

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

number of half-steps
from the reference pitch

$$f = 2^{\frac{n}{12}} f_{ref}$$

frequency of
desired pitch

frequency of the
reference pitch

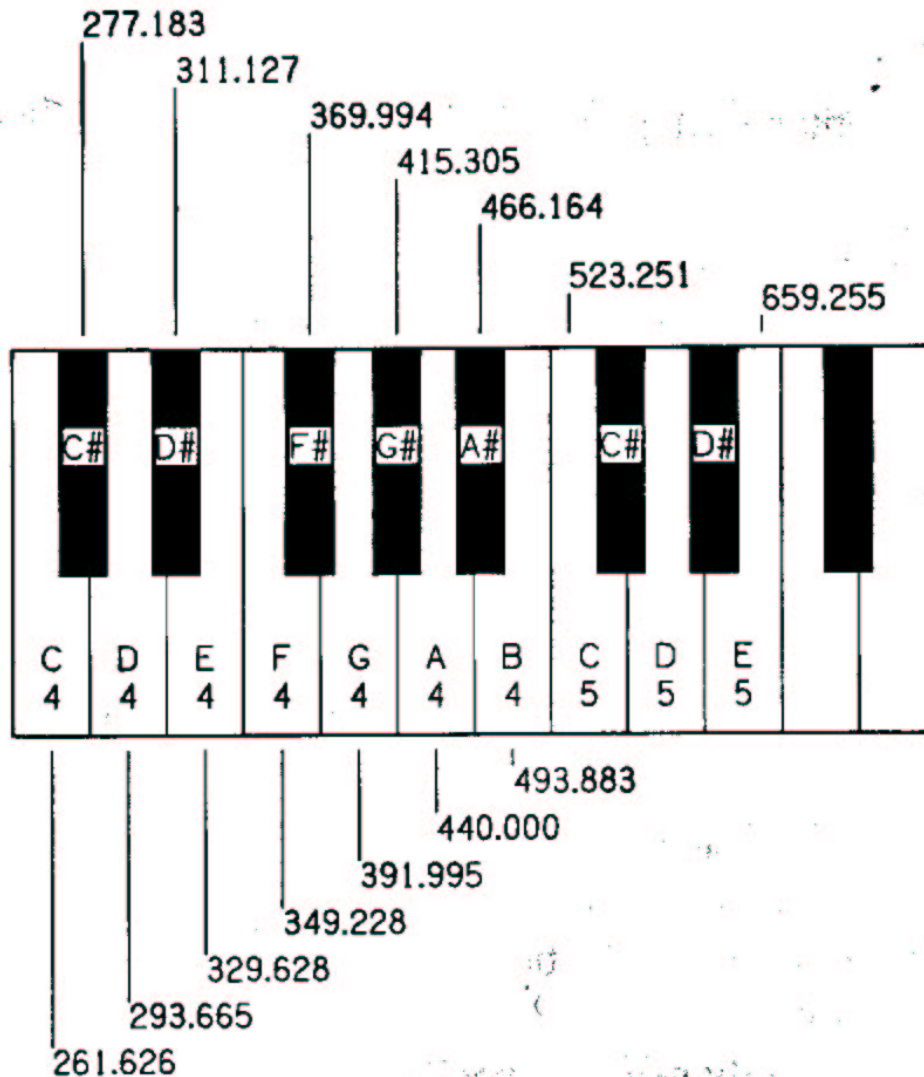
Measurements

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

number of
cents

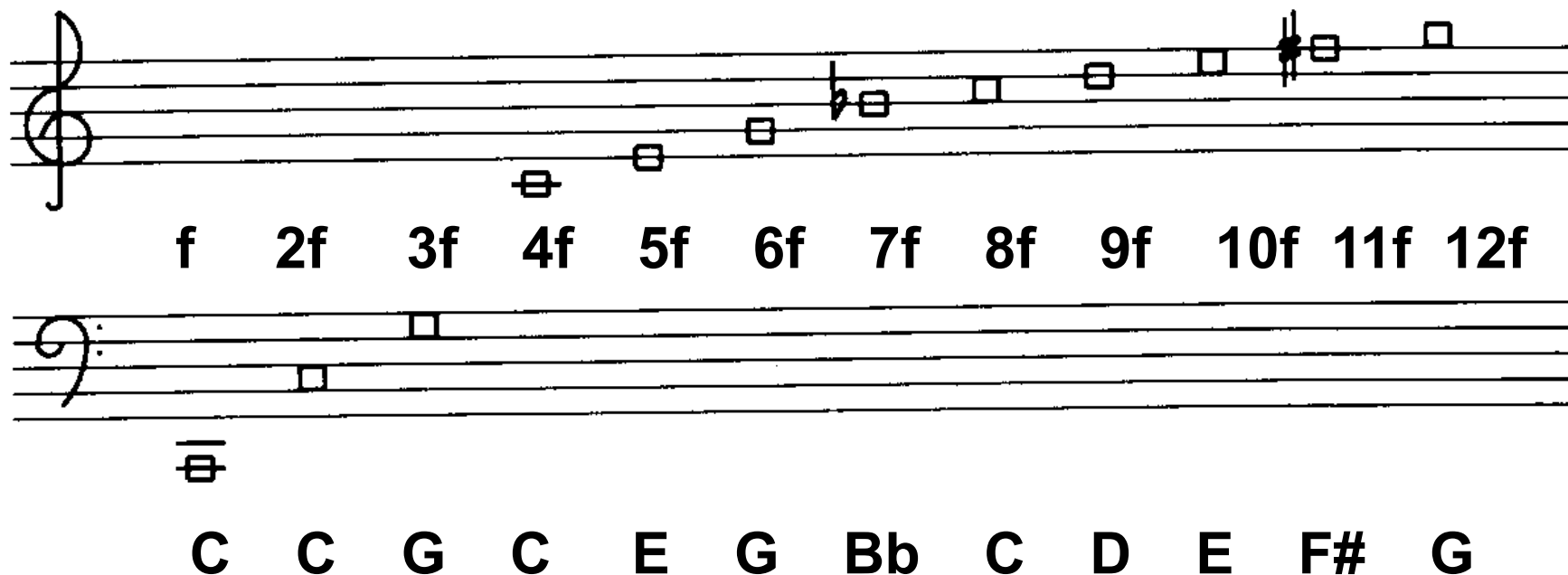
$$c = 1200 \log_2 \left(\frac{f}{f_{ref}} \right)$$

A=440 Equal tempered tuning

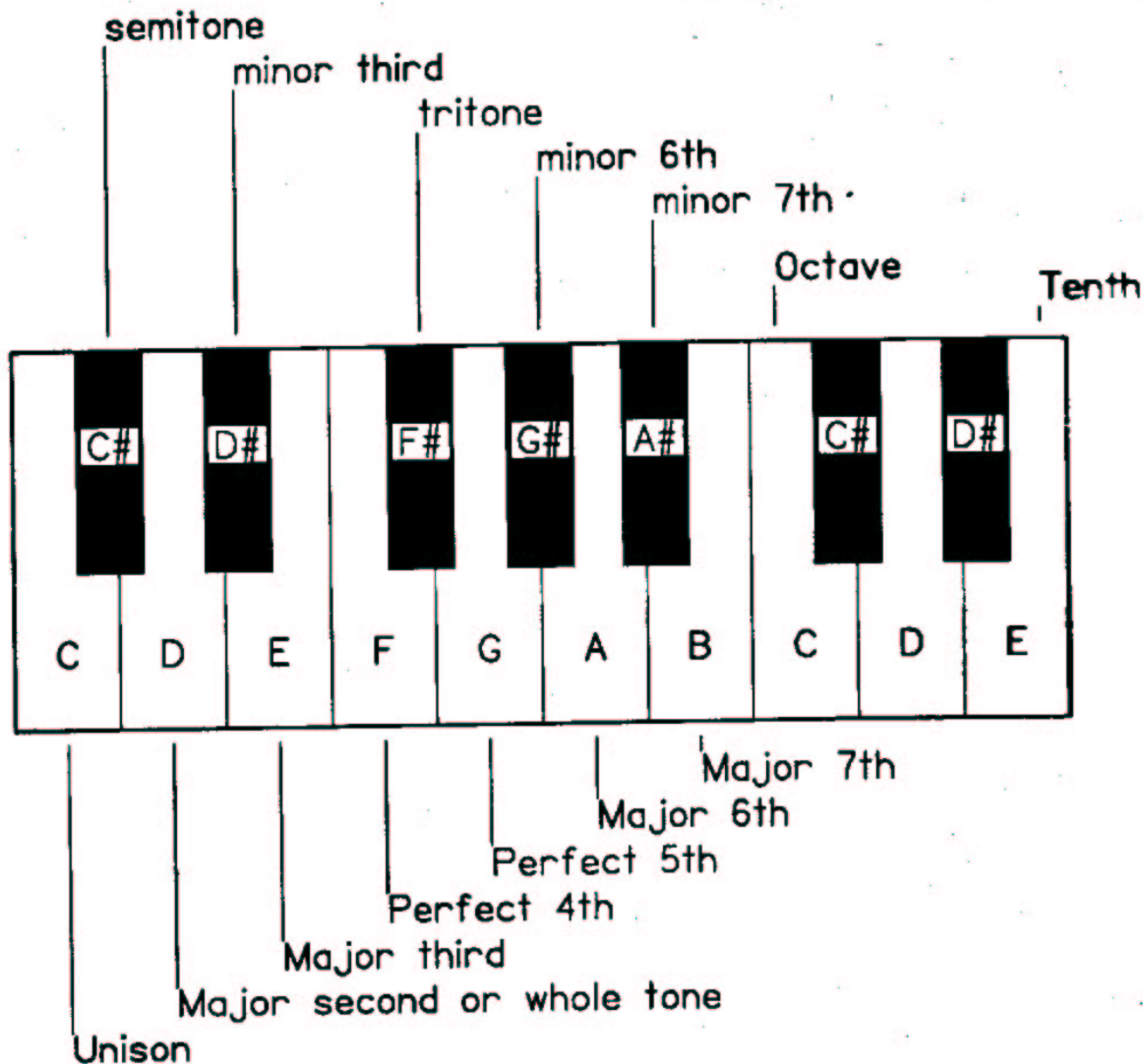


Overtone Series

- Approximate notated pitch for the harmonics (overtones) of a frequency



Musical Interval Names (from C)



Interval Names

The image displays a musical staff divided into four measures, each illustrating a specific interval. The intervals are: minor 2nd (half step), major 2nd (whole step), minor 3rd, and major 3rd. The second row shows perfect 4th, tritone (augmented 4th/diminished 5th), perfect 5th, and minor 6th (augmented 5th). The third row shows major 6th, minor 7th (augmented 6th), major 7th, and octave. Each interval is represented by two notes on a treble clef staff.

Interval Name	Interval Name	Interval Name	Interval Name
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

A musical staff in treble clef showing seven scale-tone 7th chords of the C major scale. The chords are represented by groups of notes on the staff. Below each chord are two labels: the chord name and its Roman numeral with a quality symbol.

Chord Name	Roman Numeral
C Δ	I Δ
Dm7	IIIm7
Em7	IIIIm7
F Δ	IV Δ
G7	V7
Am7	VIIm7
B \emptyset	VII \emptyset



Inverting Triads

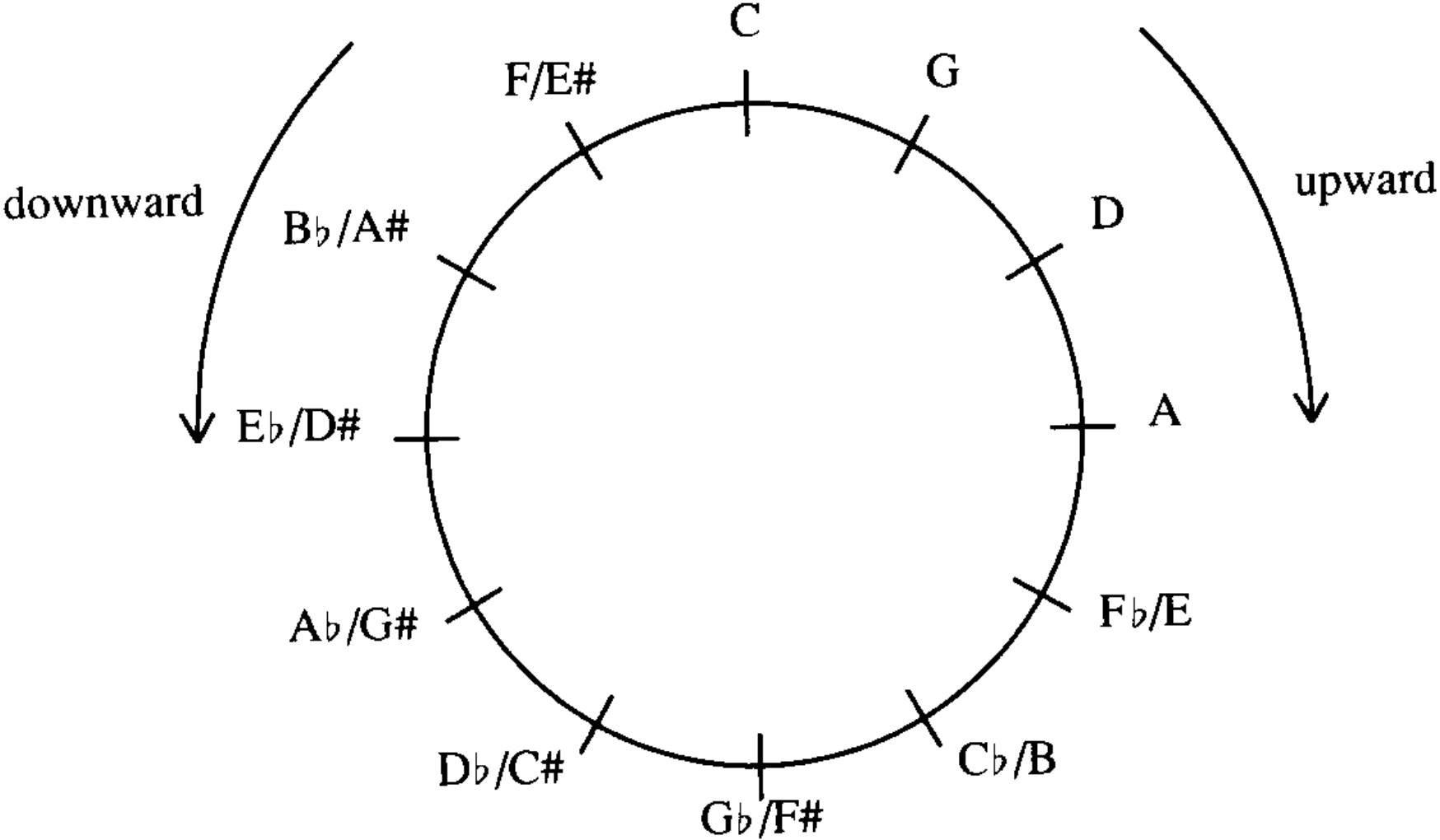
root position first inversion second inversion

root third fifth

root position first inversion second inversion

root third fifth

Circle of Fifths



Pythagorean Tuning

- The 3rd harmonic has a frequency 3 times that of the fundamental frequency.
- The name for the interval between the fundamental and the 3rd harmonic is an “octave + a perfect fifth” .
- To make a perfect 5th, you can divide the frequency of the 3rd harmonic by 2. This drops it an octave.
- Therefore, one definition of the perfect 5th 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

Pitch class	Initial frequency calculation	Freq in Hz	Divide by this to reach right octave again	Final result in Hz
C	261	261	1	261
G	$1.5^1 * 261$	391.5	1	391.5
D	$1.5^2 * 261$	587.25	1	293.625
A	$1.5^3 * 261$	880.875	2	440.437
E	$1.5^4 * 261$	1321.312	4	330.328
B	$1.5^5 * 261$	1981.969	4	495.492
F	$1.5^{11} * 261$	22575.86	64	352.748
C	$1.5^{12} * 261$	33863.79	64	529.1217

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 3/2, we can't reach that by doing $2^{(7/12)}$

$$2^{\frac{7}{12}} = 1.4983 \neq 1.5 = \frac{3}{2}$$

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