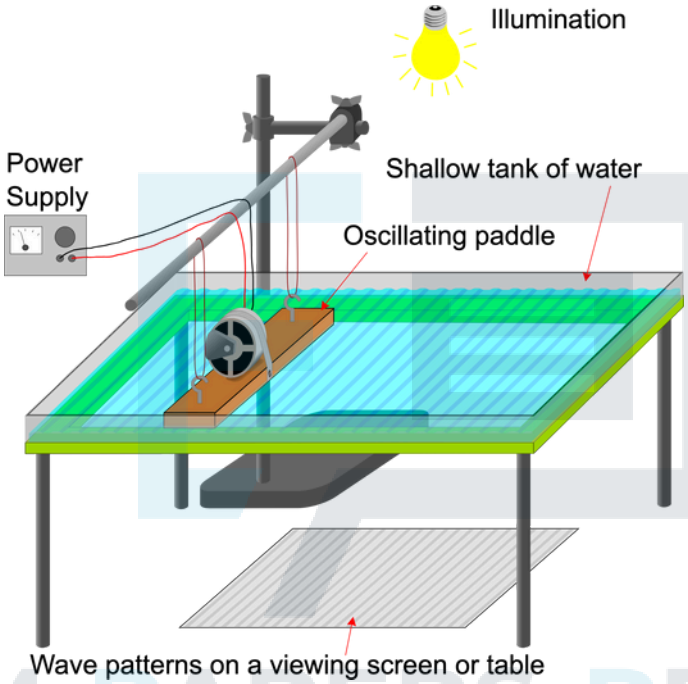
Chapter 14:

Properties of Waves

14.1 Describing Waves

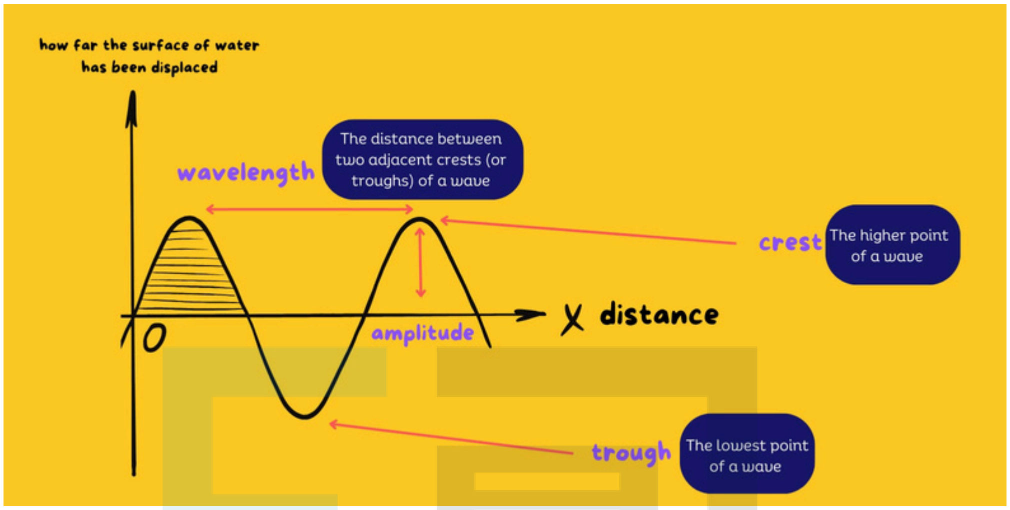
1. Physicists use waves as a model to describe the behavior of light, sound, and electromagnetic radiation.
2. Observing water waves helps us understand how waves behave because they are easily observable.
3. To better understand the wave model, a ripple tank can be used.



4. Various ripple patterns can be generated in different ways:
   a. Straight ripples
   b. Circular ripples
5. How are ripples generated?
   a. Ripples are created by vertical vibrations.
   b. A vibrating bar or dipper moves water molecules up and down.
   c. This movement then affects neighboring water molecules.
   d. While waves transfer energy, water molecules return to their original positions after the wave passes, demonstrating that waves transfer energy but not matter.

14.1.1 Wavelength and amplitude

1. Labelling the wave (x-axis = distance) Label wavelength, crest, and trough



2. The horizontal axis shows the distance, x, travelled by the wave.
3. The vertical axis shows how far the surface of the water has been displaced from its normal level.
4. In a ripple tank, the wavelength of ripples can measure a few millimeters, while their amplitude typically ranges from one to two millimeters.

Definition:

1. Crest/Peak: The crest in a wave is the highest point of the wave's amplitude.
2. Trough: The trough in a wave is the lowest point of the wave's amplitude.
3. Wavelength: Wavelength in a wave is the distance between successive crests or troughs.

14.1.2 Frequency and period

1. Labelling the wave (x-axis = time) Label period and frequency

2. Frequency and period

a. Frequency in a wave is the number of crests (or troughs) passing a point per unit of time, measured in hertz (Hz).

b. Period in a wave is the time taken for one complete cycle (one wavelength) to pass a given point, reciprocally related to frequency.

Formula:

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

Examples:

	Sea Waves	A high pitch sound
Frequency / Hz		1000
Period / s	10	

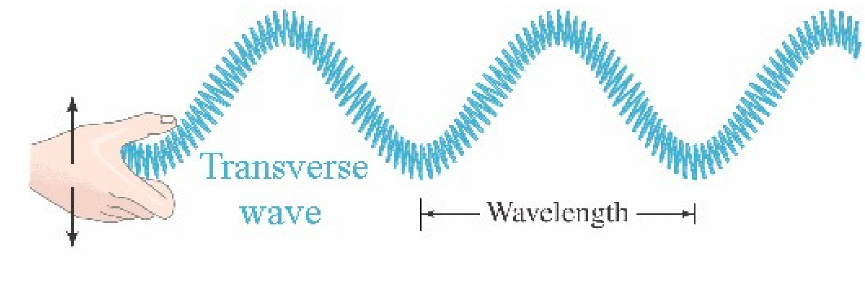
14.1.3 Wave speed

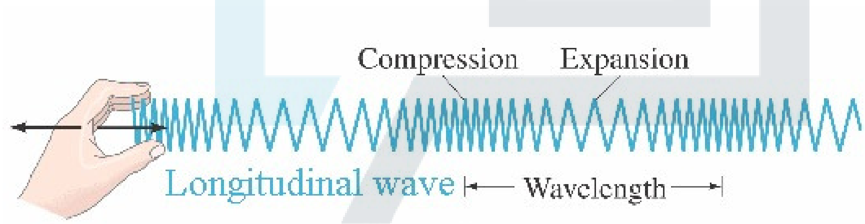
1. The wave speed is the rate at which the crest of a wave travels.
2. Waves can have very different speeds
    a. Ripple - Few centimeters per second
    b. Sound Waves - 330 m/s
    c. Light Waves - 300000000 m/s

14.1.4 Waves and energy

1. The speed of a wave corresponds to how quickly it transfers energy from one location to another.
2. A wave with a larger amplitude transfers more energy.
3. Waves transfer energy without transferring matter.
4. Earthquakes:
    a. Earthquakes are triggered by the transmission of energy through waves.
    b. Vibrations traveling through the Earth can lead to building collapses.
    c. Seismometers detect the vibrations caused by earthquakes.
    d. During an earthquake, two types of seismic waves occur:
        i. Primary seismic waves (fast-moving)
        ii. Secondary seismic waves (slow-moving)

14.1.5 Transverse and longitudinal waves





Definition:

1. Transverse wave: A transverse wave is a wave in which the oscillations or vibrations are perpendicular to the direction the wave travels.
2. Longitudinal wave: A longitudinal wave is a wave in which the oscillations or vibrations are parallel to the direction the wave travels.

Examples of transverse:

Transverse waves	**Longitudinal waves**
Ripples on water	Sound
Light and all other electromagnetic waves	Primary seismic waves (P-waves)
Secondary seismic waves (S-waves)	

14.2 Speed, frequency, and wavelength

Speed formula:

$$v = f\Lambda$$

- The speed is the number of waves passing per second multiplied by the length of each wave.

Worked Example 1:

A communication satellite emits signals with a wavelength of 1.8 meters and a frequency of 300 MHz. What is the speed of these signals?

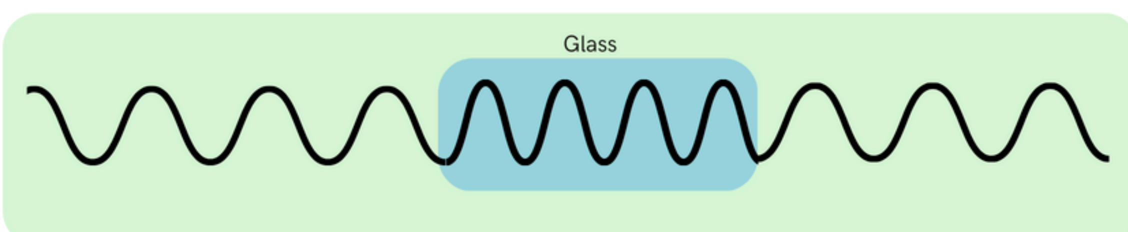
Worked Example 2:

The highest note on a guitar has a frequency of 4320 Hz. What is the wavelength of the sound waves produced when this note is played?

Assume that the speed of sound in air = 340 m/s. Give your answer to two significant figures.

14.2.1 Speed of waves on different materials

1. When waves transition from one material to another, their speed typically alters.
2. Examples:
   a. Light moves slower in glass compared to air.
   b. Sound travels faster in steel than in air.
3. Despite changes in wave speed, the frequency of the waves remains constant.
4. The wavelength of the waves is what undergoes alteration in such transitions.



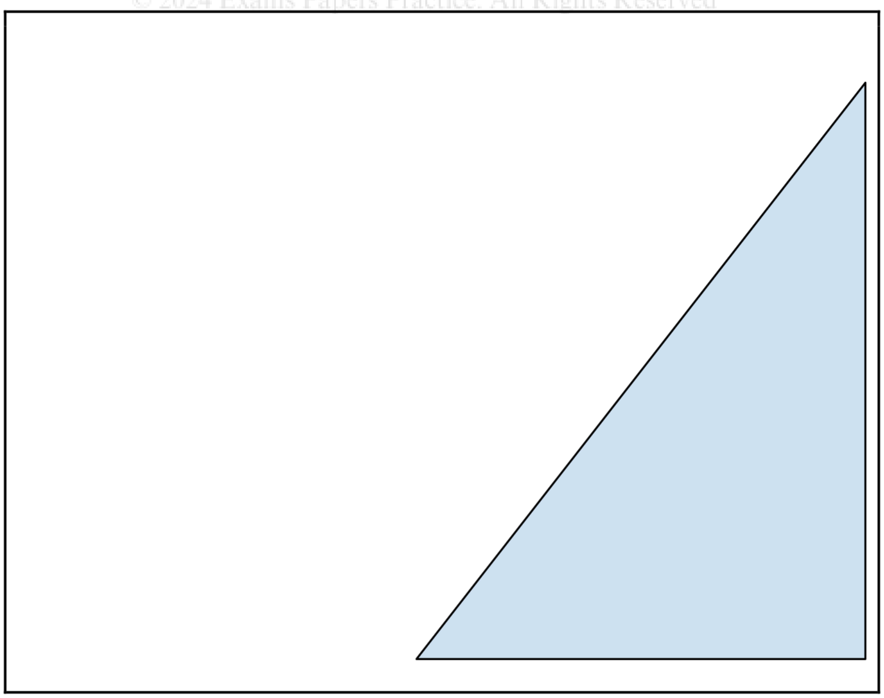
14.3 Explaining Wave Phenomena

14.3.1 Reflection of ripples

1. The diagram above provides a top-down view of the ripples.
2. The line depicted represents the crests of the ripples, known as wavefronts.
3. The distance between wavefronts is equal to the wavelength of the ripples.

14.3.2 Refraction of ripples

1. Refraction of light occurs when the speed of light changes as it moves from one medium to another.
2. The wavefront diagram below illustrates how the pattern of wavefronts changes when light travels through a shallower region.

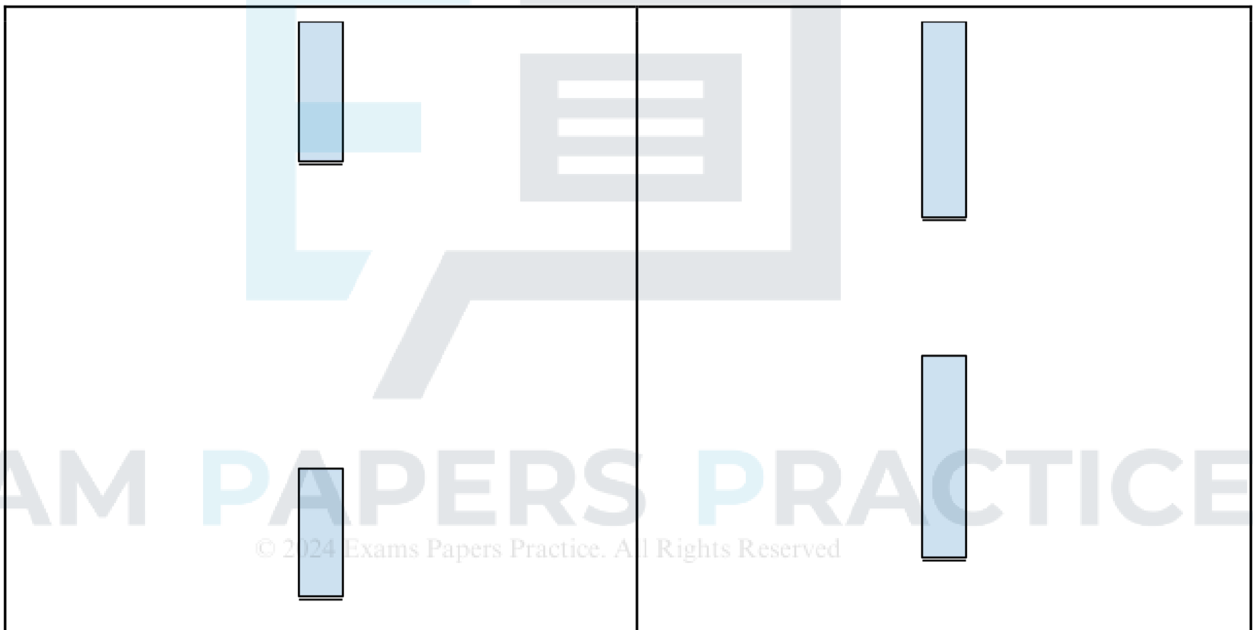


3. When a water wave travels from a deep region to a shallow region:
    a. The ripples move slower, resulting in a decrease in wavelength.
    b. The rays illustrate how the ripples change direction, becoming closer to the normal as they slow down.

<u>14.3.3 Diffraction</u>

<u>Illustrating Diffraction</u>

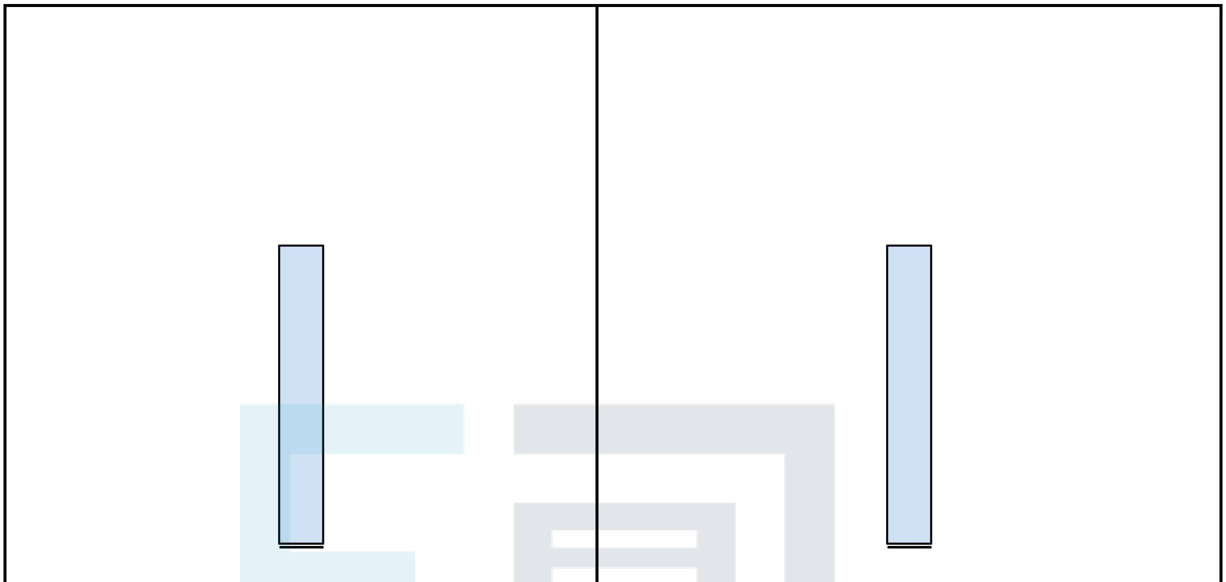
A. Passing through a gap



<u>Observation:</u>

1. Diffraction is greatest when the width of the gap matches the wavelength of the waves undergoing diffraction.

B. Passing through an edge



Observation:

1. Increasing the wavelength of waves increases the angle of diffraction.

Definition:

1. Diffraction: Diffraction is the bending or spreading of waves as they encounter an obstacle or pass through an opening, causing them to change direction and spread out.

Example of diffraction (1) - Sound

1. Sound waves exhibit diffraction when passing through doorways and open windows.
2. This phenomenon allows us to hear a person around a corner even when they are not visible.
3. This observation supports the concept that sound travels in wave form.

Example of diffraction (2) - Light

1. Light waves are diffracted when they pass through very tiny gaps.
2. Example: Halo of light

3. Explanation: Light is diffracted by tiny droplets of water in the air.