Topic 5

Pitch, Tuning, Basics of scales
Pitch (ANSI 1994 Definition)

• That attribute of auditory sensation in terms of which sounds may be ordered on a scale extending from low to high. Pitch depends mainly on the frequency content of the sound stimulus, but also depends on the sound pressure and waveform of the stimulus.
Pitch (Operational)

• A sound has a certain pitch if it can be reliably matched to a sine tone of a given frequency at 40 db SPL
Equal Temperament

• Octave is a relationship by power of 2.
• There are 12 half-steps in an octave

\[ f = 2^{\frac{12}{n}} f_{\text{ref}} \]

- \( n \): number of half-steps from the reference pitch
- \( f \): frequency of desired pitch
- \( f_{\text{ref}} \): frequency of the reference pitch
Measurements

- 100 Cents in a half step
- 2 half steps in a whole step
- 12 half steps in an octave

\[ c = 1200 \log_2 \left( \frac{f}{f_{ref}} \right) \]
A=440 Equal tempered tuning
Overtone Series

• Approximate notated pitch for the harmonics (overtones) of a frequency
Musical Interval Names (from C)
Interval Names

- minor 2nd (half step)
- major 2nd (whole step)
- minor 3rd
- major 3rd
- perfect 4th
- tritone (augmented 4th, diminished 5th)
- perfect 5th
- minor 6th (augmented 5th)
- major 6th
- minor 7th (augmented 6th)
- major 7th
- octave
Triads

C major triad

C minor triad

C diminished triad

C augmented triad
Chords in the Major Scale

Scale-tone 7th chords of the C major scale

\[
\begin{align*}
C_\Delta & \quad Dm7 & \quad Em7 & \quad F_\Delta & \quad G7 & \quad Am7 & \quad B_\# \\
I_\Delta & \quad IIm7 & \quad IIIIm7 & \quad IV_\Delta & \quad V7 & \quad VIIIm7 & \quad VII_\# \\
\end{align*}
\]
Inverting Triads

root position  first inversion  second inversion

root  third  fifth

root position  first inversion  second inversion

root  third  fifth
Circle of Fifths
Pythagorean Tuning

• The 3\textsuperscript{rd} harmonic has a frequency 3 times that of the fundamental frequency.
• The name for the interval between the fundamental and the 3\textsuperscript{rd} harmonic is an “octave + a perfect fifth”.
• To make a perfect 5\textsuperscript{th}, you can divide the frequency of the 3\textsuperscript{rd} harmonic by 2. This drops it an octave.
• Therefore, one definition of the perfect 5\textsuperscript{th} is defined as the ratio 3:2.
• Pythagorean tuning builds a scale by using the circle of 5ths and this ratio of 3:2
Pythagorean Tuning

- Intervals are based on the ratio 3:2 (the perfect fifth)
- Start with a frequency. This is the starting point of the scale.
- Get the 5th of the scale by multiplying that frequency by \( \frac{3}{2} \) (aka 1.5)
- Now, go around the circle of 5ths, building each consecutive frequency based on the one before it.
- This can give a diatonic scale, once you adjust for the really high octaves that result from repeatedly multiplying your frequency by 1.5
Pythagorean Tuning Example

Assume Middle C = 261 Hz. Find the frequencies in the C major scale using Pythagorean tuning. This scale is C, D, E, F, G, A, B, C

<table>
<thead>
<tr>
<th>Pitch class</th>
<th>Initial frequency calculation</th>
<th>Freq in Hz</th>
<th>Divide by this to reach right octave again</th>
<th>Final result in Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>261</td>
<td>261</td>
<td>1</td>
<td>261</td>
</tr>
<tr>
<td>G</td>
<td>1.5^1 * 261</td>
<td>391.5</td>
<td>1</td>
<td>391.5</td>
</tr>
<tr>
<td>D</td>
<td>1.5^2 * 261</td>
<td>587.25</td>
<td>1</td>
<td>293.625</td>
</tr>
<tr>
<td>A</td>
<td>1.5^3 * 261</td>
<td>880.875</td>
<td>2</td>
<td>440.437</td>
</tr>
<tr>
<td>E</td>
<td>1.5^4 * 261</td>
<td>1321.312</td>
<td>4</td>
<td>330.328</td>
</tr>
<tr>
<td>B</td>
<td>1.5^5 * 261</td>
<td>1981.969</td>
<td>4</td>
<td>495.492</td>
</tr>
<tr>
<td>F</td>
<td>1.5^11 * 261</td>
<td>22575.86</td>
<td>64</td>
<td>352.748</td>
</tr>
<tr>
<td>C</td>
<td>1.5^12 * 261</td>
<td>33863.79</td>
<td>64</td>
<td>529.1217</td>
</tr>
</tbody>
</table>
Problem with Pythagorean Tuning

• One octave = 2f

• A perfect 5th = (3/2)f

• What happens if you go around the circle of 5ths to get back to your original pitch class?

• \((3/2)^{12} = 129.75\)

• Nearest octave is \(2^7 = 128\)

• 128 \(\neq\) 129.75
Problem with Equal temperament

- A perfect 5th is 7 half steps. If we define the frequency of a perfect 5th as $\frac{3}{2}$, we can’t reach that by doing $2^{(7/12)}$

$$\frac{7}{2^{12}} = 1.4983 \neq 1.5 = \frac{3}{2}$$
Take away about tuning

• There are many tuning systems
  – Equal Temperament
  – Pythagorean
  – Just
  – Mean tone
  – Etc. and so on.
• Every tuning system has some “quirk” that makes one of the intervals a tiny bit off.
• Equal temperament is the easiest and most popular