

# 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

frequency of  
desired pitch

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

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

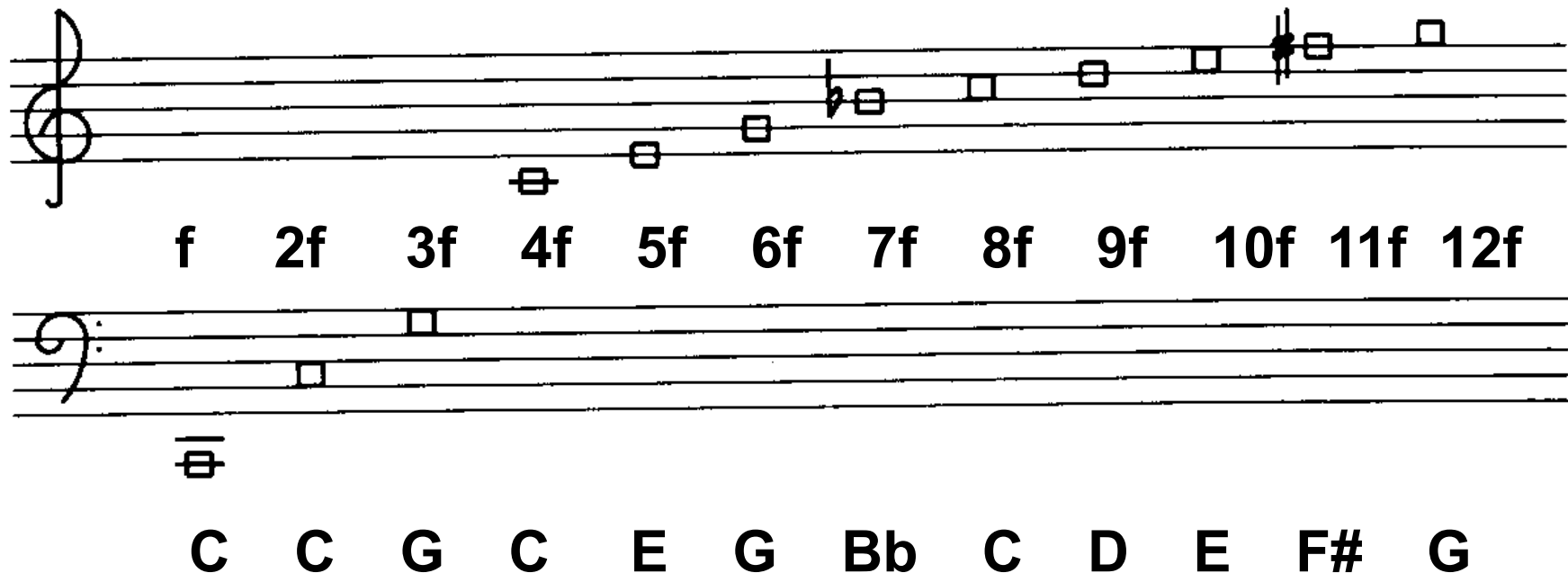
number of  
cents

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

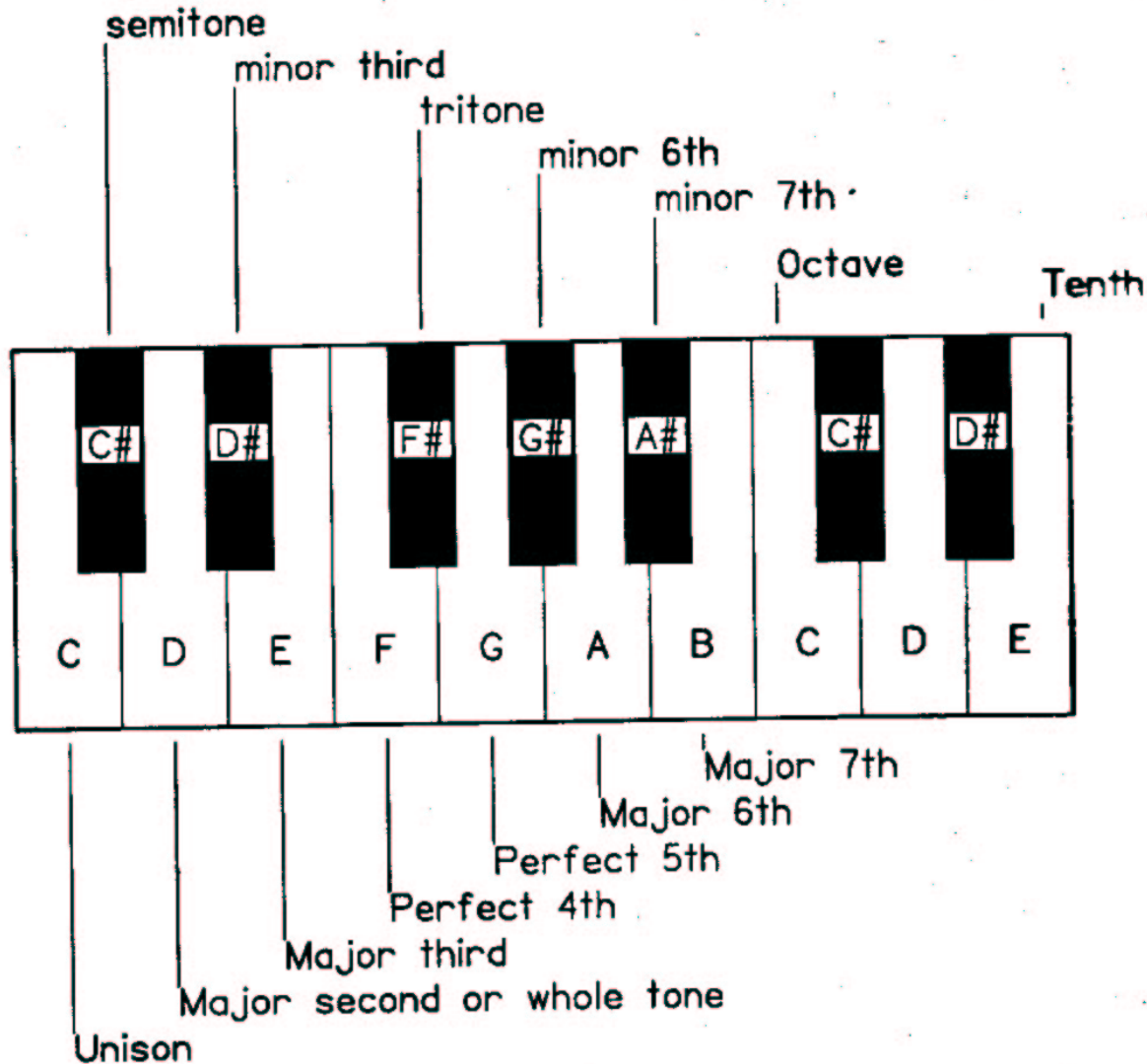


# Overtone Series

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



# Musical Interval Names (from C)





# Interval Names

The image displays three musical staves in treble clef, each divided into four measures. The first staff shows intervals: minor 2nd (half step), major 2nd (whole step), minor 3rd, and major 3rd. The second staff shows: perfect 4th, tritone (augmented 4th/diminished 5th), perfect 5th, and minor 6th (augmented 5th). The third staff shows: major 6th, minor 7th (augmented 6th), major 7th, and octave.

Interval	Staff	Measure
minor 2nd half step	1	1
major 2nd whole step	1	2
minor 3rd	1	3
major 3rd	1	4
perfect 4th	2	1
tritone augmented 4th diminished 5th	2	2
perfect 5th	2	3
minor 6th augmented 5th	2	4
major 6th	3	1
minor 7th augmented 6th	3	2
major 7th	3	3
octave	3	4

# 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 black dots on the staff lines. Below each chord are its name and Roman numeral notation.

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



# Inverting Triads

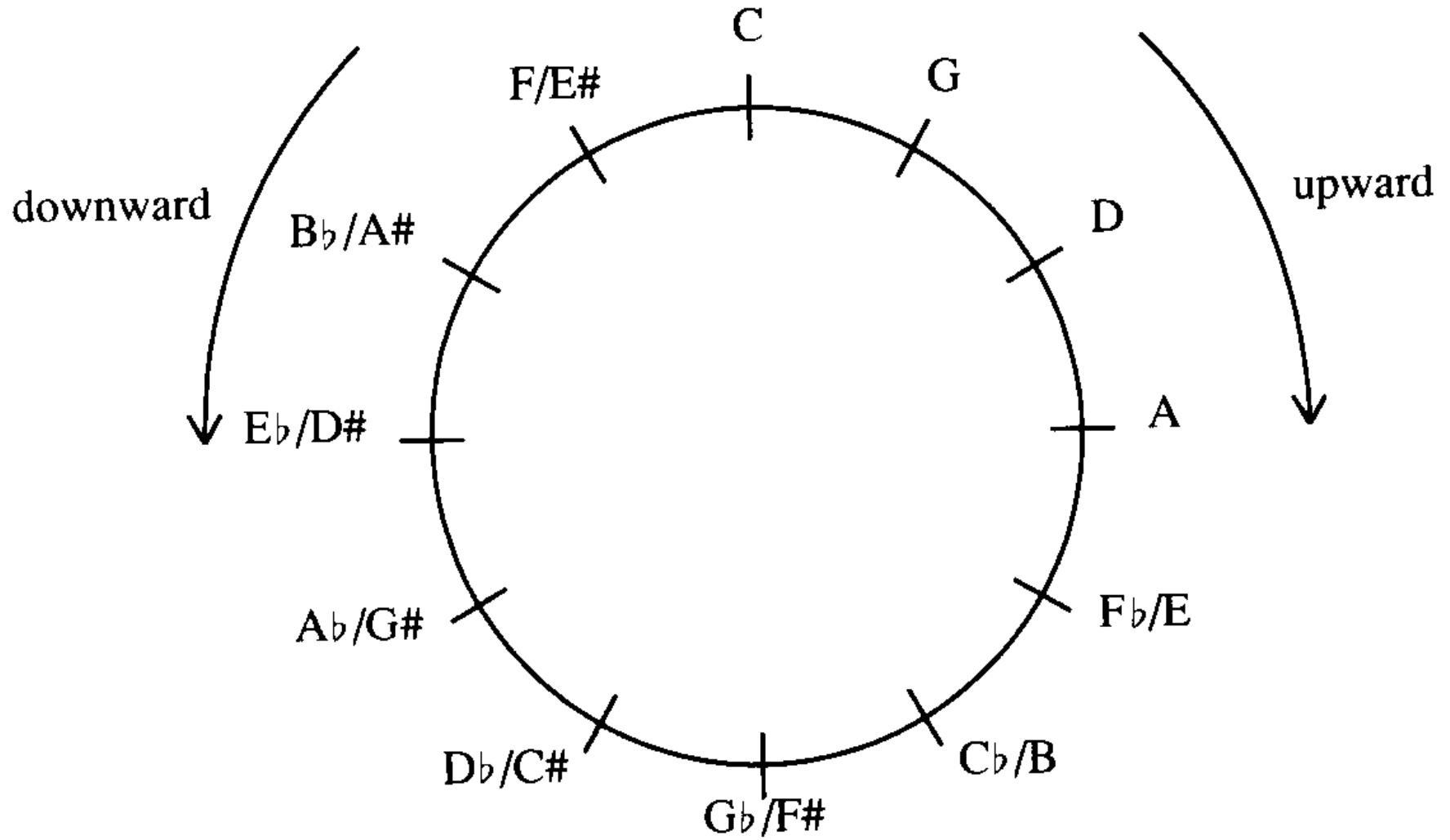
root position                      first inversion                      second inversion

root                      third                      fifth

root position                      first inversion                      second inversion

root                      third                      fifth

# Circle of Fifths



# Pythagorean Tuning

- The 3<sup>rd</sup> harmonic has a frequency 3 times that of the fundamental frequency.
- The name for the interval between the fundamental and the 3<sup>rd</sup> harmonic is an “octave + a perfect fifth” .
- To make a perfect 5<sup>th</sup>, you can divide the frequency of the 3<sup>rd</sup> harmonic by 2. This drops it an octave.
- Therefore, one definition of the perfect 5<sup>th</sup> 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 5<sup>th</sup> 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 5<sup>th</sup> =  $(3/2)f$
- 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 5<sup>th</sup> is 7 half steps. If we define the frequency of a perfect 5<sup>th</sup> 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