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, difficult 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
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](https://www.youtube.com/watch?v=Gt2zubHcER4)
Tuning (scales)

- **Pythagorean** tuning: ratios of integers sound the purest
  - octave: 1:2 (because the 8th note repeats 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 semitones of an octave are at exactly equal distance
  - Consequently, none of the intervals exactly corresponds to an integer ratio
The basic pitch of scales

- Today’s normal pitch \( (a_1) \): 440 Hz
- Historical changes
  - At the beginning pitch was measured by feet (organ pipe)
  - Possible frequencies (by A. Ellis, 1885): between 370 and 567 Hz
  - Large chaos before the sound fork was invented (in 1711)
  - G.F. Händel’s sound fork today: 422.5 Hz
  - Large classical composers based on frequencies between 415 – 423 Hz
  - Slowly increasing in romantics
  - Paris Opera: 448 Hz, Vienna opera: 456 Hz
  - The French Academy fixes in 1859: 435 Hz (Lissajous and Berlioz, Meyerbeer & Rossini)
  - Final fixing in 1939: **440 Hz @ 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
  - membranophone
- 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.cc

oboe

flute
Wind instruments/ 2: brass

- French horn
  [Link](http://www.youtube.com/watch?v=jnFl1q0IYTA)
- suzaphone
- trumpets
  - trombita
  - kornett
- tenor/bariton horn
- trombones
  - harsona
  - alt harsona
  - basszus harsona
- tuba
A musical joke on brass and on woodwind instruments

- Mnozil Brass (Wien)

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

- 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=R7rIrl6U2-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/trumpetacoustics.html#lips
Control of pitch for brass instruments

- Piston valve - trumpet

- Rotating ventil – French horn
The symphonic orchestra
Symphonic orchestra