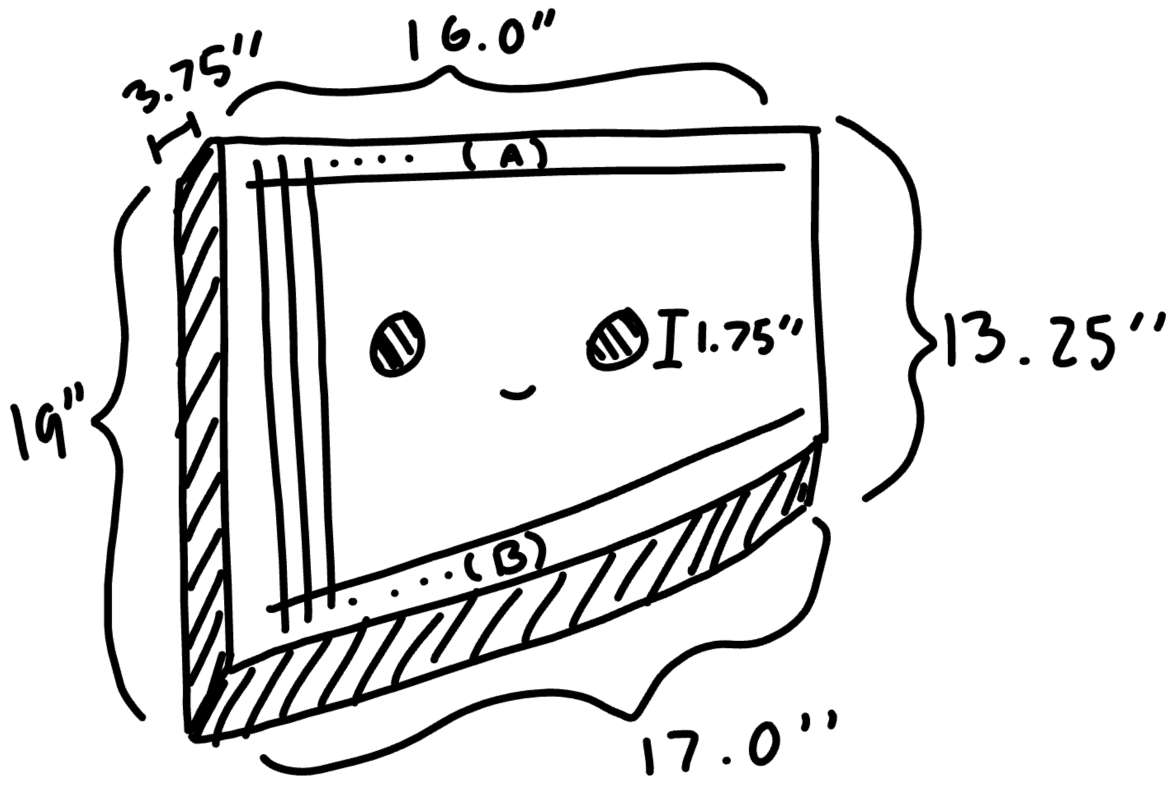
TEAM DIAMOND: B-21
~ Sounds of Music ~
Design Log



Sounds of Music - Skyview Middle School
Team Diamond: B-21 ~ Shyla Agrawal & Sanskriti Shukla

~Materials~

- Plywood
- Guitar strings (gauge 46)
- Regular nails
- Wood glue
- Regular screws
- Eye hook screws (A)
- Eye lag screws (B)
- Wall liners (for the Bridge)

~How to Tune~

You use a wrench to slowly twist the eye lag screws to tune each individual string. Twist the screw right for a higher pitch, and left for a lower pitch.

- Tuning F3 - This is how we tuned F3.

Note shown (on tuner)	Frequency (Hz)
$F^{\#}2$	91.1
$A^{\#}2$	117.8
C3	127.0
E3	164.8
F3!	174.9!

~How to Play~

You use a pick or finger to pluck the string in the middle of it.
Every string is half a step higher than the one left to it.

~About our Instrument~

Our instrument was inspired by the Indian instrument, Santoor. We made the instrument, so that it looks like the Santoor, but isn't played exactly the same way the Santoor is.

NOTES►

Different classifications of instruments:

Idiophones:

- Sound is produced by the body of the instrument vibrating, rather than a string, membrane, or column of air.
- Struck – clapping, cymbals, xylophones, bells, rattle
- Plucked – thumb piano, jaw harp
- Friction – friction sticks
- Blown – blown sticks
- Unclassified

  Membranophones
- Sound is produced by the vibration of a tightly stretched membrane.
- Struck – drums (many varieties)
- Plucked – plucked drums (a string is attached to the membrane and causes the vibration)
- Friction – friction drums (rubbed rather than struck or instruments in which a cord is attached to the membrane and rubbed)
- Singing – kazoos

  Chordophones
- Bowed Instrument
- Sound is produced by the vibration of a string or strings that are stretched between fixed points.
- Simple/Zither – musical bows, zithers
- Composite – lutes, harps, tube fiddle, violins, viola, cello, bass, guitars
- Unclassified

  Aerophones
- Sound is produced by vibrating air.
- Free – early organs, accordion, harmonica
- Non-free – flutes, recorder, oboes, clarinet, saxophone, trumpet, trombone, euphonium, tuba
- Unclassified
- **Electrophones**
- Violoncello = Cello

Physics of Music:

- Sound is measured in decibels (dB) on a logarithmic scale.
- Length (in meters) is equal to the speed of sound divided by the quantity of four times the frequency of the notes.

- Decibels are a type of logarithmic unit, where 10 times a quantity corresponds to an increase of 10 dB. That is, a sound of 30 dB has 10 times the intensity of a sound of 20 dB, and a sound of 40 dB has 10 times the intensity of one of 30 dB, and one of 50 dB has 10 times that of 40 dB, and so forth. (Sounds of Music, 2021 Invitational)
- Most commonly used method to determined the frequency of sound by a scientist: Autocorrelation
- Pressure is a measure of force per area. $\frac{measure\ of\ force}{area}$(Measure of force/area)
    - SI Unit of force: The Newton
    - SI Unit of area: m^2
    - The Newton (From Newton's Second Law) : kg•m/s^2
    - $\frac{N}{m^2} = \frac{kg \bullet m/s^2}{m^2} = \frac{kg}{m \bullet s^2}$

$$\boxed{fT = 1 \quad \text{or} \quad f = \frac{1}{T}.}$$

Vocabulary:

Wavelength (λ): The length of one cycle of the wave (measured in units of length, like meters)

Frequency (f): The # of times the wave repeats per second (unit: Hertz, Hz)

Speed (v) : how fast the wave travels, distance divided by time

*Waves physics equation: λf = v; wavelength * frequency = speed*

- Speed of sound changes based upon medium.
- Sound is fastest in solids, then in liquids.
- Slowest in gasses.

Resonance: When an object vibrates at certain frequencies at which it can sustain standing waves. Or: a reinforcement of sound (as a musical tone) in a vibrating body or system caused by waves from another body vibrating at nearly the same rate

[The example of the vibration of one string making another string vibrate is induced resonance, or driven resonance.]

Double Reed instrument: An Oboe and a Bassoon are two instruments that are double reeded. They make sound when air is pushed through the two reeds, causing them to vibrate against each other.

Resonance - <u>effect of natural vibrations being amplified;</u> An object or air column may vibrate at its fundamental frequency or an overtone when a force is applied to the object at certain frequencies. When the force is applied at other frequencies, the object or air does not vibrate with as much energy. This phenomenon is called resonance.

- occurs when two interconnected objects share the same vibrational frequency
- one of the objects is vibrating, so it forces the second object into vibrational motion
- the result is a large vibration
- if a sound wave within the audible range of human hearing is produced, a loud sound is heard.

Standing waves: waves that don't travel from one place to another.
Transverse waves: The motion of the wave is perpendicular to the motion of the sound wave from the instrument. -for example, the movement of a violin string
Longitudinal waves: This means that the air particles travel parallel to the direction of the sound wave.
Compressions: Sound waves have areas where the air particles are close. (air pressure is higher than normal atmospheric pressure); high pressure area of a wave
Rarefactions: When sound waves are farther apart (air pressure is lower than normal atmospheric pressure); a decrease in the density of something; low pressure area of a wave
Partials: The frequencies at which standing waves can occur
Harmonics: A sound wave that has a frequency that is an integer multiple of a fundamental tone

- The fundamental tone is referred to as the <u>first harmonic</u> (generally louder than the other harmonics).
- A tone played at twice the frequency of the first harmonic is the <u>second harmonic.</u>
- A tone played at 4x the frequency of the first harmonic is the <u>fourth harmonic.</u>

Node: a point where the amplitude of vibration is the minimum and pressure is the maximum; a place where no sound waves are generated
Antinode: point where the amplitude of vibration is the maximum and pressure is the minimum.
Displacement node: nothing but a pressure antinode, and vice versa
Diffraction - The phenomenon where waves spread around an object. It is partly diffraction in play when you hear sound despite being behind a wall, doorway, or other

obstacle—the sound spreads out from an opening to diffract around the object, moving radially away from any boundaries.

Dispersion - In many media which we are accustomed to, sound only travels at one speed. This does not have to be the case, however. When waves of different frequencies travel at different speeds, this is called dispersion. Air is non-dispersive, but water and ice do cause dispersion of waves.

Reflection - process of a wave bouncing off an object; Reflection occurs when a wave encounters a boundary and as a result moves in the opposite direction. Reflection is responsible for both echoes and reverberation.

-The angle of incidence (the angle at which the sound wave hits the surface) is equal to the angle of reflection (the angle at which the sound wave bounces back).

- This is known as the law of reflection, and it applies to all types of waves, including sound waves.

Refraction - Refraction is the change in the direction of a sound when the speed of sound changes. Different media vary in their speed of sound, leading to refraction as sound enters from one material to another; bending as it crosses a boundary between two materials

Displacement Amplitude - The maximum value that any single particle is displaced in a sound wave; the maximum amount that any of the air particles moves, because of the sound wave.

Power - Moving air particles have kinetic energy, so as a sound wave moves, it transports energy along with it. Power is how fast the sound wave carries this energy. Amount of energy transported divided by the time it took.

Intensity - Power transmitted per area receiving energy; $I = \frac{P}{A}$

Tempo: Rate at which notes are played

Solfège: Solfège syllables are a group of systems that connect notes to a syllable. The syllables include *do*, *re*, *mi*, *fa*, *sol*, *la*, and *ti*. Solfège systems enjoy large popularity in formal choral education.

Ultrasonic Waves: The waves whose frequencies are greater than 20,000 Hz.

Doppler Effect:

- Occurs when a source of sound or an observer are moving relative to the sound.

Medium: a material that the wave goes through

Consonance: A combination of two (or more) tones of different frequencies that results in a musically pleasing sound.

Dissonance: A combination of two (or more) tones of different frequencies that results in a musically displeasing sound.

Psychoacoustics: scientific study of sound perception and audiology. This includes speech, music, and other sound frequencies that travel through our ears.

Period: the time it takes to complete one vibrational cycle

Boundary: where one medium ends and another begins

Boundary behavior: How the wave acts when it reaches the boundary (reflect/ diffract/ transmission/ refraction)

Reverberation: when you sing (in the shower) the area is smaller, so the sound doesn't take that long to reflect back, it takes less than 0.1 sec, so it sounds like the sound is prolonged; the persistence of sound after it has been stopped due to multiple reflections from surfaces such as furniture, people, air, etc., within a closed surface

Destructive interference: when two waves traveling in the same direction are aligned at the crest of one wave and the trough of the other. The waves cancel out.

Constructive interference: when two waves traveling in the same direction overlap, and their crests combine to produce a larger wave.

Dyadic time signature: When the denominator is the power of two. So 2^1 or 2^3 would be dyatic.

Hexachord or Hexascale: When there are 6 notes, all of them would be a whole step apart, except the 3rd and 4th, which are a half step apart.

Timbre: the distinctive property of a complex sound; the quality or tonal color of a sound, and it is determined by which overtones are mixed in with the fundamentals

Decibels: unit of loudness

Wind Instrument: an instrument that makes sound when air is blown through it (e.g. Flutes, Clarinets, Oboes)

Percussion Instrument: an instrument that you pound on to create sound (e.g. Drums, Xylophone, Marimba)

Brass Instrument: a wind instrument that's made out of brass (e.g. saxophones, french horns, trumpets)

String Instrument: an instrument that makes sound when a string is played (e.g. violins, violas, cellos)

RT60: The amount of time it takes for the sound to reduce by 60 dB from its original sound level

Wave Theory: the theory that light is transmitted as waves

Sound: a disturbance that travels through a medium as a longitudinal wave

Fundamental: the lowest tone of a harmonic series; the longest wave that can fit in a tube

Overtone: a harmonic with a frequency that is a multiple of the fundamental frequency; above the fundamental note

Fundamental Frequency: lowest frequency for an instrument

Frequency: how high or low a pitch is, and is based on the rate that it vibrates at; Number of wavelengths that pass a fixed point each second

Pulse Wave: a pulse that propagates through a medium

Doppler Effect: frequency is higher when observer approaches source or when source approaches observer

Periodic Wave: the motion is repeated over and over again

Velocity: Distance divided by time (meters per second)

Propagation: the process by which a disturbance, such as the motion of electromagnetic or sound waves, moves through a medium such as air or water

Interference: when 2 waves with the same frequency and wavelength interact

Supersonic: a term that describes speeds faster than the speed of sound

Linear motion: motion that goes from one place to another without repeating

Harmonic motion: motion that repeats in cycles

Restoring Force: any force that always acts to pull a system back toward the equilibrium

Equilibrium: a state in which opposing forces or influences are balanced

Periodic Force: a repetitive force

Natural Frequency: the natural frequency at which an object vibrates when disturbed

Echolocation: the process of locating objects by emitting sounds & interpreting the reflected sound waves

Sonar: system that uses the reflection of underwater sound waves to detect objects

Ultrasound: high frequency sound waves; these waves have higher frequencies and shorter wavelengths

Resonators: instruments use these; hollow chambers that amplify sound when air inside vibrates

Attenuation: energy is lost to the medium through which a wave is traveling

Texture: how the tempo, melodic and harmonic materials are combined in a composition

Impedance: characteristics of the medium that indicates how loud a sound will be depending on the frequency and sound source

Polyrhythm: a rhythm that makes use of two or more different rhythms simultaneously

Complex Tones: Complex tones are sounds that are made up of multiple frequencies or sinusoidal waves with different amplitudes, frequencies, and phases. They are also known as composite tones or timbrally complex tones.

Meter: The organization of beats or pulses into regular patterns in music. Common meters include duple meter (e.g., 2/4, 4/4), triple meter (e.g., 3/4), and compound meter (e.g., 6/8, 9/8).

Cadence: A musical phrase or pattern that marks the end of a musical section or phrase. Cadences provide a sense of closure and resolution in music.

Descant Part: The descant part, also known as a descant line or descant melody, refers to a higher or additional melody that is played or sung above the main melody or harmony of a musical piece. The descant part often adds a higher pitch, different rhythm, or contrasting melodic material to the main melody, creating a harmonically or melodically distinct layer of music.

Resonators

Resonator of drums: inside of the sides

Resonator on guitars and violins: hollow body

Resonator on brass and woodwind instruments: the mouthpiece

Helmholtz Resonators:

- A type of acoustic resonator that is used to attenuate (reduce) specific frequencies of sound
- A Helmholtz resonator or Helmholtz oscillator is a container of gas (usually air) with an open hole (or neck or port).
- At the Helmholtz resonance, a volume of air in and near the open hole vibrates because of the 'springiness' of the air inside.
- Consist of a volume of air that is connected to the outside world by a small neck or opening
- When sound waves enter the resonator, they cause the air inside to vibrate & the resonator amplifies the sound waves at its natural frequency
- The resonant frequency of a Helmholtz resonator depends on the volume of the resonator, the length and diameter of the neck or opening, and the speed of sound in air. By adjusting these parameters, the resonator can be designed to attenuate specific frequencies of sound.
- Helmholtz resonators are used in a variety of applications, including noise reduction in HVAC systems, mufflers for internal combustion engines, and musical instruments such as bass drums and wind instruments.
- They are also used in scientific research to study the properties of sound and vibration.
- The formula for the resonant frequency of a Helmholtz resonator is given by:
  $f = (c/2\pi) * \mathrm{sqrt}(A/((l+0.8d)V))$
  where:
- f is the resonant frequency in hertz (Hz)
- c is the speed of sound in meters per second (m/s)
- A is the area of the neck of the resonator in square meters (m^2)
- l is the length of the neck of the resonator in meters (m)
- d is the diameter of the neck of the resonator in meters (m)
- V is the volume of the cavity of the resonator in cubic meters (m^3)
- This formula assumes that the resonator is operating in the frequency range where the air behaves as a compressible fluid and that the neck of the resonator is much smaller than the wavelength of the resonant frequency.

Acoustic Impedance:

- Acoustic impedance is a measure of the resistance that a medium presents to the propagation of sound waves.
- It is defined as the ratio of the sound pressure in a given medium to the volume velocity of the sound wave. In other words, it represents the resistance of a medium to the flow of sound waves through it.
- The acoustic impedance of a medium depends on its density and its speed of sound.
- The denser the medium, the higher the acoustic impedance. Likewise, the higher the speed of sound, the higher the acoustic impedance.
- Acoustic impedance is an important parameter in many areas of acoustics, including the design of audio systems, the study of ultrasound imaging, and the characterization of materials using nondestructive testing techniques such as ultrasound.
- In medical ultrasound, for example, the acoustic impedance of different tissues in the body can be used to create images of internal organs and structures.
- The formula for acoustic impedance is:
  $\underline{Z = \rho c}$
- where:
- Z is the acoustic impedance in Pa·s/m (pascal-second per meter)
- ρ (rho) is the density of the medium in kg/m^3 (kilograms per cubic meter)
- c is the speed of sound in the medium in m/s (meters per second)
- This formula indicates that the acoustic impedance of a medium is directly proportional to its density and the speed of sound within the medium. Acoustic impedance is an important parameter in acoustic wave transmission and reflection at interfaces between different media, such as air and water, or between different tissues in the human body.

<u>Sonar</u>:

- Sonar, short for "sound navigation and ranging," is a technology that uses sound waves to detect and locate objects underwater.
- Sonar works by emitting a pulse of sound waves into the water and then listening for the echoes that bounce back from objects in the environment.
- There are two main types of sonar: active and passive.
- Active sonar systems emit sound waves and listen for the echoes that bounce back, while passive sonar systems only listen for the sounds emitted by other objects in the water, such as ships or marine animals.
- Sonar is used for a variety of applications, including underwater navigation, search and rescue operations, marine resource exploration, and military applications such as submarine detection.

- In addition to its use in underwater environments, sonar is also used in the air and on land for various applications, such as detecting objects underground or measuring the thickness of ice sheets.
- A major step in the development of sonar systems was the invention of **the acoustic transducer** and the design of efficient acoustic projectors.
- These utilize piezoelectric crystals (e.g., quartz or tourmaline), magnetostrictive materials (e.g., iron or nickel), or electrostrictive crystals (e.g., barium titanate).
- These materials change shape when subjected to electric or magnetic fields, thus converting electrical energy to acoustic energy.
- Suitably mounted in an oil-filled housing, they produce beams of acoustic energy over a wide range of frequencies.

<u>Sonar Waves</u>

- <u>Sound wave propagation:</u> Sonar waves are a type of mechanical wave that propagate through a medium, such as water or air, as a series of compressions (high-pressure regions) and rarefactions (low-pressure regions). These waves travel through the medium and can bounce off objects, changing direction and speed in the process.
- <u>Frequency and wavelength:</u> Sonar waves can have different frequencies and wavelengths depending on the specific application and requirements. Higher frequencies, such as ultrasound, are used for short-range, high-resolution imaging, while lower frequencies are used for longer-range detection.
- <u>Reflection and echo:</u> When sonar waves encounter objects in the medium, they can reflect off the objects and return to the sonar system as echoes. The time delay between the emitted sound wave and the received echo can be used to determine the distance to the object.
- <u>Signal processing:</u> Sonar systems typically use sophisticated signal processing techniques to analyze the returned echoes and extract information about the location, size, shape, and composition of objects in the medium. This involves processing and analyzing the amplitude, time delay, and frequency characteristics of the echoes to generate images or other forms of data.

<u>Boundary Effects</u>

- Boundary effects refer to the influence of boundaries on sound waves, which can cause changes in the wave's behavior, such as reflection, transmission, and diffraction.
- Sound waves are affected by boundaries in a variety of contexts, such as in rooms, enclosures, and outdoor environments.
- **Reflection**: a common boundary effect that occurs when a sound wave encounters a boundary and bounces back, changing the direction and amplitude of the wave.

- The amount of reflection depends on the acoustic impedance of the two media and the angle of incidence of the wave.
    - For example, in a room with hard walls, sound waves reflect more than in a room with soft walls, which absorb more sound energy.
- **Transmission**: another boundary effect that occurs when a sound wave passes through a boundary from one medium to another.
    - The amount of transmission depends on the acoustic impedance of the two media and the angle of incidence of the wave.
    - For example, sound waves passing from air to water experience a large change in acoustic impedance, causing some of the wave energy to be transmitted and some to be reflected.
- **Diffraction**: a boundary effect that occurs when a sound wave passes through a small opening or around a barrier.
- The wave bends around the edges of the opening or barrier, causing changes in its direction and amplitude.
- The amount of diffraction depends on the size of the opening or barrier relative to the wavelength of the wave.
- Boundary effects can have significant impacts on the sound field in a space, affecting factors such as sound level, frequency response, and spatial distribution of sound.

Sound Wave stuff:

- Sound is from vibrations and air molecules that ultimately reach our ear.
- Reflections can only occur when a wave encounters a solid object.
- If a short pulse decays in amplitude, it is perceived to be higher in pitch than an identical pulse with a consistent amplitude.
- Frequency does not change with a medium change.
- It is easier to get objects to vibrate at resonant frequencies than at other frequencies.
- In an air column, the pressure node corresponds to an open end of the column.
- A longer wavelength corresponds to a larger amount of diffraction.
- The infrasonic range is any frequency below 20 Hz and can damage your body due to resonance effects.

Science behind "white noise"

- White noise is a type of noise that contains equal intensity across all frequencies within a given range, typically from 20 Hz to 20,000 Hz, which is the approximate range of human hearing. It is called "white" noise because it is analogous to white light, which is a combination of all colors in the visible spectrum. White noise is often used in various applications, such as masking background sounds, promoting relaxation or sleep, and for scientific and engineering purposes.

- The science behind white noise can be understood from its acoustic properties and how it is generated. Here are some key points:
- Equal energy across all frequencies: In white noise, the energy is evenly distributed across all frequencies within the audible range. This means that each frequency component in white noise has the same intensity or amplitude, which gives it its characteristic "flat" or "hissing" sound.
- Randomness and unpredictability: White noise is considered to be random and unpredictable, as the intensity of each frequency component changes rapidly and independently over time. This randomness is what makes white noise effective for masking or covering up other sounds, as it can help to obscure or drown out unwanted noises.
- Gaussian distribution: The amplitudes of individual samples in white noise are typically distributed according to a Gaussian or normal distribution, which means that most samples fall near the mean, with fewer samples at higher or lower amplitudes. This gives white noise its "random" or "hissing" quality.
- Broadband nature: White noise covers a wide frequency range, spanning from low frequencies to high frequencies. This makes it useful for masking or covering up sounds across the entire audible spectrum.
- Generated by random processes: White noise can be generated through various methods, such as electronically using white noise generators or through natural processes, such as the sound of wind or rushing water. It can also be simulated or approximated using mathematical algorithms or digital signal processing techniques.

Music basic note knowledge:

- Notes have letter names from A to G in order of pitch.
- They are arranged on a *staff* consisting of five bar lines.
- There are many, many notes, but only seven letter names from A to G, so letter names will begin to repeat after G.
- Notes with the same letter name are members of the same *pitch class*, and the interval separating consecutive members of a pitch class is known as an **octave**.
- We may subdivide the octave into twelve notes, each note situated a half step from the next. An interval of two half steps is called a whole step.
- Some notes exist between the others in pitch.
- We notate notes one half step above another with a **sharp** (♯) and those one half step below with a **flat** (♭).
- For example, the note one half step below E is E♭ (pronounced "E flat") or D♯ (because it is one half step above D).
- Only one half step exists between B and C, and between E and F, meaning that B sharp is C, and C flat is B.

- We also employ the words "sharp" and "flat" to describe pitches that are higher and lower respectively relative to a reference note.
- D.S. = Dal Segno
- D.C. = Da Capo
- Alla Breve: Cut time

Tonic Scale Degrees:

Major Scale:

Tonic (or Root): The first note of a major scale is called the tonic. For example, in the C major scale, the note C is the tonic.

Natural Minor Scale:

Tonic (or Root): The first note of a natural minor scale is called the tonic. For example, in the A natural minor scale, the note A is the tonic.

Harmonic Minor Scale:

Tonic (or Root): The first note of a harmonic minor scale is called the tonic. For example, in the E harmonic minor scale, the note E is the tonic.

Melodic Minor Scale:

Tonic (or Root): The first note of a melodic minor scale is called the tonic. For example, in the D melodic minor scale, the note D is the tonic.

Pentatonic Scale:

Tonic (or Root): The first note of a pentatonic scale is called the tonic. For example, in the G major pentatonic scale, the note G is the tonic.

Blues Scale:

Tonic (or Root): The first note of a blues scale is called the tonic. For example, in the F blues scale, the note F is the tonic.

Intervals:

There are two parts to an interval, the type and the distance

The distance is calculated my the spaces and lines between the two notes, including the ones that the notes are on (when they are identical, they are called a unison) (instead of 8th, its an octave)

These are the different types:

- Major (M)
- Minor (m) It will be minor when the interval is half a step smaller than a major
- Perfect (P)
- Augmented (A or +) this is if the interval is one half step higher
- Diminished (Dim) this is if the interval is one half step lower

Diatonic Modes

- Diatonic modes are scales that are derived from the major scale by starting on different scale degrees. They are also sometimes referred to as "church modes" because of their historical use in Western music during the medieval and Renaissance periods. There are seven diatonic modes, each with its own unique pattern of whole steps (W) and half steps (H). The diatonic modes are:
- Ionian mode (major): W-W-H-W-W-W-H
- Dorian mode: W-H-W-W-W-H-W- The Dorian mode is created by starting on the second scale degree of the major scale and playing the seven notes that follow, maintaining the same pattern of whole steps (W) and half steps (H) as the major scale.
- Phrygian mode: H-W-W-W-H-W-W
- Lydian mode: W-W-W-H-W-W-H
- Mixolydian mode: W-W-H-W-W-H-W
- Aeolian mode (natural minor): W-H-W-W-H-W-W
- Locrian mode: H-W-W-H-W-W-W
- Each diatonic mode has its own unique sound and musical characteristics, and they can be used to create different moods and emotions in music. The Ionian mode (major) is the most familiar and commonly used mode in Western music, while the others are less commonly used but still important in certain musical styles and genres.

Scales

Major Scales

Major scale with no sharp or flat:

- **C Major Scale:** C – D – E – F – G – A – B – C

Major scales with sharps:

- **G Major Scale:** G – A – B – C – D – E – F♯ – G
- **D Major Scale:** D – E – F♯ – G – A – B – C♯ – D
- **A Major Scale:** A – B – C♯ – D – E – F♯ – G♯ – A
- **E Major Scale:** E – F♯ – G♯ – A – B – C♯ – D♯ – E

Major scales with flats:

- **F Major Scale:** F – G – A – B♭ – C – D – E – F
- **B Flat Major Scale:** B♭ – C – D – E♭ – F – G – A – B♭
- **E Flat Major Scale:** E♭ – F – G – A♭ – B♭ – C – D – E♭
- **A Flat Major Scale:** A♭ – B♭ – C – D♭ – E♭ – F – G – A♭

  <u>Enharmonic Major Scales:</u> Scales that have the same pitches but have different note names:

- **B Major Scale:** B – C♯ – D♯ – E – F♯ – G♯ – A♯ – B-
- **C Flat Major Scale:** C♭ – D♭ – E♭ – F♭ – G♭ – A♭ – B♭ – C♭
- **F Sharp Major Scale:** F♯ – G♯ – A♯ – B – C♯ – D♯ – E♯ – F♯-
- **G Flat Major Scale:** G♭ – A♭ – B♭ – C♭ – D♭ – E♭ – F – G♭
- **C Sharp Major Scale:** C♯ – D♯ – E♯ – F♯ – G♯ – A♯ – B♯ – C♯-
- **D Flat Major Scale:** D♭ – E♭ – F – G♭ – A♭ – B♭ – C – D♭

<u>Minor Scales</u>

<u>Natural Minor Scales</u>

Natural minor scale with no sharp or flat:

- **A Minor Scale:** A – B – C – D – E – F – G – A

Natural minor scales with sharps:

- **E Minor Scale:** E – F♯ – G – A – B – C – D – E
- **B Minor Scale:** B – C♯ – D – E – F♯ – G – A – B
- **F Sharp Minor Scale**: F♯ – G♯ – A – B – C♯ – D – E – F♯
- **C Sharp Minor Scale:** C♯ – D♯ – E – F♯ – G♯ – A – B – C♯

Enharmonic Minor Scales:

- **G Sharp Minor Scale:** G♯ – A♯ – B – C♯ – D♯ – E – F♯ – G♯
- **A Flat Minor Scale:** A♭ – B♭ – C♭ – D♭ – E♭ – F♭ – G♭ – A♭
- **D Sharp Minor Scale:** D♯ – E♯ – F♯ – G♯ – A♯ – B – C♯ – D♯
- **E Flat Minor Scale:** E♭ – F – G♭ – A♭ – B♭ – C♭ – D♭ – E♭
- **A Sharp Minor Scale:** A♯ – B♯ – C♯ – D♯ – E♯ – F♯ – G♯ – A♯
- **B Flat Minor Scale:** B♭ – C – D♭ – E♭ – F – G♭ – A♭ – B♭

Natural minor scales with flats:

- **F Minor Scale:** F – G – A♭ – B♭ – C – D♭ – E♭ – F
- **C Minor Scale:** C – D – E♭ – F – G – A♭ – B♭ – C
- **G Minor Scale:** G – A – B♭ – C – D – E♭ – F – G
- **D Minor Scale:** D – E – F – G – A – B♭ – C – D

<u>Harmonic Minor Scales</u>

- **A Harmonic Minor Scale:** A – B – C – D – E – F – G♯ – A
- **E Harmonic Minor Scale:** E – F♯ – G – A – B – C – D♯ – E
- **B Harmonic Minor Scale:** B – C♯ – D – E – F♯ – G – A♯ – B
- **F Sharp Harmonic Minor Scale:** F♯ – G♯ – A – B – C♯ – D – E♯ – F♯
- **C Sharp Harmonic Minor Scale:** C♯ – D♯ – E – F♯ – G♯ – A – B♯ – C♯
- **G sharp Harmonic Minor Scale / A Flat Harmonic Minor Scale**
  G♯ – A♯ – B – C♯ – D♯ – E – F♯♯ – G♯ / A♭ – B♭ – C♭ – D♭ – E♭ – F♭ – G – A♭
- **D Sharp Harmonic Minor Scale / E Flat Harmonic Minor Scale**
  D♯ – E♯ – F♯ – G♯ – A♯ – B – C♯♯ – D♯ / E♭ – F – G♭ – A♭ – B♭ – C♭ – D – E♭

- **A Sharp Harmonic Minor Scale / B Flat Harmonic Minor Scale**
  A♯ – B♯ – C♯ – D♯ – E♯ – F♯ – G♯♯ – A♯ / B♭ – C – D♭ – E♭ – F – G♭ – A – B♭
- **F Harmonic Minor Scale:** F – G – A♭ – B♭ – C – D♭ – E – F
- **C Harmonic Minor Scale:** C – D – E♭ – F – G – A♭ – B – C
- **G Harmonic Minor Scale:** G – A – B♭ – C – D – E♭ – F♯ – G
- **D Harmonic Minor Scale:** D – E – F – G – A – B♭ – C♯ – D

  <u>Melodic Minor Scales</u> - in ascending order

- **A Melodic Minor Scale:** A – B – C – D – E – F♯ – G♯ – A
- **E Melodic Minor Scale:** E – F♯ – G – A – B – C♯ – D♯ – E
- **B Melodic Minor Scale:** B – C♯ – D – E – F♯ – G♯ – A♯ – B
- **F Sharp Melodic Minor Scale:** F♯ – G♯ – A – B – C♯ – D♯ – E♯ – F♯
- **C Sharp Melodic Minor Scale:** C♯ – D♯ – E – F♯ – G♯ – A♯ – B♯ – C♯
- **G sharp Melodic Minor Scale / A Flat Melodic Minor Scale**
  G♯ – A♯ – B – C♯ – D♯ – E♯ – F♯♯ – G♯ / A♭ – B♭ – C♭ – D♭ – E♭ – F – G – A♭
- **D Sharp Melodic Minor Scale / E Flat Melodic Minor Scale**
  D♯ – E♯ – F♯ – G♯ – A♯ – B♯ – C♯♯ – D♯ / E♭ – F – G♭ – A♭ – B♭ – C – D – E♭
- **A Sharp Melodic Minor Scale / B Flat Melodic Minor Scale**
  A♯ – B♯ – C♯ – D♯ – E♯ – F♯♯ – G♯♯ – A♯ / B♭ – C – D♭ – E♭ – F – G – A – B♭
- **F Melodic Minor Scale:** F – G – A♭ – B♭ – C – D – E – F
- **C Melodic Minor Scale:** C – D – E♭ – F – G – A – B – C
- **G Melodic Minor Scale:** G – A – B♭ – C – D – E – F♯ – G
- **D Melodic Minor Scale:** D – E – F – G – A – B – C♯ – D
- **Pentatonic Scale:** The pentatonic scale is a musical scale consisting of only five notes per octave, "penta" meaning five and "tonic" meaning notes. It is one of the most commonly used scales in music and is widely used in various cultures and musical traditions around the world. The pentatonic scale is known for its simple and universal sound, making it versatile and adaptable to many different musical styles and genres.
- The most common form of the pentatonic scale is the "major" or "diatonic" pentatonic scale, which can be constructed by taking five consecutive notes from a major scale and omitting the fourth and seventh scale degrees. For example, the C major pentatonic scale consists of the notes C, D, E, G, and A. The intervals between the notes in a major pentatonic scale are typically whole steps (W) or two whole steps and a half step (W-W-H).
- The major pentatonic scale is often used in various musical genres, such as folk, rock, blues, country, and jazz, to create melodies, solos, and improvisations. It has a happy and uplifting sound and is often associated with positive and joyful emotions.
- In addition to the major pentatonic scale, there is also the "minor" pentatonic scale, which is derived from the natural minor scale by omitting the second and sixth scale degrees. The minor pentatonic scale is commonly used in blues, rock, jazz, and many other genres to create a melancholic or bluesy sound.
- The minor pentatonic scale can also be used in combination with the major pentatonic scale to create more complex and interesting melodies, harmonies, and improvisations. This is known as "pentatonic pairing" or "dual pentatonic" approach, where both the major and minor pentatonic scales are used in a complementary manner.

Tempo names

- Largo ~ very slow ~ 40-60 bpm
- Adagio ~ Slowly with great expression ~ 60-72 bpm
- Andante ~ Walking pace ~ 72-84 bpm
- Moderato ~ moderate speed ~ 85-110 bpm
- Allegro/Vivace ~ fast, quick, and bright ~ 110-140 bpm
- Presto ~ very very fast ~ 140+ bpm

Harmonics:

- Are a natural frequency of an oscillator
- Harmonics give instruments their own unique timbre
- The first harmonic is the same as the fundamental frequency.
- We denote the nth harmonic with n, where n=1 is the fundamental frequency.
- The reason for overtones is that standing waves of different lengths can be fit onto a single musical instrument.
- Sound waves, when encountering each other, will undergo **interference**.
- At every point where both waves overlap, the pressure difference there will equal the sum of the pressure differences of the individual sound waves.
- Since it's as though we have added the waves on top of each other, we also call this the principle of superposition.
- Sound is the rapid cycling between compression and rarefaction of air. The way that sounds move through the air can be thought of as analogous to the way vibrations move along a slinky.
- Humans create music by vibrating the air column in their throats. By changing the shape/tension in their vocal cords, they can create different vibrational modes and sounds.
- The frequency at which a string will vibrate depends on its mass density, length and tension.
- If two sound waves of different frequencies interfere, a varying amplitude results from a switch between constructive interference and destructive interference between the two waves.
- This variation in the loudness of the sound is known as beats.
- The beat frequency is defined as the difference in frequency between the two original waves.
- This means that the closer the two frequencies are, the smaller the beat frequency is (meaning fewer beats per second), which makes them easier to distinguish with the human ear.
- The speed of the vibration of a sound source gives the frequency of the sound.
- The size or amplitude of the vibration gives the loudness of the sound.
- Certain beat frequencies are perceived by the human ear as a "subjective frequency" or "difference frequency.”

- Waves on a string of length L and linear mass density μ under tension T

$$f_n = \frac{nv}{2L} = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$$

- Air column of a pipe with both ends open

$$f_n = \frac{nv}{2L}$$

- Air column of a pipe with one end closed and one end open

$$f_n = \frac{nv}{4L}$$

Only odd n exist for such a pipe. In this case, the first harmonic would be n=1, followed by n=3, n=5, and so on.

Modes:

- A mode is a type of scale
- The seven main categories of mode have been part of musical notation since the middle ages.
- So, the list goes: Ionian, Dorian, Phrygian, Lydian, Mixolydian, Aeolian and Locrian. Some of them are major modes, some are minor, and some are ambiguous. Some modes are sadder or holier than others.
- Overtones with close frequencies carrying high energy are known as a formant.
- Each degree of the scale has a special name:
- 1st degree: the tonic
- 2nd degree: the supertonic
- 3rd degree: the mediant
- 4th degree: the subdominant
- 5th degree: the dominant
- 6th degree: the submediant
- 7th degree: the leading note (or leading tone)
- 8th degree: the tonic but an octave higher

Wave facts (harmonics of open and closed tubes):

- Pipes w/ both ends open —--> open pipes
- Pipes w/ exactly one end closed —> closed pipes
- In string instruments, f-holes (or rosetta) are used to amplify sound
- The end conditions of a closed tube create a node at the closed end & an antinode at the open end
- The length of a closed tube is ¼ of a wavelength
- In an open tube, the medium (ex. air) at the open ends vibrates horizontally parallel to the tube length.
- This means the standing wave has displacement antinodes at the ends of the tube for all harmonics, and a node in the middle for the fundamental.

- The simplest standing wave in an open tube is the fundamental, which has 2 antinodes and 1 node.
- Thus, there is half of a wavelength between the antinodes.

- For an open tube with length L, the wavelength of the standing waves that corresponds with the fundamental frequency is:

- A sound wave in air is an oscillating pressure wave

Ear Anatomy:

- Sound waves enter the outer ear and travel through a narrow passageway called the ear canal, which leads to the eardrum.

- The eardrum vibrates from the incoming sound waves and sends these vibrations to three tiny bones in the middle ear.

- These bones are called the malleus, incus, and stapes.

- The bones in the middle ear amplify, or increase, the sound vibrations and send them to the cochlea, a snail-shaped structure filled with fluid, in the inner ear.

- An elastic partition runs from the beginning to the end of the cochlea, splitting it into an upper and lower part.

- This partition is called the basilar membrane because it serves as the base, or ground floor, on which key hearing structures sit.

- Once the vibrations cause the fluid inside the cochlea to ripple, a traveling wave forms along the basilar membrane.

- Hair cells—sensory cells sitting on top of the basilar membrane—ride the wave.

- Hair cells near the wide end of the snail-shaped cochlea detect higher-pitched sounds, such as an infant crying.

- Those closer to the center detect lower-pitched sounds, such as a large dog barking.

- As the hair cells move up and down, microscopic hair-like projections (known as stereocilia) that perch on top of the hair cells bump against an overlying structure and bend.

- Bending causes pore-like channels, which are at the tips of the stereocilia, to open up. When that happens, chemicals rush into the cells, creating an electrical signal.

- The auditory nerve carries this electrical signal to the brain, which turns it into a sound that we recognize and understand

What causes hearing loss when in loud environments for too long?

- The hair cells in the inner ear get damaged. They transmit signals to nerves after being simulated by vibrations of cochlear fluid

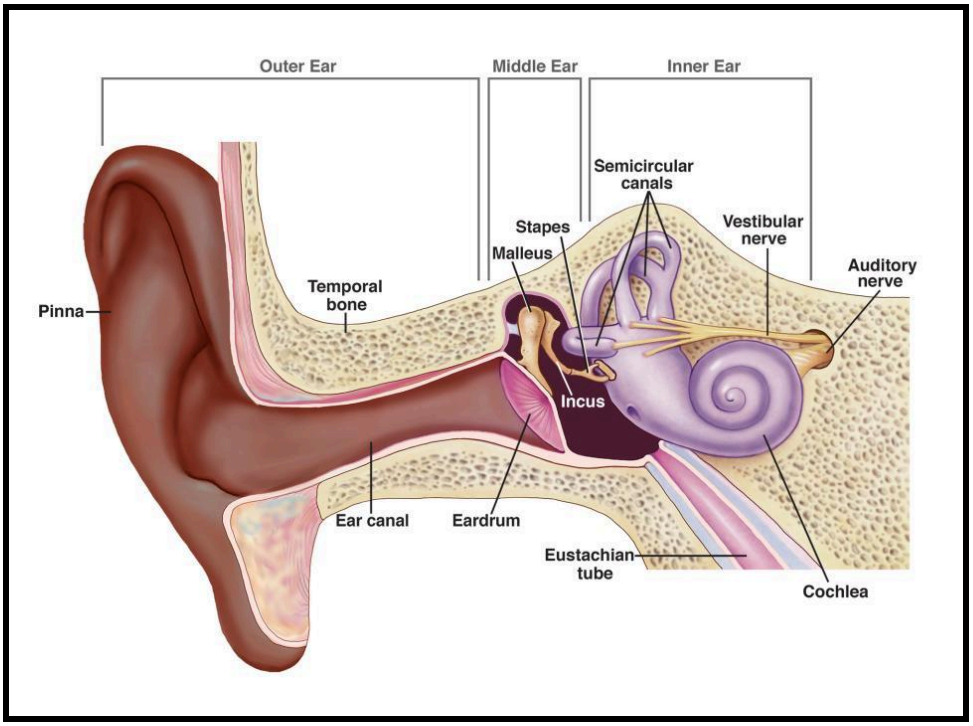
<u>Acoustic Reflex in ear</u>

The acoustic reflex, also known as the stapedial reflex or the middle ear muscle reflex, is a protective reflex that occurs in response to loud sounds. It involves the contraction of the stapedius muscle, which is one of the muscles in the middle ear, in response to sound stimuli. The stapedius muscle is attached to the stapes bone, one of the three small bones (ossicles) in the middle ear, and it plays a role in the normal functioning of the middle ear and the transmission of sound to the inner ear.

When a loud sound enters the ear, the sound waves travel through the ear canal and cause the eardrum to vibrate. These vibrations are then transmitted to the ossicles in the middle ear, including the stapes bone. The stapedius muscle, when stimulated by loud sounds, contracts and pulls the stapes bone away from the oval window, which is the opening that leads to the inner ear. This contraction of the stapedius muscle reduces the amount of sound energy that is transmitted to the inner ear, thus protecting the delicate structures of the inner ear from potential damage due to loud sounds.

The acoustic reflex is a rapid and automatic response that occurs bilaterally, meaning it typically happens in both ears simultaneously, and it can be measured using various diagnostic tests, such as tympanometry and acoustic reflex threshold testing. The presence or absence of the acoustic reflex and its threshold levels can provide information about the integrity of the middle ear and the function of the auditory system, and it is used in audiology and otology for diagnostic purposes.

The acoustic reflex is an important mechanism that helps protect the inner ear from damage caused by loud sounds, and it plays a role in regulating the transmission of sound energy through the middle ear. However, it is not always effective in preventing hearing damage in all situations, and prolonged exposure to loud sounds can still cause hearing loss over time. Therefore, it is important to practice safe listening habits, such as using hearing protection in noisy environments, to prevent hearing damage.



<u>**5 Important Properties of Sound**</u>

Property 1: Pitch/Frequency

The perception of frequency of sound by the human ear within the range of human hearing is called the pitch. The higher the frequency of the sound the higher is its pitch and a lower frequency means a lower pitch. Frequency is the number of periodic compression and rarefaction cycles that occur each second as the wave propagates through the medium.

Property 2: Amplitude/Loudness

The amplitude of the sound waves determines its loudness. The amplitude of the sound is a measure of the magnitude of the maximum disturbance of sound. The amplitude is also a measure of the energy of vibration. More energetic vibration causes a larger amplitude.

Property 3: Speed

The speed at which the sound waves travel through the medium is called the speed of sound. The speed of sound is different for different mediums. Sound travels fastest in solids since the atoms in a solid are closely packed.

Property 4: Reflection of sound

When sound waves hit the surface of a solid or light, it bounces back to the same medium. This is called the reflection of sound. Sound waves, like light waves, follow the laws of reflection.

Property 5: Timbre

Timbre is the property used to differentiate sounds of the same frequency. Timbre depends on the material through which the sound is produced.

Instruments:
Concert Pitch Instruments
Transposition: no change
Piccolo, Flute Oboe, Bassoon Trombone, Baritone B.C., Tuba Mallet Percussion
----
Bb Instruments
Transposition: up a major
2nd Clarinet, Bass Clarinet, Soprano Saxophone, Tenor Saxophone, Trumpet, Baritone T.C.

Eb Instruments
Transposition: down a minor 3rd
Soprano Clarinet, Alto Clarinet, Alto Saxophone, Baritone Saxophone
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F Instruments
Transposition: up a perfect 5th
English Horn, French Horn

G Instruments
Transposition: up a perfect 4th
Alto Flute

String Instruments:
String instruments produce sound by vibrating strings. The vibration of the strings is transmitted to a resonating chamber, such as the body of a guitar or violin, which amplifies the sound. String instruments include guitars, violins, cellos, harps, and basses. These instruments have different sizes, shapes, and materials, which affect their tone and timbre.
Wind Instruments:

Wind instruments produce sound by vibrating air columns or reeds. The musician blows air into the instrument, which causes the air column or reed to vibrate, producing sound. Wind instruments include flutes, clarinets, saxophones, trumpets, trombones, and tubas. These instruments have different shapes and sizes, which affect their sound and range.

Percussion Instruments:

Percussion instruments produce sound by being struck, shaken, or scraped. The vibrations produced by the instrument create sound waves that can be heard. Percussion instruments include drums, cymbals, tambourines, maracas, xylophones, and triangles. These instruments can have various sizes, shapes, and materials, which affect their sound and timbre.

Keyboard Instruments:

Keyboard instruments produce sound by striking strings or metal tines with hammers or plucking strings with plectra. The sound is then amplified by a resonating chamber. Keyboard instruments include pianos, organs, harpsichords, and clavichords. These instruments can have various sizes and materials, which affect their tone and timbre.

Electronic Instruments:

Electronic instruments produce sound using electronic circuits and digital signal processing. These instruments can mimic the sounds of traditional acoustic instruments, as well as produce unique synthetic sounds. Electronic instruments include synthesizers, digital pianos, electronic drums, and samplers.

Open and Closed Tubes

Open Tubes: In an open tube, the medium (ex. air) at the open end vibrates horizontally parallel to the tube length.

- This means the standing wave has displacement antinodes at the ends of the tube for all harmonics & a node in the middle for the fundamental.
- The open end of a tube is a pressure node as well as a displacement node.
- The pressure at the open end of a tube has a fixed constant value (i.e node) equal to one atmosphere.
- However, the displacement of the air molecules at the open end of the tube has a varying value (i.e antinode) since the air is free to move at the open end.
- Basically, If you're drawing a diagram of the pressure in the tube, the open ends will be nodes.
- If you're drawing a diagram of the displacement of the air in the tube, the open ends will be antinodes.
- The simplest standing wave in an open tube is the fundamental, which has 2 antinodes and 1 node.

- Thus, there is half of a wavelength between the antinodes. For an open tube with length L, the wavelength λ of the standing wave that corresponds with the fundamental frequency is:

  $L = \frac{\lambda}{2}$ or $\lambda = 2L$
- Where the fundamental frequency is:

  $f1 = \frac{v}{\lambda}$
- Standing waves with any integer multiple of the fundamental frequency can fit in an open tube.
- For an open-end organ pipe, the fundamental frequency can be calculated using the following formula:

  f1 = (nv)/(2L)
- where:
- f1 is the fundamental frequency
- n is the harmonic number (n=1 for the fundamental frequency)
- v is the speed of sound in air
- L is the length of the pipe

Closed Tubes:

- Air molecules are not free to vibrate back and forth parallel to the tube, so the displacement standing wave has a node at the closed end.
- The open end of the tube is always an antinode since the air molecules can vibrate horizontally parallel to the length of the tube.
- The simplest standing wave case in a closed tube has 1 antinode and 1 node.
- For a closed tube with length L, the standing wave that corresponds with the fundamental frequency is:

  $L = \frac{\lambda}{4}$ or $\lambda = 4L$
- The fundamental frequency is:

  $f1 = \frac{v}{\lambda}$

<u>Pitch- String Instruments</u>

- A string vibrates with a particular fundamental frequency
- However, there are 4 properties of the string that affect its frequency: length, diameter, tension, and density
- When the <u>length</u> of a string is changed, it will vibrate with a different frequency
- Shorter strings have higher frequency, and therefore higher pitch
- When a musician presses their finger on a string, they shorten its length
- The more fingers they add to the string, the shorter it becomes, and the higher the pitch becomes
- <u>Diameter</u> is the thickness of the string
- Thicker strings vibrate slower, and have lower frequencies than thinner ones

- A string stretched between 2 points, such as on a stringed instrument, will have tension
- Tension refers to how tightly the string is stretched
- Tightening the string gives it a higher frequency while loosening it lowers the frequency
- The density of a string will also affect its frequency
- Dense molecules vibrate at slower speeds
- The more dense the string is, the slower it will vibrate, meaning the lower its frequency will be
- Strings use for low pitches will be made of a more dense material than the strings used for high pitches

Symphony

Wind instruments: flute, oboe, clarinet, and bassoons
String instruments: harp, violin, viola, cello, and double bass
Percussion Instruments: timpani, snare drums, bass drums, cymbals, triangles, celestas, and pianos
Brass instruments: french horns, trumpets, trombones, and tubas

Other things about pitch!

Subsonic pitch: <20 Hz
Pitch humans can hear: 20-20,000 Hz
Ultrasonic pitch: >20,000 Hz

Instruments:

Facts about Woodwind instruments:

- Belonging to the broader family of wind instruments, woodwinds make a sound when a player blows air into a mouthpiece which then generates a reed to vibrate
- A reed is a thin piece generally made of wood or cane.
- These pieces are small and are clamped to a mouthpiece at the top of the instrument which vibrates when air is blown between the reed and the mouthpiece itself.
- This reed vibration is exactly their main distinction when compared to other types of the broader family of wind instruments.
- They can be further divided into flutes and reed instruments, the main distinction between them is the sound each of those instruments produces.
- Bands commonly have the following type of woodwind instruments: flutes, clarinets, saxophones, bassoons, and, sometimes piccolos and oboes.
- Despite their name suggesting otherwise, currently, woodwind instruments aren’t made of wood only. The name was given as in the past, wood was the only material used to make these instruments.

- In terms of sounds that each instrument makes, smaller woodwinds will play higher notes and on the contrary, larger instruments play the lower notes characterizing their lower sounds.

Bassons:

- Bassoons are woodwind instruments known for their deep and rich tone. They are typically made from maple, with some components made from metal, and consist of several parts that work together to produce sound.
- **Bocal**: The bocal is a metal tube that serves as the bassoon's mouthpiece. It is inserted into the top of the instrument and is responsible for directing the air into the instrument and shaping the sound.
- **Crook**: The crook is a curved metal tube that connects the bocal to the bassoon's body. It helps to position the bocal at the correct angle for playing.
- **Wing Joint**: The wing joint is the first section of the bassoon's body and contains the finger holes and keys for producing different notes. It also has a complex internal bore design that contributes to the bassoon's unique tone.
- **Boot Joint:** The boot joint is the second section of the bassoon's body and is connected to the wing joint. It contains additional keys and holes for producing different notes.
- **Long Joint:** The long joint is the third section of the bassoon's body and is connected to the boot joint. It contains keys and holes for producing more notes and extends the length of the instrument, which helps to produce lower pitches.

- **Bell:** The bell is the flared end of the bassoon, and it helps to project the sound and enhance the instrument's resonance.
- **Reed:** The bassoon's reed is a double reed made from a type of cane called Arundo donax. It is attached to the bocal and is responsible for producing the sound when air is blown between the two reeds and causes them to vibrate.
- **Keys and Mechanisms:** The bassoon has a complex key system with numerous keys, rods, and levers that are used to cover and uncover the finger holes, allowing the player to produce different notes. The key system also includes various mechanisms, such as octave keys and tone holes, that help in controlling the instrument's pitch and tone quality.

Timpani: a type of drum, usually with a pedal, also called a kettle drum

- The pedal increases the pitch on a timpani

Design:

- Bowl-shaped drumhead: Timpani have a bowl-shaped drumhead that is made of a thin membrane typically made of plastic or animal skin. The drumhead is stretched over the top of the drum frame and is held in place by a tensioning system, which allows for adjustments to the pitch and tone of the drum.
- Metal or wooden frame: The drumhead is attached to a metal or wooden frame, which provides structural support and stability to the drum. The frame is usually made of brass, copper, or steel, and it has a circular shape with a shallow depth.
- Tuning mechanism: Timpani have a tuning mechanism that allows the player to adjust the tension of the drumhead, which in turn changes the pitch of the drum. The tuning mechanism typically consists of a pedal or a hand-operated system that adjusts the tension of the drumhead, allowing the player to produce different pitches by changing the tension of the drumhead.
- Pedal or handle: Timpani are often equipped with a pedal or a handle that the player can use to control the tension of the drumhead. The pedal or handle is used to raise or lower the pitch of the drum by adjusting the tension of the drumhead, allowing for smooth and precise tuning changes during performances.

Function:

- Pitch control: The primary function of timpani is to produce different pitches of sound. By adjusting the tension of the drumhead using the tuning mechanism, the player can control the pitch of the drum, allowing for a wide range of musical notes to be produced.
- Articulation and dynamics: Timpani can be played with various articulations, such as mallets, sticks, or hand techniques, to produce different tones and effects. The player can also control the dynamics, or volume, of the drum by varying the force and speed of their strikes on the drumhead.
- Musical expression: Timpani are an essential part of many orchestral and ensemble compositions, providing a rich and resonant sound that adds depth and color to the music. They are often used for dramatic effects, accents, and crescendos, and are capable of producing a wide range of tonal colors and nuances that contribute to the overall musical expression.
- Ensemble playing: Timpani are often used in ensemble playing, where they are played in conjunction with other instruments, such as strings, brass, and woodwinds, to create a balanced and harmonious musical performance. The player of the timpani works closely with the conductor and other musicians to achieve the desired musical interpretation and expression.

Bongo Drums: a set of two drums typically held between the knees, and played with the fingers

Design:

Drum shells: Bongo drums have two drum shells, typically made of wood or sometimes synthetic materials, that are shaped like cylinders or barrels. The larger drum is called the hembra, and the smaller drum is called the macho.

Drumheads: Bongo drums have drumheads that are typically made of animal skin, such as goat or cowhide, although synthetic drumheads are also available. The drumheads are stretched over the open ends of the drum shells and are held in place by a tensioning system, which allows for adjustments to the pitch and tone of the drums.

Tensioning system: Bongo drums have a tensioning system that consists of metal or wooden rims, tension rods, and tuning lugs. The rims are attached to the drum shells and hold the drumheads in place. The tension rods are threaded through the rims and are used to tighten or loosen the drumheads, thus changing the tension and pitch of the drums. Tuning lugs are used to secure the tension rods and keep the drumheads at the desired tension.

Connecting hardware: Bongo drums are connected to each other with a metal or wooden rod, which is usually covered with a protective sleeve or padding. The connecting rod allows the drums to be played together as a pair, with the larger hembra drum typically played with the dominant hand and the smaller macho drum played with the non-dominant hand.

Function:

Rhythmic patterns: Bongo drums are primarily used for playing rhythmic patterns and grooves. The player strikes the drumheads with their fingers, palms, or specialized bongo drumsticks to produce different tones and sounds. Bongo drums are known for their distinctive high-pitched, sharp, and resonant sound, which can cut through the mix of other instruments in an ensemble.

Improvisation: Bongo drums are often used for improvisation in Latin American and Afro-Caribbean music, allowing the player to create unique rhythmic patterns and variations on the spot. Skilled bongo players can produce complex rhythms and syncopated patterns that add excitement and energy to the music.

Musical genres: Bongo drums are commonly used in various musical genres, such as salsa, rumba, Afro-Cuban, Latin jazz, and other Latin American and Afro-Caribbean styles. They are also used in some forms of world music, fusion, and contemporary music.

Solo and ensemble playing: Bongo drums can be played as a solo instrument or as part of an ensemble. In an ensemble setting, bongos are often used to provide rhythm and groove, complementing other percussion instruments, such as congas, timbales, and clave, as well as other melodic and harmonic instruments in the ensemble.

Xylophones: a musical instrument played by striking a row of wooden bars of graduated length with one or more small wooden or plastic mallets.

- To increase the pitch on a key of the xylophone: shorter length and increased thickness

Design:

Bars: Xylophones have wooden bars that are typically made of hardwood, such as rosewood, padauk, or synthetic materials. The bars are usually arranged in a linear fashion, with the bars increasing in length from left to right, or in a more traditional diatonic or chromatic arrangement.

Resonators: Xylophones have resonators or tubes positioned beneath the bars to amplify the sound. The resonators are typically made of metal or wood and are open at both ends. They are designed to resonate and enhance the sound of the bars when struck, producing a sustained tone.

Frame: Xylophones have a frame that holds the bars and resonators in place. The frame can be made of wood, metal, or other materials, and it usually has supports, legs, and a stand to hold the instrument at a convenient playing height.

Mallets: Xylophones are played with mallets or sticks that are typically made of wood or other materials, such as rubber, plastic, or metal. The mallets are used to strike the bars, producing sound when the bars vibrate.

Flutes:

Design

Body: Flutes have a long, cylindrical body with finger holes and/or keys along the body. The body is usually made of metal, such as silver, brass, or gold, or wood, such as grenadilla or other hardwoods. Modern flutes can also be made of plastic or other materials.

Headjoint: Flutes have a detachable headjoint that is attached to the body. The headjoint is usually made of the same material as the body and has a blowhole and a lip plate or embouchure hole where the player blows air across the edge to create sound.

Keys: Flutes may have keys or key-like mechanisms along the body and/or headjoint that are used to cover and uncover the finger holes to change the pitch of the notes. The keys are typically made of metal and are operated by the player's fingers or by rods and levers.

Footjoint: Flutes may also have a detachable footjoint that is attached to the body. The footjoint usually contains additional keys or mechanisms that extend the range of the instrument or alter its timbre.

Clarinets:
Design
Body: Clarinets have a long, cylindrical body with finger holes and/or keys along the body. The body is typically made of wood, such as grenadilla, but can also be made of plastic, metal, or other materials. The body is divided into sections, including the upper joint, lower joint, and bell, which are usually connected with tenons or joints.

Mouthpiece: Clarinets have a detachable mouthpiece that is attached to the upper joint. The mouthpiece typically has a reed attached to it, which is made of wood or synthetic material and is responsible for producing sound when the player blows air across it.
Keys: Clarinets have a complex system of keys and levers that are used to cover and uncover the finger holes to change the pitch of the notes. The keys are typically made of brass or other metals and are operated by the player's fingers or by rods and levers.
Bell: Clarinets have a flared bell at the bottom of the instrument, which helps to amplify and shape the sound produced by the instrument.

Instruments with different playing registers:

- **Clarinets** have distinct registers, including the chalumeau register (lowest), clarion register (middle), and altissimo register (highest). Each register has its own unique sound and requires different techniques and fingerings to play.
- **Flute**: The flute has different registers, including the lower register, middle register, and upper register. Flutists use different fingerings, embouchure, and air pressure to produce different pitches in each register.
- **Saxophone**: The saxophone has multiple registers, including the low register (such as the baritone saxophone), middle register (such as the tenor saxophone), and high register (such as the alto or soprano saxophone). Saxophonists use different fingerings and embouchure adjustments to play in each register.
- **Trombone**: The trombone is a brass instrument that has different playing registers, including the tenor register and bass register. Trombonists use different slide positions and techniques to produce different pitches in each register.

- **Trumpet**: The trumpet is a brass instrument with different registers, including the low register and high register. Trumpeters use different valve combinations and embouchure adjustments to play in each register.
- **Violin**: The violin is a string instrument that has different playing registers, including the low register (G and D strings), middle register (A string), and high register (E string). Violinists use different fingerings and bowing techniques to produce different pitches in each register.
- **Voice**: The human voice has different registers, including the chest register (lower range), head register (higher range), and falsetto register (highest range). Singers use different vocal techniques and registers to produce different pitches and timbres.

Saxophones:

Design:

Body: The body of a saxophone is a tube with a conical shape, featuring a curved neck and a bell at the end. The body is usually made in separate sections that are soldered or brazed together, with key holes and tone holes drilled into it to control the pitch and tone of the instrument.

Neck: The neck of a saxophone is a curved tube that connects the body to the mouthpiece. It usually contains a cork or other material that allows the player to adjust the position and angle of the mouthpiece to achieve the desired pitch and tone.

Mouthpiece: The mouthpiece is where the player blows air into the saxophone, and it contains a reed that vibrates to produce sound when air is passed over it. The mouthpiece is typically made of metal, hard rubber, or plastic, and different types of mouthpieces can affect the tone and playability of the saxophone.

Keys and Fingerings: Saxophones have a complex system of keys and fingerings that are used by the player to control the pitch and timbre of the instrument. The keys are usually made of brass or other metals and are attached to the body with rods and screws. When the player presses a key, it opens or closes tone holes on the body, changing the length of the vibrating air column and thereby altering the pitch of the instrument.

Ligature: The ligature is a device that holds the reed to the mouthpiece. It is typically made of metal or plastic and is used to secure the reed in place while allowing it to vibrate freely to produce sound.

Bell: The bell is the flared end of the saxophone's body, which helps to project and shape the sound produced by the instrument.

Finishes: Saxophones are often finished with lacquer, silver plating, or other materials to protect the brass from tarnishing and to enhance the instrument's appearance.

Types of Saxophones
Soprano Saxophone: The smallest and highest-pitched saxophone, typically in the key of Bb or Eb. It has a straight body and a curved neck, and it produces a bright and piercing sound. Soprano saxophones are commonly used in jazz, classical, and contemporary music.
Alto Saxophone: The most common saxophone, typically in the key of Eb. It has a curved body and neck, and it produces a rich and expressive sound. Alto saxophones are widely used in jazz, classical, pop, and other genres of music.
Tenor Saxophone: Larger than the alto saxophone, typically in the key of Bb. It has a curved body and neck, and it produces a warm and mellow sound. Tenor saxophones are commonly used in jazz, rock, and other contemporary music genres.
Baritone Saxophone: The largest and lowest-pitched saxophone, typically in the key of Eb or C. It has a curved body and a U-shaped neck, and it produces a deep and powerful sound. Baritone saxophones are commonly used in jazz, classical, and contemporary music, and they are known for their distinctive low-end sound.
Sopranino Saxophone: The smallest saxophone, smaller than the soprano saxophone, typically in the key of F or Eb. It has a straight body and a curved neck, and it produces a high and bright sound. Sopranino saxophones are less common than other types of saxophones and are mainly used in specialized musical contexts.
Bass Saxophone: An uncommon and large saxophone, typically in the key of Bb or C. It has a curved body and a U-shaped neck, and it produces a deep and resonant sound. Bass saxophones are mainly used in specialized musical contexts and are known for their distinctive low-end sound.
Contrabass Saxophone: The largest and rarest saxophone, typically in the key of Eb or C. It has a curved body and a U-shaped neck, and it produces an extremely low and powerful sound. Contrabass saxophones are used in very specific musical contexts, such as avant-garde music and experimental ensembles.

Oboes:
Body: The body of the oboe is typically made from wood, such as grenadilla, rosewood, or maple, although some modern oboes may also have bodies made from synthetic materials. The body is usually composed of three main sections: the top joint, middle joint, and bell, which are assembled together. The oboe has a slender cylindrical bore with finger holes and tone holes that are covered or uncovered by keys and levers.
Double Reed Mouthpiece: The oboe uses a double reed mouthpiece, which consists of two pieces of cane that are bound together and attached to a metal tube called a staple. The player blows air between the two reeds, causing them to vibrate and produce sound.

Keywork: The oboe has an extensive keywork system made of brass or other metals. The keys and levers are used to cover or uncover the tone holes, which in turn control the pitch and timbre of the instrument. The keys are operated by the player's fingers, and they may also include various mechanisms, such as octave keys, trill keys, and auxiliary keys, to facilitate playing in different registers and execute various musical techniques.
Thumbplate or Conservatoire System: The oboe can have different key systems, such as the thumbplate system (also known as the "simple system") or the conservatoire system (also known as the "full-automatic" or "semi-automatic" system). The thumbplate system requires the player to use the thumb to cover and uncover certain tone holes, while the conservatoire system uses additional keys and levers to automate some of the fingerings, making it easier to play certain passages.
Tone and Range: The oboe has a unique tone that is often described as rich, warm, and expressive, with a wide dynamic range. It has a range that spans over two octaves, typically from Bb3 to Bb6 (sounding pitch), although advanced players can extend the range further. The oboe is capable of producing a wide variety of timbral colors and expressive nuances through different fingerings, embouchure techniques, and air pressure.

Piccolos
Body: The body of the piccolo is usually made of metal, such as silver or brass, or wood, such as grenadilla or plastic/resin materials. It is cylindrical in shape and usually measures around 12-14 inches (30-35 cm) in length.
Keys: The piccolo has a complex key system that allows the player to control the pitch of the instrument. The keys are typically made of metal and are operated by the player's fingers to cover or uncover the tone holes, which changes the pitch of the notes produced.
Mouthpiece: The piccolo has a mouthpiece with a blowhole and an embouchure hole, which is where the player blows air into the instrument and produces sound. The embouchure hole is smaller than that of a flute, and the player uses their lips to create the proper embouchure to produce sound.

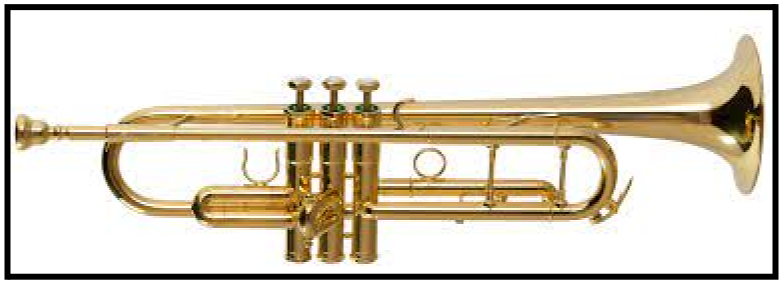
Range: The piccolo has a range that typically spans from C4 (middle C) to C7 (three octaves above middle C), although advanced players can extend the range beyond this. The piccolo is a transposing instrument, which means that the written music is notated in a different key than the sounding pitch.
Size: The piccolo is the smallest instrument in the flute family, and its small size allows for easy portability and handling. However, playing the piccolo requires additional control and precision due to its smaller size and higher pitch.

Tone: The piccolo produces a bright, penetrating, and piercing tone due to its small size and high pitch. It is capable of playing fast and agile passages with a distinct and clear sound, and it is often used to add brilliance and sparkle to ensemble performances.

Trumpets

Brass Construction: The trumpet is made of brass, which is a type of metal alloy that consists of copper and zinc. The brass construction gives the trumpet its distinctive bright and resonant sound.

Bell: The trumpet has a flared bell at the end, which is the open part of the instrument where the sound waves are radiated. The shape and size of the bell contribute to the tone and projection of the trumpet.



Valves: The trumpet typically has three piston valves, which are used to change the length of the tubing and therefore the pitch of the instrument. When the valves are pressed, they route the air through additional lengths of tubing, allowing the player to play different notes by altering the length of the vibrating air column.

Mouthpiece: The trumpet has a detachable mouthpiece that is inserted into the leadpipe, which is the first section of tubing connected to the instrument. The shape and size of the mouthpiece affect the tone, playability, and comfort for the player.

Slides: The trumpet may also have slides, such as the tuning slide and the water key (also known as spit valve). These slides are used for tuning, intonation adjustments, and condensation removal.

Bore: The bore of the trumpet refers to the diameter of the tubing, which can vary among different trumpet designs and models. The bore affects the playing characteristics of the trumpet, including the resistance, tone color, and response.

Finger Buttons and Water Keys: The trumpet has three valve finger buttons that the player presses to change the pitch of the notes, and it may also have water keys (spit valves) to remove condensation that accumulates during playing.

Range: The trumpet is a transposing instrument, which means that the written music is notated in a different key than the sounding pitch. The trumpet typically has a range from around F#3 or G3 up to around C6 or higher, depending on the player's skill level and the specific trumpet.

Trumpet Types: There are various types of trumpets, including Bb trumpet, C trumpet, D/Eb trumpet, piccolo trumpet, and bass trumpet, each with its own design and function for different musical contexts and playing styles.

Trombones

Brass Construction: The trombone is made of brass, which is a type of metal alloy that consists of copper and zinc. The brass construction gives the trombone its characteristic bright and resonant sound.

Slide: The trombone has a long U-shaped slide that is used to change the pitch. The slide consists of two parallel tubes that can be extended or retracted by the player to alter the length of the tubing and therefore the pitch of the instrument. The slide is typically moved by the player's hand, allowing for smooth glissandos, expressive playing, and accurate intonation.

Bell: The trombone has a flared bell at the end, which is the open part of the instrument where the sound waves are radiated. The size and shape of the bell affect the tone and projection of the trombone.

Mouthpiece: The trombone has a detachable mouthpiece that is inserted into the leadpipe, which is the first section of tubing connected to the instrument. The shape and size of the mouthpiece affect the tone, playability, and comfort for the player.

Bore: The bore of the trombone refers to the diameter of the tubing, which can vary among different trombone designs and models. The bore affects the playing characteristics of the trombone, including the resistance, tone color, and response.

Range: The trombone typically has a range from around E2 or F2 up to around Bb4 or higher, depending on the player's skill level and the specific trombone. The range can be extended with the use of additional techniques such as pedal tones and harmonics.

Trombone Types: There are various types of trombones, including tenor trombone, bass trombone, alto trombone, and contrabass trombone, each with its own design and function for different musical contexts and playing styles.

French Horns

Tubing: The tubing of a French horn is usually made of brass, and it is coiled into a circular shape with a flared bell at the end. The tubing is typically long and can have various numbers of coils, depending on the type of French horn.

Valves: French horns typically have three or four rotary valves, which are used to change the pitch of the instrument. These valves are located near the mouthpiece and are operated by the player's left hand. When the valves are engaged, they route the air

through additional lengths of tubing, changing the length of the air column and thus altering the pitch of the instrument.
Mouthpiece: The mouthpiece of a French horn is usually made of brass or another metal alloy, and it is inserted into the leadpipe, which is the first part of the tubing that the player blows air into. The mouthpiece is responsible for producing the initial sound and plays a crucial role in the instrument's tone and playability.
Bell: The flared bell at the end of the French horn's tubing is an important design element that contributes to the instrument's unique sound. The bell is typically made of brass and is carefully shaped to produce a resonant and projecting tone.
Water Key: Like many brass instruments, French horns often have a water key, also known as a spit valve, to allow the player to release accumulated moisture from the instrument. The water key is typically located on the tubing near the valve cluster and is operated by pressing a lever or button.
Finger Hook: French horns often have a finger hook or thumb rest near the valve cluster, which provides a comfortable grip for the player's left hand while operating the valves. This allows the player to easily manipulate the valves and control the pitch of the instrument.
Leadpipe: The leadpipe is the first part of the tubing that the player blows air into, and it plays a role in shaping the instrument's tone and response. The design of the leadpipe can vary depending on the specific type of French horn, and it is often customizable to suit the player's preferences.
Finish: The finish of a French horn can vary, but it is usually brass or silver-plated for durability and aesthetic appeal. Some French horns may also have lacquer, gold plating, or other finishes for added protection and appearance.
Range: The French horn has a wide range, typically spanning from around concert F2 or F3 up to around C6 or higher, depending on the skill level of the player and the specific French horn.

Tubas

Tubing: The tubing of a tuba is typically made of brass and is coiled into a large, conical shape. The tubing is usually quite long and can have various numbers of coils, depending on the type of tuba. The size and shape of the tubing determine the instrument's pitch and timbre.

Valves: Most tubas have three to six piston valves or rotary valves, which are used to change the pitch of the instrument. These valves are located along the tubing and are operated by the player's fingers. When the valves are engaged, they route the air through

additional lengths of tubing, changing the length of the air column and thus altering the pitch of the instrument.
Mouthpiece: The mouthpiece of a tuba is usually made of brass or another metal alloy, and it is inserted into the leadpipe, which is the first part of the tubing that the player blows air into. The mouthpiece is responsible for producing the initial sound and plays a crucial role in the instrument's tone and playability.
Bell: The bell of a tuba is typically large and flared, and it is an important design element that contributes to the instrument's tone quality and projection. The bell is usually made of brass and is carefully shaped to produce a resonant and projecting tone.
Water Key: Like many brass instruments, tubas often have a water key, also known as a spit valve, to allow the player to release accumulated moisture from the instrument. The water key is typically located on the tubing near the valve cluster and is operated by pressing a lever or button.
Finger Hooks: Tubas often have finger hooks or thumb rests located on the tubing, which provide a comfortable grip for the player's left hand while operating the valves. These hooks or rests allow the player to easily manipulate the valves and control the pitch of the instrument.

Violins
Design:
Body: The body of a violin is typically made of maple for the back, sides, and neck, and spruce for the top. The back and top are usually carved and shaped to create the distinctive violin body shape, which consists of an hourglass-like figure with curved bouts, a narrow waist, and a rounded lower bout.

Soundholes: The top of the violin features two f-shaped sound holes, also known as "f-holes", which are carefully carved to optimize the instrument's sound projection and tone quality.
Bridge: The bridge of a violin is a small, curved piece of wood that supports the strings above the body, transmitting their vibrations to the top of the instrument. The bridge is carefully shaped and adjusted to ensure proper string height, string spacing, and overall playability of the instrument.
Strings: Violins typically have four strings made of steel or synthetic materials, which are attached to the tailpiece at the bottom of the instrument and pass over the bridge, running along the fingerboard and up to the pegbox at the top. The strings are usually tuned to G, D, A, and E, from lowest to highest pitch.
Bow: The bow is an essential part of playing the violin, and it consists of a wooden stick with horsehair stretched from end to end. The player uses the bow to create sound by drawing it across the strings, causing them to vibrate and produce sound.

Chinrest, Tailpiece, and Fine Tuners: Violins often have a chinrest attached to the left side of the body, which provides support for the player's chin while playing. The tailpiece holds the strings in place and can be made of wood or other materials. Fine tuners, also known as string adjusters, are often attached to the tailpiece or the tailpiece loop, allowing for precise tuning of the strings.

Function:

The violin produces sound through the interaction of the bow and the strings. When the player draws the bow across the strings, the friction between the horsehair and the strings causes them to vibrate. The vibrations are transmitted to the body of the violin through the bridge, which amplifies the sound and projects it out through the f-holes. The player produces different pitches by pressing the strings down onto the fingerboard with their left hand, shortening the effective length of the vibrating string and raising the pitch. The player can also use various bowing techniques, such as changing the speed, pressure, and contact point of the bow on the strings, to create different tones, dynamics, and articulations.

Violas

Function:

The viola is a bowed string instrument that is slightly larger than the violin and has a lower pitch. It is an important member of the string section in an orchestra and is also used as a solo instrument, in chamber music ensembles, and in various musical genres.

Design:

The design of the viola is similar to that of the violin, with a curved body, a hollow sound box made of wood, and an f-shaped sound hole on either side of the bridge. However, the viola is slightly larger than the violin, with a longer body and a longer string length. The standard tuning for a viola is usually C, G, D, and A, which is a perfect fifth lower than the standard tuning of a violin.

The viola typically has a larger and deeper body compared to the violin, which gives it a mellower and warmer tone. It usually has a thicker and heavier bow compared to the violin bow, which helps to produce a fuller sound on the thicker strings of the viola.

The viola is played using similar techniques to the violin, including bowing and fingering. However, due to its larger size and longer string length, it requires slightly different hand positions and fingerings compared to the violin. The viola is usually played in a more upright position, and the player typically uses a slightly larger and heavier bow with a different balance point compared to the violin bow.

The viola is an important part of the string section in an orchestra, where it often provides the middle voice and harmonies. In chamber music, the viola plays a crucial role

as the bridge between the higher-pitched violin and the lower-pitched cello. The viola has a distinct timbre that gives it its own unique character and contributes to the overall sound of an ensemble.
Like the violin, the viola requires regular maintenance, including tuning, string replacement, and occasional repairs. It also requires skill and practice to master the techniques of bowing, fingering, and left-hand position to produce a beautiful tone and expressiveness.

Cellos

Size and Range: Cellos are larger than violins and violas, with an average height of around 4.5 to 5 feet (135 to 150 cm) from endpin to scroll. They have a rich and deep tone and are known for their wide range, spanning from C2 (two octaves below middle C) to A5 (two octaves above middle C).
Construction: Cellos have a hollow wooden body, typically made of maple for the back, sides, and neck, and spruce for the top. The body is divided into two main parts, the upper bout and the lower bout, with a waist in between. Cellos also have an f-shaped sound hole on the front, a bridge that supports the strings, and a tailpiece that holds the fine tuners.

Strings: Cellos have four strings, typically made of steel core with a wound metal wrapping, although some cellists may use synthetic or gut strings. The strings are tuned in perfect fifths: C2, G2, D3, and A3, with the lowest string (C2) being the thickest and the highest string (A3) being the thinnest.
Playing Techniques: Cellos are typically played with a bow made of horsehair, which is drawn across the strings to produce sound. The player uses the left hand to stop the strings at different points on the fingerboard to produce different pitches. Cellos can also be played using pizzicato (plucking the strings with the fingers), col legno (hitting the strings with the wood of the bow), and various extended techniques.
Roles in Music: Cellos play a versatile role in music, serving as both a melodic and harmonic instrument. In an orchestra, cellos are an integral part of the string section, providing rich and resonant bass tones, and often playing melodic lines or providing harmonic support. Cellos are also popular in chamber music, as solo instruments, and in various musical genres ranging from classical to jazz, rock, and beyond.
History: The cello has a long history, with early predecessors dating back to the 16th century. The modern cello as we know it today started to develop in the late 17th and early 18th centuries, with important contributions from luthiers such as Antonio Stradivari and Andrea Guarneri.
Maintenance: Like other string instruments, cellos require regular maintenance, including tuning, string replacement, and occasional repairs. Cellos also require proper care and

handling to protect the delicate wooden body and ensure optimal playability and sound quality.
In summary, cellos are large string instruments with a rich and deep tone, known for their wide range and versatility in various musical settings. They have a hollow wooden body, four strings, and are typically played with a bow. Cellos play important roles in orchestras, chamber music ensembles, and other genres of music, and require regular maintenance and skillful playing techniques to produce a beautiful tone and expressiveness.

BASS

Bass Voice: In vocal music, "bass" typically refers to the lowest male singing voice, known for its deep and resonant tone. Bass singers often provide the foundation of the vocal harmony in choral music, opera, and other vocal ensembles.
Bass Guitar: The bass guitar, often simply called "bass," is a string instrument similar in appearance to a guitar, but with a longer scale length and lower pitch. It is typically played with the fingers or a pick, and is an important instrument in many styles of music, including rock, jazz, funk, and more. The bass guitar provides the low-frequency foundation and rhythm in a band or ensemble, complementing the other instruments and helping to create the overall groove and feel of the music.
Double Bass: The double bass, also known as the upright bass, contrabass, or bass fiddle, is the largest and lowest-pitched member of the string instrument family. It is typically played with a bow or plucked with the fingers, and is a key instrument in orchestras, jazz bands, and other ensembles. The double bass provides the deep and resonant bass tones in a wide range of musical genres.
Bassline: In music production and composition, a "bassline" refers to the low-frequency melodic line or sequence of notes that provides the foundation of a piece of music. Basslines can be played on various instruments, such as bass guitar, double bass, synthesizers, or other low-pitched instruments, and are often a crucial element in defining the overall harmony, rhythm, and feel of a piece of music.
Bass Frequencies: In audio and sound engineering, "bass" refers to the lower frequencies of the audible sound spectrum, typically ranging from around 20 Hz to 250 Hz, although this can vary depending on the context. Bass frequencies are responsible for the low-end or deep tones in music and other audio signals, and are crucial in creating a balanced and full-sounding mix in recorded music or live sound reinforcement.

Double Bass

Size and Shape: The double bass is the largest member of the string instrument family and typically stands around 6 feet tall. It has a deep, resonant tone due to its large size. The body of the double bass is usually made of wood, with a hollow body and a curved shape similar to a violin or cello. The shape of the body can vary slightly depending on the maker and style of the instrument, but it generally consists of a rounded back, wide bouts, and a wide top plate.

Strings and Tuning: The double bass has four strings tuned in fourths (E1, A1, D1, G), which are usually made of metal or synthetic materials. The strings are attached to the tailpiece at the bottom of the instrument and pass over a bridge, which holds them at a certain height above the fingerboard. The strings are usually played with a bow made of horsehair or plucked with the fingers, although other techniques such as slapping or tapping can also be used.

Fingerboard and Neck: The fingerboard of the double bass is a long, wide strip of wood that extends from the body of the instrument up to the pegbox. The player presses the strings against the fingerboard with their fingers to change the pitch of the notes. The neck of the double bass is attached to the body and extends up to the pegbox, which contains the tuning pegs used to adjust the pitch of the strings.

Soundholes and Bass Bar: The double bass has two f-shaped soundholes on the top plate, which are similar in shape to those found on violins and cellos. These soundholes help to project and shape the sound of the instrument. Inside the body of the double bass, there is also a long, wooden bass bar that runs along the underside of the top plate, helping to support and strengthen the instrument while also influencing its tone.

Bridge and Tailpiece: The bridge of the double bass is a tall, curved piece of wood that stands between the top plate and the tailpiece. It supports the strings at a specific height above the fingerboard, allowing the player to play individual notes and create different pitches. The tailpiece is located at the bottom of the instrument and holds the strings in place, attaching them to the tailpiece endpin, which rests on the floor and helps to support the weight of the instrument.

Bow and Bow Holder: The bow used for playing the double bass is typically made of wood, with horsehair stretched between the ends of the bowstick. The player uses the bow to create sound by drawing it across the strings. The bow is usually held with an overhand grip, and the player can control the volume, tone, and articulation of the sound by adjusting the pressure, speed, and direction of the bow. When not in use, the bow can be stored in a bow holder attached to the tailpiece of the instrument.

Pianos:

Invention: The piano was invented by Bartolomeo Cristofori, an Italian maker of musical instruments, around the year 1700. It was initially known as the "pianoforte," which means "soft-loud" in Italian, referring to the instrument's ability to produce varying levels of loudness based on the player's touch.

Keyboard: A standard piano has 88 keys, consisting of 52 white keys and 36 black keys. The keys are made from wood, plastic, or ivory (historically), and each key corresponds to a different pitch or note.

Strings: Pianos have a complex system of strings that produce sound when struck by hammers. Modern pianos typically have three strings per key in the treble and two strings per key in the bass. These strings are made of steel and are under high tension.
Size and Weight: Pianos come in various sizes, ranging from small upright pianos to large grand pianos. Grand pianos can be quite heavy, with some concert grand pianos weighing over 1,000 pounds (450 kg) and measuring up to 9 feet (2.7 meters) in length.
Maintenance: Pianos require regular maintenance, including tuning, voicing, and regulation, to keep them in optimal playing condition. Tuning involves adjusting the tension of the strings to ensure that the piano is in tune with itself and with other instruments. Voicing involves adjusting the tone and timbre of the piano, while regulation involves adjusting the mechanical parts of the piano to ensure consistent touch and response.

Popularity: The piano has been a popular musical instrument for centuries and has been used in a wide range of musical genres, from classical to jazz, pop, rock, and more. It is often used as a solo instrument, as well as in ensembles and orchestras.
Famous Piano Manufacturers: Some of the most well-known piano manufacturers include Steinway & Sons, Yamaha, Kawai, and Bösendorfer, among others. These manufacturers are known for producing high-quality pianos with distinctive features and designs.
Historical Importance: Pianos have played a significant role in the history of music, with composers such as Ludwig van Beethoven, Wolfgang Amadeus Mozart, and Frédéric Chopin known for their piano compositions. The piano has also been a popular instrument for household use, providing entertainment and music-making opportunities for families and individuals throughout history.

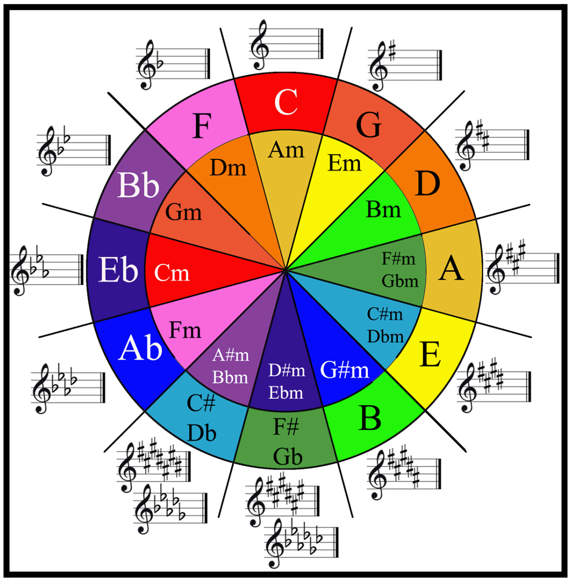
Design
Keyboard: The piano features a keyboard that consists of a row of keys, typically 88 in number for modern pianos. The keys are made of wood or plastic and are usually covered with ivory or synthetic materials. The keys are arranged in a specific pattern of white and black keys, with alternating groups of two black keys and three black keys, forming repeating patterns. When a key is pressed, it activates a mechanism that causes a hammer to strike the strings inside the piano, producing sound.
Strings: The piano has strings that are responsible for producing the sound. These strings are typically made of steel wire and are stretched across a cast-iron frame that provides support and stability to the instrument. The strings are attached at one end to tuning pins that are inserted into the pinblock, and at the other end to a wooden soundboard that amplifies the sound. The length, thickness, and tension of the strings determine the pitch and tone of the notes produced by the piano.

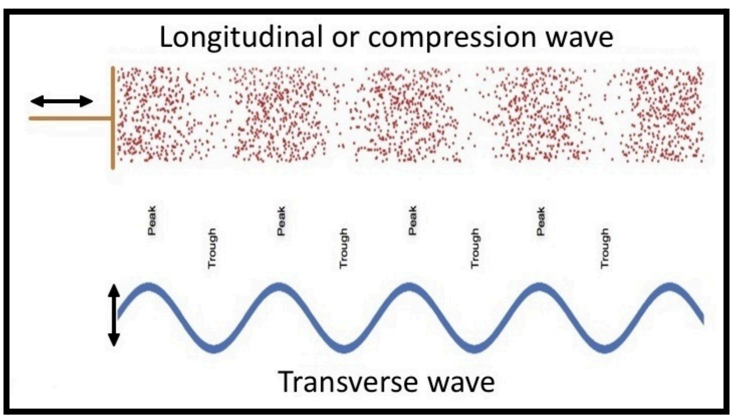
Frame and Soundboard: The piano's frame, also known as the plate, is a large cast-iron structure that holds the strings under high tension and provides stability to the instrument. The soundboard is a large, wooden resonating surface that amplifies the sound produced by the strings. It is typically made of spruce or other resonant woods and is located underneath the strings, directly connected to the piano's frame.
Action: The piano action is a complex mechanism that translates the motion of the keys into the striking of the strings. When a key is pressed, it activates a series of levers, springs, and hammers that lift and release the hammers, causing them to strike the strings and produce sound. The action also includes other components such as dampers, which stop the strings from vibrating when the keys are released, and pedals, which allow for various expressive techniques such as sustaining or softening the sound.
Pedals: The piano typically has three pedals located at the bottom of the instrument. The right pedal, known as the sustain or damper pedal, allows the player to sustain the sound by lifting the dampers from the strings, allowing them to vibrate freely even after the keys are released. The left pedal, known as the soft or una corda pedal, shifts the entire action slightly to the right, causing the hammers to strike fewer strings and produce a softer sound. The middle pedal, known as the sostenuto pedal (found in some pianos), allows the player to sustain only the notes that are being held down at the moment the pedal is pressed, while other notes played afterwards are not sustained.
Case and Lid: The piano's case is typically made of wood and serves as the external housing for the instrument. It can come in various styles and finishes, ranging from traditional to modern designs. The lid of the piano can usually be opened or closed and is used to control the volume and tone of the sound. When fully closed, it dampens the sound, while opening the lid can result in a brighter and louder sound.
Tuning Pins and Pinblock: The tuning pins are metal pins that are inserted into the pinblock, which is a wooden block located at the front of the piano. The strings are wound around these tuning pins and can be adjusted in tension to tune the piano to the desired pitch. The pinblock is an important component that provides stability to the tuning pins and helps to maintain the tuning stability of the instrument over time.

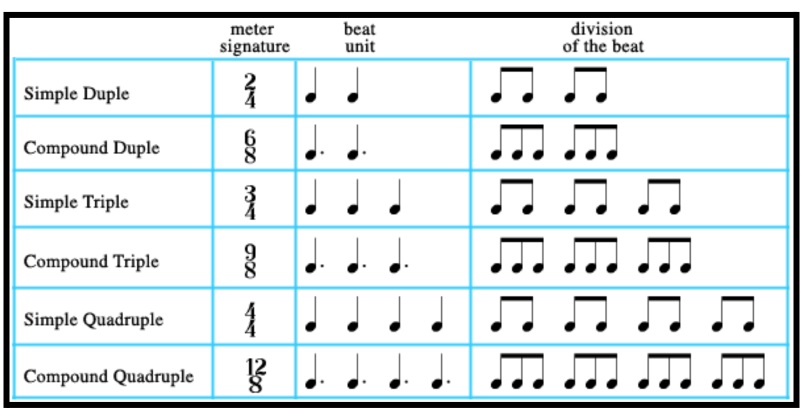
Bores of Instruments:
Conical bore: A conical bore refers to a gradual widening or tapering of the tubing towards the bell of the instrument, resembling the shape of a cone. This type of bore is typically found in instruments such as French horns, euphoniums, and tubas. Conical bores are known for producing a warm, rich, and focused sound with a characteristic "brassy" quality. The tapering bore allows for a more even distribution of harmonics, resulting in a mellower tone with a wide dynamic range.
Cylindrical bore: A cylindrical bore, on the other hand, maintains a consistent diameter throughout the length of the tubing, resembling the shape of a cylinder. This type of bore is typically found in instruments such as trumpets, trombones, and some types of tubas. Cylindrical bores are known for producing a brighter, more focused, and projecting sound with a characteristic "brilliance" or "brightness." The consistent diameter of the bore

allows for a more pronounced and defined harmonic series, resulting in a more brilliant tone with a compact dynamic range.

<u>**PICTURES►**</u>







	meter signature	beat unit	division of the beat
Simple Duple	2/4		
Compound Duple	6/8		
Simple Triple	3/4		
Compound Triple	9/8		
Simple Quadruple	4/4		
Compound Quadruple	12/8		

Shape note notation:

FORMULAS :

- Infrasound (or Infrasonic) has a frequency below 20 Hz.
- Ultrasound (or ultrasonic) has a frequency above 20 kHz.
- Speed of sound in a medium:
  $v = \sqrt{(\gamma * P / \rho)}$
  where:
  v = speed of sound
  γ = adiabatic index or ratio of specific heats of the medium
  P = pressure of the medium
  ρ = density of the medium
- Frequency of a sound wave:
  $f = v / \lambda$
  where:
  f = frequency of the sound wave
  v = speed of sound
  λ = wavelength of the sound wave
- Wavelength of a sound wave:
  $\lambda = v / f$
  where:
  λ = wavelength of the sound wave
  v = speed of sound
  f = frequency of the sound wave
- Intensity of sound:
  $I = P / A$
  where:
  I = intensity of sound
  P = power of the sound wave
  A = area of the surface that the sound wave is passing through

- Decibel (dB) level of sound:
  $L = 10 \log (I / I_0)$
  where:
  L = sound level in decibels
  I = intensity of the sound wave
  I_0 = reference intensity of sound (usually 10^{-12} W/m^2)
- Doppler effect:
  $f' = f * (v \pm v_0) / (v \pm v_s)$
  where:
  f = frequency of the sound wave emitted by the source
  f' = frequency of the sound wave received by the observer
  v = speed of sound in the medium
  v_0 = velocity of the source towards or away from the observer
  v_s = velocity of the observer towards or away from the source
- The wave velocity equation:
  $v = \lambda * f$
  where:
  v is the velocity of the wave
  λ (lambda) is the wavelength of the wave
  f is the frequency of the wave
  Adiabatic Constant Equation:
  $\gamma = C_p / C_v$
  where:
  γ = Adiabatic constant
  C_p = Specific heat capacity at constant pressure
  C_v = Specific heat capacity at constant volume

The relationship between the adiabatic constant (γ), the molar specific heat capacity at constant pressure ($C_{p,m}$), and the molar specific heat capacity at constant volume ($C_{v,m}$) can be expressed using the ideal gas law:

$\gamma = C_{p,m} / C_{v,m}$
where:
γ = Adiabatic constant
$C_{p,m}$ = Molar specific heat capacity at constant pressure
$C_{v,m}$ = Molar specific heat capacity at constant volume
Overtone Calculation
Frequency of nth overtone = Fundamental frequency × n
where:
Frequency of nth overtone is the frequency of the harmonic or overtone being calculated. Fundamental frequency is the frequency of the lowest pitch or the first harmonic. n is the harmonic number, which represents the order of the overtone being calculated. For example, the first overtone is the second harmonic ($n = 2$), the second overtone is the third harmonic ($n = 3$), and so on.