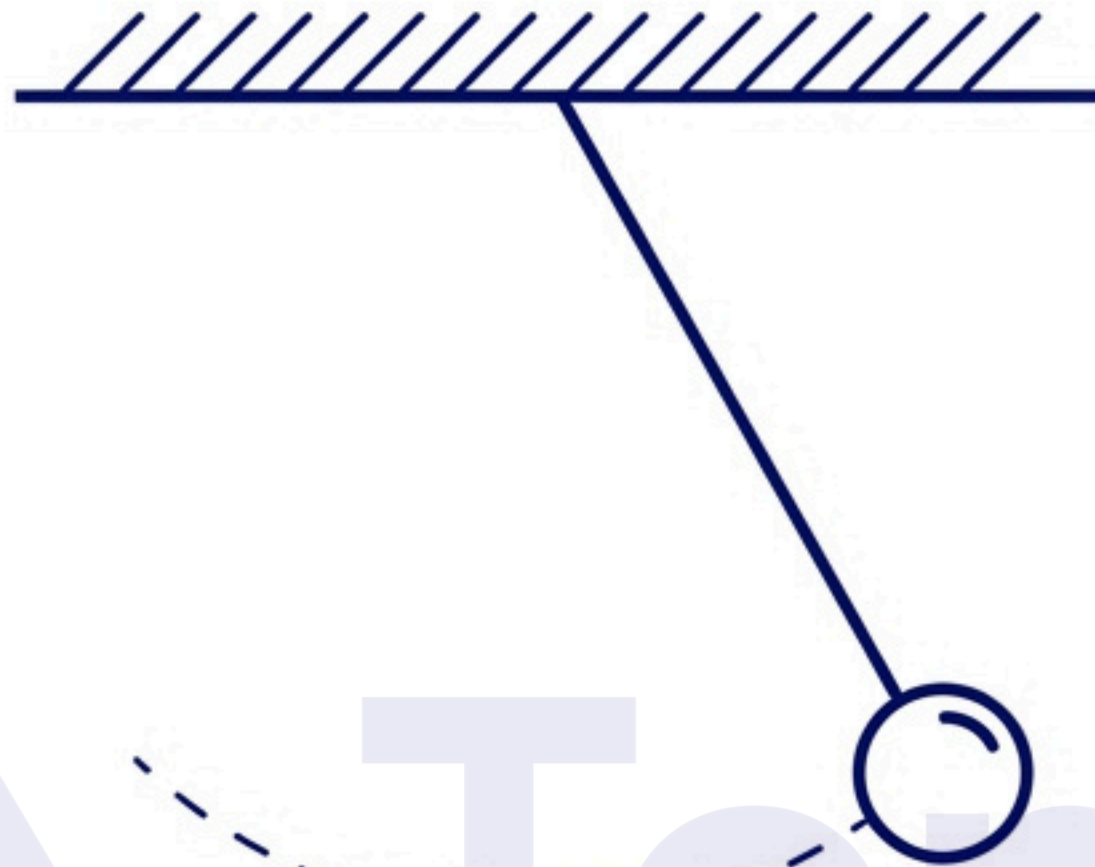
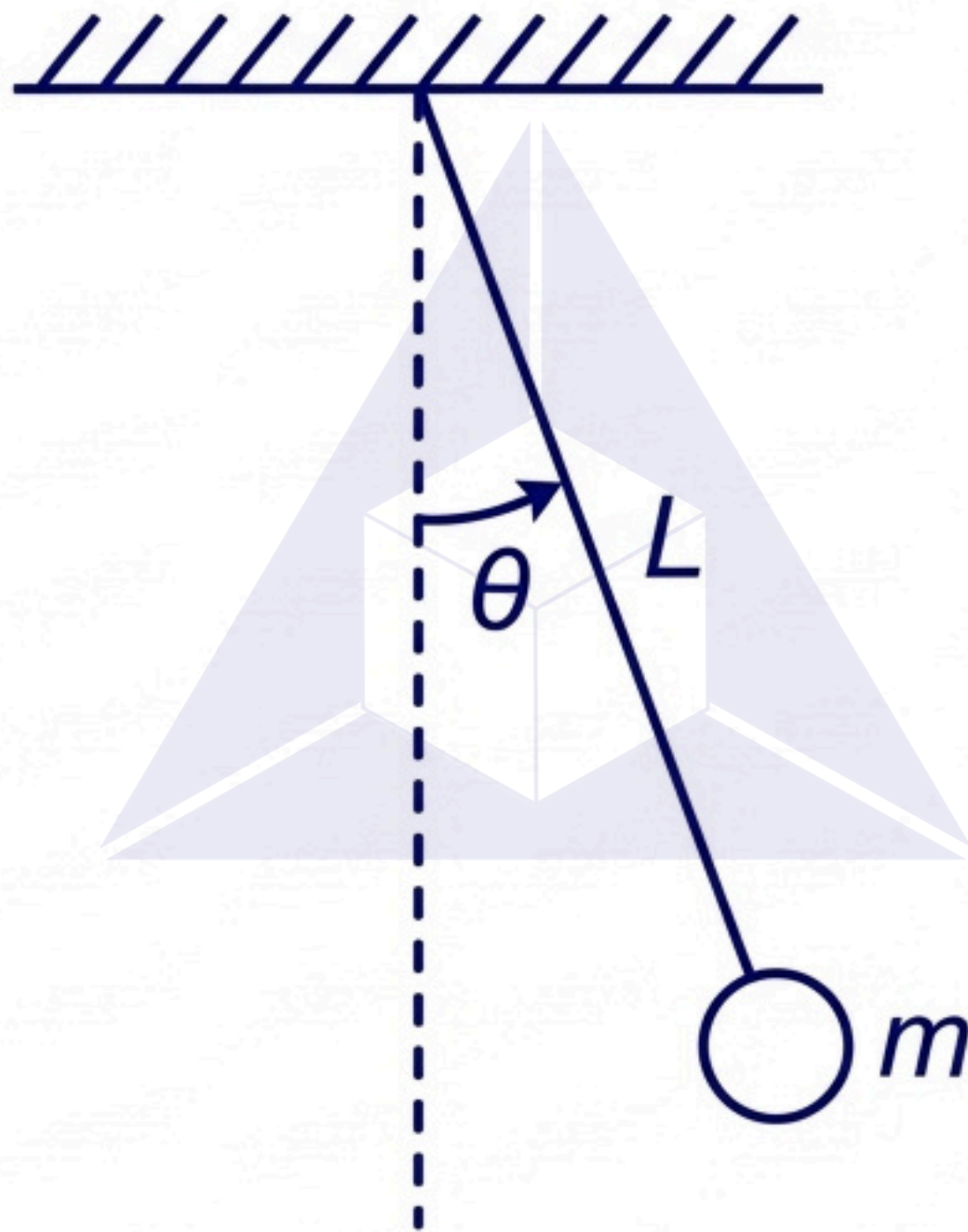




The Simple Pendulum

Why small swings behave like Simple Harmonic Motion (SHM)

Anatomy of a Simple Pendulum



Massless String (L)

Assumed to be perfectly inextensible and massless to isolate the motion of the bob.

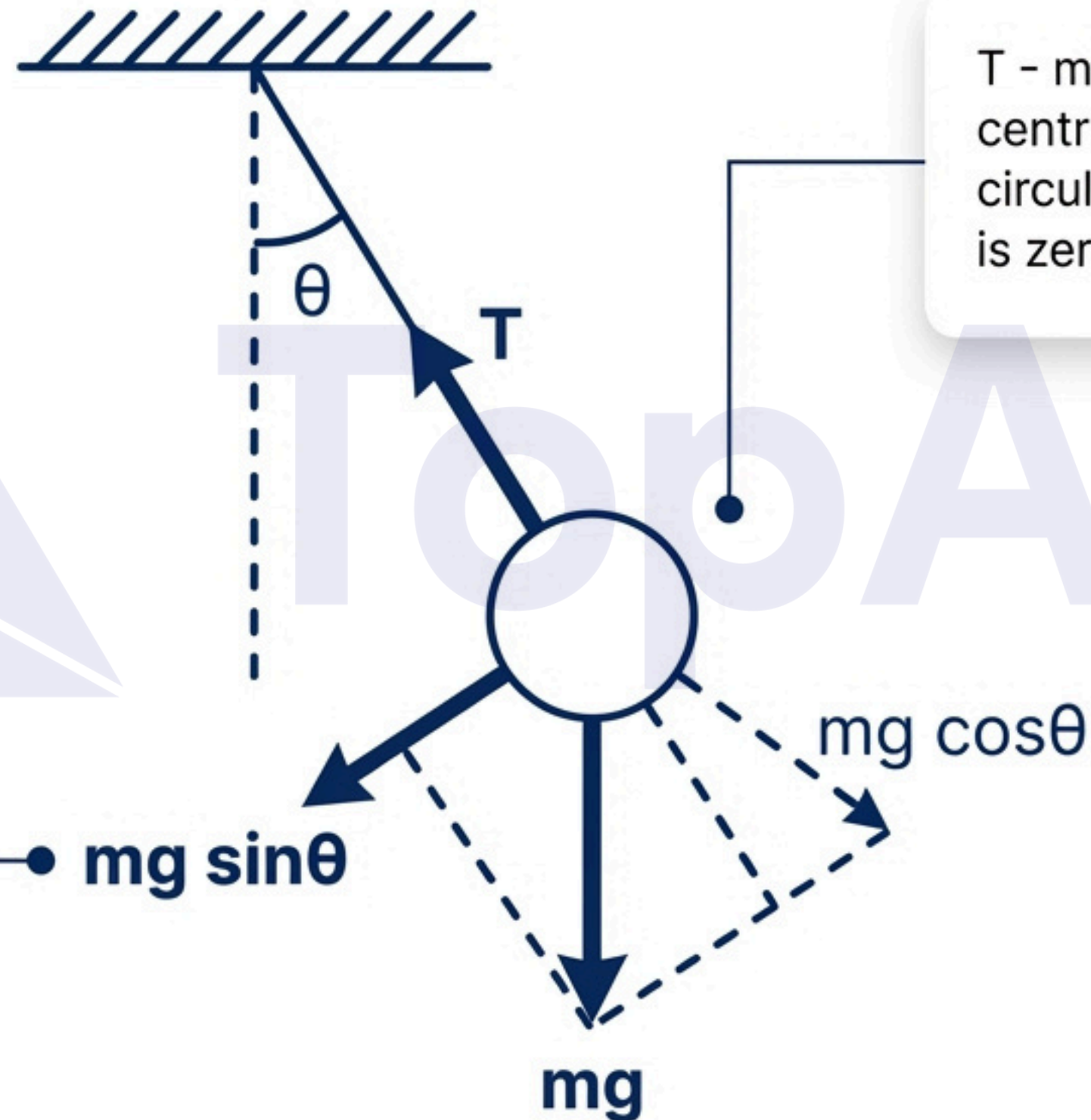
Point Mass (m)

The entire mass of the bob is treated as a single particle concentrated at its center.

Angular Displacement (θ)

The angle measured from the vertical mean position to the current position of the string.

Resolving the Forces



$mg \sin \theta$ is the active, unbalanced component actively pulling the bob back to the center.

$T - mg \cos \theta$ provides the centripetal force for circular motion. Net torque is zero along this axis.



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$$E=mc^2$$



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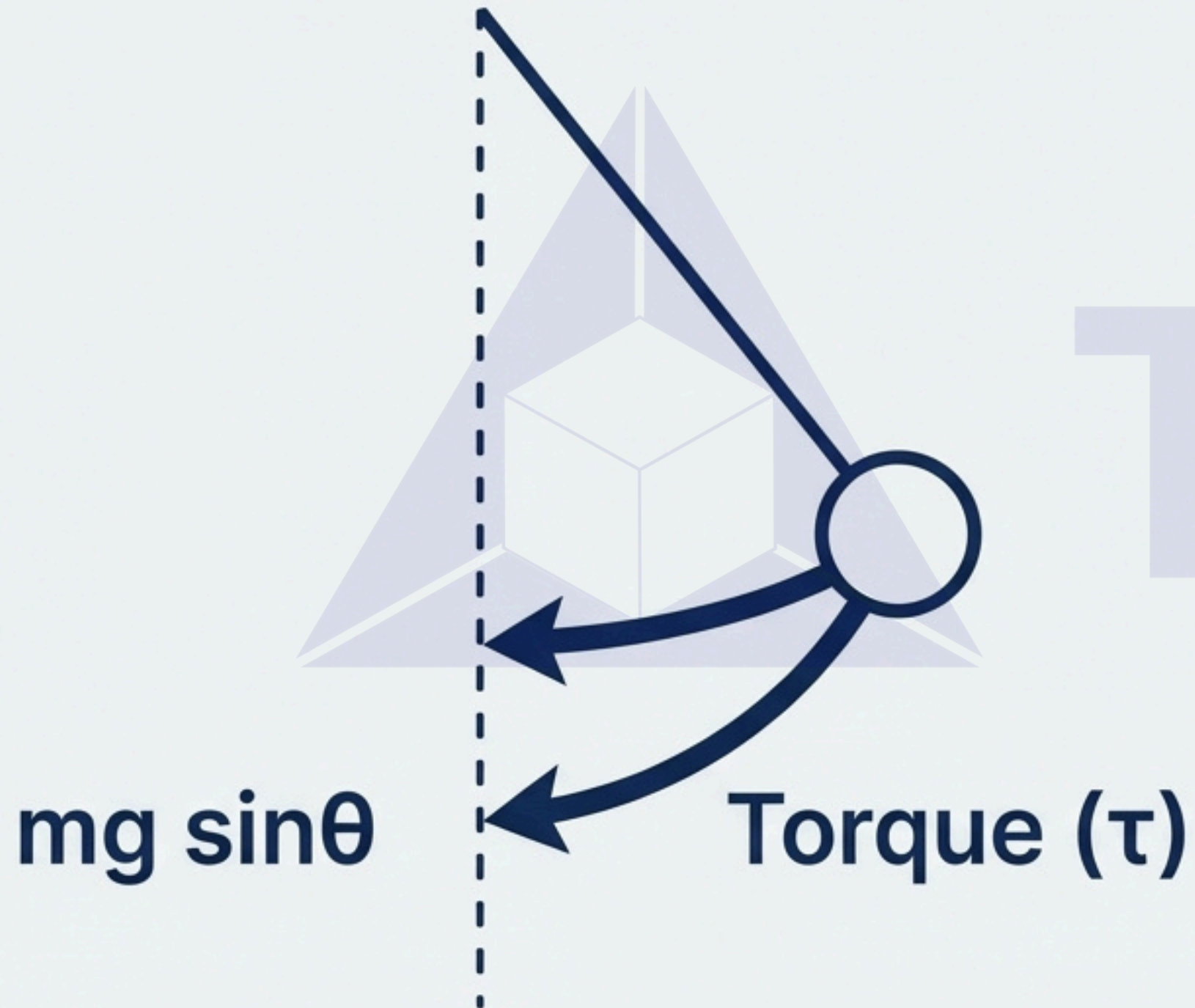
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- » Track Your Performance Smarter



The Restoring Torque



Motion along the arc is rotational. Instead of linear force, the tangential component of gravity creates a restoring torque (τ) about the point of support.

20px

$$\tau = -L(mg \sin\theta)$$

The negative sign indicates that the torque is “restoring” — it always acts in the opposite direction of the displacement to reduce the angle θ .

The SHM “Trick”: Small Angles

For a system to execute true Simple Harmonic Motion, its restoring force must be strictly proportional to displacement (θ).

The term $\sin\theta$ is not linear... unless the angle is very small.

Angle (θ°)	Radians (θ)	$\sin\theta$
5°	0.087	0.087
10°	0.174	0.174
15°	0.262	0.259

When θ is small, $\sin\theta \approx \theta$. Thus, angular acceleration becomes strictly proportional to displacement:
 $\alpha = -(mgL/I)\theta$. This unlocks perfect SHM!

The Time Period Formula

T: Time Period

Seconds required for one complete oscillation.

$$T = 2\pi\sqrt{L/g}$$

L: Length

Distance from the support to the center of the bob.

g: Gravity

Local acceleration due to gravity.

What the Formula Tells Us



Longer String → Slower Swing

Time period is directly proportional to the square root of length ($T \propto \sqrt{L}$). Quadrupling the length only doubles the time period.



Higher Gravity → Faster Swing

Time period is inversely proportional to the square root of gravity ($T \propto 1/\sqrt{g}$). A pendulum will swing slower on the moon than on Earth.



Mass Doesn't Matter

Notice what is missing from the equation? The mass (m) of the bob has absolutely zero effect on the time period.

Summary for Exams



SHM Condition: A simple pendulum only executes Simple Harmonic Motion for small angular displacements where $\sin\theta \approx \theta$.



Restoring Force: The physical motion is driven by the tangential component of gravity ($mg \sin\theta$), which creates a restoring torque toward the mean position.



The Variables: The time period ($T = 2\pi\sqrt{L/g}$) depends solely on the length of the **string** and local gravity. It is entirely independent of the bob's mass.



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