Longitudinal waves: Sound waves, seismic waves and graphs of motion*

Free High School Science Texts Project

1 Sound Waves

Sound waves coming from a tuning fork are caused by the vibrations of the tuning fork which push against the air particles in front of it. As the air particles are pushed together a compression is formed. The particles behind the compression move further apart causing a rarefaction. As the particles continue to push against each other, the sound wave travels through the air. Due to this motion of the particles, there is a constant variation in the pressure in the air. Sound waves are therefore pressure waves. This means that in media where the particles are closer together, sound waves will travel quicker.

Sound waves travel faster through liquids, like water, than through the air because water is denser than air (the particles are closer together). Sound waves travel faster in solids than in liquids.

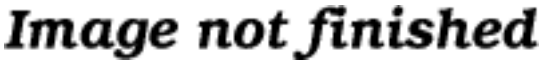

Figure 1: Sound waves are pressure waves and need a medium through which to travel.

TIP: A sound wave is different from a light wave.

- A sound wave is produced by an oscillating object while a light wave is not.

Also, because a sound wave is a mechanical wave (i.e. that it needs a medium) it is not capable of traveling through a vacuum, whereas a light wave can travel through a vacuum.

TIP: A sound wave is a pressure wave. This means that regions of high pressure (compressions) and low pressure (rarefactions) are created as the sound source vibrates. These compressions and rarefactions arise because the source vibrates longitudinally and the longitudinal motion of air produces pressure fluctuations.

Sound will be studied in more detail in Sound[1].

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†http://creativecommons.org/licenses/by/3.0/
[1]"Sound - Grade 10 (11) [CAPS]" <http://cnx.org/content/m37912/latest/>

2 Summary - Longitudinal Waves

1. A longitudinal wave is a wave where the particles in the medium move parallel to the direction in which the wave is travelling.
2. Longitudinal waves consist of areas of higher pressure, where the particles in the medium are closest together (compressions) and areas of lower pressure, where the particles in the medium are furthest apart (rarefactions).
3. The wavelength of a longitudinal wave is the distance between two consecutive compressions, or two consecutive rarefactions.
4. The relationship between the period (T) and frequency (f) is given by

$$T = \frac{1}{f} \text{ or } f = \frac{1}{T} \tag{1}$$

5. The relationship between wave speed (v), frequency (f) and wavelength (λ) is given by

$$v = f\lambda \tag{2}$$

6. Graphs of position vs time, velocity vs time and acceleration vs time can be drawn and are summarised in figures
7. Sound waves are examples of longitudinal waves. The speed of sound depends on the medium, temperature and pressure. Sound waves travel faster in solids than in liquids, and faster in liquids than in gases. Sound waves also travel faster at higher temperatures and higher pressures.

3 Exercises - Longitudinal Waves

1. Which of the following is not a longitudinal wave?
   a. seismic P-wave
   b. light
   c. sound
   d. ultrasound

   Click here for the solution[2]
2. Which of the following media can sound not travel through?
   a. solid
   b. liquid
   c. gas
   d. vacuum

   Click here for the solution[3]
3. Select a word from Column B that best fits the description in Column A:

[2] http://www.fhsst.org/l2d
[3] http://www.fhsst.org/l2v

Column A	Column B
waves in the air caused by vibrations	longitudinal waves
waves that move in one direction, but medium moves in another	frequency
waves and medium that move in the same direction	white noise
the distance between consecutive points of a wave which are in phase	amplitude
how often a single wavelength goes by	sound waves
half the difference between high points and low points of waves	standing waves
the distance a wave covers per time interval	transverse waves
the time taken for one wavelength to pass a point	wavelength
	music
	sounds
	wave speed

Table 1

Click here for the solution[4]

4. A longitudinal wave has a crest to crest distance of 10 m. It takes the wave 5 s to pass a point.
   a. What is the wavelength of the longitudinal wave?
   b. What is the speed of the wave?

   Click here for the solution[5]
5. A flute produces a musical sound travelling at a speed of $320\,m \cdot s^{-1}$. The frequency of the note is 256 Hz. Calculate:
   a. the period of the note
   b. the wavelength of the note

   Click here for the solution[6]
6. A person shouts at a cliff and hears an echo from the cliff 1 s later. If the speed of sound is $344\,m \cdot s^{-1}$, how far away is the cliff?
   Click here for the solution[7]
7. A wave travels from one medium to another and the speed of the wave decreases. What will the effect be on the ... (write only *increases*, *decreases* or *remains the same*)
   a. wavelength?
   b. period?

   Click here for the solution[8]

[4] http://www.fhsst.org/l2w
[5] http://www.fhsst.org/l2f
[6] http://www.fhsst.org/l2G
[7] http://www.fhsst.org/l27
[8] http://www.fhsst.org/l2A