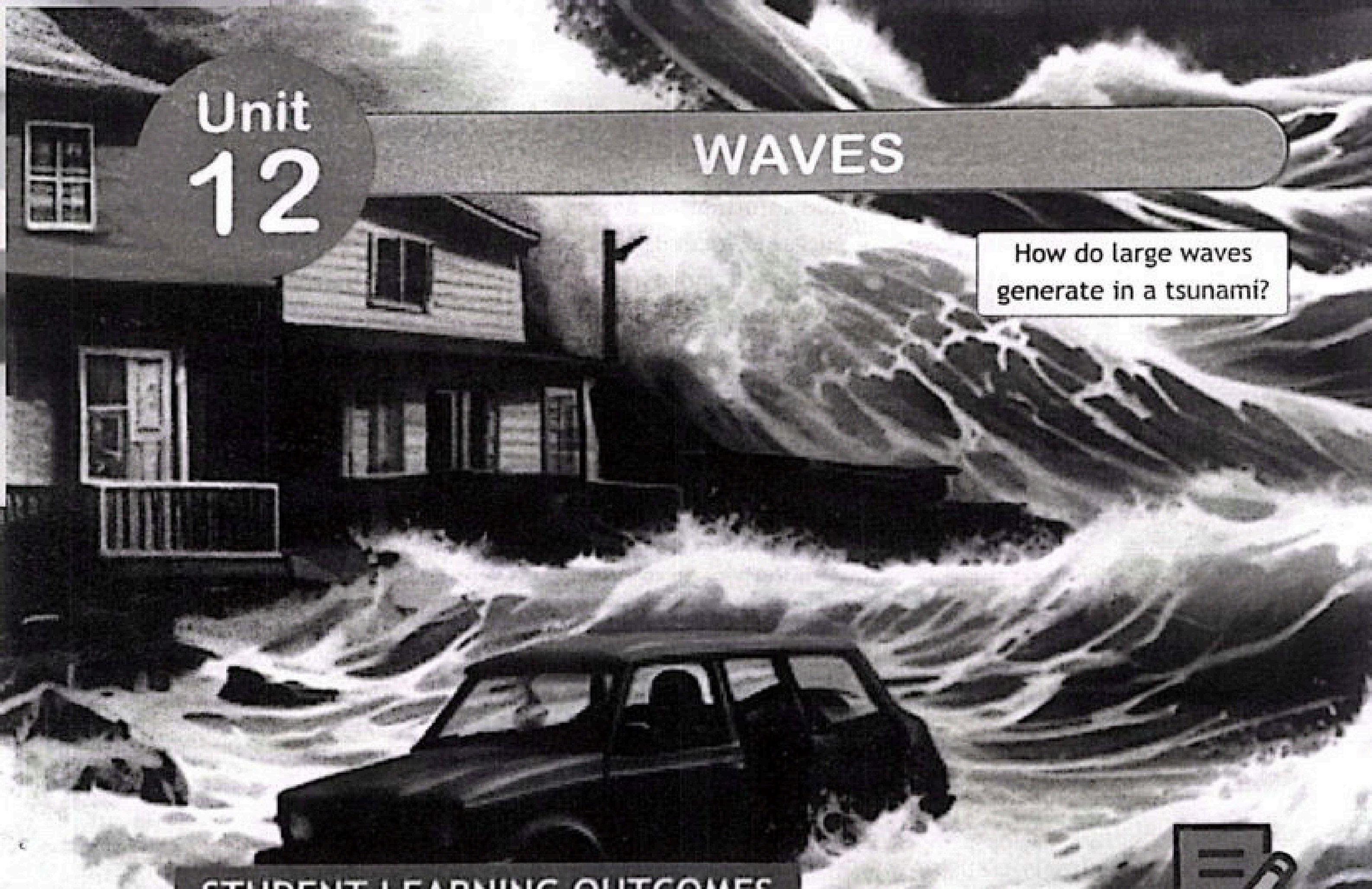


Unit 12 WAVES

How do large waves generate in a tsunami?

STUDENT LEARNING OUTCOMES

The students will:

- ✓ [SLO: P-10-D-01] Prove that waves transfer energy without transferring matter
- ✓ [SLO: P-10-D-02] Describe what is meant by wave motion [as illustrated by vibrations in ropes and springs and by experiments using water waves.]
- ✓ [SLO: P-10-D-03] Describe the features of a wave [in terms of wavefront, wavelength, frequency, time period, crest (peak), trough, compression, rarefaction, amplitude and wave speed]
- ✓ [SLO: P-10-D-04] Define the terms frequency, wavelength, and amplitude.
- ✓ [SLO: P-10-D-05] Recall and apply the equation wave speed = frequency × wavelength ($v = f \cdot \lambda$)
- ✓ [SLO: P-10-D-06] 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 S-waves (secondary)]
- ✓ [SLO: P-10-D-07] Illustrate that for a longitudinal wave, the direction of vibration is parallel to the direction of the energy transfer [including give examples such as sound waves and seismic P-waves (primary))]
- ✓ [SLO: P-10-D-08] Describe how waves can undergo reflection, refraction and diffraction
- ✓ [SLO: P-10-D-09] Describe how wavelength affects diffraction at an edge
- ✓ [SLO: P-10-D-10] 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]
- ✓ [SLO: P-10-D-11] Describe how wavelength and gap size affects diffraction through a gap

Waves are a fundamental aspect of both the natural world and technological advancements, embodying the transfer of energy and information across various mediums. From the gentle ripples on a pond to the powerful surges of ocean tides, waves are omnipresent, influencing weather patterns, communication systems, and even the fundamental structure of matter. Understanding waves involves exploring their properties, behaviors, and the principles governing their propagation, which are crucial in fields ranging from physics and engineering to medicine and environmental science. This introduction delves into the fascinating world of waves, unraveling their complexities and highlighting their significance in our daily lives and the broader universe.

12.1 WAVE MOTION

Waves play an important role in our daily life. It is because waves are carrier of energy and information over large distances. Waves require some oscillating or vibrating source. Here we demonstrate the production and propagation of different waves with the help of vibratory motion of objects, some of the waves are water waves, sound waves, electromagnetic waves etc.

12.1.1 WATER WAVES

When a stone is thrown into the water, it creates ripples that propagate outward. These ripples, or water waves, clearly transfer energy: you can see the motion of the boat bobbing up and down as the waves pass. However, the boat itself does not significantly move from its position. This illustrates that the energy from the wave causes the boat to oscillate vertically, but the boat (matter) remains mostly in the same place.

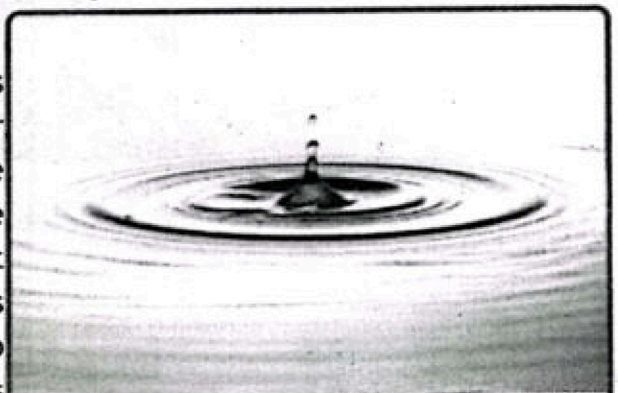


FIGURE 12.1 Water Waves

MINI LAB

When you drop a stone into a pond, it creates waves on the water's surface that spread outwards. If you place a cork a little distance away from where the stone fell, the cork will start to bob up and down as the waves reach it. This happens because the cork is getting energy from the waves.

This activity demonstrates that water waves, like other types of waves, transfer energy from one place to another without actually moving the water itself.

12.1.2 SOUND WAVES

When you speak, your vocal cords vibrate, producing sound waves that travel through the air. If you place your hand in front of a speaker, you can feel the vibrations of the sound waves, which indicates that energy is being transferred. However, the air molecules themselves do not travel from the speaker to your hand; they oscillate back and forth around their equilibrium positions. This oscillatory motion transfers the sound energy through the medium (air), but the individual air molecules stay relatively in place.

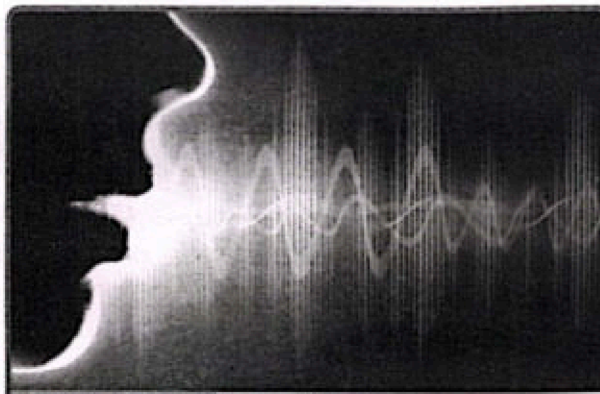


FIGURE 12.2 Sound Waves

12.1.3 ELECTROMAGNETIC WAVES

Consider light waves or radio waves, which are types of electromagnetic waves. When light from the sun reaches Earth, it brings energy that warms the planet and powers photosynthesis in plants. However, there is no medium like air or water involved in the transfer of electromagnetic waves through the vacuum of space. Instead, electric and magnetic fields oscillate perpendicular to each other and the direction of wave propagation, carrying energy across vast distances without the need for a material medium.

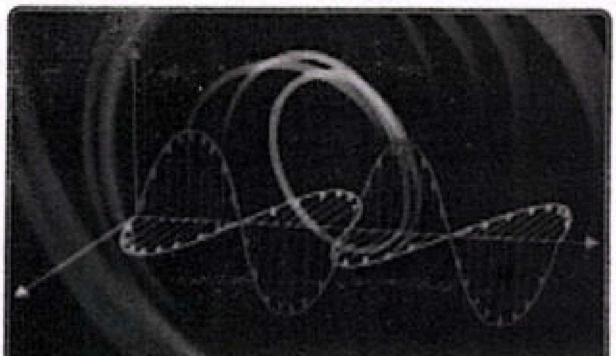


FIGURE 12.3 Electromagnetic Waves

12.1.4 WAVE IN ROPE

A wave in a rope provides a clear example of transverse wave motion, where the oscillations of the medium (the rope) are perpendicular to the direction of wave propagation.

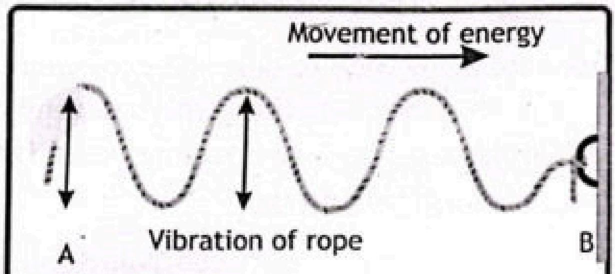


FIGURE 12.4 Waves in Rope

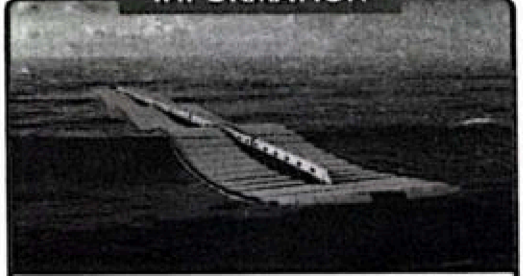
12.2 WAVE PROPAGATION

The key to understanding wave energy transfer without matter transfer lies in the nature of wave propagation. Waves are disturbances that travel through a medium (or space, in the case of electromagnetic waves), causing particles of the medium to oscillate around their equilibrium positions. Here's a step-by-step explanation:

12.2.1 OSCILLATION

In a wave, particles of the medium experience periodic oscillations or vibrations. These oscillations can be longitudinal (particles move parallel to the wave direction, as in sound waves) or transverse (particles move perpendicular to the wave direction, as in water and electromagnetic waves).

INFORMATION



Generating a high frequency wave, requires more energy per second than to generate a low frequency wave. Thus, a high frequency wave carries more energy than a low frequency wave of the same amplitude.

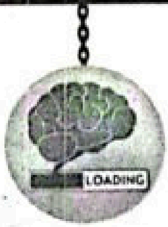
12.2.2 ENERGY TRANSFER

The energy of the wave is transferred through these oscillations. For example, in a sound wave, compressions and rarefactions of air molecules transfer kinetic and potential energy from one particle to the next.

12.2.3 NO NET MOVEMENT

Despite the oscillatory motion, the particles of the medium do not undergo a net displacement. They return to their original positions after the wave passes. Therefore, there is no overall transfer of matter, only energy.

SCIENCE TIDBITS



A human eardrum can oscillate back and forth up to 20,000 times in one second.

12.3 CHARACTERISTIC WAVE PARAMETERS

There are many ways to describe or measure a wave. Some characteristics depend on how the wave is produced, whereas others depend on the medium through which the wave travels. Certain characteristic wave parameters and their definitions are given as under.

12.3.1 WAVELENGTH 'λ'

The shortest distance between points where the wave pattern repeats itself is called the wavelength, its symbol is the Greek letter lambda 'λ'.

The unit of wavelength is 'm'. The wavelength is the repeated distance of the wave pattern—a shift of the wave pattern by one wavelength to the right (or the left) reproduces the original wave pattern. The wave length may be the distance between two successive crests or troughs as shown in figure 12.5, or it may be the distance between two successive compressions.

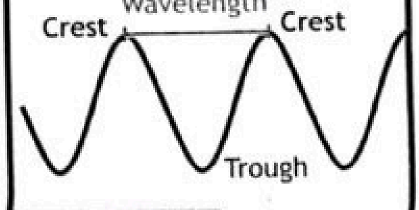


FIGURE 12.5 Wavelength

12.3.2 WAVEFRONT

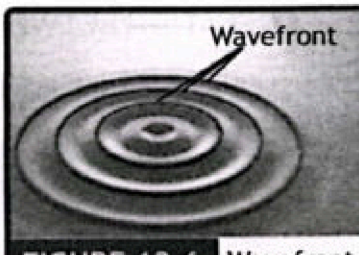


FIGURE 12.6 Wavefront

Huygens stated that light is a wave propagating through space like ripples in water or sound in air. Hence, light spreads out like a wave in all directions from a source. The locus of all points that travelled some distance during a fixed interval is called a wavefront.

12.3.3 WAVE CREST AND TROUGH

A crest point on a wave is the maximum value of upward displacement within a cycle. A crest is a point on a surface wave where the displacement of the medium is at a maximum. A trough is the opposite of a crest, so the minimum or lowest point in a cycle.

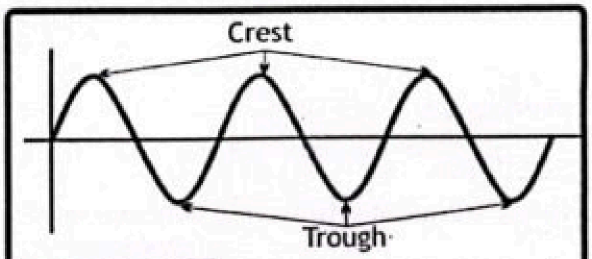


FIGURE 12.7 Wave Crest & Wave Trough

12.3.4 DISPLACEMENT

The separation between mean position and any point either on right or left of the mean position is called displacement (x). Displacement is measured in meters (m).

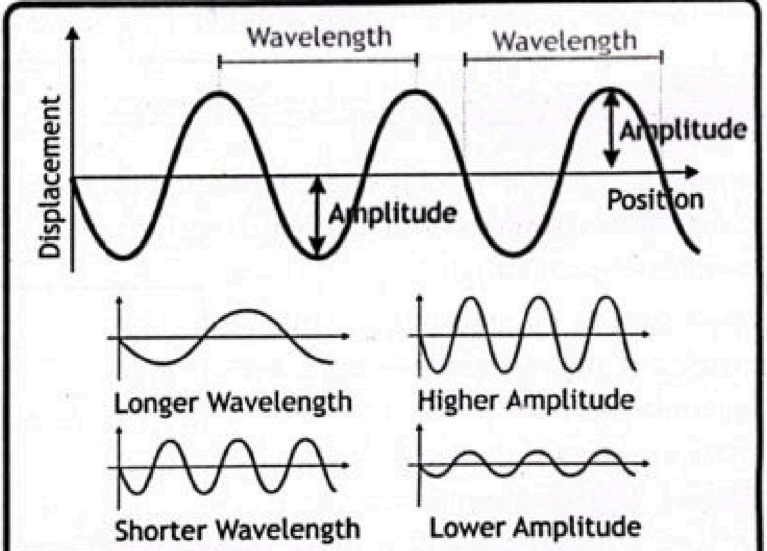


FIGURE 12.8 Displacement & Amplitude

12.3.5 AMPLITUDE

The maximum displacement form mean on either side is called amplitude (x_o). As amplitude is also a displacement that's why is measured in meters (m).

12.3.6 TIME PERIOD

The maximum displacement form mean on either side is called amplitude (x_o). As amplitude is also a displacement that's why is measured in meters (m).

12.3.7 FREQUENCY

The number of cycles completed by an oscillating body in one second is called frequency (f). It is measured in cycles per second (cps) or hertz (Hz).

12.3.8 RELATION BETWEEN TIME PERIOD AND FREQUENCY

Time period and frequency are reciprocal of each other. Greater the time period smaller will be the frequency and vice versa.

$$T = \frac{1}{f} \quad (12.1)$$

Example 12.1

A student oscillates a pendulum having 5 vibrations per second, Calculate its time period.

GIVEN:
Frequency 'f' = 5 Hz

REQUIRED:
Time Period 'T' = ?

SOLUTION:
Using frequency-time relation, we have: $T = \frac{1}{f}$ putting values $T = \frac{1}{5Hz}$

Therefore $\boxed{T = 0.2s}$ ANSWER

So the pendulum will oscillate with a period of 0.2 s.

12.4 WAVES AND THEIR TYPES

Waves are carrier of energy and information over large distances. Wave is a disturbance that moves outward from its point of origin, transferring energy by means of vibrations with little or no transport of medium.

Wave motion is related to oscillation as particles of the medium execute simple harmonic motion about their mean position when a wave passes. For example, take a rope and colour a part of it. Attach one end of the rope to the wall and wiggle the other end continuously. A wave train will be produced. The colored part of rope will execute oscillations about certain mean position, as shown in figure 12.9 (b).

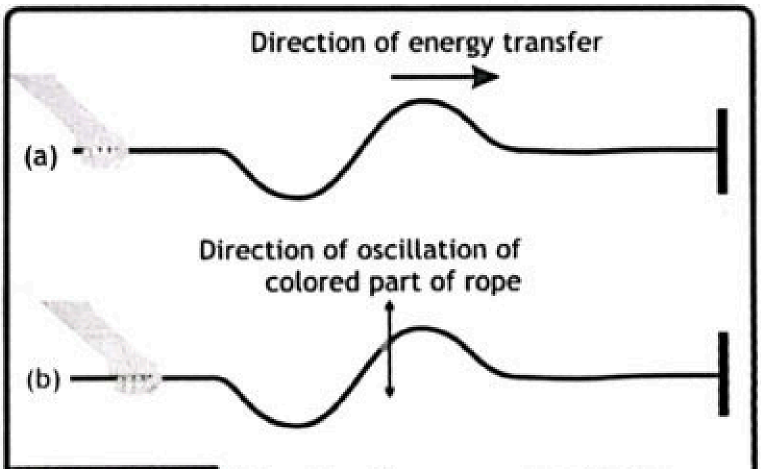


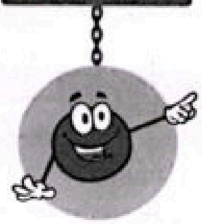
FIGURE 12.9 Direction of energy and oscillation

12.5 TYPES OF WAVES ON THE BASIS OF MEDIUM

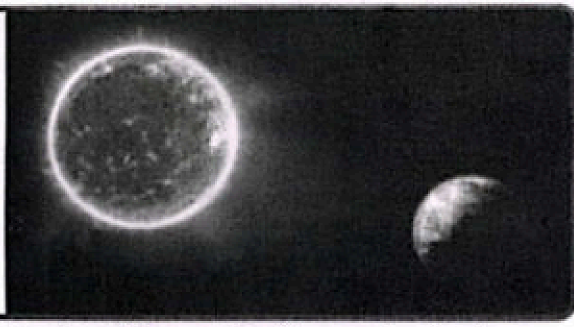
Waves are divided into two types on the basis of medium requirement.

A. Mechanical waves: Such types of waves which require material medium to propagate from one

POINT TO PONDER



We receive sun light (electromagnetic wave) but not the sound (mechanical wave) of fusion reactions occurring at the surface of earth. It is because there is vacuum in between earth and sun. Light waves can travel in vacuum but sound waves cannot.



point to another point are called mechanical waves. If medium does not exist, mechanical waves cannot travel from one point to another point. For example, sound wave, rock wave in water, seismic wave etc.

B. Electromagnetic waves: Such type of waves which do not require material medium to propagate from one point to another point are called electromagnetic waves. It means that the existence of material medium is not necessary for propagation of electromagnetic waves. It consists of electric and magnetic fields as shown in figure 12.10. Examples of electromagnetic waves are light waves, x-rays, ultraviolet waves, infrared waves etc.

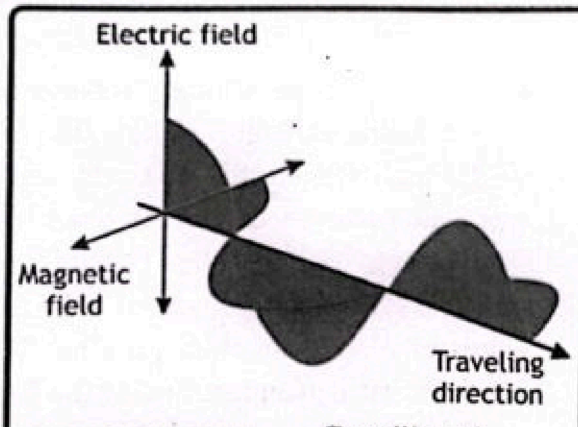


FIGURE 12.10 Travelling of Electromagnetic wave

12.6 TYPES OF WAVES ON THE BASIS OF PROPAGATION

Waves are divided into two types on the basis of their propagation.

12.6.1 TRANSVERSE WAVES

The type of waves in which the disturbance occur perpendicular to the direction of motion of the waves are termed as transverse waves. This means the vibrations are at right angles to the wave's motion as shown in figure 12.11. Transverse waves are common in nature and can be observed in various forms. Waves produced in a string when its one end is fixed to a support and the other end is moved up and down is an example of transverse waves.

A. Electromagnetic Radiation: Electromagnetic waves, such as light, X-rays, and radio waves, are examples of transverse waves. These waves do not require a medium

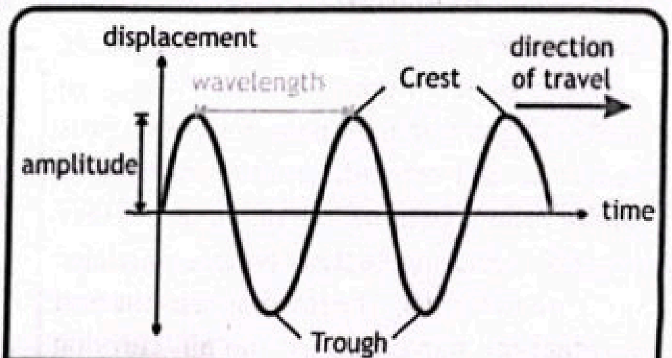


FIGURE 12.11 Transverse Waves

to travel. The electric and magnetic fields vibrate at right angles to each other and to the direction of energy transfer. For example, sunlight travels through space as an electromagnetic wave, bringing energy from the Sun to Earth.

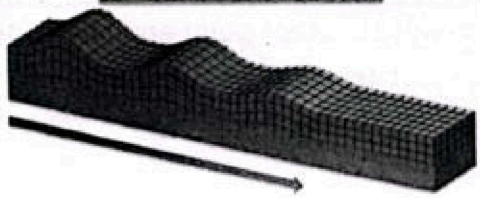
B. Waves on the Surface of Water: Waves on the surface of water are another example of transverse waves. The water particles move up and down (vibration), while the wave energy travels horizontally across the surface. For instance, when a stone is thrown into a pond, ripples spread outwards from the point of impact, showing the transverse motion of the water particles.

C. Seismic S-Waves (Secondary Waves): Seismic S-waves, produced during earthquakes, are transverse waves that move through the Earth. In these waves, the ground vibrates side-to-side or up-and-down, while the wave energy travels horizontally. Unlike P-waves, S-waves cannot travel through liquids, as they require the shear strength of a solid medium for their vibrations. These waves are critical in understanding the Earth's interior and locating earthquake epicenters.

DO YOU KNOW?

Do mechanical waves pass through vacuum, that is, empty space?

DO YOU KNOW?



Earthquake produces waves through the crust of the Earth in the form of seismic waves. By studying such waves, the geophysicists learn about the internal structure of the Earth and information about the occurrence of future Earth activity.

12.6.2 LONGITUDINAL WAVES

Type of waves in which the disturbance occur parallel to the line of travel of the wave are termed as longitudinal waves. This means that the vibrations and the energy transfer occur along the same line. A longitudinal wave can be generated with a Slinky, as shown in Figure12.12. When one end is pushed forward along its length (i.e., longitudinally) and then pulled back to its starting point, as in part a, a region where the coils are compressed together is sent traveling to the right.

Parts of the wave having higher density and pressure are called compressions and parts having smaller density and pressure are called rarefactions.

A. Sound Waves: Sound waves are a classic example of longitudinal waves. When we speak, the air particles near our vocal cords compress and expand, creating regions of compression (where particles are close together) and rarefaction (where particles are spread apart). These compressions and rarefactions move through the air, carrying sound energy to the listener. For instance,

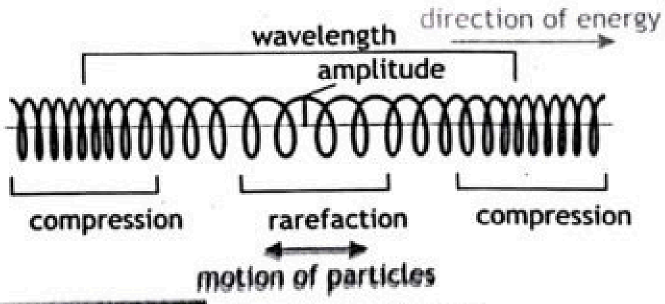
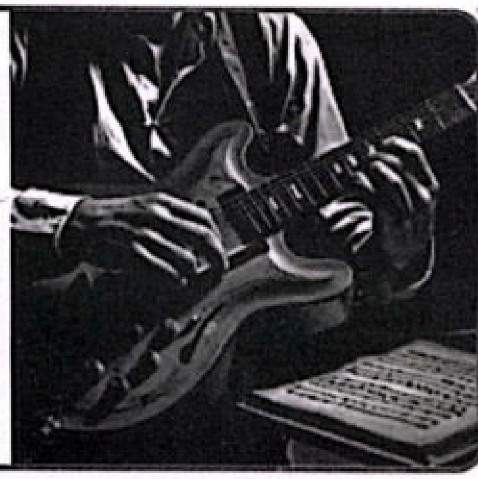


FIGURE 12.12 Longitudinal Waves

SCIENCE TIDBITS

When you pluck a guitar string, it produces transverse waves along the string, meaning the vibrations move perpendicular to the length of the string. These transverse vibrations then cause the air around the string to vibrate, producing sound waves.



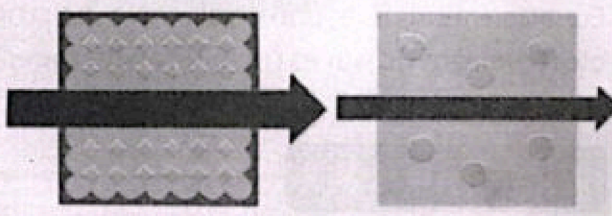
Sound waves are longitudinal waves, which mean the vibrations occur in the same direction as the wave travels, compressing and rarefying the air molecules to create the sound we hear. So, while the motion on the string is transverse, the resulting sound waves in the air are longitudinal.

when we clap, the sound travels as longitudinal waves through the air to reach someone nearby.

B. Seismic P-Waves (Primary Waves): Seismic P-waves, generated during earthquakes, are another example of longitudinal waves. These waves cause particles in the Earth to vibrate back and forth in the same direction as the wave's movement. P-waves are the fastest type of seismic wave and can travel through solids and liquids. These characteristic helps scientists study the Earth's structure and detect earthquakes. For example, the time difference between the arrival of P-waves and slower S-waves at a seismic station helps determine the location of the earthquake's epicenter.

INFORMATION

Longitudinal waves move faster through solids than through gases or liquids. Transverse waves move through solids at a speed of less than half of the speed of longitudinal waves. It is because the restoring force exerted during this up and down motion of particles of the medium is less than the restoring force exerted by a back and forth motion of particles of the medium in case of longitudinal waves.



Fastest in solids Slowest in gases

12.7 WAVE CHARACTERISTICS

Some of the main characteristics of waves are as follows:

A. Wave Cycle: As a wave passes a given point along its path, that point undergoes cyclic motion. The point is displaced first in one direction and then in the other direction. Finally, the point returns to its original equilibrium position, there by completing one cycle. Number of wave cycles are represented by 'N'. As it is a pure number, so it has no unit.

B. Frequency: The number of wave cycles passing through some point per unit time is called frequency of the waves. Mathematically:

$$f = \frac{N}{t} \quad \text{— } \boxed{12.2}$$

Frequency is measured in Hertz (Hz).

C. Time Period: The time required for one wave cycle to pass through certain point is called Time Period. It is represented by "T" and its unit seconds (s). It is the time any vibrating element of wave takes to move through one complete oscillation. Time period is the reciprocal of frequency. Mathematically:

$$T = \frac{1}{f} \quad \text{— } \boxed{12.3}$$

D. Wave Speed: The distance travelled by a wave per unit time is called wave speed. Mathematically:

$$\textit{Wave speed}\; v = \frac{\Delta d}{\Delta t} \quad \text{— } \boxed{1}$$

If a wave travels distance equal to its wavelength 'λ', then the time taken will be equal to its time period 'T'. Putting these values in equation 1:

$$v = \frac{\lambda}{T} \quad \text{— } \boxed{2}$$

As frequency is reciprocal of time period, given from equation 12.3, putting in equation 2:

$$v = f\lambda \quad \text{— } \boxed{12.4}$$

Equation 12.4 is a universal wave equation that can be used for all types of waves. For electromagnetic waves travelling with speed 'c', equation 12.4 can be given by:

$$c = f\lambda \quad \text{— } \boxed{12.5}$$

Example 12.2

An athlete in the gym moves one end of a rope up and down, whose other end is fastened with a wall, with a speed of 2.5 m/s. It produces oscillations whose wavelength is 0.5 m. Calculate the frequency of waves generated in the rope.

GIVEN:
Wavelength 'λ' = 0.5 m
Wave speed 'v' = 0.5 m/s

REQUIRED:
Frequency 'f' = ?

SOLUTION:
By universal wave equation: $v = f\lambda$ or $f = \frac{v}{\lambda}$ putting values $f = \frac{2.5 m/s}{0.5 m}$

Therefore $\boxed{f = 5 Hz}$ — **ANSWER**

The rope therefore oscillates at 5 times per second.

Example 12.3

Find the wavelengths of the lowest and highest frequency sounds that human can hear which travels with a speed of 343 m /s in air?

GIVEN:

Lowest frequency 'f_1' = 20 Hz

Highest frequency 'f_2' = 20,000 Hz

Speed of sound 'v' = 343 m/s

REQUIRED:

Low Wavelength 'λ_1'= ?

High Wavelength 'λ_2'= ?

SOLUTION:

By universal wave equation: $v = f\lambda$ or $\lambda = \frac{v}{f}$

For lowest frequency sound, the above equation becomes: $\lambda_1 = \frac{v}{f_1}$

putting values: $\lambda_1 = \frac{343\,m/s}{20\,Hz}$ Therefore $\boxed{\lambda_1 = 17.15\,m}$ ANSWER

Similarly for highest frequency sound: $\lambda_2 = \frac{v}{f_2}$

putting values $\lambda_2 = \frac{343\,m/s}{20{,}000\,Hz}$ Therefore $\boxed{\lambda_2 = 0.017\,m}$ ANSWER

12.8 PROPERTIES OF WAVES

The basic properties of waves like reflection, refraction and diffraction can be described with the help of a ripple tank by using water waves. Ripple tank is also used to calculate frequency, wavelength and speed of waves on water's surface. It also analyzes the characteristics of waves like transverse and longitudinal behavior.

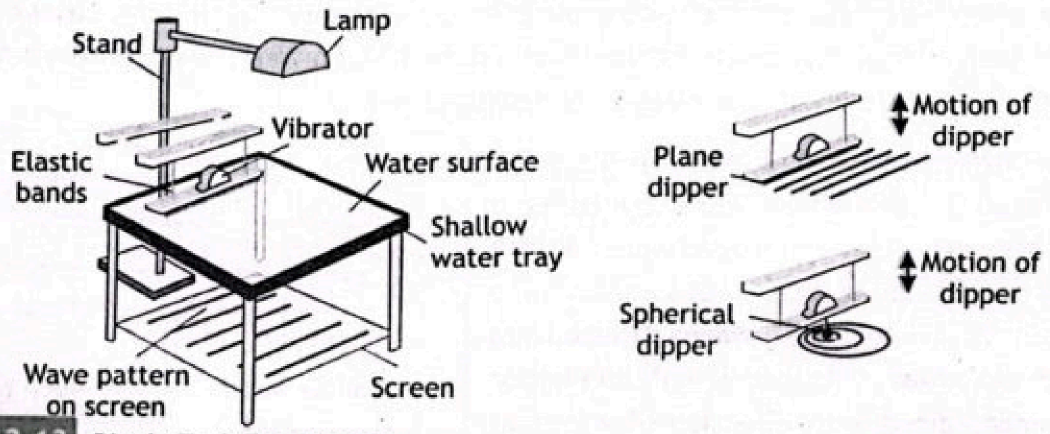


FIGURE 12.13 Ripple Tank Experiment

Basic Construction and working: A ripple tank consists of shallow tray of water with a transparent base, usually illuminated from above, so that light shines through the water. The ripples on the water show up as shadows (bright and dark lines) on the screen underneath the tank. The ripples are created by a small electric motor (vibrator). The motor has an off-center weight attached. When the motor is turned-on, it makes the strip vibrate and thus create ripples on the surface of water. Straight waves can be set up by using a straight dipper while circular waves can be formed by using a spherical dipper.

In order to get consistent plane waves, the motor assembly is lowered until it just touches the surface of water and the motor is then turned on. You should be able to see straight waves being created which travel across the surface of the tank, often called plane waves.

By lighting the wavefronts being created, clear peaks and troughs can be seen on the screen as shown in figure 12.13. The imaginary surface representing corresponding points (crests and troughs) of a wave that vibrate in unison is called a wavefront. It may be plane or spherical depending upon the dipper used

12.8.1 REFLECTION

The change in direction of a wave front at an interface between two different media or rigid barrier so that the wavefront returns in to the medium from which it is originated is called reflection as shown in figure 12.14. When a wavefront strikes a straight rigid barrier or irregular surface, it is reflected back along its original path.

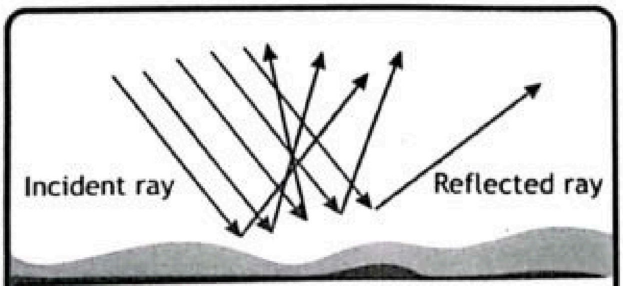


FIGURE 12.14 Reflection of Waves

12.8.2 REFRACTION

When waves travel from one medium into another its speed changes and in some cases divert from its original path, the phenomenon is called refraction. When a water wave enters a medium in which it moves more slowly, its wavelength decreases as well.

The phenomenon of refraction can be demonstrated in the ripple tank by using a boundary between shallow and deep water. A thick plastic sheet is placed in the tray at some angle to the wavefront. When water waves travel from shallow to deep water, its wavelength and hence speed changes along with direction of waves as shown in figure 12.15.

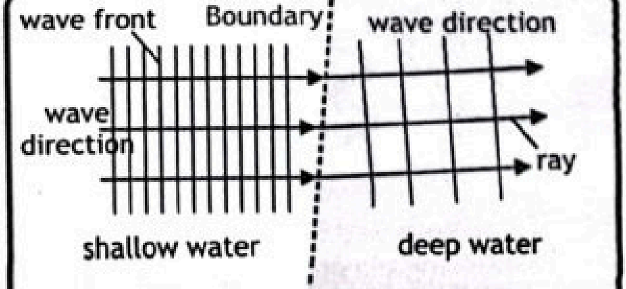
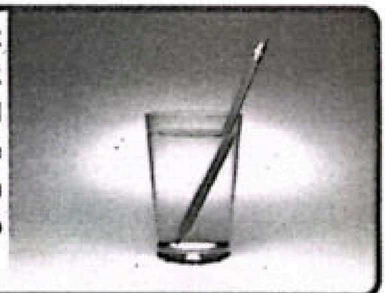


FIGURE 12.15 Refraction of Waves

MINI LAB

Place a pencil in the water, placing it so that it is tipped to one side. Look through the front of the glass and notice that the pencil is bent. The science behind it: Light "bends" when it passes though one substance to another of a different density.



12.8.3 DIFFRACTION

The bending of waves around corners of an obstacle is called diffraction. When waves pass through an aperture or opening it spreads out due to diffraction.

We can observe the phenomenon of diffraction in a ripple tank by generating straight waves and place two obstacles in such a way that the separation is comparable to the wavelength of the waves generated in the ripple tank. Waves, after passing through the narrow opening, spread out in every direction and turn into circular waves. This effect is greatest when the size of the opening is less than or equal to the size of the wavelength of generated waves as shown in figure 12.16 (a).

It is, however, to be noted that wavelength (or speed) of the wave is not affected by diffraction. If the separation is large between obstacles compared to the wavelength, it can be seen that central part of the wave is not affected, only part of the wave at the edges diffracts as shown in the figure 12.16 (b).

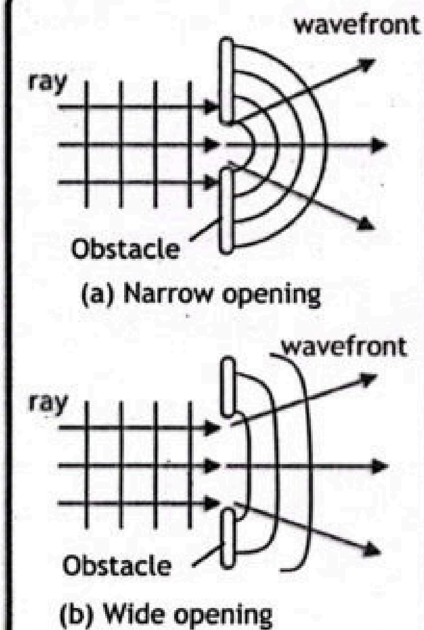


FIGURE 12.16 Diffraction

A. Wavelength and Diffraction: The wavelength is the distance between consecutive crests (or troughs) of a wave.

- **Shorter Wavelengths:** Waves with shorter wavelengths diffract less. If the wavelength is much smaller than the size of the gap, the waves will primarily travel straight through with minimal spreading.
- **Longer Wavelengths:** Waves with longer wavelengths diffract more. This means that if the wavelength is large compared to the size of the gap, the waves will spread out significantly after passing through the gap.

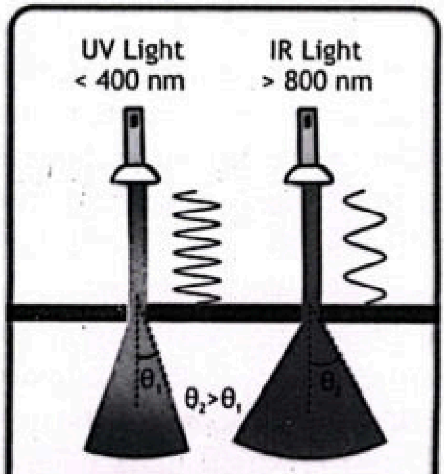


FIGURE 12.17 Wavelength and diffraction

UV light, which has a shorter wavelength, diffracts less than IR light, which has a longer wavelength, as shown in figure 12.17.

B. Gap Size and Diffraction: The size of the opening through which the waves pass.

- ***Narrow* Gaps:** When the gap size is comparable to or smaller than the wavelength of the wave, significant diffraction occurs. The waves spread out widely on the other side of the gap.
- **Wide Gaps:** When the gap size is much larger than the wavelength, diffraction is minimal. The waves pass through the gap with only slight spreading, and most of the wave energy remains in the original direction of propagation.

For example sound waves have relatively large wavelength that is why they can diffract around obstacles and through openings, allowing you to hear sounds even when you can't see the source. Whereas light wave has much shorter wavelength, visible light has a wavelength range from about 400 nm to 700 nm. When light passes through a slit or an aperture that is much larger than its wavelength, there is minimal diffraction, and the light beam remains well-defined. However, if the slit is on the order of the light's wavelength (as in a diffraction grating), significant diffraction and interference patterns can be observed.

12.9 TSUNAMIS

A tsunami is a series of large ocean waves created by underwater disturbances. These waves travel quickly across the ocean and can reach great heights when they approach the shore, causing massive flooding and damage to coastal areas as shown in figure 12.17.

FIGURE 12.18 Tsunami destruction

12.9.1 TSUNAMI GENERATION

Tsunamis are most commonly caused by underwater earthquakes, especially those that happen at tectonic plate boundaries where one plate is pushed beneath another. This sudden movement of the ocean floor displaces a large amount of water, resulting in powerful waves that travel across the ocean as shown in figure 12.18. Tsunamis can also be triggered by underwater volcanic eruptions, as the explosion displaces water and creates waves that spread outward. Additionally, landslides occurring under the ocean can displace water and generate tsunamis. The movement of sediment and rock on the seafloor causes water displacement, leading to the formation of tsunamis. Although rare, large meteorites impacting the ocean can also cause massive waves due to the significant displacement of water.

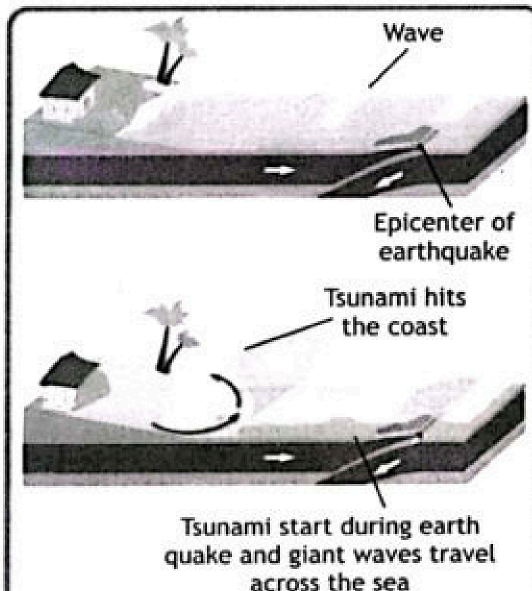


FIGURE 12.19 Tsunami generation

12.9.2 CHARACTERISTICS OF TSUNAMIS

Tsunami waves move quickly across the ocean after the initial disturbance, often traveling at speeds of 500-800 km/h (310-500 mph). In deep waters, the waves are not very high, making them hard to spot. However, as they near the coast, their speed slows down while their height increases significantly as the wave energy gets compressed.

DO YOU KNOW?

Lituya Bay, Alaska, July 9, 1958 A notable exception was the 1958 tsunami triggered by a landslide in a narrow bay on Alaska's coast. Its over 1,700-foot wave was the largest ever recorded for a tsunami.

When tsunamis hit land, they can cause massive destruction with their towering height and powerful energy, flooding coastal regions, demolishing structures, and resulting in substantial loss of life and property.

SUMMARY

- **Wave** is the energy transfer mechanism without the transport of material media.
- **Mechanical Waves** are the waves that require medium for their propagation.
- **Electromagnetic waves** are the waves that do not require any media for their propagation.
- **Transverse waves** are the waves in which particles of the medium vibrate/oscillate perpendicular to the direction of motion of waves.
- **Longitudinal waves** are the waves in which particles of the medium vibrate/oscillate parallel to the direction of motion of waves.
- **Seismic waves** are caused by the sudden movement of materials within the Earth, such as slip along a fault during an earthquake.
- **Reflection** is the throwing back by a body or surface of light, heat, or sound without absorbing it.
- **Refraction** is the change in direction of a wave passing from one medium to another caused by its change in speed.
- **Diffraction** is the bending of waves around the edges of an obstacle.
- **Tsunamis** are a series of enormous ocean waves caused by earthquakes, underwater landslides, volcanic eruptions or asteroids.

EXERCISE

MULTIPLE CHOICE QUESTIONS

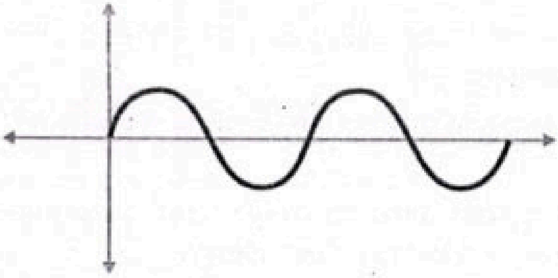
QI. Choose the best possible option in the following questions.

1. If a body performing simple harmonic motion completes its one vibration in 2 seconds, its frequency of vibration is:
   A. 2 Hz B. 1 Hz C. 0.5 Hz D. 10 Hz
2. 360 waves are passing through a point in a river in one hour, time period of the wave is:
   A. 0.1 s B. 1 s C. 10 s D. 100 s
3. Time period of electrical vibrator of ripple tank is 0.5 s, water waves in ripple tank has speed of 10 m/s and amplitude of 5 cm. Calculate the frequency of the waves.
   A. 50 Hz B. 0.5 Hz C. 200 Hz D. 2 Hz
4. Which of the followings is longitudinal wave?
   A. X- rays B. Light C. String waves D. Sound
5. When water waves enter from deep water to shallow water:
   A. Frequency of water waves increases B. Time period of water waves decreases
   C. Speed of water waves decreases D. Wavelength of water waves increases
6. Listening to radio transmission in deep valleys of mountain areas is due to:
   A. Reflection of waves B. Refraction of waves
   C. Interference of waves D. Diffraction of waves
7. Which of the following are transverse waves:
   A. X- rays B. Light C. String waves D. All of these
8. Tsunamis are most often generated by
   A. Flood B. Bomb blast C. Earth quake D. None of these
9. Waves transfer:
   A. energy B. frequency C. wavelength D. velocity
10. Which of the following characteristics of a wave is independent of the others?
    A. speed B. frequency C. amplitude D. wavelength
11. The relation between v, f and λ of a wave is:
    A. $vf = \lambda$ B. $f\lambda = v$ C. $v\lambda = f$ D. $v = \lambda / f$

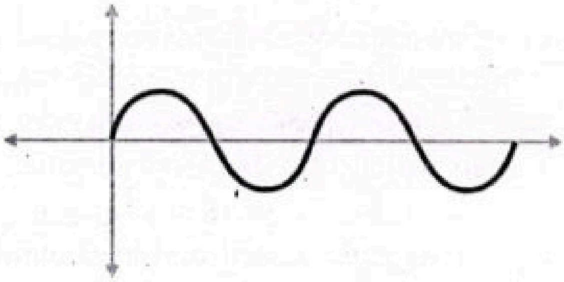
CONSTRUCTED RESPONSE QUESTIONS

QII. Follow the directions to respond to the following questions.

1. (a) In the graph below represent crest, trough and origin. (b) Also in similar graph drawn again show displacement, amplitude and wavelength.



(a)



(b)

SHORT RESPONSE QUESTIONS

QIII. Give a short response to the following questions.

1. What will happen to frequency of waves in a ripple tank if time period of electrical vibrator is decreased? What will happen to speed of waves?
2. What will happen to wavelength, speed, frequency and time period of the water waves in ripple tank if water waves enter from deep water to shallow water regions?
3. Nuclear fusion explosions are taking place at Sun, we get heat on earth but do not hear sound. Why?
4. Why do water waves refract at the boundary of shallow water and deep water? Relate this behavior to refraction of light.
5. Classify different wave types based on whether they require a medium for propagation. Justify why electromagnetic waves do not need a medium.
6. Under what conditions maximum diffraction of waves occurs?
7. Distinguish between reflection and refraction by describing how each process affects wave direction and speed. Design an experiment to demonstrate both phenomena using a ripple tank, and evaluate how changes in medium affect each process.

LONG RESPONSE QUESTIONS

QIV. Give a detailed response to the following questions.

1. How does a wave transfer energy without transferring matter? How does this principle apply to different media like ropes, water, and air?

2. Describe the key characteristics of a wave (wavelength, frequency, amplitude) and their relationships to each other. How do these characteristics affect the wave's energy and behavior?
3. Explain the relationship between wave speed, frequency, and wavelength using the equation $v = f\lambda$. Analyze a scenario where one of these variables changes and discuss the impact on the others.
4. Compare and contrast transverse and longitudinal waves, providing examples of each. Why is this distinction important in understanding wave behavior?
5. Describe how waves undergo reflection, refraction, and diffraction. Analyze a real-world scenario to illustrate these phenomena.
6. How does the wavelength of a wave affect its diffraction pattern? What factors determine the extent of diffraction, and how can this principle be applied in technology?
7. Explain the formation of tsunamis due to underwater earthquakes. Discuss how these waves change as they move from deep to shallow water and their potential impacts.
8. How does the amplitude of a wave relate to the amount of energy it carries? Use mathematical reasoning and real-world examples to support your answer.
9. Differentiate between primary (P) and secondary (S) seismic waves. How do these waves provide insights into the Earth's internal structure?
10. Discuss practical applications of wave reflection, refraction, and diffraction in technology. Provide examples and analyze their significance.

NUMERICAL RESPONSE QUESTIONS

QV. Solve the questions given below.

1. If 10 waves are produced on a long-stretched string of length 20 m. What is wavelength of the waves? What will be frequency of the wave if speed of waves is $12\ ms^{-1}$. **(Ans. 2 m, 6 Hz)**
2. In a ripple tank of length 1.5 m, waves cover this length in 2 seconds. If distance between two successive crest and trough is 10 cm then find the number of waves, frequency of waves and their time period? **(Ans. 7.5 waves, 3.75 Hz, 0.266 s)**
3. Calculate the frequency of red light of wavelength 700 nm in vacuum? **(Ans. 4.29×10^{14} Hz)**
4. A wooden bar vibrating into the water surface in a ripple tank has a frequency of 12 Hz. The resulting wave has a wavelength of 3 cm. What is the speed of the wave? **(Ans. $0.36\ m\ s^{-1}$)**
5. What is the wavelength of the radio-waves transmitted by an FM station at 90 Mhz? **(Ans. 3.33 m)**