BASIC ELEMENTS OF MUSICAL ACOUSTICS

SCALES, INSTRUMENTS AND ENSEMBLES

Study aid to learn Communication acoustics, VIHIAM 000

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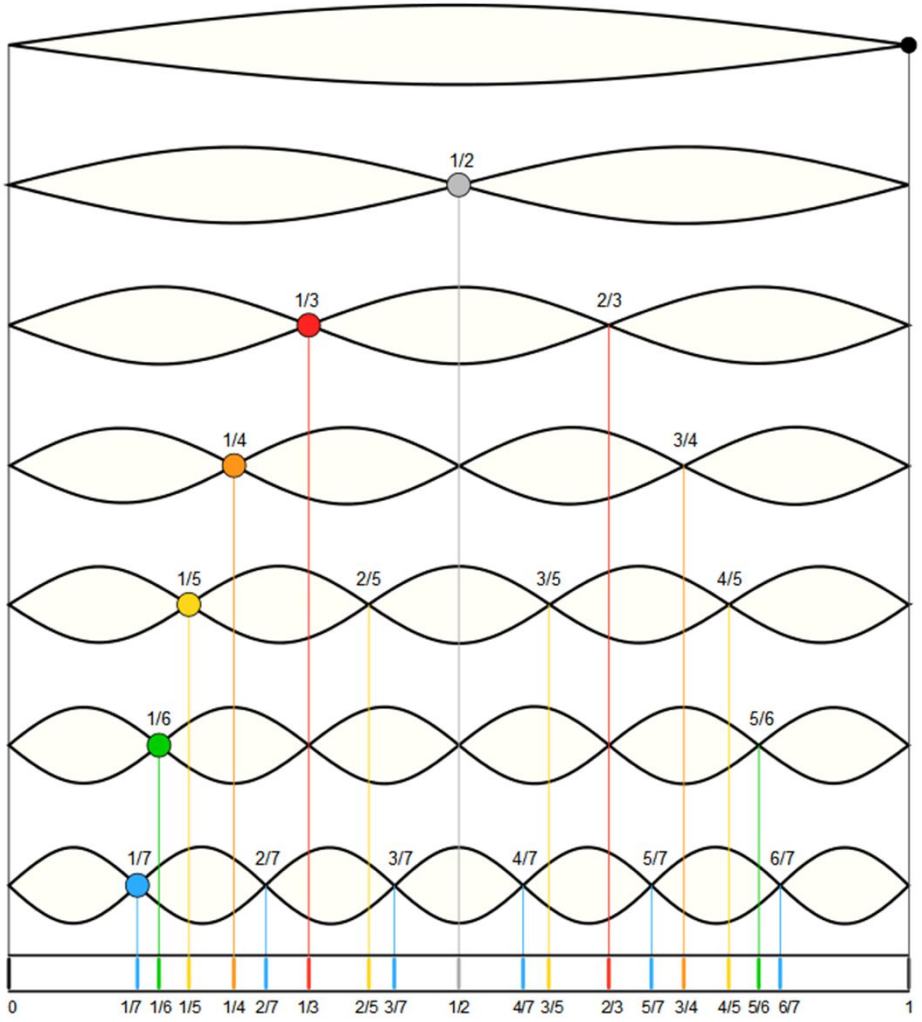
The musical sounds

- Sinusoidal signal
  - sterile, dificult to produce in natural way
  - the most similar sound is that of flute
- The sound of real instruments is harmonic
  - superposition of sinusoids
  - The **tone** is determined by their amplitude ratio
  - The sequential harmonic sounds form a musical **scale**
- Very many scales did exist, changing by era and culture
- The construction of a scale is based
  - on one basic sound and a fixed set of acceptable sounds
  - within this set, the intervals are perceived as pleasant and perfect

Relationship of music and physics: the series of harmonics

- The proportion of frequencies (eigenfrequencies) is equal to ratios of whole numbers
  - octave: 1:2
  - fifth (quinte): 2:3
  - fourth (quart): 3:4
  - major third: 4:5
  - minor third: 5:6
  - major second
  - minor second (semitone)
- Only in european music!



Diatonic and chromaticism

- Excellent presentation by Leonard Bernstein:
- https://www.youtube.com/watch?v=Gt2zubHcER4

Tuning (scales)

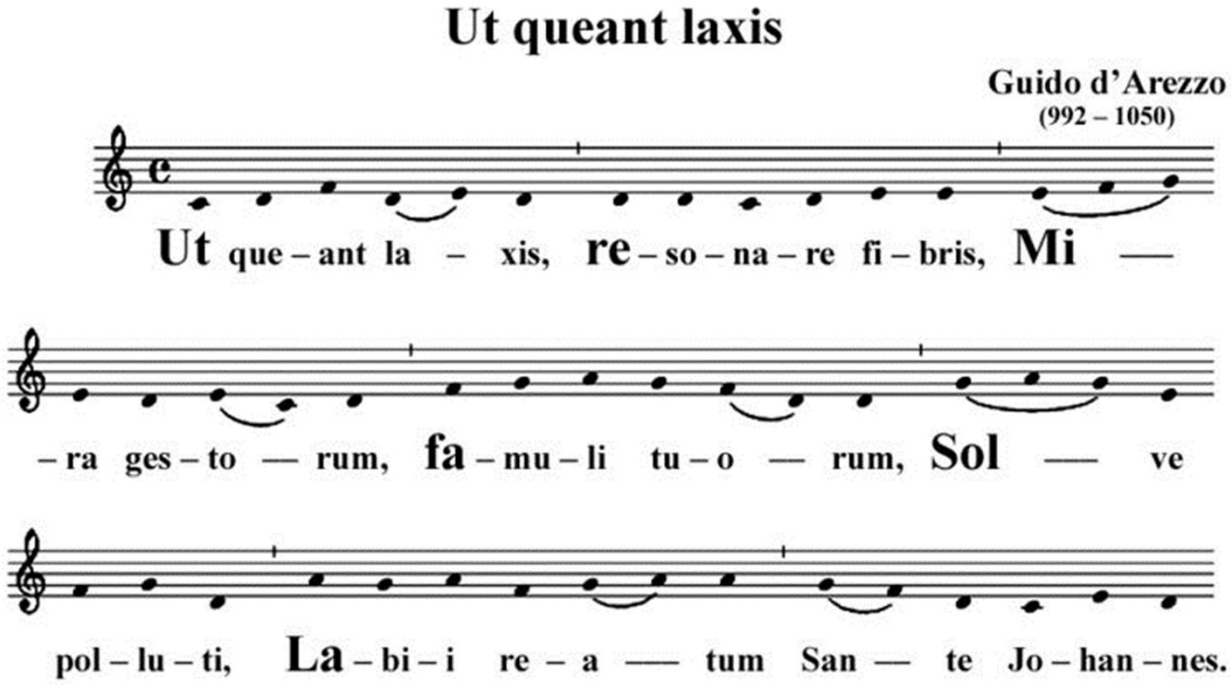
- **Pythagorean** tuning: ratios of integers sound the purest
  - octave: 1:2 (because the 8th note repeates itself after 7 notes)
  - quinte: 2:3
  - sticking to this rule, however, you cannot play all scales purely!
- XVI. – XVII. century: **central tone tuning**
  - The basic scales (F, C, G, D) nearly exactly pure
- Baroque: **well tempered** tuning
  - Nearly all scales are acceptably pure
  - J. S. Bach: Wohltemperiertes Klavier series
- Today: **balanced** tuning: the 12 semitone of an octave are at exactly equal distance
  - Consequently, none of the intervals exactly corresponds to an integer ratio

The basic pitch of scales

- http://www.music.vt.edu/musicdictionary/appendix/pitch/pitch.html
- Today's normal pitch ($\mathbf{a_1}$): 440 Hz
- Historical changes
  - At the beginning pitch was measured by f
  - Possible frequencies (by A. Ellis,1885): b
  - Larg chaos before the sound fork was inv
  - G.F. Händel's sound fork today: 422,5 Hz
  - Large classical composers based on freq between 415 – 423 Hz
  - Slowly increasing in romantics
  - Paris Opera: 448 Hz, Vienna opera: 456 I
  - The French Academy fixes in 1859-ben r (Lissajous and Berlioz, Meyerbeer & Ros
  - Final fixing in1939: **440Hz @ 20 °C**

Solmisation

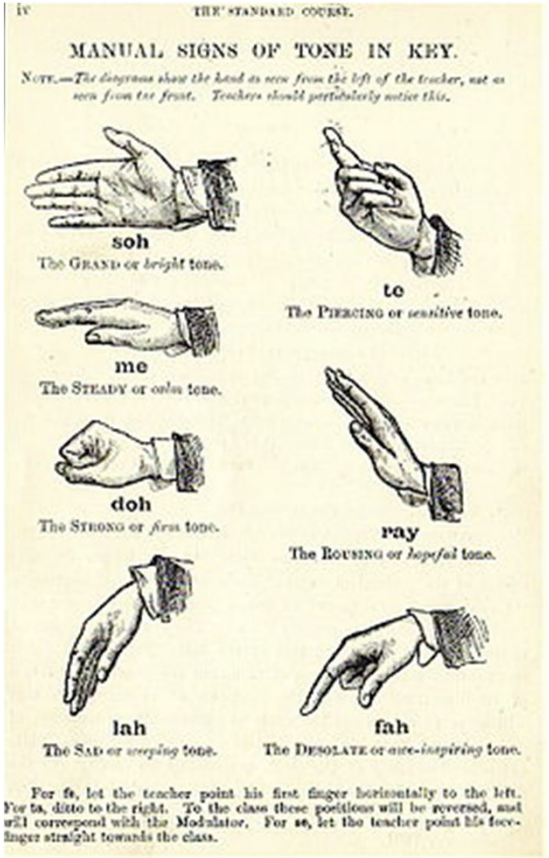
- Origin: Saint John's anthem (composed by Guido d' Arezzo, a Benedictine lived in the 11th century)



„Hogy könnyült szívvel csoda tetteidnek
zenghessék hírét szabadult szolgáid,
oldd meg, Szent János, kötelét a bűntől
szennyes ajaknak. ”

Development of solmisation

- Sarah Ann Glover has anglicized (early 17th century)
- John Curwen (1842) extended and formed into a system
- In Hungary
  - Jenő Ádám revitalized (1944)
  - Zoltán Kodály introduced into music teaching in primary school
  - nowadays highly neglected



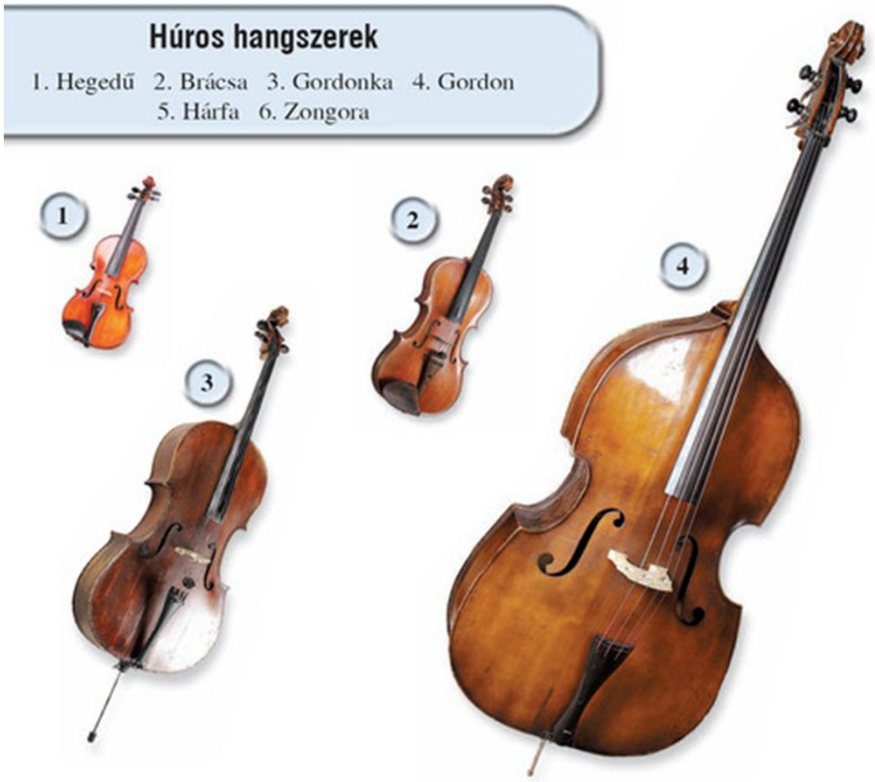
Grouping of musical instruments

According to the dominant element of sound production:

- stringed
  - chordophone
- wind
  - aerophone
- membraneous
  - membranophlne
- elastic solid
  - Idiophone

Stringed instruments / 1

- Played by bow:
  - Violin, viola, cello, doublebass
  - Many versions in earlier times: viola da gamba, viola d'amour, etc.



Stringed instruments / 2

- Plucked instruments
  - cembalo, harp, guitar, lute, mandoline, banjo, tambour…

http://www.youtube.com/watch?v=f19KEzLRL4s

Wind instruments / 1: woodwind

Bassoon
http://www.youtube.com

clarinet

Saxophone

English horn
http://www.youtube.co

oboe

flute

Wind instruments/ 2: brass

French horn
http://www.youtube.com/watch?v=jnFl1q0IYTA

suzaphone

trumpets

tenor/bariton horn

trombones

A musical joke on brass and on woodwind instruments

- Mnozil Brass (Wien)

- http://www.youtube.com/watch?v=uzpUaUIrabc

- http://www.youtube.com/watch?v=PQPk-RX-3jA

Percussion instruments

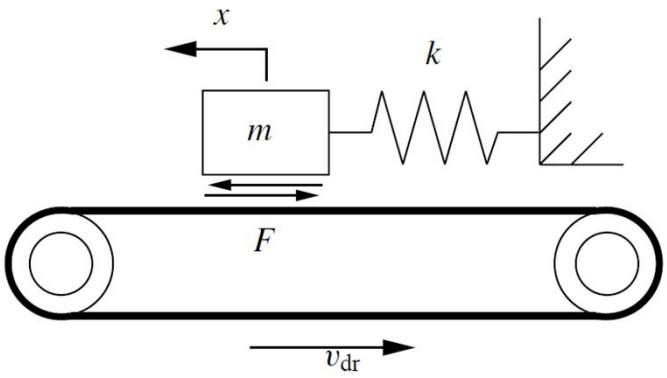
- Holló Aurél – Váczi Zoltán: Traditions Part One – The winning number… / BeFORe John7

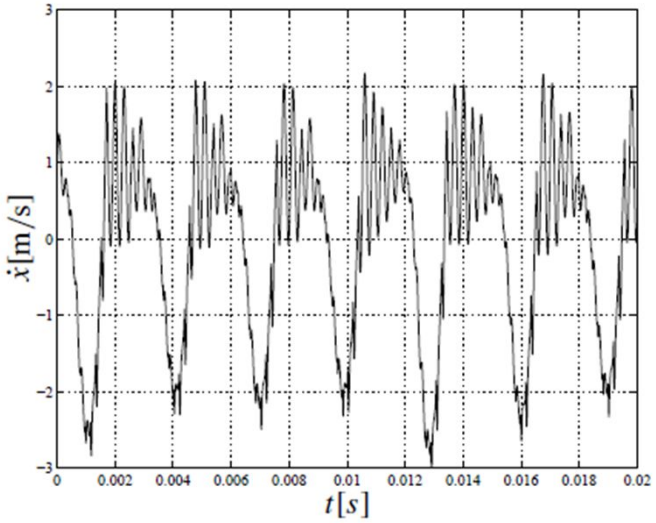
- Amadinda Percussion Ensemble, Liszt Academy of Music, Budapest, 2009

http://www.youtube.com/watch?v=R7rlrl6U2-A&list=UU59BjQMnyUXtv5Je4SxdC_Q&index=7

How does it work – stringed instruments

- Slip-stick vibration (dry friction)



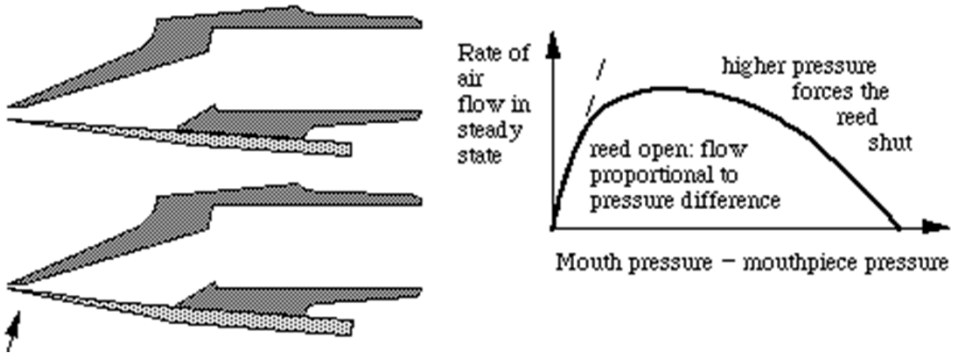


- Results in periodic vibrations with many harmonics

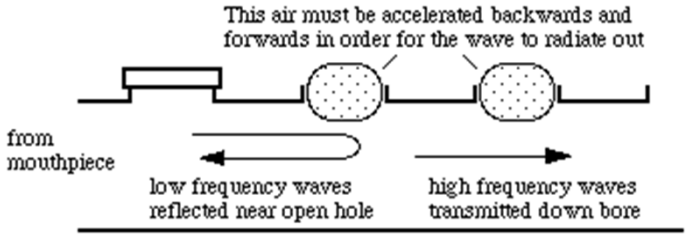
How does it work – woodwind instruments

- Clarinet
  - construction

  - Production of sound

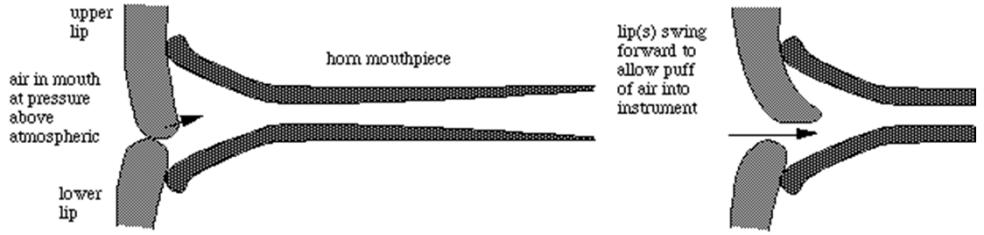


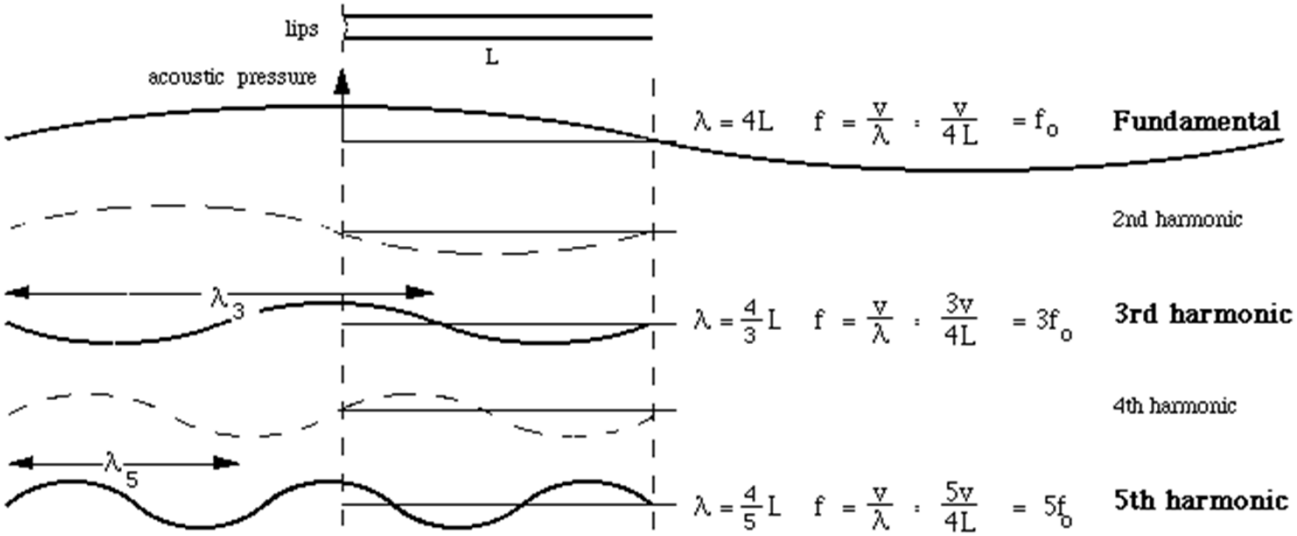
  - pitch



How does it work – brass

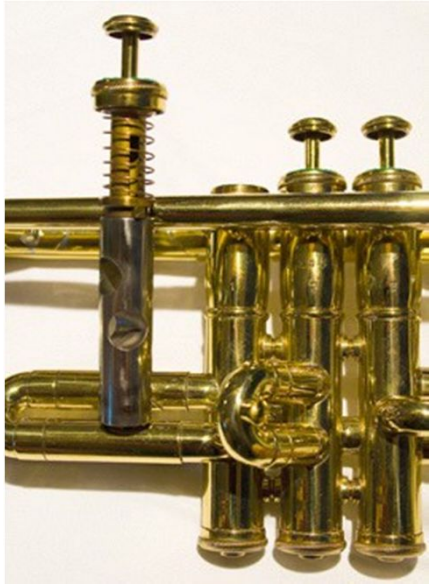
- http://newt.phys.unsw.edu.au/jw/brassacoustics.html#lips

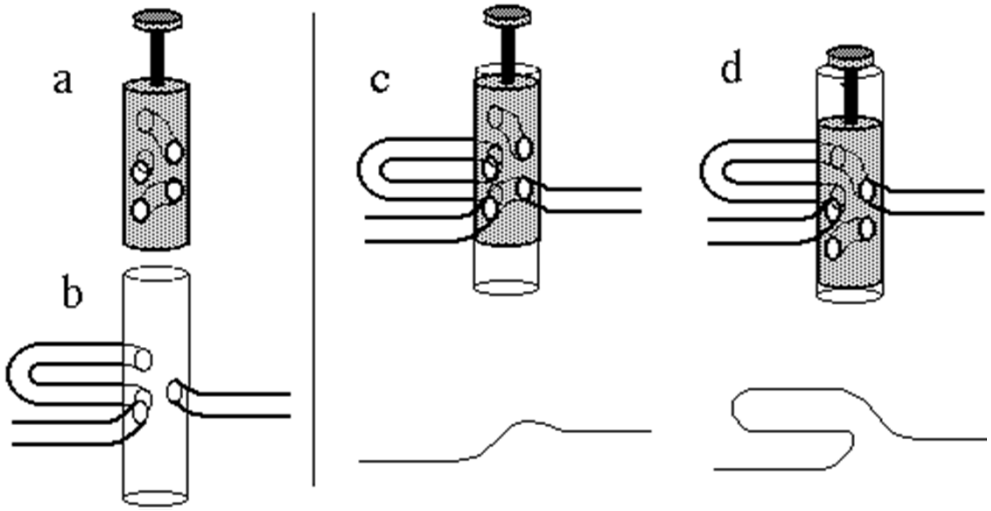




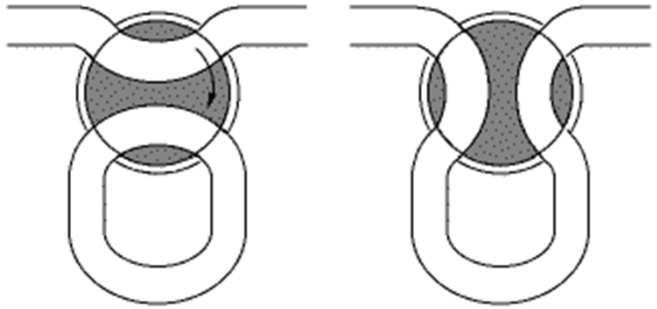
Control of pitch for brass instruments

- Piston valve - trumpet





- Rotating ventil – French horn



The symphonic orchestra

Symphonic orchestra