pitched b. High Pitched c. Normal

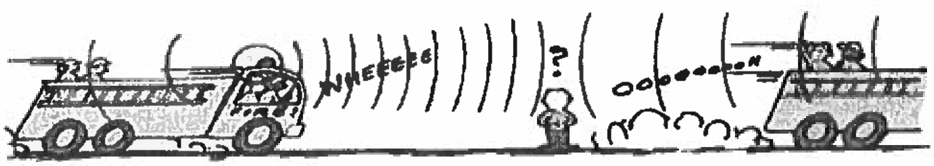
3. The changed pitch of the Doppler effect is due to changes in
   a. Wave speed b. wave frequency

4. Circle the letter of each statement about the Doppler Effect that is true.
   a. It occurs when a wave source moves towards an observer
   b. It occurs when an observer moves towards a wave source
   c. It occurs when a wave source moves away an observer
   d. It occurs when an observer moves away a wave source

5. True / False: A moving wave source does not affect the frequency of the wave encountered by the observer.

6. True / False: A higher frequency results when a wave source moves towards an observer.

7. Two fire trucks with sirens on speed towards and away from an observer as shown below.



   A) Which truck produces a higher than normal siren frequency?
   B) Which truck produces a lower than normal siren frequency?

8. Which sound property describes how high or low a sound seems to a person?

____

9. The police car has passed the woman standing on the sidewalk, but has not yet passed the man. Which observer hears the siren at a higher pitch?

____

____

10. What happens to the pitch of the siren heard by the man as the police car goes past him and moves away?

____

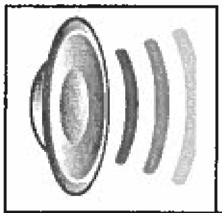
11. Is the frequency of the siren in the picture changing along with the pitch?

____

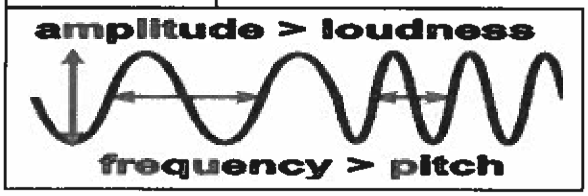
12. If you were riding in the police car, what change would you hear in the pitch of the siren as you moved away from the woman?

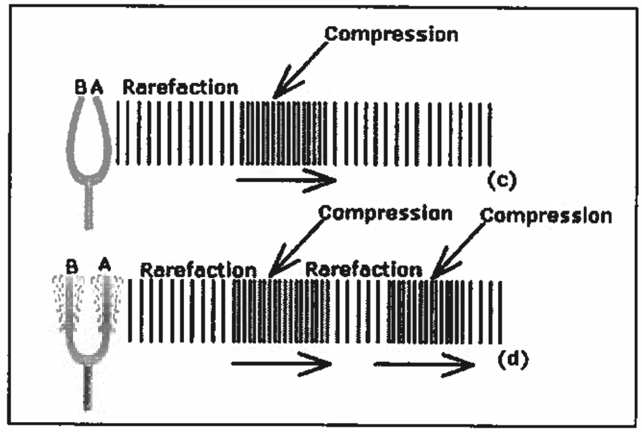
____

Name: ____________________ Date: ____________ Class: ______



Sound Web Quest





Go to this website: http://www.philtulga.com/MSSActivities.html

1. What is the unit for volume or loudness: ____________________ How is it abbreviated: ________

2. According to this website, how fast can sound travel? ______________________________

3. Will sound travel faster at 58°C or 88°C? ______________

Explain why this happens? ______________________________

4. Based on what you learned from question #3, answer the following questions about the speed of sound by writing down the medium in which you think sound would travel faster through:

a. Water ***or*** air (write down which one)
b. solid ***or*** air (write down which one)
c. water ***or*** solid (write down which one)

d. Explain why you think these are going to move faster? ______________________________

5. Go to number 5 on the website titled **Waves**: read it and click on the hyperlink **Thunderstorm Stopwatch** activity.
a. If it takes 10 seconds for it to thunder after it lightning strikes how far is the storm? ____________

b. If it takes 20 seconds how far is the storm? ______________

6. Objects which vibrate faster produce a higher ______________, and objects which vibrate more slowly produce a lower ______________.

7. If you make a musical instrument shorter, will it have a higher ***or*** lower frequency?

8. Draw a tuning fork on your paper. Then draw a diagram similar to the one on the website that's shows how many waves will pass in 1 second if it has a frequency of 10 Hz

Go to this website: http://www.glenbrook.k12.il.us/gbssci/Phys/Class/waves/u10l1a.html

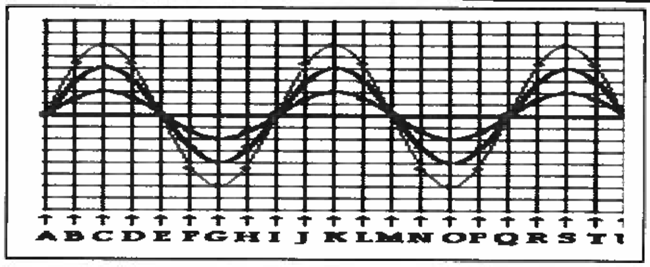
Click on the Transverse and Longitudinal Wave Applet

9. A transverse wave is a wave in which particles of the medium move in a direction ________________ to the direction which the wave moves.

a. Label the crests and troughs:

b. Label 2 wavelengths on this wave

c. Label 2 amplitudes on this wave

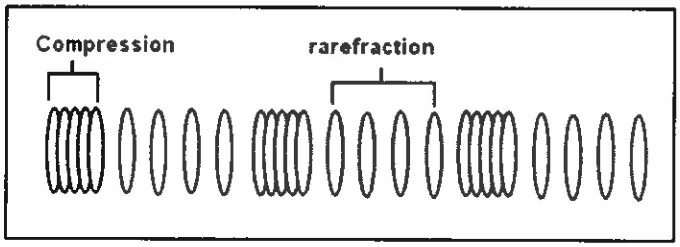


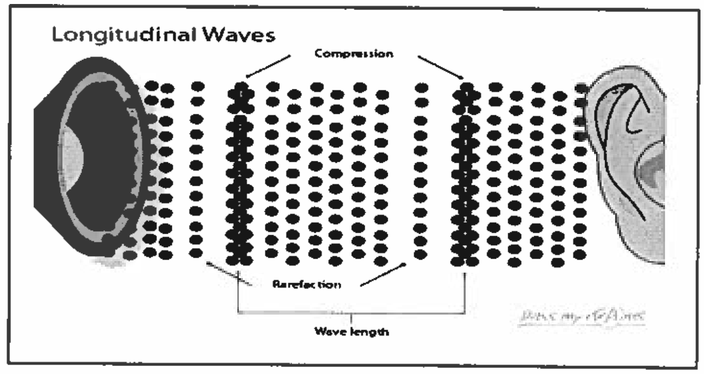
10. A longitudinal wave is a wave in which particles of the medium move in a direction ________________ to the direction which the wave moves.

a. When particles or waves are clustered together in a longitudinal wave they are called ______________

b. When particles or waves are spread apart in a longitudinal wave they are called _________________

c. Label all of the compressions (C) and Rarefactions (R) by drawing a diagram of a longitudinal wave similar like the examples that you see here....





11. Assume that the diagrams below are the number of waves produced in 1 second. Rank them in order 1-6, one being the highest frequency and 6 being the lowest frequency.

a. ______ 

b.______ 

c.______ 

d.______ 

e. ______ 

f. ______ 

Go to this website: http://www.school-for-champions.com/science/sound.htm

12. Does sound travel in a vacuum? _________ Why? ____

13. Under the heading **"Characteristics of Sound,"** copy the equation for the velocity of sound.

____

14. Take the mini-quiz by clicking on the gray tab at the top of the web page. Write the correct answers on your paper.

1)___________ 2) _____________ 3) ___________