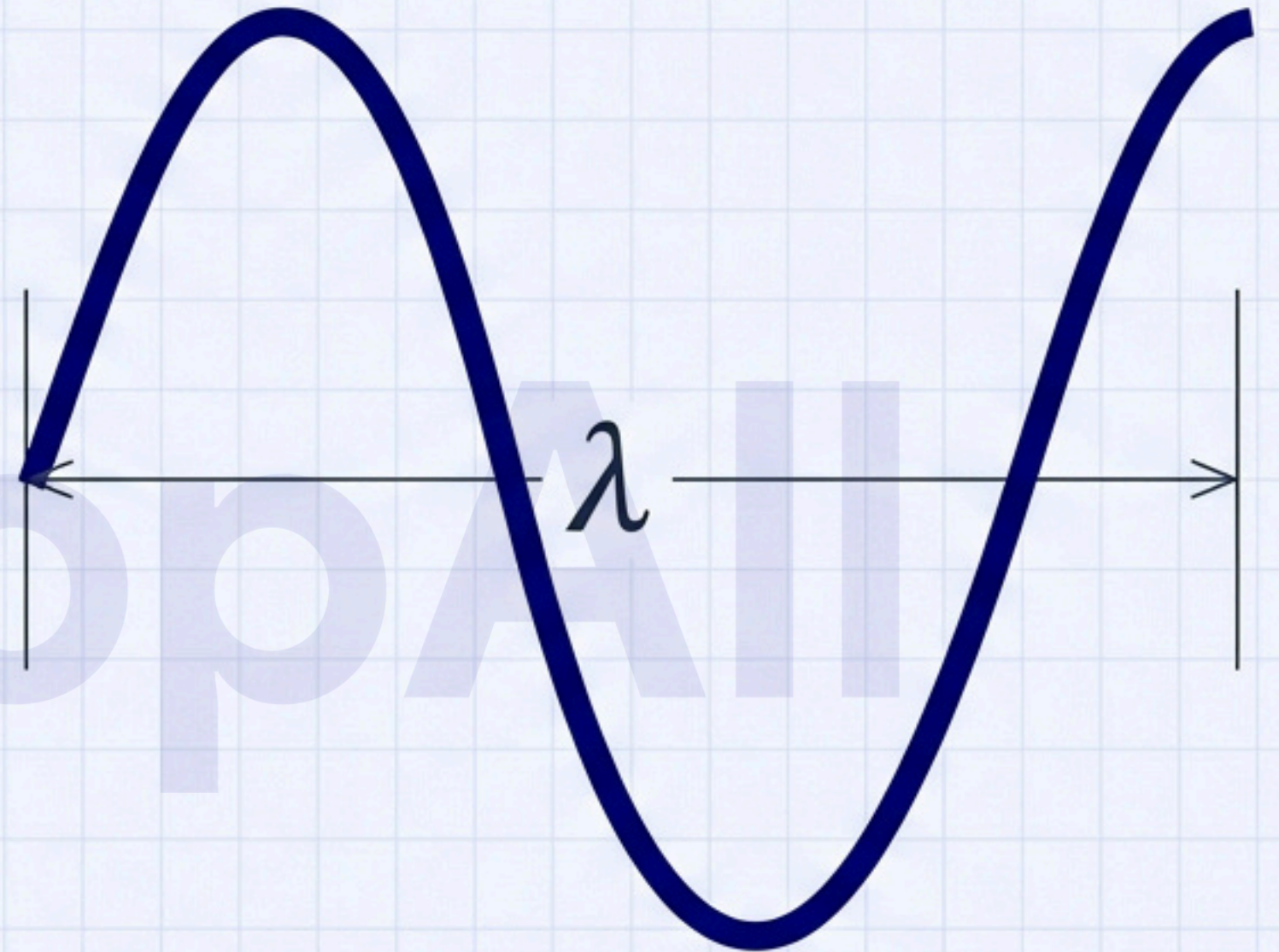
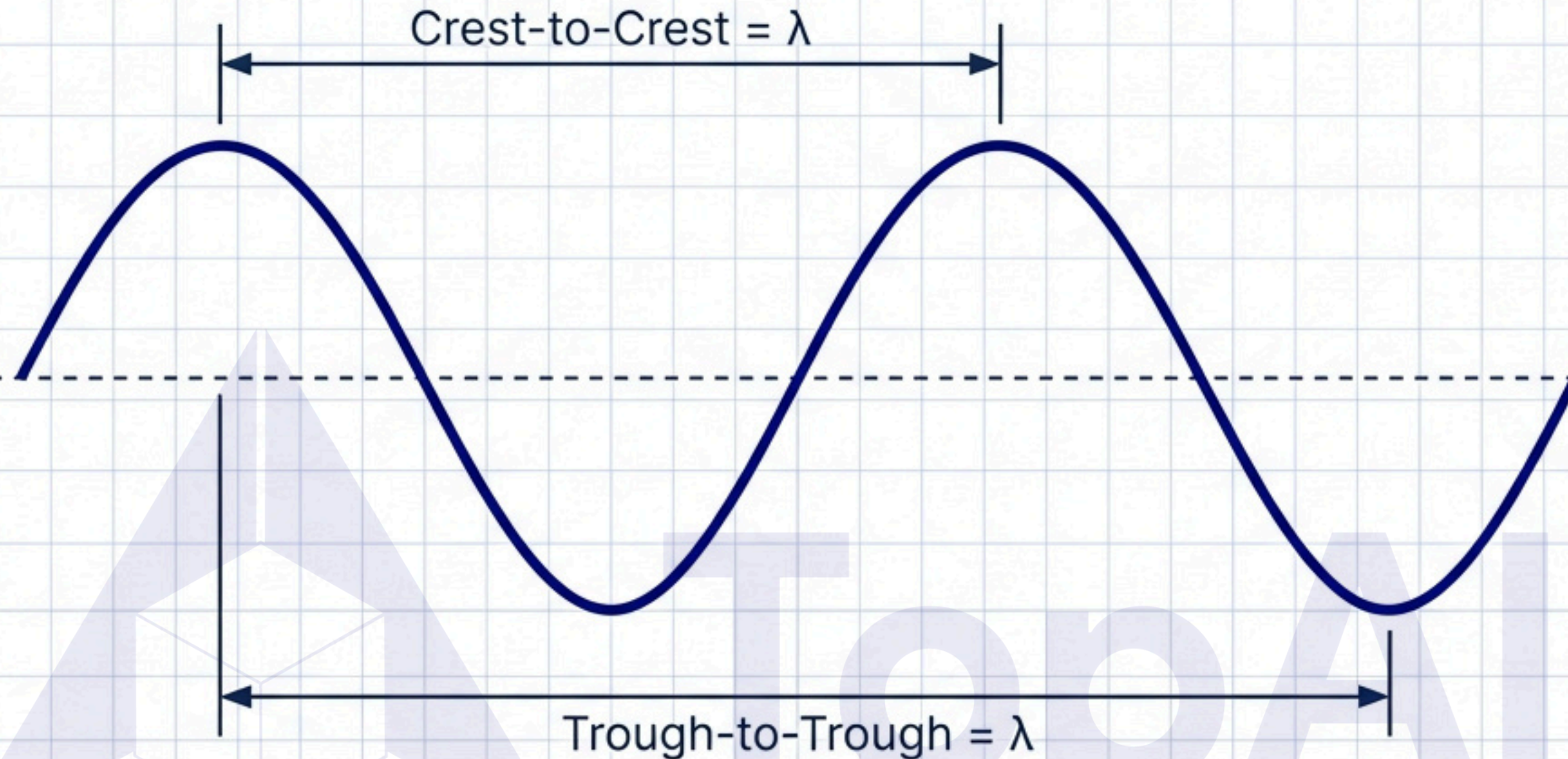


Wavelength & Angular Wave Number

Decoding the spatial properties of progressive waves

Master the relationship between physical wave distance (λ) and angular wave number (k) for NEET & JEE.

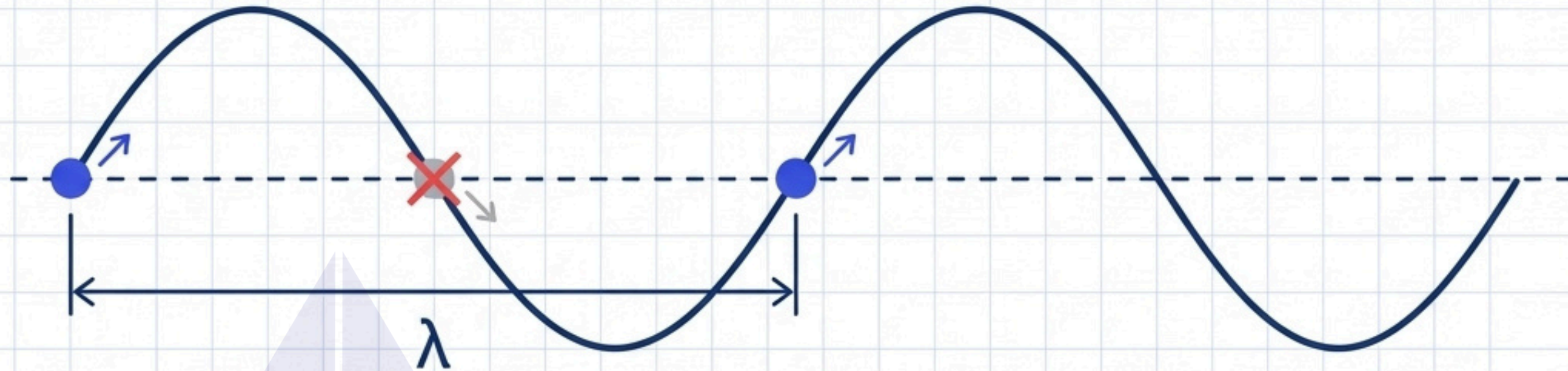




GEOMETRIC DEFINITION

The Physical Distance of One Wave Cycle

- Wavelength (λ) is the minimum distance between two nearest points on a wave that have the exact same phase.
- For simplicity, we typically measure this as the distance between two consecutive crests.
- It can equally be measured between two consecutive troughs.



CONCEPTUAL FOCUS

Beyond Crests and Troughs

- “Same phase” means particles have the exact same displacement AND are moving in the exact same direction.
- A wavelength can be measured between any two consecutive points matching this criteria.

[EXAM TIP] Zero-displacement points are only in the same phase if their slopes match!



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CORE FORMULAS

Spatial Displacement (at $t=0$)

$$y(x, 0) = a \sin(kx)$$

(Eq. 14.5)

The shape of the wave frozen in time is a sine wave depending only on position x .

Angular Wave Number (k)

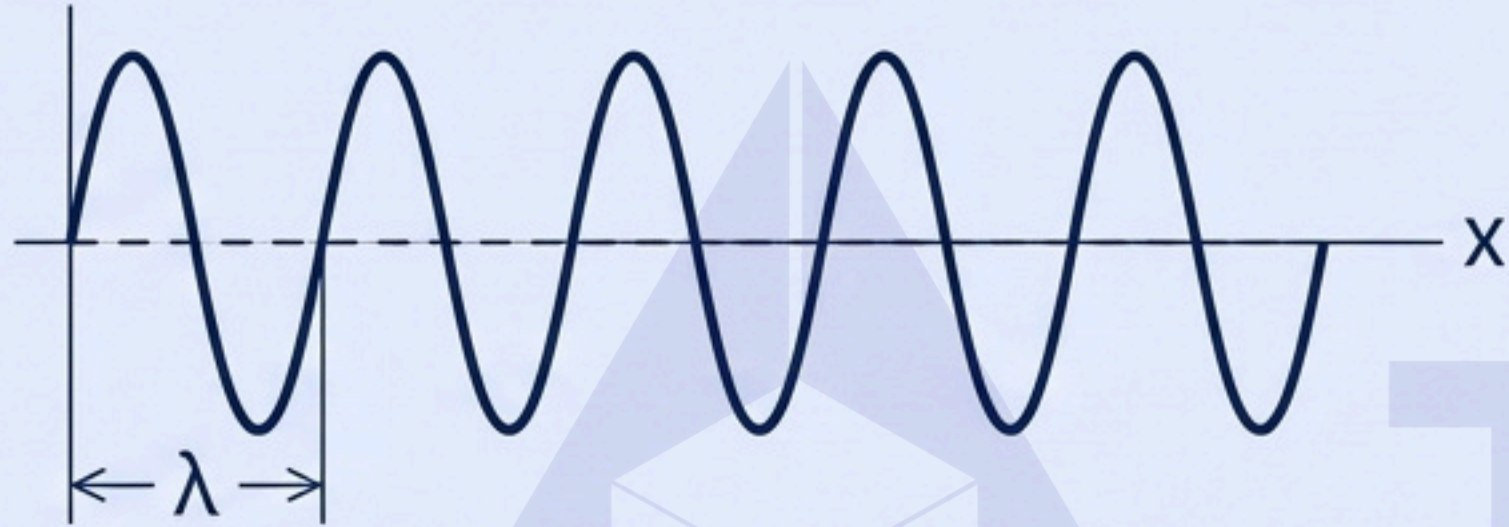
$$\lambda = \frac{2\pi}{k} \quad \text{OR} \quad k = \frac{2\pi}{\lambda}$$

(Eq. 14.6)

k is the propagation constant. It represents 2π times the number of waves that can fit in 1 meter.

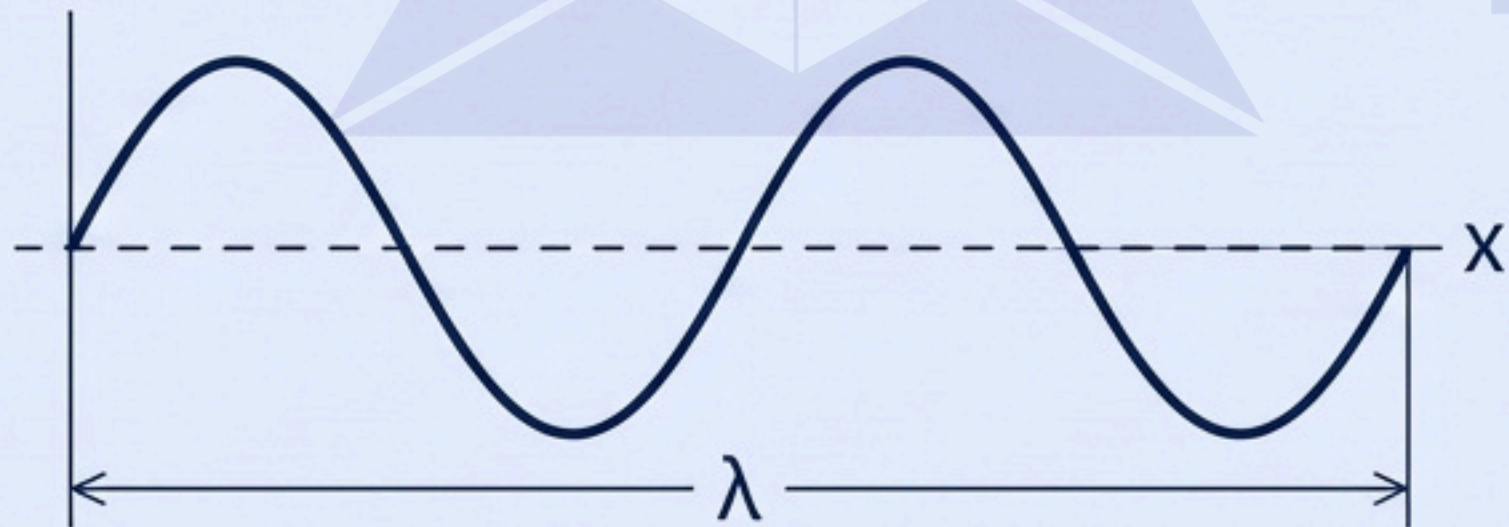
SI Unit: rad m^{-1}

How Wave Density Changes



High Angular Wave Number (k)

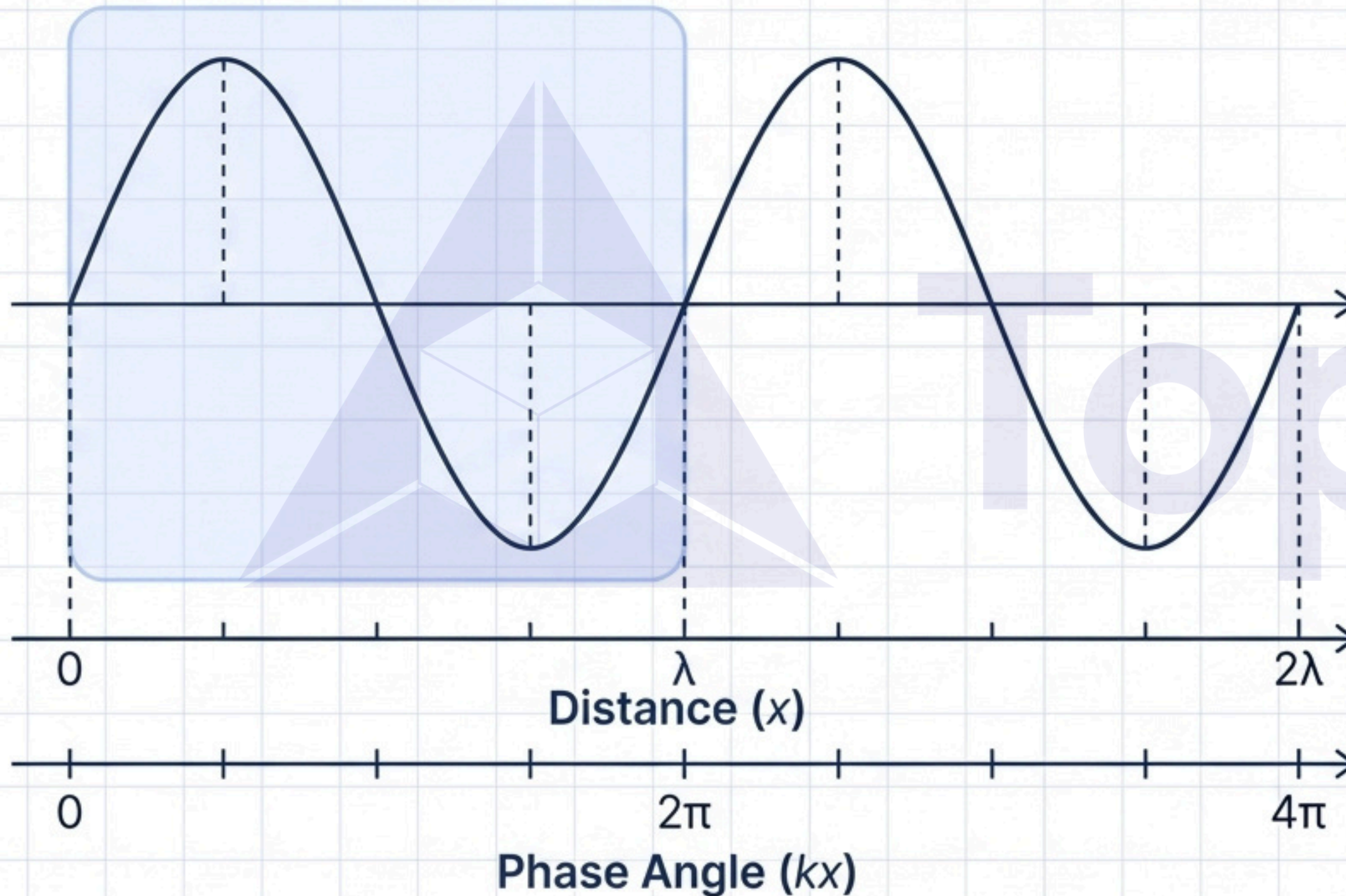
→ Waves are packed closely together in space. Wavelength (λ) is short.



Low Angular Wave Number (k)

→ Waves are stretched out. Wavelength (λ) is long.

Why does $\lambda = 2\pi/k$?



- The sine function mathematically repeats its exact value after every 2π change in angle.
- Therefore, wave displacements at point x and point $x + (2n\pi/k)$ are identical.
- Setting $n = 1$ gives the minimum spatial distance between identical phases: $\lambda = 2\pi/k$.

Key Takeaways

- ✓ **Wavelength (λ)** is the minimum distance between two points in the exact same phase (e.g., crest-to-crest).
- ✓ **Angular Wave Number (k)** is the spatial frequency of the wave, measured in rad m^{-1} .
- ✓ They are strictly inversely related by the formulas: $\lambda = 2\pi/k$ and $k = 2\pi/\lambda$.
- ✓ The spatial wave equation frozen at $t = 0$ is $y(x, 0) = a \sin(kx)$.

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