Glossary for Physics of Sound and Music (Ruiz)

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acoustic guitar – musical instrument made of wood with 6 strings, frets, and a sound cavity

acoustic traumatic notch – an audiogram with a hearing loss where the loss is only in a small band of frequencies – thus the dip in the audiogram plot (graph), an upside-down V-notch

acoustical – relating to sound

acoustic waves – sound waves traveling in air, fluid, or solid

acoustics – the study of sound

ADSR – see envelope generator

alternating current (AC) – current that flows back and forth in a wire or circuit element

Ampère's law – electrical current through a coil produces a magnetic field inside the coil

amp (also ampère) – the unit for current; amp is abbreviated as A

amplifier – device that increases the amplitude of an electrical wave

amplitude – the measure of the wave strength from the equilibrium (center line) to the highest point of a wave. Sometimes engineers like to measure from the very bottom to the very top and thus obtain twice this value. To avoid confusion we refer to the later as "anti-peak-to-peak" amplitude or simply as "peak-to-peak" amplitude. Do not confuse this with measuring horizontally from one peak to the next, in which case you obtain the wavelength.

amplitude modulation (AM) – the change of the amplitude of a wave

analog signal – a signal that can take on any numerical value between its minimum and maximum values

AND – the result for $Y = A \cdot B$ with $Y = 1$ only if both $A = 1$ and $B = 1$

antenna – a metallic structure (can even be a single wire) used for the purpose of picking up an electrical signal. The incoming electromagnetic wave makes electrons in the antenna wiggle in step with the incoming wave.

antinode – a place on a wave that undergoes maximum change, e.g., displacement antinode means maximum changes in displacement (movement) at that point; pressure antinode (in a pipe) means maximum changes in pressure

antiskating force – the force that a little spring exerts outward on the bent record player arm so that the arm is not pulled in to the center of the record as the record is played

anvil – the middle bone in the middle ear

aperiodic – not periodic

Armstrong, Louis – famous historical jazz trumpet player

attack – the time for the sound to reach a maximum level from its start. A short or abrupt attack is characteristic of an explosive or plucking sound.

audio in – phrase used to describe the input audio signal in electrical form entering a circuit section or module

audio out – phrase used to describe the output audio signal in electrical form leaving a circuit section or module

audio signal – electrical signal that when sent to an amplifier and speaker can be heard

audiogram – a medical record of an ear's ability to hear where hearing threshold in dB is plotted along the downward vertical axis and frequency along the horizontal axis at the top of the plot

audiology – the study of speech and hearing loss

auditory – pertaining to the perception of sound

auditory nerve – the "biological wire bundle" through which electrical signals are carried to the brain from the organ of Corti

aural harmonics – harmonics introduced by the ear due to distortion of the original waveform if the original sound is too loud or if there is some imperfection in the ear/brain system

Autumn Leaves – song from 1930s serving as our signature song in a minor key for the 4-7-3-6-2-5-1 progression in a minor mode or key

Bach, Johann Sebastian – baroque composer, master at using the cycle of fifths

balanced modulator – a device that accepts two sine waves as input and then sends out two sine waves, but one with the sum frequency and the other with the difference frequency

balanced modulation – process whereby the sum and difference frequencies of two sine waves are produced

baffle – a barrier with a hole in it so that a speaker can be inserted, thus preventing the out-of-phase waves leaving the rear from destructively interfering with the waves leaving the front of the speaker

bandpass filter – a filter that passes frequencies from some lower limit to some higher limit

bandwidth – the difference of the maximum frequency and minimum frequency that defines the range of permitted frequencies in a bandpass filter

Baroque Period – period in European music from 1600-1750 characterized by grand long melodic lines

Bartók, Béla – modern Hungarian composer who lived in Asheville for 3 months due to health reasons, use of notes spaced by fifths to obtain an eerie beautiful sound

basilar membrane – membrane of length 3.5 cm in the cochlea on which sits the organ of Corti, which organ detects sound waves. The basilar membrane has varying degrees of stiffness, increasing as one nears the oval window. The membrane responds by resonance where the higher the frequency of the incoming sound wave, the closer to the oval window the sound is detected. Each octave corresponds to 3.5 mm and we can hear 10 octaves.

bass – low frequencies; also, the stringed instrument that produces the lowest pitches in the string family

bass control – amplifier control for low-pass filter so that you can adjust the strength of the lower frequencies

bassoon – a woodwind instrument that acts as an open pipe and has the lowest musical range of the four common woodwinds: flute, oboe, clarinet, and bassoon

battery – a device that separates plus and minus charges inside it and thus can produce a direct current when inserted in a circuit

beats – the pulsations that occur when two waves have nearly the same frequency

beat frequency – the pulsation frequency that occurs when two waves have nearly the same frequency. The beat frequency is given by the difference of the frequencies. The frequency of the actual tone undergoing the pulsations is given by the average of the frequencies of the two original waves.

Beethoven, Ludwig van – a transition composer that bridges the classic and romantic periods in music. He helps usher in the romantic period with music heroic in proportion.

bel – a unit of sound level (loudness)

bell jar – jar used to place a bell inside and pump out the air so that no sound can be heard. It is used to demonstrate that sound needs a medium to travel through while light does not (since you can see the bell when there is no air inside the jar).

Berlioz, Hector – romantic French composer who wrote his *Symphonie Fantastique* as sexual sublimation for his beloved Harriet Smithson since she rejected him. What happened after she heard the symphony? He introduces the Dies Irae them in the 5th movement of his symphony, which movement is called *Dream of a Witches' Sabbath*. He also includes Church bells, an example of inharmonicity.

Bernstein, Leonard – conductor who invited Louis Armstrong and other black musicians in the mid 1950s to perform *St. Louis Blues* with composer W. C. Handy and his wife in the audience. Bernstein also discovered the black pianist André Watts from Philadelphia.

Berry, Chuck – a prince of rock 'n roll, whose *Mabellene* (1955) neutralizes the blues with all 1-chords off and on throughout the piece

binary – two-valued, either 0 or 1, true or false

binary number – a number using 1s or 0s such as 1101, where reading from right to left you have 1s, 2s, 4s, 8s, etc. Therefore 1101 is equivalent to 1(8) + 1(4) + 0(2) + 1(1) = 13.

binaural beats – beats perceived in the brain when two pitches close in frequency are played separately into each ear low in volume to avoid bone conduction. The beats are still perceived in the brain even though there are no physical beats present. The waves do not mix in space, but only in the brain.

binaural effects – perceptual sound effects possible since we have two ears such as the perception of sound direction

blue noise – high-frequency noise

blues – song following the pattern of 12 sections (measures or bars) with harmonic content 1-4-1-1, 4-4-1-1, 5-4-1-1 where substitutions for harmony are allowed.

blues scale – a scale of six notes developed to blend well with the blues harmonic chord progression

Brahms, Johannes – romantic composer, study orchestration with Robert Schumann, lived with the Schumanns for a time, Uncle to the Schumann kids, composer of the *Academic Festival Overture*

brass – the orchestral instruments made of metal based on open-pipe physics. The four brass instruments of the orchestra are the French horn, trumpet, trombone, and tuba.

bridge – on a guitar, the place where the strings are fastened opposite to the end that contains the tuning pins

brilliance – term in acoustics when reverb is present for high frequencies but not much is there for low frequencies

broadband noise – white noise

Can't Take My Eyes Off You – song from 1960s serving as our signature song in a major key for the 4-7-3-6-2-5-1 progression. The mid section uses the progression.

capacitor – electrical component (in its basic design, two plates) that can store electricity

Carlos, Wendy – renown musician on the synthesizer. Her record “Switched-On Bach” which used the Moog Synthesizer in the late 1960s created a sensation.

carrier wave – the wave upon which a modulation is applied

cartridge – name given to record player component, fitting at the end of the arm, that translates the mechanical vertical motions of the stylus into electrical signals via the Faraday principle. The cartridge consists of the stylus at its bottom and two tiny magnets that can move inside coils at the top.

cello - the instrument in the orchestral string family that has a lower musical range compared to the viola but a higher one compared to the bass

Classic Period in Music - the time from roughly 1750 - 1800. The music, in contrast to the grand baroque period that preceded it, is known for its Simplicity, Order, Balance, elegance, and Restraint (SOBER). Two of its major composers were Haydn and Mozart.

CD – a compact disc

CD player – a device that converts binary data on a CD in the form of pits into sound using laser light to reflect off the pits

charge – an electrical plus or electrical negative

chord – the dressing up of a degree of the scale so that you obtain a harmonic group of tones to accompany a melody. Chords can be labeled such as the 1-chord, meaning a chord built on the first degree of the scale. The simple major chord is built using Do-Mi-Sol simultaneously – a triad. When you add a low bass note (H1), then Do-Mi-Sol become H4, H5, and H6 relative to your H1. Think of chords are including harmonics that go with a given degree of the scale.

chorus effect – the effect whereby a group of sound sources are producing the same sound, e.g., singers in a choir singing the same song

chromatic scale – the equal-tempered twelve-tone scale

circle of fifths – same as cycle of fifths

circuit – an electrical system with wires and electrical components

circuit element – an electronic component of an electrical system. The basic circuit elements are the battery (V), bulb (B), resistor (R), capacitor (C), coil or inductor (L), transistor (T), and diode (D).

clarinet – a woodwind instrument that acts as a closed pipe and has a lower musical range than the oboe and a higher musical range than bassoon

clarity – term in acoustics for little overall reverb

closed pipe – a pipe closed on one end and open on the other where we designate the pipe length as L. The natural modes of the longitudinal vibrations are the odd harmonics and they have frequencies f_1, $3f_1$, $5f_1$, etc., where f_1 is the frequency of the first harmonic (fundamental). The corresponding wavelengths are $\lambda_1 = 4L$, $\lambda_3 = 4L/3$, $\lambda_5 = 4L/5$, and so on. For each

frequency f and its associated wavelength λ the wave relation is always true: $v = \lambda f$, where v is the speed of waves in the medium inside the pipe, the medium usually being air.

cochlea – the coiled region of the inner ear than contains the auditory detection mechanism

coil – a wire wound in the form of circles forming a cylindrical structure with empty space inside

colored noise – noise resulting after white noise is passed through a filter

Coltrane, John – jazz saxophonist from North Carolina who brought a modern dissonant "Stravinskyesque" sound to jazz. An example is his version of the Rodgers and Hammerstein *My Favorite Things*, which inspired the *Doors* for their improvisational section to *Light My Fire*.

compact disk – CD, a disk that contains digital information such as audio, video, text, images, etc.

complex periodic wave – any periodic wave that is not a sine wave

compression – a squeezing together of the medium in a longitudinal wave, analogous to the crest of a transverse wave

consonance – pleasing combination of tones. The five most consonant intervals in order from most consonant to least are 1:1 (unison), 2:1 (octave), 3:2 (fifth), 4:3 (fourth), 5:4 (third).

constructive interference – interference where the crest of one wave lines up with the crest of the other and so do the troughs. We obtain a bigger wave and the waves are said to be in phase.

contrabass – the bass stringed instrument, also simply called bass

control voltage – voltage used to control a synthesizer module

Coulomb's law – like charges repel, unlike charges attract

crescendo –musical term for a gradual increase in loudness

crest – the part of a wave above the "sea level" reference line of the wave

current – the flow of electricity

cutoff frequency – the frequency in a filter which determines whether a signal can pass through a filter or not

cycle of fifths – the movement by fifths through the 12 notes in the scale. Songs typically use portions of the cycle.

cymbals – metallic plates slightly conical that crash together producing noise with a strong presence of high frequencies

damped wave – a wave that reduces its amplitude to zero as time goes on

damped harmonic motion – harmonic motion that decreases in amplitude such that eventually the motion stops

decay – the time it takes for the sound to drop in amplitude after the attack phase until it reaches the sustain level

decrescendo – musical term for a gradual decrease in loudness

De Morgan's Theorems – First Theorem: $\overline{A \cdot B} = \overline{A} + \overline{B}$, which translates as NOT(A AND B) equals (NOT A) OR (NOT B), Second Theorem: $\overline{A + B} = \overline{A} \cdot \overline{B}$, which translates as NOT(A OR B) equals (NOT A) AND (NOT B)

dbx compander – tape circuit that compresses the signal strength when recording so that the 100-dB dynamic range is squeezed into 50 dB in order for the tape to handle it – then on playback, the circuitry expands the signal to achieve the full 100-dB dynamic range. Otherwise, the limited magnetic tape cannot faithfully produce a range of 100 dB on its own – you would reach a saturation point similar to an "overexposure" in photography.

Debussy, Claude – French impressionistic composer who composed the orchestral work *La Mer* (The Sea)

deci – the metric prefix for 1/10, e.g., a decibel is 1/10 of a bel

decibel (dB) – a measure of the loudness of a sound equal to 1/10 of a bel

decibel Scale – scale where a tenfold increase of sound sources translates to an additional 10 dB on the decibel scale and a twofold increase in sound sources results in an additional 3 dB on the decibel scale

degree of the scale – the location of the note in the major scale where Do is 1, Re is 2, Mi is 3, Fa is 4, Sol is 5, La is 6, Ti is 7, and Do' is 8.

delayed light – a circuit that allows a light bulb to stay on for a short time after you release the switch

demodulator – a circuit section that extracts the transmitted information contained in the modulated carrier wave

destructive interference – interference where the crest of the first wave lines up with the trough of the second and the trough of the first lines up with the crest of the second, thus canceling each other out. The sum wave is zero. The waves are said to be out of phase or 180 degrees out of phase.

devil's tone – a tritone interval, so called because of the perceived tension in the sound of the interval. A tritone is often used in the harmony of the 5-chord to heighten the tension to resolve to the 1-chord.

diatonic scale – the just diatonic scale, i.e., the major scale tuned to perfect ratios – Do (1:1), Re (9:8), Mi (5:4), Fa (4:3), Sol (3:2), La (5:3), Ti (15:8), Do' (2:1)

Dies Irae (The Day of Wrath) – the haunting Medieval theme in a minor key inspired by the Biblical Day of Judgment

digital sampling rate – the rate at which one samples the value of signal. For CD quality, the sampling rate needs to be approximately double the highest frequency we can hear. Therefore the sampling rate used is 2 x 20,000 Hz = 40,000 Hz = 40 kHz.

digitize – to convert analog information into digital information (strings of 1s and 0s)

diffraction – the bending of a wave due to passing through an opening, around a corner, or around an obstacle. The opening or obstacle size must be comparable to the wavelength of the wave.

dimmer circuit – circuit with a battery, light bulb, and resistance arranged in a single loop. The bulb glows dimmer due to the presence of the resistor.

diode – a circuit element that allows electricity to pass only in one direction

direct current (DC) – current that flows in one direction in a circuit section

discrete signal – a signal that can only take on specific values between its minimum and maximum value. When the unit increments are really small, the signal appears to be continuous (analog).

displacement – change in position, e.g., when the medium is moved away from its natural position (equilibrium) forming a crest (above equilibrium, i.e., positive displacement) or trough (below equilibrium, i.e., negative displacement)

displacement antinode – a place where maximum movement of the medium occurs

displacement node – a place where no movement of the medium occurs

dissonance – the opposite of consonance

Dolby – the system by which you boost the higher frequencies when you record on a cassette tape (Dolby recording filter) and then you play the tape back through a filter that reduces the higher frequencies back to normal (Dolby playback filter). The playback filter also reduces the annoying high-frequency hiss that is characteristic on playback without the filter.

Doppler effect – the change in pitch due to the relative motion between the sound source and the observer. The pitch is higher when the source and observer approach each other and the pitch is lower when the source and observer move away from each other.

driven oscillation – an oscillation resulting from an agent (driver) forcing a system to oscillate. The system being driven (the "drivee") oscillates at the same frequency as the driver but the amplitude of response depends on the frequency.

drum – percussive instrument with a vibrating membrane, i.e., a vibrating two-dimensional surface, producing a noise with an abrupt attack. A kettledrum also includes a tuned pitch since the cavity of the drum in this case acts as a Helmholtz resonator, i.e., encouraging the air mass to swish around and produce a low-pitch tone.

duty cycle – the percentage of the wavelength taken up by the width of a rectangular crest or pulse. A pulse wave with a 50% duty cycle is a square wave; a pulse wave with a small duty cycle is a pulse train wave.

dynamic range – the range of loudness from softer to louder sounds

dynamics – range of loudness or capability to produce on a musical instrument or electronic system both soft and loud sounds

eardrum – membrane that vibrates when sound enters the ear, serving as the boundary between the outer and inner ear

earplug – small padded material placed in the outer ear to decrease the sound level. Good ones can decrease sound levels by 30 dB and more.

echo – the reflection of sound from an object or surface

echolocation – locating objects by reflecting sound waves off the objects. A bat sends out high-frequency sound waves that reflect off objects and then return to the bat.

electric field – force field due to the presence of a charge. If the charge is positive, then the force field is such that a negative charge will be pulled in towards the positive charge and a positive charge will be repelled. The force field gets weaker as you move farther and farther away from the charge.

electric guitar – guitar that employs the Faraday principle to convert the vibrating metallic strings into electrical signals that are then amplified and sent out through speakers

electrical force law – Coulomb's law: like charges repel, unlike charges attract

electricity – moving charges

electricity and magnetism – phrase used to describe the four physical laws of electricity and magnetism and their study

electromagnet – magnet formed by passing current through a coil than surrounds a piece of iron or other suitable substance

electromagnetic pick-up – see pick-up

electromagnetic pick-up set – see pick-up set

electromagnetic wave (EM wave) – a transverse wave requiring no medium to travel in since a changing electric field creates a magnetic field (Ampère's law extended) and a changing magnetic field creates an electric field (Faraday's law). The wave propagates itself. All EM

(pronounced E and M) waves, whether they are visible or invisible, travel at the speed of light (300,000 km/s).

electron – an elementary particle with charge –1 that serves as a building block in the make-up of atoms. The electrons exists in the region than surrounds the inner positive nucleus. It is the electrons in outer atomic shells of metals that travel as electricity in wires made of metals such as copper.

electronics – the use of electrical components to build devices such as radios

Ellington, Duke – jazz band leader, composer, pianist. His *Blues in Orbit* (1958) gives a modern version of the blues for the early years of the Space Age. His *Satin Doll* is built on the 2-5 and 2-5-1 sequence from the circle of fifths.

embouchure – the opening that serves as one open end of the orchestral flute over which the performer blows air to make the flute resonate

envelope – the amplitude shape of the sound spanning the attack, decay, sustain, and release phases

envelope generator (ADSR) – the synthesizer module that controls the attack time, decay time, sustain level, and release time of an audio signal and starts the process when the trigger voltage is received

equal-tempered scale – the twelve-tone scale where each note is a half-step interval away from each of its adjacent notes

equal temperament – tuning the notes on the piano so that all adjacent notes, i.e., all half steps, have the frequency ratio given by the twelfth root of 2

equalizer – device containing a group of bandpass filter circuits with amplifier controls so that you can adjust the sound level in each frequency band

equilibrium – the state of the medium when no waves are present

Eustachian tube – tube connecting the back of the mouth to the middle ear serving for pressure adjustments when we climb to high altitudes or return to low altitudes

Faraday's law – a changing magnetic field inside a coil produces electrical current in the coil

fifth - the musical interval from Do to Sol, which outlines the beginning of "Twinkle, Twinkle Little Star," which is also an interval of 7 half steps.). In the Just Diatonic Scale with perfect ratios, the interval of a fifth is 3:2.

filter (electrical) – a device that allows the passage of electrical waves with a certain frequency range

filter tracking – technique used in synthesizers where the filter cutoff shifts its frequency to adjust for the note you are playing, thereby producing a similar altering of the harmonics for all the notes you play

Fitzgerald, Ella – historical jazz singer who sings our signature 1-6-2-5 song *Heart and Soul*. She also appeared in a *Memorex* commercial breaking a glass with her amplified voice.

flash – name for a circuit where a capacitor first touches a battery to store electricity and then the capacitor touches a light bulb to release the stored electricity, making the bulb flash briefly

flashlight – a circuit with a battery and light bulb arranged in a loop

Fletcher-Munson Curves – a series of graphs published in the 1930s that shows the equivalent hearing threshold, and equivalent loudness levels, over all frequencies and loudness in human perception. Each equivalent curve has a distinct phon value. The phon value is set to agree with the decibel value at 1000 Hz.

flute – a woodwind instrument that acts as an open pipe and has the highest range of the four common woodwinds: flute, oboe, clarinet, and bassoon

fourth – the musical interval from Do to Fa, e.g., the beginning of “Here Comes the Bride,” which is also an interval of 5 half steps. In the Just Diatonic Scale with perfect ratios, the interval of a fourth is 4:3.

formant – an enhanced frequency region in a spectrogram due to the resonance structure of the system generating the sound. Resonances of some of the frequencies produced result in enhancements of those frequencies.

Fourier analysis – the breaking down of a complex periodic wave into its harmonics, including the amounts of each harmonic present (the harmonic amplitudes)

Fourier spectrum – the bar graph you get for the Fourier recipe of a particular periodic wave where the amplitude of each harmonic is represented along the vertical axis and the harmonic number or frequency along the horizontal

Fourier synthesis – the construction of a complex periodic wave by adding the appropriate amounts of its harmonics and lining the harmonics up correctly (the phases)

Fourier’s theorem – any periodic wave with frequency f can be built by using sine waves with frequencies f, 2f, 3f, 4f, and so on by adding appropriate amounts of each (and possibly needing to shift the phases of some of the harmonics before you add them)

French horn – a brass instrument with a second lowest musical range of the brass, the lowest being the tuba

frequency – the number of times something repeats during a time interval. The common example used often is the number of cycles per second, written as 1/s and defined as hertz, i.e., Hz.

frequency modulation (FM) – the change of the frequency of a wave

fret – a ridge on a guitar to mark the place where one should place a finger to obtain a note of the scale

fullness – term in acoustics used when reverb is present for all frequencies

fundamental – the first harmonic in the harmonic series

Garner, Erroll – jazz pianist who played completely by ear, never learning to read music.

gating – an example of amplitude modulation where you apply a square-wave modulator to a sound wave such that you hear the sound during the crest-phase of the modulator and do not hear the sound during the trough-phase of the modulator

generator – device that generates electricity via the Faraday principle, e.g., moving a magnet in and out of a coil generates alternating current in the coil

Gillespie, Dizzie – jazz trumpet player, colleague of Charlie Parker, who together were forerunners of the bebop era (a fast-paced jazz era with 2-5 sequences inserted in the blues as well as dissonant improvisations).

golden rule – the rule that in constructing a guitar, the next fret should be placed 1/18 of the distance from the current fret to the bridge

graph – a plot of data where the vertical axis represents one characteristic or parameter and the horizontal axis another such as distance and time respectively. One can then say that we are plotting distance against time.

green noise – mid-frequency noise

Greensleeves – song dating back to Elizabethan times (1580). Modern harmonization makes this song a perfect fit for the 4-7-3-6-2-5-1 in the minor mode or key. The tune is popular today as “What Child is This?” during Christmas time.

ground – the part of the circuit where the minus side of the battery is found

guitar – instrument with 6 stings and a series of frets

hair cell – one of about 20,000 cells on the organ of Corti for the detection of sound waves of various frequencies from 20 to 20,000 Hz

half step – the musical interval where the ratio is given by the twelfth root of 2, which we can remember as the rounded-off value of 1.06. Going up a half step in frequency is analogous to gaining 6% in interest so that your original $100 becomes $106.

half wave – one half of the wavelength, e.g., a crest or trough of a sine wave

hammer – the first bone in the middle ear, the bone that attaches to the eardrum

Handy, William Christopher (WC) - jazz composer known as the "father of the blues"

harmonic – a sine wave with frequency in the series f, 2f, 3f, etc. where f is the first frequency

harmonic motion – natural motion with smooth crests and troughs described by a sine wave such as that made by a mass attached to a spring. The same as simple harmonic motion.

harmonic series – the harmonics f, 2f, 3f, and so on, sometimes designated as H1, H2, H3, …

Haydn, Franz Joseph – composer of the classic period in music and known as the "father of the sonata"

hearing loss – a condition where the hearing threshold at any frequency tested is greater than 0 dB. This means that the frequency must be played louder than 0 dB for you to hear it.

hearing threshold – the dB level at which the sound needs to be produced so that you can barely hear it. One is typically tested at 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz. The normal threshold is 0 dB for all frequencies tested, which is analogous to 20/20 in vision. Results for each ear are plotted on an audiogram.

Heart and Soul – song from the 1930s that serves as our signature song for the 1-6-2-5 progression from the circle of fifths

Helmholtz resonator – a device shaped like a big empty apple cider jug. When you blow across the top, the entire air mass swishes around producing a very low pitch. This is unlike the longitudinal standing waves produced in narrow pipes.

hi-fi – short for high fidelity

high fidelity – a term dating back to the 1950s meaning that the reproduction of sound with vinyl records, early tape recorders, and the radio was of true fidelity – faithful reproductions compared to what was available prior to this time

high-pass filter – a filter that passes high frequencies

hiss – high-frequency noise, typically 5000 Hz and above

Holiday, Billie – famous historical jazz singer known as Lady Day

horn – a metal instrument based on open-pipe physics. See brass and the French horn.

house system – the external amplifier and speaker system in a room or auditorium

impressionism – period in the latter part of the 19th century which aims for an impression rather than detailed focus such as a catchy tune or sharp image in a painting. The two giants are the two Claudes: Debussy in music and Monet in painting. This period is included in romanticism for piano competitions but in the humanities and arts it is considered a separate period: romanticism more like 1800-1850 and impressionism more like 1850-1900.

inductor – another name used for a coil circuit element

inertia – the property that an object remains at rest or moves at constant velocity unless acted upon by a force. Sometimes used interchangeably with mass.

inharmonic partials – frequencies that are not part of the harmonic series

inharmonicity – term to describe a sound that consists of frequencies that are not in the harmonic series f, 2f, 3f, etc. for the tone or sound. Examples include bells, gongs, and noise.

in phase – two waves with the same wavelength are such that the crest of one wave lines up with the crest of the other wave. The phase shift of one with respect to the other is 0 degrees.

inner ear – the region of the ear beyond the oval window which transmits sound via fluid conduction and from which electrical signals are sent to the brain

interference – the effect due to superimposing two waves, i.e., adding two waves together

interval – the musical jump or span from one note to another, e.g., a fifth is the interval you span going from Do to Sol

intimacy – term in acoustics for the presence of reflections reaching the hearer within 20 ms after the direct sound reaches the hearer

Jobim, Antonio Carlos – Brazilian composer known as "Tom" who composed many bossa nova songs, e.g., *One Note Samba* which has a charming pair of 2-5-1 sequences in its middle section.

just diatonic scale – the major scale tuned to perfect ratios – Do (1:1), Re (9:8), Mi (5:4), Fa (4:3), Sol (3:2), La (5:3), Ti (15:8), Do' (2:1)

Khachaturian, Aram – modern Armenian composer who used extensively the half step and small intervals, giving his music a non-western element, characteristic of Armenia

kettledrum – a drum that also includes a tuned pitch since the cavity in this case acts as a Helmholtz resonator, i.e., encouraging the air mass to swish around producing a low-pitch tone.

keyboard (KBD) – unit that sends out along the voltage-control wire a different voltage for each key that is pressed and sends out along the trigger control wire a common signal when any key is pressed down. The voltage-control wire connects to the VCO and the trigger control goes to the ADSR.

Laura – movie from 1944 where composer David Raksin uses four 2-5-1 progressions in the key song for the movie, also named *Laura*.

Lissajous figure – a stationary pattern formed when a horizontal wave motion is combined with a vertical wave motion because the frequency ratio can be expressed with whole numbers such as 1:1, 3:2, or 4:3

liveness - term in acoustics for the presence of sufficient reverb

longitudinal standing wave – a harmonic vibration in a pipe so named because the "dancing pattern" has a "kind of stationary characteristic" with its fixed displacement nodes and moving antinodes in between

low-frequency oscillator (LFO) – synthesizer module that generates a periodic control voltage in the range from 0 to 25 Hz that is used to modulate a carrier wave

low-pass filter – a filter that passes low frequencies

lower sideband – the inharmonic frequency components on the left side of center in a spectrum due to balanced modulation

LRC circuit – a circuit consisting of an inductor (coil), resistor, and capacitor. L = inductor, R = resistor, C = capacitor.

kilo – the metric prefix for 1000, e.g., 1 kilosecond = 1000 seconds

kilowatt hour – useful for electrical costs since it includes the wattage (current you draw times the voltage you are using, i.e., P = IV) and also the time (hour). The typical charge is about 10 cents per kilowatt hour, i.e., 10 cents per kWh.

larynx – the space in the vocal track lying above the vocal folds

linear tracking – term used in record players where the arm is straight and thus there is no skating force to deal with

longitudinal wave – a wave where the medium moves parallel (or antiparallel) to the direction of propagation of the wave

loudness – the perceived strength of an acoustic wave as experienced by the ear/brain system where stronger perceived waves are said to be louder

LP – long-playing record. The LP record turns slowly at 33 and 1/3 rotations per minute in contrast to records turning at 45 rotations per minute and the very early ones that turned at 78 rotations per minute.

Mach speed – the speed in units where the value “1” stands for the speed of sound in the medium under consideration. At standard temperature and pressure, Mach 1 = 340 m/s = 1125 ft/s = 750 mi/h.

magnetic dipole – a magnet with its north and south pole. Also, small “baby magnets” residing on a magnetic tape.

magnetic force law – like poles (two norths or two souths) repel and unlikes attract

magnetism – term to describe magnets and their physical nature

magnetic field – force field that surrounds a magnet or a field that is produced when you send current through a coil with nothing inside the coil. The magnetic field is produced in the space inside the coil for such a situation. The farther you get away from the source of the field, the weaker its effects.

major key (song in) – a song that sounds happy because the third degree of the scale is used in the song as well as in the root harmony (1-chord)

major scale – Do, Re, Mi, Fa, Sol, La, Ti, Do', which in the equal-tempered scale has these adjacent intervals: Do-Re (whole step), Re-Mi (whole step), Mi-Fa (half step), Fa-Sol (whole step), Sol-La (whole step), La-Ti (whole step), Ti-Do' (half step)

Mancini, Henry – composer of film music. He employs two consecutive 5th intervals effectively in his theme for the movie *Condorman*.

Marsalis, Wynton – famous trumpet player who gives a nice analogy of playing the blues with playing within the boundary of a basketball court. Marsalis also likes to give the Albert Murray description of blues as a vaccination against real sadness.

mass – "stuff" that makes up any object. See inertia.

masking – the covering up of sound by one sound as in the sounds of a fan drowning out a conversation

medium – the environment such as air or a spring through which a wave can travel

Mersenne's laws – three string laws: 1) longer strings have lower pitches, 2) greater string tension means higher pitch, and 3) heavier strings have lower pitches

microphone – a device that translates the mechanical motion of a diaphragm into an electrical signal via Faraday's law

middle ear – the region of the ear from the eardrum to the oval window consisting of three tiny bones that vibrate in step with incoming sound waves

milli – the metric prefix for 1/1000, e.g., 1 millisecond = 1/1000 of a second

minor key (song in) – a song that sounds mysterious or sad because the root harmony (1-chord) is built using the minor third (tone a half-step lower than the third) and the song may use the minor third in the melody line

minor third – the musical interval from Do to a half step lower than Mi, i.e., an interval equal to three half steps

modular synthesizer – electronic circuits designed in modules that can synthesize and manipulate sound characteristics. See synthesizer.

modulation – changing a property of a wave such as its amplitude or frequency

modulator – the wave that modulates a carrier wave in some way

monopole – term that refers to a single north magnetic pole or single south magnetic pole, either of which have never been found alone. Magnets always come with a north and south pole.

moogerfooger – a balanced modulator. See balanced modulator and balanced modulation.

mouth cavity – open passage beyond the mouth that serves as a resonance chamber producing formants in the sound made by the vocal system

Mozart, Wolfgang Amadeus - composer of the classic period in music. A child prodigy and super genius composer often used as a "yardstick" to measure other composers.

Murphy's law – law named after electrical engineer, which law is commonly stated as "If something can wrong, it will." Engineers make back-up systems because of this law and it is prudent to do so in real life situations, e.g., never let things go to the last minute.
Murray, Albert – author of *Stomping the Blues*, blues is like an antidote or vaccine.

Moog, Bob – inventor of the Moog Synthesizer. He spent the last 25 years of his life mostly in Asheville and associated with UNC Asheville. His company Moog Music is in downtown Asheville.

Moog synthesizer – synthesizer invented by Moog. See synthesizer for more about Moog as inventor of the synthesizer.

Moogerfooger – a balanced modulator developed by Bob Moog

music synthesizer – see synthesizer

musical range – the range of tones that can be produced by a musical instrument or singer. The musical range for the piano is about 7 octaves from the lowest note at 27.5 Hz to the highest pitch at 4186 Hz.

musical scale – a discrete set of tones from which one can compose a tune. Examples include the major scale, the common minor scale, blues scale, whole-tone scale, pentatonic scale (black keys only on the piano).

"Musician's Scale" – term used by your instructor to refer to the major scale (Do-Re-Mi-Fa-Sol-La-Ti-Do')

musical temperament – see temperament

NAND – the NOT of AND which can be written as $Y = \overline{A \cdot B}$

nasal cavity – open air passage beyond the nose that serves as a resonance chamber producing formants in the sound made by the vocal system

neurosensory hearing loss – hearing loss of specific frequencies due to damage of hair cells in the inner ear

neutron – an elementary particle with charge zero that serves as a building block in the make-up of the nucleus of atoms

node – a place on a wave that does not change, e.g., displacement node means no displacement; pressure node (in a pipe) means no change in pressure

noise – term to describe the presence of all frequencies from 100 Hz to 10,000 Hz

noise generator (N) – synthesizer module that generates all frequencies (noise)

NOR – t he NOT of OR which can be written as $Y = \overline{A + B}$

NOT – the value $Y = \overline{A}$, where Y = 1 if A = 0 and Y = 0 if A = 1

oboe – a woodwind instrument that acts as an open pipe and has a slightly lower musical range than the flute and a higher musical range than the clarinet

octave – the musical interval from Do to Do' which starts the song "Somewhere, Over the Rainbow," which is also an interval of 12 half steps. The two notes form an interval of an octave if their frequency ratio is 2:1.

ohm – the unit of resistance; ohm is abbreviated by the Greek letter Ω (capital omega)

Ohm's law – the law V = IR, where V is the voltage, I is the current, R is the resistance and R is constant. However, the rule V = IR can always be applied whether R is constant or not.

open pipe – a pipe open on each end where we designate the pipe length as L. The natural modes of the longitudinal vibrations are called harmonics and they have frequencies f_1, $2f_1$, $3f_1$, etc., where f_1 is the frequency of the first harmonic (fundamental). The corresponding wavelengths are λ_1 = 2L, 2L/2, 2L/3, and so on. For each frequency f and its associated wavelength λ the wave relation is always true: v = λ f, where v is the speed of waves in the medium inside the pipe, the medium usually being air.

OR – the result for Y = A + B with Y = 1 if either A = 1 or B = 1

orchestra – large group of instruments including the strings, woodwinds, brass, and percussion

organ of Corti – the organ in the cochlea that detects sound waves and from which the auditory nerve goes to the brain

oscillation – the generic term for vibration or production of one cycle of a periodic wave

oscilloscope – an electrical measuring instrument that sweeps out a picture of an electrical wave

oval window – the boundary between the middle ear and inner ear

overtone – any harmonic above the fundamental (1^{st} harmonic). Thus the first overtone is the 2^{nd} harmonic, the second overtone is the 3^{rd} harmonic and so on.

overtone series – the overtones: H2, H3, H4, H5, and so on. When you include the fundamental with the overtone series you get the harmonic series.

out of phase – two waves with the same wavelength where the crest of one wave lines up with the trough of the other wave. The phase shift of one with respect to the other is 180 degrees.

outer ear – the region of the ear from the ear lobe to the eardrum

Parker, Charlie "Bird" – jazz saxophonist who incorporated the 2-5 in the blues formula

partial – any harmonic in the harmonic series H1, H2, H3, .. (f, 2f, 3f, …)

peak-to-peak amplitude – a measure equal to twice the amplitude

perfect ratio – a ratio of two whole numbers such as 2:1, 1:2, 3:2, 2:3, etc.

period – the time it takes to complete one cycle of anything that repeats such as a periodic wave

periodic wave – a wave pattern that repeats

periodicity pitch – the fundamental perceived by the ear/brain system even if no fundamental is present since H2 and H3 imply a periodicity of a fundamental H1. So the ear/brain system puts in the fundamental during the perceptual processing even though it is not physically there.

Peterson, Oscar – Jamaican-Canadian jazz pianist who had phenomenal technique. A Franz Liszt of Jazz Piano.

phase – the horizontal shift of a wave, where 360 degrees represent a shift of one wavelength. A phase of 180 degrees means you have shifted a wave by one-half wavelength so that a crest has moved over to where a trough was initially located. A phase shift of 90 degrees means you have shifted the wave by one-quarter wavelength.

phon – a unit that designates the same loudness value. A value of zero means we can barely hear it. Humans are not that sensitive to low pitches. Therefore, 0 phons at 20 Hz has to be 70 dB according to a scientific meter for us to barely hear it. The phons are matched with dB values at 1000 Hz. Therefore, 60 phons = 60 dB for perception at 1000 Hz.

“Physicist’s Scale” – term used by your instructor to refer to the scale you would get using just the harmonics: f, 2f, 3f, …

piano – percussive instrument with 88 keys and 88 hammer/string units (single strings for low pitches, double for intermediate pitches, triple for the highest pitches), all under high tension. The musical range is from 27.5 Hz to 4186 Hz, a span of a little more than 7 octaves.

pianoforte – name for the piano, meaning soft-loud in Italian. The piano was an innovation capable of soft and loud sounds depending on how hard you hit the keys. It was therefore named pianoforte, which was shortened to piano.

pick-up – a small coil near the metallic string of an electric guitar that picks up changing magnetic fields as the nearby metallic string vibrates. The vibrating string disturbs the magnetic field inside the coil, thus inducing electrical signals in the coil via Faraday’s principle.

pick-up set – a set of pick-ups so that each electric guitar string has its own pick-up. You can have more than one set of pick-ups on the guitar, where a second pick-up set is placed at another location along the strings.

pink noise – noise with a greater presence of low frequencies

pipe – see open and closed pipe

pitch – the perception of the frequency of a sound wave where higher frequencies are said to have higher pitch

physics – the study of the fundamental properties and laws of matter and energy

place theory of hearing – the idea that the location of the detection of sound along the 3.5-cm basilar membrane depends on the frequency. Each octave of 10 octaves is detected over a distance of 3.5 cm / 10 = 3.5 mm of the basilar membrane with the higher and higher frequencies being detected on the stiffer and stiffer sections of the basilar membrane. These stiffer sections are closer to the oval window.

plot – graph

pole – either end of a bar magnet: a magnetic north pole or magnetic south pole

power – the product of the current and voltage, i.e., P = IV. Your electrical company charges you for the power (which includes how much current you draw and at which voltage). But in addition, they charge you for the time duration you use it.

power supply – a device you plug in and obtain voltage so that you do not have to use batteries. A typical power supply in a lab is one that ranges from 0 to 5 volts, producing direct current.

preamplifier – an amplifier than enhances a very weak signal, which in turn is further amplified by another amplifier and then sent to a speaker for everyone to hear the sound

presbycusis – natural hearing loss of high frequencies as one ages

pressure antinode – a place where maximum change in pressure occurs

pressure node – a place where no change in pressure occurs, e.g., the open end of a pipe which is free and always takes on the atmospheric pressure of the surrounding environment

Prokofiev, Sergei – Russian modern composer using dissonance for beauty and innovative use of the 9th in form a chord to replace the usual classical chord ending with the 8th

propagation – the traveling of a wave. To propagate is the same as to travel in this context.

proton – an elementary particle with charge +1 that serves as a building block in the make-up of the nucleus of atoms

pulse – a wave disturbance that does not repeat

pulse-train wave – a wave with a narrow pulse in each wavelength. The Fourier amplitudes are 1, 1, 1, 1, 1, 1, 1, 1, 1, etc. for the Fourier components H1, H2, H3, H4, H5, H6, H7, H8, H9, and so on

pulse wave – a wave consisting of a “rectangular building” and “courtyard.” If the building takes up half the wavelength, you have a square wave. If the building is very narrow, you have a pulse train wave.

pulse-width modulation (PWM) – a form of timbral modulation where the pulse-width of a rectangular-shaped wave changes its width

pulse-width – the width of a rectangular-shaped wave crest

Q-value – a measure of how tall and thin the resonance graph is. High Q-value means tall and narrow width; low Q-value means short and wide.

quality factor – see Q-value

Rachmaninoff, Sergei – Russian composer who had a nervous breakdown after a poor performance of his first symphony. He was cured by the Moscow physician Dr. Dahl who kept telling Rachmaninoff positive things over and over again daily for more than three months. Rachmaninoff then wrote his Second Piano Concerto and dedicated it to Dr. Dahl.

radio – a device that receives electromagnetic waves and extracts the sound information for us to hear. It at least contains a tuner and a demodulator. It may also include an amplifier and speaker so that it is a self-contained unit with no need for an external amplifier and speaker.

Rainey, Ma - early jazz singer known as the "mother of the blues"

ramp wave – a wave with a ramp waveform. The Fourier amplitudes are 1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9, etc. for the Fourier components H1, H2, H3, H4, H5, H6, H7, H8, H9, etc.

Ravel, Maurice – French impressionistic composer

RC circuit – a circuit consisting of a resistor and capacitor, characteristic of filter circuits. R = resistor, C = capacitor

receiver – a console sound component that contains a radio and amplifier as well as inputs to the amplifier for a record player, tape deck, or CD. You may be able to connect all three at the same time but you will still need to buy a speaker system in order to hear anything.

record player – device that converts the mechanical vibrations of the stylus (as it rides over the hills and valleys of a vinyl record) into electrical signals via Faraday’s law

reflection – the bouncing of a wave off a surface

rarefaction – a stretching of the medium in a longitudinal wave, analogous to a trough of a transverse wave

red noise – low-frequency noise

refraction – a change in direction of a wave due to a change in the wave properties of the medium

Reissner membrane – protective membrane above the tectorial membrane in the cochlea

release – the time it takes for the sound to go from its sustain level to zero after the key is released

resistor – circuit element that limits the flow of electricity

resonance – the phenomenon occurring when a driven oscillatory system gives the greatest amplitude of response. The frequency at which this occurs is called the resonance frequency.

resonance circuit – the LRC circuit, the electrical analogy of the mechanical resonance system. L = inductor (coil), R = resistor, C = capacitor

resonance curve – the plot or graph of the amplitude response (vertical axis) versus the frequency (horizontal axis)

resonance filter – bandpass filter with a transmission graph that resembles the resonance curve

resonance frequency – the frequency that results in the greatest response of a driven oscillating system

reverb – echo. Also, a synthesizer module (REV) that adds reverb to the sound.

reverberation time (RT) – the time it takes for the sound level to drop 60 dB

ring modulator – same as balanced modulator, so called because the basic circuit design in the first models resembled a ring

Romantic Period in Music - roughly the time spanning 1800 - 1900. This period reacts against the simplicity and order of the classic period that preceded it. Romantic music can be excessive in nature, exaggerated, and over the top.

round window – the end of the sound path in the inner ear and located below the oval window

Saint-Saëns – romantic composer, use of many harmonics in his Third Symphony that includes an organ, composer of *Danse Macabre* (*The Skeleton Dance*) with its dramatic use of the tritone

sample and hold – phrase used to describe the fact the voltage in the control-voltage sent out by the keyboard in a synthesizer retains its value even after the key is released

sampling rate – see digital sampling rate

saw tooth wave – a ramp wave

scala tympani - lower chamber in the unwound cochlea through which sound passes after being detected by vibrating a section of the basilar membrane

scala vestibuli – upper chamber in the unwound cochlea through which sound first enters before being detected by the basilar membrane

Schumann, Clara Wieck - super talented daughter of piano teacher Friedrich Wieck who was groomed by her father to be one of the best pianists in Europe. Also, romantic composer and wife of Robert Schumann, who also studied piano with her dad.

Schumann, Robert - romantic composer known for his bipolar nature producing many works during his manic phases and attempting suicide twice during depression stages. He died in an insane asylum, believed to be the result of contracting syphilis in his youth. He married his former piano teacher's daughter Clara.

scope – abbreviated form for oscilloscope, often used by personnel in physics and electronics labs

second – the musical interval from Do to Re, e.g., the beginning of the song “Doe a Deer, a Female Deer, …,” which is also an interval of 2 half steps (1 whole step). In the Just Diatonic Scale with perfect ratios, the interval of a second is 9:8.

semitone – a half step

seventh – the musical interval from Do to Ti, which was prominently used by John Williams in the theme to the movie *Superman* in 1978, which is also an interval of 11 half steps.). In the Just Diatonic Scale with perfect ratios, the interval of a seventh is 15:8.

sidebands – the inharmonic frequency components on either side of the center in a spectrum due to balanced modulation

simple harmonic motion – natural motion with smooth crests and troughs described by a sine wave such as that made by a mass attached to a spring. The same as harmonic motion.

sine wave – the motion made by a mass attached to a spring, the simplest and most natural waveform. The Fourier amplitudes are 1, 0, 0, 0, 0, 0, 0, 0, 0, etc. for the Fourier components H1, H2, H3, H4, H5, H6, H7, H8, H9, and so on. In other words, you just have one Fourier component – the fundamental H1.

sixth – the musical interval from Do to La, e.g., the beginning of the song “My Bonnie Lies Over the Ocean,” which is also an interval of 9 half steps. In the Just Diatonic Scale with perfect ratios, the interval of a sixth is 5:3.

skating force – the force on a bent record player arm that tends to pull the arm towards the center of the record as the record is played. This is counteracted with the antiskating outward force due to a little spring attached to the arm.

shock wave – a wave with a large “V” (in two dimensions) or “cone structure” (in three dimensions) that is created when an object travels faster than the wave speed in the medium. An example is a speeding motor boat making a V-formation in the water.

Smith, Bessie - early jazz singer known as the "Empress of the Blues"

SONAR – SOund Navigation And Ranging. One can determine the depth of water by noting the time it takes a sound wave to leave the boat to reach the bottom and reflect back to the boat. You need to use the speed of sound in water, which is 1500 m/s.

sonata - "classic" form in music consisting of exposition, development, and recapitulation. In the exposition there is the primary theme followed by a contrasting secondary theme.

sonic boom – an acoustic shock wave

source – term used for source of sound or source of electrical signal

speaker – device that converts electrical oscillations into the mechanical vibrations of a diaphragm via Ampère’s law

spectrogram – a plot of frequencies on the vertical axis against time on the horizontal where louder sounds appear with thicker lines. If you view a spectrogram on a computer, it is possible that louder sounds are represented with brighter lines and/or different colors.

Spivey, Victoria - early jazz singer and known for singing "Black Snake Blues"

square wave – a wave with a square crest and upside-down square trough waveform. The Fourier amplitudes are 1, 0, 1/3, 0, 1/5, 0, 1/7, 0, 1/9, etc. for the Fourier components H1, H2, H3, H4, H5, H6, H7, H8, H9, and so on.

staccato – sound with an abrupt attack and abrupt release

standing wave – any single harmonic vibration on a string or in a pipe so called because the “dancing pattern” has “kind of a stationary characteristic” with its stationary displacement nodes and moving displacement antinodes in between each pair of displacement nodes

static electricity – excess charge on an object which can then attach itself to another object, e.g., rubbing a balloon on your arm will enable a balloon to stick to a wall due to static electricity

stirrup – the third bone in the middle ear, the bone that connects to the oval window

Stravinsky, Igor – Russian born modern composer with innovative rhythm and use of clashing harmonics (1/2 step apart) in his *Rite of Spring* (1913)

string – used as an ideal model for string physics. A string of length L is fixed on each end. The natural modes of the transverse vibrations are called harmonics and they have frequencies f_1, $2f_1$, $3f_1$, etc., where f_1 is the frequency of the first harmonic (fundamental). The corresponding wavelengths are λ_1 = 2L, 2L/2, 2L/3, and so on. For each frequency f and its associated

wavelength λ the wave relation is always true: $v = \lambda f$, where v is the speed of waves on the string.

strings – instruments in the string family where vibrating strings are used to make sounds: violin, viola, cello, and bass. In the typical orchestra you might find a group of 10 violins categorized as the first violins, another 10 violins categorized as the second violins, about 8 violas, 10 cellos, and 6 basses.

stylus – a needle (best being diamond) that rides over the hills and valleys of a vinyl record

sum displacement – addition of the displacements for two waves or more, remembering that positive heights are above the "sea level" reference line and negative heights are below. You need to combine the displacements including the relevant plus or minus signs during your addition.

supersonic – faster than the speed of sound, i.e., greater than Mach 1

sustain – the level for the sound as the user keeps a finger on the key

synthesizer – electronic device producing sound where one of the inventors was Robert Moog (1934-2005). Moog was a resident of Asheville for roughly his last 25 years of his life and former Artist in Residence at UNC Asheville. He was also a former adjunct professor in our Department of Physics.

tape recorder – a device that converts a signal stored on a magnetic tape into electrical signals via the Faraday principle. The signal is stored on the tape by different orientations of "baby magnets" (magnetic dipoles) during the length of the tape. When a recording is made, Ampère's principle is used to convert electrical signals to magnetic storage by aligning "baby magnets" on the magnetic tape as the tape is pulled across the recording head.

tape speed – the speed of tape in a tape recorder. Cassette tape speed is 1 and 7/8 inches per second, which we often approximate as 2 inches per second. The standard speeds in reel-to-reel tape recorders are double and quadruple that for the cassette. These standard speeds are 3 and 3/4 inches per second and 7 and 1/2 inches per second. There are even faster tape speeds such as 15 inches per second. The faster tape speeds allow for better sound quality.

Taps – a theme that is composed using only the harmonics H3, H4, H5, and H6

Tatum, Art – Black American Jazz Pianist legally blind since childhood due to early cataract complications. Supreme technique at the piano in a flamboyant "romantic" style. A Franz Liszt of Jazz Piano.

Tchaikovsky, Peter – romantic Russian composer known for his long melodic lines, long dramatic endings, e.g., use of the rapidly alternating 1-chord and 5-chord at the end of a work. Disastrous marriage, no consummation, because he was gay. Use of inharmonic sounds with bells and cannons in his *1812 Overture*.

tectorial membrane – membrane just above organ of Corti that interacts with hair cells on the organ of Corti as sound is detected by the cochlea

temperament – a prescription for tuning, e.g., in equal temperament, one adjusts the frequency ratios from one note to the next so that each ratio is a constant 1.059…, the twelfth root of 2

theremin – early electronic device invented by Leon Theremin where an eerie pitch is produced depending on where your right hand is relative to a vertical metal rod. The closer to the rod, the higher the pitch. The left hand controls the loudness – when near a metal ring with your left hand, the sound level diminishes.

Theremin, Leon – inventor of the Theremin

third – the musical interval from Do to Mi, e.g., the beginning of the "Marine's Hymn," which is also an interval of 4 half steps (2 whole steps).). In the Just Diatonic Scale with perfect ratios, the interval of a third is 5:4.

timbre (or timber) – the perception of the waveform of a wave, which allows us to distinguish one instrument from another such as a flute from an oboe

timbral modulation (TM) – the change of the timbre of a wave

tinnitus – internal perception of sound as a ringing or buzzing when there is no sound present, occurring at places on the frequency spectrum where there is an actual hearing loss

tracking force – the force of that the stylus exerts on a vinyl record, the typical value being the weight of one gram of mass

trachea – the space in the vocal track lying below the vocal folds

transistor – circuit element that can act as a switch and amplifier. It has two input wires and one output wire. One input (B = Base) accepts a tiny amount of current and this activates the transistor so that lots can flow from the other input (C = Collector) and out the common output (E = Emitter).

transmission – the passing of an electrical signal through a filter or other circuit element

transposing – the act of changing the key of a song or scale from one starting frequency (Do) to a new starting frequency. All relative relationships in the song or scale are kept so that the song or scale is recognizably the same but higher or lower in pitch.

transverse wave – a wave where the wave disturbance moves sideways (perpendicular) to the direction of propagation of the wave

treble control – amplifier control for a high-pass filter so that you can adjust the strength of the higher frequencies

tremolo – the musical term for an amplitude modulation, i.e., periodic changes in loudness levels alternating between louder and softer levels

triad – musical term for three tones played simultaneously as a harmony, i.e., a chord

triangle wave – a wave with a triangle crest and upside-down triangle trough waveform. The Fourier amplitudes are 1, 0, 1/9, 0, 1/25, 0, 1/49, 0, 1/81, etc. for the Fourier components H1, H2, H3, H4, H5, H6, H7, H8, H9, and so on.

trigger voltage – voltage control sent from keyboard (KBD) to the envelope generator (ADSR) to initiate the ADSR sequence

tritone – an interval corresponding to three whole steps

trough – the part of a wave below the "sea level" reference line of the wave. The "sea level" line is the horizontal equilibrium line drawn through the middle of the wave.

trombone – the brass instrument without values that extends in order to produce different notes and having a musical range a little smaller than that of the French horn

trumpet – the brass instrument with three valves and the highest musical range in the brass family

tuba – the brass instrument with three valves that has the lowest musical range in the brass family

tuner – a resonance electrical circuit that can tune in to pick up a radio signal. You tune in by changing either the capacitor value or inductor value (for the coil) in the circuit.

twelfth root of 2 – the number "a" such that when taken as a factor 12 times and multiplied, you obtain 2, i.e., a x a x a x a x a x a x a x a x a x a x a = 12. The value for a = 1.05946309…, which in class we take to be 1.06.

tweeter – speaker with a small light membrane to support the rapid motion of high frequencies, i.e., waves with short wavelengths

twelve-tone scale – the scale with twelve tones, each one half-step from each other

two-way speaker system – see two-way crossover network

two-way crossover network – a circuit that accepts an input signal and directs the low frequencies to the woofer and the high frequencies to the tweeter

"Twirl-a-Tune" – a corrugated plastic toy often going by various names which produces harmonics when twirled, beginning with the 2^{nd} harmonic (H2) and reaching higher harmonics as it is twirled faster and faster

tympani – a set of typically three kettledrums, one usually tuned to the 1 (first degree of the key of the piece being played), another to the 5, and the third to the 4 or whatever the composer calls for

ultrasound – sound with a frequency above the range of human hearing, i.e., above 20,000 Hz. Also, the image of a fetus made by ultrasound.

unison – the name given when two identical pitches are played together. Their ratio is 1:1. An example is going from Do to Do, the same note.

unit – in physics, this designates the word that goes with the number when you make a measurement, e.g., for a weight of 120 pounds (120 lb), the value is 120 and the unit is lb

upper sideband – the inharmonic frequency components on the right side of center in a spectrum due to balanced modulation

vacuum tube – a tube with air pumped out and electrical properties that serves as a component in a circuit. Two common vacuum tubes are the tube version of the diode and the tube version of the transistor.

VCA – see voltage-controlled amplifier

VCF – see voltage-controlled filter

VCO – see voltage-controlled oscillator

velocity – technically the speed you are going AND the direction you are going; however, often just used to represent your speed without a concern for the direction

vibrato – the musical term for a gentle frequency modulation where the frequency changes do not vary too far from the original pitch. The result is a quivering pitch characteristic of singers.

viola – the instrument in the orchestral string family that has a lower musical range compared to the violin but a higher one compared to the cello

violin – the instrument in the orchestral string family that has the highest musical pitches compared to the others such as the violas or cellos

vocal cords – see vocal folds

vocal folds – the vibrating biological component producing sound in the human vocal system, also referred to as vocal cords. The vocal-folds end is approximated as a closed pipe end.

vocal formants – formants in the sound spectrogram produced by the uniqueness of one's vocal system that includes the resonance cavities of the mouth and nose. The simple closed-pipe model of the vocal tract for a male adult gives a closed-pipe length of 15 cm and a fundamental of roughly 500 Hz. This is the first formant region or first formant, also called the first principal formant region or first principal formant. The second formant region corresponds to the next harmonic in a closed pipe, the third harmonic (1500 Hz). The third formant region is the fifth harmonic (2500 Hz) and so on.

volt – the unit for voltage; volt is abbreviated as V

voltage – the effective strength of a battery's ability to produce current

voltage-controlled oscillator (VCO) – synthesizer module that accepts a voltage that then determines the frequency of the electrical wave that is produced. A VCO can typically be set to

produce a few different basic waveforms such as sine, triangle, square, ramp, and pulse train waves.

voltage-controlled amplifier (VCA) – synthesizer module where the amplitude of the audio signal entering the amplifier is changed according to the value of the control voltage applied to the amplifier

voltage-controlled filter (VCF) – synthesizer module where the timbre is altered as the audio signal entering the VCF is passed through a filter with the cutoff or central frequency determined by the VCF control voltage. The filter type (LP, BP, HF) is set by a switch on the filter.

warmth – term in acoustics when reverb is present for low frequencies but not much is there for high frequencies

wave – a traveling disturbance

waveform – the shape of one pattern of a periodic wave

watt – the unit for wattage

watt hour – see kilowatt hour

wattage – the power, given by the product of the current and voltage (P = IV)

Watts, André – outstanding black pianist from Philadelphia discovered by Leonard Bernstein

wavelength – the distance corresponding to one pattern of a periodic wave

whispering chamber – an elliptically-shaped room where sound from one of two special points (each called a focus) gets reflected by the chamber walls so that the reflected wave heads towards the other special point (the second focus)

white noise – fairly equal presence of all frequencies from 100 to 10,000 Hz. White noise is named after an analogy with white light since white light consists of all frequencies of colors.

whole step – two half steps

whole tone scale – the six-note scale where each note is a whole tone step away from its two closest neighboring notes

Williams, John - composer of music for film. In *Superman* he employs the dissonant 7th interval in an effective way.

wire – electrical component made of metal such as copper that allows for the passage of electricity. The resistance of a wire in a circuit can be assumed to be zero, i.e., R = 0 ohms. This assumption breaks down if the wire gets to be extremely longer and longer. Wires in a circuit are typically very short.

woofer – speaker with larger membrane to support the slower motion of low frequencies, i.e., waves with long wavelengths

woodwinds – originally made of wood, instruments where the performer blows air against an edge or reed to excite the pipe into resonance. The basic woodwind types in the orchestra are the flute, oboe, clarinet, and bassoon. There are two of each in the standard orchestra.

XNOR – the NOT of XOR

XOR – the Exclusive OR. For A and B as input, you get a 1 if either A or B is 1 but not both.