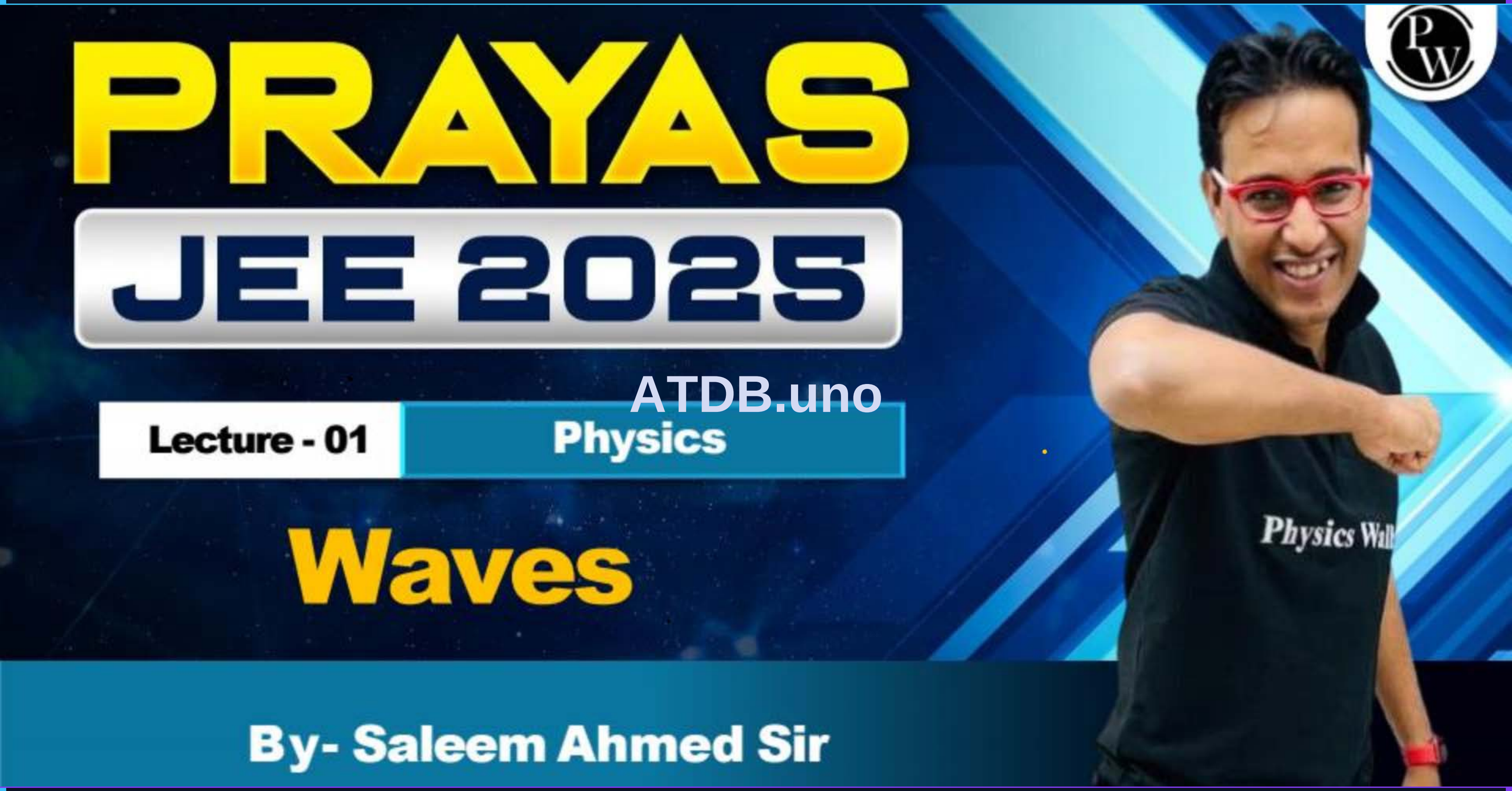
PRAYAS

JEE 2025

Lecture - 01

Physics

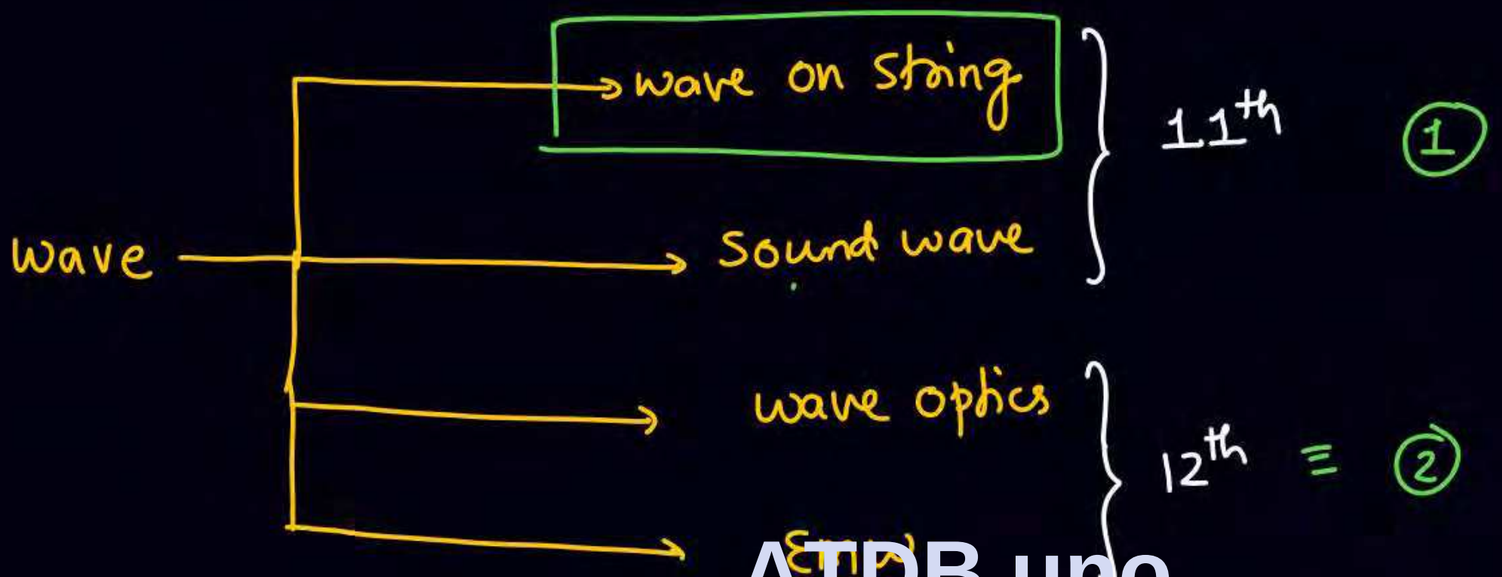
Waves



By- Saleem Ahmed Sir

Topics to be covered

1. Wave Introduction
2.
3.
4.



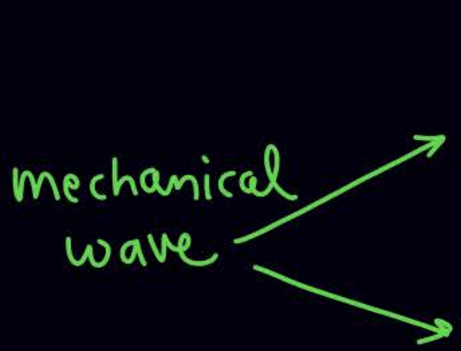
Classification of wave

1. Based on dir^{n} of displacement of dir^{n} → Transverse wave, Longitudinal wave
2. " medium → mech. wave, Non mech. wave
3. " Energy ≡ Travelling wave, Progressive wave.

Stationary wave, Standing wave

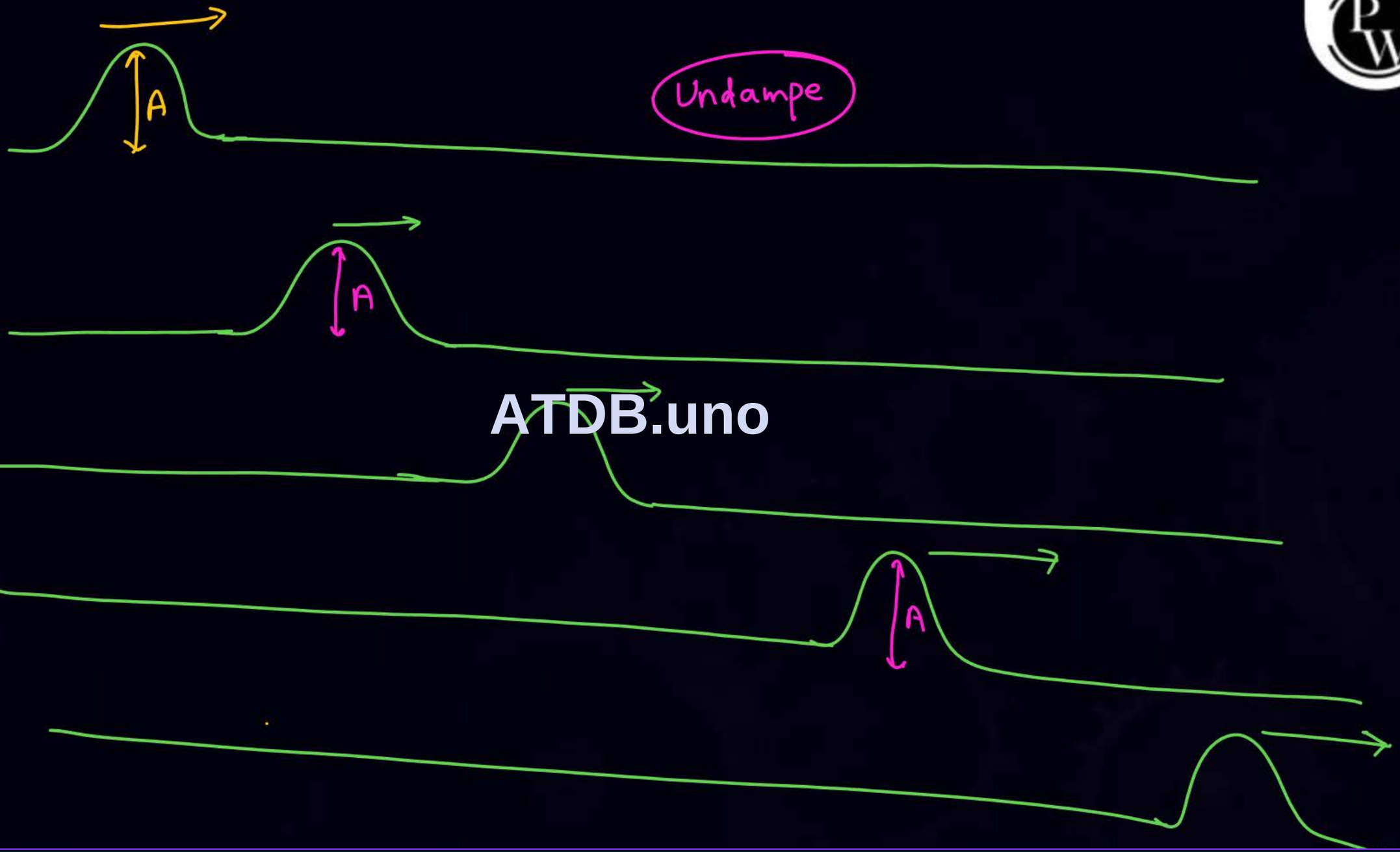
Wave on string (Transverse mech. wave)

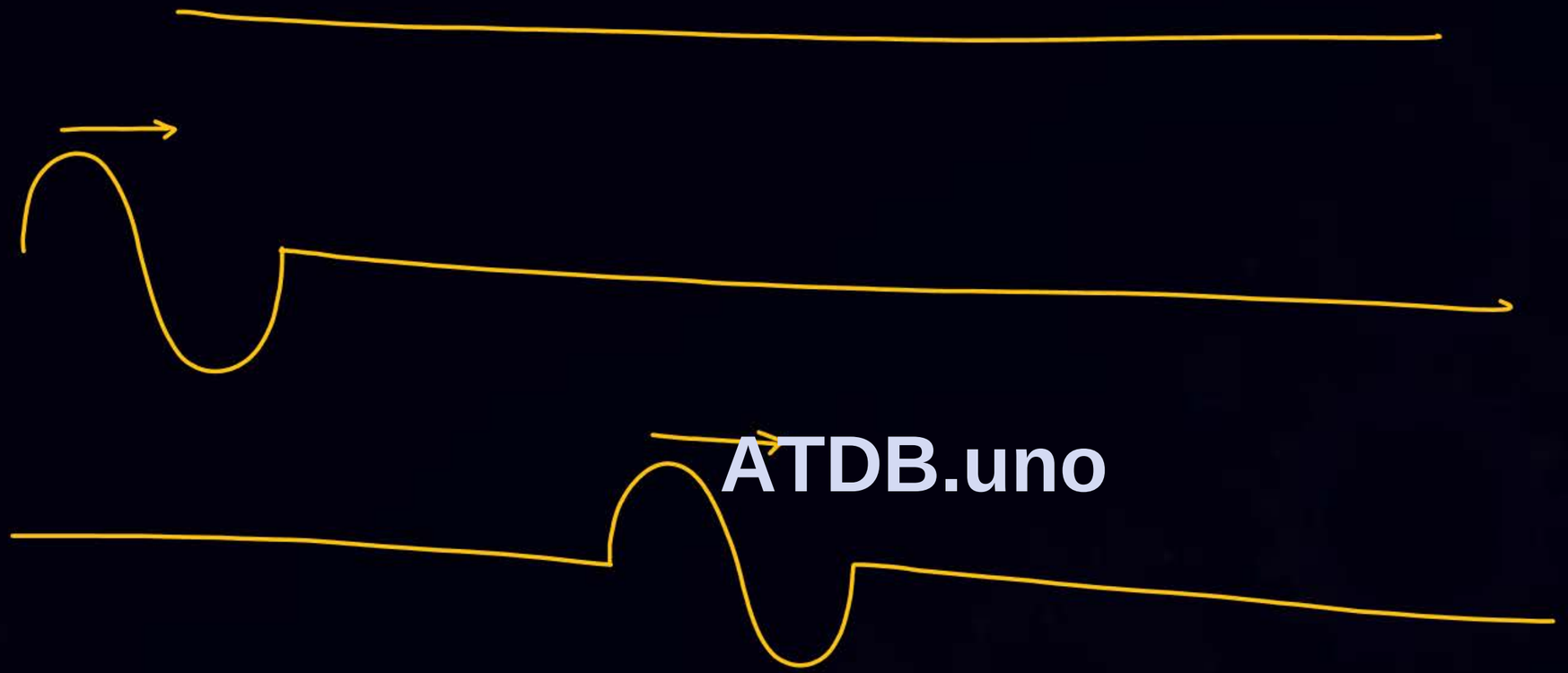
Wave ⟶ Transfer of energy from one point to another w/o the bulk transfer of matter.



Transverse wave ⟹ If displacement of particle is perpendicular to the wave velocity.
Ex. Wave on string.

Longitudinal wave ⇒ If displacement of particle is along the dirⁿ to the wave velocity.
Ex. Sound wave.





inertia
Elasticity

$y = f(x, t)$

→ Displacement of particle

* wave velocity
* SHM Eqⁿ

Equation of wave ⇉ $y = A\sin(\omega t \pm kx + \phi)$

→ (SHM)

हर एक वेव SHM कर रही है

∴

Equation of transverse wave (SHM)

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

- y → Displacement of particle
- A → Amplitude

$(\omega t \pm kx + \phi)$ ⟶ phase

$$k = \frac{2\pi}{\lambda}$$

$$\omega = \frac{2\pi}{T} = 2\pi f$$

$$V_{wave} = V_w = \frac{\omega}{k} = \frac{\text{coff. of } t}{\text{coff of } x}$$

⟶ (wave speed)

Results

$y = A \sin(\omega t - kx + \phi)$ → Displacement of particle

$y = A \sin(-\omega t + kx + \phi)$

x और t का coff. के sign opposite हैं ⇒ $V_w \longrightarrow +x$

$y = A \sin(\omega t + kx + \phi)$

$y = A \sin(-\omega t - kx + \phi)$

x और t का coff. के sign Same हैं ⇒ $V_w \longrightarrow -x$

Q Eqⁿ of wave on string is given by

$$y = 10 \sin\left(\frac{\pi}{2}t - \frac{\pi}{6}x + \pi/3\right)$$

① Amplitude = A = 10

② $\omega = \pi/2$,

③ wavelength $\lambda = ?$

$$k = \frac{\pi}{6}$$

$$k = \frac{2\pi}{\lambda} = \frac{\pi}{6} \Rightarrow \boxed{\lambda = 12}$$

④ T = ?

$$\omega = \frac{2\pi}{T}$$

$$\frac{\pi}{2} = \frac{2\pi}{T}$$

$$T = 4 \text{ sec}$$

* ⑤ wave speed

$$V_w = \frac{\omega}{k} = \frac{\pi/2}{\pi/6} = 3 \text{ m/s}$$

Q Eqⁿ of wave on string is given by

$$y = 10 \sin\left(\frac{\pi}{2}t - \frac{\pi}{6}x + \pi/3\right)$$

Q $\vec{V}_{wave} = \frac{\omega}{k}(+\hat{i}) = \frac{\pi/2}{\pi/6}(+\hat{i}) = 3\hat{i}$

Q Find y of the particle at $x = 1$

put $x=1 \Rightarrow y = 10 \sin\left(\frac{\pi t}{2} - \frac{\pi}{6} + \frac{\pi}{3}\right)$

$$y = 10 \sin\left(\frac{\pi t}{2} + 30^\circ\right)$$ SHM

$x = 1 \Rightarrow v = f(t)$

$$v = \frac{dy}{dt} = 10 \times \frac{\pi}{2} \cos\left(\frac{\pi t}{2} + 30\right)$$

Q Find y, v, a of the particle at $x = 1$ at $t = 1$ sec

put $x = 1$

$$y = 10 \sin\left(\frac{\pi t}{2} + 30^\circ\right) = A \sin(\omega t + 30)$$

$$v_y = A\omega \cos(\omega t + 30)$$

$$a_y = -A\omega^2 \sin(\omega t + 30)$$

$t = 1 \Rightarrow y = 10 \sin\left(\frac{\pi}{2} + \frac{\pi}{6}\right) = \checkmark$

$$v = 10 \frac{\pi}{2} \cos\left(\frac{\pi}{2}t + 30\right) = 5\pi \cos 120^\circ$$

$$= -\frac{5\pi}{2}$$

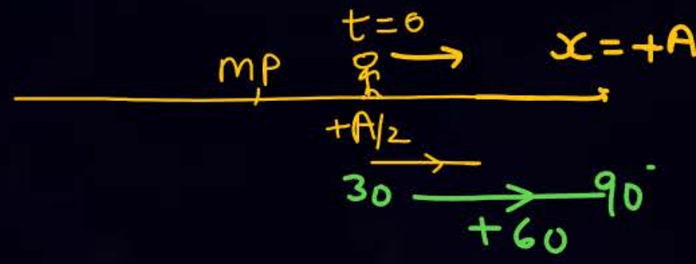
put

∴

Q $y = 10 \sin\left(\frac{\pi t}{2} - \frac{\pi x}{6} + \pi/3\right)$

find location, v, acc of particle at $x = 1$ at $t = 0$ sec

put $x = 1$ $\quad y = 10 \sin\left(\frac{\pi t}{2} + \pi/6\right) = \boxed{A \sin(\omega t + 30)}$



$y = 10 \sin\left(\frac{\pi t}{2} + \pi/6\right) \Longrightarrow t = 0 \Rightarrow y = \frac{A}{2} = \frac{10}{2} = 5$

$V = 5\pi \cos\left(\frac{\pi t}{2} + \pi/6\right) \Rightarrow V = 5\pi \cdot \frac{\sqrt{3}}{2}$ (At $t = 0$ sec)

$a = -\frac{5\pi^2}{2} \sin\left(\frac{\pi t}{2} + \pi/6\right) \quad a = -\frac{5}{4}\pi^2$

$360 \longrightarrow T$

$60 \longrightarrow \frac{T}{6} = \frac{4}{6}$

$\frac{2}{3}$

Q $y = 10\sin\left(\frac{\pi t}{2} - \frac{\pi x}{6} + \pi/3\right)$

find v of particle at $x = 1$ at $t = \frac{2}{3}$ sec

put $x = 1$ ⇒ $y = 10\sin\left(\frac{\pi t}{2} + \pi/6\right)$

$v = 5\pi\cos\left(\frac{\pi t}{2} + \pi/6\right)$

$t = \frac{2}{3}$ sec, $v = 5\pi\cos\left(\frac{\pi}{2}\cdot\frac{2}{3} + \frac{\pi}{6}\right)$

$v = 0$

particle ≡ ε·p पर है
$v = 0$, a_{max}

$$y = 20 \sin\left(\frac{\pi t}{4} - \frac{\pi x}{3} + \frac{\pi}{2}\right)$$

(1) $A = 20$

$\omega = \pi/4 = \frac{2\pi}{T}$

$T = 8$

$k = \pi/3 = \frac{2\pi}{\lambda}$

$\lambda = 6m$

$V_w = \frac{\omega}{k} = \frac{\pi/4}{\pi/3} = \frac{3}{4}\left(+\hat{i}\right)$

(2) $x = 1$, $t = \frac{1}{2}$ पर

$y = 20 \sin\left(\frac{\pi t}{4} + \pi/6\right)$

$y = 20 \sin\left(\frac{\pi}{8} + \pi/6\right)$

$V_y = 20\frac{\pi}{4} \cos\left(\frac{\pi}{4} t + \pi/6\right)$

∴

(3) V_{max} of any particle

$= A\omega$

$= 20 \times \frac{\pi}{4}$

Basics of Waves

Introduction to waves :

Wave definition :

A wave is a disturbance that propagates in space, transports energy and momentum from one point to another without actual transport of matter.

SOMETIMES WE CAN INTERPRET THAT ENERGY AS MEANINGFUL INFORMATION

Introduction to Waves :

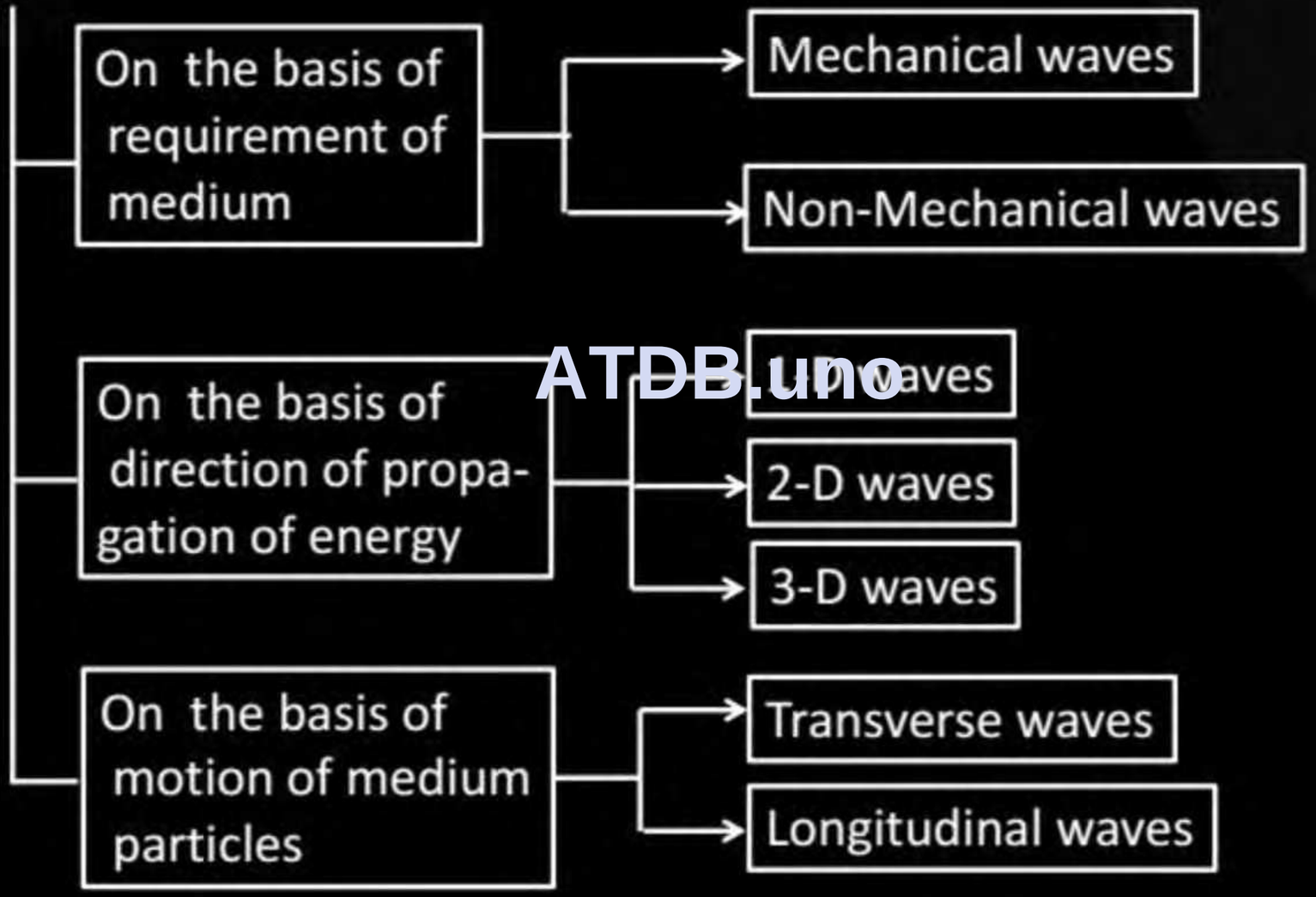
EX: ripples on a pond (water waves), the sound we hear, light, radio and TV signals etc.

Analogy :

You (in Kota) want to communicate your friend (in Delhi).

1. Write a letter
2. Use telephone

Classification of Waves



Classification of Waves :

On the basis of direction of flow of energy:

- 1-D waves: energy flows only in one dimension.

  EX: string wave

- 2-D waves: energy flows in two dimensions.

  EX: water wave

- 3-d waves: energy flows in three dimensions

  EX: sound wave, light wave

Classification of Waves :

On the basis of motion of medium particles:

- Transverse waves: direction of wave propagation and particle oscillations is perpendicular.

  EX: string wave, light wave

- Longitudinal waves: direction of wave propagation and particle oscillations is parallel.

  EX: sound wave

NOTE :

- All longitudinal waves are mechanical waves.
- All EM waves are transverse waves.

Classification of Waves :

On the basis of motion of medium particles:

- **Mechanical waves :** waves which require medium for propagation i.e. waves which can not propagate in vacuum.

  Ex: sound wave , string waves , seismic waves.

- **Non mechanical waves:** waves which require no medium for propagation i.e. which can propagate both in medium and vacuum.

  Ex: all electromagnetic waves.

Home work

- Complete fluid KPP
- pyD modules Fluid Exercise
-