Lesson Description

In this lesson we:

- Define a longitudinal wave
- Compare longitudinal and transverse waves
- Discuss sound as a longitudinal wave
- Solve longitudinal wave problems

Demonstration

- Play with a slinky spring.
- PhET Simulation
  [http://phet.colorado.edu/sims/wave-on-a-string/wave-on-a-string_en.html](http://phet.colorado.edu/sims/wave-on-a-string/wave-on-a-string_en.html)

Key Concepts

**Longitudinal Waves**

A longitudinal wave is a wave where the particles in the medium move parallel to the direction of propagation of the wave.

A medium is the substance or material through which a pulse or a wave moves.

By comparison:

A transverse pulse where all of the particles disturbed by the pulse move perpendicular (at a right angle) to the direction in which the pulse is moving.

- direction of motion of wave
- motion of particles in spring is back and forth

A compression is a region in a longitudinal wave where the particles are closest together.

A rarefaction is a region in a longitudinal wave where the particles are furthest apart.

- compressions
- rarefactions

The wavelength in a longitudinal wave is the distance between two consecutive points that are in phase. i.e. between two consecutive compressions or between two consecutive rarefactions.

The amplitude is the maximum displacement from equilibrium.
i.e. this would be the maximum increase (or decrease) in pressure from the equilibrium pressure that is caused when a compression (or rarefaction) passes a point.

The frequency of a wave is the number of wavelengths per second. Symbol: $f$ measured in hertz (Hz)

$$f = \frac{1}{T}$$

The speed of a wave - same as the speed of transverse waves:

Wave speed is the distance a wave travels per unit time

$$v = \frac{\text{distance travelled}}{\text{time taken}} = \frac{\lambda}{T}$$

$$v = \lambda \cdot f$$

Summary table of Physical Quantities in Waves

<table>
<thead>
<tr>
<th>Physical Quantities</th>
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</thead>
<tbody>
<tr>
<td><strong>Quantity</strong></td>
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<tr>
<td>Amplitude ($A$)</td>
</tr>
<tr>
<td>Wavelength ($\lambda$)</td>
</tr>
<tr>
<td>Period ($T$)</td>
</tr>
<tr>
<td>Frequency ($f$)</td>
</tr>
<tr>
<td>Wave speed ($v$)</td>
</tr>
</tbody>
</table>

**Key Concepts**

**Sound Waves**

A **longitudinal wave** is a wave where the particles in the medium move **parallel** to the direction of propagation of the wave.

Sound waves are pressure waves caused by objects which are vibrating. Sound waves **need a medium through which to travel.**

As the source of the sound vibrates it creates regions of high pressure and regions of low pressure.

Speed of sound waves depends on the medium.
- **Phase:**
  - Solids: particles are closer together – therefore sound waves move fastest in solids.

- **Temperature:**
  - Higher temperature – particles move faster, higher kinetic energy – therefore sound waves move faster.

- **Air pressure:**
  - Higher air pressure – therefore waves move faster found at sea level where air is denser.

**Applications**

Echoes: Sound waves are reflected off smooth surfaces. You can hear a repeat of “hello” a split second later.

This reflecting property of sound waves is used in Sonar, by animals like bats and dolphins – Echolocation.

**Key Concepts**

\[ \text{velocity} = \frac{\text{displacement}}{\text{time}} \]

Remember that the distance traveled by the sound wave is twice the distance away from the reflecting object.

Other properties of sound:

**Pitch** of sound relates to the **frequency** of the sound wave. e.g middle “C” is 256 Hz. The higher the pitch the higher the frequency.

The human ear can detect a wide range of frequencies. Frequencies from 20 to 20 000 Hz are audible to the human ear. Any sound with a frequency below 20 Hz is known as an infrasound and any sound with a frequency above 20 000 Hz is known as an ultrasound.

**Loudness** of sound relates to the **amplitude** of the sound wave. The higher the amplitude the louder the sound.
Questions

Question 1

A flute produces a musical note travelling at a speed of 320 m.s\(^{-1}\). The frequency of the note is 256 Hz. Calculate:

a. The period of the note.
b. The wavelength of the note.

Memo answer to Question 1

Solution:

a) \( T = \frac{1}{f} \)

\[
T = \frac{1}{256} = 0.00391 \text{ Hz or } 3.91 \times 10^{-3} \text{Hz}
\]

b) \( v = \lambda \cdot f \)

\[
\lambda = \frac{v}{f} = \frac{320}{256} = 1.25 \text{ m}
\]

Question 2

Calculate the speed of sound in air if it takes 1.3 s for you to hear an echo when the distance from you to the reflecting surface is 450 m.

Links

- [www.everythingscience.co.za](http://www.everythingscience.co.za)
- PhET Simulation [http://phet.colorado.edu/sims/wave-on-a-string/wave-on-a-string_en.html](http://phet.colorado.edu/sims/wave-on-a-string/wave-on-a-string_en.html)