Created by Jason van Tol

The Physics of Music – Lesson 1

Materials:

- Paper for name tags (x12)	- Laptop with speakers & power cord
- Slinky	- Printout of Longitudinal Sound Wave and Transverse Model
- Whiteboard + Markers (x3)	- Printout of Constructive and Destructive Interference Check
- Guitar	- Clarinet
- Piano (keyboard)	

Introduction

Make name tag on top of paper, plus three things you like or like to do (**for me to take home**). I go first. In pairs, introduce partner to me (and rest of group).
(10 min)

Overview of Topic

We're going to explore the science (and maybe a bit of math depending on students' interest and numeracy skills) of sound and music. We will look at learn how to use a wave to model sound; the proper vocabulary to talk about different characteristics of sound waves; and of course how sound waves and their properties can be used to compose music. Finally, hopefully by the end of the unit we can make our own simple instruments, explore different sounds, and play some music!

Title Page: Get students to make a title page in their notebooks for the unit. Title: Acoustics and the Physics of Music.

Questions, Questions, Questions! (ORALLY)

The basis of one's own education is asking questions – questions about things that you care about and are interested in.

On your sheet of paper with your name tag, write down any questions you have and things you would like know about sound and music (**for me to take home**). First on own or in pairs, then share one with group. **Can be anything!!**
Examples:
- What is a sonic boom, and how does it work?
- Why are some people deaf? What is tone deafness?
- Why are the frets on a guitar not evenly spaced?
(5 min).

Star Wars!

What's wrong (physically impossible) with the following scenes from Star Wars:

https://www.youtube.com/watch?v=g54KvnPWdO8&list=RDg54KvnPWdO8&start_radio=1

Sound Fact to Write Down: Sound needs a medium (a physical material) to travel through. If you were in outerspace, you could not have a conversation – nor breathe! There's no air for the sound to travel through. Tell this to the directors of Star Wars!

Question: Do you think you could have a conversation underwater? Try it next time you're at the beach or pool; or even in your bathtub?
(5 min)

Scientific Models:

In science, we use models to understand the world around us. A model is a simplified version of some part of the world that we wish to study. A common model used in science to study a range of phenomena, including sound, is a wave.

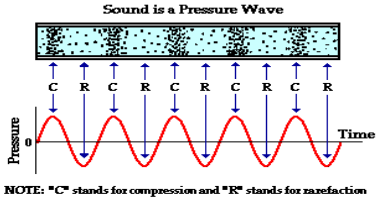
Transverse vs Longitudinal waves:

Demonstrate using **SLINKY** Transverse and Longitudinal waves.

Science Fact to Write / **Diagram** Down:
Transverse Waves: the *medium* moves *perpendicular* to the direction of the wave.
Longitudinal Waves: the *medium* moves *parallel* to the direction of the wave.
(Might have to teach parallel and perpendicular)
(10 min)

Question / Think, Pair, Share: Which one of these wave models, a longitudinal wave or a transverse wave, is a better, or more accurate model for sound? DON'T ANSWER YET – CONTINUE BELOW
(5 min)

Compressions and Rarefactions
To help answer the question above, consider the diagram below. On top, a sound wave is shown moving through the air, with high and low pressured air particles – high pressure where they are bunched up, low pressure where they are sparse. Below, is a diagram showing the air pressure – again, high when the air particles are bunched together, low where there are few of them. Some important vocabulary:
Compressions: The high pressure places on the wave.
Rarefactions: The low pressure places on the wave.



Now go to:
http://www.physicsclassroom.com/class/sound/Lesson-1/Sound-is-a-Pressure-Wave
For a simple video, and for a more detailed video, try:

http://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Simple-Wave-Simulator/Simple-Wave-Simulator-Interactive
(don't rush this, take time to ensure that everyone gets this)

Summary to write down: A *sound wave is a longitudinal wave*; the air particles move parallel to the direction of the wave, being compressed and rarefied. However, we usually *model sound as a transverse wave* because it's easier to 'see' the wave move, just like with the slinky. Also, although the sound wave moves through air as a longitudinal wave, the source of the sound (a guitar string, your vocal chords, or even just your washing machine) in many cases will vibrate as a transverse wave.
(10 min)

Ruben's Tube:
Watch the following video of a Ruben's Tube:
https://www.youtube.com/watch?v=gpCquUWqaYw

Question: Using your knowledge of sound waves, how can you explain what you see?
(5 min)

BREAK TIME
(5 min)

After break recap; We know that:
- sound needs a medium through which to travel
- sound is a longitudinal wave; made up of air particles being compressed and rarefied as it travels
- we often model sound as a transverse wave because it makes it easier to see

Segue: The Sound of Music:
So far we have just been talking about the nature of sound, but music is more than just any old sound. Often times we want to produce particular sounds.

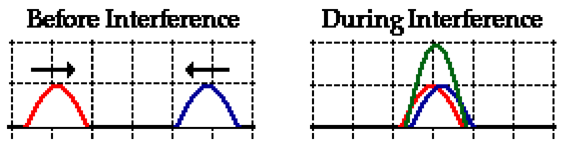
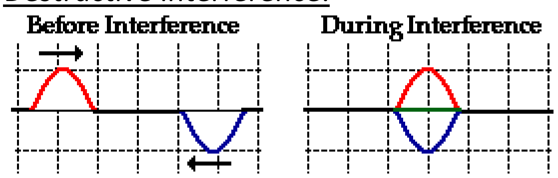
Travelling versus Standing waves (Nodes and Anti-nodes):
Demonstrate again using the slinky, travelling and standing (transverse) waves.

Ask students to describe what they see. (Don't worry about harmonics yet).

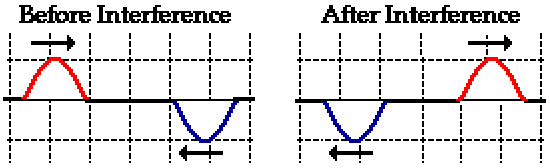
Science Fact to diagram and write down:
Travelling wave: A wave that moves through the medium
Standing wave: A wave that appears to stay still in some parts, and vibrate only in others – it appears to 'stand' in particular places in the medium. Standing waves are important for producing music.
(5 min)

<u>Question / Think, Pair Share</u>: How/why does a standing wave occur? Why don't we see any waves travelling up and down the medium as we do in a travelling wave??
(5 min)

<u>Constructive and Destructive Interference</u>:
Explain: when two waves travelling through a medium meet, we say that they interfere with one another. Draw, and get st.s to draw, the following diagrams:

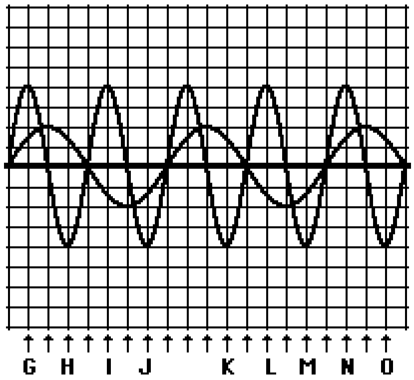
Constructive Interference:	Destructive Interference:
	

Note also that interference does not alter each individual wave in any way:



This adding or subtracting of waves that interfere with one another is called the <u>Principle of Superposition</u>. One application of destructive interference is in <u>NOISE CANCELLATION HEADPHONES</u>.
(10 min)

<u>Check your understanding:</u>
Which letters represent a place where constructive interference occurs? Destructive?



<u>Interference with the *Right Timing* causes Standing Waves</u>
Answer to Question and Think, Pair, Share from about: Explain, (don't rush this), and look here:
http://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Standing-Wave-Patterns/Standing-Wave-Patterns-Interactive
<u>Nodes and Anti-nodes</u>:

Also, the places where we get no net displacement of the medium (where the medium appears at rest) are called nodes. Places where we get maximum displacement are called anti-nodes.
(5 min)

Harmonics:
A standing wave with one antinode is called the first harmonic. A standing wave with two antinodes is called the second harmonic. A standing wave with three antinodes is called the third harmonic, and so on.
Demonstrate with SLINKY again if apt.

Number of Antinodes	Number of Nodes	Harmonic Name	Diagram
1	2	First harmonic	
2	3	Second harmonic	
3	4	Third harmonic	
4 …	5 …	Fourth harmonic …	 …

(10 min)

Acoustic Levitation:
Watch the following video Acoustic Levitation.

Questions: Using your knowledge of standing waves, how can you explain what you see? What do you think the man is doing when he turns the knob on the oscilloscope? Explain.
(5 min)

The importance of standing waves in music:
In music, many instruments produce standing waves with a series of harmonics superimposed on top of another (that is they will interfere with one another as discussed above). When you pluck the string on a guitar, for example, you generate a certain combination of harmonics, each with its own volume and decay, which determines the unique sound of the instrument.

Can you hear the difference?
Although we haven't yet discussed exactly what a note is, go ahead and play a note common to the piano (keyboard), guitar, and clarinet. Recommend middle C – it's easy to play with one hand on the clarinet.
Close your eyes and see if you can hear the difference.
(10 min)

Evelyn Glenni:
Although you can use your ears to hear the sounds of the clarinet, piano, guitar and everything else, Evelyn Glenni is deaf. Watch the video of her performing.

Question: How do you think she's able to play along with the rest of the orchestra? Hint: She always performs barefoot.
(5 min)

Homework:
Start thinking about /researching (if possible) ways to make some simple instruments.

Summary + Feedback

So what did we learn today? Was there anything interesting or surprising? **ANY QUESTIONS** about anything we did today?

Tell me what you liked or didn't like and ways to improve next lesson?
(10 min)

Other ideas:
Show Chladni plate, Daniel Kish