WAVES

* Introduction

Waves: disturbance of continuous vibrations in a medium through energy travels from point to another without any actual molecular movement.

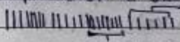
* Types of WAVES

(no medium reqt)

mediummechanical (medium) | non - mechenical

- longitudenal particle movement in direction of wave

(compression & rarifraction)



rarifraction

compression

eg. sound, water etc

(vibration in age piche...

molecule

wave

- transverse wave particle movement perpendi of direction of wave

(vibration in upar niche)

(crest, through)

wave

e.g. light

* Equation of Wave

$$y = A\sin(\omega t \pm kx)$$

instant of time

displacement on wave (wave direction)

displacement of particle | Amplitude (max displacement of particle on wave) | angular frequency of particular | wave number (icdk :)) (idk)

∴ if ωt sign and kx sign are same (++, --) than opposite to the direction of x

else in the direction of x

e.g. $y = A\sin(\omega t - kx)$ (opp, than $+x$) → $+x$ (!= in direction (opposite))

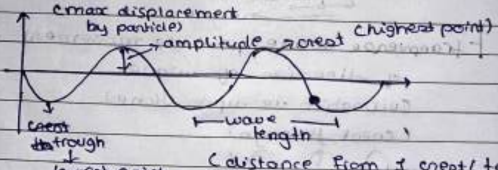
$y = A\sin(\omega t + kx)$ (==, than opp) → (-x dire)

$y = A\sin(kx - \omega t)$ (!=, than in dir) → $+x$ dir

$y = A\sin(\omega t + kz)$ (==, than opp) → $-z$ dir

$y = A\sin(-\omega t - kz)$ (==, than opp) → $-z$ dir

* Transverse Wave



(distance from 1 crest/trough to next)

λ wavelength: (min) distance after which wave repeats itself.

T time period: time to cover wavelength

$$\text{velocity} = \frac{\text{displacement}}{\text{time}} = \frac{\lambda}{T} = V_{wave}$$

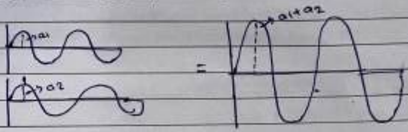
Period and frequency

↳ T ⇒ time taken by wave to cover it's wavelength (λ)

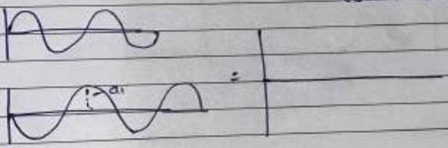
↳ f (ν) ⇒ no. of cycles of waves per second
(on crest to another (next) in 1 cycle)

Superposition of wave

* when crest meets crest (constructive meeting)
(same direction)



* when crest meets trough (destructive)
(same direction)



* crossdomne

$y_{net} = y_a + y_b$
$= A\sin(\omega_1 t_1 + k_1 x_1) + A\sin(\omega_2 t_2 + k_2 x_2)$

* Standing Waves a.k.a stationary waves
(oppo direction)

when 2 waves with same amplitude, frequency and wavelength, but different (opposite) direction of propogation, they create a illusion that wave isn't travelling, it's just moving up and down at one position.

WAVES by Jagrut Awaaz

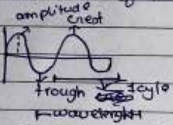
wave: disturbance that travels carrying energy without any molecular movement

types
- mechanical requires medium to propogate
  - tranaverse
  - logitudenal
- non mechanical (electromagnetic)
  doesn't require medium to propogate

mechanical waves

*** tranaverse waves**

when particles move perpendicular to the direction of wave propogation → wave



crest to crest distance.

*** longitudnal waves**

when particles move in direction of the wave propagation → wave

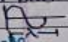
has contractions and rarefractions

contractions rarefractions

wavelength : distance between one contraction to next contraction

Transverse Waves	Longitudinal WAVES
particle movement ⊥ to wave propogation direction	particle movement in direction of wave propogation
has crest & trough	has contractions and rarefractions
Stone in pond (water waves)	sound waves

Definitions

1. Time Period (T) $= 1/f$ sec : time required to complete one cycle (cover wavelength) [also for particle: $\frac{1}{t}$]
2. Frequency (n) (f) $= 1/T$ Hz (hertz) : no. of cycles completed in one unit time
3. wavelength (λ) m : distance between one crest to next crest
   or distance travelled by the particle to get back to its own position (start) $\frac{1}{2}$ or 
   also represented as $\mathring{A}$ (angstorm), $1\mathring{A} = 10^{-10}$ m
4. speed of wave (v) m/s $= \lambda / T$ $= \lambda f$: distance travelled by a wave in a unit time

5. Simple harmonic motion:
   type of back and forth motion where an object moves around a central point, and restoring force pulling it back is directly portional to the displacement to that point.
   - obj moves around a central position
   - the force pulling it back is always directed towards the centre
   - The far it goes stronger the pull back.

(B)

6 Amplitude: max displacement made by the particle

7 Phase: state of motion of the particle at an instant of time.

has details about

1) displacement of particle

2) direction of motion

$$\boxed{y = \cancel{\sin A(\omega t \pm kx)}\ A \sin(\underbrace{\omega t \pm kx}_{\text{phase}})}$$

A: amplitude

ω: angular frequency (how many radians the wave rotates per second) ($\omega = 2\pi f$)

t: current instant of time

k: wave number (how many radians of phases the wave completes per unit distance)

$k = 2\pi/\lambda$

x: position in space where you're observing the wave

±: direction of the wave propagation

(− = moving in +x direction (same)

\+ moving in −x direction (oppo)

ωt = spacetime term kx = space term

if two particles in one wave have same displacement and direction, then they are in same phase

Relationship Between velocity, wavelength and frequency

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

v → velocity, T → Time period, λ → wavelength, f → frequency

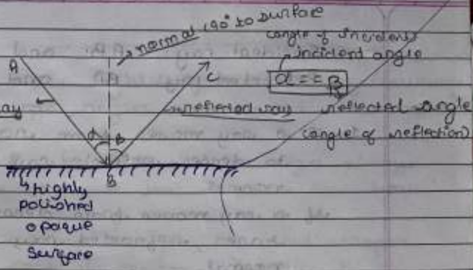
simply velocity = $\dfrac{\text{displacement}}{\text{time}}$

phenomenon in which a wave bounces back after striking a surface (boundary) instead of ...

bending of a wave (due to change in speed) as it passes from one medium ...

* Reflection

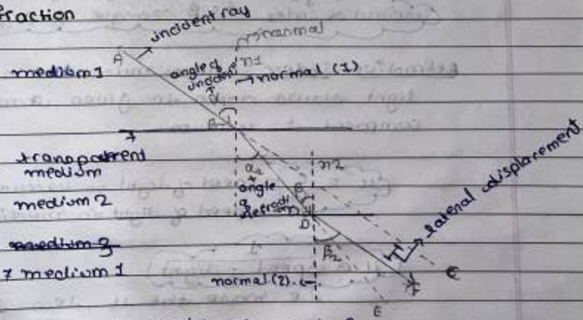
phenomenon in which a wave bounces back after striking a surface (boundary) instead of passing through it.



1. angle of incident = angle of reflection
2. incident ray, normal, reflected ray are always in same medium
3. incident ray, normal and reflected ray are co-planer
4. incident ray and reflected are always on either side of normal
   (exception: if $\alpha = 90$, than all on normal)

* Refraction

bending of a wave (due to change in speed) as it passes from one medium to another, caused by a change in its speed.



Angle of Incidents: α_1 and β_1
normals : n_1 and n_2
Angle of Refraction: α_2 and β_2

Incident ray: AB and BD
Refracted ray: BD and DF
a.k.a emergent ray

1. if a ray moves from rarer medium to denser, refracted ray bends towards the normal.
   if a ray moves from denser medium to rarer, refracted ray bends away from normal.

$$\begin{bmatrix} \text{rare} \rightarrow \text{dense} \Rightarrow \text{towards} \\ \text{dense} \rightarrow \text{rare} \Rightarrow \text{away} \end{bmatrix}$$

2. normal, incident, refracted, emergent ray are coplaner
3. angle of incident ≠ angle of refraction
   Snell's law

$$\underset{\text{refractive index}}{\mu} = \frac{\sin\alpha \rightarrow \text{angle of incidence}}{\sin\beta \rightarrow \text{angle of refraction}}$$

<u>Refractive</u> <u>Index</u>: how much the speed of light slows down in given a medium compared to vaccum

$$\mu = \frac{c \rightarrow \text{speed of light in vaccum } (3.8 \times 10^8 \text{ m/s})}{v \rightarrow \text{speed of light in medium}}$$

$$\mu \propto \frac{1}{\text{speed of light}}$$

i.e more the μ, less the speed of light in that medium

$\alpha = i$ $\beta = r$ $\mu \propto \rho$ (density)

Extras

Why does light ray move away/towards (change angles) when medium changed??

Fermat's Principal of Least Time: "light always takes the path that requires less time"

- when medium changes, its speed changes.
  - if rarer to denser: ↓ speed
  - denser to rarer: ↑ speed
- the frequency remains same but wavelength differs (adjusts), this causes change in direction)
- so when
  - rare → dense, speed is slow, it moves towards the normal (shorter path) to reach on expected (eg) time

* **Absolute Refractive Index**

~~refractive~~ speed of light in the medium compared to speed of light in the vacuum.

n_g = absolute refractive index of glass = 1.5

∵ with respective to vacuum.

* **Relative Refractive Index**

speed comparasion of light between two custom mediums

$n_{oil-water} = \frac{\text{speed of light water}}{\text{light speed in oil}}$

* **Critical Angle**

angle at which light ~~reflects back in same medium~~ refracts parellel to surface

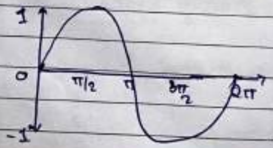
* **Total Internal Reflection**

when light reflects back in same medium instead of refracting.

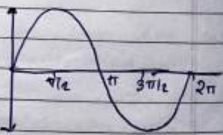
this θ is > critical angle..

SHM (Simple Harmonic Motion)
Wave Equation

graph of sin θ



SHM graph



MAHIS explained!

(if we consider start from mean, than we take sin
if we consider extreme (A) point as start than cos)

Sinusidal: shape of sin wave)
(Basically we take sin because SHM graph as sinusidal and cosinusoidal)

the structure of simple harmonic motion is similar to the structure of sin graph, so acc to sin, we can compare them and say SHM follow sin so equation includes sin

$$y = A\sin(\omega t)$$

y → displacement, A → Amplitude, ω → angular frequency $(2\pi f = 2\pi/T)$, t → time (instant of time we are taking about)

this is different from wave equation, this doesn't consider space term.
This is the Simple Harmonic Equation
, basically the motion of a particle (point) that oscilates back and forth in time.
"Oscillation at one fixed point"

Intensity : rate of flow of wave energy per unit area, held perpendicular to the direction of propagation

$$I = \frac{P}{A}$$ (power (energy transfered per unit time) $P = \frac{W}{T}$) (area normal to the wave)

$\therefore$ $I \propto A^2$ (amplitude) (Explained by MAHI!!)

"how much energy a wave is delivering per unit area per secound."

* Reverberation
persistance of sound in a space after the original sound source has stopped.

Reverberation Time: time taken for the sound in a space to decay by 60 decibels (DB) after the sound source shuts "how long sound lingers."

IA: time during which the energy density of the sound falls to millionth (10^{-6}) of its initial value after the source is shutoff.
(initial intensity / 10^6)

depends upon 1> size of room/space
2> density of medium
3> design
4> total absorption in sabins

when reveberation time < 0.5, (room) space feels dry
when reveberation time > 2.3, feels confusing

ECHO

reflection of a sound that arrives at the listener's ear after a noticeable delay

reveberation is when multiple reflections overlap quickly, so the sound seems to linger rather than repeat distinctly

Echo: a seperate repeated sound (noticeable delay)
Reveberation: a lingering sound (↓ delay)

the time gap between them is (should be) more 1/10th of the second for the echo to be produced.
distance from source and reflecting surface should be more than 17m

$$\text{coefficient of absorption of sound} = \frac{\text{sound energy absorbed by surface}}{\text{sound energy incidented on the surface}}$$

ratio of the sound energy absorbed by the surface to that the total sound energy incidented on the surface.

coefficient of absorption α absorption of sound

simple bhai :)

Sabine's formula for reverberation of time

reverberation time $t = \dfrac{0.165\,V}{\Sigma as}$ unit sec

V = volume of hall (m^3)

a = coefficient of absorption of reflecting surface

s = surface area of reflecting surface m^2

Σas : total absortion of room $= A$ (m^2)

sum of a and s of every material in room

m^2 (Σas / A) of absorption is called sabins

∵ here 0.165 is one of the commonly used sabins constants, so it has unit $\frac{s}{m}$

∵ these sabins constants where only created to convert unit of $\frac{V}{A}$ (m) into unit of reverbation time (s)

∵ this can also be 0.161, 0.162, 0.164