

CM533 Multimedia Time-based Assets: Introduction to Sound

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Introduction to sound

- ▶ What is sound?
 - ⊙ If a tree falls in a forest and nobody is there to hear it, does it make a sound?
 - ⊙ Discuss...
- ▶ Different from vision
 - ⊙ Can only attend to one visual stream at once, yet can monitor several auditory streams
 - ⊙ When you mix sounds from several sources we still perceive them as separate sources

Sound perception

- ▶ Sound is a construction of the mind
- ▶ Neural coding & processing of information from auditory system, integration with information from other sensory systems, and responding to the result is what defines hearing
- ▶ Sound is temporal
 - ⦿ (what is a sound of zero duration?)
 - ⦿ Though it has some spatial characteristics. Discuss.
- ▶ Silence. Silence? Silence!

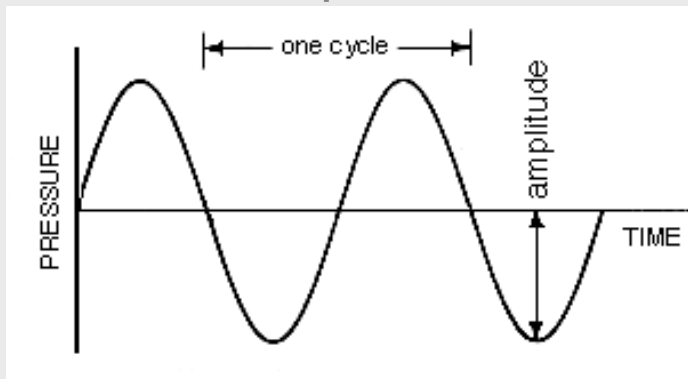
Physical definition

- ▶ Vibration of an object produces sound. If we hear the vibration, the sound is audible
 - ⊙ Hitting a table causes vibration
 - ⊙ Blowing across a bottle causes complex vibrations
 - ⊙ Plucking a guitar string causes it to vibrate
- ▶ What's the difference between the sounds made by hitting a table, blowing a trombone, whistling?
- ▶ Fourier showed that any vibration can be resolved into a sum of sinusoidal vibrations

Sinusoids



- ▶ Sinusoids (aka sine waves) describe relationships between displacement and time



- http://www.keypress.com/sketchpad/java_gsp/sinewaver.html

Attributes of sine wave

- ▶ Frequency (no. of cycles per second, Hz)
- ▶ Amplitude (height of wave)
- ▶ Starting phase
 - ⦿ <http://www.udel.edu/idsardi/sinewave/sinewave.html>
- ▶ What does frequency relate to?
- ▶ What does amplitude relate to?

Properties of sound

- ▶ Sound has four main properties
 - ⊙ Frequency
 - ⊙ Phase
 - ⊙ Intensity
 - ⊙ Timbre/harmonic structure
- ▶ Instruments control these properties = expression
- ▶ In music we talk about pitch. Is it the same as frequency?
 - ⊙ Concert pitch is where the A above middle C has a frequency of 440Hz

Frequency

- ▶ No. of cycles per second of a periodic wave measured in Hertz abbrev. to Hz
- ▶ Related to musical pitch
 - ⊙ Lowest piano key \cong 50 Hz
 - ⊙ Highest piano key \cong 4000 Hz
- ▶ We can hear sounds up to \cong 20 KHz
- ▶ We can hear sharp edged waves at 1/60 Hz or even 1/3600 Hz (1 per hour)
 - ⊙ Where pulses blend into a single homogenous pitch is considered the low range of hearing
 - ⊙ No theoretical limit to this, but **pitch** begins at \cong 25 Hz



Phase

- ▶ Periodic waves measured in degrees of phase
- ▶ Phase = how far through the cycle a wave has progressed
 - ⦿ Begins at 0° , halfway through at 180° and complete at 360°
- ▶ Phase does not affect how we hear a single wave...
- ▶ ...**does** affect how waves interact which does affect our perception



Intensity

- ▶ Intensity or amplitude is the height and depth of the peaks and valleys of a wave.
- ▶ The higher the amplitude, the higher the wave, the more you will see your speaker cones move
- ▶ Measured in decibels - dB: a relative scale
 - ◉ 0 dB is the threshold of human hearing ($0.000000000001 \text{ W/m}^2$)
 - ◉ 3dB is a doubling of intensity
 - ◉ Pain threshold 120dB-140dB
 - ◉ 90dB (or prolonged exposure to lower levels) can cause permanent hearing damage
- ▶ Increase amplitude by providing more energy



Power ratios and decibels

P/P_r	Ratio expressed in decibels
1,000,000	60 dB
10,000	40 dB
1,000	30 dB
100	20 dB
10	10 dB
4	6 dB
1	0 dB
$1/4$ (=0.25)	-6 dB
$1/10$ (=0.1)	-10 dB
$1/100$ (=0.01)	-20 dB

P is the power of the measured sound in watts per square metre P_r is the reference-level power, or 10^{-12} watts-per-square-metre.
Number of decibels is $10 \log_{10}(P/P_r)$

Example intensities

Description	Intensity
Threshold of hearing	0 dB
Outdoors, no people or traffic	20 dB
Background noise in a library	40 dB
Ordinary speaking voice	60 dB
Heavy traffic	85 dB
Power lawnmower up close	90 dB
Motorcycle (rider)	90 dB
Chainsaw	100 dB
Rock music at concert	110 dB
Jet plane takeoff at 100 yards	120 dB
Threshold of pain	140 dB

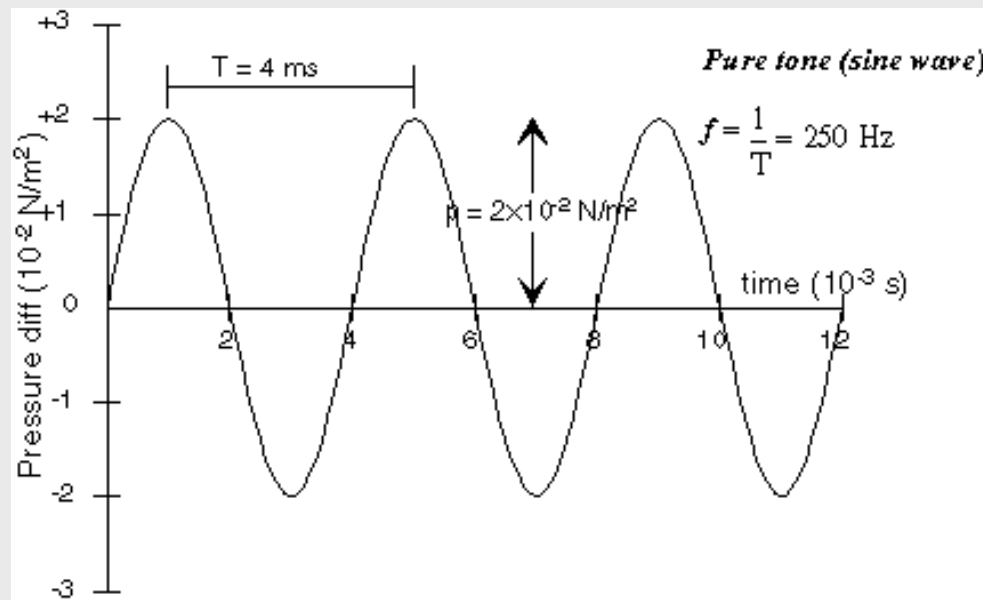
Harmonic structure

- ▶ Presence and strength of upper harmonics
- ▶ Related to timbre
- ▶ Bright sounds have sharper edges
- ▶ Dull sounds have smoother shape

Complex sounds



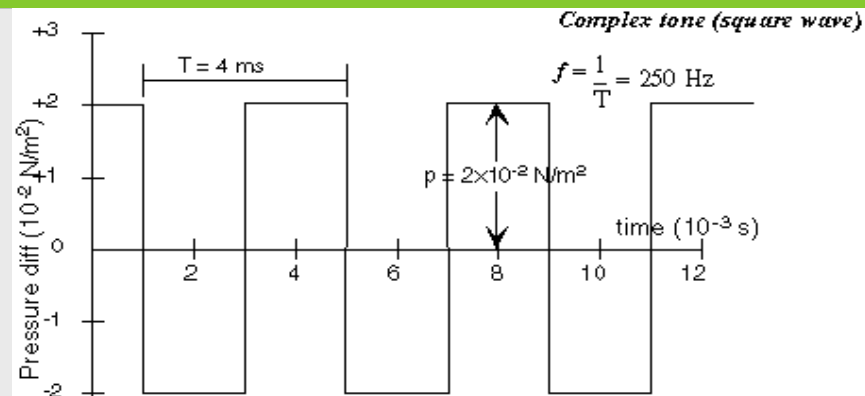
- ▶ Most sounds are not pure tones, but combinations of frequencies
- ▶ Pure tone:



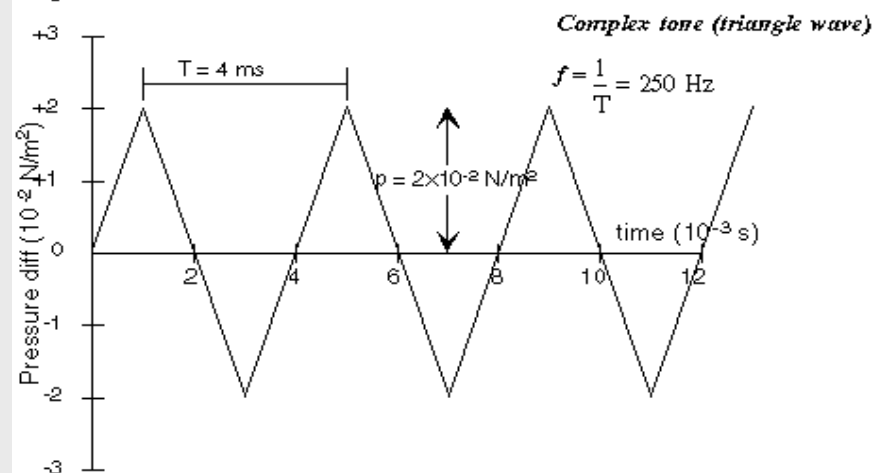
Complex sounds



- ▶ Square wave



- ▶ Triangle wave



Timbre

- ▶ What differentiated the sound of the three tones we heard earlier? How would you describe them?
- ▶ The quality that differentiates how tones sound is called timbre
- ▶ Different instruments have different timbres



Periodic sounds

- ▶ Waveforms that repeat (e.g. sine wave)
 - ⦿ “a wave that has a sinusoidal pattern of condensations and rarefactions”(1)

(1) http://ffden-2.phys.uaf.edu/212_fall2003.web.dir/Dennis_Jackson/periodicsoundwaves.html



a-periodic sounds

- ▶ Sounds with no repeating pattern
 - ⦿ e.g. drum sounds
 - ⦿ noise



Harmonic sounds

- ▶ Where all the harmonics (partials) are integer multiples of the fundamental
 - ◉ e.g. pulse, triangle, saw waves



inharmonic sounds

- ▶ Sounds with non-integer harmonic series
- ▶ E.g. bells, drums

