

Student's Learning Outcomes (SLOs)

After studying this chapter, students will be able to:

- prove that waves transfer energy without transferring matter.
- describe what is meant by wave motion [as illustrated by vibrations in ropes and springs and by experiments using water waves].
- State the types of waves:
 - (i) transverse waves
 - (ii) longitudinal waves
- describe the features of a wave [in terms of wave front, wavelength, frequency, time period, crest (peak), trough, compression, rarefaction, amplitude and wave speed].
- define the terms frequency, wavelength and amplitude.
- recall and apply the equation wave speed = frequency $\times$ wavelength; $v = f\lambda$
- illustrate that for a transverse wave the direction of vibration is at right angles to the direction of the energy transfer [including giving examples such as electromagnetic radiation, waves on the surface of water, and seismic waves].
- illustrate that for a longitudinal wave, the direction of vibration is parallel to the direction of the energy transfer [including giving examples such as sound waves and seismic P-waves (primary)].
- describe how waves can undergo reflection, refraction and diffraction (using ripple tank).
- describe how wavelength affects diffraction at an edge.
- describe how wavelength and slit size affect diffraction through a slit.
- analyze the phenomenon of tsunamis generated under the surface of water [in terms of underwater earthquakes/volcanic activity generating waves that increase in frequency and amplitude as they encounter increasingly shallow water].

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

Introduction

Q1: What is wave? Describe its importance.

Ans. The concept of waves demonstrates the transfer of energy from one place to another without the transfer of the matter.

Importance:

Waves play a vital role in understanding various phenomena of our everyday life.

Waves are all around us from small ripples on a quiet lake to the loud sound of thunder in the sky.

12.1

Waves and Nature of Waves

Q.2: Define waves. Explain the nature of waves. How do waves transfer energy without the transfer of matter? Support your answer with examples.

Ans. Waves:

"Waves can transfer energy from one place to another without transferring matter."

OR "A wave is a disturbance that travels through a medium, transferring energy from one point to another without the physical transfer of matter."

Mechanism: As waves travel through a medium, they cause the particles within it to vibrate. These vibrations allow energy to be transferred from one particle to the next as shown in Fig. 12.1.

Particle behavior: The particles themselves do not move along with the wave. They simply oscillate around their original position.

Energy Transfer: Energy is passed from one particle to the next through these vibrations.

Illustrative examples:

i. Water waves (Ripples):

When a twig is dropped into still water, ripples spread across the surface, as shown in Fig. 12.2. These ripples carry energy outward, yet the water and twig remain mostly in place.

- **Observation:** These ripples carry energy from the center.

- **Matter check:** If you watch a leaf on the water, it bobs up and down but does not move forward with the ripple. This proves the water itself is staying in place while the energy moves through it.



Fig 12.2: Ripples in water showing energy transfer without transfer of matter

ii. Sound waves:

When a guitar string is plucked, it creates vibrations that travel through the air as sound waves (Fig. 12.3)

- **Observation:** These vibrations create a wave that travels to our ears.

- **Matter check:** The air particles do not travel from the guitar to your ear. Instead, they vibrate in place, passing the energy forward to neighbouring particles until it reaches the listener.

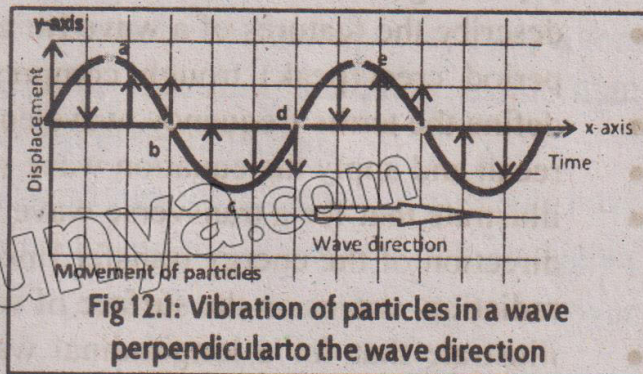
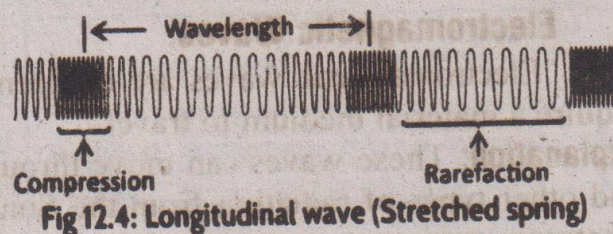
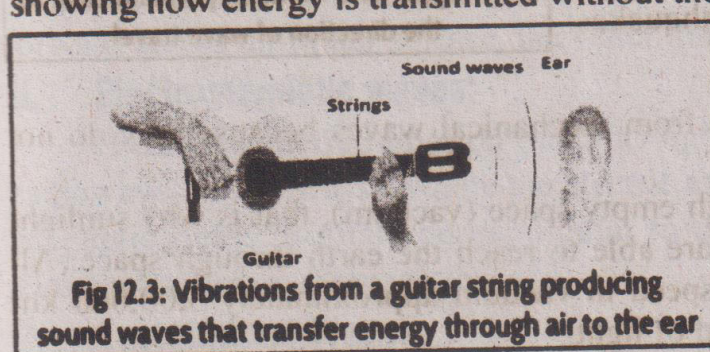


Fig 12.1: Vibration of particles in a wave perpendicular to the wave direction

iii. Spring (slinky):

When one end of a stretched spring is pushed and released, longitudinal waves move through the spring as shown in Fig. 12.4.

- **Observation:** The spring develops regions of compression (where the coils are close together) and rarefaction (where the coils are spread out).
- **Matter check:** These compressions and rarefactions travel along the spring, showing how energy is transmitted without the entire spring moving forward.

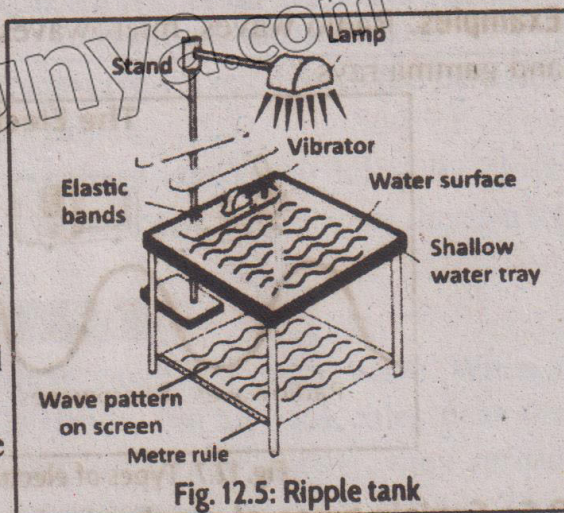


Q.3: Explain a simple and effective way to understand wave motion through an experiment?

Ans. Water wave Experiment to Demonstrate Wave Motion: A simple and effective way to understand wave motion is through an experiment using a ripple tank, as shown in Fig. 12.5.

Setup: In this setup

- A shallow tray is filled with water to a uniform depth.
- A bar, connected to a motor, vibrates up and down gently on the water's surface.
- This disturbance generates ripples or wave crests that spread outward across the water surface.



12.2

Types of Waves

Q.4: Explain types of waves?

(OR) What are mechanical and electromagnetic waves? Explain

Ans. Types of waves: There are two main types of waves:

- Mechanical waves
- Electromagnetic waves

1. Mechanical Waves:

"Mechanical waves are waves that require a material medium such as air, water, or a solid material to travel."

Explanation: These waves cannot pass through vacuum because they rely on the vibration of particles in the medium to transfer energy. The particles of the medium vibrate and pass the energy along, even though the particles themselves do not move with the wave.

Observation in rope. A simple way to observe this is by moving one end of a rope up and down. The wave travels along the rope, but each part of the rope only moves vertically while the wave itself moves forward, as shown in Fig. 12.6.

Examples: Examples of mechanical waves include sound waves, water waves, vibrations on a rope or spring, and seismic waves produced by earthquakes.

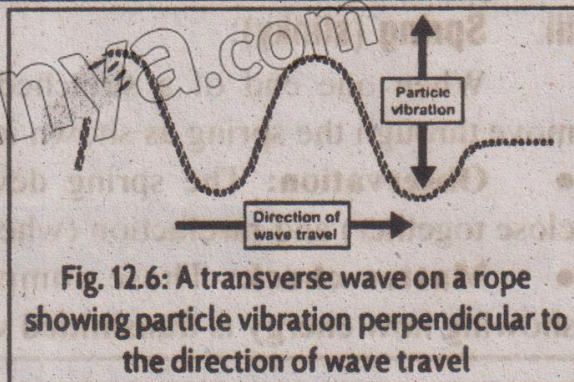


Fig. 12.6: A transverse wave on a rope showing particle vibration perpendicular to the direction of wave travel

2. Electromagnetic Waves:

"Electromagnetic waves are different from mechanical waves because they do not require a material medium to travel."

Explanation: These waves can move through empty space (vacuum), that is why sunlight and other types of radiation from the Sun are able to reach the earth through space. All electromagnetic waves travel at the same speed in vacuum approximately 3,00,000 km per second ($3 \times 10^8 \text{ ms}^{-1}$), known as the speed of light.

The electromagnetic spectrum: These waves differ in their wavelengths and frequencies. The full range of these waves is called the electromagnetic spectrum as illustrated in Fig. 12.7.

Examples: Radio waves, microwaves, infrared rays, visible light, ultraviolet rays, X-rays, and gamma rays.

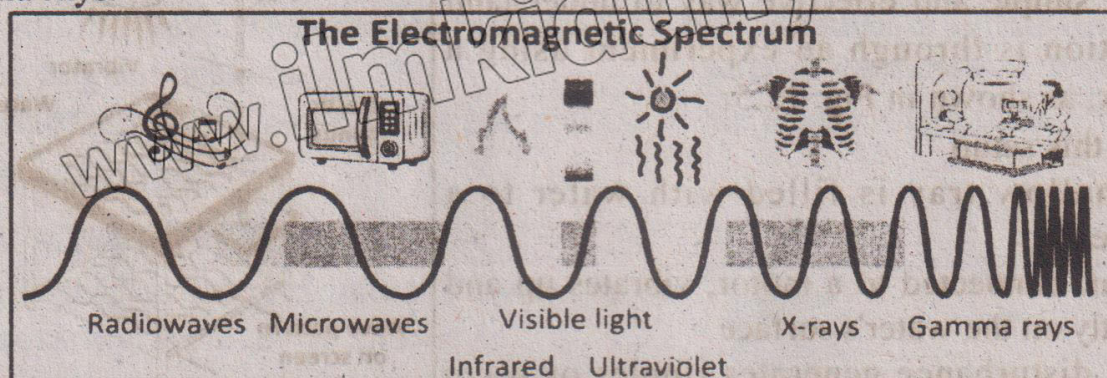


Fig. 12.7: Types of electromagnetic waves arranged by wavelength

Q.5: Explain types of mechanical waves.

Ans. Types of mechanical waves:

Mechanical waves are divided into two main types, depending on how the particles of the medium vibrate in relation to the direction the wave travels. These are:

1. Transverse Waves
2. Longitudinal Waves

1. Transverse Waves:

"In transverse waves, the particles of the medium vibrate at right angles to the direction in which the wave is travelling."

Explanation: This perpendicular vibration causes the energy to transfer through the medium without any significant forward movement of the particles themselves.

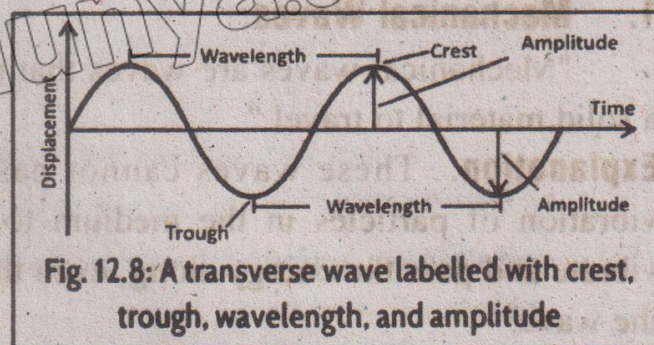


Fig. 12.8: A transverse wave labelled with crest, trough, wavelength, and amplitude

Crests and troughs: These waves consist of the highest points known as crests and the lowest points called troughs.

Example: If you hold one end of a rope and move it up and down. While the wave travels horizontally along the rope, the rope segments move vertically.

Examples:

i. Water waves:

An excellent example of a transverse wave is a water wave. As the wave moves forward across the water surface, the water molecules move up and down.

ii. Electromagnetic waves:

Electromagnetic radiation (such as light, radiowaves, and X-rays), where the electric and magnetic fields oscillate perpendicular to the direction of energy propagation.

2. Longitudinal Waves:

"In longitudinal waves, the particles of the medium vibrate parallel to the direction in which the wave is travelling."

Explanation: Instead of moving up and down like in transverse waves, where the particles move back and forth along the same path as the energy flow.

Compressions and rarefaction: This motion creates regions where particles are close together, known as compressions, and regions where particles are spread apart, known as rarefactions (Fig. 12.9).

Example of sound waves:

A common and important example of a longitudinal wave is a sound wave. When a sound is produced, such as when someone claps his hands, the air molecules near the hands are first pushed together, forming a compression. Immediately after, they spread apart into a rarefaction as the wave continues to move forward through the air. This sequence of compressions and rarefactions allows sound to travel to our ears without the air itself moving permanently from the source to the listener.

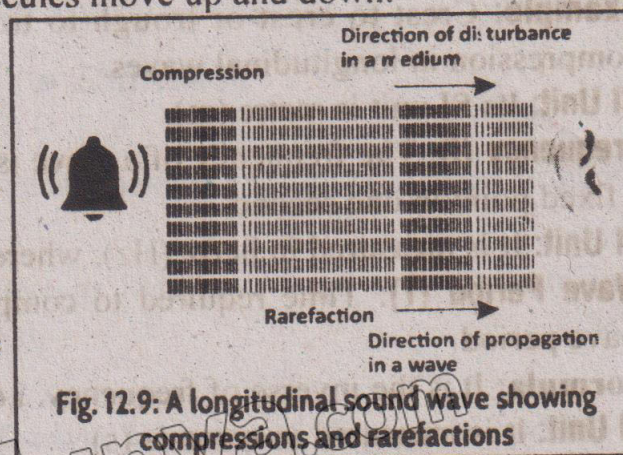


Fig. 12.9: A longitudinal sound wave showing compressions and rarefactions

12.3

Terms and Parameters of Waves

Q.6: Define following terms and parameters:

Crest, Trough, Compressions, Rarefactions, Amplitude, Wavelength, Frequency, Wave period, Wave Front.

Ans. Crest:

The crest is the region of a transverse wave, above the mean position. It is the upper part of a wave.

Trough: The trough is the region of a transverse wave, below the mean position. It is the lower part of a wave.

Compression: A compression is a region in a longitudinal wave where the particles of the medium are close together, resulting in high pressure.

Rarefaction: A rarefaction is a region in a longitudinal wave where the particles are spread apart, resulting in low pressure.

Amplitude: The amplitude of a wave is the maximum displacement of a point on the wave from its undisturbed (rest) position. It indicates the energy carried by the wave.

Wavelength (λ): The wavelength is the distance between two corresponding points on adjacent waves.

Example: Crest to crest or trough to trough in transverse waves, or compression to compression in longitudinal waves.

SI Unit: Its SI unit is metre (m).

Frequency (f): The frequency of a wave is the number of complete wave cycles that pass a fixed point in one second.

SI Unit: It is measured in hertz (Hz), where; 1 Hz = 1 wave per second.

Wave Period (T): Time required to complete one wave to pass a fixed point is called wave period.

Formula: It is the inverse of frequency. i.e. $T = 1/f$.

SI Unit: It is measured in seconds (s).

Wave Front: A wave front is an imaginary surface on which all the points have same phase of vibration (i.e., have the same displacement and direction of motion).

It represents the leading edge of the wave as it travels through a medium.

Q.7: Express the mathematical representation of wave speed (v)/ wave equation?

Ans. The wave speed is the rate at which the wave propagates through a medium.

Mathematical representation:

As,

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

Let us consider a wave:

$$\text{Distance travelled} = \lambda \text{ (wavelength)}$$

$$\text{Time taken} = T \text{ (time period)}$$

Then $v = S/t$

Since $S = \lambda$ and $t = T$

Substitute into the formula:

$$v = \frac{\lambda}{T} \dots\dots\dots (12.1)$$

Now, $\frac{1}{T} = f$ (Where f is frequency)

So, $v = f \times \lambda \dots\dots\dots (12.2)$

where,

v = The wave speed (in meters per second)

f = The frequency (in Hertz)

λ = The wavelength (in metres).

Equation (12.2) is known as wave equation. This is used to calculate wave speed.

Q.8: Briefly explain the properties of waves?

Ans. Properties of Waves:

One of the most fascinating aspects of waves is how they behave when they encounter obstacles or pass from one medium into another. These behaviours are essential for understanding how energy travels through different materials.

Wave behaviors:

These behaviors includes.

- Reflection
- Refraction
- Diffraction

1. Reflection of Waves:

Reflection occurs when waves strike a surface and bounce back into the same medium.

2. Refraction of Waves:

This is the change in direction of a wave as it passes from one medium into another, typically caused by a change in its speed.

3. Diffraction of Waves:

This involves the spreading or bending of waves as they pass through in opening or around the edge of an obstacle.

Q.9: Describe the reflection of waves using a ripple tank experiment and explain how the incident and reflected wave fronts are observed?

Ans. Reflection of waves:

"Reflection is the bouncing back of waves into the same medium after striking the surface of another medium." (OR)

"Reflection is a fundamental property of waves that occurs when waves strike a surface and bounce back into the same medium. This behavior is common to all types of waves, including water, sound and light."

Experimental observation (The Ripple Tank):

Reflection can be clearly observed using a ripple tank, which is a shallow glass container filled with water often used in classroom.

Setup: In a ripple tank setup, straight water waves are generated by a vibrating bar moving across the tank.

Process: When these waves strike a straight barrier placed in their path, they reflect from the surface.

The Law of Reflection: The way waves bounce off a surface is not random; it follows a specific mathematical rule.

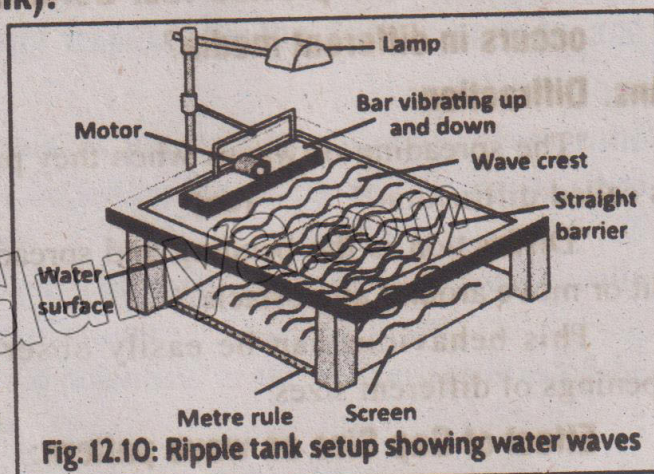


Fig. 12.10: Ripple tank setup showing water waves

Angle of incidence: The angle at which the incoming waves approach the barrier.

Angle of reflection: The angle at which the waves reflect away from the barrier.

The Law: These two angles are always equal to one another.

Angle of incidence = Angle of reflection

Q.10: Explain the reflection of waves.

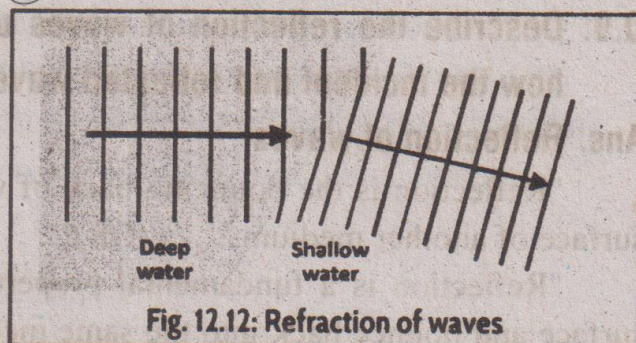
Ans. Reflection of waves:

"When a wave passes from one medium into another at an angle, its wavelength and speed change, causing the wave to change direction. This process is called refraction."

(or) "Refraction occurs when waves pass from one medium into another and change direction due to change in speed."

Process: As the water waves cross into this shallow region, they slow down and bend, demonstrating the refraction of waves. Although the speed and wavelength of the waves change during this process, their frequency remains the same. This bending occurs because waves travel faster in deeper water and slower in shallow water, creating a noticeable change in direction.

This change in wave behaviour is also illustrated in Fig. 12.12, where wave fronts are shown bending as they pass from deep water into shallow water, with a shorter wavelength in the shallow region. The bending clearly shows how the direction and spacing of the waves are affected by the depth of the water.



Q.11: What is diffraction? Describe the factors that influence the amount of diffraction and provide real-world examples to explain how this phenomenon occurs in different media?

Ans. Diffraction:

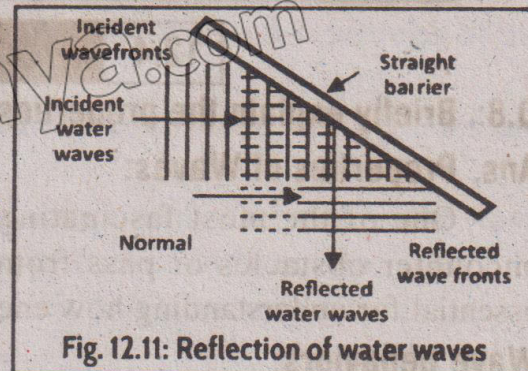
"The spreading of waves when they pass through a slit or move around an obstacle is called diffraction." (or)

"Diffraction is the bending and spreading of waves as they pass through a narrow slit or move around an obstacle."

This behaviour can be easily observed in water waves when they encounter openings of different sizes.

● **Effect of Gap Size on wave pattern:**

The visual pattern of the wave changes significantly based on how the gap size compares to the wavelength.



- **Gap wider than wavelength:**

When the size of slit is wider than the wavelength, the waves pass mostly straight through with only slight bending at the edges (Fig. 12.13-a).

- **Gap nearly equal to wavelength:**

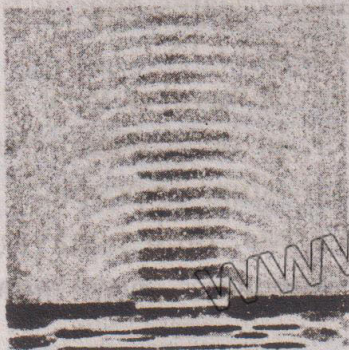
If the slit size is nearly equal to the wavelength, the waves spread out more and appear almost circular beyond the gap (Fig. 12.13-b).

- **Gap smaller than wavelength:**

When the size of slit is smaller than the wavelength, the waves show maximum diffraction, forming strong circular patterns (Fig. 12.13-c).

This shows that the amount of diffraction increases when the size of slit is closer to or smaller than the wavelength of the waves.

Example: A common example is how we can still hear someone speaking even when he is behind a wall. This happens because sound waves, which have relatively long wavelength diffract around corners and obstacles, allowing the sound to reach us even without a direct line of sight.



(a) Size of slit is larger than the wavelength of the water waves



(b) Size of slit is the same as the wavelength of the water waves



(c) Size of slit is smaller than the wavelength of the water waves

Fig. 12.13: Diffraction of water waves

12.5

Seismic and Tsunami Waves

Q.12: Compare seismic waves and tsunami waves in detail, highlighting their sources, nature of motion, speed, energy transfer on the Earth's surface and coastal regions.

Ans. Seismic and tsunami waves are natural waves produced by disturbances in the Earth's crust and ocean. Understanding them is important for safety and readiness since they have the potential to do a great deal of harm.

Seismic Waves: Seismic waves are those that pass through the earth and are typically created by earthquakes, volcanic eruptions, or explosions.

Seismometers detect these waves, which aid scientists in their investigations of the Earth's insides.

- **Primary Waves (P-Waves):**

These are the fastest seismic waves and the first to be detected during an earthquake.

Explanation: P-waves can travel through solids, liquids, and gases. They move by compressing and expanding the material in the same direction as the wave travels, similar to a slinky toy being pushed and pulled. This compressional movement where alternating regions of high and low density represent compressions and rarefactions.

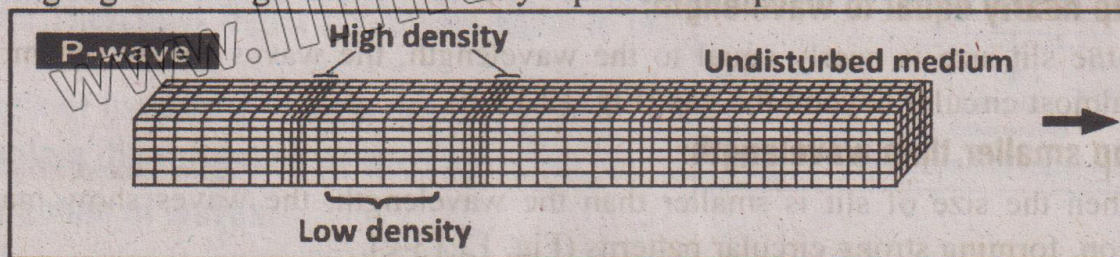


Fig. 12.14: P-wave showing longitudinal motion

Tsunami waves: Tsunamis are extremely large and powerful ocean waves caused by sudden disturbances under the sea.

These disturbances may include underwater earthquakes, volcanic eruptions, or landslides.

Explanation: When such events occur, they can cause a sudden shift in the ocean floor, which pushes a huge volume of water upward. This disturbance creates energy that spreads across the ocean as long, fast-moving waves, as shown in Fig. 12.15.

Characteristics of Tsunami Waves: In the deep ocean, tsunami waves travel at very high speeds, often reaching up to 800 kilometres per hour. However, in deep water, these waves are often just a few centimeters in height and go unnoticed by ships or people.

Coastal areas: As tsunami waves approach shallow coastal areas, their behaviour changes dramatically due to their interaction with the sea floor.

1. Wave speed decreases:

As the water becomes shallower, the bottom of the wave touches the ocean floor, slowing the wave down.

2. Wavelength shortens:

The distance between wave crests becomes smaller.

3. Frequency increases:

More waves arrive at the shore in a shorter period of time.

4. Amplitude increases:

As the energy gets compressed into a smaller space, the wave height increases significantly.

5. Towering waves:

This transformation can result in towering waves, sometimes reaching heights of 30 meters (100 feet) or more, causing severe coastal flooding, destruction of buildings, and loss of life.

6. Real-life example:

A tragic real-life example is the 2004 Indian Ocean tsunami, caused by a massive undersea earthquake near Sumatra. The earthquake displaced a huge section of the ocean floor, triggering tsunami waves that travelled across thousands of kilometres. These

waves struck the coastlines of countries such as Indonesia, Sri Lanka, India, and Thailand, reaching heights of over 15 meters in some areas and causing massive devastation and loss of more than 230,000 lives.

DO YOU KNOW?

Radiowaves are electromagnetic waves that travel at the speed of 3,00,000 kilometre per second through air.

Out at sea, a tsunami is only about 1 m high, and could pass a boat without being noticed, as it approaches the shore. Its sudden deceleration from about 250ms^{-1} to 15ms^{-1} creates the enormous waves.



Brain Teaser

1. When we shake a stretched slinky spring side-to-side and then push it back and forth. What two types of waves did we just create?

Ans. Transverse and longitudinal waves.

2. Two waves travel at the same speed, but one has a higher frequency. Which has the shorter wavelength?

Ans. The wave with the higher frequency has the shorter wavelength.

3. If waves do not carry matter, how does a tsunami destroy buildings when it hits the shore?

Ans. A tsunami destroys buildings by transferring the immense energy it carries to the shore, exerting powerful forces that can overcome the structural integrity of buildings.

Tidbits

1. Why do waves move energy from one place to another without dragging particles with them?

Ans. Waves carry energy across oceans, air, and even empty space without dragging particles along with them.

2. Describe infrared radiation and explain why it is committed by warm objects?

Ans. Infra means below, infrared waves have a lower frequency than red waves. Warm objects radiate light in the infrared region of the spectrum.

3. What does frequency tell us, and why is an FM radio station called 88.0 MHz?

Ans. Frequency tells us how many waves pass a point in the second. That is why FM radio station is called "88.0 MHz". It is sending 88 million waves cycles per second.

4. Explain the time period with an example?

Ans. The time period tells how long one complete wave takes to pass a point like the rhythm heartbeat of the wave.

5. Explain why tsunamis are not caused by tides and describe their real causes?

Ans. Though often called tidal waves, tsunamis are not caused by tides they are the result of undersea earthquakes, landslides, or volcanic eruptions.

Examples

12.1 A wave takes 5 seconds to complete 10 cycles. If the wavelength of the wave is 1.2 metres, calculate:

(a) frequency of the wave

(b) speed of the wave

Solution:

Given that; Number of cycles = 10

Time $t = 5$ seconds

Wavelength $\lambda = 1.2$ m

To find: (a) Frequency $f = ?$

(b) Speed of wave $v = ?$

We know that: $f = \text{Number of cycles} / \text{Time}$

$$f = 10 / 5 = 2 \text{ Hz}$$

As $v = f \times \lambda$

Substituting the values $v = 2 \times 1.2 = 2.4 \text{ ms}^{-1}$

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

12.1

Waves and Nature of Waves

- Waves is transferred from one place to another by:
(a) Matter (b) Energy (c) Particles (d) Medium
- When a wave travels through a medium, the particles of the medium:
(a) Travel with the wave to the destination (b) Move in a straight line for ever
(c) vibrate as oscillate around their original positions
(d) Remain completely motionless
- In the example of a twig in water ripples, the twig mostly stays in place while the ripples move outward. This demonstrates:
(a) Energy transfer without matter transfer
(b) Mater transfer without any energy transfer
(c) Both energy and mater transfer (d) No transfer of matter and energy
- When a guitar string is plucked, the sound waves reach our ears because:
(a) Air particles travel from the string to our ears
(b) The string itself travels to our ears.
(c) Air particles vibrate in place to pass the energy forward
(d) Gravity pulls the sound toward us.

12.2

Types of Waves

- Waves that require a material medium (like air, water, or a solid) to travel are called:
(a) Electromagnetic waves (b) Mechanical waves
(c) Sound waves (d) light waves
- Which of the following is Not an example of a mechanical wave?
(a) Sound waves (b) Water waves (c) Radio waves (d) Seismic waves

7. Electromagnetic waves are unique because they travel through:
 (a) only solids (b) only liquids
 (c) a vacuum (empty space) (d) only air
8. All electromagnetic waves travel at the same speed in a vacuum, which is approximately:
 (a) 340 m/s (b) 3,000 km/s (c) 300,000 km/s (d) 1,000,000 m/s
9. Which part of the electromagnetic spectrum has a lower frequency than red light?
 (a) ultraviolet (b) X-rays (c) infrared (d) gamma rays
10. In a transverse wave, the particles of the medium vibrate:
 (a) parallel to the direction of the wave
 (b) at right angles to the direction of the wave.
 (c) in the opposite, direction of the wave (d) They do not vibrate at all

12.3

Terms and Parameters of Waves

11. The highest point of transverse waves is called:
 (a) Troughs (b) Compressions (c) Crests (d) Rarefactions
12. In a longitudinal wave, the particles of the medium move:
 (a) Back and forth along the same path as the energy flow
 (b) Up and down perpendicular to the wave
 (c) In circles (d) Only toward the source
13. A region in a longitudinal wave where the particles are spread apart is called a:
 (a) Compression (b) Crest (c) Rarefaction (d) Trough
14. Sound waves are example of:
 (a) Transverse waves (b) Electromagnetic waves
 (c) Longitudinal waves (d) Stationary waves
15. The maximum displacement of a point on a wave from its rest position is the:
 (a) Wavelength (b) Frequency (c) Amplitude (d) Time period
16. The distance between two corresponding points on adjacent waves (e.g, crest to crest) is the:
 (a) Amplitude (b) Wavelength (c) Velocity (d) Displacement
17. What is the SI unit for wave length?
 (a) Hertz (Hz) (b) Seconds (s)
 (c) Metre (m) (d) Metre per second (m/s)
18. The number of complete wave cycles that pass a fixed point in one second is the:
 (a) Time period (b) Wave Speed (c) Frequency (d) Amplitude
19. Frequency is measured in:
 (a) seconds (s) (b) Hertz (Hz) (c) metres (m) (d) watt (W)
20. The time taken for one complete wave cycle to pass a point is the:
 (a) Frequency (b) Wave period (T) (c) Wavelength (d) Speed

21. What is the mathematical relationship between period (T) and Frequency (f)?
 (a) $T = f$ (b) $T = 1/f$ (c) $T = f^2$ (d) $T = v \times f$
22. An imaginary surface on which all points have the same phase of vibration is a:
 (a) Rarefaction (b) Trough (c) Wavefront (d) Crest
23. Which formula represents the wave equation?
 (a) $v = f/\ell$ (b) $v = f \times \lambda$ (c) $v = \lambda/f$ (d) $v = f + \ell$

12.4 Properties of Waves

24. The bouncing back of waves into the same medium after striking a surface is:
 (a) Refraction (b) Reflection (c) Diffraction (d) Absorption
25. According to the law of reflection:
 (a) Angle of incidence > Angle of Reflection
 (b) Angle of incidence < Angle of Reflections
 (c) Angle of incidence = Angle of reflection (d) The angle are always 90° .
26. Refraction occurs because waves change their _____ when moving from one to another.
 (a) Frequency (b) Speed (c) Amplitude (d) Color
27. When water wave moves from deep water into shallow water, they:
 (a) Speed up (b) Slow down and bend
 (c) Stay the same speed (d) Disappear
28. During refraction, which property of the wave remains the same?
 (a) Speed (b) wave length (c) Frequency (d) Direction
29. The bending and spreading of waves as they pass through a narrow gap or around an obstacle is:
 (a) Reflection (b) Refraction (c) Diffraction (d) Transmission
30. To observe maximum diffraction, the size of the gap should be:
 (a) A much larger than the wavelength (b) Nearly equal to the wavelength
 (c) Much smaller than the amplitude (d) Made of metal
31. We can hear some one speaking from behind a wall even if we can't see them because of:
 (a) Reflection (b) Refraction
 (c) Diffraction of sound waves (d) Speed of light

12.5 Seismic and Tsunami Waves

32. Seismic waves are produced by:
 (a) Wind (b) Earthquakes (c) Tides (d) Sound speakers
33. The instrument used to detect seismic waves is called :
 (a) Speedometer (b) Seismometer (c) Barometer (d) Thermometer
34. Which seismic waves are the fastest and detected first?
 (a) S-waves (b) Surface waves
 (c) Primary waves (P-waves) (d) Tsunami waves

35. P-wave travel through :
 (a) only solids (b) only liquids
 (c) only gases (d) solids, liquids, and gases
36. What is the primary cause of a tsunami?
 (a) Strong surface winds
 (b) underwater disturbances like earthquakes as lands slides
 (c) The gravitational pull of the moon (d) Changes in ocean temperature
37. How does the speed of a tsunami wave change as it approaches shallow coastal areas?
 (a) The speed increases significantly (b) The speed remains constant
 (c) The speed decreases (d) The wave stops completely
38. In the deep ocean why are tsunami often unnoticed by ships?
 (a) Because they travel very slowly (b) Because they only occur at night
 (c) Because their wave height (amplitude) is only a few centimeters
 (d) Because they travel deep underwater and don't reach the surface

Answers

- | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|
| 1. (b) | 2. (c) | 3. (a) | 4. (c) | 5. (b) | 6. (c) | 7. (c) |
| 8. (c) | 9. (c) | 10. (b) | 11. (c) | 12. (a) | 13. (c) | 14. (c) |
| 15. (c) | 16. (b) | 17. (c) | 18. (c) | 19. (b) | 20. (b) | 21. (b) |
| 22. (c) | 23. (b) | 24. (b) | 25. (c) | 26. (b) | 27. (c) | 28. (c) |
| 29. (c) | 30. (b) | 31. (c) | 32. (b) | 33. (b) | 34. (c) | 35. (d) |
| 36. (b) | 37. (c) | 38. (c) | | | | |

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques
 (Knowledge, Understanding, Application, Analytical & Conceptual)

12.1

Waves and Nature of Waves

1. What is a wave?

Ans. A wave is a mechanism that transfer energy from one place to another through the vibrations of particles in a medium, without the transfer of matter itself.

2. How do particles move as a wave passes through a medium?

Ans. Particles do not move along with the wave. They simply oscillate (vibrate) around their original fixed positions.

3. Provide two everyday examples of energy transfer through waves?

Ans. Ripples in water caused by a twig.

- Sound waves from a plucked guitar string travelling through the air.

12.2

Types of Waves

4. What are mechanical waves?

Ans. "Mechanical waves are the waves that require a material medium (like air, water or

a solid) to travel they cannot pass through a vacuum.

5. What are electromagnetic waves?

Ans. "There are waves that do not require a material medium and can travel through empty space (vacuum) at the speed of light."

6. Name four examples of electromagnetic waves.

Ans. • Radio waves • Micro waves • Visible light • X-rays

7. What is the speed of electromagnetic waves in a vacuum?

Ans. The speed of electromagnetic waves in a vacuum is approximately $3 \times 10^8 \text{ ms}^{-1}$ (300,000 km per second).

8. Define a transverse waves.

Ans. "A transverse wave is one where the particles of the medium vibrate at right angles (perpendicular) to the direction of the waves travel."

9. Define a longitudinal wave.

Ans. "A longitudinal wave is one where the particles of the medium vibrate parallel to the direction in which the wave travels."

12.3 Terms and Parameters of Waves

10. What is a crest and a trough?

Ans. In a transverse wave, a crest is the highest point above the mean position, and a trough is the lowest point below the mean position.

11. What are compressions and rarefactions?

Ans. In a longitudinal wave, compressions are regions where particles are close together (high pressure), and rarefactions are regions where particles are spread apart (low pressure).

12. Define Amplitude?

Ans. "Amplitude is the maximum displacement of a point on the wave from its undisturbed (rest) position."

13. Define wavelength?

Ans. "Wavelength is the distance between two corresponding points on adjacent waves, such as from crest to crest on compression to compression."

- Its SI unit is the meter (m)

- It is represented by λ .

14. What is frequency?

Ans. "Frequency is the number of complete wave cycles that pass a fixed point in one second."

- Its SI unit is Hertz (Hz)

- It is represented by f .

15. What is the relationship between time period (T) and frequency (f)?

Ans. The relationship between time period (T) and frequency (f) is that they are inversely proportional.

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

16. State the wave equation?

Ans. The wave speed (v) is equal to the frequency (f) multiplied by the wavelength (λ).

$$v = f \times \lambda$$

12.4

Properties of Waves

17. What is Reflection of waves?

Ans. Reflection occurs when waves strike a surface and bounce back into the same medium.

18. State the law of Reflection?

Ans. The angle of incidence is always equal to the angle of reflection.

Angle of incidence = Angle of reflection

19. Define refraction?

Ans. Refraction is the change in direction and speed of waves as they pass from one medium into another.

20. What happens to the speed and wavelength of water wave when it enters shallow water?

Ans. The wave slows down and its wavelength becomes shorter.

21. Does the frequency of a wave change during refraction?

Ans. No, the frequency remains the same even though the speed and wavelength change.

22. What is diffraction?

Ans. "Diffraction is the bending and spreading of waves as they pass through a narrow gap or pass around an obstacle.

23. Under what condition is diffraction most prominent?

Ans. Diffraction is maximum when the size of the gap is smaller than the wavelength of the wave. If the gap is much longer, the wave passes mostly straight through.

12.5

Seismic and Tsunami Waves

24. What are P-waves and how do they move?

Ans. Primary waves (P-waves) are the fastest seismic waves. They are longitudinal waves that move by compressing and expanding material in the same direction as the wave travels.

25. What causes a tsunami?

Ans. Tsunamis are triggered by sudden under sea disturbances, such as earthquakes, volcanic eruptions, or land slides, which shift the ocean floor and push a huge volume of water upward.

26. How does a tsunami change as it reaches shallow water?

Ans. Its speed decreases and wavelength shortens, but its amplitude (height) increases significantly sometimes to 30 meters or more as energy is compressed into a smaller space.

Exercise Questions (Solved)



A. Multiple Choice Questions

★ Tick (✓) the correct answer.

12.1 The direction of vibration in a longitudinal wave is:

- (a) at right angles to the wave direction
- (b) in circular motion
- (c) opposite to the wave direction
- (d) in the same direction as the wave travels

12.2 Which part of a transverse wave carry the lowest point?

- (a) Crest
- (b) Compression
- (c) Rarefaction
- (d) Trough

12.3 Which of the following wave type requires a medium to travel?

- (a) X-rays
- (b) Light waves
- (c) Radiowaves
- (d) Sound waves

12.4 The property of a wave which indicates how much energy it carries is:

- (a) crest
- (b) amplitude
- (c) wavelength
- (d) speed

12.5 A wave front is:

- (a) the distance between two crests
- (b) a region of high pressure in a wave
- (c) a line joining points that vibrate in phase
- (d) the outer edge of a wave medium

12.6 The wave phenomenon which occurs when waves change direction due to a change in speed is:

- (a) diffraction
- (b) reflection
- (c) absorption
- (d) refraction

12.7 What happens to wave speed and wavelength when a tsunami approaches shallow water?

- (a) Speed increases, wavelength increases
- (b) Speed decreases, wavelength shortens
- (c) Speed remains the same, wavelength shortens
- (d) Speed increases, wavelength stays constant

12.8 Which wave behaviour explains how sound is heard around a corner?

- (a) Reflection
- (b) Refraction
- (c) Interference
- (d) Diffraction

Answers

12.1 (d) 12.2 (d) 12.3 (d) 12.4 (b) 12.5 (c) 12.6 (d) 12.7 (b)
12.8 (d)

B. Short Answer Questions

12.1 What do waves transfer from one place to another?

Ans. Waves transfer energy from one place to another without transferring matter.

12.2 Name any two examples of mechanical waves.

Ans. Examples of mechanical waves are:

- 1. Sound waves
- 2. Water waves

12.3 Which type of wave can travel through vacuum?

Ans. Electromagnetic waves (e.g, light waves, X-rays) travel through vacuum.

12.4 What is the difference between transverse and longitudinal waves?

Ans. In transverse waves, the particles of the medium oscillate perpendicular to the direction of wave propagation, while in longitudinal waves, the particles oscillate parallel to the direction of wave propagation.

12.5 What is meant by wavelength?

Ans. Wavelength is the distance between two consecutive corresponding points of the same phase on a wave, such as two adjacent crests or troughs.

12.6 Write the definition of frequency.

Ans. Frequency is the number of complete wave cycles that pass a given point per second.

12.7 What causes a tsunami in the ocean?

Ans. Tsunamis are caused by large underwater disturbances such as earthquakes, volcanic eruptions or landslides.

C. Constructed Response Questions

12.1 Why sound cannot travel through space, but light can? Explain using the concept of wave types.

Ans. Sound waves are mechanical waves that require a medium to travel, while light waves are electromagnetic waves that can travel through a vacuum.

12.2 A student shakes one end of a rope and observes waves move along it. What kind of wave is this, and how do the particles move?

Ans. This is a transverse wave, and the particles move perpendicular to the direction of wave propagation.

12.3 How does the amplitude of a wave relate to the energy it carries? Give an example to support your answer.

Ans. The amplitude of a wave is directly proportional to the square of the energy it carries. A larger amplitude means more energy. For example, a loud sound wave has a larger amplitude and carries more energy than a quiet sound wave.

12.4 Why do we still hear a person talking even if he is behind a wall? Explain using the concept of diffraction.

Ans. We still hear a person talking behind a wall due to diffraction, which is the bending of sound waves as they pass around the edges of the wall, allowing the sound to spread and reach our ears.

12.5 If size of slit, a wave passes through is much smaller than the wavelength, what will happen to the wave after passing through the slit? Explain briefly.

Ans. When a wave passes through a slit whose size is much smaller than the wavelength, the wave will spread out in all directions after passing through the slit. This phenomenon is known as diffraction. The smaller the slit relative to the wavelength, the more the wave will spread out. In the extreme case where the slit is much smaller than the wavelength, the wave essentially behaves like a point source radiating outwards spherically.

D. Comprehensive Questions

12.1 Explain how waves transfer energy without transferring matter. Give examples from daily life.

Ans. For Answer See Q.2

12.2 Describe the difference between mechanical and electromagnetic waves with suitable examples.

Ans. For Answer See Q.4

12.3 What are transverse and longitudinal waves? Explain each with the help of diagrams and examples.

Ans. For Answer See Q.5

12.4 Discuss the properties of waves; such as reflection, refraction, and diffraction. Support your answer with examples.

Ans. For Answer See Q.8

12.5 What is diffraction? How do wavelength and slit size affect the diffraction of waves?

Ans. For Answer See Q.11

E. Numerical Problems

12.1 The wavelength of a wave is 2 metres and its frequency is 5 Hz. What is the speed of the wave?

Given:

$$\text{Wavelength } (\lambda) = 2\text{m}$$

$$\text{Frequency } (f) = 5 \text{ Hz}$$

Required:

$$\text{Speed } (v) = ?$$

Formula:

$$v = f\lambda$$

Solution:

$$v = f\lambda$$

By putting the above values

$$v = (5\text{Hz}) (2\text{m})$$

$$v = 10 \text{ ms}^{-1}$$

Result:

The speed of the wave is 10ms^{-1}

12.2 A wave travels at a speed of 300ms^{-1} and has a wavelength of 3metres. Calculate its frequency.

Given:

$$\text{Speed } (v) = 300 \text{ ms}^{-1}$$

$$\text{wavelength } (\lambda) = 3\text{m}$$

Required:

$$\text{Frequency } (f) = ?$$

Formula:

$$f = \frac{v}{\lambda}$$

Solution:

$$f = \frac{v}{\lambda}$$

By putting the above values

$$f = \frac{300\text{ms}^{-1}}{3\text{m}}$$

$$f = 100 \text{ Hz.}$$

Result:

The frequency of the wave is 100 Hz.

12.3 A sound wave has a frequency of 250 Hz and a speed of 340 ms^{-1} . Find its wavelength.

Given:

$$\text{Frequency } (f) = 250 \text{ Hz.}$$

$$\text{Speed } (v) = 340 \text{ ms}^{-1}$$

Required:

$$\text{Wavelength } (\lambda) = ?$$

Formula:

$$\lambda = \frac{v}{f}$$

By putting the above values

$$\lambda = \frac{340 \text{ ms}^{-1}}{250 \text{ Hz}}$$

$$\lambda = 1.36 \text{ m}$$

Result:

The wavelength of the sound wave is 1.36 m.

12.4 A wave has a frequency of 50 Hz. How much time does it take to complete one wave?

Given:

Frequency (f) = 50 Hz.

Required:

Time period (T) = ?

Formula:

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

Solution:

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

By putting the above values

$$T = \frac{1}{50 \text{ Hz}}$$

$$T = 0.02 \text{ s}$$

Result:

It takes 0.02 sec to complete its one wave.

12.5 A wave has a wavelength of 0.5 m and frequency of 200 Hz. Calculate the speed of the wave.

Given:

Wavelength (λ) = 0.5 m

Frequency (f) = 200 Hz

Required:

Speed (v) = ?

Formula:

$$v = f\lambda$$

Solution:

$$v = f\lambda$$

By putting the above values

$$v = (200 \text{ Hz}) (0.5 \text{ m})$$

$$v = 100 \text{ ms}^{-1}$$

Result:

The speed of the wave is 100 ms⁻¹

12.6 The time period of a wave is 0.02 seconds. Calculate the frequency of the wave?

Given:

Time Period (T) = 0.02 s

Required:

Frequency (f) = ?

Formula:

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

Solution:

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

$$f = \frac{1}{0.02 \text{ s}}$$

$$f = 50 \text{ Hz}$$

Result:

The frequency of the wave is 50 Hz.

