# TALKING ABOUT SOUND AND MUSIC\*

## Catherine Schmidt-Jones Nelson Lee

Based on Talking about Sound and  $Music^{\dagger}$  by Catherine Schmidt-Jones

This work is produced by The Connexions Project and licensed under the Creative Commons Attribution License  $^{\ddagger}$ 

#### Abstract

For middle school and up, an introduction to some acoustics terms and how they relate to music.

Music is the art of sound, so let's start by talking about sound. Sound is invisible waves moving through the air around us. In the same way that ocean waves are made of ocean water, sound waves are made of the air (or water or whatever medium) they are moving through. When something vibrates, it disturbs the air molecules around it. The disturbance moves through the air in waves - each vibration making its own wave in the air - spreading out from the thing that made the sound, just as water waves spread out from a stone that's been dropped into a pond.

<sup>\*</sup>Version 1.1: Mar 13, 2006 7:34 pm -0600

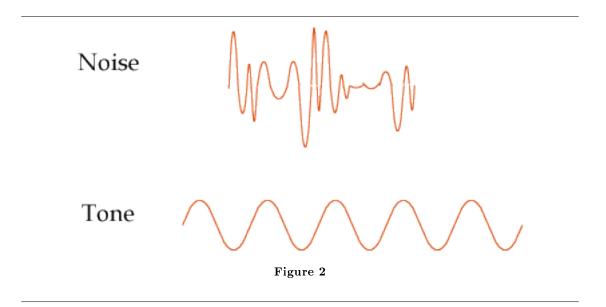
<sup>†</sup>http://cnx.org/content/m12373/1.2/

<sup>&</sup>lt;sup>‡</sup>http://creativecommons.org/licenses/by/2.0/



Figure 1: A ripple in water causing waves to propagate from the point where presumably drops of water fell.

Connexions module: m13512 3



A tone (the kind of sound you might call a musical note) is a specific kind of sound. The vibrations that cause it are very regular - all the same size and same distance apart. Musicians have terms that they use to describe tones. But this kind of (very regular) wave is useful for things other than music, so scientists and engineers also have terms that describe tonal sound waves. It can be very useful to know both the scientific and the musical terms and how they are related to each other.

For example, the closer together the waves of a tonal sound are, the higher the note sounds.

#### Wave and Sound Interaction

The following link is to an animation that will help one build intuition between frequency (how close waves are to one another) and the tonal pitch one actually hears. Click  $here^1$ .

- For starters, in the lower box on the right-hand side under "Audio Control", click on the box "Audio enabled".
- Within the "Audio Control" box, click on "Listener". This will allow you to hear the waves the person in the application is hearing.
- Adjust the "Amplitude" bar. How does the wave look differently? How does it affect the sound?
- Slide the "Frequency" bar. How does this affect how the waves appear as they travel to the listener. How does the pitch change to the listener?

#### Key Terms and Definitions of Them

Musicians talk about the pitch<sup>2</sup> of the sound, or name specific notes<sup>3</sup>, or talk about tuning<sup>4</sup>. Scientists and engineers, on the other hand, talk about the frequency<sup>5</sup> and the wavelength<sup>6</sup> of the sound. They are all essentially talking about the same thing.

#### The Concepts and Where to Find Them

```
1 http://cnx.org/content/m13512/latest/sound.jnlp
2 "Pitch: Sharp, Flat, and Natural Notes" <a href="http://cnx.org/content/m10943/latest/">http://cnx.org/content/m10943/latest/</a>
3 "Duration: Note Lengths in Written Music" <a href="http://cnx.org/content/m10945/latest/">http://cnx.org/content/m10945/latest/</a>
4 "Tuning Systems" <a href="http://cnx.org/content/m11639/latest/">http://cnx.org/content/m10945/latest/</a>
5 "Frequency, Wavelength, and Pitch", Figure 1: Wavelength, Frequency, and Pitch <a href="http://cnx.org/content/m11060/latest/#fig1b">http://cnx.org/content/m11060/latest/#fig1b</a>
6 "Frequency, Wavelength, and Pitch", Figure 1: Wavelength, Frequency, and Pitch <a href="http://cnx.org/content/m11060/latest/#fig1b">http://cnx.org/content/m11060/latest/#fig1b</a>
```

• Wavelength - An introduction to wavelength, frequency, and pitch is presented in Frequency, Wavelength, and Pitch<sup>7</sup>. You can find out more about the (Western) musical concept of pitch in Pitch: Sharp, Flat, and Natural Notes<sup>8</sup>.

- Wave Size The other measurement you can make of regular, tonal waves is the size of each individual wave its "height" or "intensity" rather than its wavelength. In sound waves, this is a measurement of the loudness of the sound. Amplitude<sup>9</sup> is a short discussion of wave size. Musicians have many terms to discuss what they call Dynamics<sup>10</sup>.
- Types of Waves There are two basic types of waves. Most diagrams show transverse waves which "wave" up-and-down as they move left-and-right. These are easier to show in a diagram, and most of the familiar kinds of waves light waves, radio waves, water waves are transverse. But sound is made of longitudinal waves, which "wave" in the same direction that they move. These are harder to draw, and a little harder to imagine, than transverse waves, but you will find some helpful suggestions at Transverse and Longitudinal Waves<sup>11</sup>.
- Standing Waves Most natural sounds are not tones. In order to produce the extremely regular vibrations that make tonal sound waves, musical instruments, see Standing Waves and Musical Instruments<sup>12</sup> and Standing Waves and Wind Instruments<sup>13</sup>. To find out more about how the waves created in an instrument are related to each other musically, see Harmonic Series<sup>14</sup> and Tuning Systems<sup>15</sup>.
- Sound and Ears For a brief description of what happens when a sound reaches your ear, see Sound and Ears 16
- The Math Students struggling with the math needed for these ideas can look at Musical Intervals, Frequency and Ratio<sup>17</sup> and Powers, Roots, and Equal Temperament<sup>18</sup>.

#### Suggestions for presenting these concepts to a class

• Decide which of the concepts you will be presenting to your class, and prepare your lectures/presentations accordingly. You will probably need about one class period for each related set of concepts. Sound and Ears<sup>19</sup> is particularly geared towards younger students. The concepts in Frequency, Wavelength, and Pitch<sup>20</sup>, Transverse and Longitudinal Waves<sup>21</sup>, and Amplitude<sup>22</sup> can be presented to just about any age. Standing Waves and Musical Instruments<sup>23</sup>, Standing Waves and Wind Instruments<sup>24</sup>, Harmonic Series<sup>25</sup> and Tuning Systems<sup>26</sup> are probably best presented to older students (middle school and up). Musical Intervals, Frequency and Ratio<sup>27</sup> and Powers, Roots, and Equal Temperament<sup>28</sup> can be used either to remind older students of the math that they have learned and its relevance to music, or as extra information for younger students working on these math concepts.

```
<sup>7</sup>"Frequency, Wavelength, and Pitch" <a href="http://cnx.org/content/m11060/latest/">http://cnx.org/content/m11060/latest/</a>
 8"Pitch: Sharp, Flat, and Natural Notes" <a href="http://cnx.org/content/m10943/latest/">http://cnx.org/content/m10943/latest/</a>
 {\it 9} \verb|"Sound Amplitude and Musical Dynamics"| < | http://cnx.org/content/m12372/latest/> \\
10"Dynamics and Accents in Music" <a href="http://cnx.org/content/m11649/latest/">http://cnx.org/content/m11649/latest/</a>
11"Transverse and Longitudinal Waves" <a href="http://cnx.org/content/m12378/latest/">http://cnx.org/content/m12378/latest/</a>
12"Standing Waves and Musical Instruments" <a href="http://cnx.org/content/m12413/latest/">http://cnx.org/content/m12413/latest/</a>
13"Standing Waves and Wind Instruments" <a href="http://cnx.org/content/m12589/latest/">http://cnx.org/content/m12589/latest/</a>
^{14}"Harmonic Series" <http://cnx.org/content/m11118/latest/>
^{15}"Tuning Systems" <a href="http://cnx.org/content/m11639/latest/">http://cnx.org/content/m11639/latest/</a>
<sup>16</sup>"Sound and Ears" <a href="http://cnx.org/content/m12365/latest/">http://cnx.org/content/m12365/latest/</a>
17" Musical Intervals, Frequency, and Ratio" <a href="http://cnx.org/content/m11808/latest/">http://cnx.org/content/m11808/latest/</a>
18" Powers, Roots, and Equal Temperament" <a href="http://cnx.org/content/m11809/latest/">http://cnx.org/content/m11809/latest/</a>
^{19}"Sound and Ears" <http://cnx.org/content/m12365/latest/>
^{20} "Frequency, Wavelength, and Pitch" <\! http://cnx.org/content/m11060/latest/>
^{21} "Transverse and Longitudinal Waves" <\! http://cnx.org/content/m12378/latest/>
^{22}"Sound Amplitude and Musical Dynamics" < http://cnx.org/content/m12372/latest/>
23"Standing Waves and Musical Instruments" <a href="http://cnx.org/content/m12413/latest/">http://cnx.org/content/m12413/latest/</a>
<sup>24</sup>"Standing Waves and Wind Instruments" <a href="http://cnx.org/content/m12589/latest/">http://cnx.org/content/m12589/latest/</a>
^{25}"Harmonic Series" <a href="http://cnx.org/content/m11118/latest/">http://cnx.org/content/m11118/latest/</a>
<sup>26</sup> "Tuning Systems" <a href="http://cnx.org/content/m11639/latest/">http://cnx.org/content/m11639/latest/</a>
<sup>27</sup> "Musical Intervals, Frequency, and Ratio" <a href="http://cnx.org/content/m11808/latest/">http://cnx.org/content/m11808/latest/</a>
<sup>28</sup>"Powers, Roots, and Equal Temperament" <a href="http://cnx.org/content/m11809/latest/">http://cnx.org/content/m11809/latest/</a>
```

• Include suggested activities, worksheets, and demonstrations whenever possible, particularly for younger students.

- Younger students will benefit from the activities and worksheets in Sound and Music<sup>29</sup>.
- Worksheets that cover the basic concepts for older students are available here. Download and copy these PDF files as handouts for your class: Sound Waves handout $^{30}$  and Waves Worksheet $^{31}$ . There is also a Worksheet Answer  $Key^{32}$ . In case you have any trouble with the PDF files, these handouts are also included as figures at the end of this module, but they will look better if you print out the PDF files.
- Use the exercises in the modules for class participation and discussion.

<sup>&</sup>lt;sup>29</sup>"Sound and Music Activities" <a href="http://cnx.org/content/m11063/latest/">http://cnx.org/content/m11063/latest/</a>

<sup>30</sup> http://cnx.org/content/m13512/latest/waves1.pdf 31 http://cnx.org/content/m13512/latest/waves3.pdf

<sup>&</sup>lt;sup>32</sup>http://cnx.org/content/m13512/latest/waves4.pdf

Connexions module: m13512 6

## **Sound Waves** Longitudinal Waves pile up:left to right **Longitudinal and Transverse Waves** In longitudinal waves, the waves "pile up" in the same direction that they are moving. Sound waves are longitudinal waves, but they are often pictured as if they were transverse, because its easier to picture. All waves are moving from left to right Transverse Waves pile up: up and down In transverse waves, the waves "pile up" in a different direction from the direction that they are moving. Light waves and water waves are transverse waves. The waves are all travelling at about the same speed, so this is the number of each wave that will reach the ear in a hundredth of a second. Short wavelength means lots of waves; high frequency, high sound Frequency The longer the wavelength, the lower the frequency, and the lower the sound. Long wavelength means fewer waves; low frequency, low sound **Amplitude** Louder The bigger the difference in the highs and lows of the waves, the louder the sound. Softer

Figure 3

Connexions module: m13512 7

### Sound and Music Worksheet

Match both the science/engineering terms on the left and the music terms on the right with the definitions in the middle. You will use some of the definitions twice.

	A. Waves in the air caused by vibrations		
Low Frequency	B. Waves that move in one direction, but "wave" in another direction		
Longitudinal Waves	C. Waves that move and "wave" in the same direction		
Frequency	D. The distance between one wave and the next wave		
High Amplitude	E. How often a single wave goes by		
White Noise	Dynamic level F. How big the difference is between the high points		
Amplitude	and the low points of the waves Soft note		
Sound Waves	G. Big difference between highs and lows Music		
Standing Waves	H. Small difference between highs and lows High note		
Transverse Waves	I. Lots of short waves Sounds		
Wavelength	J. Very few long waves Loud note		
High Frequency	K. Waves that can keep vibrating in or on something for a long time. because they "fit"		
Low Amplitude	L. A sound that is a mixture of all wavelengths		
	M. Sounds that are organized by people		
Give short answers:			
1. Can sound travel through empty space? Why or why not?			
2. How are sound waves like water waves? How are they not like water waves?			
3. Name 2 ways a player of a musical instrument can change the sound of the instrument.			
4. How can an instrument with only 4 strings get more than 4 different pitches?			
5. When a trumpet player pushes down a valve, she opens an extra loop of tubing. What does this do to the trumpet? To the sound?			
Figure 4			

### Sound and Music Worksheet

Match both the science/engineering terms on the left and the music terms on the right with the definitions in the middle. You will use some of the definitions twice.

	A. Waves in the air caused by vibrations	
J Low Frequency	B. Waves that move in one direction, but "wave" in another direction	
C Longitudinal Waves	C. Waves that move and "wave" in the same direction	
Frequency		J Low note
_G High Amplitude	D. The distance between one wave and the next wave	_E_ Pitch
White Noise	E. How often a single wave goes by	Dynamic level
Amplitude	F. How big the difference is between the high points and the low points of the waves	H Soft note
A Sound Waves	G. Big difference between highs and lows	_M_ Music
K Standing Waves	H. Small difference between highs and lows	High note
B Transverse Waves	I. Lots of short waves	A Sounds
Wavelength	J. Very few long waves	_G Loud note
I High Frequency	K. Waves that can keep vibrating in or on something	
H Low Amplitude	for a long time, because they "fit"	
	L. A sound that is a mixture of all wavelengths	
	M. Sounds that are organized by people	

#### Give short answers:

- Can sound travel through empty space? Why or why not?
   No; there can be no sound vibrations where there is no air.
- How are sound waves like water waves? How are they not like water waves?Both can have frequency and amplitude, but water waves are transverse and sound waves are longitudinal.
- Name 2 ways a player of a musical instrument can change the sound of the instrument.

They can make the pitch higher or lower or make the sound louder or softer.

- 4. How can an instrument with only 4 strings get more than 4 different pitches? You can make the vibrating part of the string shorter, and the pitch higher, by holding the string down with one finger.
- 5. When a trumpet player pushes down a valve, she opens an extra loop of tubing. What does this do to the trumpet? To the sound?

This in effect makes the trumpet longer, so the sound is lower.

Figure 5