Chapter 10
Auditory Content

The Design and Implementation of Multimedia Software

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Jones and Bartlett Publishers

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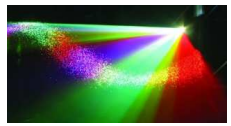
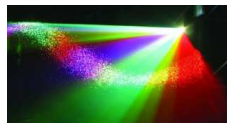


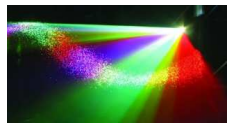
About this Chapter

- The physics of sound.
- The biology of hearing.
- The psychology of auditory perception.
- Auditory output devices, and how they can be used to present auditory content.



What's Next

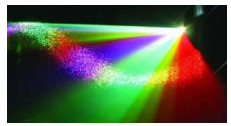
We need to consider the physics of sound.



A Definition

Definition

Sound is a series of vibrations moving as waves through air or other gases, liquids, or solids.



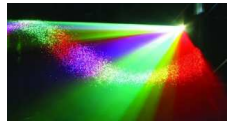
Sound Waves in Air

- Compressions/Condensations:

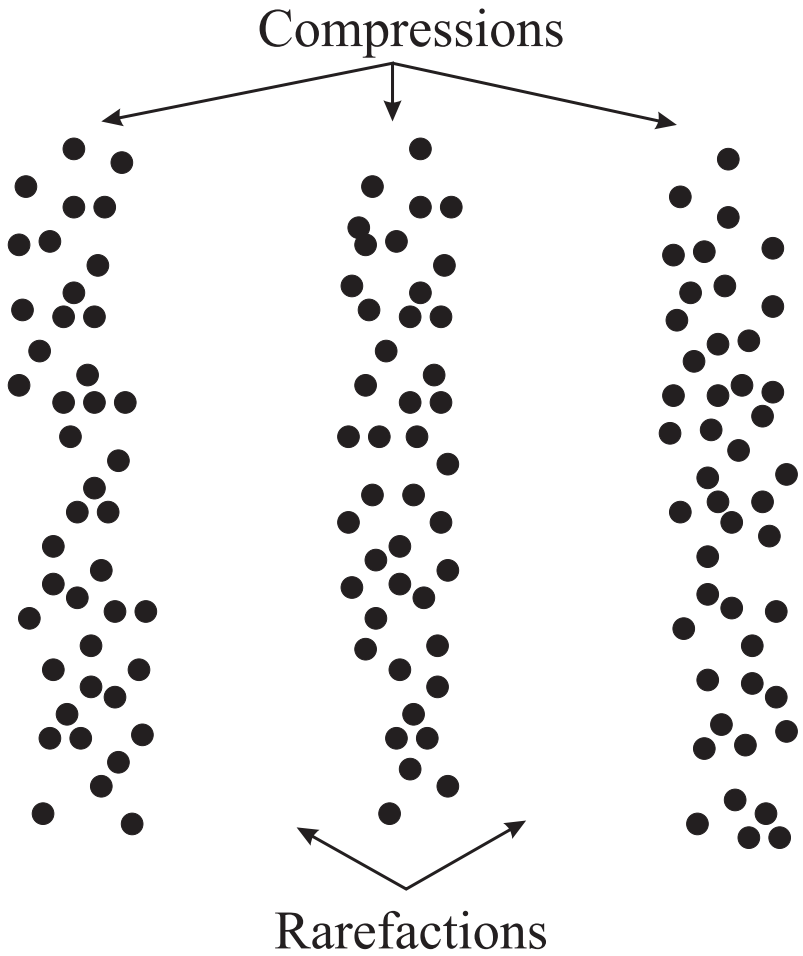
  Air molecules are pushed closer together and, hence, the air pressure is higher.

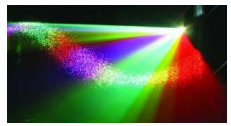
- Rarefactions:

  Air molecules are pulled farther apart and the air pressure is lower.



Sound Waves in Air (cont.)





Properties of Sound Waves in Air

- Longitudinal:

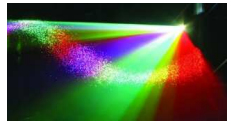
  The wave is in the direction of travel.

- Traveling:

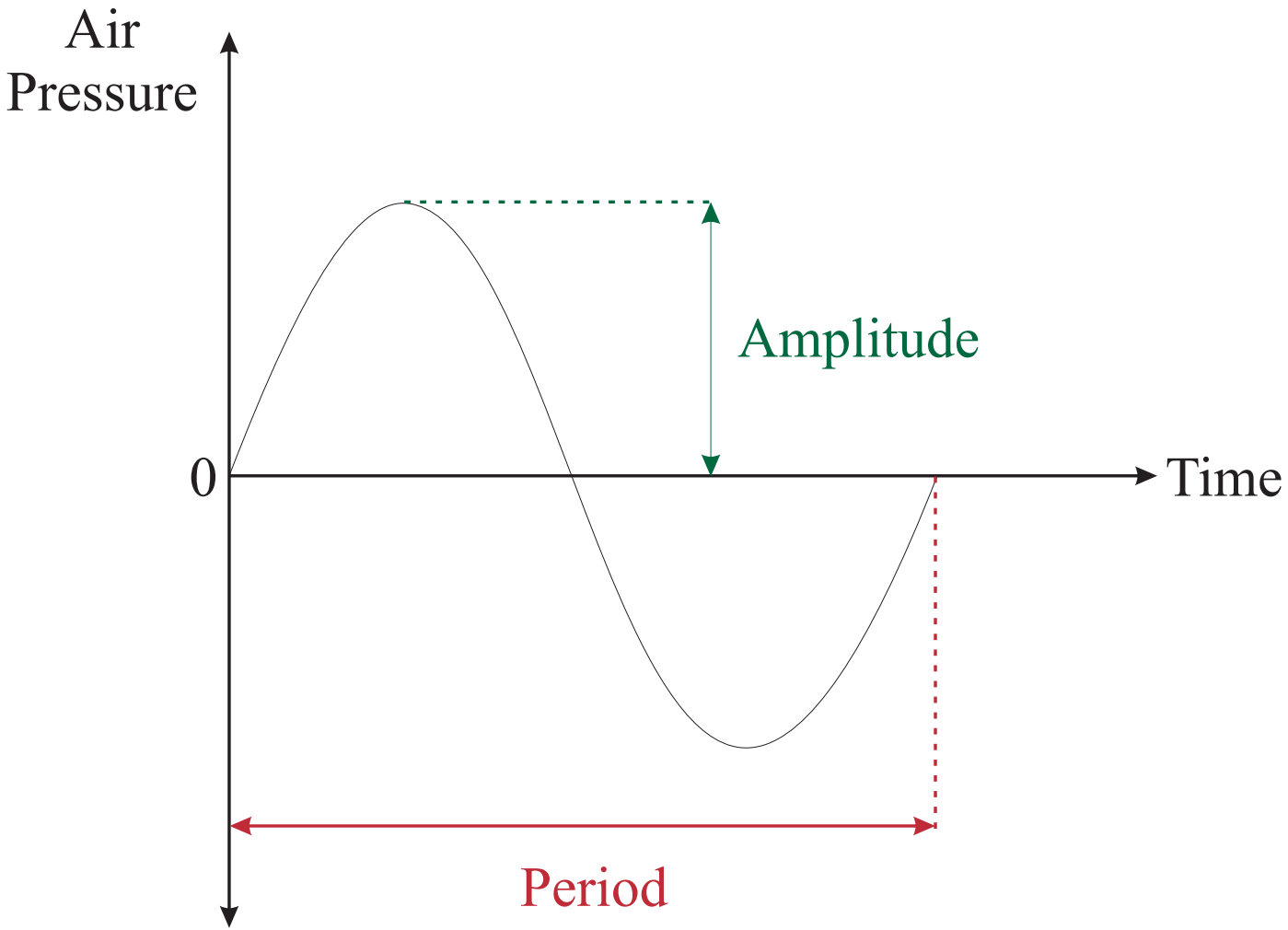
  Air molecules disturb neighboring molecules, transferring their energy to them.

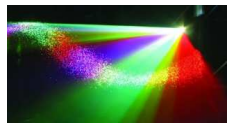
- Omnidirectional:

  The waves typically radiate spherically from the source.



A Periodic Pressure Wave

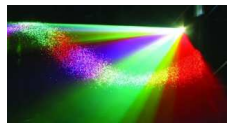




Reflection and Absorbtion

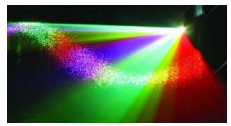
Definition

A *free field* is an environment in which there are no reflections.



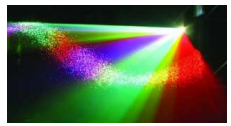
What's Next

We need to consider the biology of hearing.

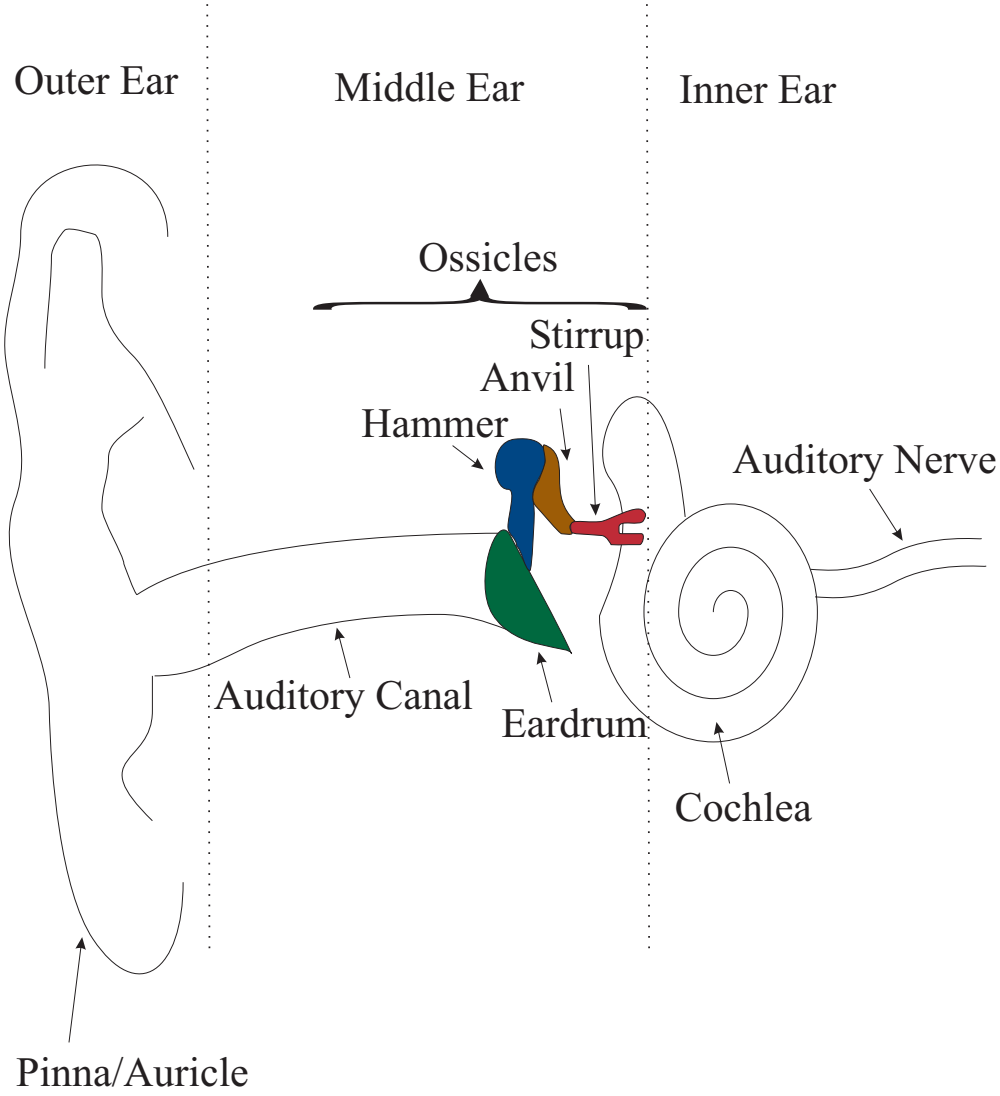


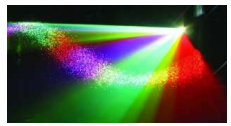
Organs Involved

- We sense sound using organs called ears.
- We interpret the sensation using the brain.



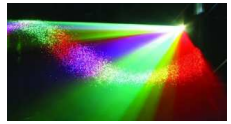
The Human Ear





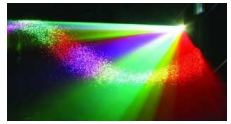
The Sensing Process

- Sound waves are collected by the *auricle/pinna*.
- They travel through the auditory canal to the *eardrum*.
- The compressions and rarefactions result in a change in pressure on the two sides of the eardrum.
- The difference in pressure causes the eardrum to vibrate.



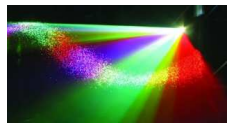
The Sensing Process (cont.)

- The vibrations of the eardrum are transmitted through the *ossicles*.
- The stirrup pushes a membrane and the movement of the membrane is transferred to the *endolymph fluid* in the *cochlea*.
- This causes the *basilar membrane* to move. (Each point on the basilar membrane is 'tuned' to a small range of frequencies.)
- This causes the *stereocilia* to vibrate, causing a voltage difference, that leads to the release of a neurotransmitter which initiates the transmission of impulses along the *auditory nerve*.



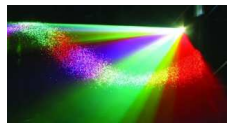
What's Next

We need to consider the psychology of auditory perception.



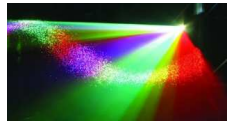
Processing in the Brain

- Most of the output of the auditory nerve is processed in the auditory cortex (in the temporal lobe).
- Some processing is also done in the frontal lobe and the parietal lobe.



Volume – A Simplified Approach

- Sound pressure levels are measured in decibels (dB), which is a logarithmic unit.
- Humans normally perceive differences in amplitude as differences in *volume*.
- 0dB is loosely defined to be the softest sound that is audible to humans.
- 120dB sounds are painful.

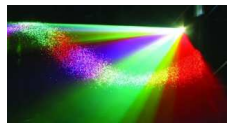


Thresholds

Definition

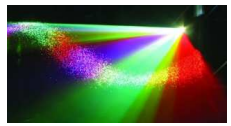
The *threshold* of a neuron is the lowest level of sound that causes a measurable change in response.

- The threshold varies inversely with its spontaneous firing rate.
- Continued exposure to auditory stimuli leads to *adaptation* (an apparent decrease in volume).
- Continued exposure to auditory stimuli also leads to *fatigue* (an increase in the threshold for subsequent stimuli)



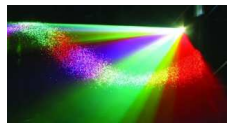
Pitch and Frequency

- The greater the frequency, the higher the pitch.
- Humans can hear sounds from about 15Hz (i.e., 15 cycles per second) to 18kHz (i.e., 18,000Hz).

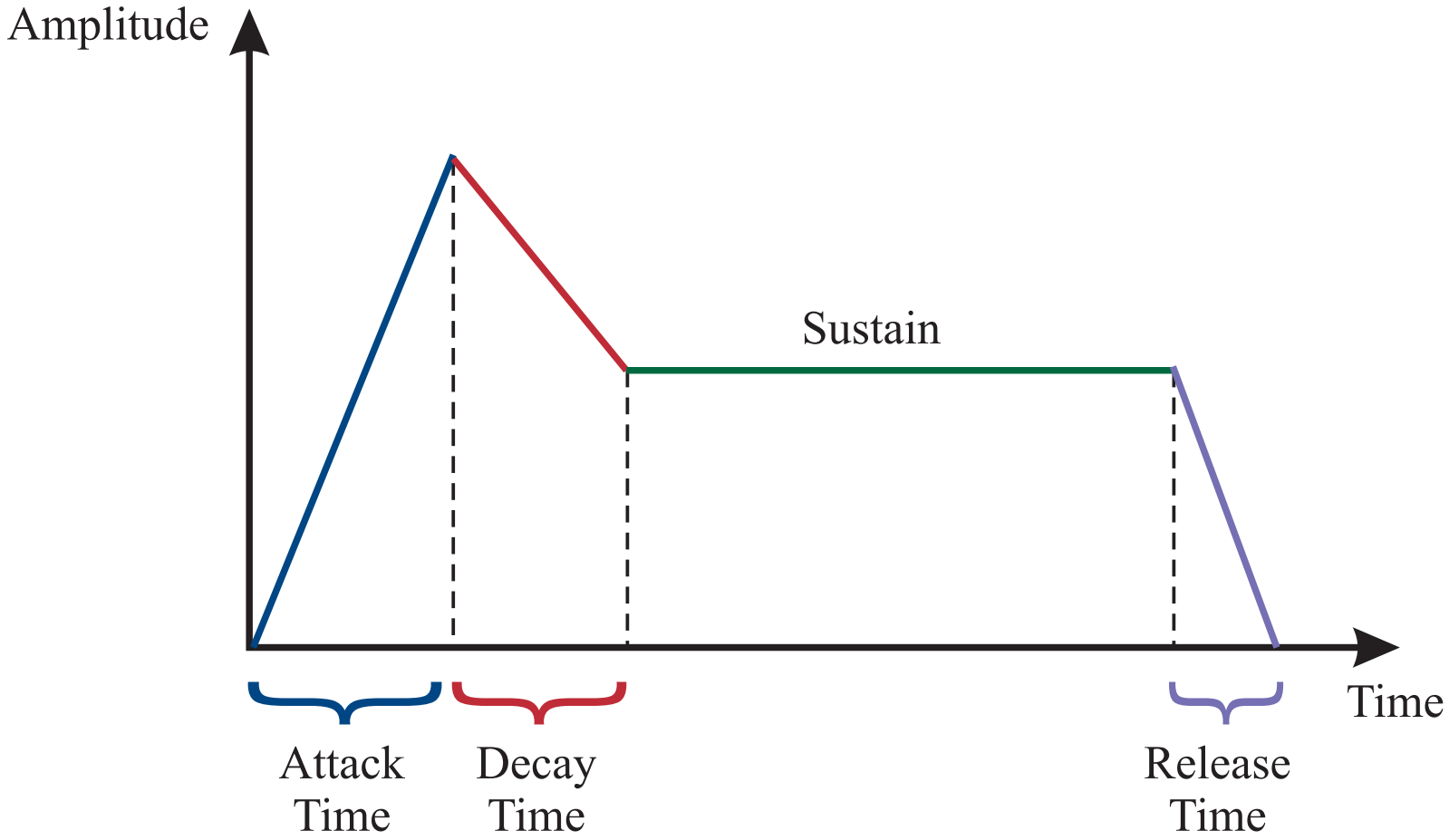


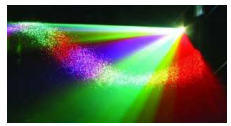
Timbre – The Concept

- Two sound waves with the same pitch and volume, but produced by a piano and a trumpet, are perceived very differently.
- These differences, often referred to as *timbre*, are subjective.



A Stylized Envelope





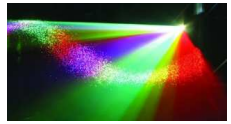
Localization Mechanisms

- *Interaural time difference* – the difference in the time it takes for a sound to reach both ears.

  Most people can detect a difference of about 20 microseconds.

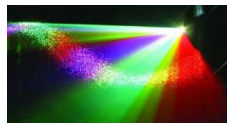
- *Interaural density difference* – the difference in amplitude caused by our head interfering with the sound wave.

- Frequency filtering performed by the outer ear.



Common Uses of the Term "Noise"

- In the context of noise pollution, it usually refers to amplitude.
- In the context of a restaurant, it usually refers to the fact that there are many sources (e.g., many different conversations, televisions, pots and pans) of auditory content.
- In the context of popular music, it usually refers to a anything your mother doesn't like.

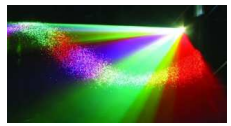


Colors of Noise

Definition

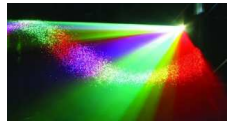
Noise is a signal that is generated by a random process.

- *White noise* is a signal that has equal power in every band with the same width.
- *Red noise* is a signal that arises from a "random walk" (more formally, a signal that arises from Brownian motion).



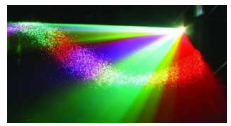
Reflections

- Except in a free field, some sound waves reach the ear directly from the source and others reflect off of one or more surfaces before reaching the ear.
- When a reflected sound wave (with smaller amplitude because of the loss of energy) arrives at the ear after the original sound wave we perceive an echo or reverberation.



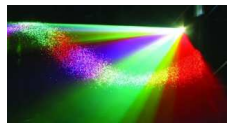
What's Next

We need to consider auditory output devices.



Conventional Loudspeakers

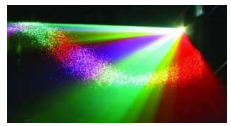
- Components:
  - Diaphragm
  - Electromagnet
  - Basket
- Classification:
  - Subwoofers
  - Woofers
  - Mid-range
  - Tweeters



Aural Rendering

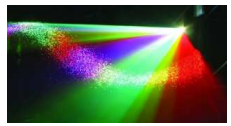
Definition

Aural rendering is the process of taking an internal representation of auditory content and presenting it using an auditory output device.



What's Next

We need to design and auditory content system.

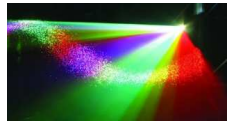


Requirements

F10.1 Manage individual ‘pieces’ of auditory content.

F10.2 Manage ‘aggregate’ auditory content.

F10.3 Render/present auditory content.



A Conceptual Model of an Auditory Content System