

WAVES:-

Waves are disturbance that transfer energy through space or a medium without the net movement of matter, characterized by properties such as wavelength, frequency, & amplitude.

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Example:-

→ When you throw a stone into a pond, you see ripple moving across the water. The water shouldn't move to the edge — only the energy moves in the form of waves.

→ When you speak, sound waves travel through the air to reach someone's ears. The air itself doesn't move — just the sound energy moves as a wave.

Q:- "Waves as a carrier of Energy." Justify?

→ **ENERGY TRANSFER:-** Waves are a way to transmit energy without physically transporting matter.

→ **VIBRATION:-**

Waves cause particles in a medium (like air or water) to oscillate or vibrate. This vibration transfers energy from one particle to the

next.

→ NO MATTER MOVEMENT :-

The particles themselves don't travel with the wave, it's the disturbance (the wave) that wave move through the medium.

→ EXAMPLE :-

- ⇒ Sound waves transfer energy through vibrating air molecule, Water waves transfer energy through oscillating water particles.
- ⇒ Electromagnetic wave (like light) transfer energy through oscillating electric & magnetic field.

TWO TYPES OF WAVES :-

→ Electromagnetic waves

→ Mechanical waves.

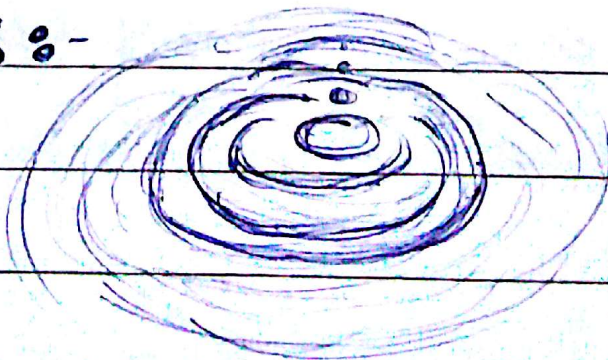
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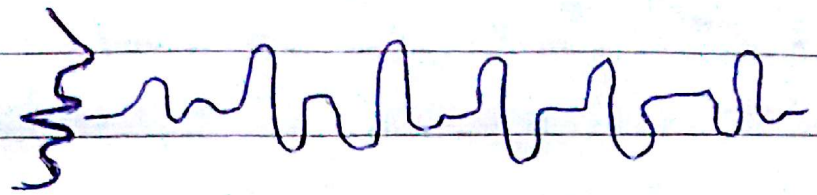
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Examples of waves :-

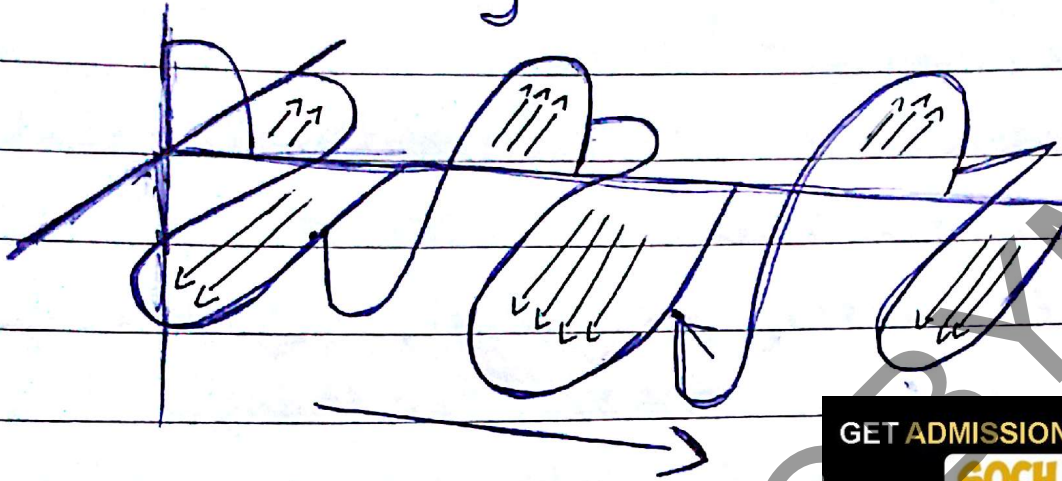
→ Water Waves :-



→ Sound Waves :-



→ Electromagnetic Waves :-

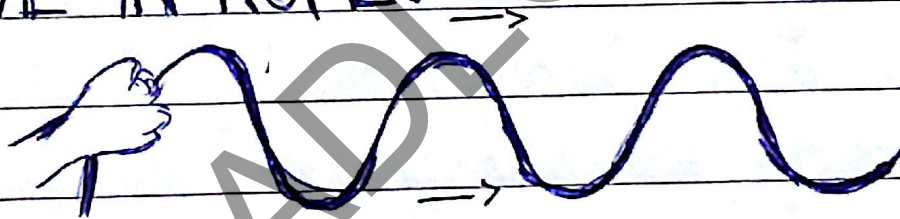


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→ WAVE IN ROPE :-



Wave propagation :-

→ Wave propagation refers to how a wave travels or spreads through a medium or space.

It is the movement of energy from one point to another using vibrations or oscillations. This concept applies to all types of waves — mechanical, electromagnetic, & matter waves.

TYPES OF WAVE PROPAGATION :-

1. Mechanical Waves :-

- Mechanical waves need a medium (like air, water, or solids) to travel.
- They move by vibrating particles in the medium to pass energy.
- Can be transverse or longitudinal, depending on how particles move.
- Example :- Sound, water waves, seismic waves.
- They can't travel in vacuum (like space).

2. Electromagnetic Waves :-

- Electromagnetic waves don't need a medium; they can travel through space.
- Formed by the vibration of electric & magnetic fields.
- Always transverse in nature.
- Travel at the speed of light in a vacuum.
- Example :- light, radio waves, X-rays, micro-waves.

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understanding propagation by the
formation of waves

in rope !!

→ When you shake an end of rope, a wave forms & travels along its length, This happens becauz the energy from your motion is transferred through the ropes particles.

Steps - by - Steps Explanation:-

1. **INITIAL DISTURBANCE:-** You create a distribution at one end of the rope by moving it up & down
2. **ENERGY TRANSFER:-** The energy from your motion is transferred to the adjacent particles in the rope.
3. **PARTICLE MOTION:-** Each particle moves up & down, passing the energy to the next particle.
4. **WAVE PROPAGATION:-** The wave travel along the rope as the energy is transferred from particle to particle

⇒ Key Points:-

→ **WAVE TYPE:-** The wave on a rope is a transverse wave, where particles move perpendicular to the waves direction.

→ **WAVE CHARACTERISTIC:-** The wave's speed, frequency, & wavelength are determined by

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the rope's properties & the energy input.

2. main types of wave motions:-

→ LONGITUDINAL WAVES:-

- The particles move parallel to the direction the wave is ~~can~~ moving.
- Like compressing & releasing a spring — the compression moves forward.
- EXAMPLE:-

- Sound waves
- Seismic waves.

• The angle b/w the particles, energy & wave is 0° so " $\theta = 0^\circ$ ".

→ TRANSVERSE WAVE:-

- Energy moves forward, but particles move up & down
- The waves has high points (crest) & low points (troughs).
- EXAMPLE:-

- Light waves
- Water waves
- waves on strings

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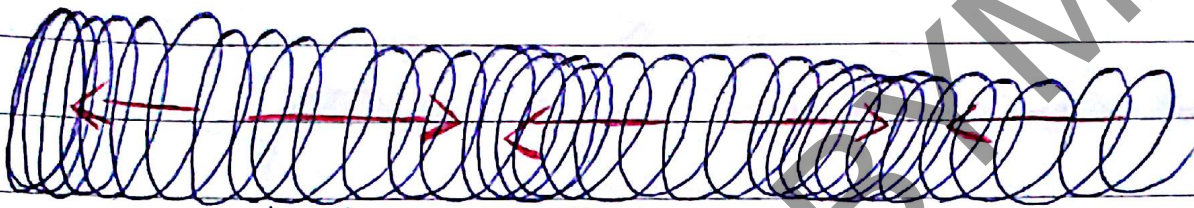
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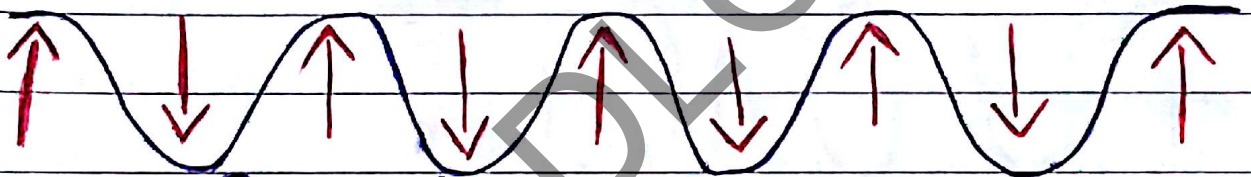
- Particles vibrate at 90° to the direction of wave travel

Diagrams:-

→ LONGITUDINAL WAVE:-



→ TRANSVERSE WAVE:-



Oscillation:-

→ It is the to & fro motion of an object about a central position over time.

→ Wave $\Leftrightarrow$ Oscillation.

Qs based QnA:-

? Differentiate between transverse wave & longitudinal wave.

? Differentiate between mechanical & electromagnetic wave?

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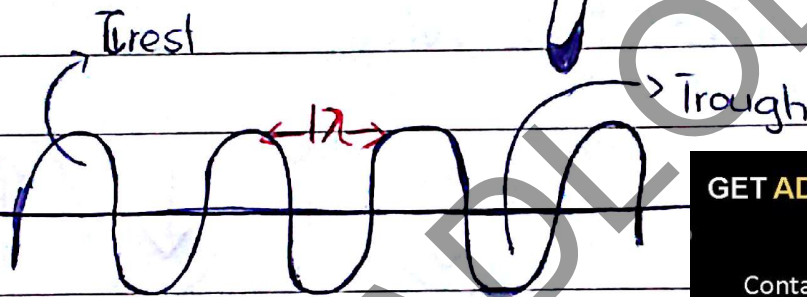
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? Wave are the carrier energy? Justify.

These are veryyy
important for
exams!!!

wavelength



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- a) The distance between 2 successive crests is called wavelength
- b) The distance between 2 successive trough is called wavelength
- c) The complete 1 crest & 1 trough can form a simple wavelength.

* Crest : The highest point of wave

* Trough : The lowest point of wave

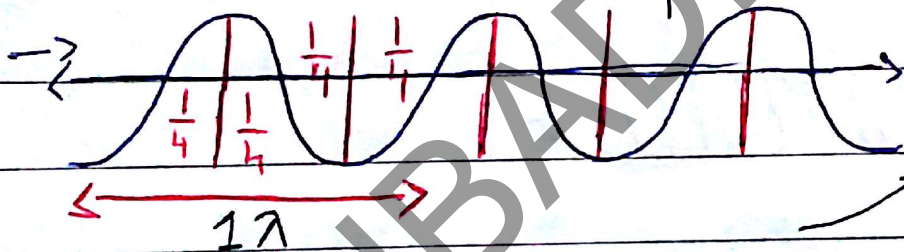
$\Rightarrow$ PKMZ :- (Physics kahani mak zubani)

$\rightarrow$ Dekho wave is like a pizza. Pizza has 4 slices right ?? So, 4 slices make one pizza! Simple is not it?

$\rightarrow$ Acha dekho... 4 slices make 1 pizza, toh how would we say 1 slice of pizza? We will say $1/4$! Right? kyunke 4 slices mein se 1 slice liya toh we got $1/4$ part? Haina?

$\rightarrow$ Now, agar hum do slices le lein toh we will say that we got $2/4$ part of pizza! That's how it is.

$\rightarrow$ One crest has 2 parts so as 1 trough.



∴ One crest has 2 parts & 1 trough also. A wave is made of 4 parts

∴ We know that :

1 trough + 1 crest = 1 wave

1 trough + 1 trough = 1 wave

1 crest + 1 crest = 1 wave

$$\text{So, } \frac{1}{4} + \frac{1}{4} + \frac{1}{4} + \frac{1}{4} = \frac{4}{4} = 1$$

$\rightarrow$ 1 wavelength $\Rightarrow$ 1 lamda (λ)

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lambda.

→ lambda (λ) represents the wavelength. — the distance between 2 corresponding points in consecutive cycle of wave.

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→ For example:

- From crest of wave to crest or trough to trough in a water wave
- From compression to compression in a sound wave
- From peak to peak in a light wave (electromagnetic)

= formula :-

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

- λ = wavelength (in meters)
- v = wave speed (in m/s)
- f = frequency (in Hz)

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? Define Wavelength?

? Define Wavefront?

? Define Crest & Trough?

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Displacement :-

→ Displacement in a wave refers to how far a point has moved from its rest position.

→ In amplitude, it's the maximum displacement — shows wave's energy

→ The distance of a point on the wave from its equilibrium position at a given time. Displacement varies as the wave oscillate.

→ Displacement will be negative & positive.

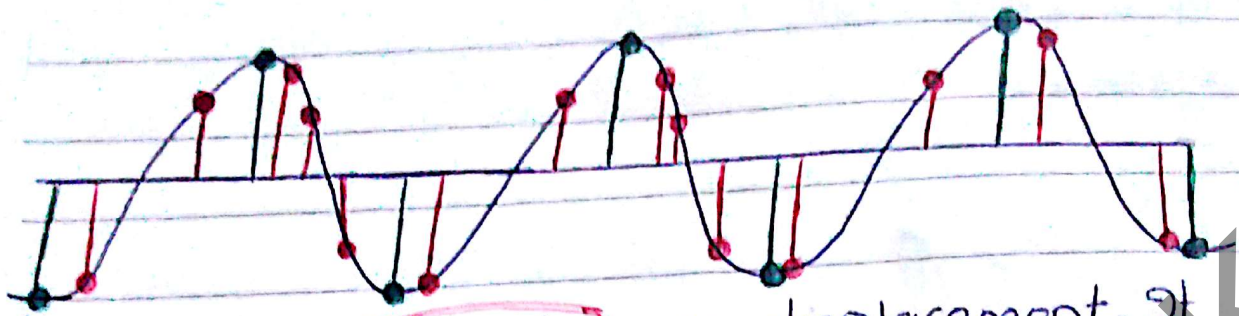
• POSITIVE DISPLACEMENT :-

⇒ The point on the wave is above the equilibrium line (e.g; a crest in a transverse wave)

• NEGATIVE DISPLACEMENT :-

⇒ The point on the wave is below the equilibrium line

⇒ [e.g, a trough in a transverse wave].



→ All the red points are displacement. It can never be the highest points like green.

→ The green points are amplitude points.

Amplitude :-

→ The ~~max~~ maximum displacement from the mean position either to the left or to the right is called amplitude.

OR

→ The peak point of displacement is called amplitude.

→ Amplitude will be positive if it is above.

→ Amplitude will be Negative if it is below.

→ It is measured in meters (m)

✓ Every amplitude is displacement but not every displacement is an amplitude.

⇒ (Green dots are amplitude)

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frequency:-

$\Rightarrow$ Frequency is the number of wave

cycle that pass a point in one second.

$\rightarrow$ Symbol:- represented by 'f'.

$\rightarrow$ Unit:- Measured in Hertz [Hz].

$\rightarrow$ [1Hz = 1 wave per second]

$\rightarrow$ Formula:- $f = \text{frequency}$, $T = \text{time period}$.

$\rightarrow$ Relation with time period:-

Frequency & time

periods are inversely related.

[$\uparrow$ frequency $\uparrow$, time period $\downarrow$]

Example:- If 5 waves pass in 1 second $\Rightarrow$
frequency = 5Hz

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time period:-

$\Rightarrow$ The time it

takes to complete 1 full type cycle of a repeated event.

$\rightarrow$ Unit:- Seconds (s)

$\rightarrow$ Symbol:- represented by [T]

Example:- If a fan blade takes 0.2 seconds to complete one rotation, the time period is 0.2 s

Difference b/w frequency & time period:

→ Frequency tells you how much waves are produced per second

→ Time period tells you how much time or how long it takes to produce one wave.

→ They are inversely proportional: as frequency increases, time period decreases & vice versa!

Self based Questions:-

Q:- Differentiate between amplitude & displacement?

Q:- Differentiate between frequency & time period?

Seismic Waves:-

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⇒ Seismic waves produced during an earthquake. They are the waves that travel through the Earth after an earthquake. Causes the ground to shake side-to-side or up & down

⇒ P-WAVES [PRIMARY WAVES]

→ P-WAVES (Primary waves) :-

- MOVES FAST, fast propagation

- Travel through solids, liquids, & gases.

- Move particles back & forth

→ S-WAVES (Shear waves) :-

- Moves slower than P-waves, slow propagation

- Only travel through solids.

- Move particles side to side.

→ Primary waves :- are longitudinal waves.

→ Seismic waves :- transverse wave.

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Formulas of all terms :-

≈ Wave length :-

⇒ A wavelength is the distance between two identical points of a wave, such as crest to crest or trough to trough. It shows how long one wave is & is measured in meters. Wavelength is represented by Greek lambda (λ).

≈ Wave cycle :-

⇒ Other name for wave-length :-

≈ frequency :-

=> Number of waves passing a point per second.

$$f = \frac{N}{t}$$

$\therefore f$ = frequency

$\therefore N$ = no. of waves

$\therefore t$ = time

time period :-

=> Time taken for one complete wave.

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

$\therefore T$ = time taken

$\therefore f$ = frequency

Wave speed :-

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=> The distance travelled by a wave per unit time is called wave speed.

derive $V = f\lambda$

Since, $\text{speed} = \frac{\text{Distance}}{\text{time}}$

$$\Rightarrow V = \frac{\Delta d}{\Delta t} \quad \text{--- (i)}$$

$$\Rightarrow \Delta d = 1 \lambda \quad \text{--- (ii)}$$

$$\Rightarrow \Delta t = T \quad \text{--- (iii)}$$

Put eq(ii) & eq(iii)

$$\Rightarrow V = \frac{1 \times \lambda}{T} \Rightarrow V = \frac{1}{T} \times \lambda \quad (iv)$$

$$\Rightarrow \boxed{\therefore f = \frac{1}{T}} \quad (v)$$

$\Rightarrow$ Put eq (iv) & eq (v)

$$\Rightarrow \boxed{V = f \times \lambda} \quad \text{Derived formula}$$

810 based Questions :-

Q1:- What is the definition of frequency in the context of waves?

Q2:- How is frequency related to the time period of a wave?

Q3:- What does one complete wave cycle consist of?

Q4:- Write the for wave speed & explain its term?

Q5:- How does increasing the frequency effect the waves time periods?

WAVE DEMONSTRATION BY :-

ripple tank :-

important for 810 in exams!! vv. imp concept!

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=> DEFINITION:-

A shallow glass-bottomed tank of water used to study the behavior of water waves such as reflection, refraction, diffraction & interference.

=> CONSTRUCTION:-

- Shallow transparent tank filled with water.
- Light source above or below the tank.
- Wave generator (vibrating bar or dipper)
- White screen or table beneath the tank
- Support stand to hold the tank above the screen.

=> CAN DEMONSTRATE:-

- Reflection:- waves bounce off barriers.
- Refraction:- waves bend in shallow water.
- Diffraction:- waves spread through gaps.
- Interference:- waves overlap & forms patterns.

=> MAIN PARTS:-

- Glass Tank → holds water
- Light Source → shows wave shadows.
- Vibrator/Motors → makes ripples
- Barriers/Object → change wave direction.

=> TYPES OF WAVES:-

- Water waves → Transverse
- Circular waves → Longitudinal.

=> ADVANTAGE:

- Visual learning

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⇒ How it works:-

A ripple tank is a shallow tray filled with water, usually illuminated from above or below. A vibrating dipper, either a straight bar or a point source, creates waves on the water's surface. The waves are projected onto a screen (often a white sheet of paper) below the tank, allowing for visualization of the wave patterns. The dark & light patches on the screen correspond to the crests & troughs of the waves.

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SLO Based Questions :-

Q:- What is ripple tank. Explain its principle & its construction + working mechanism with Diagram?

(Important SLO Based, hot topic)³

Q:- Explain how diffraction is observed in a Ripple Tank using a barrier with a gap?

Q:- How can we observe wave refraction in a Ripple Tank?

Properties of ripple tanks:-

→ Barrier of Ripple Tank is slanted:-

⇒ In a ripple tank, the barrier is often placed at a slight angle so, that reflected waves are directed toward the sides rather than straight back into the main observation area.

⇒ This prevents unwanted interference with the incoming waves, ensuring the central wave pattern remains clear, stable, & easy to study.

⇒ The slight tilt is a simple but effective way to produce cleaner experimental results & more accurate observations of wave behavior.

Reflections

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⇒ When water waves in a ripple tank hit a solid object (like a straight barrier, a wall or a metal strip), they can't pass through, so they bounce back into the tank. This bounce back is called "Reflection".

⇒ WHAT HAPPENED:-

→ The wave fronts (lines showing crests) travel toward the barrier.

→ When they meet the barrier, the water particles at the barriers stop moving forward & push the

motion back into the tank.

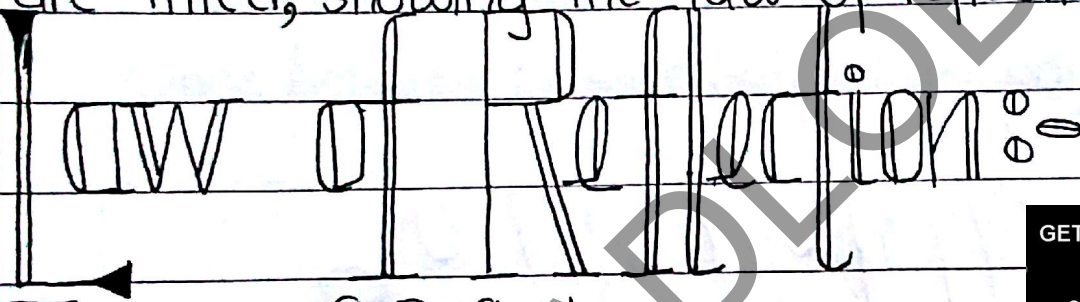
→ The spacing between the reflected wave fronts form & travel away from the barrier.

→ The spacing between wave crests & their speed stay the same — only the direction changes.

⇒ OBSERVATIONS:-

→ With a straight → the reflected waves are parallel to the incident waves but go the opposite way.

→ With the slanted barrier → the reflected waves are tilted, showing the law of reflection.



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The Law of Reflection:-

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

→ Angle of incidence → the angle between the incoming wave & imaginary line called the normal

→ Angle of reflection → the angle between the reflected wave & the small normal.

→ Both angles are measured on the same side of the normal & both lie in the same plane.

→ This law applies to light waves, sound waves & water waves in ripples.

→ For instance; when ripple hits a barrier they bounce back off at exactly the same angle they were hit by.

SLO Based Questions:-

? State the law of reflection for waves of water in a ripple tank?

? Why is barrier slanted?

? Does changing water depth effect reflected wave speed?

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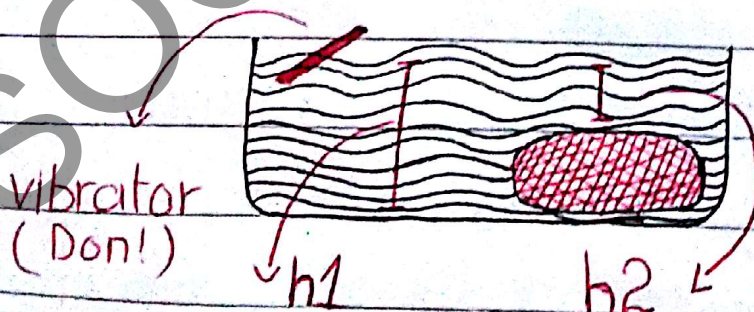
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Refraction:-

This topic is veryyy imp!!!

→ PKMZ of this topic:-



$\therefore h_1 \text{ \& } h_2$ are water depth

$\therefore h_1 > h_2$

deep water
گہرا پانی

shallow water
سہرا پانی

=> Acha dekho, ek vibrator hota hai jo pani mein waves banata hai, Ye waves ka number fix hota (frequency constant hoti hai)

=> Pani ke 2 parts hote hain:-

- Deep water ka depth: h_1
- Shallow water ka depth: h_2

=> Aur dekho, $h_1 > h_2$

=> Scene ye hota hai ke, deep water me wave ki speed zyada hoti hai, shallow water me kam hoti hai.

=> Matlab depth zyada $\rightarrow$ speed zyada!

=> Depth kam $\rightarrow$ speed kam!

=> WAVE EQUATION KA SCENE:-

$$V = f\lambda$$

yahan par:-

- $f \Rightarrow$ frequency (constant, kyunki vibrator fix hai)
- $\lambda \Rightarrow$ wavelength

Toh dekho, agar frequency constant hai $\rightarrow V \propto \lambda$

Matlab wavelength badhegi toh speed bhi badhegi

$\rightarrow$ Toh final scene ye hai ke:-

- (1) Deep water $\rightarrow$ wavelength badhegi $\rightarrow$ speed fast
- (2) Shallow water $\rightarrow$ wavelength choti $\rightarrow$ speed slow.

Simple!!

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formal notes format :-

⇒ REFLECTION :-

When water waves move from deep to shallow water, their speed decreases due to the change in depth. This causes the waves to bend & change direction.

⇒ WAVELENGTH :-

The frequency wavelength also decreases as the waves enter shallow water.

⇒ Frequency :-

The frequency remains constant during reflection because it depends on the source, not medium.

⇒ Vibrator :- Device producing waves in the ripple tank

⇒ Number of waves (fixed) :- The vibrator produce fix number of waves.

• WATER DEPTH :-

h_1 = deep water depth

h_2 = shallow water depth

Relationship ⇒ $h_1 > h_2$

• OBSERVATION :-

→ In deep water, the speed of water waves is maximum compared to shallow water.

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→ Depth is proportional to speed of water waves.

Depth $\propto$ Speed of water waves

→ WAVE EQUATION & SPEED RELATION:-

• Given equation:-

$$v = f\lambda$$

where

v = wave speed

f = frequency (constant)

λ = wavelength

• Since frequency is constant:

$$v \propto \lambda$$

wave speed is proportional to wavelength

Summary :-

→ When water is deeper (h_1), waves travel faster.

→ When water is shallower (h_2), waves travel slower.

→ Speed changes because wavelength changes while frequency is constant.

Self Based Questions :-

? Why water waves slow down in h_2 ?

? How does the wavelength of water waves change during refraction?

? Does frequency of water waves change during refraction?

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diffraction :-

→ Diffraction is the bending of waves & spreading of waves — like light, sound & water — when they encounter an obstacle or pass through a narrow opening.

⇒ IT'S MOST NOTICABLE :-

→ The size of the obstacle / opening is similar to the wavelength of the wave.

→ The wave travels through a slit & forms a pattern of bright & dark fringes

→ Edges or corners cause the wave to "wrap around" rather than just stop.

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Quick Points :-

→ $GAP \approx WAVELENGTH \rightarrow MORE BENDING$

→ All waves: water, sound, light

→ SMALLER GAP $\rightarrow$ MORE DIFFRACTION

→ BIGGER GAP $\rightarrow$ LESS DIFFRACTION

→ LONGER WAVELENGTH $\rightarrow$ MORE BENDING

→ SHORT WAVELENGTH $\rightarrow$ MORE LESS BENDING

• Examples :-

• Sound around a corner:-

Even if someone is speaking in another room, you can hear them because sound waves bend around doorways.

• Light through a narrow slit:-

Shine a laser through a hair or a fine slit & you will see a spreading pattern of bright & dark fringes on the wall.

• Ocean waves around a rock:-

Waves bend & spread into the sheltered area behind a rock.

• CDs/DVDs rainbow color:-

The fine grooves act like many tiny slits, diffracting light into colors.

SO Based Questions :-

? What is diffraction?

? You can hear the sound but can't see source?

? Why does a CD show rainbow colors?

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Tsunamis :-

→ DEFINITIONS :-

- ⇒ A tsunami is a series of large ocean waves caused by under water disturbances.
- ⇒ These waves travel fast across oceans & grow taller near shores, causing flooding & destruction.

→ CAUSES :-

- ⇒ Underwater earthquakes (main causes), especially at tectonic plate boundaries.
- ⇒ Volcanic eruptions under the sea.
- ⇒ Meteorite impacts (rare but powerful)

→ PROCESS :-

⇒ Sudden movement of the ocean floor ⇒ displace water → creates wave

⇒ Waves spread outwards across the ocean.

→ CHARACTERISTICS :-

• Speed :-

→ Travels at 500 - 800 km/h in deep water

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→ Hard to detect in deep ocean.

• Near the Coast:-

→ Speed slows down, but wave height increases.

→ Energy gets compressed → tall, powerful waves.

• Effects :-

→ Massive destruction :- flood, damaged building, loss of life, property.

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SO Based Questions :-

? Define tsunami in one word?

? List 3 main causes of tsunamis?

? How an underwater earthquake forms the tsunamis?

? State 2 warning signs of a tsunami?

MD!! XD