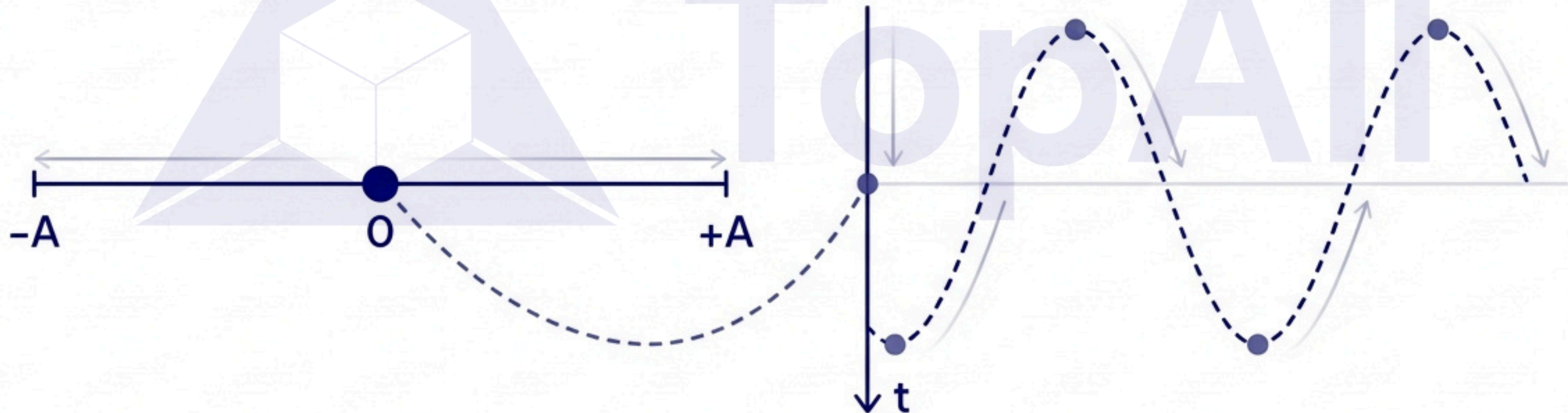


Simple Harmonic Motion

The simplest and most important oscillation

Class 11 Physics • Chapter 13.3

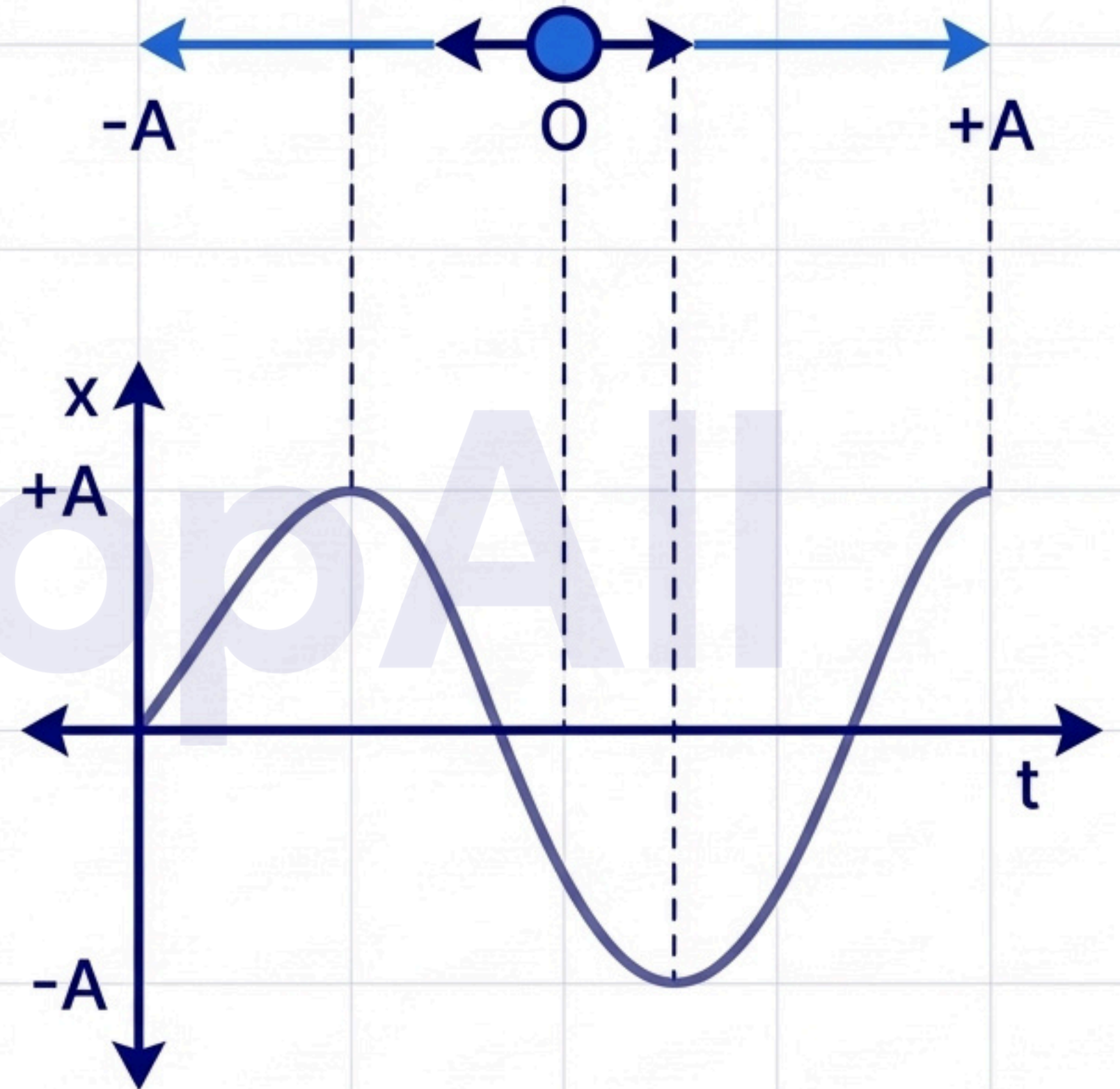


What is Simple Harmonic Motion?

Not all periodic motion is Simple Harmonic Motion (SHM). A bouncing ball repeats its motion, but it is not SHM.

Simple harmonic motion arises uniquely when a particle's displacement is a sinusoidal function of time.

Displacement x as a continuous, periodic function of time.



The Equation of Motion

$x(t) \rightarrow$ Displacement

The particle's position at any given time t .

$\omega \rightarrow$ Angular Frequency

How fast the oscillation repeats.

$$x(t) = A \cos(\omega t + \phi)$$

$A \rightarrow$ Amplitude

Maximum displacement from the origin.

$\phi \rightarrow$ Phase Constant

The starting state of the motion at $t=0$.

$(\omega t + \phi) \rightarrow$ Phase

The time-dependent state of the motion.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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Key Highlights

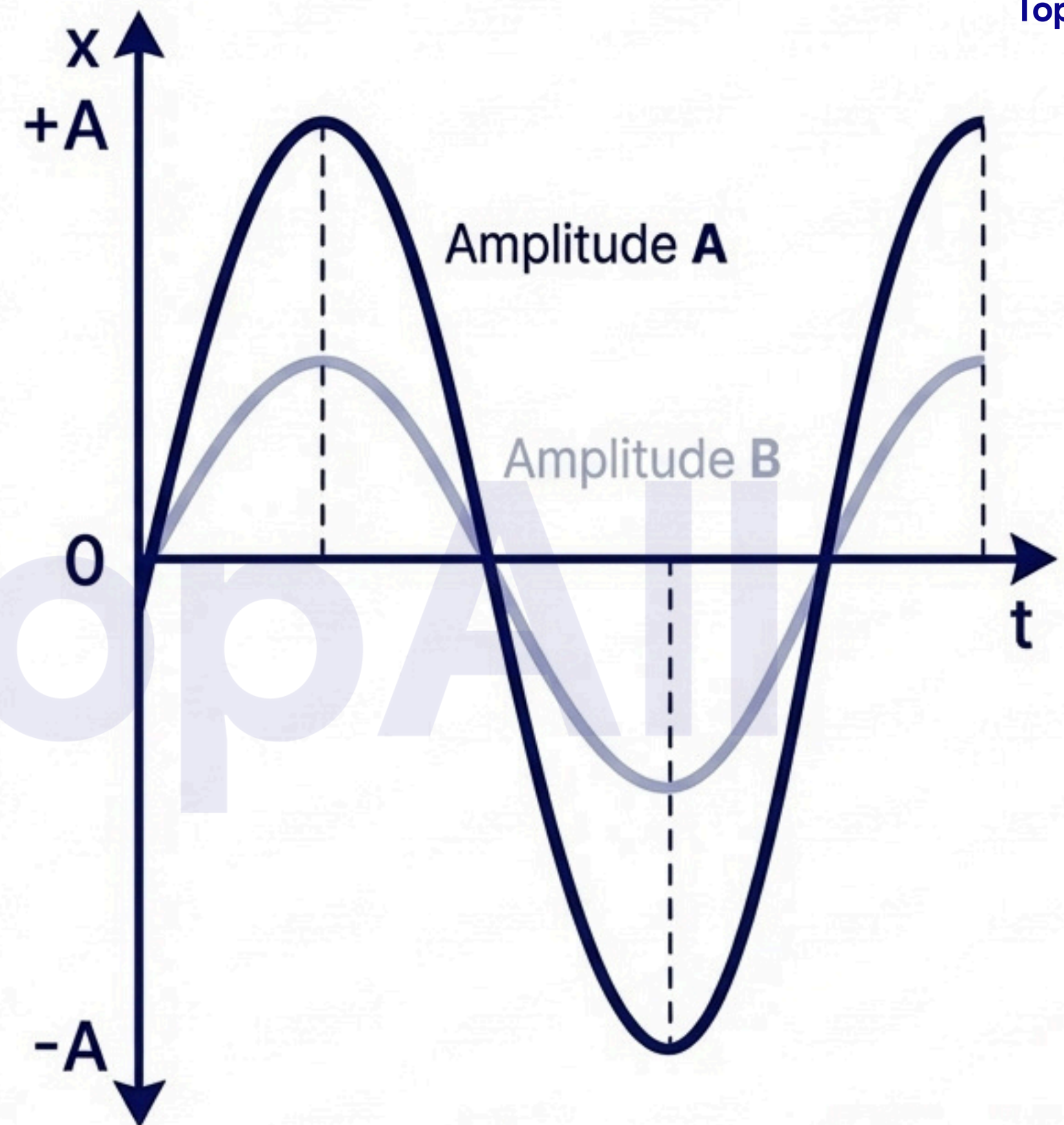
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Parameter Focus: Amplitude (A)

Amplitude dictates the magnitude of the maximum displacement of the particle. The cosine function varies from $+1$ to -1 , meaning the particle's physical limits are bounded exactly between $+A$ and $-A$.

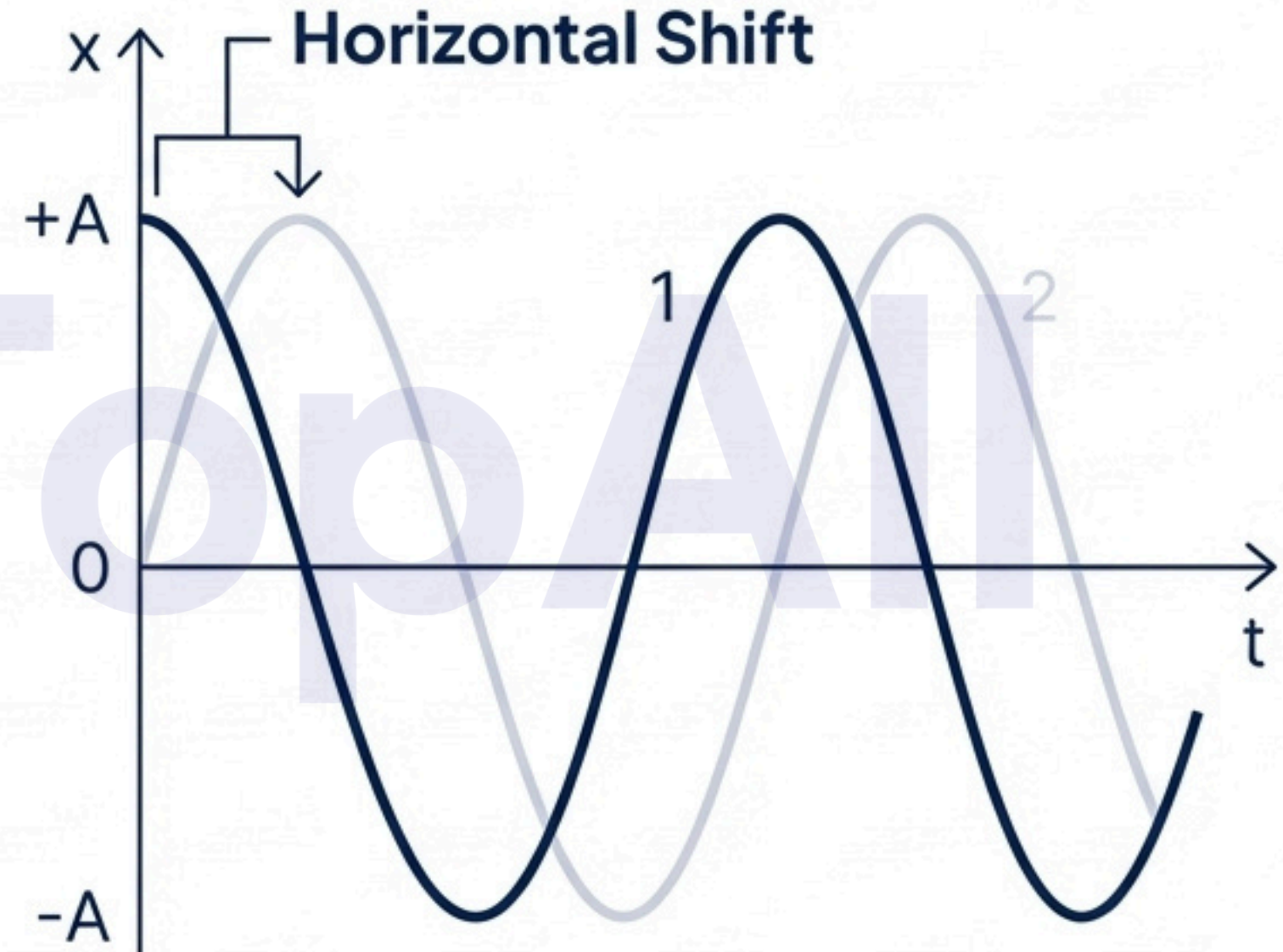
Changing A stretches the graph vertically, but does not affect the timing of the oscillation.



Parameter Focus: Phase Constant (ϕ)

While amplitude defines the bounds, the Phase Constant (ϕ) determines the starting position and velocity of the particle at $t = 0$.

Think of Phase as tracking the state of motion. Two pendulums swinging with the exact same rhythm, but released a split-second apart, have different phases.



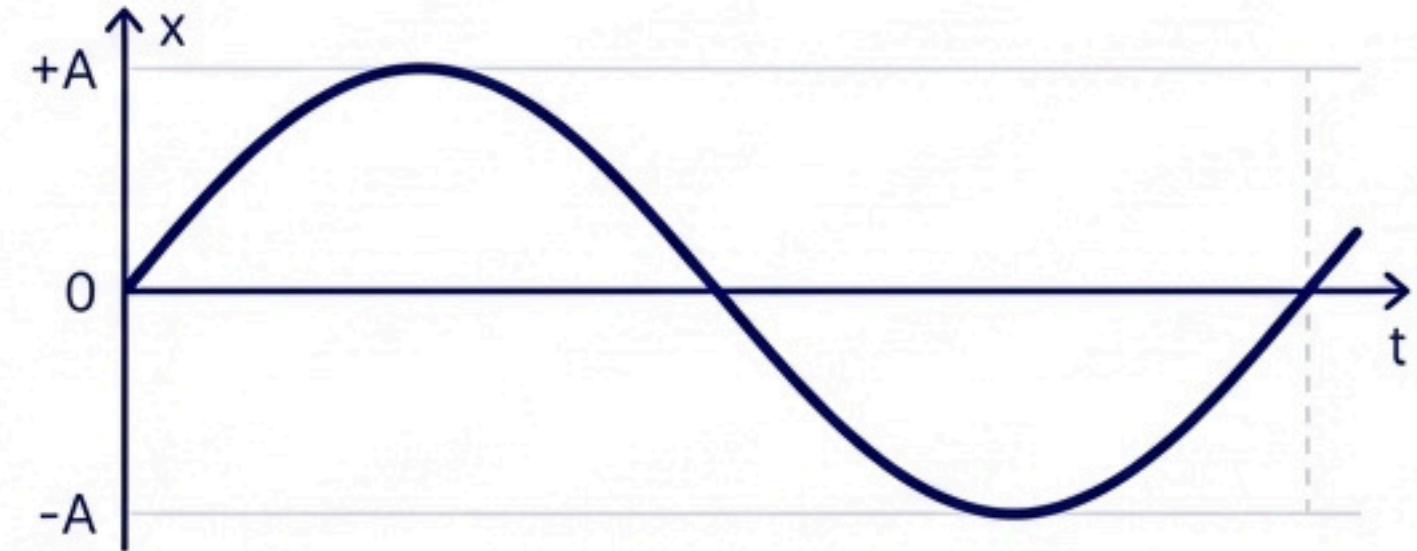
Parameter Focus: Angular Frequency (ω)

Angular frequency (ω) dictates how rapidly the cosine function cycles. It is directly tied to the Period (T)—the time required for one complete oscillation.

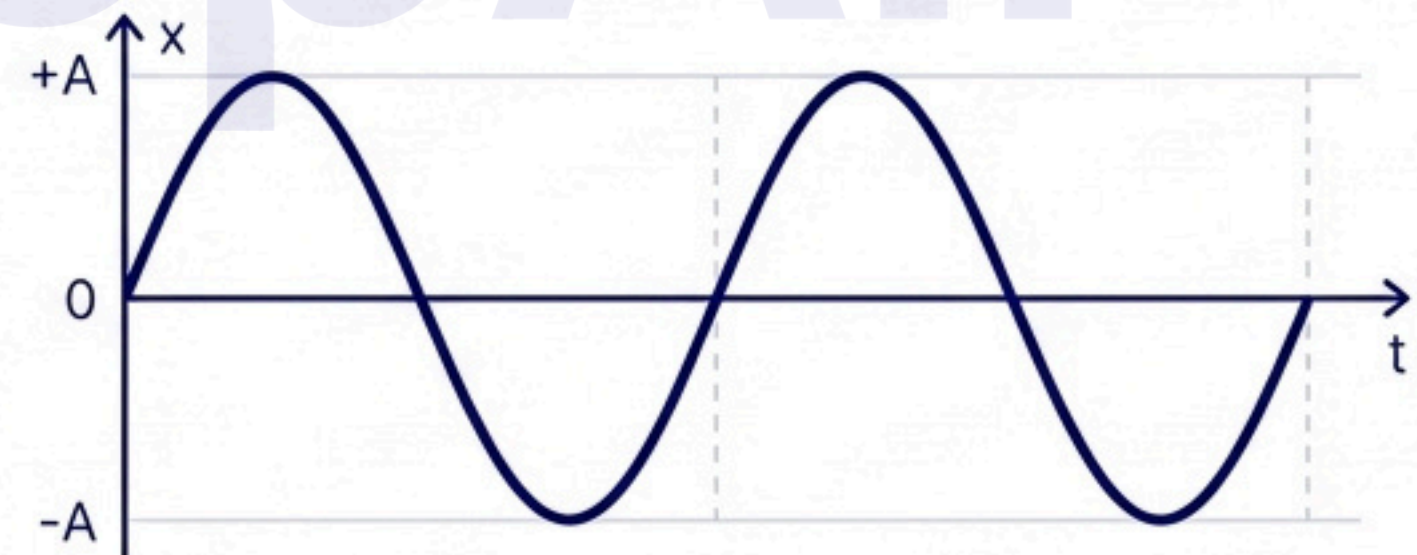
$$\omega = \frac{2\pi}{T}$$

A higher ω physically compresses the mathematical graph horizontally.

Slower Oscillation (Larger T , Smaller ω)



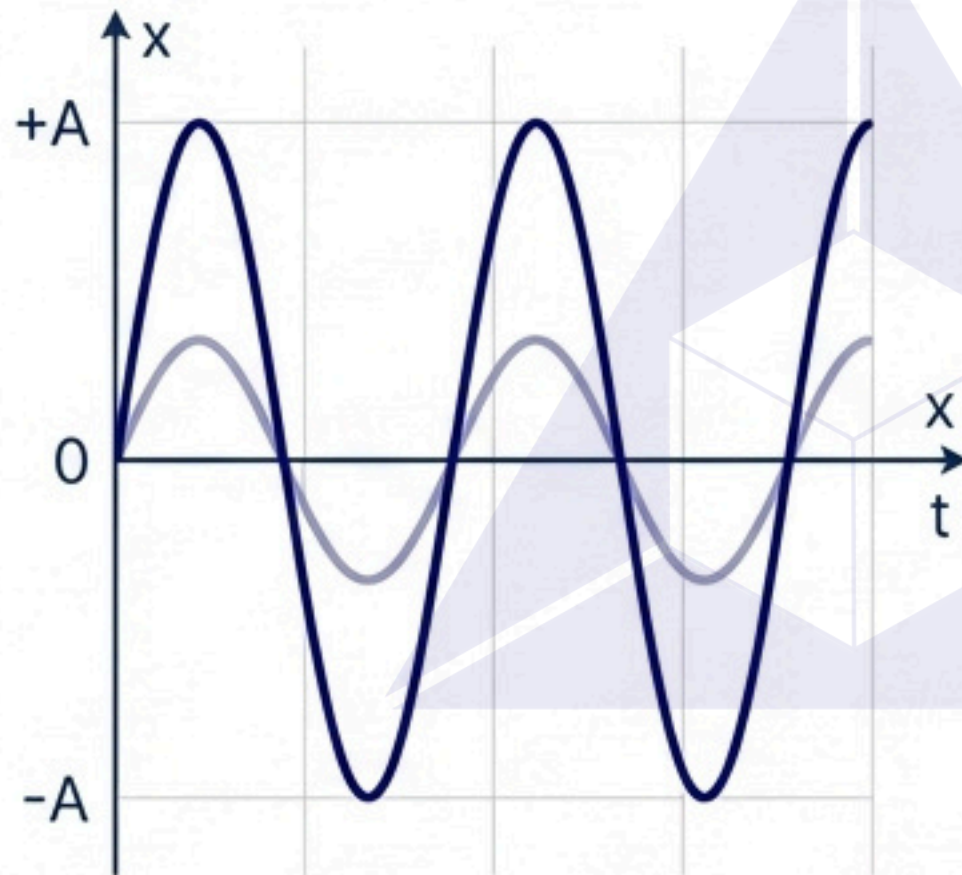
Faster Oscillation (Smaller T , Larger ω)



Synthesizing the Parameters

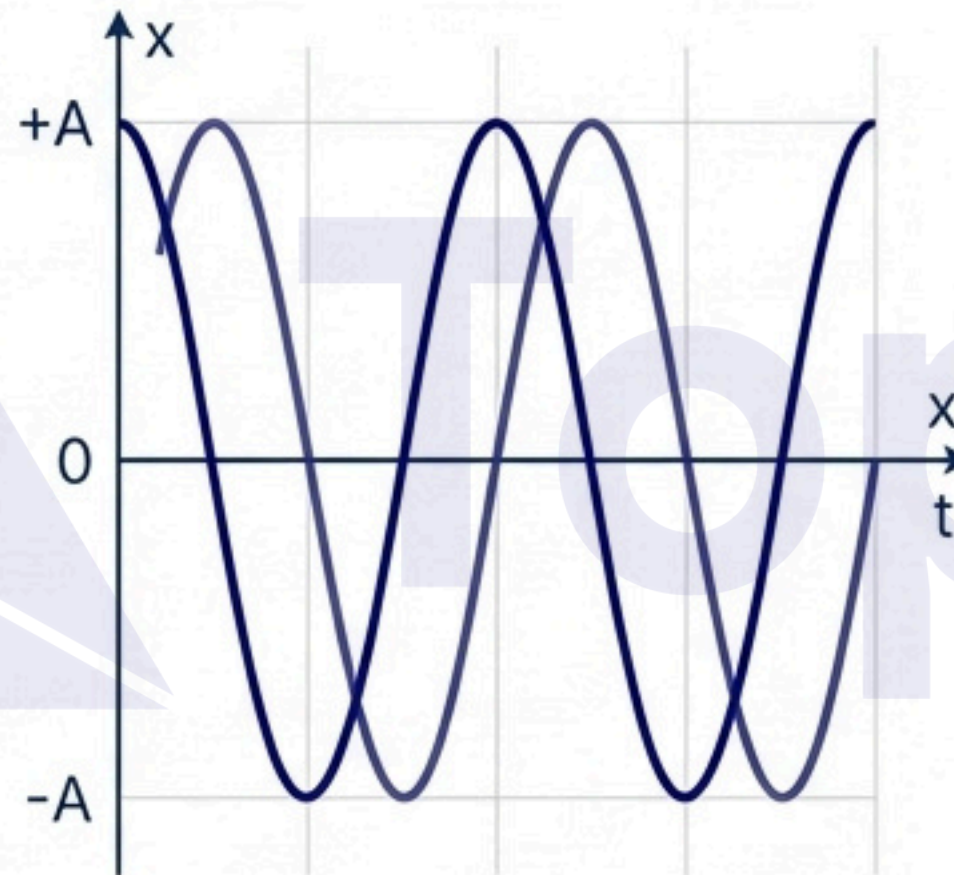
How altering a single variable transforms the motion.

Changing Amplitude (A)



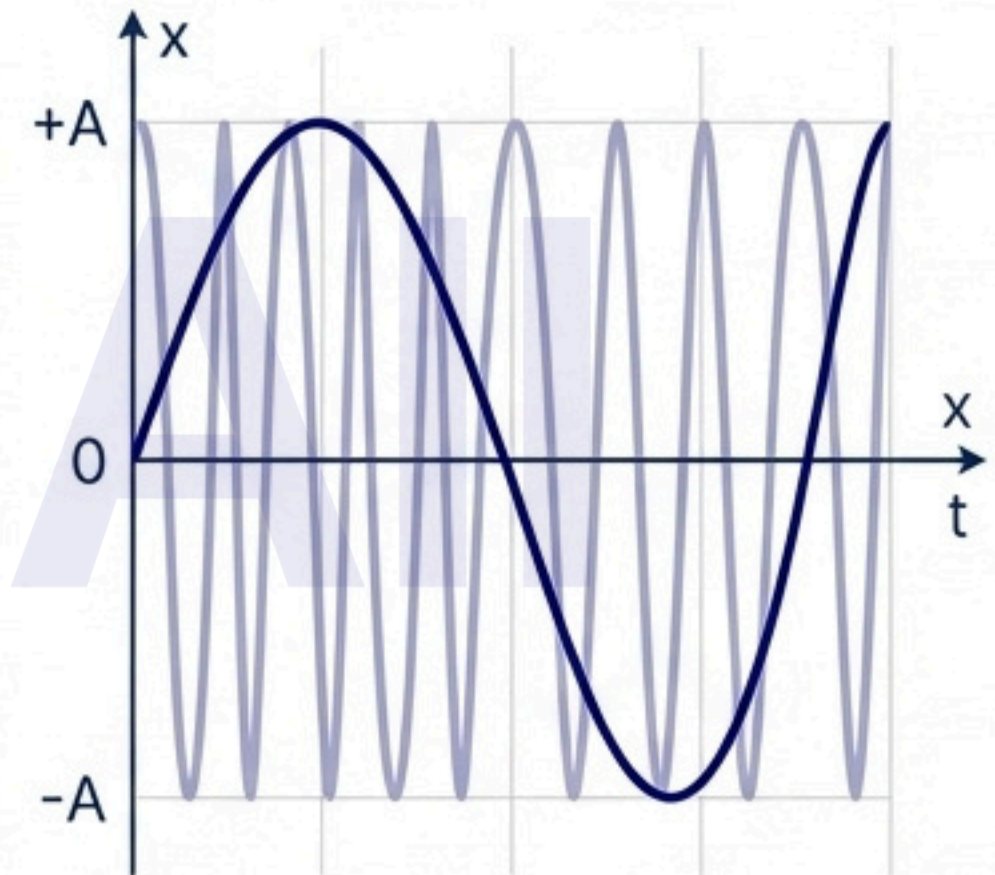
Inter
Vertical stretch. Same speed,
different limits.

Changing Phase (ϕ)



Inter
Horizontal shift. Same speed,
different starting states.

Changing Period (T)



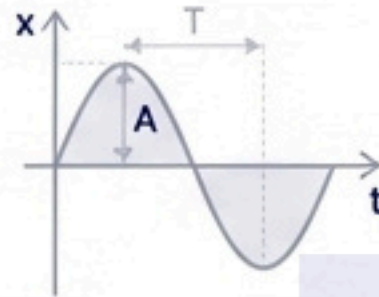
Inter
Horizontal compression. Same
limits, different speeds.

Mastery Summary

The defining characteristics of Simple Harmonic Motion

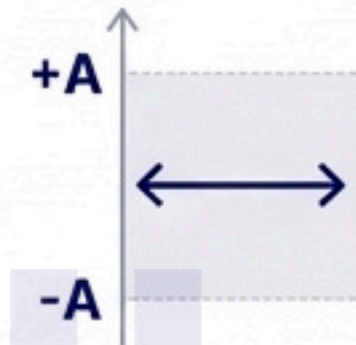
The Definition

SHM is purely sinusoidal.
Displacement must mathematically follow
 $x(t) = A \cos(\omega t + \phi)$.



Amplitude A

Controls maximum displacement.
Bounds the particle's physical motion strictly between +A and -A.



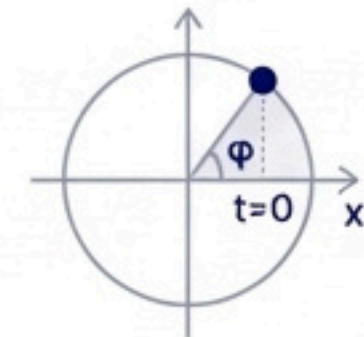
Speed ω

Controls the speed of repetition. A higher angular frequency (ω) yields a proportionally shorter period (T).



State ϕ

Controls the starting state.
Determines the exact position and trajectory of the particle at the instant $t=0$.



You now have a complete mathematical model of the universe's most important oscillation.



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