Topic 5

Pitch, Tuning, Basics of scales

EECS 352: Machine Perception of Music and Audio
Bryan Pardo 2008

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

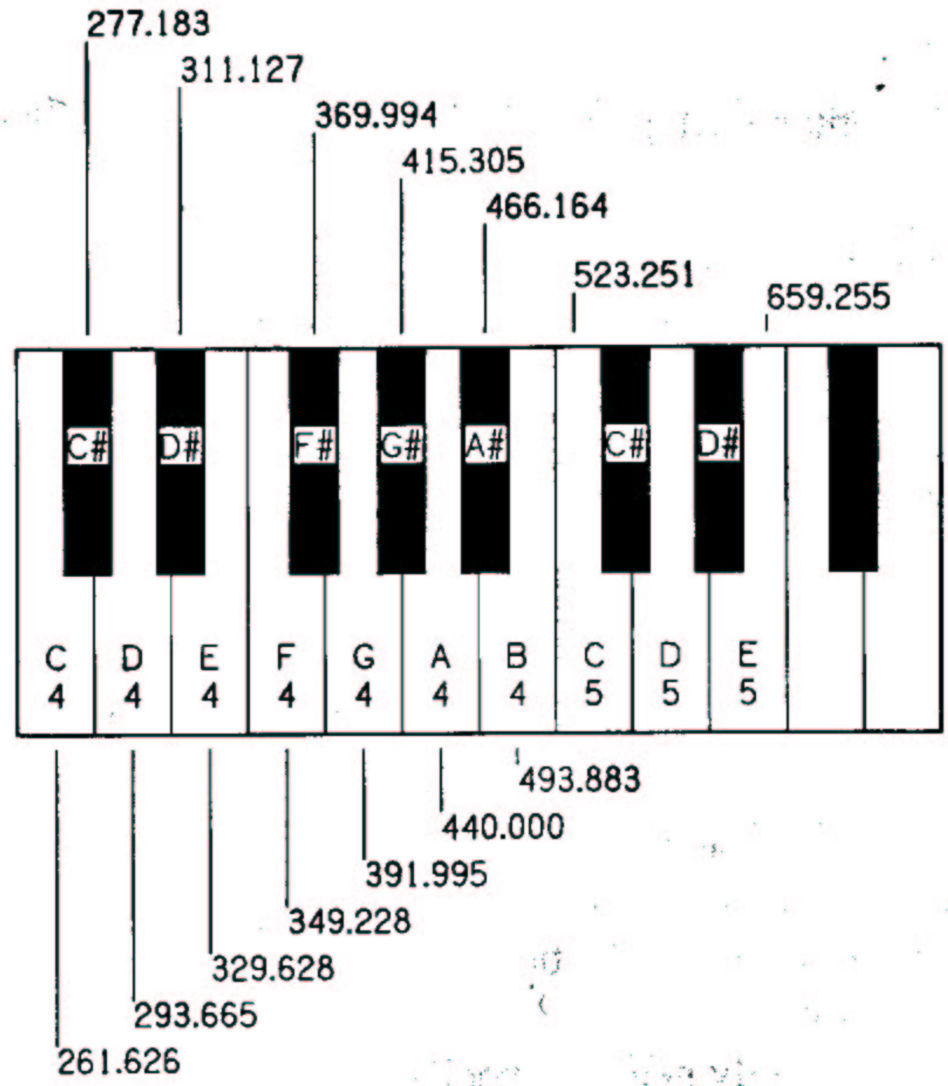
Measurements

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

number of cents

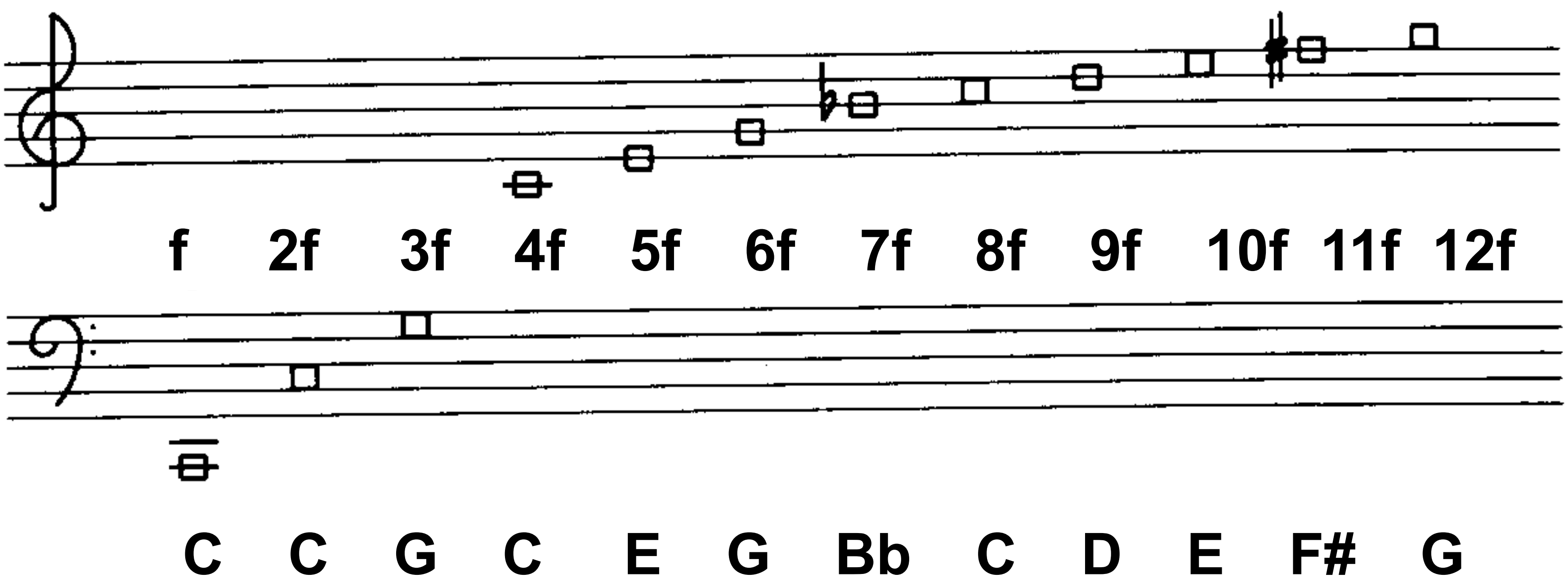
$$c = 1200 \log_2 \left(\frac{f}{f_{ref}} \right)$$

A=440 Equal tempered tuning

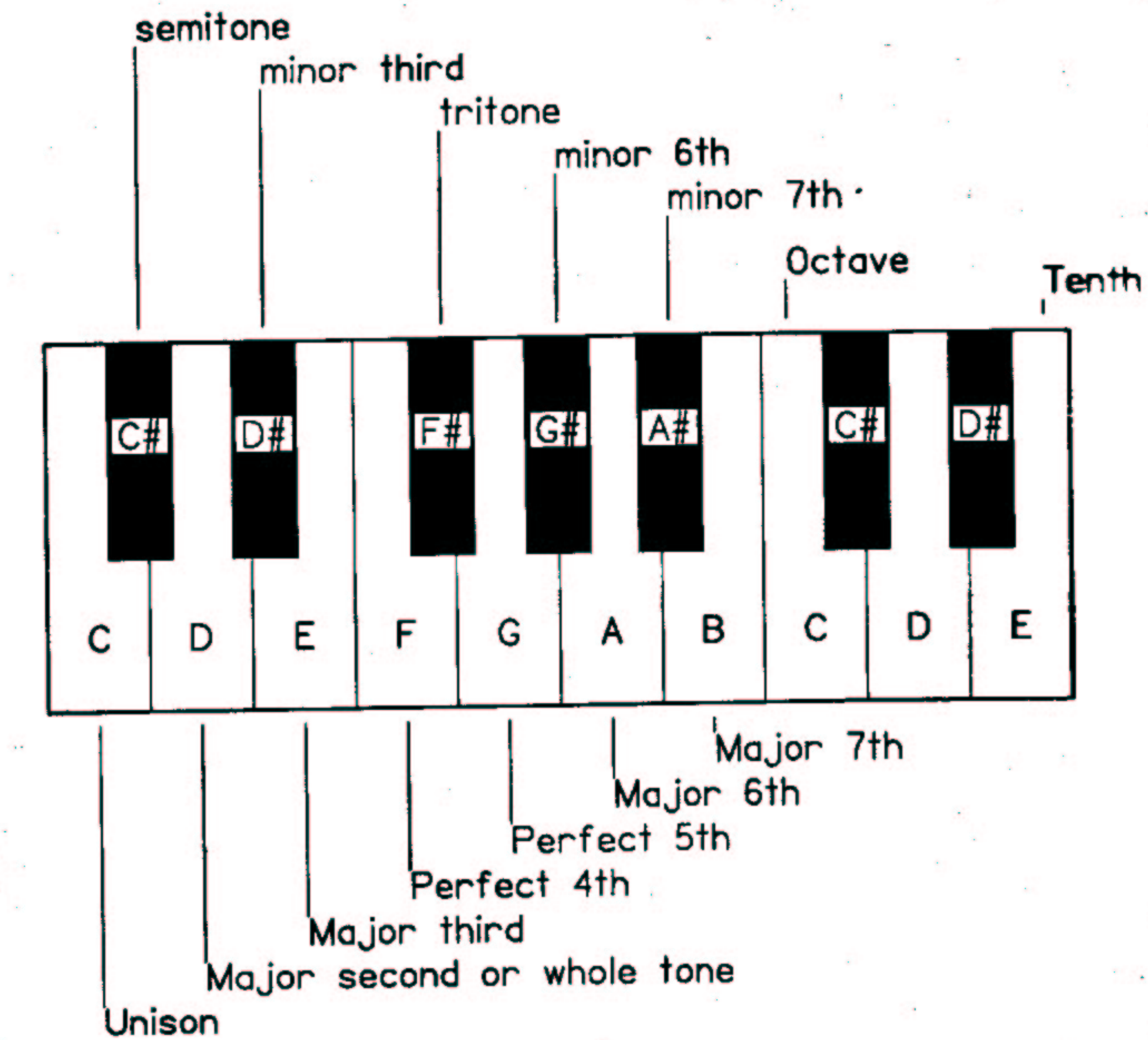


Overtone Series

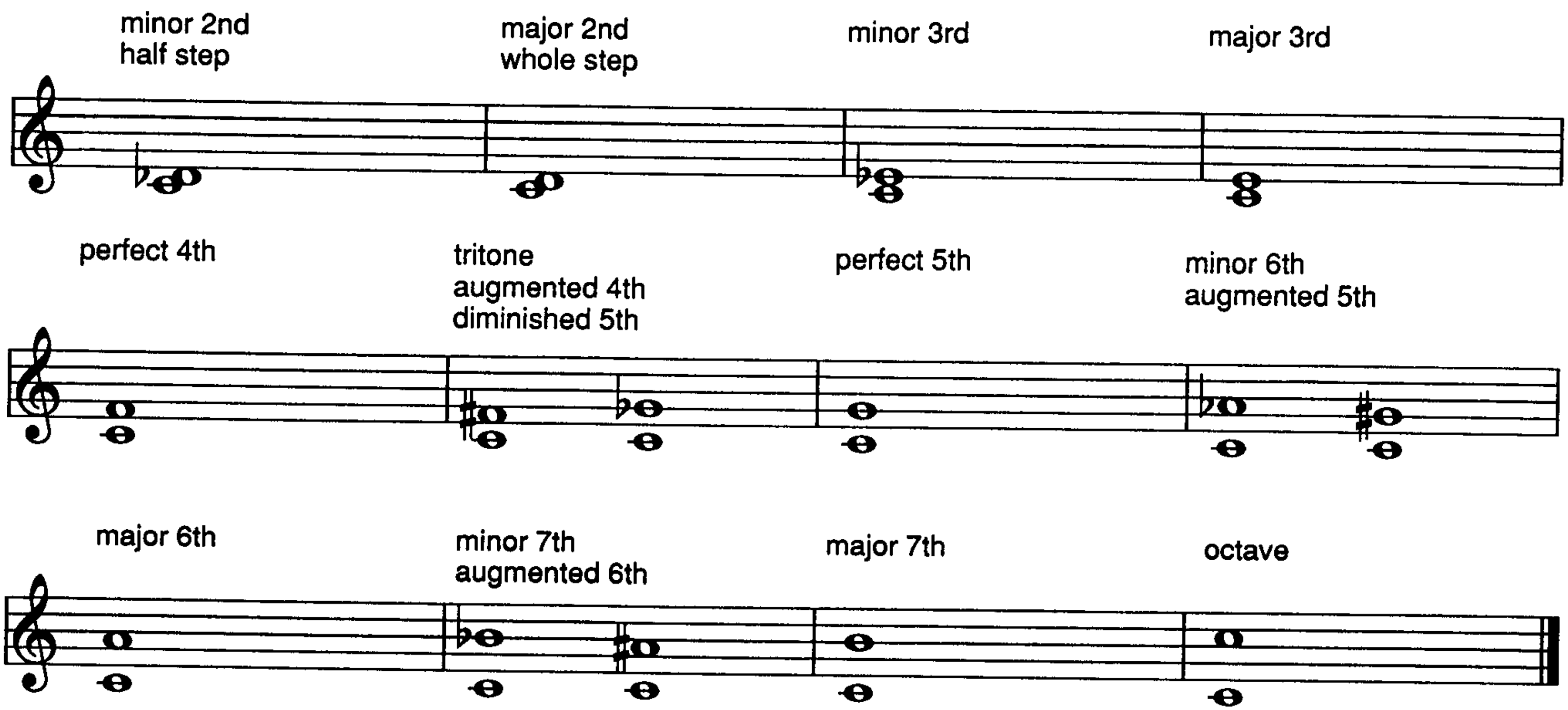
- Approximate notated pitch for the harmonics (overtones) of a frequency



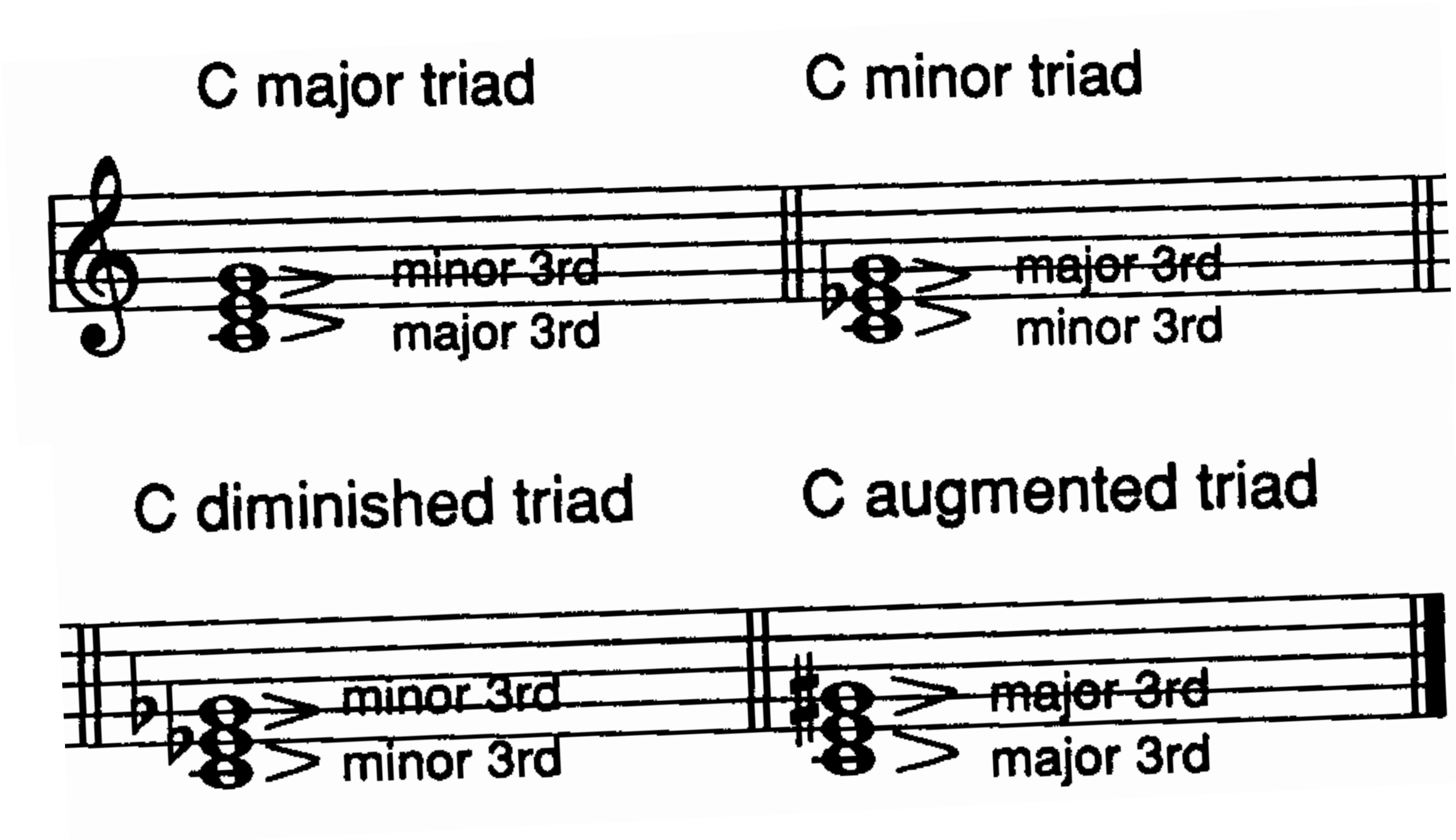
Musical Interval Names (from C)



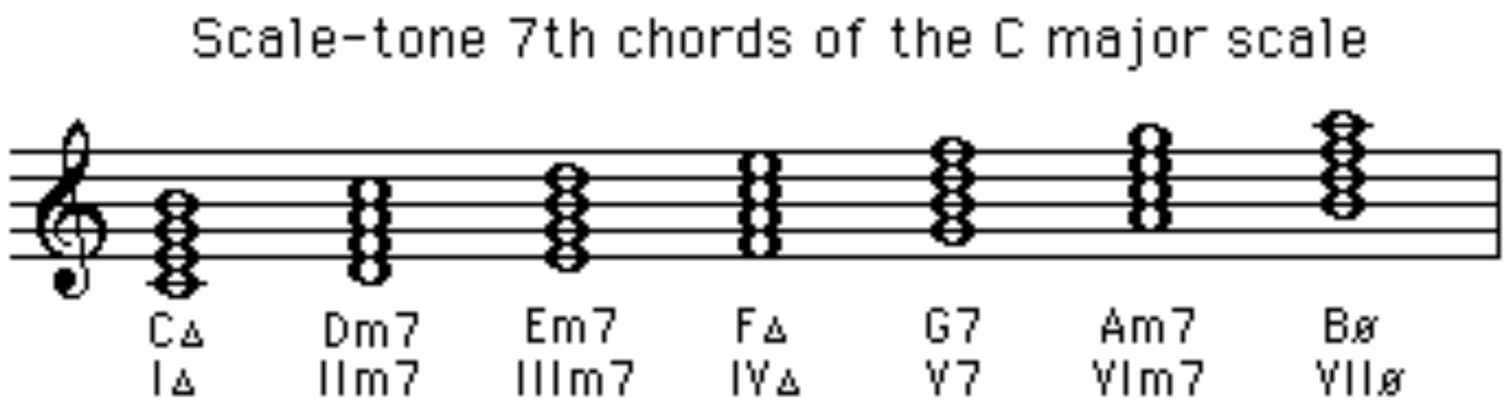
Interval Names



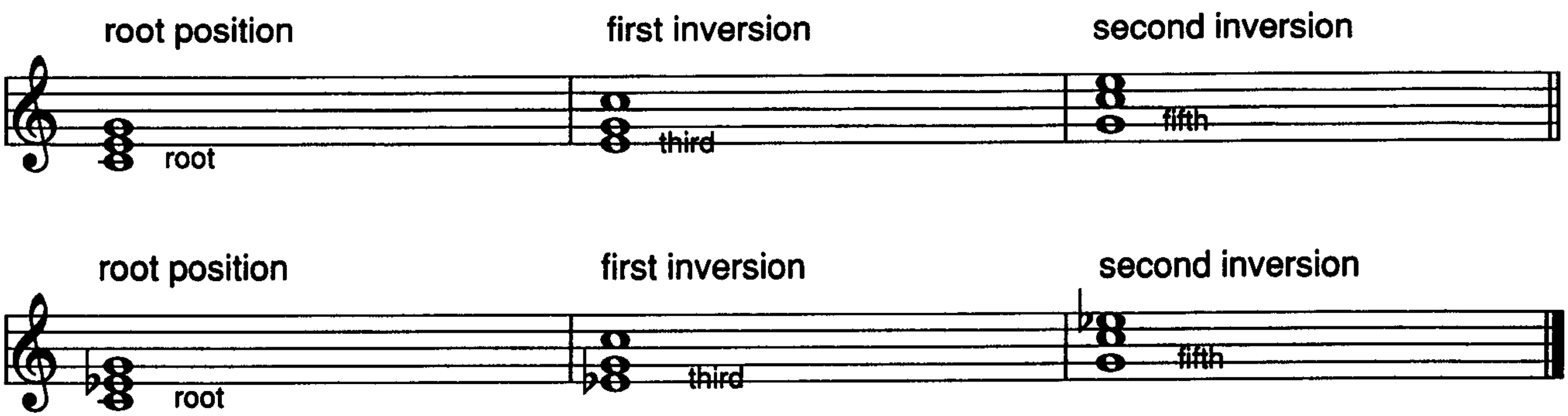
Triads


C major triad
minor 3rd
major 3rd
C minor triad
major 3rd
minor 3rd
C diminished triad
minor 3rd
minor 3rd
C augmented triad
major 3rd
major 3rd

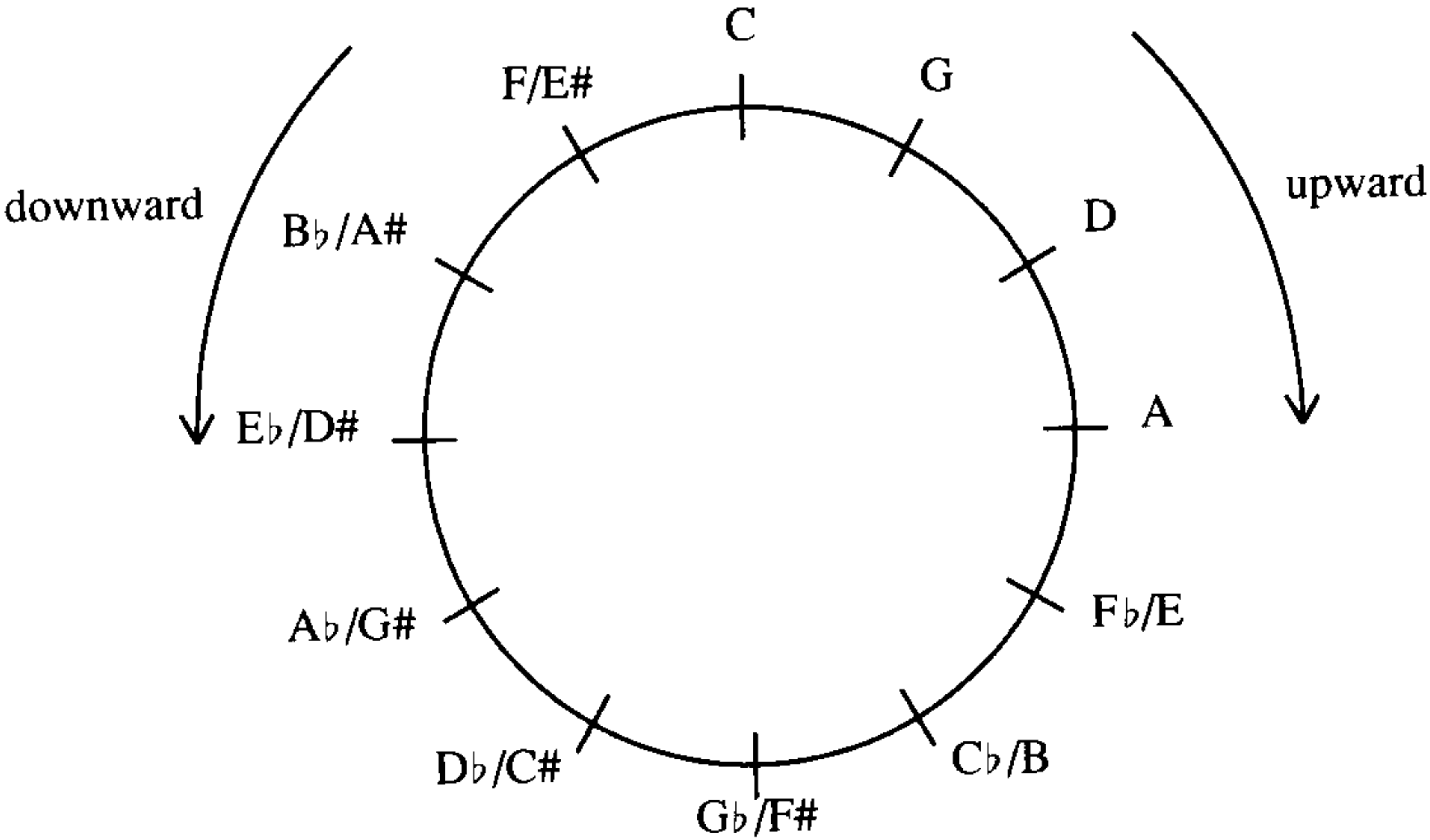
Chords in the Major Scale



Inverting Triads



Circle of Fifths



Pythagorean Tuning

- The 3^{rd} harmonic has a frequency 3 times that of the fundamental frequency.
- The name for the interval between the fundamental and the 3^{rd} harmonic is an "octave + a perfect fifth" .
- To make a perfect 5^{th}, you can divide the frequency of the 3^{rd} harmonic by 2. This drops it an octave.
- Therefore, one definition of the perfect 5^{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 5^{th} of the scale by multiplying that frequency by 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 != 129.75

Problem with Equal temperament

- A perfect 5^{th} is 7 half steps. If we define the frequency of a perfect 5^{th} 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