Talking about Sound and $Music^*$

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

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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.

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[†]http://cnx.org/content/m12373/1.2/

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



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 here¹.

- 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 pitch² of the sound, or name specific notes³, or talk about tuning⁴. Scientists and engineers, on the other hand, talk about the frequency⁵ and the wavelength⁶ 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" http://cnx.org/content/m10943/latest/

³"Duration: Note Lengths in Written Music" http://cnx.org/content/m10945/latest/

⁴"Tuning Systems" http://cnx.org/content/m11639/latest/

⁵"Frequency, Wavelength, and Pitch", Figure 1: Wavelength, Frequency, and Pitch http://cnx.org/content/m11060/latest/#fig1b

⁶"Frequency, Wavelength, and Pitch", Figure 1: Wavelength, Frequency, and Pitch

http://cnx.org/content/m11060/latest/#fig1b

- Wavelength An introduction to wavelength, frequency, and pitch is presented in Frequency, Wavelength, and Pitch⁷. You can find out more about the (Western) musical concept of pitch in Pitch: Sharp, Flat, and Natural Notes⁸.
- 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. Amplitude⁹ is a short discussion of wave size. Musicians have many terms to discuss what they call Dynamics¹⁰.
- 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 Waves¹¹.
- 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 Instruments¹² and Standing Waves and Wind Instruments¹³. To find out more about how the waves created in an instrument are related to each other musically, see Harmonic Series¹⁴ and Tuning Systems¹⁵.
- Sound and Ears For a brief description of what happens when a sound reaches your ear, see Sound and Ears¹⁶
- The Math Students struggling with the math needed for these ideas can look at Musical Intervals, Frequency and Ratio¹⁷ and Powers, Roots, and Equal Temperament¹⁸.

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 Ears¹⁹ is particularly geared towards younger students. The concepts in Frequency, Wavelength, and Pitch²⁰, Transverse and Longitudinal Waves²¹, and Amplitude²² can be presented to just about any age. Standing Waves and Musical Instruments²³, Standing Waves and Wind Instruments²⁴, Harmonic Series²⁵ and Tuning Systems²⁶ are probably best presented to older students (middle school and up). Musical Intervals, Frequency and Ratio²⁷ and Powers, Roots, and Equal Temperament²⁸ 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.

⁷"Frequency, Wavelength, and Pitch" < http://cnx.org/content/m11060/latest/>

⁸"Pitch: Sharp, Flat, and Natural Notes" http://cnx.org/content/m10943/latest/

 $^{^9}$ "Sound Amplitude and Musical Dynamics" http://cnx.org/content/m12372/latest/

¹⁰"Dynamics and Accents in Music" http://cnx.org/content/m11649/latest/

¹¹"Transverse and Longitudinal Waves" http://cnx.org/content/m12378/latest/

¹²"Standing Waves and Musical Instruments" http://cnx.org/content/m12413/latest/

¹³"Standing Waves and Wind Instruments" http://cnx.org/content/m12589/latest/

¹⁴"Harmonic Series" http://cnx.org/content/m11118/latest/

 $^{^{15}}$ "Tuning Systems" <http://cnx.org/content/m11639/latest/> ¹⁶"Sound and Ears" http://cnx.org/content/m12365/latest/

¹⁷ "Musical Intervals, Frequency, and Ratio" < http://cnx.org/content/m11808/latest/> ¹⁸"Powers, Roots, and Equal Temperament" http://cnx.org/content/m11809/latest/

 $^{^{19}&}quot;Sound and Ears" < http://cnx.org/content/m12365/latest/> <math display="inline">$

 $^{^{20}&}quot;{\rm Frequency},$ Wavelength, and Pitch" $<\!{\rm http://cnx.org/content/m11060/latest/}>$

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" http://cnx.org/content/m12413/latest/

²⁴"Standing Waves and Wind Instruments" http://cnx.org/content/m12589/latest/

²⁵"Harmonic Series" http://cnx.org/content/m1118/latest/

²⁶"Tuning Systems" http://cnx.org/content/m11639/latest/

²⁷"Musical Intervals, Frequency, and Ratio" http://cnx.org/content/m11808/latest/

²⁸"Powers, Roots, and Equal Temperament" http://cnx.org/content/m11809/latest/

- Include suggested activities, worksheets, and demonstrations whenever possible, particularly for younger students.
- Younger students will benefit from the activities and worksheets in Sound and Music²⁹. ٠
- 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 handout³⁰ and Waves Worksheet³¹. 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.

²⁹"Sound and Music Activities" < http://cnx.org/content/m11063/latest/>

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

³²http://cnx.org/content/m13512/latest/waves4.pdf



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 Low note D. The distance between one wave and the next wave ____ High Amplitude Pitch E. How often a single wave goes by Dynamic level White Noise F. How big the difference is between the high points Soft note ____ Amplitude and the low points of the waves Music ____ Sound Waves G. Big difference between highs and lows High note ____ Standing Waves H. Small difference between highs and lows Sounds Transverse Waves I. Lots of short waves Loud note _ Wavelength J. Very few long waves ____ 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

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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 definiitons twice.

	A. Waves in the air caused by vibrations	
J Low Frequency	B. Waves that move in one direction,	
C_ Longitudinal Waves	but wave in another direction	
E Frequency	C. Waves that move and "wave" in the same direction	Low note
G High Amplitude	D. The distance between one wave and the next wave	E_ Pitch
L 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	Music
K Standing Waves	H. Small difference between highs and lows	High note
B Transverse Waves	I. Lots of short waves	A Sounds
D 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 int	
	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.
- 3. 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