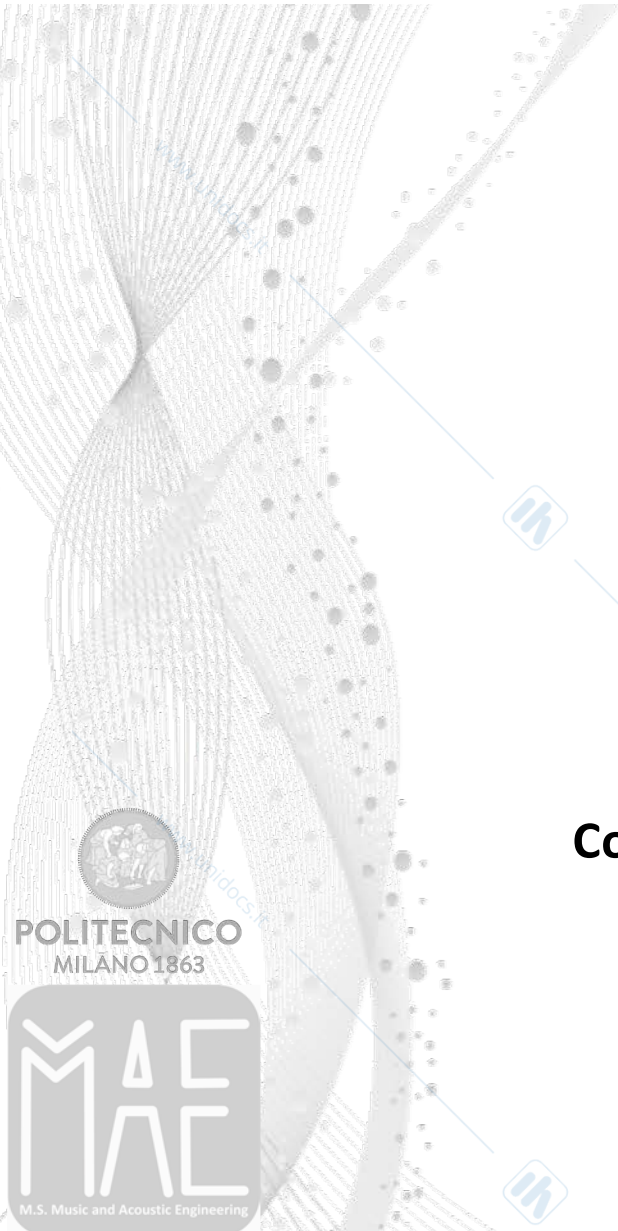


# Tonal Organization

Augusto Sarti

**Computer Music Representations and Models**

M.Sci. Music and Acoustic Engineering



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# References and readings

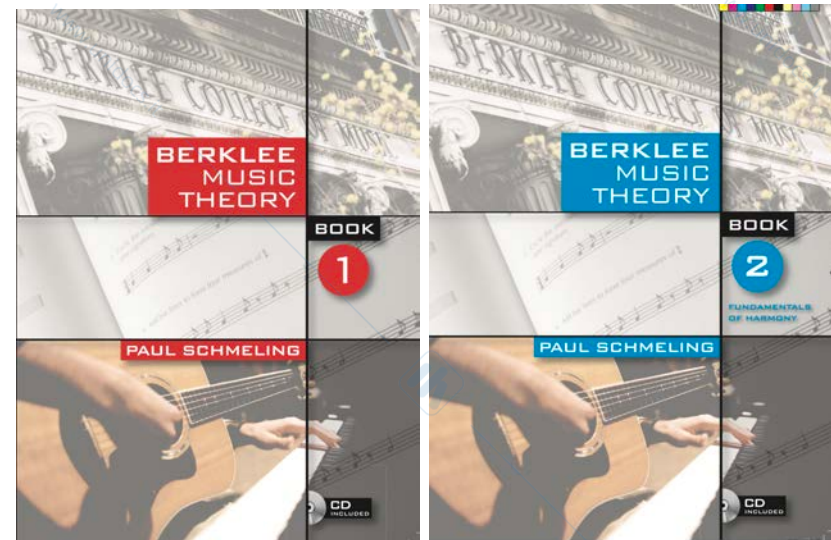
## Music Notation and Basics

Both units of “Notes and Rhythm” and “Reading Music” are excellent primers for those who don’t have a solid music background

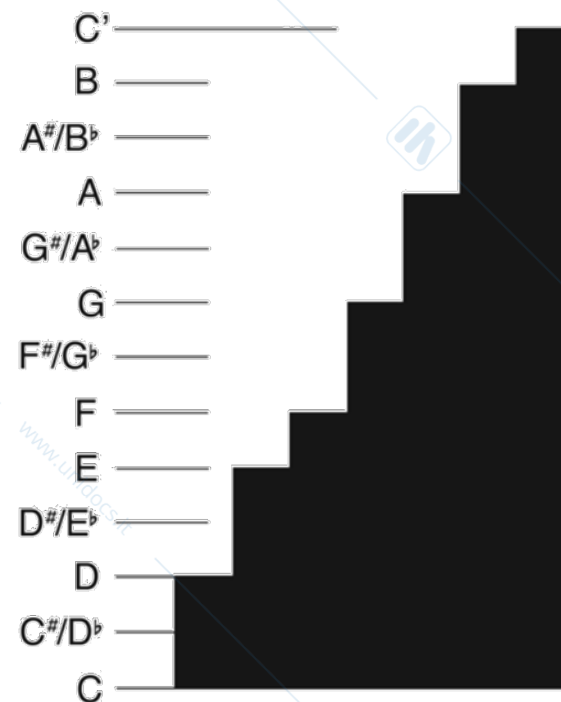
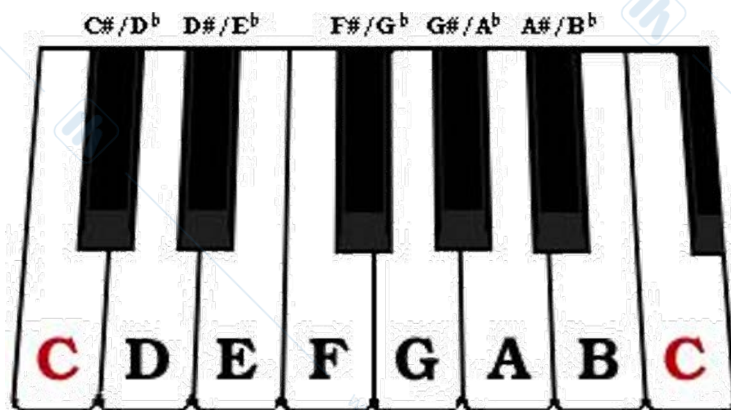
- <https://www.khanacademy.org/humanities/music/music-basics2>

## General Music Overview

- Excellent resources (for those who want to know more of music theory) are
  - P. Schmeling “Berklee Music Theory”, Vol. 1 and 2. Berklee Press.



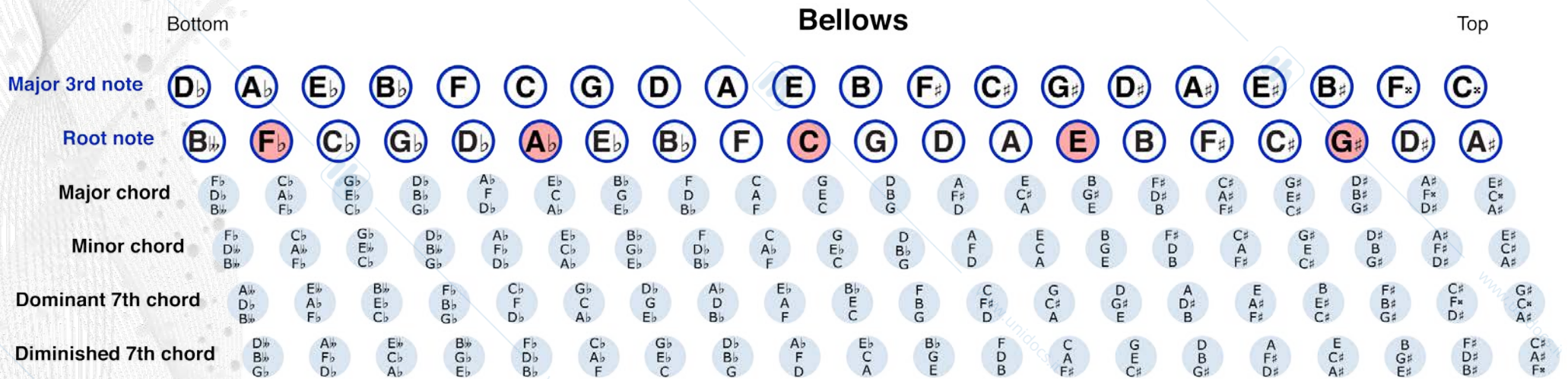
# Why this structure?



Pitch progression staircase

# Why not this one?

- Stradella button keyboard



## Player's Hand



**Button with concave depression**

Use as navigation points.  
(Bass-note button)



**Bass-note button**

Sounds one or more of the same note (in different octaves) when played.



**Chord button**

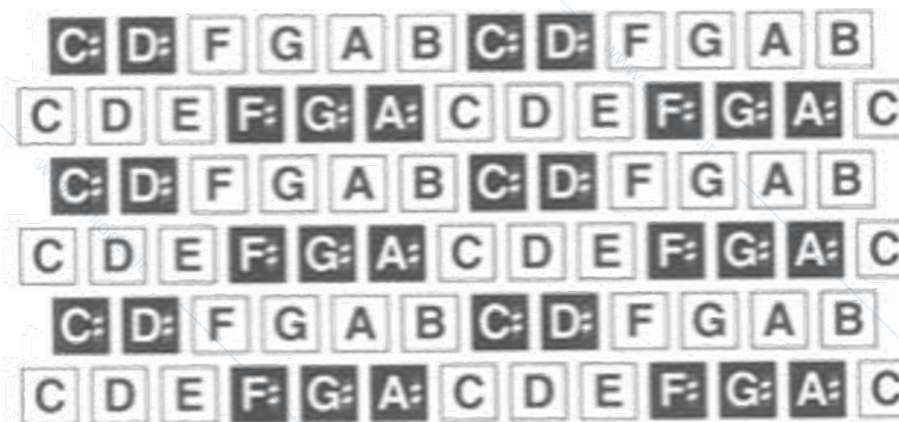
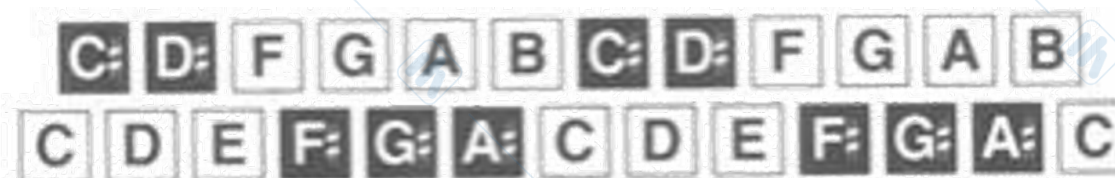
Sounds a three-note chord when played.

# Stradella variations

- **Stradella bass system** (std bass): arranged in a circle of fifths and uses single buttons for bass notes and additional rows of single buttons for preset major, minor, dominant seventh, and diminished chords. The dominant seventh and diminished chords are three-note chord voicings that omit the fifths of the chords
- **Belgian bass system:** variation used in Belgian chromatic accordions. Also arranged in a circle of fifths but in reverse order. Three rows of basses, three rows of chord buttons allowing easier fingering for playing melodies, combined chords, better use of fingers one and five, and more space between the buttons. Rarely used outside of Belgium
- **Various free-bass systems** for greater access to playing melodies and complex basslines on the left-hand manual and to forming one's own chords note-by-note. These are often chosen for playing jazz and classical music. Some models can convert between free-bass and Stradella bass; this is called converter bass. The free-bass left hand notes are arranged chromatically in three rows with one additional duplicate row of buttons

# Why not this one?

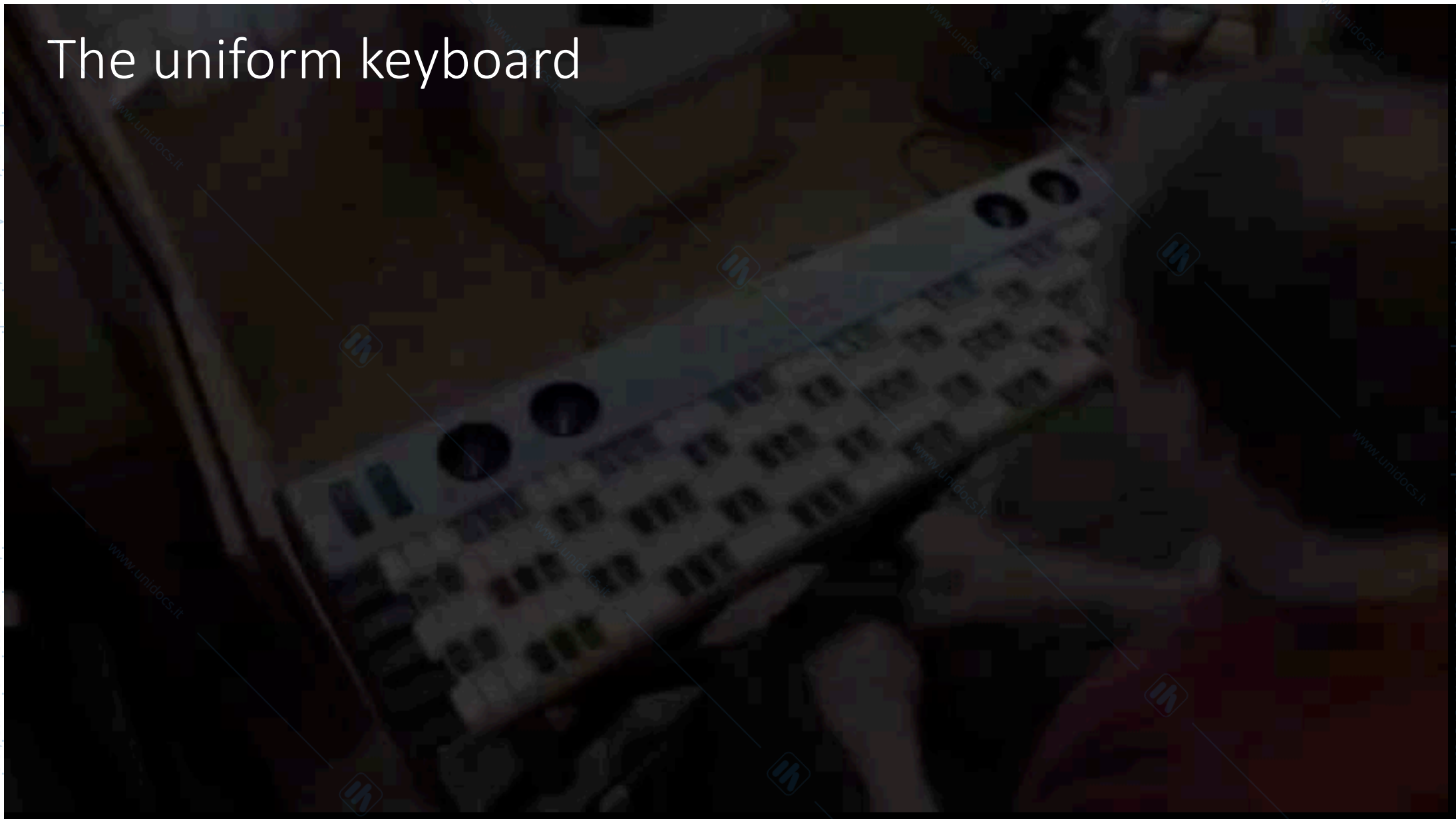
## The uniform keyboard



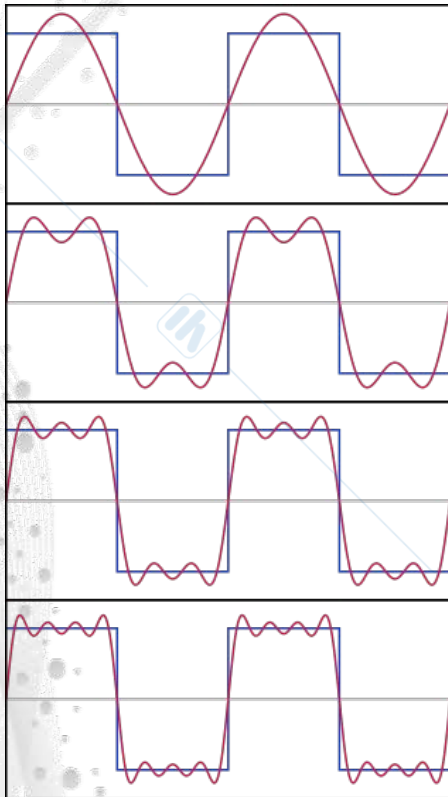
  
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MILANO 1863

  
M.S. Music and Acoustic Engineering

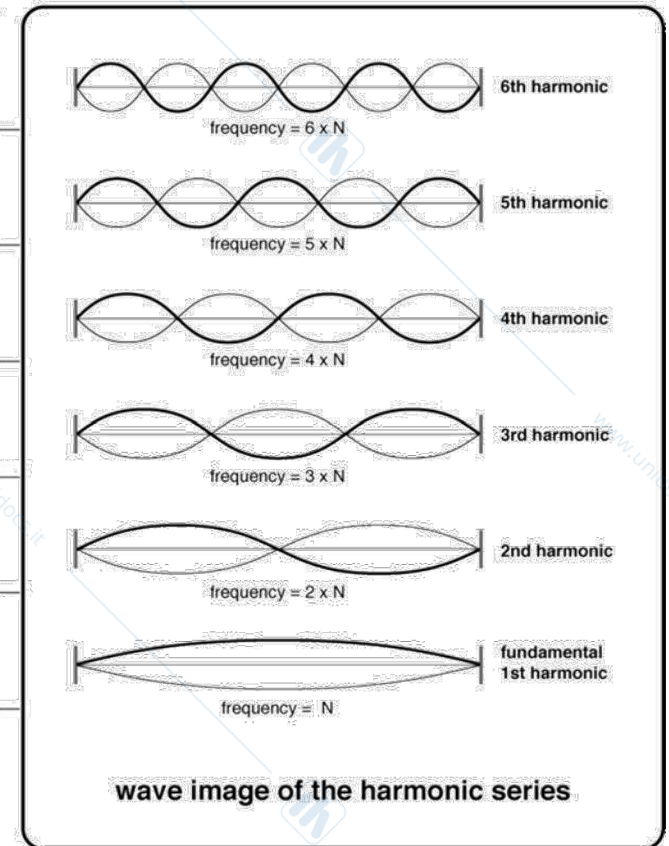
# The uniform keyboard



# Tonal progression of partials



Interval	Tone	Frequency
2nd Perfect Fifth	G <sub>1</sub>	1536
Major Third	E	1280
2 <sup>nd</sup> Octave	C <sub>2</sub>	1024
Perfect Fifth	G	768
1st Octave	C <sub>1</sub>	512
Fundamental	C	256



# Tonal progression of partials

The diagram illustrates the tonal progression of 16 partials on a musical staff. The notes are numbered 1 through 16. Intervals are labeled above and below the staff with arrows indicating the direction of the interval.

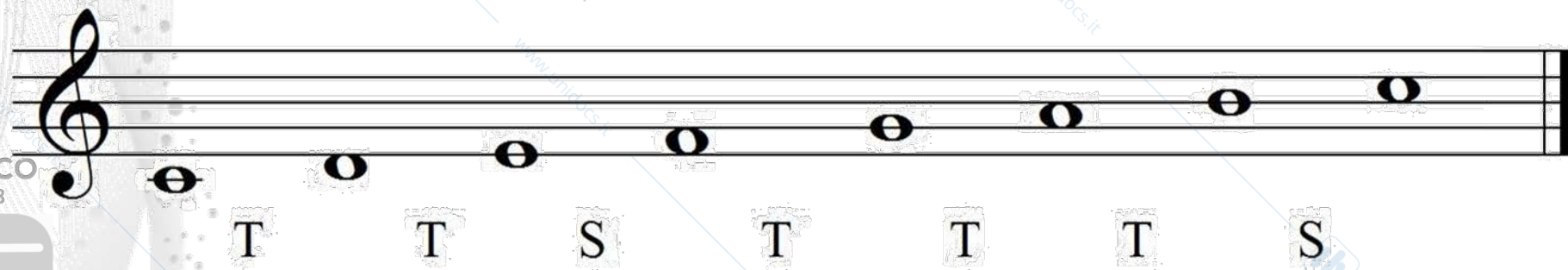
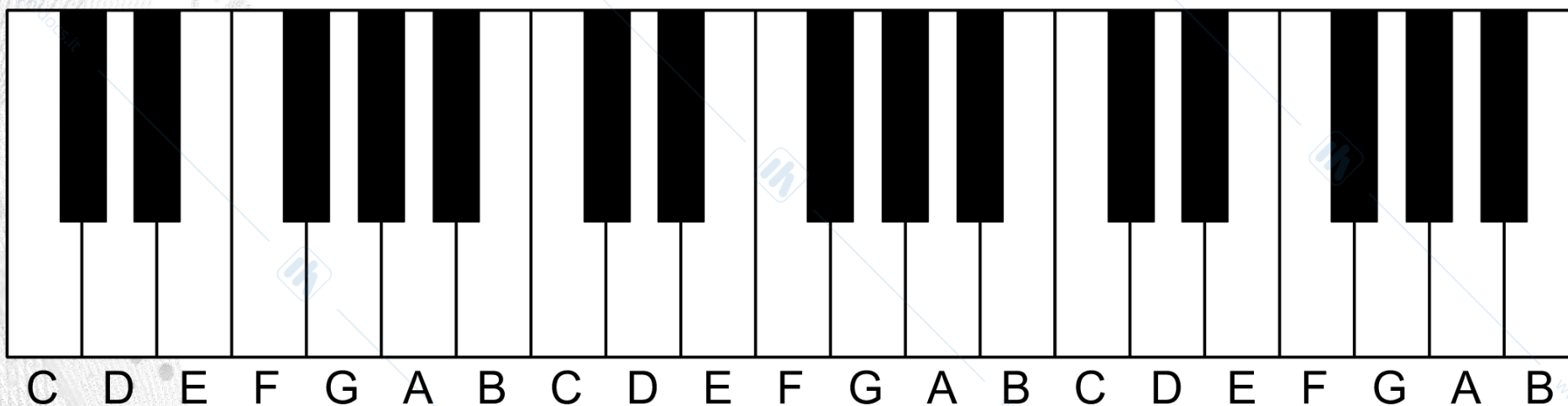
Partial	Interval Label
1	octave ↓
2	
3	perfect fourth ↓
4	
5	minor third ↓
6	
7	supermajor second ↓
8	
9	"lesser tone" ↓
10	
11	lesser undecimal neutral second ↓
12	
13	lesser tridecimal 2/3-tone ↓
14	
15	just diatonic semitone ↓
16	

Interval	Partial
perfect fifth ↑	1
major third ↑	3
subminor third ↑	5
"greater tone" ↑	7
greater undecimal neutral second ↑	9
greater tridecimal 2/3-tone ↑	11
septimal diatonic semitone ↑	13



# Ionian keyboard – in order of relevance



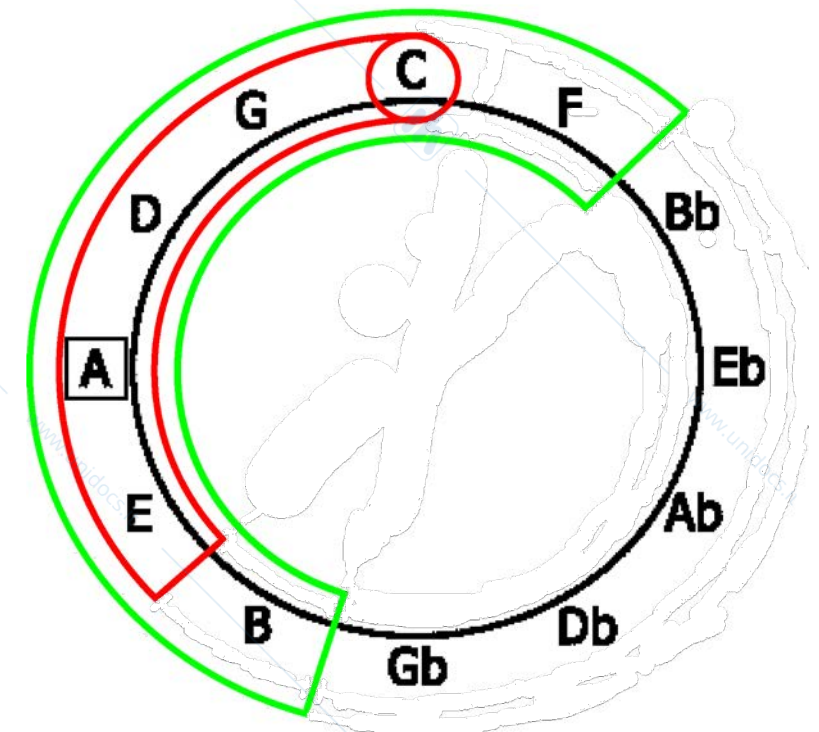
Ionian scale

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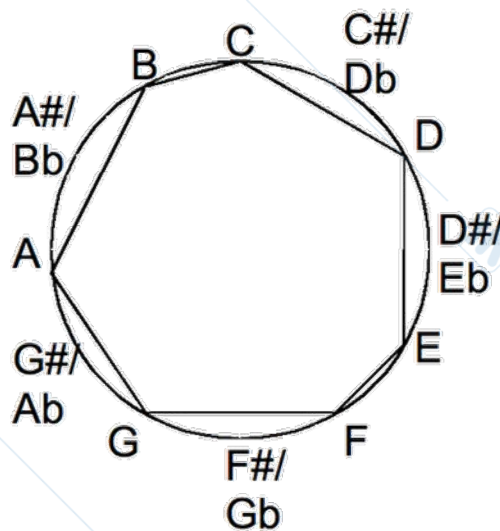
# Ionian keyboard

- A different interpretation of white notes choice: the seven pitches of a diatonic (ionian) scale are obtained by using a chain of six perfect fifths
  - The seven natural pitches that form the C-major (ionian) scale can be obtained from a stack of perfect fifths starting from F
  - F—C—G—D—A—E—B



# Counting the steps (on the log-frequency axis)

An irregular polygon in the chromatic circle



An irregular staircase



	0	1	2	3	4	5	6	7	8	9	10	11	
Ionian	1	0	1	0	1	1	0	1	0	1	0	1	Major



# Translational transformations within the ionian scale

If play the ionian scale starting every time from a different note we obtain «Church» Modes (modal scales), which are characterized by different distributions of irregular intervals

The image displays seven church modes on a treble clef staff in 4/4 time. The modes are arranged in two rows. The first row contains Ionian Major, Dorian, Phrygian, and Lydian. The second row contains Mixolydian Dominant 7th, Aeolian Minor (classical/pure minor), and Locrian. Each mode is represented by a sequence of notes on a staff, with the mode name written below it.

Mode	Notes (starting from the mode's tonic)
Ionian Major	C, D, E, F, G, A, B, C
Dorian	D, E, F, G, A, B, C, D
Phrygian	E, F, G, A, B, C, D, E
Lydian	F, G, A, B, C, D, E, F
Mixolydian Dominant 7th	G, A, B, C, D, E, F, G
Aeolian Minor (classical/pure minor)	A, B, C, D, E, F, G, A
Locrian	B, C, D, E, F, G, A, B



# Translational transformations seen as bit rotations

	0	1	2	3	4	5	6	7	8	9	10	11	
Ionian	1	0	1	0	1	1	0	1	0	1	0	1	Major
Dorian	1	0	1	1	0	1	0	1	0	1	1	0	Minor
Phrygian	1	1	0	1	0	1	0	1	1	0	1	0	Minor
Lydian	1	0	1	0	1	0	1	1	0	1	0	1	Major
Myxolydian	1	0	1	0	1	1	0	1	0	1	1	0	Major
Aeolian	1	0	1	1	0	1	0	1	1	0	1	0	Minor
Locrian	1	1	0	1	0	1	1	0	1	0	1	0	Minor
Ionian	1	0	1	0	1	1	0	1	0	1	0	1	Major

What decides whether it is minor or major?

# Shift back to tonal reference

Ionian major

Phrygian minor

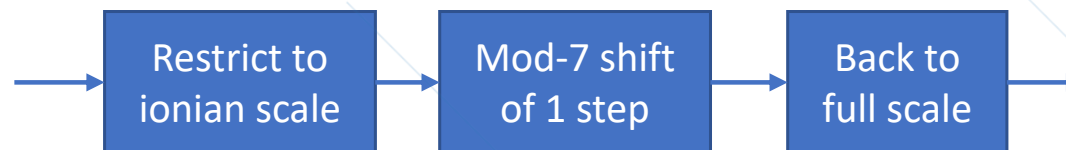
Lydian major

Mixolydian major

Aeolian minor

Locrian minor

Dorian minor



## Reordered from brightest to darkest

	0	1	2	3	4	5	6	7	8	9	10	11	
Lydian	1	0	1	0	1	0	1	1	0	1	0	1	Major
Ionian	1	0	1	0	1	1	0	1	0	1	0	1	Major
Myxolydian	1	0	1	0	1	1	0	1	0	1	1	0	Major
Dorian	1	0	1	1	0	1	0	1	0	1	1	0	Minor
Aeolian	1	0	1	1	0	1	0	1	1	0	1	0	Minor
Phrygian	1	1	0	1	0	1	0	1	1	0	1	0	Minor
Locrian	1	1	0	1	0	1	1	0	1	0	1	0	Minor

Hamming distance = 2 from one scale to next  
(move location of 1 note)

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Take every other note in a 7-note scale...

	0	1	2	3	4	5	6	7	8	9	10	11	
Lydian	1	0	1	0	1	0	1	1	0	1	0	1	Major
Ionian	1	0	1	0	1	1	0	1	0	1	0	1	Major
Maj	1	0	0	0	1	0	0	1	0	0	0	1	Major
Dorian	1	0	1	1	0	1	0	1	0	1	1	0	Minor
Phrygian	1	1	0	1	0	1	0	1	1	0	1	0	Minor
min7	1	0	0	1	0	0	0	1	0	0	1	0	Minor

...and you get chords

one chord may fit several scales

## Other scales (not necessarily of 7 notes)

	0	1	2	3	4	5	6	7	8	9	10	11	
Chromatic	1	1	1	1	1	1	1	1	1	1	1	1	-
Pentatonic	1	0	1	0	1	0	0	1	0	1	0	0	Major
Blues	1	0	0	0	1	0	1	1	1	0	1	0	Major
Exatonic	1	0	1	0	1	0	1	0	1	0	1	0	-

4096 different scales!

## Other scales (not necessarily of 7 notes)

Scales are often described according to the number of different pitch classes they contain:

- **Chromatic**, or dodecatonic (12 notes per octave)
- **Octatonic** (8 notes per octave): used in jazz and modern classical music
- **Heptatonic** (7 notes per octave): the most common modern Western scale
- **Hexatonic** (6 notes per octave): common in Western folk music
- **Pentatonic** (5 notes per octave): the anhemitonic form (lacking semitones) is common in folk music, especially in Asian music; also known as the "black note" scale
- **Tetratonic** (4 notes), **Tritonic** (3 notes), and **Ditonic** (2 notes): generally limited to primitive music

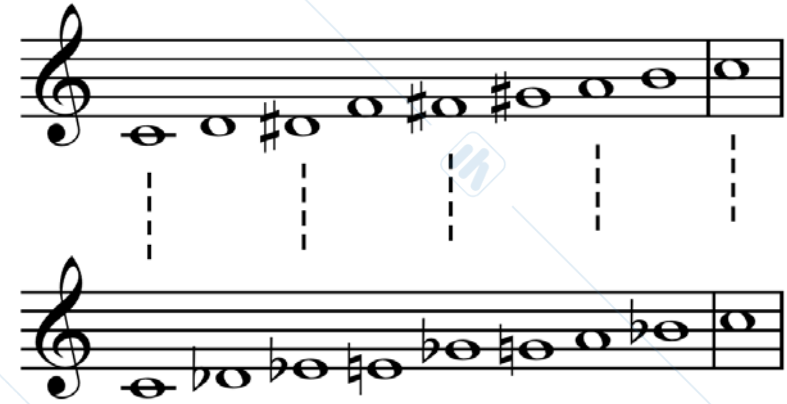
## Scales in western music

- They generally consist of seven notes
- They are most often separated by whole-step and half-step intervals
  - The harmonic minor scale includes a three-semitone step;
  - the anhemitonic pentatonic includes two of those and no semitones.
- Western music in the Medieval and Renaissance periods (1100–1600) tends to use the white-note diatonic scale C–D–E–F–G–A–B
  - The seventh note (B) is used less often
  - Accidentals are rare, and somewhat unsystematically used, often to avoid the tritone



## Examples of octatonic scale

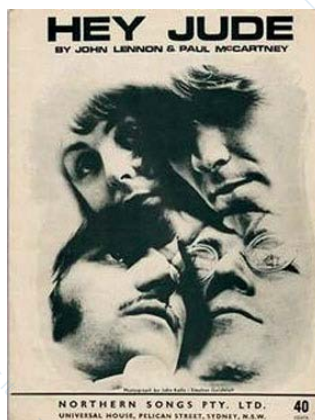
- The scale most often meant by this term is one in which the notes ascend in **alternating intervals of a whole step and a half step**, creating a symmetric scale
- In classical theory, in contradistinction to jazz theory, this scale is commonly simply called the octatonic scale (or octatonic collection), although there are in total forty-two non-enharmonically equivalent, non-transpositionally equivalent eight-tone sets possible



Change scale... change mood...



from ionian...



...to aeolian



# An aerial view

1. **Chord:** group of notes usually played at the same time

Major Minor Major7 Minor7 Dominant7 Semidiminished Diminished



2. **Scale:** monotonically increasing or decreasing tonal sequence of musical notes



3. **Modal scale:** a scale generated from a “mother scale” by selecting a different starting point

## Examples

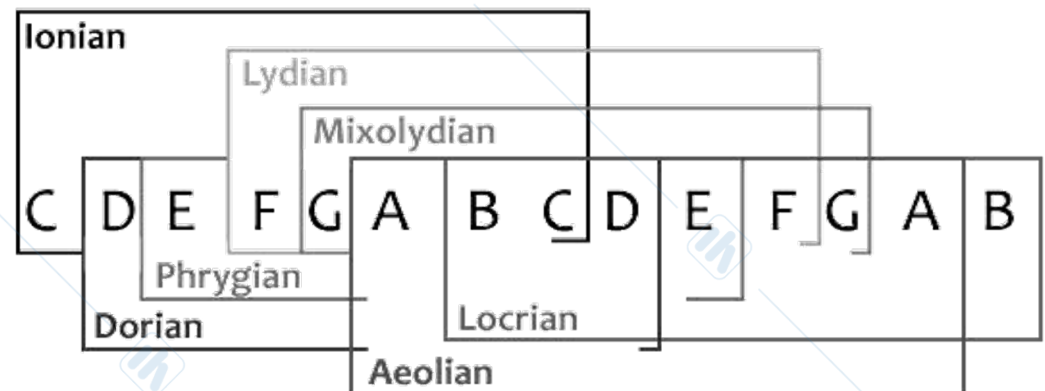
Ionian



Dorian



Phrygian



# An aerial view

## 4. Harmonic progression:

- sequence of chords.
- One of the fundamental structural pillars of musical forms

## 5. Relation btw chords and scales

- chords are obtained through 2:1 subsampling of modal scales or other scales whose intervals are do not exceed 2 H-T
- Different scales can be subsampled to the same chords

**PEACE** - HAROLD SILVER

(BALLAD)

**Maj7**  
 Ionian  
 Lydian  
 Pentatonic  
 ...

**Min7**  
 Dorian  
 Eolian  
 Phrygian  
 ...

**Dom7**  
 Mixolydian  
 Lydian b7  
 Superlocrian  
 ...



# Scale adaptation

[https://www.dropbox.com/s/clzwbjhg0716qw1/scale\\_adaptation.mov?dl=0](https://www.dropbox.com/s/clzwbjhg0716qw1/scale_adaptation.mov?dl=0)

The screenshot shows a web application titled "mode\_standalone (presentation)". The interface is divided into several sections:

- Modal Scales Detector:** The main title of the application.
- Metronome:** Includes an "on/off" toggle (currently off), a "bpm" input field set to "120", and a "reset" button.
- Actual chord:** A display showing "F Maj7".
- Chord Progression Input:** A text input field containing "F Maj7" with a "clear" button below it. To the right, there is a piano-roll style visualization of notes and a set of buttons labeled "5", "7", "6", "8", and "32".
- Control Panel:** Contains three settings: "Use chord knowledge" (checked), "Outliers tolerance" (set to 10), and "Minimum scale length" (set to 5).

The main area of the application is a large grid, likely for displaying scale notes or chord progressions. The bottom of the browser window shows a standard macOS-style dock with various application icons.

# Modes and patterns

Melodic lines and patterns are often developed on a sequence of scales

Example **Cm7**: *C Eb D F Eb G F A G Bb A C Bb D C*

Sequence of interval distances in half-tones:

+3, -1, +3, -2, +4, -2, +4, -2, +3, -1, +3, -2, +4, -2

Sequence of interval distances in **C Dorian** scale

+2, -1, +2, -1, +2, -1, +2, -1, +2, -1, +2, -1, +2, -1

# Patterns on different modes

[https://www.dropbox.com/s/9n1blma0i8vkcsd/modal\\_patterns.mov?dl=0](https://www.dropbox.com/s/9n1blma0i8vkcsd/modal_patterns.mov?dl=0)

The screenshot displays a desktop environment with two musical diagrams. The top diagram, titled "Chromatic steps", shows a series of horizontal lines representing a chromatic scale. The bottom diagram, titled "Modal steps", shows a series of horizontal lines representing a modal scale. The desktop background is a dark image of a piano keyboard with "FP-7" visible. The taskbar contains icons for 2013book, - See the Brother's Name3, Universal Document Converter, Macintosh HD, Ecolabur, Chapter Editor, and Scramata 11-07-03-04.png.