MODULE 3 SOUND

Would you like to try placing your palm on your throat while saying – "What you doin?" What did your palm feel? Were there vibrations in the throat? Try it again and this time, say – "Mom! Phineas and Ferb are making a title sequence!"

In the previous module you learned about wave properties and common characteristics like pitch and loudness. You will also learn the 2 kinds of waves according to propagation. These are the longitudinal and transverse waves. Sound is an example of a longitudinal wave. It is also classified as a mechanical wave. Thus there has to be matter for which sound should travel and propagate. This matter is better known as medium.

Terms to Remember

Longitudinal Wave
- Wave whose motion is parallel to the motion of the particles of the medium

Mechanical wave
- Wave that need a medium in order to propagate

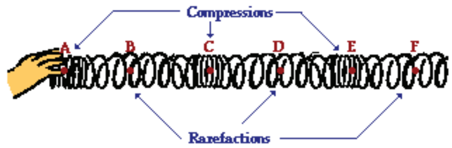


Figure 1. Longitudinal wave

How does sound propagate?

In Activity 1, you will try to explore how sound is produced. You are going to use local materials available in your community to do this activity. You can do "*Art Attack*" and be very creative with your project.

Activity 1
My own sounding box

Objectives

In this activity, you should be able to construct a sounding box to

1. demonstrate how sound is produced; and
2. identify factors that affect the pitch and loudness of the sound produced.

Materials Needed

- shoe box
- variety of elastic or rubber bands (thin and thick)
- extra cardboard – optional
- pair of scissors or cutter
- ruler

TAKE CARE! **Handle all sharp tools with care.**

Procedure

1. Cut and design your shoe box as shown in Figure 2.
2. Put the rubber bands around the box. Make sure that the rubber bands are almost equally spaced and that the rubber bands are arranged according to increasing thickness from the lower end to the other end of the box.

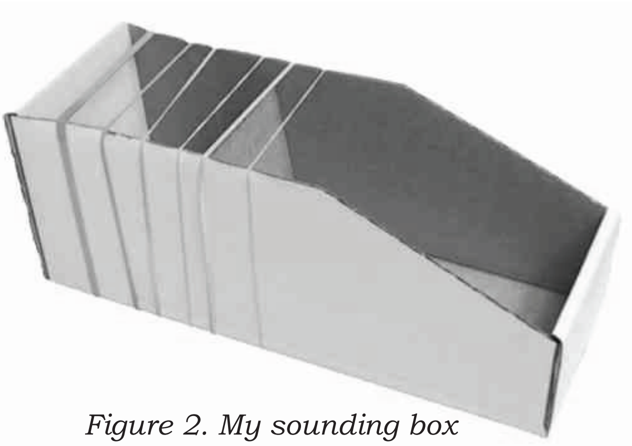


Figure 2. My sounding box

3. Use your finger to pluck each rubber band. Listen to the sound produced.

   Q1. What physical signs did you observe when you plucked each band. Did you hear any sound? What produced the sound?

   Q2. How different are the sounds produced by each band with different thickness?

4. This time use the fingers of one hand to stretch one of the elastics. Pluck the elastic with the fingers of the other hand and observe.

   Q3. Are there changes in the note when you plucked the stretched band?

5. Repeat step 4 with the other elastic bands.

   Q4. Arrange the elastics in sequence from the highest note to the lowest note produced.

When we talk or make any sound, our vocal cords vibrate. When there are no vibrations felt, no sound is produced. This means that sounds are caused by vibrations. Vibrations of molecules are to the to-and-fro or back-and-forth movement of molecules. Vibrations are considered as a disturbance that travels through a medium. This vibratory motion causes energy to transfer to our ears and is interpreted by our brain. Sound waves are examples of **longitudinal waves**. They are also known as mechanical waves since sound waves need medium in order to propagate.

In Activity 1, vibrations produced by the elastic band produced sound. The sounding box amplified (increase in amplitude) this sound.

Sound waves can travel in air. When they come in contact with our eardrums, the vibrations of the air force our eardrums to vibrate which is sensed and interpreted by our brain.

Can sound waves also travel in other media like solids and liquids?

You can try this one. Place your ear against one end of a tabletop. Ask a friend to gently tap the other end of the table with a pencil or a ruler. What happens? Then ask your friend to again gently tap the other end of the table but this time, make sure that your ear is not touching the table. What happens? In which situation did you encounter louder and more pronounced sound? In which situation did you encounter the sound clearly?

Sound is produced by the slight tapping of the table with a pencil or a ruler. This can be heard clearly at the other end of the table. This shows that sound waves can also travel through wood or solid. Sound is more distinct in solids than in air. This also means that sound is heard much louder when it travels in solids than in air.

What about in liquids? Can sound travel in liquids too? Liquids are better transmitters of sound than gases. If two bodies are struck together underwater, the sound heard by a person who is underwater is louder than when heard in air, but softer than in solids.

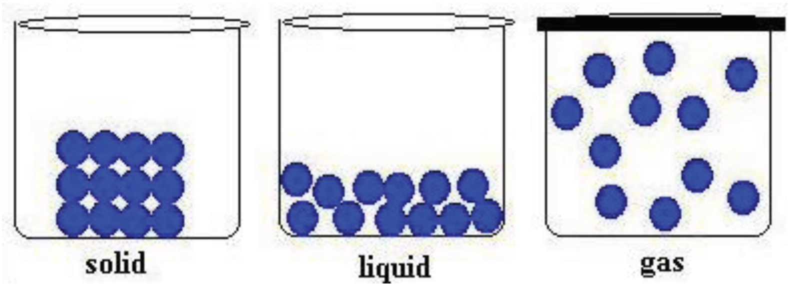


Figure 3: Molecules of different media

As you can see in Figure 3, particles of solids are more closely packed than particles of liquid and gas. This is why sound produced in solids is much more distinct and loud than when it is propagated or produced in liquids and gas. Between liquids and gases, on the other hand, liquid particles appear more closely spaced than gases. This means that louder sound will be produced in liquids than in gases.

Spacing of particles of the medium like solid, liquid and gas is an important factor on how would is transmitted. Take a look at Figure 3, liquid particles are closer to each other than the particles in the gas. Sound waves are transmitted easier in liquids. Between liquids and solids, the particles of solids are even closer together than the liquid molecules; therefore, sound travels even faster in solids than in liquids. Since different media transmit sound differently, sound travels at different speeds in different materials. Since solid is the best transmitter of sound, ***sound travels fastest in solids and slowest in gases.***

The table below shows the speed of sound in different materials.

Table 1: Speed of sound in different materials

Materials	Speed of Sound V (m/s)
Air (0^oC)	331
He (0^oC)	1005
H (20^oC)	1300
Water	1440
Seawater	1560
Iron and Steel	5000
Aluminum	5100
Hard wood	4000

Sound speed is dependent on several factors such as (1) atmospheric pressure, (2) relative humidity, and (3) atmospheric temperature. Remember these weather elements you studied in your earlier grades? High values of these elements lead to faster moving sound. When you are in the low lands and the surrounding is hot, sound travels fast. Do you want to know why sound travels faster in hot air? There are more molecular interactions that happen in hot air. This is because the hot particles of air gain more kinetic energy and so there is also an increase in the mean velocity of the molecules. Since sound is a consequence of energy transfer through collisions, more collisions and faster collisions means faster sound.

Going a little deeper on this, speed of sound basically depends on the *elastic property* and the *inertial property* of the medium on which it propagates. The elastic property is concerned with the ability of the material to retain or maintain its shape and not to deform when a force is applied on it. Solids as compared to liquids and gases have the highest elastic property. Consequently, solid is the medium on which sound travels fastest. This means that the greater the elastic property, the faster the sound waves travel. The iniertial property, on the other hand, is the tendency of the material to maintain its state of motion. More inertial property means the more inert (more massive or greater mass density) the individual particles of the medium, the less responsive they will be to the interactions between neighbouring particles and the slower that the wave will be. Within a single phase medium, like air for example, humid air is more inert than humid air. This is because water that has changed to vapor is mixed with the air. This phenomenon increases the mass density of air and so increases the inertial property of the medium. This will eventually decrease the speed of sound on that medium.

Sound cannot travel in a vacuum. Remember that sound is a mechanical wave which needs medium in order to propagate. If no matter exists, there will be no sound. In the outer space, sound would not be transmitted.

Sound waves possess characteristics common to all types of waves. These are frequency, wavelength, amplitude, speed or velocity, period and phase. Just like other waves, sound also exhibits wave properties just like reflection, refraction, diffraction, and interference. More than these properties are pitch and loudness of sound. *Pitch* refers to the highness or lowness of sound. *Loudness* is how soft or how intense the sound is as perceived by the ear and interpreted by the brain. Do you want to find out more characteristics and properties of sound? Activity No. 2 will let your discover some of these properties using your sounding box.

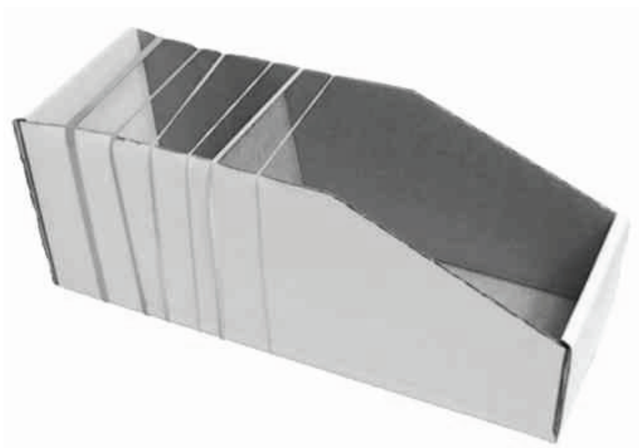
Activity 2
Properties and characteristics of sound

Objective

In this activity, you will use your sounding box to describe the characteristics of sound and compare them with those of sound produced by a guitar.

Materials Needed

- Sounding Box
- Wooden rod
- Ruler
- Guitar



Procedure

Part 1: Sounding the Box...

1. Label the rubber bands of your sounding box as S1, S2 and so on. Labeling should start with the thinnest rubber band.

2. Pluck each rubber band. Listen to the sounds produced.

   Q1. What did you observed when you plucked each of the rubber bands and sound is produced? How then is sound produced?

   Q2. Is there a difference in the sound produced by each of the rubber bands? How do they differ?

   Q3. Which band produced a higher sound? Which band produced a lower sound?

   Q4. How can you make a softer sound? How can you make a louder sound?

   Q5. What factors affect the pitch and loudness of the sound produced by the rubber bands?

3. Stretch one of the rubber bands and while doing so, pluck it again.

   Q6. Is there a change in the sound produced when you pluck the rubber band while stretching it? How does stretching the rubber band affect the pitch of the sound produced?

4. Place a ruler (on its edge) across the sounding box as shown in Figure 3. Pluck each rubber band and observe.

   Q7. Is there a difference in the sound produced when the ruler is placed across the box?

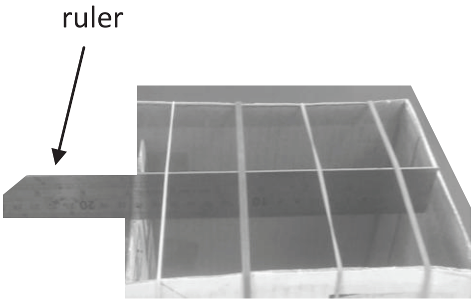


Figure 3: With stretch rubber bands

5. Move the ruler off center to the left or to a diagonal position so that one side of each rubber band is shorter than the other side (Figure 4). Pluck again each rubber band on each side of the ruler and observe.

Figure 4: Diagonal Stretching of the bands

Q8. Which part of the rubber band (shorter side or longer side) provides higher pitch? Which part provides lower pitch?

Q9. Again, what factors affect the pitch of the sound produced by the rubber bands?

Part 2: The Guitar...

6. Strum each guitar string without holding the frets. (String #0 is the lower most string while string #6 is the uppermost string.)

7. Record all you observations in the table provided.

String #	Pitch (High or Low)
0	
1	
2	
3	
4	
5	
6	

Q10. Which string vibrates fastest when strummed?

Q11. Which string vibrates slowest when strummed?

Q12. Which string has the highest frequency?

Q13. Which string has the highest pitch?

Q14. Which has the lowest frequency?

Q15. Which string has the lowest pitch?

Q16. How would you relate pitch and frequency?

The highness or lowness of sound is known as the **pitch** of a sound or a musical note. In Activity No. 2 you were able to relate vibrations, frequency and pitch using your improvised sounding box and a guitar. The pitch of a high frequency sound is also high and a low frequency sound is also; lower in pitch.

When you were in your earlier grades you studied about the human ear. Our ear and that of animals are the very sensitive sound detectors. The ear is a part of the peripheral auditory system. It is divided into three major parts: *the outer ear, the middle ear and the inner ear.*

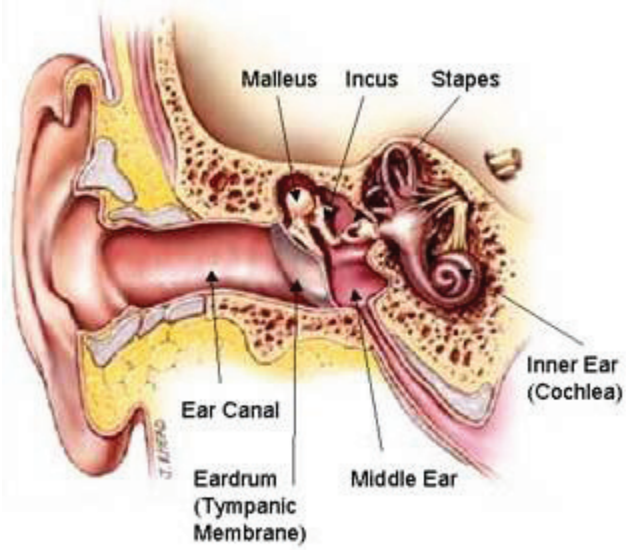


Figure 4: The human ear

The outer ear called the *pinna* collects the sound waves and focuses them into the ear canal. This canal transmits the sound waves to the eardrum.

The ear canal is the eardrum membrane or the *tympanum*. It separates the outer and the middle ears physically. Air vibrations set the eardrum membrane in motion that causes the three smallest bones (*hammer, anvil and stirrup*) to move. These three bones convert the small-amplitude vibration of the eardrum into large-amplitude oscillations. These oscillations are transferred to the inner ear through the oval window.

Behind the oval window is a snail-shell shaped liquid –filled organ called the *cochlea.* The large-amplitude oscillations create waves that travel in liquid. These sounds are converted into electrical impulses, which are sent to the brain by the auditory nerve. The brain, interprets these signals as words, music or noise.

Did you know that we can only sense within the frequency range of about 20 Hz to about 20000 Hz? Vibrational frequencies beyond 20 000 Hz is called ***ultrasonic frequencies*** while extremely low frequencies are known as ***infrasonic frequencies***. Our ear cannot detect ultrasonic or infrasonic waves. But some animals like dogs can hear sounds as high as 50 000 Hz while bats can detect sounds as high as 100 000 Hz.

We can see images of your baby brother or sister when the OB-Gyne asks your mommy or nanay to undergo ultrasound. ***Ultrasonic waves*** are used to help physicians see our internal organs. Nowadays, ultrasonic technology is of three kinds: 2-dimensional, 3-dimensional, and 4-dimensional categories. In the 3- and 4-dimensional ultrasonic technologies, the features of the fetus are very clearly captured.

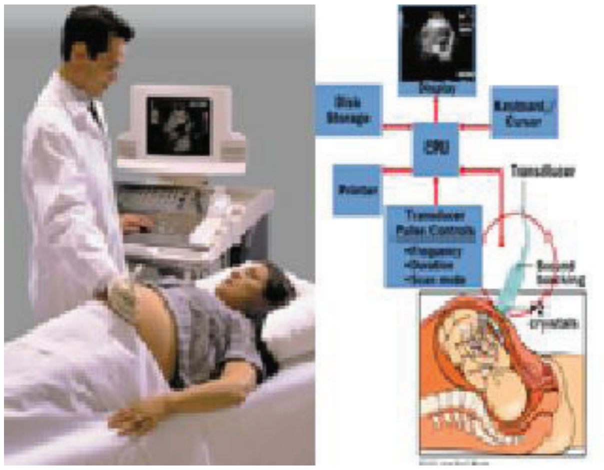


Figure 5: Ultrasound

It has also been found that ultrasonic waves can be used as rodent and insect exterminators. The very loud ultrasonic sources in a building will usually drive the rodents away or disorient cockroaches causing them to die from the induced erratic behavior. What other applications of sound do you have in mind? Do you want to share them too?

Loudness and Intensity

Do you still remember intensity of light in the previous module? In sound, intensity refers to the amount of energy a sound wave. Figure 6 shows varying intensity of sound. High amplitude sounds usually carry large energy and have higher intensity while low amplitude sound carry lesser amount of energy and have lower intensity.

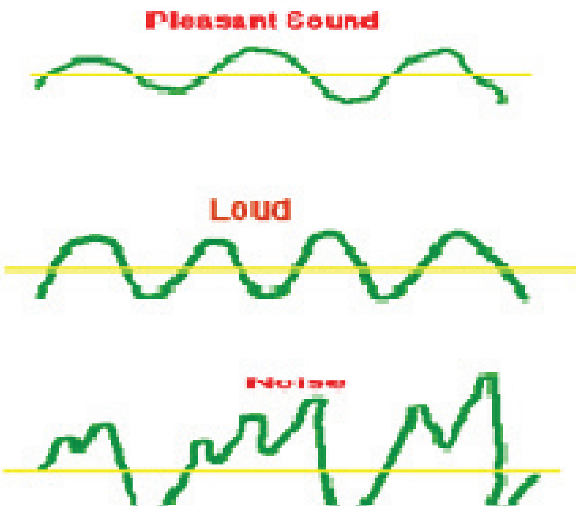


Figure 6: Varying sounds

Sound intensity is measured by various instruments like the oscilloscope. ***Loudness*** is a psychological sensation that differs for different people. Loudness is subjective but is still related to the intensity of sound. In fact, despite the subjective variations, loudness varies nearly logarithmically with intensity. A logarithmic scale is used to describe sound intensity, which roughly corresponds to loudness. The unit of intensity level for sound is the decibel (dB), which was named after *Alexander Graham Bell* who invented the telephone. On the decibel scale, an increase of 1 dB means that sound intensity is increased by a factor of 10.

Figure 7: Father and Son Duo

Father and son duo interprets the loudness of a sound differently. The son considers the rock music a soft music while the father considers it a loud sound. The father may even interpret the sound as a distorted sound, which is known as noise. Noise is wave that is not pleasing to the senses.

Table 2. Sound Levels of different sound sources

Source of sound	Level (dB)
Jet engine, 30 m away	140
Threshold of pain	120
Amplified rock music	115
Old subway train	100
Average factory	90
Busy street traffic	70
Normal conversation	60
Library	40
Close whisper	20
Normal breathing	10
Threshold of hearing	0

Let's see how you interpret sound yourselves. Look for 3 more classmates and try Activity 3. This will test your ability to design and at the same time show your talents!

Activity 3
Big time gig!

Objectives

In this activity, you should be able to:

1. create musical instruments using indigenous products and
2. use these instruments to compose tunes and present in a Gig. Students may also utilize other indigenous musical instruments.

Materials Needed

- Indigenous materials such as sticks, bottles or glassware available in your locality to be used as musical instrument
- Localized or improvised stringed instruments
- Localized or improvised drum set

Procedure

1. Form a group of four (4). One can play a stringed instrument, while the other can play the drum and the 3rd member can use the other instrument that your group will design or create. The last member will be your group's solo performer.

2. Look for local materials which you can use to create different musical instruments.

3. Try to come up with your own composition using the instruments you have created.

4. In the class GIG you are to play and sing at least 2 songs (any song of your choice and your original composition).

5. Check the Rubric included to become familiar with the criteria for which you will be rated.

Big Time Gig!

Rubric Scoring

Task/ Criteria	4	3	2	1	Score
Improvised/ Localized musical instruments	• Makes use of local or indigenous materials • The improvised instruments produce good quality sound comparable to standard musical instruments.	• Makes use of local materials only. • The improvised instruments produce good quality sound.	• Makes use of local materials only. • The improvised instruments produce fair quality sound.	• Makes use of local materials only. • The sound produced by the improvised instruments is not clear and distinct.	
Composition	The group's original composition has good melody. The lyrics provided are thematic and meaningful	The group's original composition has fair melody and the lyrics provided are thematic and meaningful	The group's original composition has fair melody and the lyrics provided are ***NOT*** thematic but meaningful	The group's original composition has fair melody and the lyrics provided are ***NEITHER*** thematic nor meaningful	
Performance	• The group was able to successfully use the improvised musical instruments in their GIG. • The group was able to provide good quality rendition or performance.	• The group was able to successfully use the improvised musical instruments in their GIG. • The group was able to provide fair rendition.	• The group was able to use the improvised musical instruments but some were out of tune • The group was able to provide fair rendition.	• The group was able to use the improvised musical instruments but MOST were out of tune • The group was able to provide fair rendition	
Cooperation and Team Work	Each one of them completed their task so as to come up with the expected output - GIG	3 out of 4 members completed their task so as to come up with the expected output - GIG	2 out of 4 completed their task so as to come up with the expected output - GIG	Only 1 out of the 4 members did his/her job	
				TOTAL	

How was your GIG? Did you enjoy this activity? Aside from the concepts and principles in sound you learned and applied for a perfect performance what other insights can you identify? Can you extend your designs to come up with quality instruments using indigenous materials? You can be famous with your artworks…

Sound waves are mechanical waves than need for a medium for sound to propagate. Vibrations of the medium create a series of compression and rarefaction which results to longitudinal waves. Sound can travel in all media but not in vacuum. Sound is fastest in matter that is closely packed like solid and slowest in gas. Speed of sound is dependent on factors like temperature, humidity and air pressure. High temperature brings much faster sound. Increased humidity, on the other hand makes sound travel slower. As pressure is increased, speed is also increased. Inertial and elastic properties of the medium also play an important part in the speed of sound. Solids tend to be highly elastic than gases and thus sound travel fastest in solids. In a single phase matter however, the inertial property which is the tendency of the material to maintain its motion also affect speed of sound. Humid air is more massive and is more inert than dry air. This condition brings lesser molecular interactions and eventually slower sound. Sound, just like other waves do have characteristics such as speed, frequency, wavelength, amplitude, phase and period. Like any other wave, sound exhibit properties like reflection, refraction, interference and diffraction. Other properties are loudness and pitch. Pitch is dependent on the frequency of sound wave. The higher frequency the higher the pitch of the sound produced.

Organisms like us are capable of sensing sound through our ears. Just like other organism, our ears do have parts that perform special tasks until the auditory signals reach and are interpreted by our brain. Frequencies beyond the audible to human are known as ultrasonic (beyond the upper limit) and infrasonic (below the lower limit). Intensity and loudness are quantitative and qualitative descriptions of the energy carried by the wave. High amplitude waves are intense and are sensed as loud sound. Low amplitude sound waves are soft sound. Music is a special sound that forms patterns and are appealing to our sense of hearing.

Reading Materials/Links/Websites

http://www.physicsclassroom.com/Class/sound/u11l2c.cfm

http://en.wikipedia.org/wiki/Sound#Sound_wave_properties_and_characteristics

http://personal.cityu.edu.hk/~bsapplec/characte.htm

http://www.slideshare.net/agatonlydelle/physics-sounds