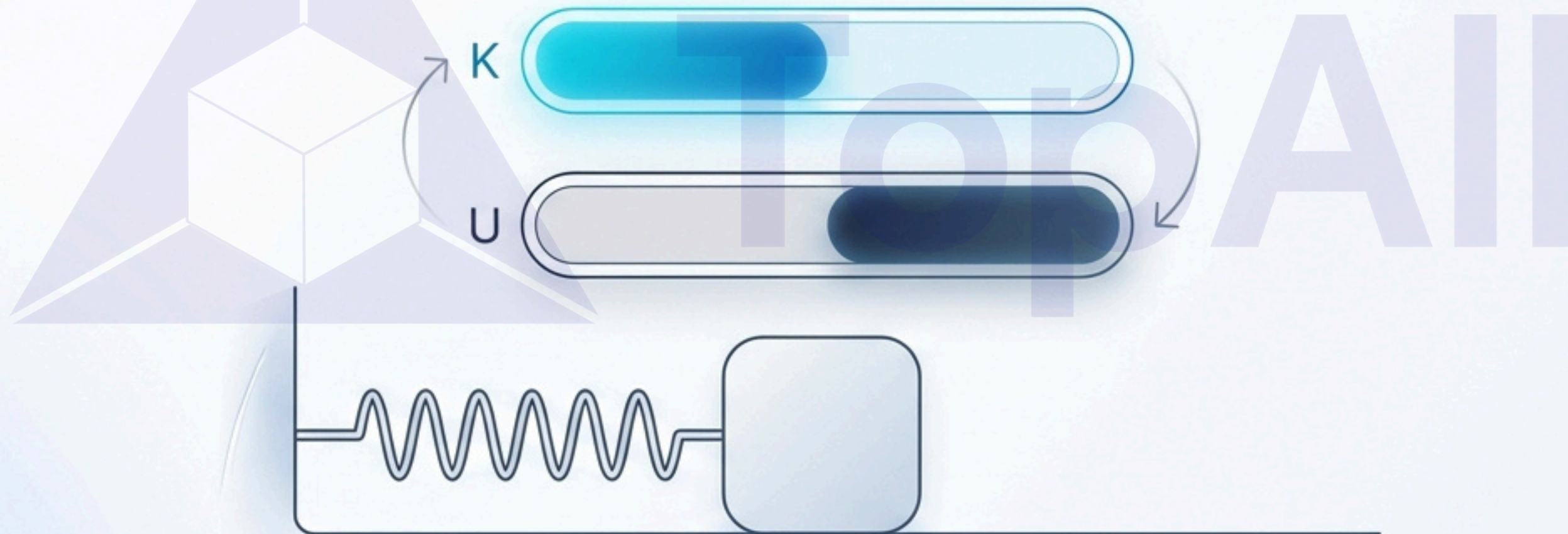


Energy in SHM

Kinetic and potential energy keep trading places



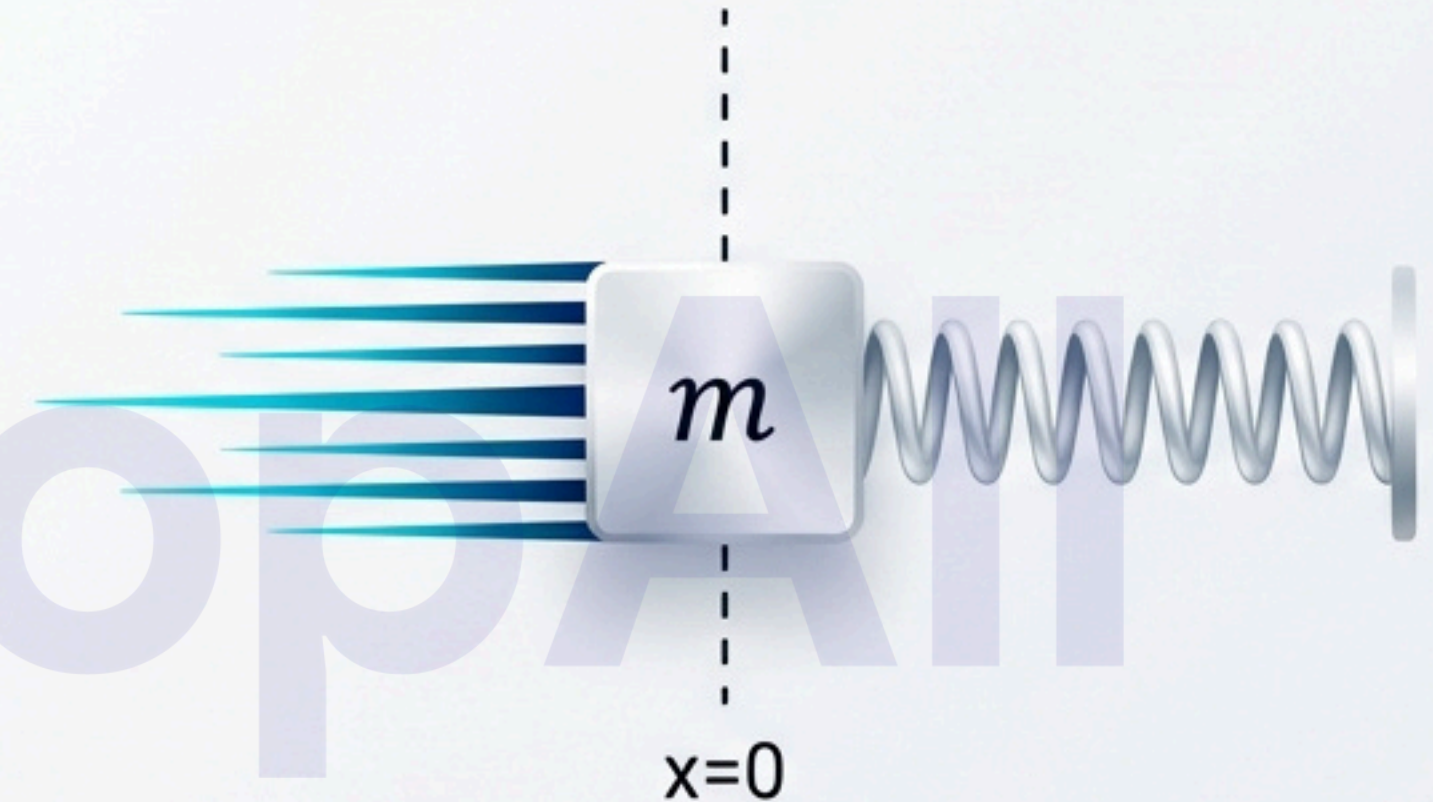
Kinetic Energy (K)

Key Idea: Energy of motion peaks when the object is moving fastest.

$$K = \frac{1}{2}mv^2$$

Since velocity $v = -\omega A \sin(\omega t + \varphi)$,
kinetic energy is periodic:

$$K = \frac{1}{2}kA^2 \sin^2(\omega t + \varphi)$$



K



Maximum at the mean position (v is max). Zero at the extremes.

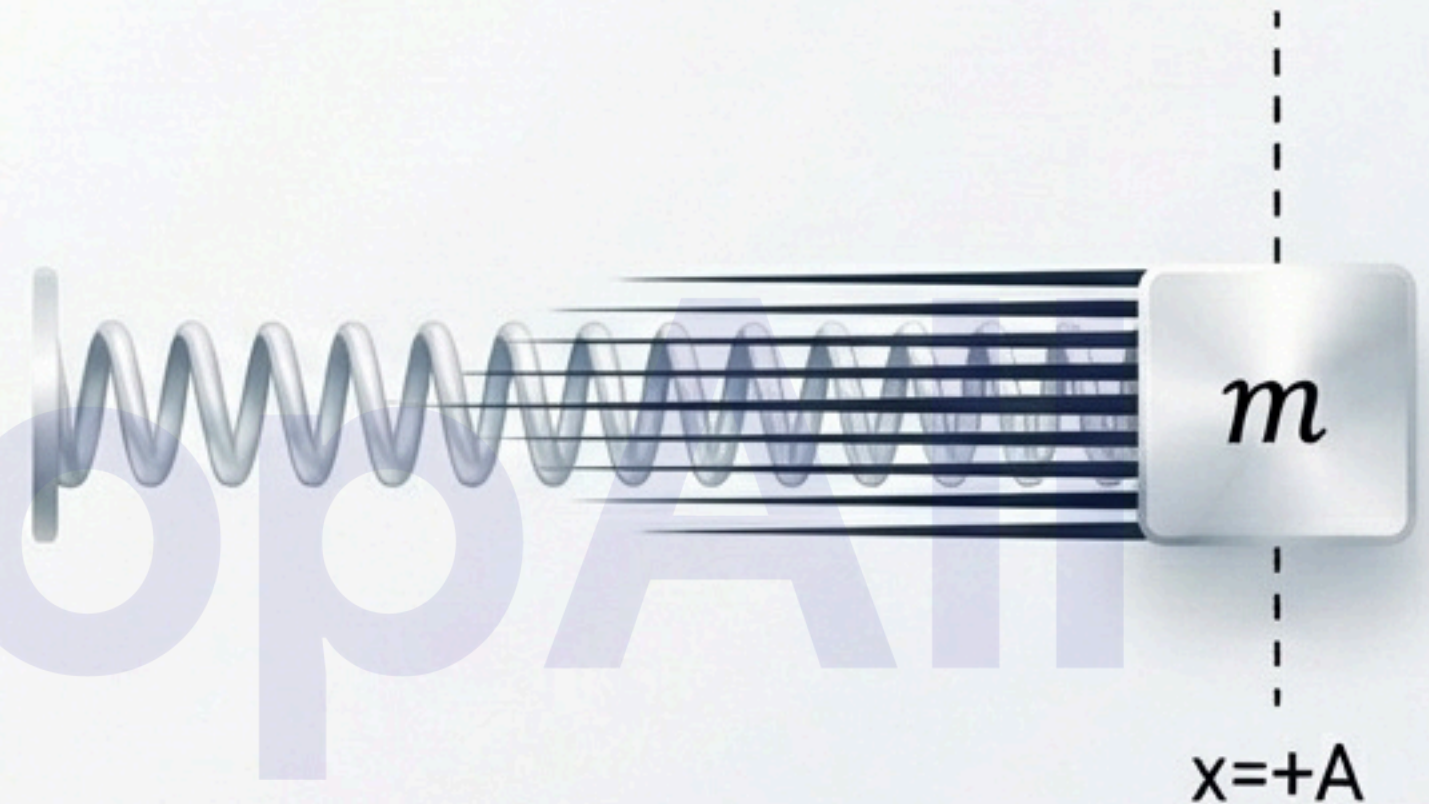
Potential Energy (U)

Key Idea: Stored energy peaks when the spring is fully stretched or compressed.

$$U = \frac{1}{2} k x^2$$

Since displacement $x = A \cos(\omega t + \varphi)$,
potential energy is also periodic:

$$U = \frac{1}{2} k A^2 \cos^2(\omega t + \varphi)$$



U

Maximum at the extremes ($x = \pm A$). Zero at the mean position.



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$$E=mc^2$$



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The Law of the Oscillator

Key Idea: Energy transforms, but the total amount never changes.

$$E = K + U = \text{Constant}$$

$$E = \frac{1}{2}kA^2 \sin^2(\omega t + \varphi) + \frac{1}{2}kA^2 \cos^2(\omega t + \varphi)$$

$$E = \frac{1}{2}kA^2 [\sin^2(\omega t + \varphi) + \cos^2(\omega t + \varphi)]$$

$$E = \frac{1}{2}kA^2$$

E

K

U

The Energy Dance

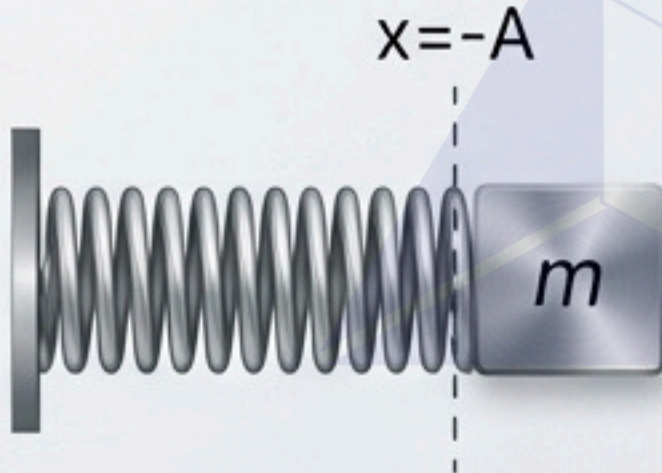
Key idea: Tracking exact values at the three critical milestones of motion.

Left Extreme

Stats

$$x = -A$$

$$v = 0$$



U 100%

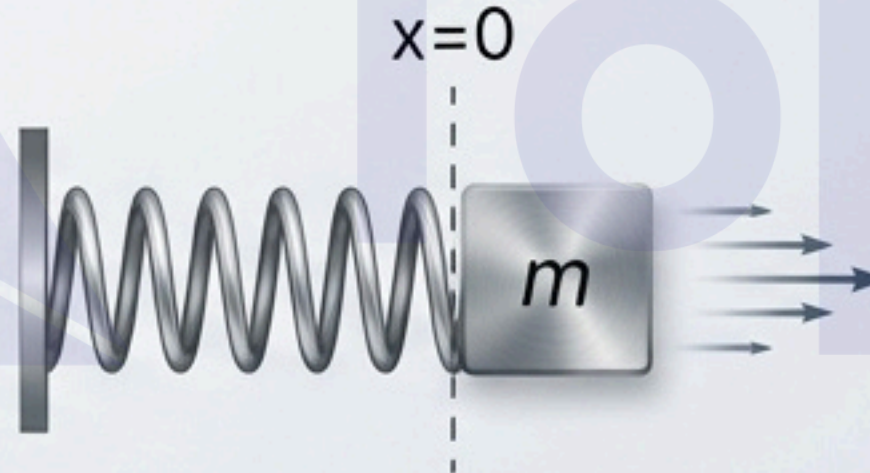
K

Mean Position

Stats

$$x = 0$$

$$v = v_{\max}$$



U

K

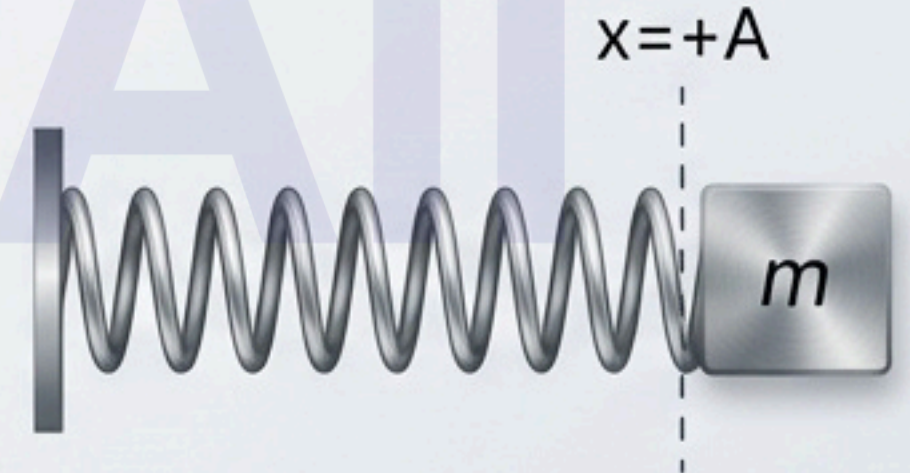
100%

Right Extreme

Stats

$$x = +A$$

$$v = 0$$



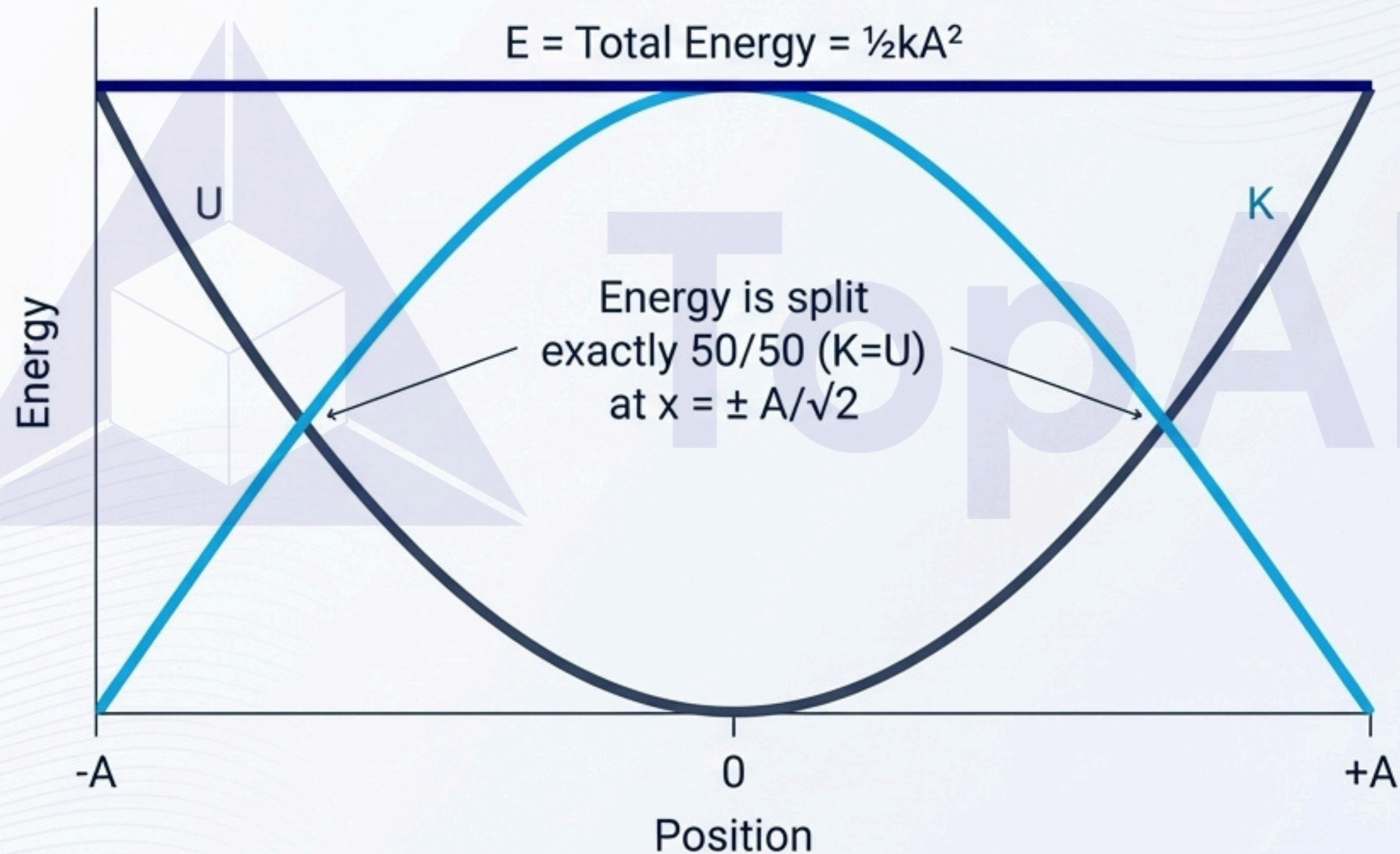
U

100%

K

Visualizing the Conservation

The overlapping curves of energy versus position.



Summary: Energy in SHM

Distilling Chapter 13.7 for exam readiness.



1. Dynamics

Both K and U vary continuously, peaking twice during each full period ($T/2$). They are periodic, but never negative.

2. Conservation

Total mechanical energy ($E = \frac{1}{2}kA^2$) remains absolutely constant in an ideal simple harmonic oscillator.

3. Transformation

Energy endlessly shifts form between kinetic (motion) and potential (stored position), but is never lost.

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