

1. Find the period of a sound wave of (a) 20.0 Hz and (b) 20,000 Hz.
2. A sound wave has a wavelength of  $2.25 \times 10^{-2}$  m and a frequency of 15 kHz. Find its speed.
8. A 60.0-cm guitar string has a mass of 1.40 g. If it is to play the note A at a fundamental frequency of 440 Hz, what must the tension be in the string?
9. A 1.50-m length of wire with a mass of 0.035 kg is stretched between two points. Find the necessary tension in the wire such that the wave may travel from one end to another in a time of 0.0900 s.
17. The E string of a violin is vibrating at a fundamental frequency of 659 Hz. Find the wavelength and frequency of the third, fifth, and seventh harmonics. Let the length of the string be 60.0 cm.
18. A steel wire that is 1.45 m long and has a mass of 45 g is placed under a tension of 865N. What is the frequency of its fifth harmonic?
22. A sound wave in air has a velocity of 335 m/s. Find the temperature of the air.
23. A lightning flash is observed and 12 s later the associated thunder is heard. How far away is the lightning if the air temperature is 15.0 °C?
27. You are trying to design three pipes for a closed organ pipe system that will give the following notes with their corresponding fundamental frequencies, C: 261.7 Hz, D: 293.7 Hz, E: 329.7 Hz. Find the length of each pipe. Assume that the speed of sound in air is 343 m/s.
28. Repeat problem 27 for an open organ pipe.
4. 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?
7. 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?
2. 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.

29. A train is moving at a speed of 90.0 m/s and emits a whistle of frequency 400.0 Hz. If the speed of sound is 343 m/s, find the frequency observed by an observer who is at rest (a) in advance of the moving source and (b) behind the moving source.

30. A stationary police car turns on a siren at a frequency of 300 Hz. If the speed of sound in air is 343 m/s find the observed frequency if

(a) the observer is approaching the police car at 35.0 m/s

(b) the observer is receding from the police car at 35.0 m/s.

31. 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. If the speed of sound in air is 343 m/s find the frequency heard by the gangster.

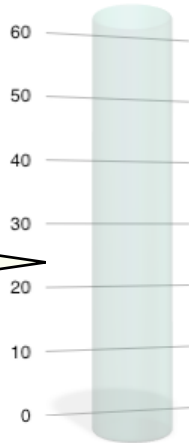
32. Two trains are approaching each other, each at a speed of 100 m/s. They each emit a whistle at a frequency of 225 Hz. If the speed of sound in air is 343 m/s, find the frequency that each train engineer hears.

39. The intensity of an ordinary conversation is about  $3 \times 10^{-6} \text{ W/m}^2$ . Find the intensity level of the sound.

40. An indoor rock concert has an intensity level of 70 dB. Find the intensity of the sound.

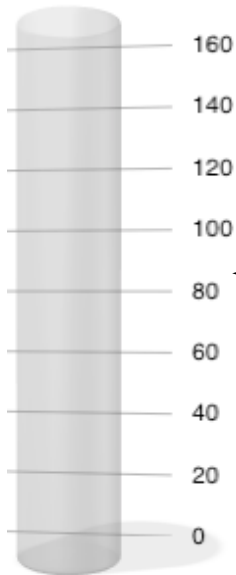
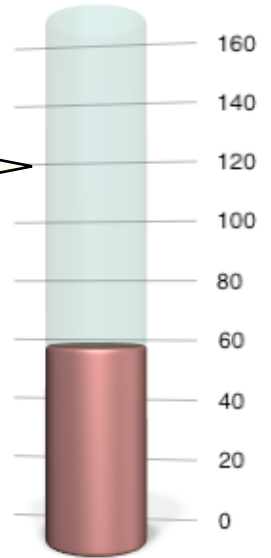
### Open Tube

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



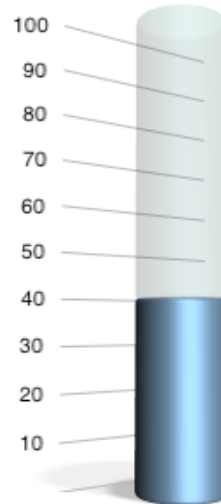
### Closed Tube

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

