Sound Spectra

- The frequencies of all the sinusoidal component that make it up
- The amplitude of each sinusoidal component present

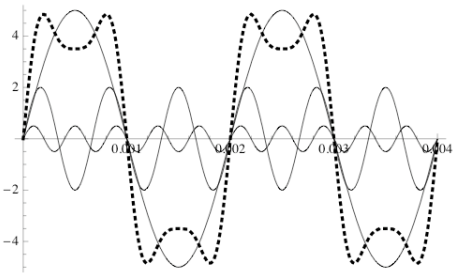
Periodic Complex Waves

- The repetition frequency determines the pitch
- The Fourier components of a complex wave belong to a harmonic series, with the repetition frequency of this complex wave as the fundamental frequency
- The repetition frequency is the largest common factor of all the frequencies present in the spectrum

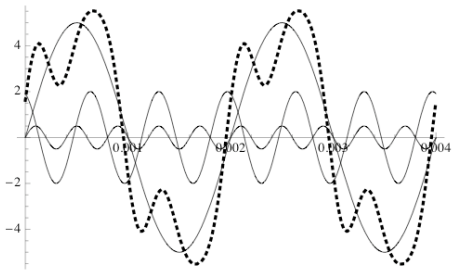
What are the repetition frequency of the following waves?

- A: 10, 20, 30 and 40 Hz
- B: 5, 6, 10 and 12 Hz
- C: 6, 12 and 18 Hz
- D: 18, 24, and 60 Hz

What is the spectrum of the complex wave (thick dotted line)?



What is the spectrum of the complex wave (thick dotted line)?



Ohm's law of hearing

- The ear is sensitive to the amplitudes but not the phases of the harmonics of a complex wave

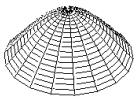
Musical Instruments

- Percussion
- String
- Wind
- Human voice

Percussion Instruments

- Striking a hard object
  - Deformation of the object
  - Pass on to adjoining material
- Include:
  - Membranophones: vibration of a flexible membrane mounted on some rigid frame
  - Metallophones: vibration of metallic objects
  - Xylophones: vibration of wooden objects

Drumhead



http://www.kettering.edu/~drussell/Demos/MembraneCircle/Circle.html

Timpani

http://www.music.vt.edu/musicdictionary/textt/Timpani.html

Vibraphone

http://www.youtube.com/watch?v=gZt7VySrAEE

Cowbell

http://www.music.vt.edu/musicdictionary/textc/Cowbell.html

Cymbal

http://www.music.vt.edu/musicdictionary/textc/Crashcymbals.html
http://www.music.vt.edu/musicdictionary/texts/Suspendedcymbal.html

Gong

http://www.music.vt.edu/musicdictionary/textg/Gong.html

Xylophone or Marimba

Xylophone

- http://www.youtube.com/watch?v=BHP5xjBP-9I&feature=related

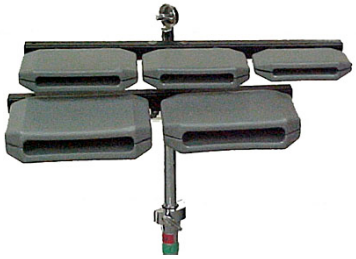
Human Xylophone

- http://www.youtube.com/watch?v=IS52az45ZlA&feature=related

Mouth Percussion

- http://www.youtube.com/watch?v=EYvKE0Wfqp8&feature=related

Temple Blocks



http://www.music.vt.edu/musicdictionary/textt/Templeblocks.html

Wood Blocks

http://www.music.vt.edu/musicdictionary/textw/Woodblock.html

Wood Fish

Properties of the Sound

- Loud or Soft
  - Amplitude of the strike
  - Surface area
- Transient
- No clear pitch in most cases
  - Specific shapes
- Frequency depends on
  - Size
  - Vibration speed
    - material
    - mass or inertia

- Two bars of different length but made of the same material
  - Short one has higher frequency
- Two bars of the same size and shape, but different material
  - Steel and cast iron, steel is stiffer

Natural modes of vibration

- The frequency or frequencies at which an object tends to vibrate with when disturbed
- Musical instruments and other objects are set into vibration at their frequency when a person hits, strikes, strums, plucks or somehow disturbs the object. The input of energy disturbs the particles and forces the object into vibrational motion at its natural frequency

Natural modes of a circular membrane

- Node (point of no displacement)
  - Nodal diameter
  - Circular nodal lines
- Figure 9-16 (+ –: move at opposite direction)
- Figure 9-17

http://en.wikipedia.org/wiki/Vibrations_of_a_circular_drum

http://www.youtube.com/watch?v=s9GBf8y0lY0

Drums don't produce definite pitch

- The many natural mode frequencies do not belong to a harmonic series

Tympani

- Membrane on kettle
  - Mode 1 dissipates fast
  - Mode 4, 6, 8, 9 (with circular nodal lines) are less excited (striking point at half to three-fourths of the way out)
  - Air lowers the frequencies

➔ produces frequencies within a harmonic series

Striking points and vibration recipes

- Strike in the center – dull thump
- The center is on the nodal lines of may natural modes (2, 3, 5, 6, 7, 8,…); only those few circularly symmetric modes (1, 4, 9..) are excited. Therefore the sound lacks richness and brightness because so many of the drum's natural frequencies are missing.

Striking points and vibration recipes

- A large, soft object hits a drumhead wntirely within one + or – region of some mode, the mode is strongly excited
- If the area struck includes both + and – regions, the mode is excited little

Striking points and vibration recipes

- Hard mallets exert a large pressure on a tiny area and excite many modes – bright sound
- Soft mallets exert smaller pressure over a larger area of contact and excite only the lower modes – duller sound