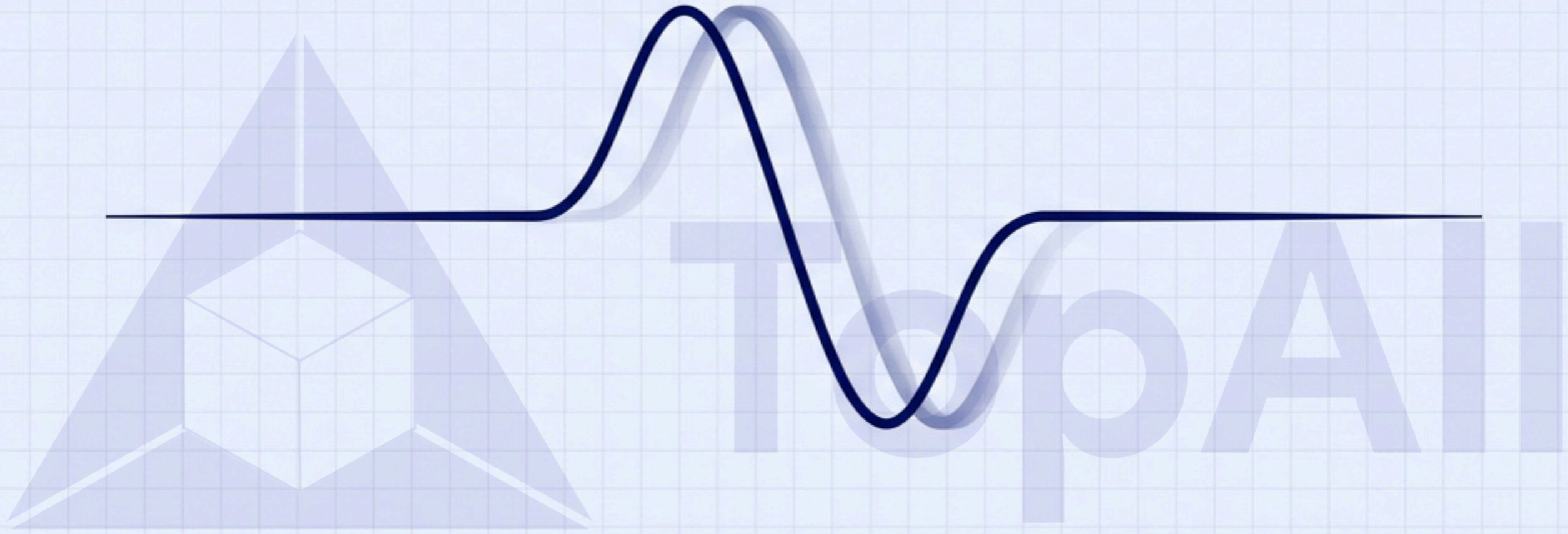


CHAPTER 14 • WAVES • SECTION 14.4.1

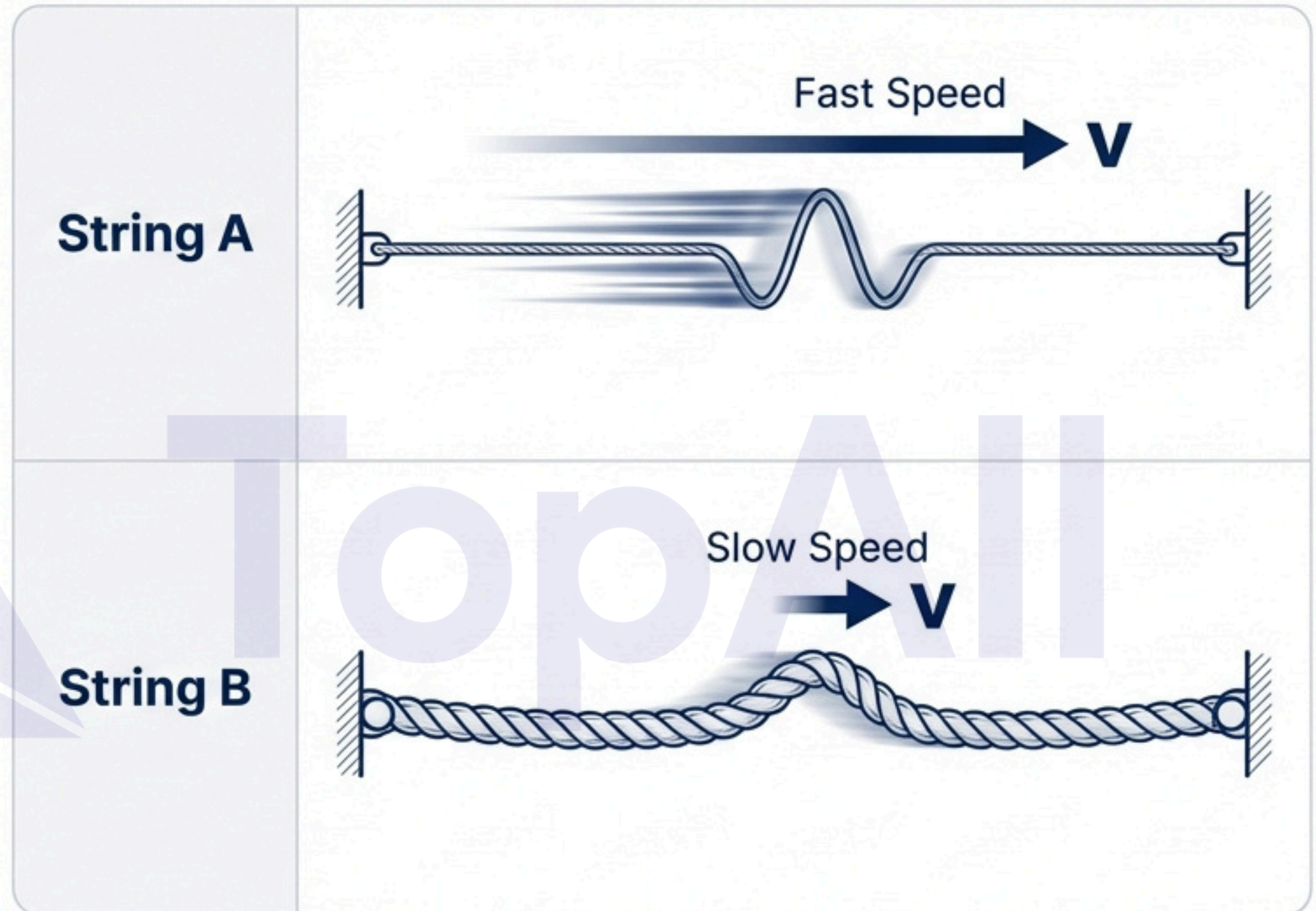


Speed of a Transverse Wave on a Stretched String

Understanding how the medium dictates wave propagation for NEET & JEE.

The Medium Dictates the Speed

- Wave speed does not depend on how you pluck the string.
- It depends entirely on two physical properties of the medium itself.



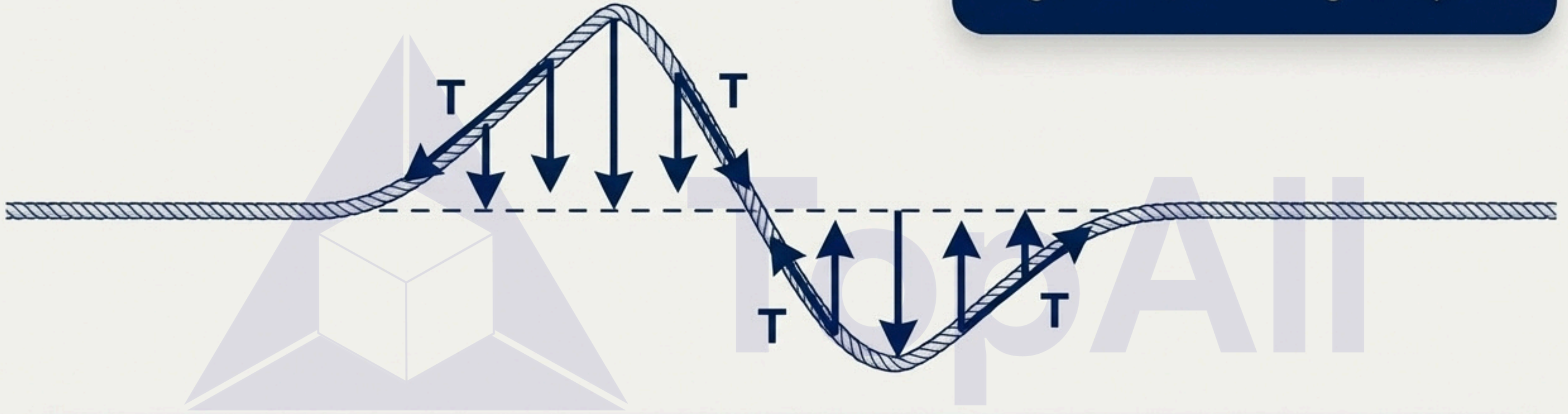
[1] Restoring Force (Tension)

[2] Inertia (Mass Density)

H2: The Snap-Back Effect

Exam Tip Badge

Higher Tension = Higher Speed



When a string is disturbed, the tension (T) acts as a **restoring force**.

A tighter string snaps back to equilibrium faster, forcing the wave pulse to propagate forward at a higher velocity.



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$$E=mc^2$$



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H2: The Sluggishness of Mass



High m/L

$$\mu = \frac{m}{L}$$

(Mass per unit length)



Low m/L

- Total mass (m) isn't enough; we must look at how mass is distributed across the string's length (L).
- μ represents the **inertia** of the medium.

Exam Tip Badge

Greater μ = Lower Speed

Heavier, thicker strings resist acceleration, slowing down the wave pulse.

H2: Dimensional Analysis to Exact Formula

Dimensional analysis yields $v = C \sqrt{T/\mu}$ (Eq. 14.13).
Exact derivation proves the constant $C = 1$.

The diagram shows a horizontal string under tension, represented by a thick black line. A vertical dashed line in the center represents the equilibrium position. Two blue dots on the string, one above and one below the equilibrium line, are connected by a double-headed horizontal arrow. An arrow points from this double-headed arrow to a box labeled "Restoring Force". Another arrow points from the same double-headed arrow to a box labeled "Inertia". In the center of the string, there is a large white box with a black border containing the equation $v = \sqrt{\frac{T}{\mu}}$ (Eq. 14.14). The background features a faint, stylized illustration of a string with a wave pulse.

$$v = \sqrt{\frac{T}{\mu}} \text{ (Eq. 14.14)}$$

Key Insight: Wave speed v is **completely independent of the wave's frequency or shape**. It relies only on the medium (T and μ).

H2: Who Controls What?

$$\lambda = \frac{v}{\nu} \text{ (Eq. 14.15)}$$

SOURCE sets
Frequency (ν)



MEDIUM sets
Speed (v)



**WAVELENGTH
(λ) is forced
to adapt.**



If a wave moves from a **loose string** to a **tight string**, its speed (v) increases. Since frequency (ν) remains constant (locked by the source), the wavelength (λ) must **stretch out**.

H2: Section 14.4.1 Summary



Success

- Speed on a string depends only on medium properties: Tension (T) and Linear Mass Density (μ).
- $v = \sqrt{T/\mu}$ (Eq. 14.14)
- Higher tension increases speed; greater mass per unit length decreases speed.
- Wavelength adapts to the medium's speed via $\lambda = v/v$ (Eq. 14.15).

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