10th Class Physics

Chapter 12 — WAVES

Complete Combined Booklet

Compiled from four source documents — all content preserved:

Part A — Unique Notes (Main Chapter Notes)

Part B — Additional Short Questions & MCQ Answers

Part C — Long Questions, Complete Notes

Part D — Numerical Problems with Complete Solutions

PART A — Unique Notes (Main Chapter Notes)

Chapter 12: WAVES

UNIQUE NOTES | PHYSICS - 10

Key Concepts

- Waves and nature of waves
- Types of waves
- Terms and parameters of waves
- Properties of waves
- Seismic and tsunami waves

Q.1 What is a wave motion? Explain with examples from daily life. (OR) Explain how waves transfer energy without transferring matter. Give examples from daily life.

Key points: Waves (Definition, Explanation, Examples)

Waves

Definition: *"The mechanism by virtue of which energy is transferred from one place to another without transferring matter is called wave or wave motion."*

1. Explanation

- 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. However, the particles themselves do not move along with the wave. They simply oscillate around their original positions.

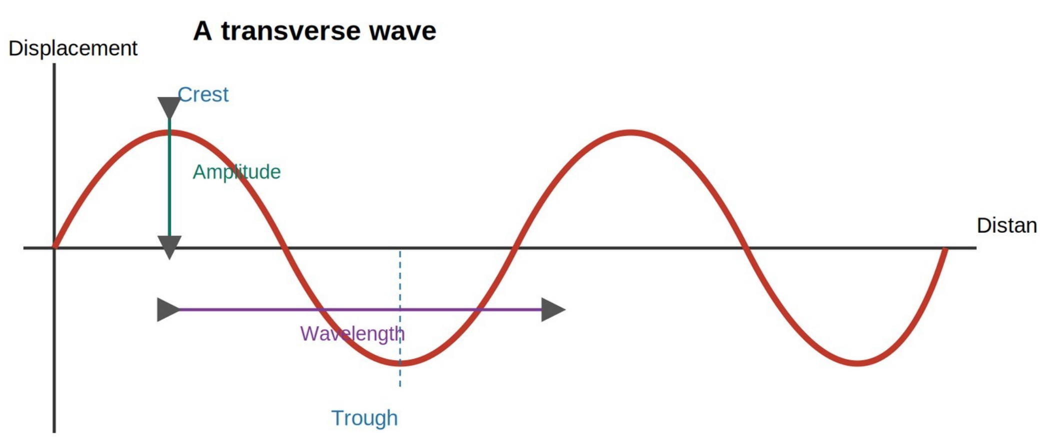


Fig. 12.1: Vibration of particles in a wave perpendicular to the wave direction

2. Examples

- For example, when a twig is dropped into still water, ripples spread across the surface. These ripples carry energy outward, yet the water and the twig remain mostly in place.
- A similar effect occurs with sound waves. When a guitar string is plucked, it creates vibrations that travel through the air as sound waves. The air particles do not move toward our ears; instead, they vibrate in place to pass the energy forward.

- The same principle is illustrated by vibrations in a spring. When one end of a stretched spring is pushed and released, longitudinal waves move through the spring. The spring develops regions of compression (where the coils are close together) and rarefaction (where the coils are spread out). These compressions and rarefactions travel along the spring, showing how energy is transmitted without the entire spring moving forward. This experiment visually demonstrates wave motion and how longitudinal waves (such as sound) travel through matter.
- A simple and effective way to understand wave motion is through an experiment using a ripple tank. 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.

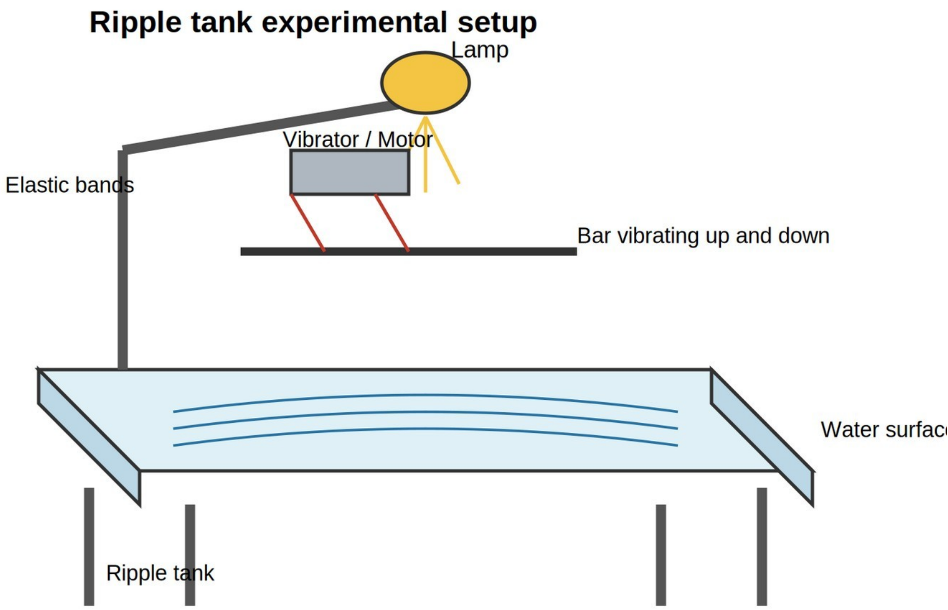


Fig. 12.5: Ripple tank

Q.2 Differentiate between mechanical waves and electromagnetic waves with suitable examples. (OR) Describe different types of waves.

Key points: Types of Waves (Mechanical waves, Electromagnetic waves, Electromagnetic wave spectrum)

Types of Waves

There are two main types of waves:

- 1. Mechanical Waves
- 2. Electromagnetic Waves

1. Mechanical Waves

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

a. 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.

- 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.

b. Examples

Examples of mechanical waves include:

- (i) Sound waves
- (ii) Water waves
- (iii) Vibrations on a rope or spring
- (iv) Seismic waves produced by earthquakes

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

2. Electromagnetic Waves

Definition: *"Electromagnetic waves are waves which do not require a material medium to travel."*

a. 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.

b. Examples

Examples of electromagnetic waves include:

- (i) Radio waves
- (ii) Microwaves
- (iii) Infrared rays
- (iv) Visible light
- (v) Ultraviolet rays
- (vi) X-rays, and gamma rays

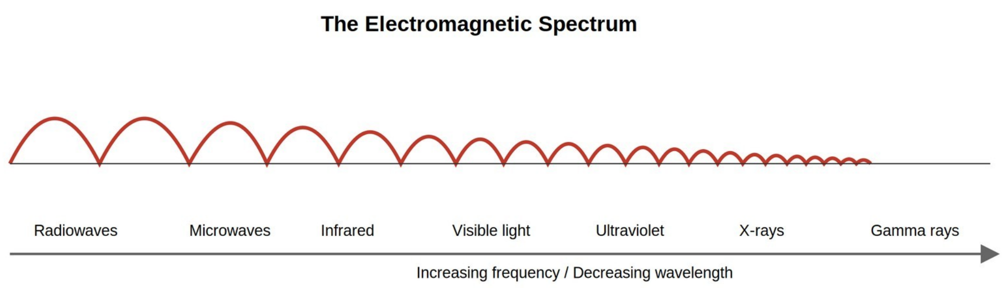
These waves differ in their wavelengths and frequencies, but they all travel at the same speed in vacuum — approximately 3,00,000 km per second (3×10^8 m s^{-1}), known as the speed of light.

> **Do You Know?**
>
> Radiowaves are electromagnetic waves that travel at the speed of 3,00,000 kilometre per second through air.

> **Tidbit**
>
> Infra means below; infrared waves have a lower frequency than red waves. Warm objects radiate light in the infrared region of the spectrum.

3. Electromagnetic Wave Spectrum

The range of all the electromagnetic waves is called the electromagnetic spectrum, as illustrated below.



The electromagnetic spectrum: radiowaves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays

Q.3 What are transverse and longitudinal waves? Explain with the help of diagrams and examples. (OR) Describe types of mechanical waves.

Key points: Types of mechanical waves (Transverse waves, Longitudinal Waves)

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

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

a. Explanation

- This perpendicular vibration causes the energy to transfer through the medium without any significant forward movement of the particles themselves.
- A simple way to observe a transverse wave is by holding one end of a rope and moving it up and down. While the wave travels horizontally along the rope, the rope segments move vertically.
- This motion results in the formation of the highest points known as crests and the lowest points called troughs.

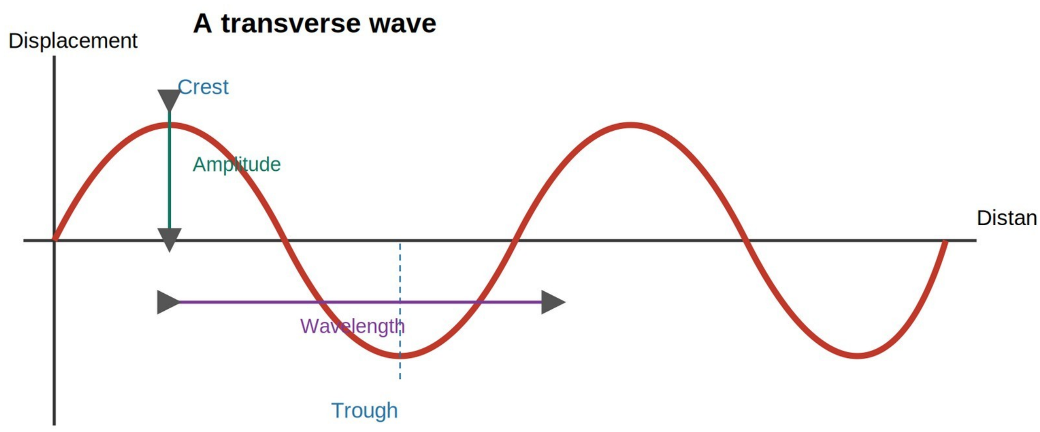


Fig. 12.8: A transverse wave labelled with crest, trough, wavelength, and amplitude

b. Examples

- 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 rather than along with the wave.
- Another important example is electromagnetic radiation (such as light, radiowaves, and X-rays), where the electric and magnetic fields oscillate perpendicular to the direction of energy propagation.

Brain Teaser — When we shake a stretched slinky side-to-side and then push it back and forth, what two types of waves did we just create?

When the slinky is shaken side-to-side, transverse waves are created because the particles move perpendicular to the direction of wave travel. When it is pushed back and forth, longitudinal waves are produced as the particles vibrate parallel to the direction of energy transfer. Both waves show different particle motions but transfer energy along the slinky.

2. Longitudinal Waves

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

a. Explanation

In longitudinal waves the particles move back and forth along the same path as the energy flow. This creates regions where particles are close together, known as compressions, and regions where particles are spread apart, known as rarefactions.

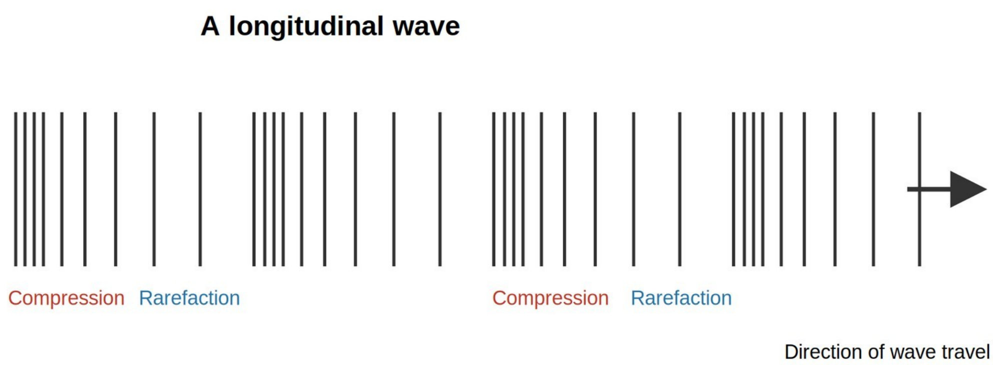


Fig. 12.9: A longitudinal sound wave showing compressions and rarefactions

b. Examples

- 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.

Q.4 Describe following terms of the waves: (1) Crest (2) Trough (3) Compression (4) Rarefaction (5) Amplitude (6) Wavelength (7) Frequency (8) Time period (9) Wave front

Key points: Key terms of the waves

Terms of Waves

The definitions of these key terms are given below:

1. Crest

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

2. Trough

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

3. Compression

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

4. Rarefaction

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

5. 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.

> **Brain Teaser — Two waves travel at the same speed, but one has a higher frequency. Which has the shorter wavelength?**
>
> The wave with the higher frequency has the shorter wavelength. This is because wave speed is equal to frequency multiplied by wavelength. If the speed remains constant and frequency increases, the wavelength must decrease.

6. Wavelength (λ)

The wavelength is the distance between two consecutive corresponding points on adjacent waves (e.g., crest to crest or trough to trough in transverse waves, or compression to compression in longitudinal waves). Its SI unit is metre (m).

7. Frequency (f)

The frequency of a wave is the number of complete wave cycles that pass a fixed point in one second. It is measured in hertz (Hz), where; 1 Hz = 1 wave per second.

> **Tidbit**
>
> Frequency tells us how many waves pass a point in one second. That is why an FM radio station is called “88.0 MHz”. It is sending 88 million wave cycles per second.

8. Wave Period (T)

The period of a wave is the time it takes for one complete wave cycle to pass a fixed point. It is the inverse of frequency: i.e., $T = 1 / f$. It is measured in seconds (s).

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

9. Wave Front

A wave front is an imaginary surface on which all the points have the 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.5 What is a wave speed/wave equation? Derive its expression.

Key points: Wave speed and its derivation

Wave Speed (v) / Wave Equation

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

As, Speed = Distance travelled / Time taken

Derivation

Let us consider a wave:

- Distance travelled = λ (wavelength)
- Time taken = T (time period)

Then, $v = S / t$

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

Substitute into the formula: $v = \lambda / T$ …………… (1)

Now, $1 / T = f$ (where f is frequency)

So, $v = f \times \lambda$

> **Do You Know?**
>
> The waves are all travelling at about the same speed, so this is the number of each wave that will reach the ear in a hundredth of a second. A short wavelength means lots of waves, high frequency, high sound. A long wavelength means fewer waves, low frequency, low sound.

Q. What type of waves are radiowaves, and at what speed do they travel through air? Ans. Radiowaves are electromagnetic waves. They travel through air and vacuum without the need for a material medium. Their speed is approximately 300,000 kilometres per second, which is the speed of light.

Q.6 Discuss following properties of waves: (i) Reflection (ii) Refraction (iii) Diffraction with reference to ripple tank experiment. Also discuss how wavelength and gap size influence diffraction of waves.

Key points: Properties of waves (Reflection, Refraction and Diffraction)

Properties of Waves

Ripple tank (a shallow glass container filled with water) is a device used to explain the properties of waves such as reflection, refraction and diffraction.

1. Reflection of Waves

Definition: *"Reflection is the bouncing back of waves into the same medium after striking the surface of another medium."*

a. Explanation

- Reflection occurs when waves strike a surface and bounce back into the same medium.
- This behaviour can be clearly observed using a ripple tank. In this setup, when straight water waves generated by a vibrating bar move across the tank and strike a barrier, they reflect from the surface.
- The angle at which the waves approach the barrier is called the angle of incidence, and the angle at which they reflect is called the angle of reflection.
- These two angles are always equal. This is called the law of reflection: Angle of incidence = Angle of reflection.

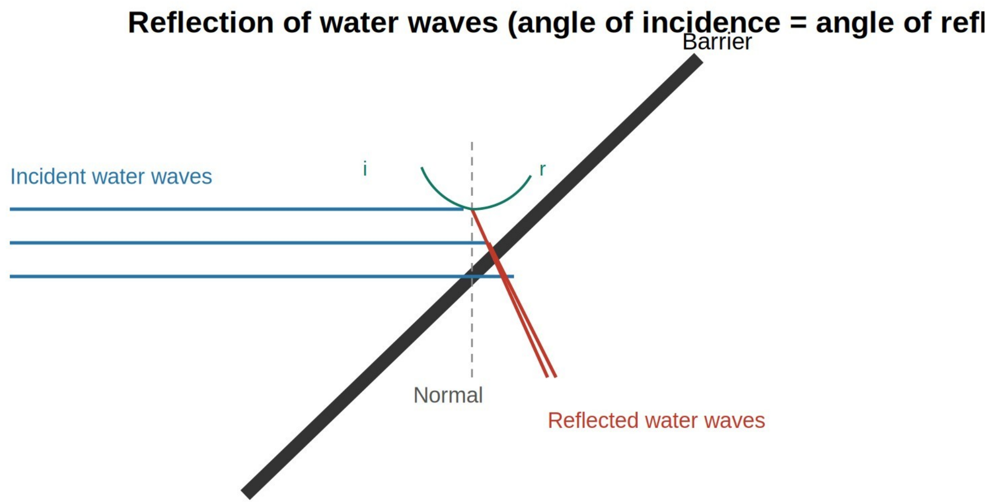


Fig. 12.11: Reflection of water waves

b. Examples

This property is common to all types of waves, including water waves, sound waves (such as echoes), and light waves (as seen in mirrors).

2. Refraction of Waves

Definition: *"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."*

Explanation

- Refraction occurs when waves pass from one medium into another and change direction due to change in speed.
- As the water waves cross into a 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.

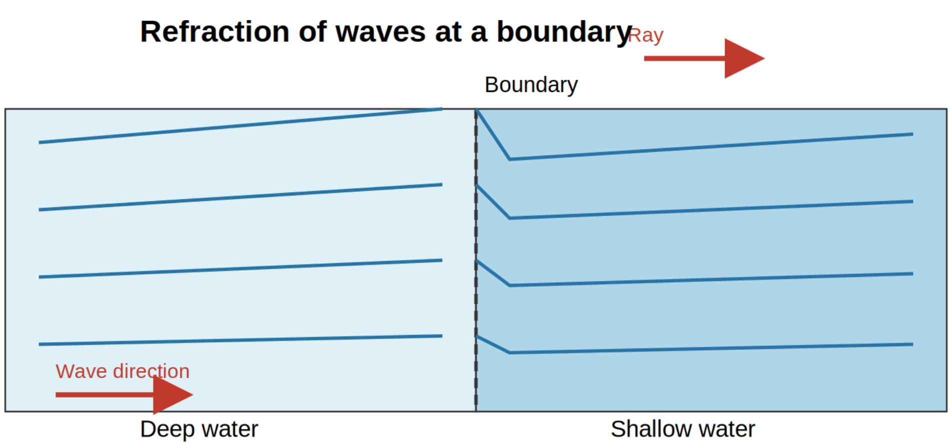


Fig. 12.12: Refraction of waves — wave fronts bend as they pass from deep water into shallow water

The bending clearly shows how the direction and spacing of the waves are affected by the depth of the water.

Do You Know? — Reflection and transmission of waves

A wave encountering a denser medium will be partially reflected and partially transmitted; if the wave speed is less in the denser medium, the wavelength will be shorter.

Q. What does long wavelength and short wavelength indicate about frequency and sound?

Ans. A long wavelength means fewer waves pass a point in one second, resulting in low frequency and low sound. A short wavelength means many waves pass a point per second, resulting in high frequency and high sound. Thus, wavelength and frequency are inversely related.

3. Diffraction of Waves

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

a. Explanation

- Diffraction is the bending and spreading of waves as they pass through a narrow gap or move around an obstacle.
- This behaviour can be easily observed in water waves when they encounter openings of different sizes.
  - (i) When the gap is wider than the wavelength, the waves pass mostly straight through with only slight bending at the edges.
  - (ii) If the gap size is nearly equal to the wavelength, the waves spread out more and appear almost circular beyond the gap.
  - (iii) When the gap is smaller than the wavelength, the waves show maximum diffraction, forming strong circular patterns. This shows that the amount of diffraction increases when the gap size is closer to or smaller than the wavelength of the waves.

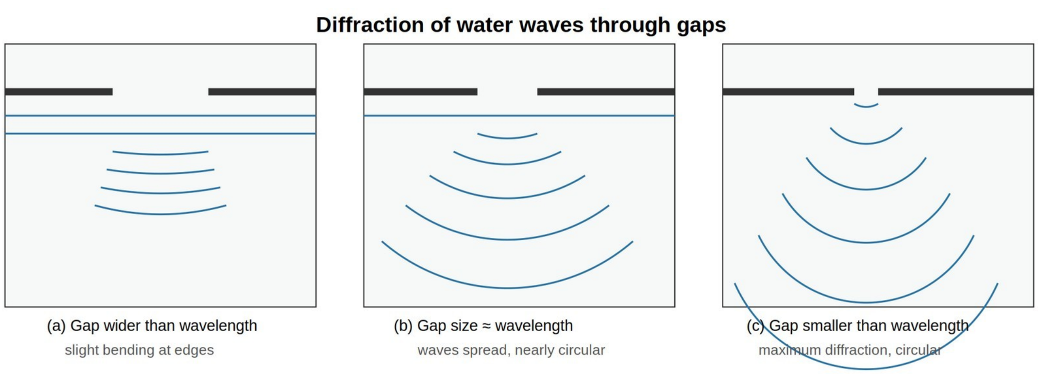


Fig. 12.13: Diffraction of water waves through gaps of different sizes relative to wavelength

b. 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 wavelengths, diffract around corners and obstacles, allowing the sound to reach us even without a direct line of sight.

- Additionally, waves with longer wavelengths diffract more than those with shorter wavelengths when passing through the same gap.

Q.7 What are seismic waves? Explain phenomenon of tsunami generated under the surface of water.

Key points: Seismic and Tsunami Waves

Seismic and Tsunami Waves

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.

1. 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. 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 shows alternating regions of high and low density representing compressions and rarefactions.

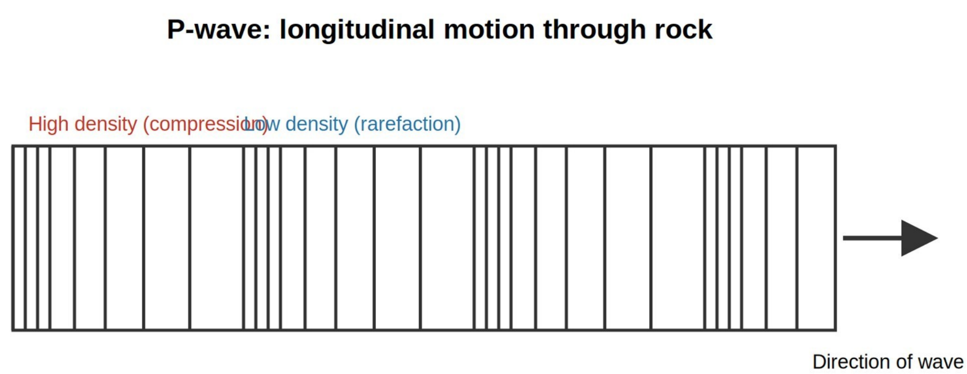


Fig. 12.14: P-wave showing longitudinal motion

2. 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.
- 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.

a. Characteristics of Tsunami Waves

  - i. 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 centimetres in height and go unnoticed by ships or people.
  - ii. As tsunami waves approach shallow coastal areas, their behaviour changes dramatically due to their interaction with the sea floor:

- Wave speed decreases: As the water becomes shallower, the bottom of the wave touches the ocean floor, slowing the wave down.
- Wavelength shortens: The distance between wave crests becomes smaller.
- Frequency increases: More waves arrive at the shore in a shorter period of time.
- Amplitude increases: As the energy gets compressed into a smaller space, the wave height increases significantly.

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

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

b. 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 metres in some areas and causing massive devastation and loss of more than 2,30,000 lives.

> **Do You Know?**
>
> Out at sea, a tsunami is only about 3 feet high, and could pass a boat without being noticed, as it approaches the shore. Its sudden deceleration from about 250 m s^{-1} to 15 m s^{-1} creates the enormous waves.

> **Q. Why can a tsunami pass unnoticed in deep sea but become destructive near the shore?**
>
> Ans. In deep sea, a tsunami has very small height and travels very fast, so it may not be noticed. As it approaches shallow water, its speed decreases and wavelength shortens. The amplitude increases sharply, creating very high waves that cause destruction near the shore.

Formula Sheet

Sr. #	Formula / Expression	Description
1	$v = f\lambda$	Wave Equation
2	$T = 1 / f$	Relation between Period and Frequency
3	$f = n / t$ = number of waves / time	Frequency
4	Angle of incidence = Angle of reflection	Laws of Reflection

Solved Examples

Example 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 = f = ? (b) speed of the wave = V = ?

Given that: Number of cycles = n = 10; Time t = 5 seconds; Wavelength λ = 1.2 m

To find: (a) Frequency f = ? (b) Speed of wave v = ?

Solution: We know that; $f = n / t$ = Number of cycles / Time

As $f = 10 / 5 = 2$ Hz

$v = f \times \lambda$

Substituting the values: $v = 2 \times 1.2 = 2.4$ m s^{-1}

Result: Frequency and speed of wave are 2 Hz and 2.4 m s^{-1} respectively.

Multiple Choice Questions Exercise

#	Question	A	B	C	D
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
2	Which part of a transverse wave carries the lowest point?	(a) Crest	(b) Compression	(c) Rarefaction	(d) Trough
3	Which of the following wave types requires a medium to travel?	(a) X-rays	(b) Light waves	(c) Radio waves	(d) Sound waves
4	The property of a wave which indicates how much energy it carries is:	(a) crest	(b) amplitude	(c) wavelength	(d) speed
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
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
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
8	Which wave behaviour explains how sound is heard around a corner?	(a) Reflection	(b) Refraction	(c) Interference	(d) Diffraction

Answer Key: 1-d, 2-d, 3-d, 4-b, 5-c, 6-d, 7-b, 8-d

SLO Based Additional MCQs + Past Papers MCQs of Punjab Boards

Motion and Energy Transfer

#	Question	A	B	C	D
1	What is the primary thing transferred by waves from one point to another?	(a) Matter	(b) Energy	(c) Particles	(d) Medium
2	Which of the following is a key characteristic of wave motion?	(a) Particles travel with the wave	(b) Energy is transferred without transferring matter	(c) The medium moves forward	(d) Waves cannot be reflected

Types of Waves

#	Question	A	B	C	D
3	Which of the following is an example of a mechanical wave?	(a) Light wave	(b) Radio wave	(c) Sound wave	(d) X-ray
4	Which type of wave can travel through a vacuum?	(a) Sound wave	(b) Water wave	(c) Seismic wave	(d) Light wave
5	Mechanical waves require a ______ to travel.	(a) vacuum	(b) medium	(c) force	(d) electric field

Transverse and Longitudinal Waves

#	Question	A	B	C	D
6	In a transverse wave, the particles of the medium vibrate:	(a) parallel to wave direction	(b) at right angles to wave direction	(c) in circular paths	(d) not at all
7	In a longitudinal wave, regions where particles are pressed together are called:	(a) crests	(b) troughs	(c) compressions	(d) rarefactions
8	Which of the following is a longitudinal wave?	(a) Water wave	(b) Light wave	(c) Sound wave	(d) Radio wave

Wave Parameters and Features

#	Question	A	B	C	D
9	The maximum displacement of a wave from its rest position is called:	(a) wavelength	(b) frequency	(c) amplitude	(d) speed
10	The distance between two consecutive crests is called:	(a) amplitude	(b) frequency	(c) wavelength	(d) period
11	What does the amplitude of a wave indicate?	(a) its speed	(b) its wavelength	(c) the energy it carries	(d) its frequency
12	The number of waves passing a point per second is called:	(a) amplitude	(b) wavelength	(c) frequency	(d) period

Wave Properties

#	Question	A	B	C	D
13	The bouncing back of waves when they hit a barrier is called:	(a) refraction	(b) diffraction	(c) reflection	(d) transmission
14	The bending of waves as they pass from one medium to another due to a change in speed is called:	(a) reflection	(b) diffraction	(c) refraction	(d) interference
15	The spreading of waves as they pass through a narrow gap is called:	(a) reflection	(b) refraction	(c) diffraction	(d) absorption

Wave Equation and Calculations

#	Question	A	B	C	D
16	What is the formula for wave speed?	(a) $v = f / \lambda$	(b) $v = f + \lambda$	(c) $v = f \times \lambda$	(d) $v = \lambda / f$
17	If the frequency of a wave is 50 Hz and its wavelength is 2 m, what is its speed?	(a) 25 m/s	(b) 52 m/s	(c) 100 m/s	(d) 0.04 m/s

Seismic and Tsunami Waves

#	Question	A	B	C	D
18	What causes a tsunami?	(a) Strong winds	(b) Underwater earthquakes	(c) Moon's gravity	(d) Tidal forces
19	As a tsunami approaches shallow water, what happens to its wavelength?	(a) It increases	(b) It remains the same	(c) It shortens	(d) It becomes zero
20	Which of the following is a characteristic of P-waves?	(a) they are transverse waves	(b) they are the slowest seismic waves	(c) they can travel through solids, liquids, and gases	(d) they only travel through solids

Answer Key: 1-b, 2-b, 3-c, 4-d, 5-b, 6-b, 7-c, 8-c, 9-c, 10-c, 11-c, 12-c, 13-c, 14-c, 15-c, 16-c, 17-c, 18-b, 19-c, 20-c

Exercise Short Questions

12.1 What do waves transfer from one place to another?

Waves transfer energy from one place to another without transferring matter. This is a fundamental characteristic of all waves, whether they are mechanical waves like sound or electromagnetic waves like light. Particles of the medium vibrate but remain in their original positions while passing energy to neighboring particles.

12.2 Name any two examples of mechanical waves.

Examples of mechanical waves are: (i) Sound waves (ii) Water waves. These waves require a material medium to travel.

12.3 Which type of wave can travel through vacuum?

Electromagnetic waves can travel through vacuum. They do not require a material medium. Light and radio waves are common examples.

12.4 What is the difference between transverse and longitudinal waves?

Transverse Waves	Longitudinal Waves
Types of waves in which particles vibrate perpendicular to the direction of wave travel are called transverse waves.	Types of waves in which particles vibrate parallel to the direction of wave travel are called longitudinal waves.
They have crests and troughs.	They have compressions and rarefactions.
Examples: Water waves, electromagnetic waves.	Examples: Sound waves, seismic P-waves.

12.5 What is meant by wavelength?

Wavelength: The distance between two consecutive corresponding points on adjacent waves, such as crest to crest or compression to compression, is called wavelength. Symbol: λ. Unit: metre (m).

12.6 Write the definition of frequency.

The number of complete cycles that pass a fixed point in one second is called frequency. Symbol: f. Unit: hertz (Hz).

12.7 What causes a tsunami in the ocean?

A tsunami is caused by sudden disturbances under the sea. These include underwater earthquakes, volcanic eruptions, or landslides. Such disturbances displace a large volume of water.

SLO Based Additional Short Questions + Past Papers Short Questions of Punjab Boards

Wave Motion and Energy Transfer

Q.1 How do waves transfer energy without moving matter? Give a daily life example.

Waves transfer energy through the vibration of particles in a medium. The particles oscillate in place and pass energy to neighboring particles without moving forward themselves. For example, when a stone is dropped in water, ripples spread outward carrying energy, but the water molecules do not travel with the ripples.

Q.2 Why can sound not travel through space? Explain.

Sound is a mechanical wave that requires a material medium to travel. Space is a vacuum with no particles to vibrate. Therefore, sound cannot travel through space.

Types of Waves

Q.3 Differentiate between mechanical and electromagnetic waves with examples.

Mechanical waves need a medium to travel, such as sound waves or water waves. Electromagnetic waves do not require a medium and can travel through vacuum, such as light and radio waves.

Q.4 What are transverse waves? Give examples.

Transverse waves are waves where the particles of the medium vibrate perpendicular to the direction of wave travel. This creates crests and troughs. Examples include water waves and electromagnetic waves like light.

Q.5 What are longitudinal waves? Give examples.

Longitudinal waves are waves where particles vibrate parallel to the direction of wave travel, forming compressions and rarefactions. Sound waves are longitudinal. Unlike transverse waves, they do not have crests and troughs. Other examples include seismic P-waves.

Wave Characteristics

Q.6 Define wavelength and frequency. How are they related to wave speed?

Wavelength is the distance between two consecutive crests or compressions. Frequency is the number of waves passing a point per second. They are related to wave speed by the formula: $v = f\lambda$.

Q.7 What does the amplitude of a wave indicate? Give an example.

Amplitude indicates the energy carried by a wave. Larger amplitude means more energy. For example, a loud sound has higher amplitude in its sound wave compared to a soft sound.

Q.8 What is a wave front? How is it useful in understanding wave behavior?

A wave front is an imaginary surface where all points vibrate in the same phase. It helps visualize how waves spread out and interact with obstacles, such as during reflection or refraction.

Q.9 Define crest, trough, compression, and rarefaction.

Crest is the highest point above mean position in transverse waves; trough is the lowest point below mean position. Compression is where particles are close together (high pressure) in longitudinal waves; rarefaction is where they are spread apart (low pressure). These terms describe wave structure.

Wave Properties

Q.10 Explain reflection of waves with an example from daily life.

Reflection occurs when waves bounce back after hitting a barrier. The angle of incidence equals the angle of reflection. An example is an echo, where sound waves reflect off walls or mountains.

Q.11 What is refraction of waves? Why does it occur?

Refraction is the bending of waves when they pass from one medium to another due to a change in speed. It occurs because waves travel at different speeds in different media, like light bending when entering water.

Q.12 Describe diffraction of waves. How does gap size affect it?

Diffraction is the spreading of waves as they pass through a gap or around an obstacle. If the gap size is smaller than or equal to the wavelength, diffraction is more pronounced. Sound diffracts around corners, allowing us to hear even without direct line of sight.

Seismic and Tsunami Waves

Q.13 What are seismic waves? Name the two main types.

Seismic waves are waves generated by earthquakes or volcanic activity that travel through the Earth. The two main types are P-waves (longitudinal) and S-waves (transverse).

Q.14 How are tsunamis formed? Explain in brief.

Tsunamis are formed by underwater disturbances such as earthquakes, volcanic eruptions, or landslides. These events displace large volumes of water, generating long, fast-moving waves that grow in height as they approach shallow coasts.

Constructed Response Questions

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

Ans. Sound cannot travel through space, but light can.

Reason: Sound waves are mechanical waves and require a material medium. Space is a vacuum with no medium, so sound cannot travel. Light waves are electromagnetic waves that do not require a medium and can travel through vacuum.

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

Ans. It is a transverse wave.

Reason: When the rope is shaken up and down, the wave travels horizontally along the rope. The particles of the rope vibrate up and down (perpendicular to the direction of wave travel). The wave transfers energy along the rope without moving the rope forward. This is why it is a transverse wave.

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 related to the energy it carries.

Reason: Amplitude is the maximum displacement of a point on the wave from its rest position. Higher amplitude means the wave disturbs the medium more, requiring and transferring more energy.

Example: A loud sound (like a shout) has a higher amplitude and carries more energy than a soft whisper, which has a lower amplitude.

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 hear sound behind a wall due to diffraction.

Reason: Diffraction is the bending and spreading of waves as they pass through a narrow gap or around an obstacle. Sound waves have relatively long wavelengths that diffract around corners and obstacles like walls, allowing sound to reach us even without direct line of sight.

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

Ans. The wave will show maximum diffraction and spread out circularly.

Reason: When the gap size is smaller than the wavelength, diffraction is maximum. The wave bends strongly at the edges of the gap and spreads out in a circular pattern on the other side. It is almost as if the gap itself were a new source of circular waves.

Comprehensive Questions

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

Ans. See Q.#1 of theory.

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

Ans. See Q.#2 of theory.

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

Ans. See Q.#3 of theory.

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

Ans. See Q.#6 of theory.

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

Ans. See Q.#6, (last part) of theory.

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 Data:

- Wavelength = λ = 2 m
- Frequency = f = 5 Hz

To Find: Speed of the wave = v = ?

Solution:

Using the wave equation: $v = f\lambda$

$v = 5 \times 2$

$v = 10$ m/s

Result: v = 10 m/s

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

Given Data:

- Speed of the wave = v = 300 ms^{-1}
- Wavelength = λ = 3 m

To Find: Frequency = f = ?

Solution:

Using the wave equation: $v = f\lambda$

$f = v / \lambda$

$f = 300 / 3$

$f = 100$ Hz

Result: f = 100 Hz

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

Given Data:

- Frequency of sound wave = f = 250 Hz
- Speed of sound = v = 340 ms^{-1}

To Find: Wavelength = λ = ?

Solution:

Using the wave equation: $v = f\lambda$

$\lambda = v / f$

$\lambda = 340 / 250$

$\lambda = 1.36$ m

Result: λ = 1.36 m

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

Given Data:

- Frequency = f = 50 Hz

To Find: Time period = T = ?

Solution:

Using the relation: $T = 1 / f$

$T = 1 / 50$

$T = 0.02$ s

Result: T = 0.02 s

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

Given Data:

- Wavelength = λ = 0.5 m
- Frequency = f = 200 Hz

To Find: Speed of the wave = v = ?

Solution:

Using the wave equation: $v = f\lambda$

$v = 200 \times 0.5$

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

Result: $v = 100\ ms^{-1}$

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

Given Data:

- Time period = T = 0.02 s

To Find: Frequency = f = ?

Solution:

Using the relation: $f = 1 / T$

$f = 1 / 0.02$

$f = 50$ Hz

Result: f = 50 Hz

Important Questions of Board Examination

Important Long Questions

- (i) Define wave and explain its types. (OR) What is a wave? Describe its types and define them with examples.
- (ii) Distinguish between longitudinal and transverse waves with suitable examples.
- (iii) What is meant by wave equation? Derive a relation for wave equation i.e. $v = f\lambda$.
- (iv) Define and explain the following properties of waves with reference to ripple tank: (a) Reflection (b) Refraction (c) Diffraction

Important Short Questions

- (i) What is meant by wave motion? Give examples.
- (ii) Define mechanical waves. Give examples.
- (iii) Define electromagnetic waves with examples.
- (iv) Define: (i) Compression (ii) Rarefaction
- (v) What is wave speed? Write down its equation.
- (vi) Define reflection of a wave.
- (vii) Define refraction.
- (viii) Define diffraction.
- (ix) Define seismic wave.
- (x) Define tsunami waves.
- (xi) Define crest and trough of a wave.
- (xii) What is frequency? Write its units.
- (xiii) Differentiate between transverse and longitudinal waves.
- (xiv) Define wave length and amplitude.
- (xv) Define wave front.

PART B — Additional Short Questions & MCQ Answers

10th Class Physics - Chapter 12: Waves

Additional Short Questions & MCQ Answers

Multiple Choice Questions (Additional MCQs)

1. P-waves travel through: (a) only solids (b) only liquids (c) only gases (d) solids, liquids, and gases ✓

2. What is the primary cause of a tsunami? (a) Strong surface winds (b) underwater disturbances like earthquakes or landslides ✓ (c) The gravitational pull of the moon (d) Changes in ocean temperature

3. 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

4. In the deep ocean why are tsunamis 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

Additional Short Questions

12.1 Waves and Nature of Waves

Q.1: What is a wave?

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

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

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

Q.3: Provide two everyday examples of energy transfer through waves.

Answer: 1. Ripples in water caused by a twig. 2. Sound waves from a plucked guitar string travelling through the air.

Q.4: What are mechanical waves?

Answer: Mechanical waves are the waves that require a material medium (like air, water or a solid material) to travel.

Explanation: These waves cannot pass through a vacuum because they rely on the vibration of particles in the medium to transfer energy.

Q.5: What are electromagnetic waves?

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

Q.6: Name four examples of electromagnetic waves.

Answer: 1. Radio waves 2. Microwaves 3. Visible light 4. X-rays

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

Answer: The speed of electromagnetic waves in a vacuum is approximately 3×10^8 ms^{-1} (300,000 km per second).

Q.8: Define a transverse wave.

Answer: A transverse wave is one where the particles of the medium vibrate at right angles (perpendicular) to the direction of the wave's travel.

Q.9: Define a longitudinal wave.

Answer: 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

Q.10: What is a crest and a trough?

Answer: ● Crest: In a transverse wave, a crest is the highest point above the mean position. ● Trough: In a transverse wave, a trough is the lowest point below the mean position.

Q.11: What are compressions and rarefactions?

Answer: ● Compressions: In a longitudinal wave, compressions are regions where particles are close together (high pressure). ● Rarefactions: In a longitudinal wave, rarefactions are regions where particles are spread apart (low pressure).

Q.12: Define Amplitude.

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

Q.13: Define wavelength.

Answer: Wavelength is the distance between two corresponding points on adjacent waves, such as from crest to crest or compression to compression.

- Symbol: λ (lambda)
- SI Unit: Metre (m)

Q.14: What is frequency?

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

- Symbol: f
- SI Unit: Hertz (Hz)

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

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

$T = 1 / f$

- T = Time period (in seconds)
- f = Frequency (in Hertz)

Q.16: State the wave equation.

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

$v = f \times \lambda$

- v = Wave speed (ms^{-1})
- f = Frequency (Hz)
- λ = Wavelength (m)

12.4 Properties of Waves

Q.17: What is Reflection of waves?

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

Q.18: State the law of Reflection.

Answer: The angle of incidence is always equal to the angle of reflection. Angle of Incidence = Angle of Reflection

Q.19: Define refraction.

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

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

Answer: ● The wave slows down. ● Its wavelength becomes shorter.

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

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

Q.22: What is diffraction?

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

Q.23: Under what condition is diffraction most prominent?

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

12.5 Seismic and Tsunami Waves

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

Answer: 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.

Q.25: What causes a tsunami?

Answer: Tsunamis are triggered by sudden underwater disturbances, such as: ● Earthquakes ● Volcanic eruptions ● Landslides. These events shift the ocean floor and push a huge volume of water upward.

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

Answer: ● Its speed decreases ● Its wavelength shortens ● Its amplitude (height) increases significantly, sometimes to 30 metres or more, as energy is compressed into a smaller space.

Summary Table: Key Concepts

Concept	Definition	Key Points
Wave	Disturbance that transfers energy without transferring matter	Particles vibrate but don't move with the wave
Mechanical Wave	Requires a medium to travel	Sound, water, seismic waves
Electromagnetic Wave	Does not require a medium	Light, radio, X-rays
Transverse Wave	Particles vibrate perpendicular to wave direction	Crests and troughs
Longitudinal Wave	Particles vibrate parallel to wave direction	Compressions and rarefactions
Reflection	Waves bounce back from a surface	Angle of incidence = Angle of reflection

Concept	Definition	Key Points
Refraction	Waves change direction when entering new medium	Speed and wavelength change; frequency stays same
Diffraction	Waves bend/spread around obstacles or through gaps	Most prominent when gap < wavelength

Quick Comparison Chart

Feature	Transverse Waves	Longitudinal Waves
Particle Vibration	Perpendicular to wave direction	Parallel to wave direction
Key Features	Crests and Troughs	Compressions and Rarefactions
Examples	Water waves, Light waves	Sound waves, P-waves
Can travel through vacuum?	Only electromagnetic	No (mechanical only)

PART C — Long Questions, Complete Notes

10th Class Physics - Chapter 12: Waves

Long Questions - Complete Notes

Importance of Waves

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.

Definition of 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.

Particle Behavior

The particles themselves do not travel 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. These ripples carry energy outward, yet the water and twig remain mostly in place.

- Observation: 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.

ii. Sound Waves:

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

- Observation: 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.

iii. Spring (Slinky):

When one end of a stretched spring is pushed and released, longitudinal waves move through the spring.

- Observation: The spring develops regions of compression (where the coils are close together) and rarefaction (where the coils are spread out).
- Matter Check: These compression and rarefaction 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.

Water Wave Experiment to Demonstrate Wave Motion

A simple and effective way to understand wave motion is through an experiment using a ripple tank.

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.

There are two main types of waves:

- 1. Mechanical Waves
- 2. 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.

Examples

- Sound waves
- Water waves
- Vibrations on a rope or spring
- Seismic waves produced by earthquakes

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), which 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 300,000 km per second ($3 \times 10^8\ ms^{-1}$), 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.

Examples

- Radio waves
- Microwaves
- Infrared rays
- Visible light
- Ultraviolet rays
- X-rays
- Gamma rays

Q.5: Explain 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:

- 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.

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

- Water Waves: An excellent example of a transverse wave. As the wave moves forward across the water surface, the water molecules move up and down.
- Electromagnetic Waves: Electromagnetic radiation (such as light, radio waves, 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, the particles move back and forth along the same path as the energy flow.

Compressions and Rarefactions

This motion creates regions where particles are close together, known as compressions, and regions where particles are spread apart, known as rarefactions.

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 their 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.

Q.6: Define following terms and parameters:

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: 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: 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: $T = 1/f$ (inverse of frequency)
- SI Unit: Seconds (s)

Wave Front: A wave front is an imaginary surface on which all the points have the 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.

Wave Speed

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

Mathematical Representation

As, Speed = Distance travelled / Time taken

Let us consider a wave:

- Distance travelled = λ (wavelength)
- Time taken = T (time period)

Then $v = S/t$

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

Substitute into the formula: $v = \lambda / T$ ... (12.1)

Now, $1/T = f$ (where f is frequency)

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

Where:

- v = The wave speed (in meters per second, ms^{-1})
- f = The frequency (in Hertz, Hz)
- λ = The wavelength (in metres, m)

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

12.4 Properties of Waves

Q.8: Briefly explain the 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 Behaviours

- 1. Reflection
- 2. Refraction
- 3. 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 an 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.

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 classrooms.

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.

- 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 refraction 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 water waves cross into a 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 shown where wave fronts bend 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.

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.

Quick Questions

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?

Answer: Transverse and longitudinal waves.

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

Answer: 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?

Answer: 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?

Answer: 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 emitted by warm objects.

Answer: 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?

Answer: Frequency tells us how many waves pass a point in one second. That is why an FM radio station is called “88.0 MHz”. It is sending 88 million wave cycles per second.

4. Explain the time period with an example.

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

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

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

Example Problem

Problem: 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 = Number of cycles / Time

$f = 10/5 = 2$ Hz

As $v = f \times \lambda$

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

Objective Type Questions

12.1 Waves and Nature of Waves

1. Waves is transferred from one place to another by: (a) Matter (b) Energy ✓ (c) Particles (d) Medium

2. 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 or oscillate around their original positions ✓ (d) Remain completely motionless

3. 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) Matter transfer without any energy transfer (c) Both energy and matter transfer (d) No transfer of matter and energy

4. 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

5. 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

6. Which of the following is NOT an example of a mechanical wave? (a) Sound waves (b) Water waves (c) Radio waves ✓ (d) Seismic waves

Summary of Key Formulas

Quantity	Symbol	Formula	SI Unit
Frequency	f	f = Number of cycles / Time	Hertz (Hz)
Wave Period	T	$T = 1/f$	Seconds (s)

Quantity	Symbol	Formula	SI Unit
Wave Speed	v	$v = f \times \lambda$	Metres per second (ms^{-1})
Wavelength	λ	$\lambda = v/f$	Metres (m)

Key Terms Glossary

Term	Definition
Wave	A disturbance that transfers energy through a medium without transferring matter
Mechanical Wave	A wave that requires a material medium to travel
Electromagnetic Wave	A wave that does not require a medium to travel (can travel through vacuum)
Transverse Wave	Wave where particles vibrate perpendicular to wave direction
Longitudinal Wave	Wave where particles vibrate parallel to wave direction
Crest	Highest point of a transverse wave
Trough	Lowest point of a transverse wave
Compression	Region in longitudinal wave where particles are close together
Rarefaction	Region in longitudinal wave where particles are spread apart
Amplitude	Maximum displacement from rest position
Wavelength	Distance between corresponding points on adjacent waves
Frequency	Number of complete wave cycles per second
Time Period	Time for one complete wave to pass a point
Reflection	Bouncing back of waves from a surface
Refraction	Bending of waves when passing between media
Diffraction	Spreading of waves around obstacles or through openings

PART D — Numerical Problems with Complete Solutions

10th Class Physics - Chapter 12: Waves

Numerical Problems with Complete Solutions

Conceptual Questions

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

Answer: See Q.2 (Main Chapter Notes, Part A)

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

Answer: See Q.4 (Main Chapter Notes, Part A)

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

Answer: See Q.5 (Main Chapter Notes, Part A)

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

Answer: See Q.8 (Main Chapter Notes, Part A)

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

Answer: See Q.11 (Main Chapter Notes, Part A)

Numerical Problems

Problem 12.1

Given:

- Wavelength (λ) = 2 m
- Frequency (f) = 5 Hz

Required:

- Speed (v) = ?

Formula: $v = f \times \lambda$

Solution:

$v = f \times \lambda$

$v = (5\ Hz) \times (2\ m)$

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

Result: The speed of the wave is $10\ ms^{-1}$

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

Problem 12.2

Given:

- Speed (v) = 300 ms^{-1}
- Wavelength (λ) = 3 m

Required:

- Frequency (f) = ?

Formula: $f = v / \lambda$

Solution:

$f = v / \lambda$

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

$f = 100\ Hz$

Result: The frequency of the wave is 100 Hz

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

Problem 12.3

Given:

- Frequency (f) = 250 Hz
- Speed (v) = 340 ms^{-1}

Required:

- Wavelength (λ) = ?

Formula: $\lambda = v / f$

Solution:

$\lambda = v / f$

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

$\lambda = 1.36\ m$

Result: The wavelength of the sound wave is 1.36 m

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

Problem 12.4

Given:

- Frequency (f) = 50 Hz

Required:

- Time Period (T) = ?

Formula: $T = 1 / f$

Solution:

$T = 1 / f$

$T = 1 / 50\ Hz$

$T = 0.02\ s$

Result: It takes 0.02 seconds to complete one wave cycle

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

Problem 12.5

Given:

- Wavelength (λ) = 0.5 m
- Frequency (f) = 200 Hz

Required:

- Speed (v) = ?

Formula: $v = f \times \lambda$

Solution:

$v = f \times \lambda$

$v = (200\ Hz) \times (0.5\ m)$

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

Result: The speed of the wave is 100 ms^{-1}

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

Problem 12.6

Given:

- Time Period (T) = 0.02 s

Required:

- Frequency (f) = ?

Formula: $f = 1 / T$

Solution:

$f = 1 / T$

$f = 1 / 0.02\ s$

$f = 50\ Hz$

Result: The frequency of the wave is 50 Hz

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

Summary of Formulas Used

Formula	When to Use
$v = f \times \lambda$	To find wave speed when frequency and wavelength are given
$f = v / \lambda$	To find frequency when speed and wavelength are given
$\lambda = v / f$	To find wavelength when speed and frequency are given
$T = 1 / f$	To find time period when frequency is given
$f = 1 / T$	To find frequency when time period is given

Quick Reference Table

Quantity	Symbol	SI Unit	Formula
Speed	v	ms^{-1}	$v = f \times \lambda$
Frequency	f	Hz (s^{-1})	$f = v/\lambda = 1/T$
Wavelength	λ	m	$\lambda = v/f$
Time Period	T	s	$T = 1/f$

Important Relationships to Remember

- 1. Speed = Frequency × Wavelength ($v = f\lambda$)
- 2. Frequency = 1 / Time Period ($f = 1/T$)
- 3. Time Period = 1 / Frequency ($T = 1/f$)
- 4. Wavelength = Speed / Frequency ($\lambda = v/f$)

Tips for Solving Wave Problems

- 1. Identify the given quantities - Read the problem carefully and note what is given (v, f, λ, or T)
- 2. Identify what is required - Determine what you need to find
- 3. Choose the correct formula - Select the appropriate formula based on given and required quantities
- 4. Substitute values carefully - Make sure units are consistent
- 5. Write the final answer - Include the correct units

End of Booklet — All Content from the Four Source Documents Preserved