



Chapter 2



Basic Science: Analog and Digital Audio

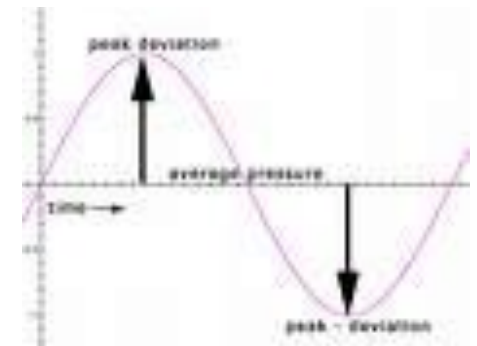
It's an Analog World

- [Analog - Definitions from Dictionary.com](#)
- If a tree falls in the forest, does it make a sound? (see 2.1)
- Cycle, sine wave (see 2.2)
- Cycles per second=frequency
- Heinrich Hertz (Hz)
- kHz (1,000 Hz.)
- MHz (1 million Hz.)



Loudness

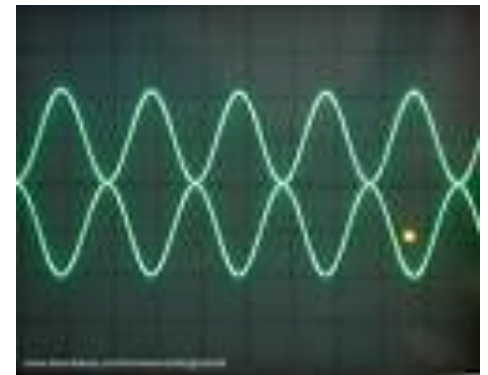
- Sound is created from vibration, compression (high pressure) and rarefaction (minimum pressure) of molecules
- Amplitude – size of sound wave (see 2.3)
- Amplitude is measured in decibels (from Alexander Graham Bell)
- Dynamic range – difference between softest and loudest sound of a given item.
- Humans hear sounds from 0 db to above 120 db (see 2.4)



Phase

- Difference in time in two sound waves as they travel from one place to another.
- Waves “in phase” reinforce each other, amplitude is increased.
- Wave “out of phase” weaken each other, amplitude is decreased (see 2.7 and 2.8).
- If enough out of phase, waves may be nearly inaudible.

Out of phase

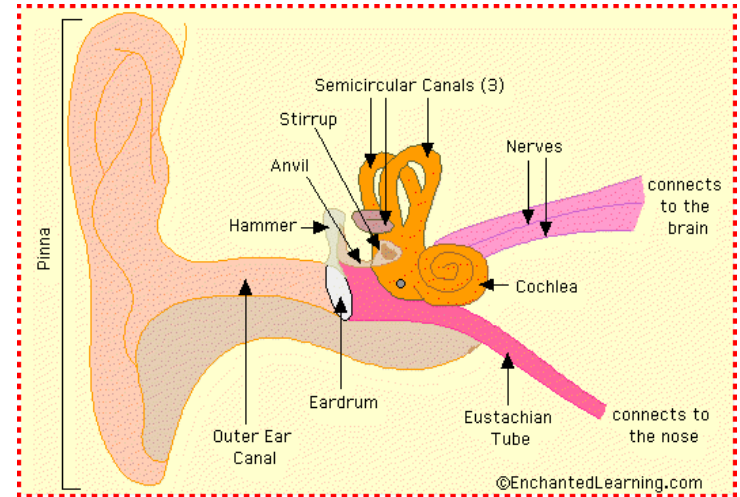


Your ears: How They Work and How to Take Care of Them

- Outer, middle, inner ear (see 2.9)
- Compression, rarefaction push and pull the eardrum back and forth.

[Compression and rarefaction](#)

- Hammer, anvil and stirrup at back of eardrum amplify the sound, transfer sound to cochlea.
- 30,000 hair cells are located in cochlea; each cell connected to auditory nerve.
- Electrical signals sent to the auditory cortex of the brain, and perceived as sound.



You only get one set of ears

- Audio production people are listening to levels 10-15 db higher than in the past.
- Up to 26% of audio and music production personnel have hearing loss.
- Recommended maximum sound pressure in studio should be no higher than 85 db (for monitors and headphones).
- Foam ear plugs reduce sound by up to 30 db.
- One of critical listening tests is to turn monitors down to a low level and see if it sounds clear.



It's a Digital World

- Edison invented first (analog) recording system (the phonograph).
- Analog sound relies on an *analogous* relationship between the original sound wave and its electrical representation; digital does not.
- Analog sound is *continuous*; digital relies on *sampling* of the original sound wave.

[Sampling](#)

- Development of transistor in 1947 made digital technology, using integrated circuits, possible.

[Transistor radio video](#)

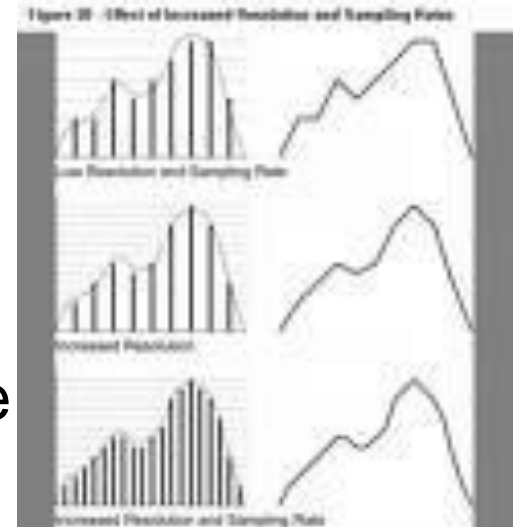
- Sony released first compact disc (CD) player in 1982.



Analog-to-digital conversion

- AD conversion is done by *sampling*; converter reads samples of the analog signal and assigns a binary number to each sample (*quantization*).
- *Nyquist theorem*: sampling must be twice the highest frequency we are recording or playing back (which is related to hearing range).
- So: humans can hear up to about 20,000 Hz.; standard sampling rate for CDs is 44,100 Hz. (44,100 samples per *second*).
- Higher the sampling rate, more accurate the sound.

[Example of sampling rate](#)



Analog-to-digital conversion (continued)

- Morse code is a binary (digital) system.
- Digital words are assigned to samples.
- Two-bit systems allow for four digital “words:” 1-1, 1-0, 0-1, 0-0.
- Four-bit systems (1-1-1-1, 1-1-1-0, etc.) allow 16 binary words, still very crude for reproducing sound (see 2.11).
- Eight-bit systems produce telephone-line quality sound.
- 16-bit systems are standard for recording CDs, and allow 65,536 words (16 to the fourth power).
- Adobe Audition allows up to a 96,000 Hz. sampling rate and 32-bit words.

