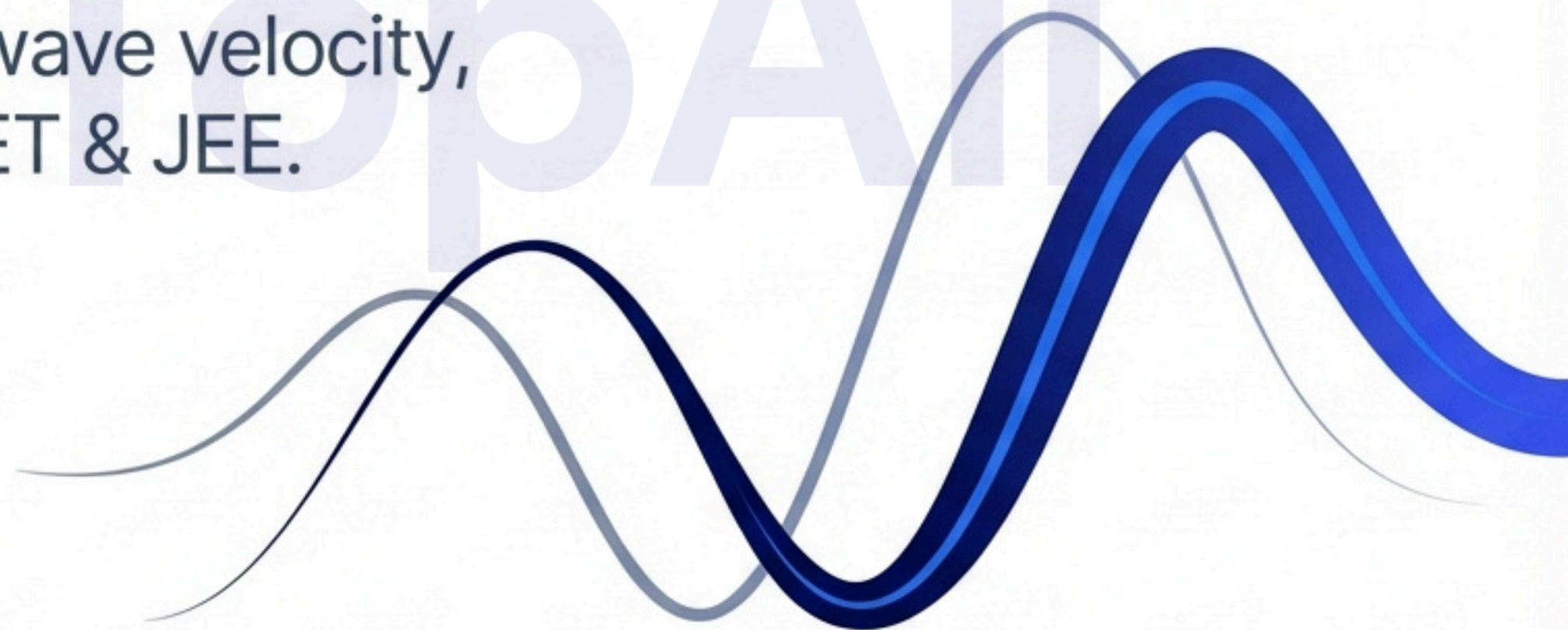


The Speed Of A Travelling Wave

Understanding phase motion, wave velocity, and frequency relations for NEET & JEE.

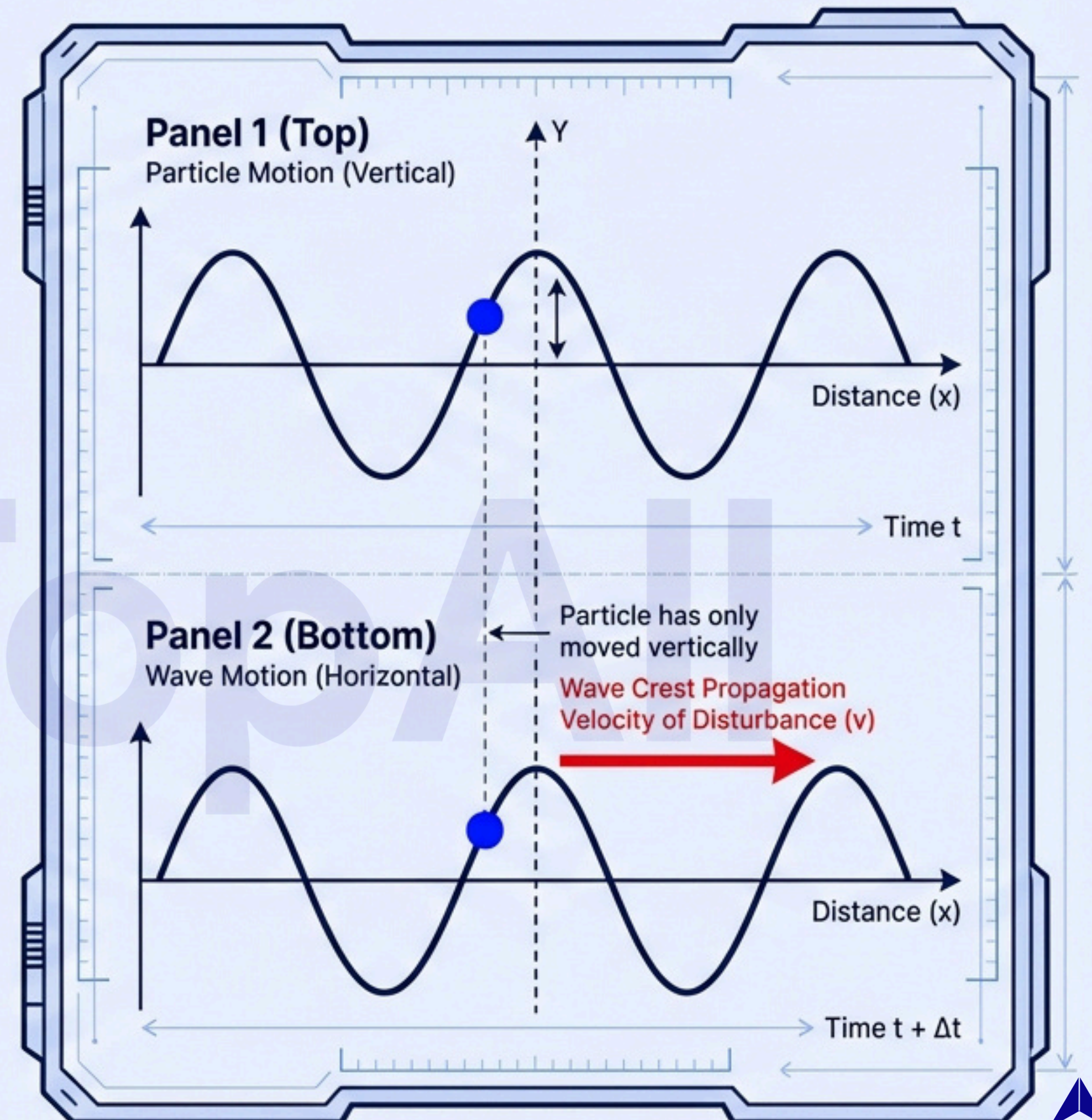


The Illusion of Motion

**The medium oscillates.
The pattern propagates.**

- In a travelling wave, matter does not flow forward.
- Particles merely oscillate about their mean equilibrium positions.
- What actually moves forward is the disturbance (the wave pattern) carrying energy and information.

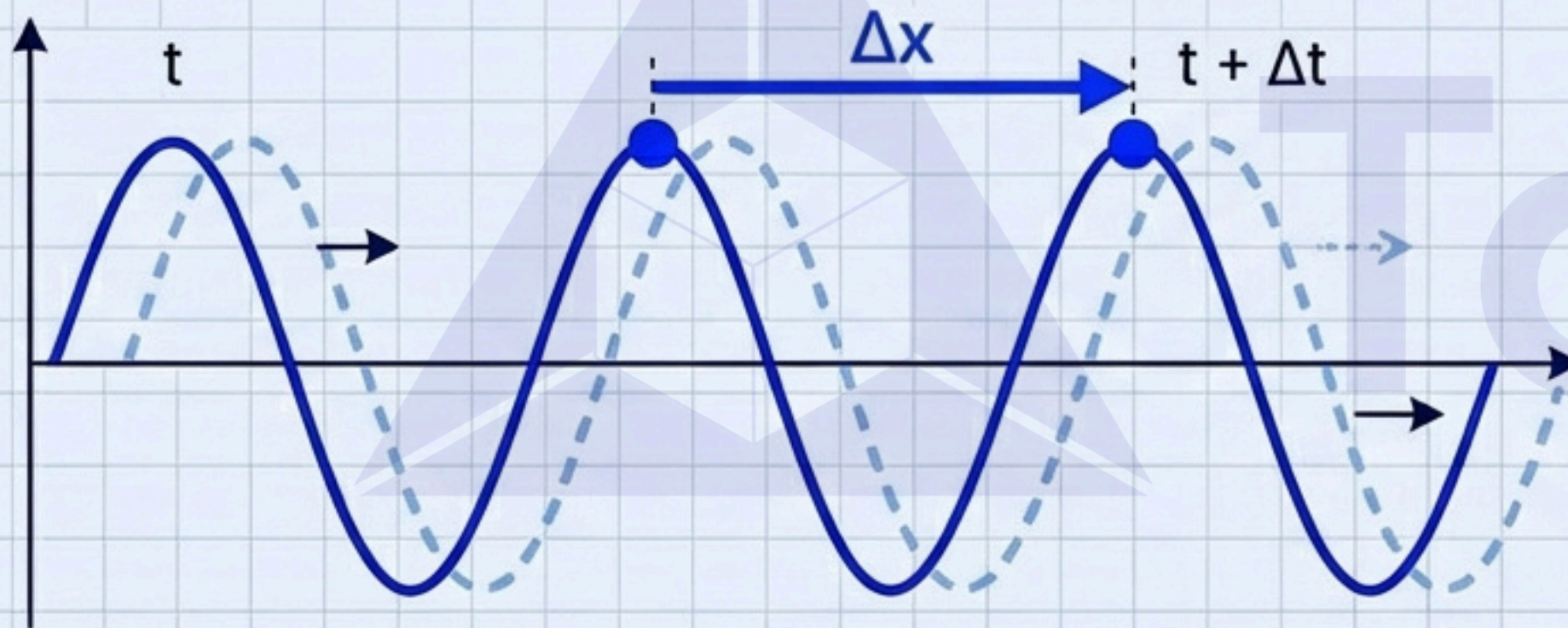
[CONCEPT] Wave speed is the speed of the disturbance, NOT the particles.



Tracking the Wave Speed

How do we calculate the wave's speed?

We pick a specific point on the wave with a constant phase (like a crest) and track how far it moves over time.



[FIGURE 14.8] Progression of a harmonic wave

At time t , the crest is at position x .

At time $t + \Delta t$, the crest shifts right by Δx .

$$\text{Speed} = \Delta x / \Delta t$$



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Motion of a fixed phase point

Step 1: For a point of constant phase:

$$kx - \omega t = \text{constant}$$

Step 2: As time changes by Δt , position changes by Δx to maintain the exact same phase:

$$k(x + \Delta x) - \omega(t + \Delta t) = \text{constant}$$

Step 3: Subtracting Step 1 from Step 2 simplifies directly to:

$$k\Delta x - \omega\Delta t = 0$$

Step 4: Rearranging and taking the limit as Δt gets vanishingly small gives the velocity:

$$dx/dt = \omega / k$$

[FORMULA] $v = \omega / k$

Expressing speed in terms of wavelength and frequency

$$v = \frac{\omega}{k} \rightarrow v = \lambda v = \frac{\lambda}{T}$$

Substitute angular frequency:
 $\omega = 2\pi v = 2\pi / T$

Substitute wave number:
 $k = 2\pi / \lambda$

In the time T (one full oscillation), the wave pattern travels exactly one wavelength (λ).

Don't confuse the medium with the message.

Particle Velocity (v_p)	Wave Velocity (v)
• Equation: $v_p = \partial y / \partial t$ • Nature: Changes constantly with time (oscillates in Simple Harmonic Motion). • Direction: Transverse (up/down) or Longitudinal (back/forth).	• Equation: $v = dx / dt = \omega / k$ • Nature: Remains constant (in a uniform, non-dispersive medium). • Direction: Always forward (the direction of propagation).

[EXAM TIP] Questions often ask for maximum particle speed ($v_{p,\max} = a\omega$) vs wave speed ($v = \omega/k$). Know the difference.

1. Wave speed is determined by tracking a point of constant phase (like a crest).
2. Angular velocity formula: $\mathbf{v} = \boldsymbol{\omega} / \mathbf{k}$
3. Observable physical formula: $\mathbf{v} = \lambda \nu$
4. Wave speed (constant propagation) is fundamentally different from particle speed (local oscillation).

[NEXT UP]

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