Science Of Music Study Guide

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Contents

1 Musical Definitions

Please refer to the file on Canvas for the full list of definitions. Below are the definitions the professor highlighted in class.

1.0.1 Acoustical Beating

The audible vibration created when two or more frequencies, that are not quite in a simple whole number relationship to each other, are sounded together. For example if 100 and 102 Hz are played together you can hear the 2 vibrations per second difference.

1.0.2 Audiation

"The mind's ear", or the ability to hear previously heard sounds in one's mind.

1.0.3 Chord

Three or more different pitches occuring simultaneously.

1.0.4 Consonance and Dissonance

The concept of relatively pleasing sound, due to combinations of particular harmonies, melodic progressions, and/or rhythms. What is consonant or dissonant depends on what is culturally the norm.

1.0.5 Dynamics

Level(s) of loudness or softness in a piece of music. Italian terms such as forte and piano are used. Adding an "issimo" is a suffix that means even more of that quality and adding "mezzo" means not so much of this. Pianissimo versus mezzo piano.

1.0.6 Harmony

Two or more different pitches occuring simultaneously, usually creating a sense of consonance or dissonance.

1.0.7 Instrumentation

The set of instrumental components (e.g. a quintet of flute, clarinet, oboe, bassoon, and horn) in an ensemble, piece of music, or at a particular point in a piece.

1.0.8 Melody

The succession of notes (usually pitched) forming a recognizable pattern, a.k.a. the "tune", "ditty", or "theme". In Jazz it is called the "head".

1.0.9 Motive

A recognizable, prominent melodic or rhyhmic fragment, somewhere between 2 and 7 notes in length, that is used as a basis of development and adapted throughout a piece.

1.0.10 Music

Sound(s) which cause, or have as their purpose, an emotional experience and/or temporal aesthetic reaction in the minds and/or behaviors of one or more listeners. These sounds are ususally organized with respect to time, and incorporate accepted principles of construction.

1.0.11 Note

One melodic or rhyhmic event; also, it's written representation.

1.0.12 Octave

Distance between two pitches whose frequencies are in a 2:1 Hertz relationship.

1.0.13 Pitch

An audible uniform frequency, of sufficient duration, that produces a psychomusical sensation. The Western pitch system contains 12 different pitches A through G, with repetitions at the octave.

1.0.14 Range

The full extent of pitches, from highest to lowest tones, that an instrument, voice, or composition has.

1.0.15 Rhyhm

A series of musical sounds in some combination of short and long durations. Often notated using note values such as whole notes, half notes, quarter notes, eighth notes, etc.

1.0.16 Scale

Divisions of the naturally occuring octave into x number of steps. The ordered collection of pitches or frequencies that result when a given mode is played with respect to a given key center. There are hundreds to thousands of scale types.

1.0.17 Timbre

The particular sound signature of an instrument or voice.

1.0.18 Triad

A chord consisting of three pitches in a root-third-fifth relationship.

2 What are waves

A wave is a motion in space that involves a rising and falling action. There are electromagnetic waves, pressure waves, on others. In the case of sound we look at pressure waves. Below is an illustration of what the parts of a wave are. Remember when looking at graphs of waves the x axis and y axis are parts of a graph and they have value! The y axis in our case is usually pressure or displacement (velocity).

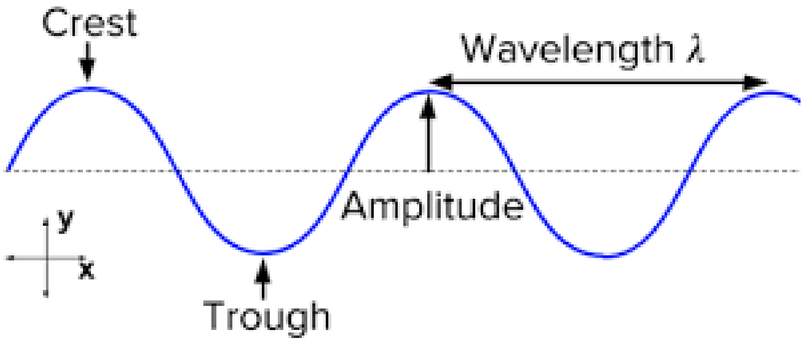


Figure 1: Parts of a transverse wave.

2.1 Simple Harmonic Motion

The movement of a mass on a spring.

2.2 Amplitude and Frequency

The **amplitude** of a wave is how high and low the crest and troughs of the waves go. A sound wave with a higher amplitude would sound louder, and a lower amplitude would sound quieter. (Sound Pressure Level) The **frequency** of a wave is how many times in a second the wave goes from crest to crest. For example A=440Hz would have 440 crests in pressure/displacement occur every second. Higher frequencies have a higher pitch and lower frequencies have a lower pitch.

2.2.1 Overtones, Partials, Harmonics

Any note being played has overtones associated with it. The fundamental or first harmonic has a first overton or second harmonic that is 2 times the frequency and an octave higher. Any harmonic associated with a fundamental is an integer multiplier of the frequency. For example the fith harmonic would be at a frequency that is 5 times the fundamental.

2.3 Standing Waves

The wave appears to only be moving up and down, but the components of the wave are actually moving side to side as well.

2.4 Resonance

Recall the Tacoma narrows bridge. Everything has a natural frequency with which it wants to vibrate. Resonance would be matching that frequency, for example pushing a child on a swing with the right timing.

2.4.1 Mechanical Coupling

Mechanical coupling is resonance that couples one object to another, which the professor illustrated with his music box and a desk.

3 Variables to Know

$Variable$	$Abbreviation$	$Units$	$UnitsAbrv$	$Misc$
$Frequncy$	f	$Hertz$	Hz	$\frac{1}{sec}$
$SpeedOfSound$	$C(V_{air})$	$Meters/Second$	m/s	$344m/s$
$Wavelength$	λ	$Meters$	m	
$Length$	L	$Meters$	m	

4 Equations to Know

Wavelength:

$$\lambda = \frac{C}{f}$$

Drt equation:

$$d = rt$$

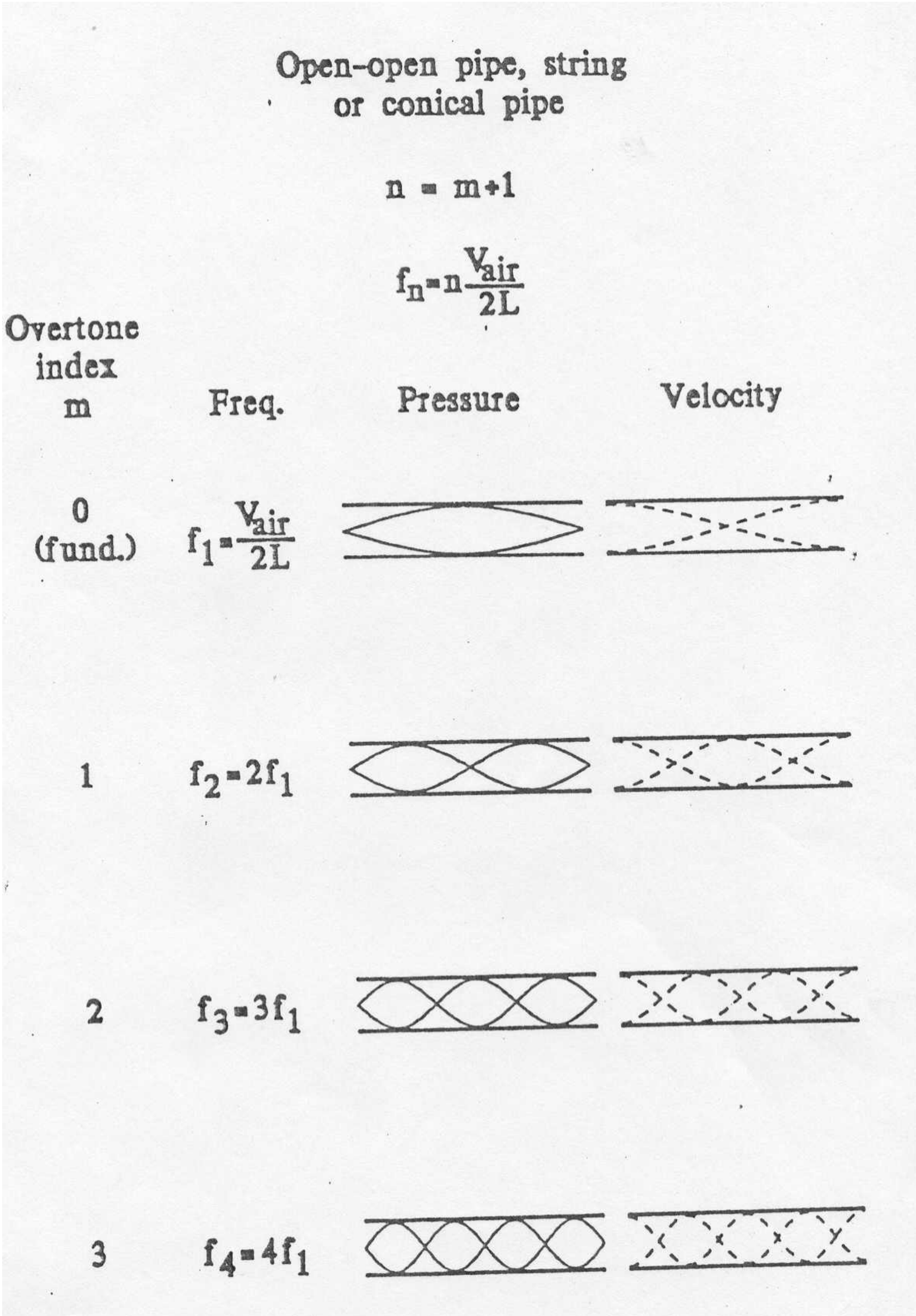
This is common equation where distance is equal to rate times time.

Area of a circle follows the equation $A = \pi * r^2$.

Open-Open Pipe fundamental:

$$f_1 = \frac{C}{2L}$$

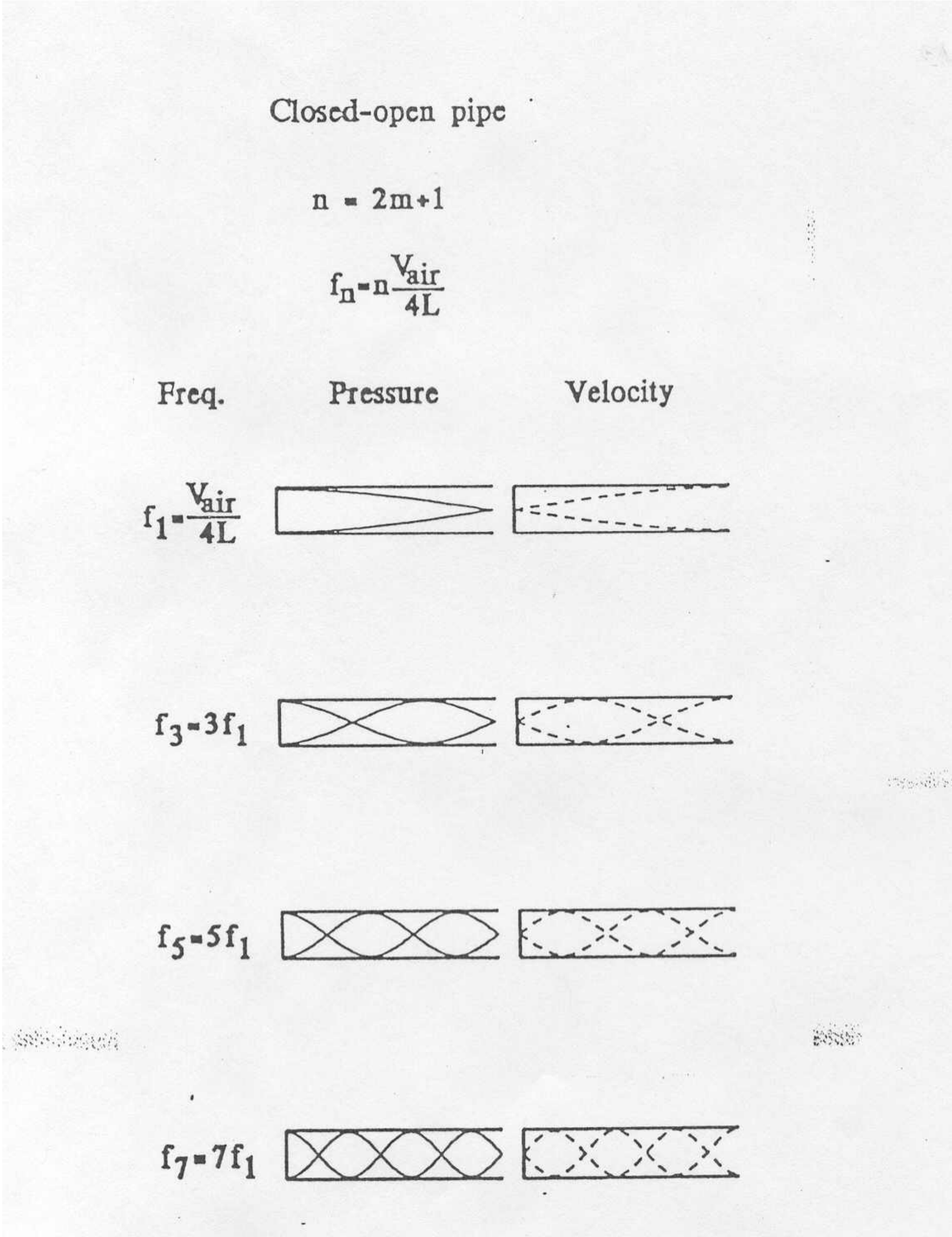
The open-open pipe is also called a half wave resonator, strings also follow the half wave resonation pattern. The overtones follow increasing consecutive integer harmonic multiples. Below is an illustration of the half wave resonator sound waves.



Open-Close Pipe fundamental:

$$f_1 = \frac{C}{4L}$$

The open-closed pipe is also called a quarter wave resonator. The overtones follow an increasing consecutive odd integer harmonic multiples. Below is an illustration of the quarter wave resonator sound wave.



4.1 End Correction

Remember you need to multiply the radius value by 2 if it is the acoustical length for an open-open pipe. The following equation is for a closed-open pipe.

$$L_A = L_P + 0.61 * r$$

- L_A is the acoustical length
- L_P is the physical length
- r is the radius of the tube/pipe

5 Sound Intensity Level

Loudness ia a subjective perception; whereas the sound intensity level is measure of power over a given area due to the pressure waves. For example you need to add eight more players to make something "sound" twice as loud (from one base player). Sound intensity level, since it would be measured as power over an area, is measured in watts per meter squared, however we transform this into a logarithmic scale using decibel units due to the large range of hearing in the ear.

5.1 Logarithms

Logarithms are the inverse of exponents. Below are some logarithmic properties to recall what logarithms are:

$$log_b a = x; b^x = a$$

$$log(x * y) = log(x) + log(y)$$

$$log(x/y) = log(x) - log(y)$$

$$log(x^a) = a * log(x)$$

5.2 Decibels

Our basis of 0 dB starts at $1 * 10^{-12} \frac{W}{m^2}$. 100 dB would be $1 * 10^{-2} \frac{W}{m^2}$. This makes every change in 10 dB equal to multiplying our sound level by 10, so a change in 1000, would be a change in 30 dB.

5.2.1 Rules of thumb

1. Doubling the sound intensity level requires adding 3 decibels (doubling in volume).
2. Doubling the distance from a sound source, you subtract 6 decibels (quartering the volume).

5.3 Hearing Limits

The standard ear drum has a SIL range between 0 dB and 120 dB (starts to damage). You can see the power over area of these units by using the calculation methods stated above.

6 The Amazing Ear

6.1 Outer Ear

6.2 Middle Ear

6.2.1 Malleus: Hammer

6.2.2 Incus: Anvil

6.2.3 Stapes: Stirrup

6.3 Inner Ear

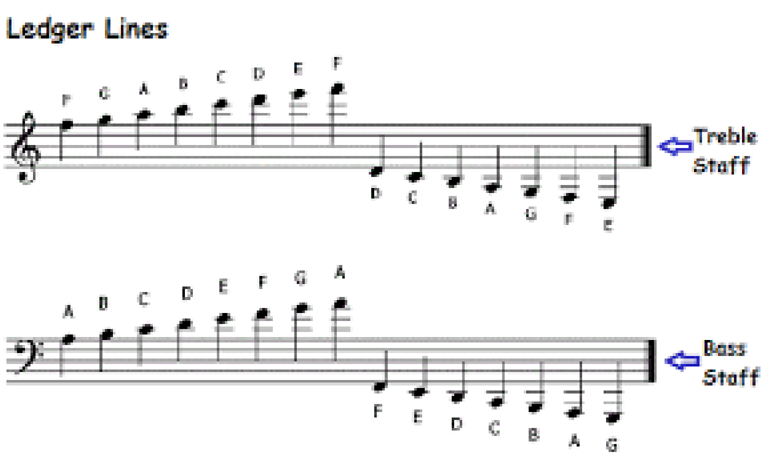
7 Pitch and Pitch Names

A pitch as defined above is an audible uniform frequency, of sufficient duration, that produces a psychomusical sensation. The Western pitch system contains 12 different pitches A through G, with repetitions at the octave. If you wish to reference the pitch names you can look a tthe staff below. Recall there is no B sharp/C flat and there is no E sharp/F flat.

7.1 Pitch versus Frequency

Pitches are subjective, while frequencies are objective. You could assign middle C to any value of frequency. For example in the A=440 tuning system middle C is 261 Hz, but in physics lab middle C is often 256 Hz.

7.2 Musical Staff



8 Misc

8.1 Timbre

Timbre is the soudn signature of a particular instrument or voice. This is directly correlated to the instruments power spectrum. The power spectrum illustrates the relative power of overtones when a fundamental is played.

8.2 ADSR

1. Attack Time
2. Decay Time
3. Sustain Level
4. Release Time

8.3 Combination Tones

When two pitches are played you can often hear the difference tone or summation tone from the combination of the two. For example if 400 Hz and 500 Hz are both played, the 100 Hz ptich and 900 Hz pitches are also audible to the human ear.

8.4 Psychoacoustics

8.4.1 Octave Equivalence

Playing a seuqence of pitches in varying octave has the same recognizable sequence of notes played in the same octave. Dr. Latten illustrated this by playing happy birthday through various octaves.

8.4.2 Fundamental Tracking

The brain supplies or tracks the missing fundamental that is produced through combination tones.

8.4.3 Masking

Two sounds that are close to each other might have one mask the other sound. Our perception would only hear the louder of two similar sounds. There are some types of masking: temporal masking and backward masking. The sensitivity range of the frequency will also determine which sound is masked out.

8.4.4 Tonal Fusion

Two different instruments are playing together, but it sounds like there is only one instrument playing.