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Original Research Article

Multidisciplinary aspects of Musical Instruments - (Arts, Physics and Engineering)

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Abstract

Musical Instruments evolved with time are intimately related to culture. The basic structure of all musical instruments is a sound source and a resonating body that enhances sounds at particular frequency. Sound sources (vibrating media) include the violin string, drum membrane, Wood or metallic bar and Air stream in wind Instruments. The aim of the musical instrument is to provide excellent sound quality, aesthetic look and easy to play and control. Music does not emerge from random creative inspiration. They involve structure , pattern ,repetation and other charecteristics that makes them recognisable to the human ears .Music is a sort of science , a facinating , pulsating type of sound .All music emerges from the principles found in physics and Maths. Sound waves are made of a series of high and low point. Controlling different types of waves represents important principles of Physics. The laws of vibration states that everything in the universe is constantly in motion vibrating in at its own particular frequency. The beauty and emotion evoked when listening to music is aesthetic art of music. The structure of musical instruments shows an aesthetic artistic look. Fixing of Sound post in violin, wax board in Vina and the mouth holes and finger holes in Flute are works of perfect engineering. The design of musical instrument is part of Art, Construction is part of Engineering and sound production is part of basic physics totally it is the multi-disciplinary aspect of Musical Instruments.

Keywords: Musical instruments - Physics - Vibrations - sound waves - wave length. Harmonics - Frequency.

INTRODUCTION

Sound is created when an object vibrates. The vibrations cause the particles in the air around the object to vibrate.The Particles in the air then bump into their neibours setting them into a vibrating motion as well which lets the vibration travel further . In Physics vibrations are commonly described as waves Special about musical instrument is that they create so called standing waves instead of random vibrations. In standing waves some points the nodes the vibration remain fixed while the rest vibrates with maximum amplitude which refers to the highest and lowestpoints of the wave. It is these standing waves that we experience as harmonic tones when we are listening to music.Other irregular random waves that we hear are noise instead .

Musical instruments and resonator:

The aim of the musical instrument is to provide excellent sound quality, aesthetic look and easy to play and control. Music does not emerge from random creative inspiration. All musical Instruments originate sound by causing the matter to vibrate. The vibrations create sound waves moving through the air. Most of the musical Instruments use resonance to amplify the sound waves and make the sound louder. Resonance occurs when an object vibrates in response to sound waves of a certain frequency. In stringed Instruments like vina, the strings are plucked and in violin, the strings are bowed to produce sound. Vibrations from the strings hit the hollow body which is the resonator of the Instrument and bouncing of the resonator produces sound.

Types of vibrations in Music:

There are many types of vibrations in music according to the instrument type. They are vibration of strings, vibration of air, vibration of reeds, vibration of vocal cord, vibration of membranes and so on. Another type of vibration is mode of vibration that is oscillating, reciprocating and periodic. The basic structure of all musical instrument is a sound source and a resonant body that enhances sounds at particular frequencies. When a string, reed or drum head vibrates, those vibrations cause air molecules to knock into one another in repeating patterns known as sound waves. In Mechanical, acoustical or electrical vibrations are the sources of sound. In most of the musical instruments sound production depends upon the collective behavior of several vibrations.

1 Stringed Instruments - Vina, violin, Guitar.
2. Percussion Instruments - Mridangam, Tabla, Drums.
3. Wind Instruments - Flute, Nagaswaram, Clarinet.
4. Auto phones - Cymbles, Bells,

Sound waves:

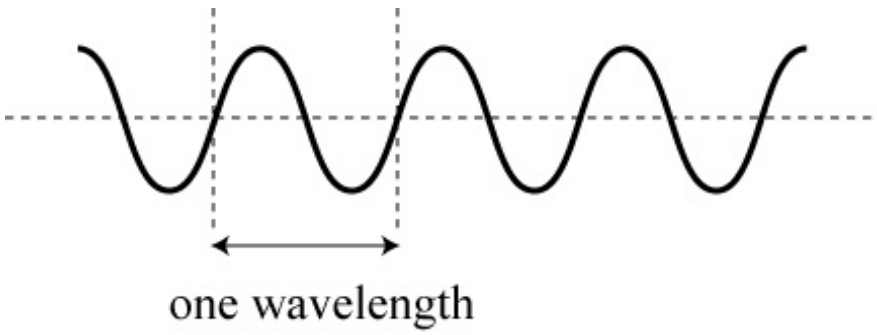
Vibration is \the mechanical oscillation of an object from an equilibrium point. Sound energy causes the molecules to move back and forth in the same direction through which the sound is travelling. This is known as a longitudinal wave. When the molecule vibrates up and down perpendicular to the direction of the waves travels which is known as Transverse Waves. Sound waves are made of a series of high and low points. As they move through the medium such as air, the air particles compress and decompress. So, we can assume that sound waves are also pressure waves. Controlling these different types of waves represents important principles of Physics. Sound waves are invisible to our eyes unless we find a way to make the sound waves move something that we can see. Gamma rays has the maximum frequency in the electromagnetic spectrum. Sound is the transmission of kinetic energy from particles in the source to the particle in the medium in which the sound travels. Sound travels as a wave due to collision in the material in which it moves.

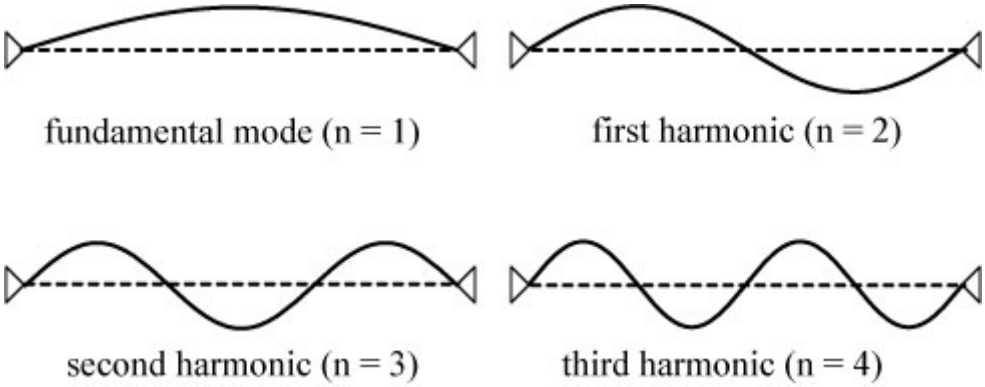
1. Longitudinal waves: Vibration of the wave moves parallel to the direction in which the wave is travelling.
2. Transverse Waves: The vibration is at 90 degrees to the motion of the waves.
3. Compression: High density part of the wave.
4. Refraction: Low density part of the wave.

Vibrations on Stringed Instruments:

A simple example of a system is a pendulum or swing that can be driven at resonance, most of the objects have multiple resonance frequencies The next example on order of complexity is a vibrating string which is fixed at both ends like those on Guitar or Vina. If we mechanically drive the string of Guitar, we would find that it has a lowest (fundamental) frequency which we will call f and then higher order of frequencies (harmonics) at 2f, 3f ,4f and on to infinity. The vibration of string (which we call as modes) look different for each Harmonic.

Wave length: Strings of different lengths, thickness and tensions will have different fundamental frequencies. But they will all follow the same pattern, higher - order resonant frequencies will all be integer multiples of the fundamentals. The fundamental and harmonic modes are one round trip of waves on the string in a single wave length. A single cycle of a wave, the size of a wave length is one for which the wave has completed one complete up \ down motion. So, the fundamental mode is only a half- wave length. A full round trip of the wave back and forth across the string constitutes a complete wave length. When we play on the string of Guitar a tone those fundamental frequencies, we are always adding to the vibration of the string in the same way at the same point in the string cycle. This is explained in the below diagram.





Nodes and Harmonics:

It is to be noted that each higher harmonics have point where the string amplitude is zero. There is no motion on the string at these points which are called nodes We play by putting a finger on the string at those points blocking the motion there and it will not affect the harmonics mode at all. This technique is used in Guitar Playing and is known as a pitch harmonic. The wave themselves do not move or change the shape at all except to move up and down essentially, they stand in place. Because of this they are known as Standing Waves.

Laws of Vibrations:

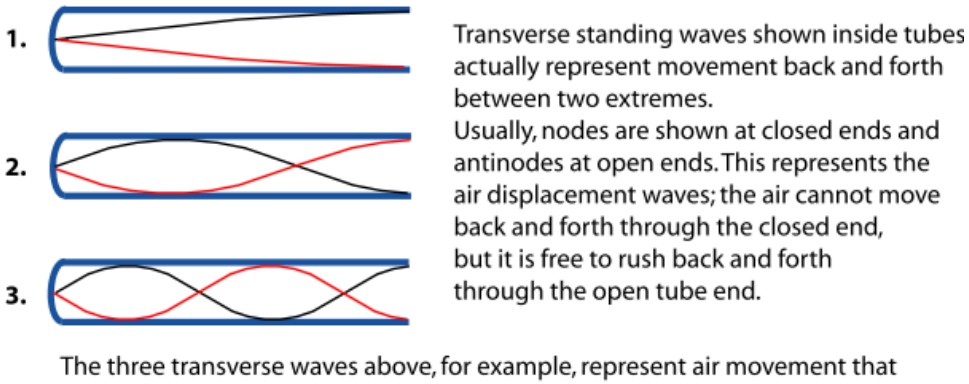
Laws of Vibration of Stringed Instruments:

1.Law of Length: The fundamental frequency of vibration of a string is inversely proportional to the length of the vibrating string if the tension and mass per unit length are constant.

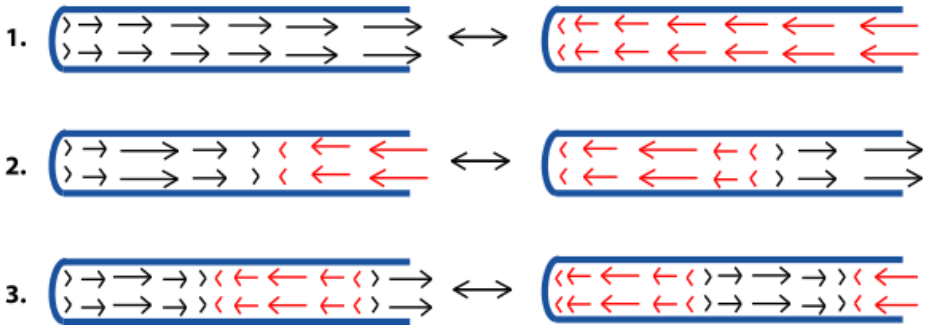
2. Law of Tension: The fundamental frequency of vibration in a string is directly proportional to the square root of tension if the vibrating length and mass per unit length are constant.

3. Law of Linear density: The fundamental frequency of vibration of a string is inversely proportional to square root of mass per unit if the tension and the vibrating length are constant.

Vibration of air column:



The three transverse waves above, for example, represent air movement that goes back and forth between the state on the left and the state on the right (the shorter the arrow, the less the air in that area is moving) :



Standing Waves:

It is also called stationary waves. Combination of two waves moving in opposite direction, each having the same amplitude and frequency. A standing wave in a musical instrument allows for consistency and predictability of the wave in order to produce a tone. In wind instruments (Clarinet, Flute). a standing wave is trapped by resonance in a resonating chamber .Here in this because the observed wave pattern is characterized by points that appear to be standing still, the pattern is often called Standing wave .A standing wave is a wave where the overall pattern does not appear to move . For the standing wave\ on a string the basic condition that must be met is that both ends of the strings must be fixed in place. In wind instruments most of the sound is produced by the standing waves in the air column inside the instrument. All standing wave patterns consists of nodes and internodes.

Amplitude and Sound:

One important property of waves in physics is their frequency which describes how many waves pass one point during specific time. In the larger frequency the more waves pass the point and they are high pitched. In contrast in the smaller frequency the less waves pass the point and they are low pitched. The amplitude tells us how loud a tone is. The larger amplitude gives the higher wave and the louder tone sound and the smaller amplitude gives a softer tone sound.

Musical Instruments and vibrations:

All Percussion Instruments will have a hollow body. When it is being hit with sticks, hands, or with something this hollow body starts vibrating and creates the tones we hear. The wind instruments include brass instruments (Trumpets, Saxophone) wood wind instruments (Nagasvaram) all have a hollow tube and a mouth piece. When the player blows through the mouth piece the air column inside the tube is set into a vibration and a tone can be heard. All Stringed instruments work through the vibrations of tensioned strings. The vibrating motion can be started by different methods. The string can be plucked like Guitar, vina, bowed like violin, Cello and hit like piano. Striking the head of the drum changes the shapes and compresses the air inside the body. The compressed air presses the bottom head and changes its shape which will be transmitted to the drum shell and reflected back. Repetition of this action will create a vibration. While playing the drum the membrane vibrates and hence produces sound.

Music and arts:

Music is the most universal performing Arts and it is seen all around the world. It ia an integral part of cultural heritage including rituals, festive events and oral tradions. The beauty and emotion evoked when listening to music is aesthetic art of music. The structure of musical instruments shows an aesthetic artistic look. The musical instruments are of beautiful shapes, bright and shining colours and its sound triggers various emotions and feelings with in us. Music is an art because it comes from the soul and it has creations on many and various forms. The musical instruments like Indian vina with its beautiful structure is called Queen of Indian Instruments. All the musical instruments have beautiful shapes and colours also represents symbolizes some natural characters. A piano can represent contentment and in another angle romance. Different types of horns and their sound represents nobility accomplishment and solitude The trumpet and other brass instruments represents excitement and energy. The flute and the violin are more divine and melodi

Musical Instruments and Engineering:

Each musical instrument is unique in its structure and sound. The construction of all musical instruments will come under Engineering. Each Instrument has measurements of length, breath and height according to its shape and structure. Some of the structures in musical instruments need accurate fixing to get the original sound. For example, the sound post in violin. The fixing of the sound post under the bridge is very critical and minute work. Like that in flute the fixing of hole position with particular diameter and the gap in between the holes are difficult technical works. If the space in between varies the sound will be affected. The space between the mouth hole and the finger hole and the space between the finger holes should be according to the measurements and it is a difficult task like engineering. In Vina fixing the Wax board on the body or Dandi is a laborious and critical one the gap in between the frets should be in perfect measurement other vice the sound of the Vina will be spoiled. So, fixing a wax board is a mathematically complicated engineering work.

CONCLUSION:

The beauty and emotion evoked when listening to music is aesthetic art of music. The structure of musical instruments shows an aesthetic artistic look.

Fixing of Sound post in violin, wax board in Vina and the mouth holes and finger holes in Flute are works of perfect engineering.

The laws of vibration are the second of the 12 universal laws. It states that everything in the universe is constantly in motion vibrating at its own particular frequency.

In the larger frequency more waves pass the point and they are high pitched. In contrast in the smaller frequency less waves pass the point and they are lower tone sound
The larger amplitude gives the higher wave and the louder the tone sound and the smaller amplitude gives a softer tone sound.
The higher harmonics each have points where the string amplitude is zero. There is no motion on the string at these points which are called nodes.
Strings of different lengths, thickness and tensions will have different fundamental frequencies. All standing wave patterns consists of nodes and internodes.
The design of musical instrument is part of Art, Construction is part of Engineering and sound production is part of basic physics totally it is the multi-disciplinary aspect of Musical Instruments.

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