Created by Jason van Tol

The Physics of Music – Lesson 2

Materials:

- Paper for notes	- 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)	- Students' Name Tags

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

This lesson we're going to extend the ideas built up in the first lesson. We'll look at what causes standing waves and how they are used in the production of music. Also, we're going to have a go at some mathematics used to model these waves and we'll need some computers to do this. One computer between two or three students will be enough. Oh, and of course, we'll have a go at playing your instruments!

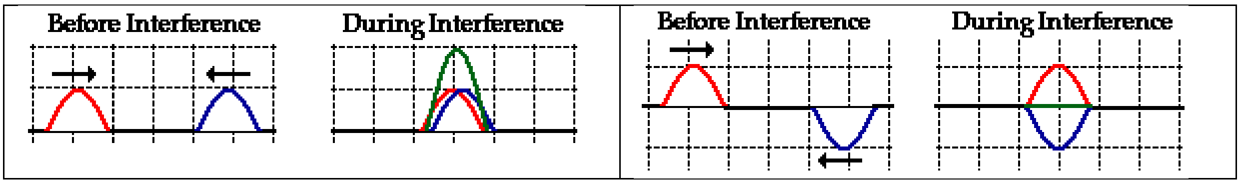
Recap of Standing Waves

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

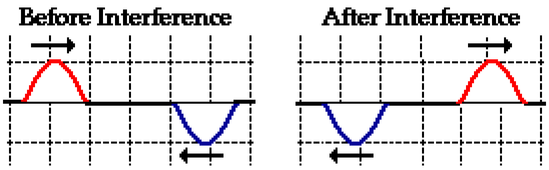
Question / Think, Pair Share: How/why does a standing wave occur? Why don't we see any waves travelling up and down the medium as we do in a travelling wave?? Where do the travelling waves go?
(5 min)

Constructive and Destructive Interference:
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:



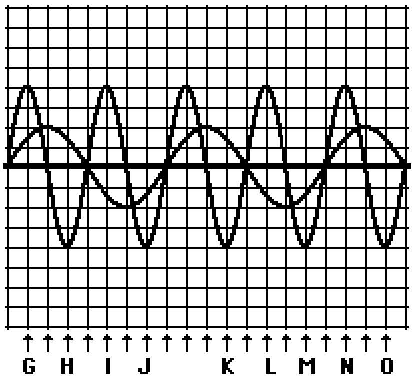
Note also that interference does not alter each individual wave in any way:



(5 min)

Check your understanding:

ALONE OR IN PAIRS Which letters represent a place where constructive interference occurs? Destructive?



(5 min)

Noise Cancellation Headphones:

This adding or subtracting of waves that interfere with one another is called the Principle of Superposition. One application of destructive interference is in NOISE CANCELLATION HEADPHONES.

ACTIVITY: Get st.s to draw a wave – ask if they want to draw the 180 degree opposite cancellation wave ALONE OR IN PAIRS.

(5 min)

Interference with the *Right Timing* causes Standing Waves

Answer to Question and Think, Pair, Share from about: 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)

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. Are the balls / bubbles at the nodes or anti-nodes?
(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 – called the **TIMBRE**.

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)

BREAK TIME
(5 min)

DESMOS Exploration:
I introduce DESMOS to students and show them how to use the site.
In Pairs/Threes: Get st.s to play around with the equation y = 2sin(2x+2) +2, *by changing one number at a time*. And to determine what A, B, C, and D represent for the wave with equation: y=Asin(Bx+C) +D
(20 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)

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.
(5 min)

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

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