Created by Jason van Tol

The Physics of Music – Lesson 3

Materials:

- Paper for notes	- Laptop with speakers & power cord
- Slinky	- Printout of Longitudinal Sound Wave and Transverse Model
- Whiteboard + Markers (x3)	- Kalimba
- Guitar + TUNER	- Clarinet
- Piano (keyboard)	- Didgeridoo

Introduction / Review of Lesson 1

If new st., get others to explain core ideas from last lesson. If not, get them to explain to the group what they recall.
(5 min)

Overview of Topic

In the first half of this lesson we're going to again extend the ideas we learned in the last lesson. This will cover the use of standing sound waves to produce harmonics, and the use of the mathematical wave model we looked at to represent the volume and pitch of a sound, all of which are essential in music. In the second half of the lesson I'm also going to ask all students to start researching some aspect of, or phenomenon relating to, sound / music. The aspect or phenomenon can be anything you're interested in, so long as it has something to do with sound / music. You can work alone or as a pair. There's no time limit to your presentation – it's basically an opportunity to apply some of the concepts and models we've looked at to teach your friends about something you find interesting, and hopefully include some of the concepts and principles we've learned. We will give the presentations in the last week (week 4) so that you have plenty of time to prepare.

Recap: Interference with the *Right Timing* causes Standing Waves

Answer to Question and Think, Pair, Share about Standing Waves are created by Traveling ones: Explain, and **HIDE GREEN WAVE** (don't rush this), here:
http://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Standing-Wave-Patterns/Standing-Wave-Patterns-Interactive

HIDE GREEN WAVE, SHOW BLUE AND ORANGE TRAVELLING WAVES IN SLO-MO. PERIODICALLY GET ST.S THE CHECK THEIR UNDERSTANDING OF INTERFERENCE. THEN REVEAL:
Nodes and Anti-nodes:
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 or website again if apt.
Activity GET STUDENTS TO FILL OUT TABLE, INCLUDING DIAGRAM, either on own notes, or on whiteboard

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)

TIMBRE - The importance of harmonics (standing waves) in music:
All Class Question: Who's heard of the word 'timbre'? What does it mean? How does it relate to harmonics?
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 – called the **TIMBRE**.

Review Wave Model:
Recall mathematical model from last week on DESMOS. We looked at a wave with equation: y=Asin(Bx+C) +D, and st. came up with their, essentially correct explanation of what changing A, B, C, and D do the resulting waveform. We're going to focus specifically on A and B as these are essential in music:
(5 min)

Amplitude and Frequency:
Teach:
A is called the ***amplitude*** of the wave and determines the ***volume*** of the sound. The higher the amplitude, the louder the sound. CAN DEMO WITH GUITAR. The **volume is measured in decibels**, which is a measure of relative sound pressure.

B is called the ***frequency*** of the wave and determines the ***pitch*** of the sound. The higher the frequency – the greater the number of *cycles* in on second, the higher the pitch. Again, can demo with guitar. **Frequency is measured in Hertz**,
B can also represent the *wavelength*; the frequency and the wavelength are inversely related:

Frequency= 1/wavelength.
In other words, the higher the frequency the shorter the wavelength, the lower the frequency, the longer the wavelength.
C and D are horizontal and vertical shifts respectively.
(5 min)

Chladni Plate:
Watch the following video of a Chladni Plate.

Questions: Using your knowledge of standing waves, how can you explain what you see? Is the sand lying at the nodes or anti-nodes? What do the Hertz represent and why do you think changing them changes the patterns on the plate? Explain.
(5 min)

Can you hear the difference? Similarity?
All class activity We will discuss what exactly a note is in a minute, but 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.

All class activity When I play my didgeridoo, can you use the piano keyboard to determine what note it is? Don't worry about the name of the note yet, just use your ears to listen for the one that sounds most similar.
(10 min)

Notes on Notes:
Music is composed of sounds from individual instruments (TIMBRES). However, most instruments can produce many different frequencies, or pitches, and each one of these is called a **NOTE**.
When an orchestra tunes up together, they all tune their instruments to **middle A**, which has a frequency of **440 Hz**. **Middle C**, which is close to the middle of a grand piano, has a frequency of about **262 Hz**.
The human ear can detect frequencies roughly in the range from 20 Hz (the most bassy), to about 20,000 Hz, though the range declines as we age. Other animals have different ranges of detectable frequencies.
People with perfect pitch can hear and name specific pitches. For example, a car horn may be a B-flat (or close to it).
All class activity Some instruments are tuned to completely different frequencies, and pitches, than those of western musical instruments. **DEMO KALIMBA WITH TUNER.**
(5 min)

Intervals
The difference between two notes is called an interval. Musical instruments are designed to play specific notes with specific intervals. That is, to sound notes that are a particular 'distance' apart. More specifically, in Western music, the smallest interval – that is, the frequency ratio between any two successive notes, is given by $\sqrt[12]{2} \approx 1.059$ ... and is called a semitone. However, the most important interval is called the octave, which is a doubling

of the frequency of a note. In fact, octaves are so important, that the notes they generate have the same name. (i.e. one octave above middle C is still a C!).

ActivityIn pairs/alone:
- See if you can come up with the frequency of the notes one, two, and three octaves above middle C. Middle A.
- See if you can come up with the frequency of the notes one, two, and three octaves ***below*** middle C. Middle A.
- See if you can come up with the frequency of the notes one semitone above middle C. One semitone below middle C. One semitone above and below middle A. (You might need a calculator for this).
Any questions about this topic??
(10 min)

BREAK TIME
(5 min)

Suggestions for Sound / Music Research Topics:
Next week you will present to the class something you know about a topic related to sound / music. You can choose whatever topic you like, so long as it's related to sound / music. If you're having trouble coming up with a topic, here are a few suggestions of questions that I happen to think are interesting:

- Why are some people deaf and what causes it?
- Why are some people tone deaf and what causes it?
- What is perfect pitch, how many people have this ability and what causes it?
- What is a sonic boom and how/why does it happen?
- Why are the frets on a guitar board not evenly spaced? Why are they spaced the way they are?

(5 min)

Research Time!:
(30 min)

Playing Musical Instruments:
Activity – Alone or in Pairs Now you try: play sounds on an instrument of your choice, and try and adjust the amplitude (volume) and frequency (pitch) of the notes you play. Think about the difference in the wave forms you're playing while playing them.
See if you can use the piano keyboard to the same note another instrument.

****CHALLENGE QUESTION****: Can you determine the frequency of a random note you select on your instrument?
(10 min)

Jam Time:
Pairs or all Group Pick up an instrument and let's have a jam!
(10 min) (120 min to here)

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

<u>Summary + Feedback</u>

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?
(5 min)

<u>Other ideas:</u>
Daniel Kish