

# Theatre for Youth

and Outreach Program



Maxwell C.

King Center

for the performing arts

kingcenter.com



2018-2019



*Let Your Imagination Take You Places!*

## Michel Lauzière: Science of Sound

Tuesday, January 29, 10:30 am

With Special Thanks

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Dear teachers and students,

Thank you for your interest in the King Center Theatre for Youth (TFY) Program. Our mission is to inspire, nurture and sustain a lifelong appreciation for the performing arts among our youth theatre guests. This is accomplished by the diverse array of entertaining and educational performance arts offerings.

The study resource guide made possible by each artists and their management team to augment the live theatre experience. We hope you find the guide useful as you integrate the experience with your classroom learning.

A live theatrical experience can leave a memorable impact even after the show is over...now, *Let Your Imagination Take You Places!*

We are looking forward to your attendance at the show.

Yours in the arts,

A handwritten signature in black ink, appearing to read "Karen".

Karen Wilson  
Director,  
Theatre for Youth Program



*I was recently asked to speak about sound, and how it works. I realized that, although I was able to explain sound in my own words, I was not familiar enough with many of the terms used by real experts.*

*So I learned the scientific vocabulary; and now I feel ready to talk about the basics of sound . . . in my own words !*

*Michel Lauzière*

# SCIENCE OF SOUND

## SOUND

is a **WAVE** of **PRESSURE** caused by a **VIBRATING** source.

Three key words : **WAVE**, **PRESSURE** and **VIBRATION**.

What is a

## WAVE ?

It is a **DISTURBANCE** traveling through a **MEDIUM**, transmitting **ENERGY**, not matter.

At first glance, this definition of a wave may seem a bit technical... So let me use the most familiar wave example we all know: water waves. Pour some water in a bowl or in an aluminum pan. Wait until the surface becomes perfectly flat, at rest. Then, with your finger, gently tap on the surface. You can see the slight «bumps» and troughs in the level of water moving outward in concentric circles. In this very simple example, the **MEDIUM** (the support that is needed to carry a wave) is the water. This

medium is in «equilibrium» (meaning that the surface is flat, as it naturally tends to be). Then you cause a **DISTURBANCE** (the water under your finger is pushed lower than the normal level). And the ripples that are formed carry the **ENERGY** you applied, without really moving the water. No current has been created. The molecules of water at the surface are displaced upwards and downwards, but they do not move with the wave.

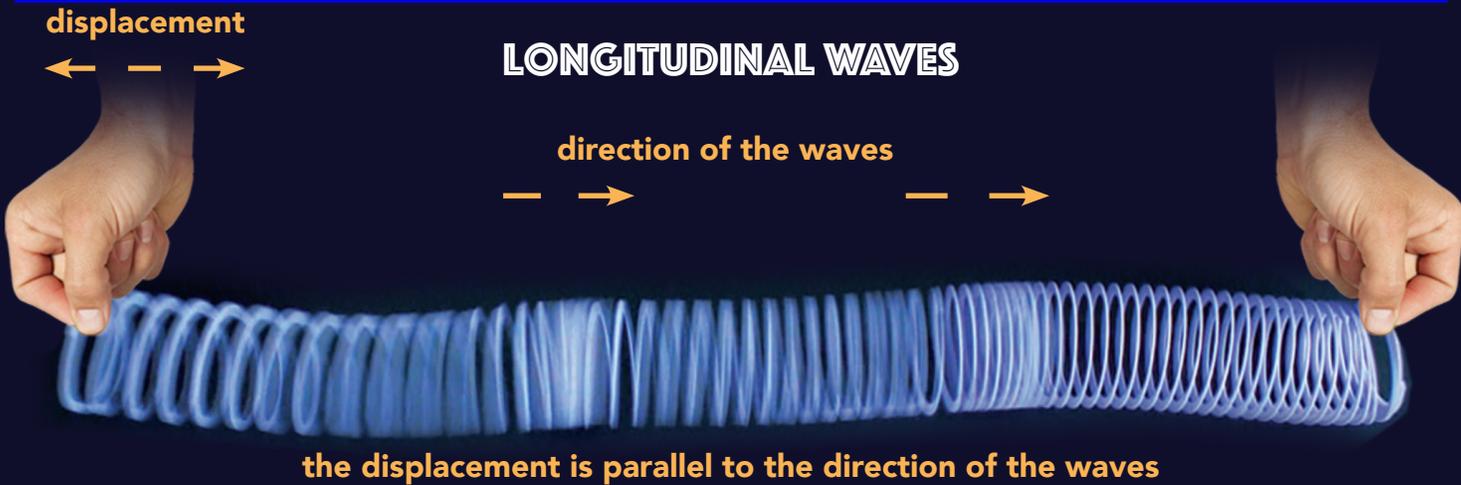
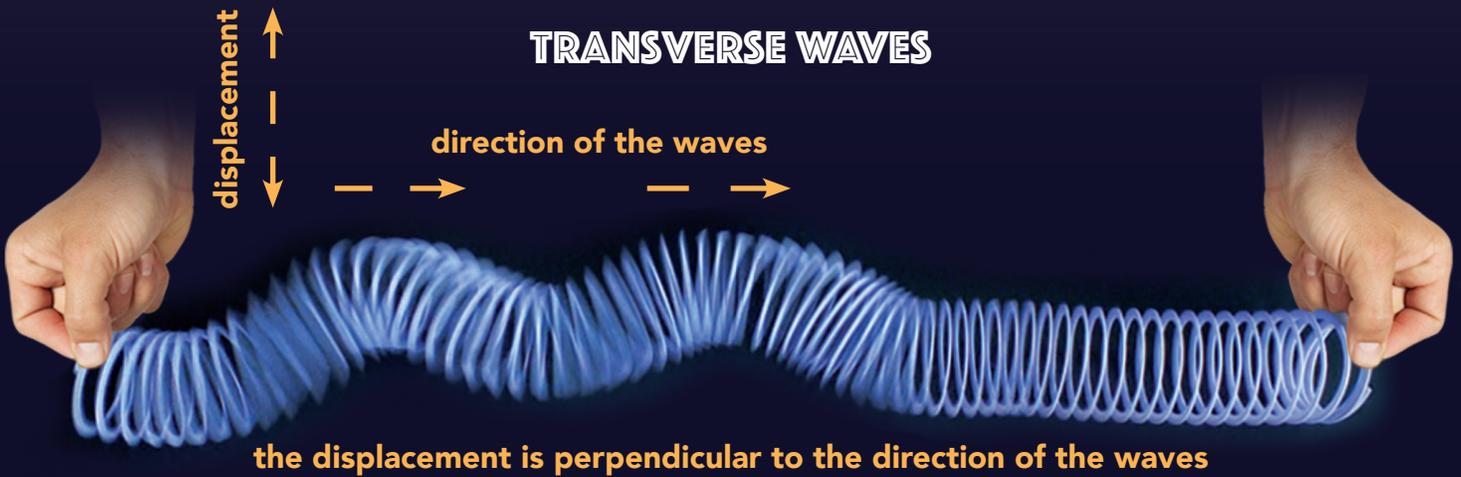
# A WAVE TRANSPORTS ENERGY, NOT MATTER

This is essential. The particles of a medium do not travel with the wave in the process of transmitting it. Think about a **stadium wave** (Also called a Mexican wave). Imagine that you are sitting in a crowded stadium where this is happening. At some point, as you see people on your left side quickly standing up and sitting down again, you do the same thing ; and immediately after you, the folks on your right side do the same as well. This repeated pattern creates a human wave that travels around the stadium. In this analogy, the crowd represents the medium; the spectators represent the particles of matter in the medium. As these «spectators / particles» stand up and sit down, they create a disturbance in the medium (a wave), but they do not exchange seats during the process ! People are temporarily «disturbed» or «displaced» from their rest position, but they come back to their original position.

# TRANSVERSE WAVES AND LONGITUDINAL WAVES

Water waves and stadium waves are two examples of **transverse waves**. In both cases, the displacement of the particles is perpendicular to the direction of the wave. When a stadium wave (I love this analogy) comes to you (the spectator / particle) from the side (laterally), you transmit it by an «up and down» displacement. That is why it is called a transverse wave, just like water waves. Sound waves though, are **longitudinal waves**. In this type of wave, the displacement is parallel to the direction of the wave. Try to imagine a stadium wave

«longitudinal style»! The people in the crowd would transmit such a wave (coming laterally) by a lateral displacement. They would get pushed from one side, they would bounce off the person on the other side, who would bump into the next... Such a wave of compressed people would be neither spectacular nor friendly; and fortunately, nobody has ever tried it !... But it would be a good example of a **longitudinal pressure wave, like sound is !**



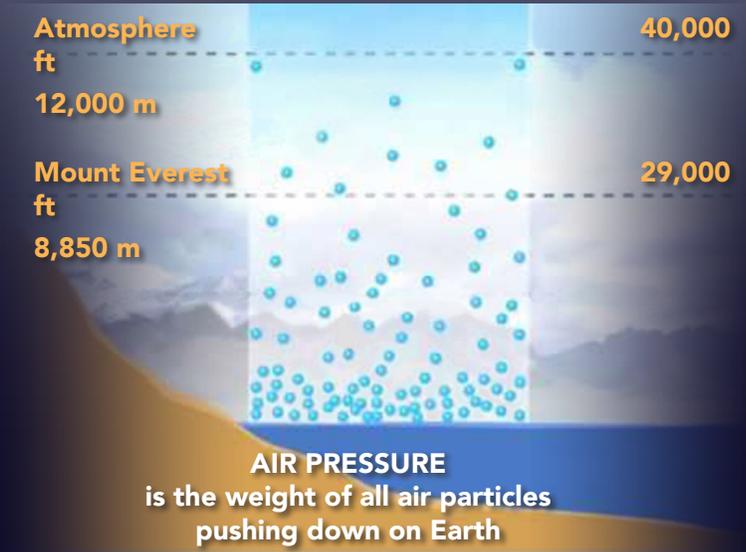
The difference between transverse waves and longitudinal waves can be illustrated by using a SLINKY. In the longitudinal waves photo, quick «push-and-pull» hand moves cause moving zones where the coils are compressed tighter together, followed by zones where the coils are further apart. If this model is transposed to air, tighter coils represent compressed air particles, while more distant coils suggest rarefied air particles. This helps to visualize the propagation of sound. Except that

actual sound waves move much faster! NOTE : Sound also travels through liquids and solids. Sound waves under water (not to be confused with surface waves) travel four times faster than they do in air. Since water is denser than air, molecules take less time to collide into each other as they transmit the wave. The speed of sound in the air (approx. 1,150 feet per second) varies depending on temperature, humidity, pressure...

# AIR PRESSURE

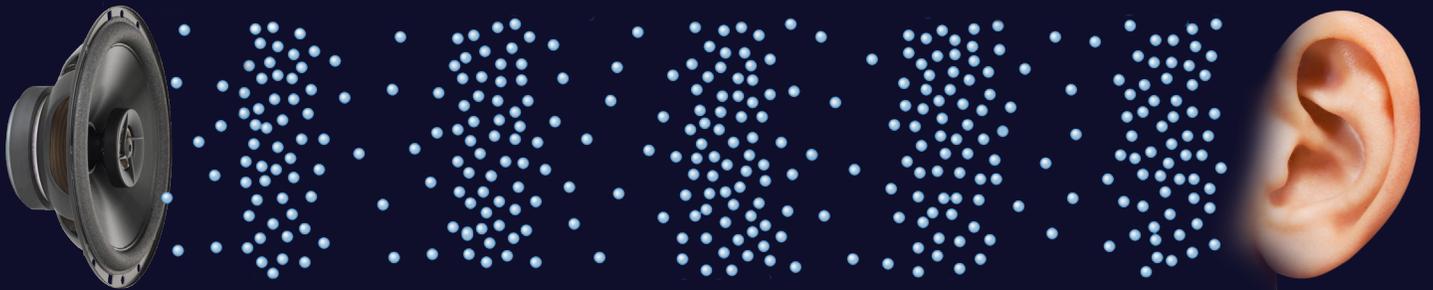
Air pressure is the result of the weight of all the air that is above us.

Air is under greater pressure on the ground (or at sea level) than in altitude, because it has more weight «on its shoulders». Like the acrobats at the bottom of a human pyramid feel more pressure than the one at the top does. At high pressure air particles are squeezed closer together (denser air). At low pressure the molecules have more «room» to spread apart from each other, (making the air less dense). Temperature also influences air pressure; and this is one of the numerous factors that determine the weather. **But since we want to focus on sound, let's consider air in equilibrium, at a given altitude and temperature. Like the surface of a quiet pond naturally tends to be flat, the air pressure around us tends to be even as well...Until some disturbance occurs : VIBRATIONS !**

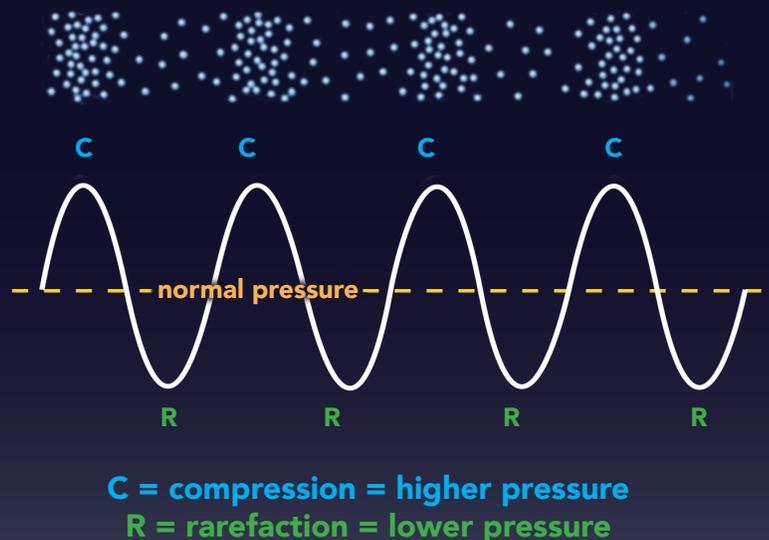


# VIBRATION

A vibration is a quick back and forth motion of matter.



All sounds are caused by vibrations. Whatever vibrates, transmits the vibration to the air by alternately pushing and pulling on it. That is how the quickly shaking membrane of a loudspeaker operates. Every time the membrane pushes forward, it hits the air particles that are in contact with it. These air particles bump into others, creating a fast-travelling layer of compressed air. Immediately after, as the membrane pulls back, a layer of rarefied air follows. One «push-and-pull» cycle (one vibration) causes one «compression-rarefaction» cycle (one wave). When these tiny variations in air pressure reach us, they push and pull our eardrums... And so, we hear a sound !

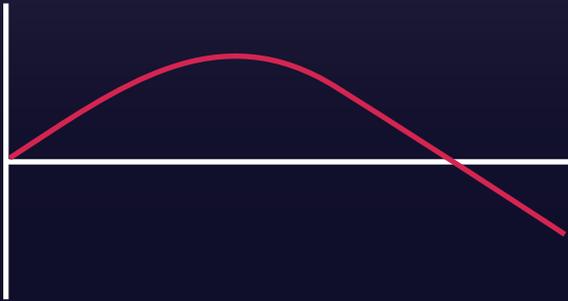


# FREQUENCY

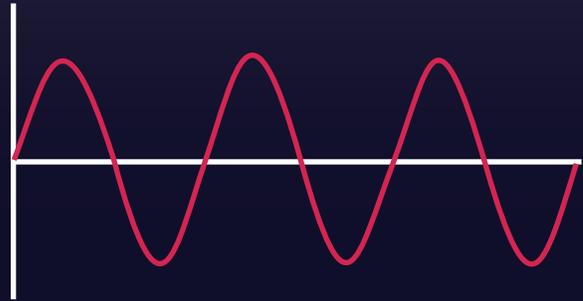
The frequency is the rate at which something vibrates.

To be perceived as sounds, many sound waves (compression-rarefaction cycles) need to reach our eardrums in a very short time. At least 20, and up to 20,000 every second ! This is called frequency (it tells us how frequently something occurs)... It is measured in Hertz (Hz). 20 cycles per second = 20 Hz. This is a very low frequency (deep, low-pitched sound). 20,000 cycles per second = 20,000 Hz. This

is a very high frequency (piercing, high-pitched sound). Some sound waves can not be sensed by the human ear, because their frequency is either too low (infrasounds), or too high (ultrasounds). The hearing range differs from one species to another. Elephants, for instance, hear frequencies as low as 5 Hz; whereas dolphins can sense up to 150,000 Hz.



**Lower frequency:  
deeper pitch**



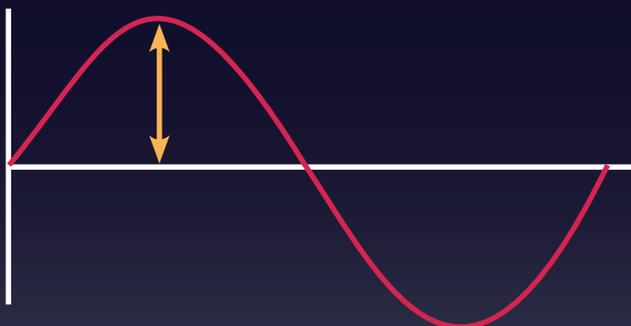
**Higher frequency:  
higher pitch**

# AMPLITUDE

The amplitude is the extent to which air particles are displaced from their equilibrium.

Amplitude determines the loudness of sound. Hit a drum with a stick. If you hit hard, the drum skin will be displaced far away from its normal position in both directions of its vibrational motions. This will translate into an important displacement of air particles from their own equilibrium position. Result : important air compressions and rarefactions, which means a high amplitude (loud) sound.

On the other hand, hitting the drum gently, will obviously produce a low amplitude (quieter) sound. It is important to specify that a variation in the amplitude does not change the frequency. Play a piano note with energy or play it softly, the frequency of the musical note (pitch) will remain the same.



**Louder**



**Quieter**

Examples of how I put elementary sound notions into practice in my performances...

Here are some of my

# HOMEMADE INSTRUMENTS



## THE « HORN-O-PHONE »

Eighteen old style bulb horns, are attached to an overall. Each horn produces a different musical note. Playing music becomes a choreography of goofy moves and contortions!

When the bulb of a horn is squeezed, a current of air is forced through a narrow tube in which a free reed is enclosed. A **free reed** is a thin metal tongue fixed at one end over an opening of the same shape but just large enough to allow it to oscillate freely at the other end. So when a flow of air is forced into the opening, the reed quickly swings back and forth, alternately allowing air in, and stopping it. The frequency (pitch) of each note depends on the length and thickness of the reed. Then, the sound is acoustically amplified by the conical shape of the horn.

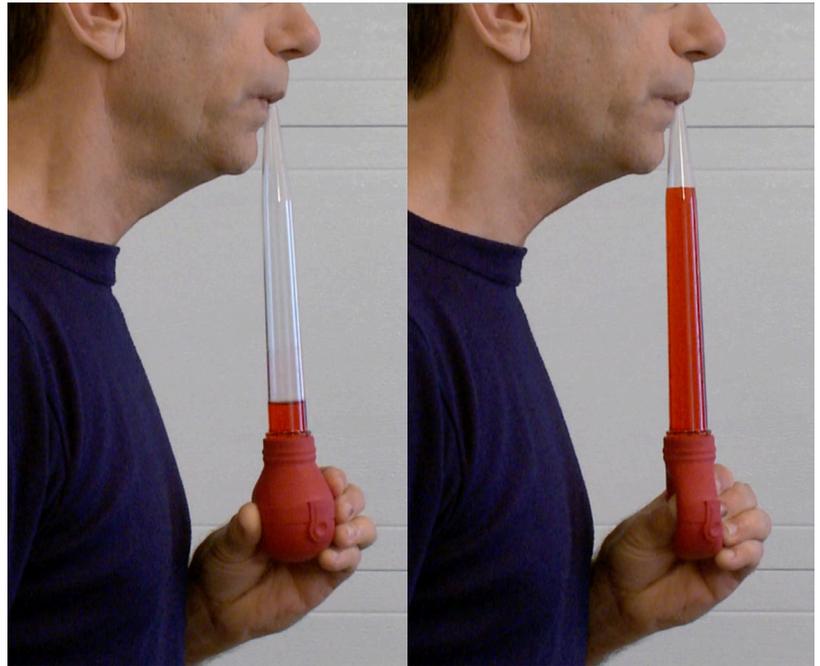
### THE « DISH-O-PHONE »

An array of cups, bowls, pots and pans... A total of eighteen items, carefully selected and (almost) tuned! Generally speaking, smaller and thicker items vibrate at higher frequencies, while bigger and thinner elements have a lower pitch.



### THE « SPOON-O-PHONE »

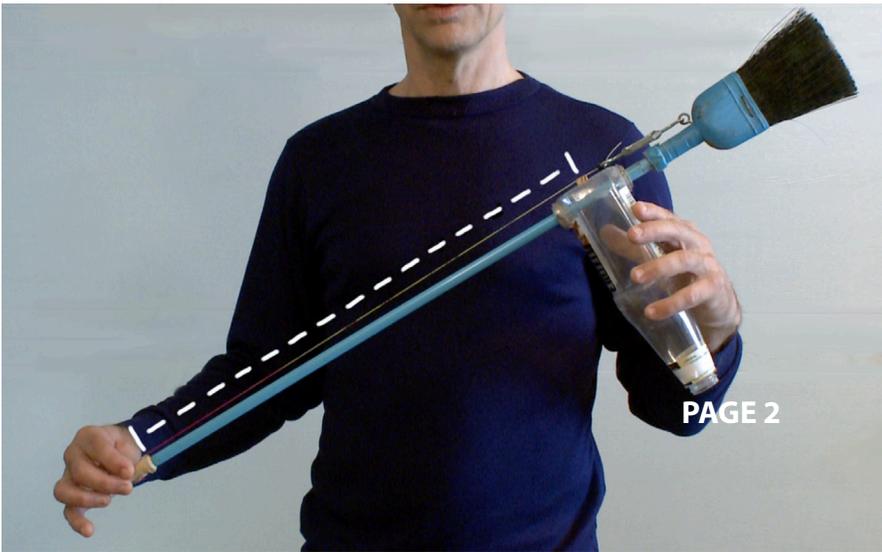
This instrument has similarities with an African instrument called Kalimba. The sound is produced by plucking the ends of plastic spoons fixed to a wooden box at one end. The pitch is determined by the size, the thickness, and the sturdiness of a spoon. The length of the free (vibrating) part is also crucial. The wooden box acts as a **resonance chamber**. The sound waves bounce back and forth on the internal walls of the box with low loss of energy, they interfere and reinforce each other, creating an acoustic resonance that amplifies the sound.



### THE « TURKEY-BASTER-O-PHONE »

In this wind «instrument», the vibrating element is... air itself. The turkey baster works like panpipes, producing sound by vibrating a column of air inside the tube. When the air column inside the tube is longer, air compressions take more time to travel down and bounce back up (lower pitch). As one raises the level of liquid inside the tube by squeezing the bulb, the air column is shortened, and consequently the period of time it takes for air compressions to go down and back up is shortened as well (higher pitch).





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### THE « SLIDE-BROOM-O-PHONE »

An empty plastic ketchup bottle; a long handled small broom sliding through the pierced bottle; and a tensed nylon string attached to both ends of the broom, but sliding outside of the bottle, over a «bridge». By sliding the broom (and string) back and forth, one can control the frequency of this musical contraption. As the sliding motions occur, the vibrating part of the string increases or decreases in length.

Longer = lower pitch;  
shorter = higher pitch.



### THE « PLASTIC-BOWL-O-PHONE »

Here, I use a tracing wheel (tool normally used for fabrics, similar to a cogwheel), and a plastic bowl. A small electrical motor makes the bowl rotate at a constant speed. As soon as it touches the surface, the wheel starts spinning and every «tooth» of the wheel produces a tiny vibration. The frequency of those vibrations can be controlled by applying the wheel closer to the center of the spinning surface (low frequencies), or further away from the center (higher frequencies). In other words, by increasing the length of the radius, one increases the length of the circumference. Far from the center, the wheel covers a longer distance in one rotation. Therefore it spins faster and it vibrates faster.



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