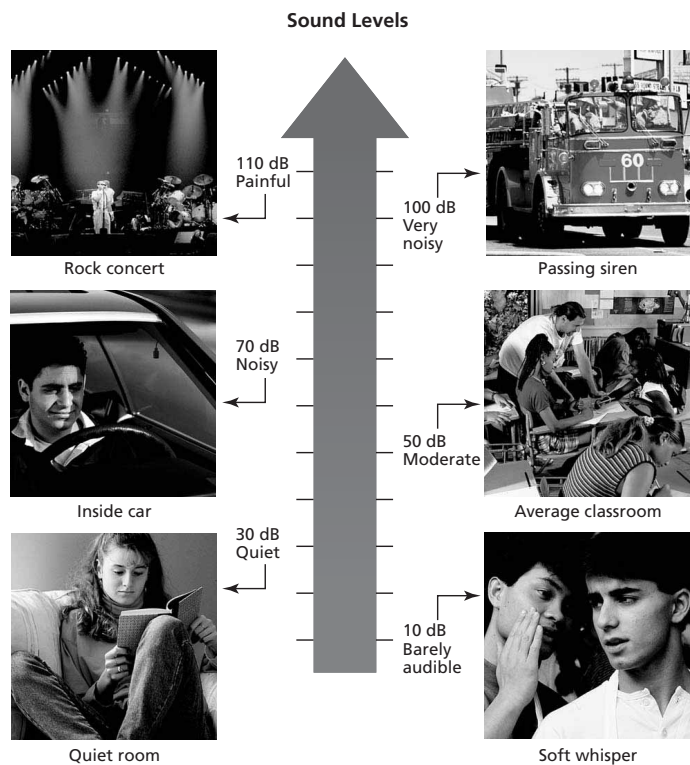


Assume that the speed of sound in air is 341 m/s, at 20°C, unless otherwise noted.

1. If a sound wave is traveling when the temperature is 20°C and has a wavelength of 2.45 m, what is the frequency of the sound?
2. How long is a wave that has a frequency of 440 Hz and is moving through sea water at 1530 m/s?
3. A particular note played on a trumpet has a frequency of 440 Hz. What is the frequency of the note that is one octave higher?
4. While tuning his violin, the violinist compares the pitch his string produces to the pitch produced by an electronic tuner. If the tuner produces a note with a frequency of 412 Hz and the violin plays a note with a frequency of 415 Hz, what is the beat frequency produced?
5. Two instruments are playing so that the beat frequency between them is 4 Hz. If one of them is playing a frequency of 359 Hz, what are the possible frequencies the other instrument is playing?
6. The sound a mosquito makes is produced when it beats its wings at the average frequency of 620 wing beats per second. What is the wavelength of the sound waves produced by the mosquito?
7. You are listening to an outdoor concert on a day when the temperature is 0°C. The sound of a wavelength of 0.490 m is emitted by a flute on the stage 125 m from where you are standing.
 - a. What is the time elapsed before you hear the sound emitted from the stage?
 - b. What is the frequency of the sound?
8. A train is moving at a speed of 90.0 m/s and emits a whistle of frequency 400.0 Hz. Find the frequency observed by an observer who is at rest
 - a. in advance of the moving source and
 - b. behind the moving source.
9. A stationary police car turns on a siren at a frequency of 300 Hz. Find the observed frequency if
 - a. the observer is approaching the police car at 35.0 m/s and
 - b. the observer is receding from the police car at 35.0 m/s.
10. A species of bat navigates by emitting short bursts of sound waves that have a frequency range that peaks at 58.0 kHz. If a bat is flying at 4.0 m/s toward a stationary object,
 - a. What is the frequency of the sound waves reaching the object?
 - b. What is the frequency of the reflected sound waves detected by the bat?
11. A police car traveling at 90.0 m/s, turns on a siren at a frequency of 350 Hz as it tries to overtake a gangster's car moving away from the police car at a speed of 85 m/s. Find the frequency heard by the gangster.
12. Two trains are approaching each other, each at a speed of 100 m/s. They each emit a whistle at a frequency of 225 Hz. Find the frequency that each train engineer hears.

13. A train moving east at a velocity of 20 m/s emits a whistle at a frequency of 348 Hz. Another train, farther up the track and moving east at a velocity of 30 m/s, hears the whistle from the first train. What is the frequency of the sound heard by the second train engineer?
14. You hear the siren of a fire engine as you stand on the side of the road. As it approaches, the siren which broadcasts at a frequency of 645 Hz is heard by you as being 660 Hz. How fast is the fire engine traveling?
15. A friend talks to you as she walks past you at a speed of 2.25 m/s. Why do you not notice a Doppler shift in her voice as she passes?



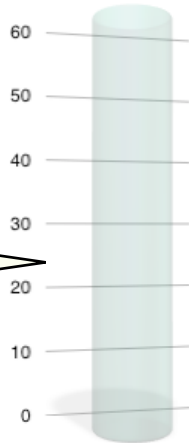
16. What is the typical sound level of a fire engine siren? State your answer in decibels.
17. Rustling leaves have a sound level of about 20 dB. Between which two pictured items does this fall on the scale?
18. Loud talking has a sound level of about 60 dB. Between which two items does this fall on the scale?
19. According to the scale, which is louder: a rock concert or a passing siren?
20. Which item on the scale has a moderate sound level?
21. Which item on the scale can be described as very noisy?
22. The pain threshold for humans is about 110 dB. Which item on the scale might cause the average person discomfort?

23. What decibel level measures a sound 1 billion times louder than one that is 10 dB?
24. What decibel level is five thousand times softer than one that is 86 dB?
25. What decibel level measures a sound that is 80 times softer than one that is 95 dB?
26. How many times louder is a 60 dB sound than the threshold of hearing?
27. How many times softer is a 45 dB sound than one that is 95 dB?
28. How many times louder is a 105 dB sound than one that is 102 dB?
29. If one student is yelling in the cafeteria at 86 dB, what is the level of 200 identical students all yelling at one time?
30. If you turn down the volume on your iPod "halfway", how many decibels lower is a sound that is half as loud?

31. A saxophone plays a tune in the key of B-flat. The saxophone has a second harmonic frequency of 466.2 Hz when the speed of sound is 331 m/s. What is the length of the pipe that makes up the saxophone? A saxophone should be treated as a pipe closed at one end.
32. A clarinetist plays a clarinet on a cold day. At one point she produces the sound of middle F sharp, which has a frequency of 370 Hz, by playing the third harmonic of low B. If the speed of sound in the air is 331 m/s, what is the length of the clarinet? A clarinet resembles a pipe closed at one end.
33. A penny whistle plays a tune in the key of G with a fundamental frequency of 392.0 Hz. The speed of sound in air is 331 m/s. What is the length of the penny whistle? Treat the penny whistle as a pipe closed at one end.
34. An organ pipe that is open at both ends has a fundamental frequency of 370.0 Hz when the speed of sound in air is 331 m/s. What is the length of this pipe?
35. What is the fundamental frequency of a viola string that is 35.0 cm long when the speed of waves on this string is 346 m/s?
36. What is the fundamental frequency of a mandolin string that is 42.0 cm long when the speed of waves on this string is 329 m/s?
37. What is the fundamental frequency of a cello string that is 0.85 m long when the speed of waves on this string is 499 m/s?
38. A pipe that is open at both ends has a fundamental frequency of 277.2 Hz. If the pipe is 0.75 m long, what is the speed of the waves in the pipe?
39. A pipe that is closed on one end has a seventh harmonic frequency of 466.2 Hz. If the pipe is 1.53 m long, what is the speed of the waves in the pipe?
40. A pipe that is open at both ends has a fundamental frequency of 125 Hz. If the pipe is 1.32 m long, what is the speed of the waves in the pipe?
41. A 330 Hz tuning fork is vibrating after being struck. It is placed on a table near but not directly touching other objects, including other tuning forks. Eventually one glass and one other tuning fork start vibrating. Explain why this happens.
42. The first harmonic in a pipe closed at one end is 487 Hz.
- Find the next two harmonic frequencies that will occur in this pipe.
 - What are the corresponding wavelengths of the first three harmonics?
(Hint: assume the speed of sound is 341 m/s)
 - What is the length of this pipe?
 - Repeat this exercise for a pipe open at both ends.
43. A piano tuner uses a 440 Hz tuning fork to tune a string that is currently vibrating at 445 Hz.
- How many beats per second does he hear?
 - What other frequency could produce the same sound effect?

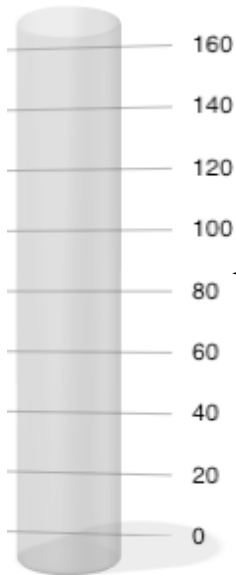
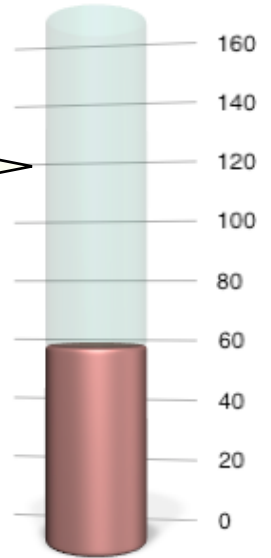
Open Tube

Harmonic _____
Overtone 1st
Wavelength _____
Frequency _____
Length 60 cm
Velocity 341 m/s



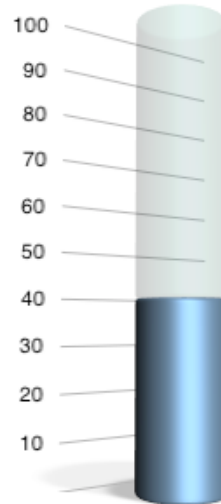
Closed Tube

Harmonic 5th
Overtone _____
Wavelength _____
Frequency _____
Length 100 cm
Velocity 341 m/s



Open Tube

Harmonic 4th
Overtone _____
Wavelength _____
Frequency _____
Length 160 cm
Velocity 341 m/s



Closed Tube

Harmonic _____
Fundamental Frequency
Wavelength _____
Frequency _____
Length 60 cm
Velocity 341 m/s

Guitar String

Harmonic _____
Fundamental Frequency
Wavelength 1.8 m
Frequency _____
Length _____
Velocity 140 m/s



Harp String

Harmonic 3rd
Overtone _____
Wavelength _____
Frequency _____
Length 2.1 m
Velocity 180 m/s

