

Chapter 2

Sound and Its Measurement

Sound may be regarded objectively if we consider its waves in terms of their frequency, intensity, phase, and spectrum. Sounds may also be studied subjectively, in terms of pitch, loudness, or the interactions of signals producing masking or localization. In discussing sound energy it is always important to specify precisely the various aspects and appropriate measurement references, such as hertz, decibels (IL, SPL, HL, or SL), mels, sones, or phons.

LEARNING OBJECTIVES

Understanding this chapter requires no special knowledge of mathematics or physics, although a background in either or both of these disciplines is surely helpful. From this chapter, readers should be able to

- 2.1 Describe sound waves and their common attributes, and express the way these characteristics are measured.
- 2.1 Discuss the basic interrelationships among the measurements of sound and demonstrate the ability to perform simple calculations (although at this point it is more important to grasp the physical concepts of sound than to gain skill in working equations).
- 2.2 Understand the different references for the decibel and when they are used.
- 2.3 State the difference between physical acoustics and psychoacoustics.
- 2.4 Discuss the reasons for audiometer calibration and what this may entail in general terms.

Vocabulary Items

American National Standards Institute	Amplitude
Aperiodic	Artificial ear
Artificial mastoid	Beats
Bel	Brownian motion
Cancellation	Complex wave
Components	Compression

Cosine wave	Damping
Decibel	Dyne
Elasticity	Erg
Force	Forced vibration
Formant	Fourier analysis
Free vibration	Frequency
Fundamental frequency	Harmonics
Hearing level	Hertz
Intensity	Intensity level
International Organization for Standardization	Inverse square law
Joule	Kinetic energy
Localization	Logarithm
Longitudinal waves	Loudness
Loudness level	Mass
Mass reactance	Microbar
Newton	Octave
Ohm	Oscillation
Overtones	Period
Phase	Phon
Pitch	Potential
Power	Pressure
Quality	Rarefaction
Ratio	Reactance
Resonance	Resonant frequency
Sensation level	Sinewaves
Sinusoidal	Sound level meter
Sound pressure level	Spectrum
Stiffness	Stiffness reactance
Threshold	Transverse wave
Velocity	Vibration
Watts	Wavelength
Waves	Work

Chapter 2 Test Items

Essay Questions

1. Describe what is meant by Sound Pressure Level, Hearing Level and Sensation Level and how these are used.
2. How would you calibrate an audiometer for air conduction and bone conduction, both with and without electroacoustic equipment?

Short Answer Questions

1. Sound travels through air in the form of ____.
2. Three types of waves discussed in this book are ____, ____, and ____.
3. Waves are described as a series of ____ and ____.
4. Two types of vibration described above are ____ and ____.
5. The two major effects on frequency are ____ and ____.
6. The velocity of sound is its ____.
7. The formula for wavelength is ____.
8. The number of beats per second is determined by the difference between two ____.
9. The lowest frequency of vibration in a complex sound is called the ____.
10. Formant frequencies of the human voice are determined by the ____.
11. Two sine waves may be contrasted by their differences in ____, ____, and ____.
12. Decibels cannot be simply added or subtracted because they are ____.

13. The decibel reference on audiometers is _____.
14. Any discussion of decibels must include their _____.
15. The psychological correlate of frequency is _____.
16. The ability to localize sound requires that the individual have _____.
17. The threshold shift of one sound that is caused by the introduction of a second sound is called _____.
18. Audiometer earphones are used to test hearing by _____.
19. An oscillator is placed on the forehead or mastoid to test hearing by _____.
20. The decibel reference used in sound-level meters is _____.

Multiple Choice Questions

1. The zero dB reference level for most sound level meters is
 - a. 20 dynes per cm squared
 - b. 20 micropascals
 - c. 0 dB
 - d. 40 watts
2. One parameter not looked at in electroacoustic calibration of audiometers is
 - a. frequency
 - b. intensity
 - c. duration of tonal presentation
 - d. attenuator linearity
3. The alternating regions of low pressure and high pressure produced by an object's vibration are called, respectively:
 - a. constructive, destructive
 - b. rarefactions, condensations
 - c. condensations, compressions
 - d. troughs, valleys

4. When a sound source produces energy at more than one frequency, the result is a _____ sound.
 - a. sinusoidal
 - b. simple
 - c. loud
 - d. complex

5. The reference value for sound power is:
 - a. 10^{-16} watt/cm²
 - b. 10^{-4} watts/cm²
 - c. 20μPa
 - d. 10^{-12} dynes/cm²

6. A complex sound is found to have the following frequency components: 100 Hz, 200 Hz, 300 Hz, 400 Hz, and 500 Hz. Its fundamental frequency is:
 - a. 50 Hz
 - b. 100 Hz
 - c. 300 Hz
 - d. 500 Hz

7. Complete cancellation of a sound may occur when a _____ encounters a _____.
 - a. rarefaction, rarefaction
 - b. condensation, condensation
 - c. rarefaction, condensation
 - d. deflection, reflection

8. An object has one frequency at which it will vibrate at its greatest amplitude. This frequency is known as the _____.
 - a. peak amplitude
 - b. resonant frequency
 - c. octave frequency
 - d. harmonic frequency

9. Frequency and intensity are _____ measurements of sound.
 - a. physical
 - b. perceptual
 - c. intuitive
 - d. reflective

10. Pitch and Loudness are _____ measurements of sound.
 - a. physical

- b. reflective
 - c. intuitive
 - d. perceptual
11. The amount of time it takes a waveform to complete one cycle is called its _____
- a. wavelength
 - b. phase
 - c. period
 - d. duration
12. The _____ of a sine wave is determined by the number of cycles completed in one second.
- a. phase
 - b. frequency
 - c. duration
 - d. wavelength
13. An increase of _____ dB corresponds to a doubling of sound pressure.
- a. 2
 - b. 4
 - c. 6
 - d. 12
14. At its resonant frequency, a mass vibrates
- a. With the least amount of applied energy
 - b. With the greatest amount of applied energy
 - c. At its least possible amplitude
 - d. As a free vibration
15. The velocity of sound in air is said to be
- a. 20 mph
 - b. 1130 ft/sec
 - c. 5286 ft/sec
 - d. 14.7 mph
16. The period of a sound can be calculated as
- a. Period = 1/frequency
 - b. Period = frequency/1
 - c. Period = $1/\pi$
 - d. Period = frequency/20 μ Pa
17. Masking may take place when
- a. The masker precedes the signal

- b. The signal precedes the masker
 - c. The masker and signal coexist in time
 - d. All of the above
18. If the fifth harmonic of a sound is 500 HZ, the fundamental frequency is
- a. Indeterminable from the above information
 - b. Determined by wavelength
 - c. 100 Hz
 - d. 250 Hz
19. The unit of measurement in equal loudness contours is
- a. mel
 - b. sone
 - c. decibel
 - d. phon
20. The period of a 100 Hz tone is
- a. 1/1000 sec
 - b. 1/100 sec
 - c. 1/10 sec
 - d. 1 sec

Chapter 2 Test Item Answer Key

Essay Items

1. In addition to defining SPL, HL and SL, the student's answer should show an understanding how these relate for audiometric testing.
2. A complete response should include discussion of the different purposes between an artificial ear and artificial mastoid and the need for intensity level calibration as well as frequency and attenuator linearity calibration. The response should include mention of the different couplers for supra-aural earphones and insert receivers as well as acknowledgement that the SPL to reach audiometric zero differs for these two transducers and what this means clinically. Finally, recognition of the difference between electroacoustic calibration and biologic calibration and the need for both should be demonstrated in the answer.

Short Answer Items

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|-----------------------------------|--|
| 1. waves | 12. logarithmic |
| 2. transverse, longitudinal, sine | 13. Hearing Level (HL) |
| 3. compressions, rarefactions | 14. references |
| 4. forced, free | 15. pitch |
| 5. mass, stiffness | 16. similar hearing sensitivity in both ears |
| 6. speed | 17. masking |
| 7. $w=v/f$ | 18. air conduction |
| 8. frequencies | 19. bone conduction |
| 9. fundamental frequency | 20. sound-pressure level |
| 10. vocal tract | |
| 11. frequency, intensity, phase | |

Multiple Choice Items

- | | | |
|------|-------|-------|
| 1. b | 8. b | 15. b |
| 2. c | 9. a | 16. a |
| 3. b | 10. d | 17. d |
| 4. d | 11. c | 18. c |
| 5. a | 12. b | 19. d |
| 6. b | 13. c | 20. b |
| 7. c | 14. a | |

