

NEET / JEE PHYSICS MODULE • SECTION 5.7

The Concept of Potential Energy

Understanding stored energy through position, configuration, and rigorous mathematical formalization.

What is Potential Energy?

Potential energy is stored energy by virtue of a body's specific position or configuration. Left to itself, a system releases this stored energy as kinetic energy.



By Configuration

Energy stored by internal deformation. Examples include a stretched bow-string or compressed fault lines in the Earth's crust before an earthquake.

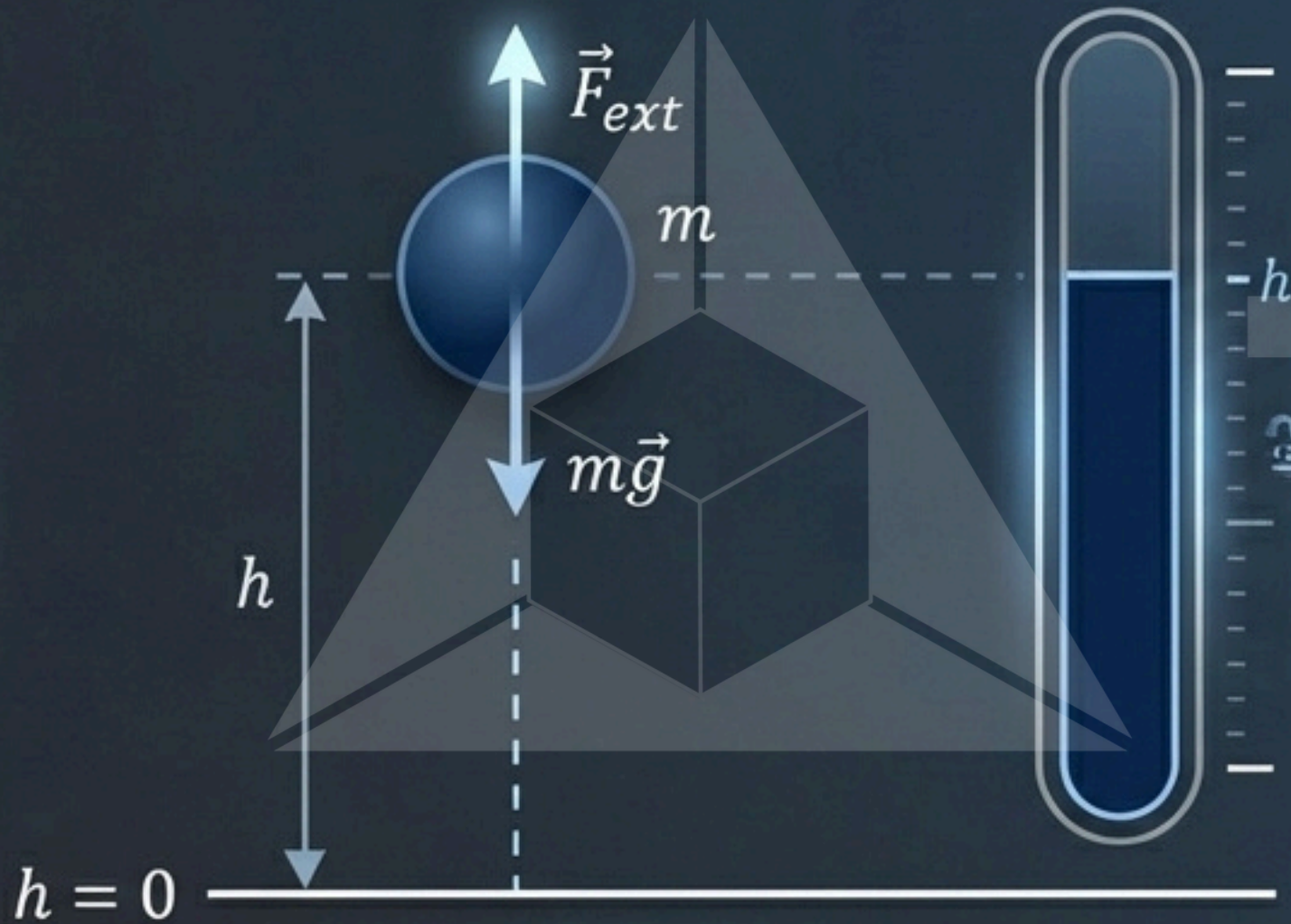


By Position

Energy stored by a body's location within a force field (like gravity). Example: A mass lifted against the Earth's gravitational pull.

The Storage Phase: Lifting Against Gravity

Physics Engine UI - State 1



Raising the ball to height h requires work done by an external agency against the gravitational force.

$$W = mgh$$

This exact work is not lost; it is stored as Gravitational Potential Energy.

⚠ ASSUMPTION: This assumes $h \ll R_E$ (height is much smaller than Earth's radius), allowing g to be treated as a constant.



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$$E=mc^2$$



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Key Highlights

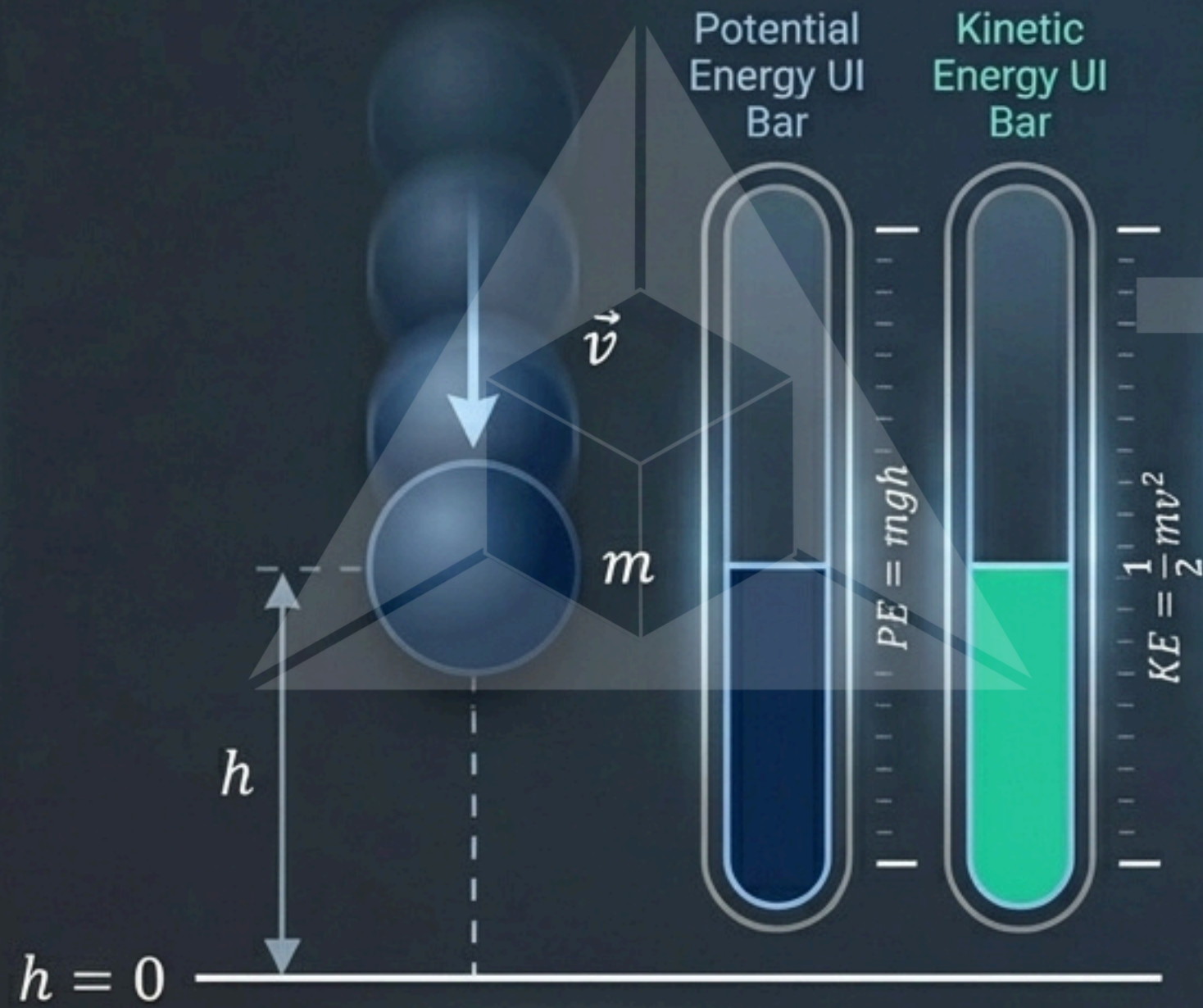
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The Release Phase: Manifestation as Kinetic Energy



Physics Engine UI - State 2



When external constraints are removed, the ball accelerates downward.

Just before hitting the ground, kinematics tells us: $v^2 = 2gh$

Multiplying by $m/2$ reveals the energy transformation:

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

Insight: The potential energy at height h flawlessly manifests as kinetic energy upon reaching the ground.

Mathematical Formalization



m : Mass of the object (kg)

g : Constant acceleration due to gravity (9.8 m/s^2)

$$V(h) = mgh$$

h : Variable height above the zero-reference point

The Force-Potential Gradient

$$F = -\frac{dV}{dh}$$

The negative sign mathematically indicates that the gravitational force points downward (opposite to increasing height).

Dimensional Match

Dimensional Formula:
 $[\text{ML}^2\text{T}^{-2}]$ (Joules)

Mathematically equivalent to Work.

Section 5.7 Summary



High-Yield Exam Takeaways

- **Core Definition:** Potential energy $V(x)$ is the stored capacity for work due to an object's position or configuration.
- **Gravitational PE:** Near Earth's surface ($h \ll R_E$), the potential energy function is $V(h) = mgh$.
- **Calculus Link:** Force is the negative derivative of potential energy: $F = -\frac{dV}{dh}$.
- **System Constraint:** The concept of potential energy is only mathematically valid for conservative forces (where work depends only on initial and final positions, not the path).



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