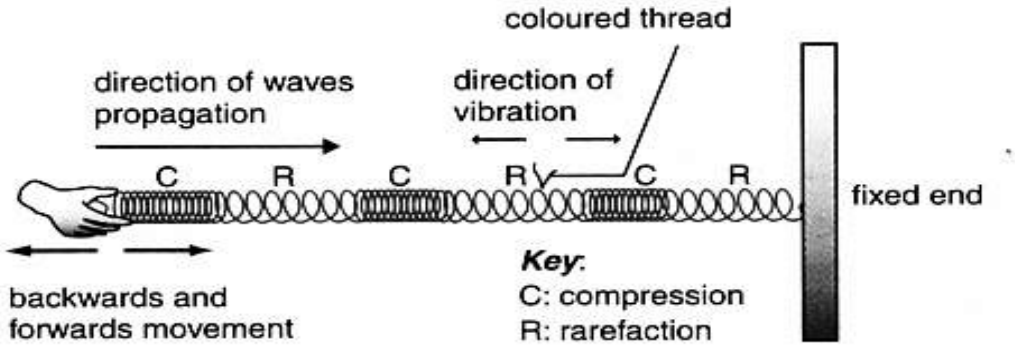
CHAPTER 13: WAVES

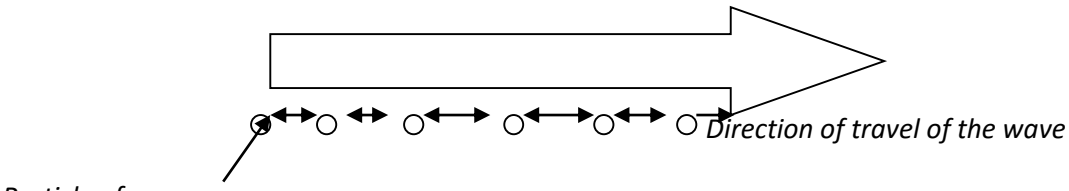
13.0 INTRODUCTION

A **wave** is a disturbance which can transfer energy without the particles of wave having to move from one place to another.

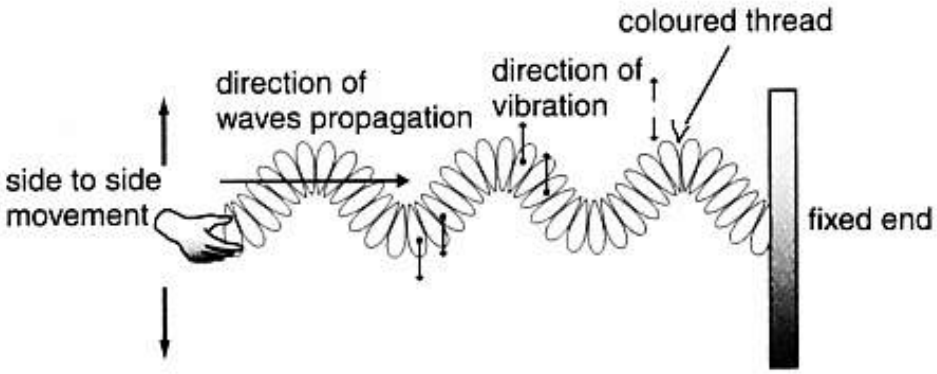
13.10 TYPES OF WAVES

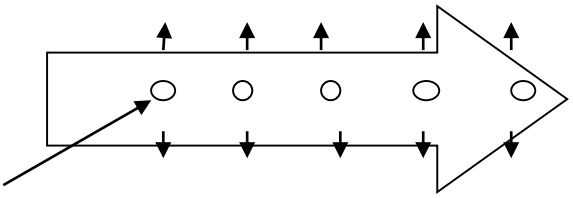
1. **Longitudinal waves**: are waves where the particles of the wave vibrate parallel to the direction of propagation.
   Eg. *Sound waves, pulses on slinky.*





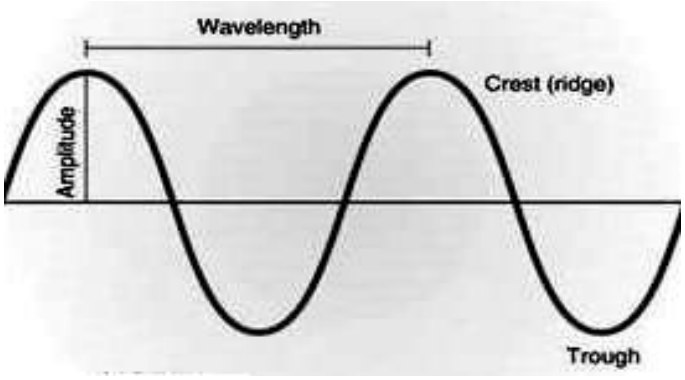
2. **Transverse waves**: where the particles vibrate perpendicular to the direction of propagation of the wave.
   Eg: *Light waves, waves on a string.*





Direction of travel of the wave

Particle of wave



13.20 DEFINITIONS

1. *Amplitude:* is the maximum displacement of the particle from its equilibrium (rest) position.
2. *Frequency*: number of waves passing a point in one second.
   Units: Hertz (Hz)

3. *Period, T*: is the time taken for one wave to pass any point.

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

4. *Wavelength* λ*:* is the distance between two successive corresponding positions in a wave.

   E.g.: distance between crest – crest.

The wave velocity, frequency and wavelength are related by the wave equation:

$$v = f \times \lambda$$

where: v = wave velocity (m/s)

f = frequency (Hz)

λ = wavelength (m)

Note:

$v = f \times \lambda$ but $f = \frac{1}{T}$ *therefore* $v = \frac{\lambda}{T}$

Examples:

1. A string vibrates with a frequency of 400Hz. Find the period and the wavelength of the sound wave produced if the velocity of sound is 332 m/s?
   Frequency= 400Hz

   Period = $\frac{1}{frequency}$

   $= \frac{1}{400\ Hz}$

   = 0.0025 s

   velocity = frequency x wavelength

   332m/s= 400Hz x wavelength

   wavelength= $\frac{332\ \text{m/s}}{400\ \text{Hz}}$

   Wavelength= 0.83 m

2. 6 complete waves of wavelength 2.5 m pass a point in 1 second. Calculate the velocity of the wave.

   Velocity = frequency x wavelength

   Velocity = 6 x 2.5 m

   Velocity = 15 m/s

13.30 ECHO

An echo is the sound you hear when you make a noise and the sound wave reflects off a distant object. Besides the novelty of hearing your words repeated, echoes can be used to estimate the distance of an object, its size, shape and velocity, as well as the velocity of sound itself.

Sound is a waveform made from vibrating matter. The sound wave travels through matter—especially air—in a straight line. When the wave hits a different material, some of it is reflected, absorbed and transmitted through the material. In the case of a sound wave in air hitting a solid wall, most of the sound is reflected then you can hear the reflected waveform or echo.

Since sound travels at approximately 300 meters per second and if a wall is 15 meters away, the sound would return in 0.1 second. This can be seen from the relationship:

$$d = V \times t$$

where d = the distance the sound wave traveled back and forth,
V = velocity of sound, and
t = the time it takes the sound to go back and forth.

t = 30 m / 300 m/s = 0.1 sec.

Note that the distance was doubled to show the back and forth motion of the sound.

13.40 EXERCISES

1. A ship using an echo sounding device receives an echo from the bottom 0.8 s after the sound is emitted. If the velocity of sound in water is 1500 m/s, what is the depth of water?

2. Orange light has a wavelength of 600 nm. Calculate the frequency if the speed of light in vacuum ($c = 3 \times 10^8$ m/s).

3. A particular TV program is transmitted by electromagnetic wave of frequency 7.5×10^8 Hz, which travel at the speed of 3×10^8 m/s. Calculate the wavelength and period of the wave?

4. A man stands 200 m away from a foot of the hill and shouts. The echo is heard 1.2 seconds later. Calculate the speed of sound in air.

5. A man standing 504 m from a cliff claps his hands and hears the echo 3 s later. Calculate the velocity of sound.