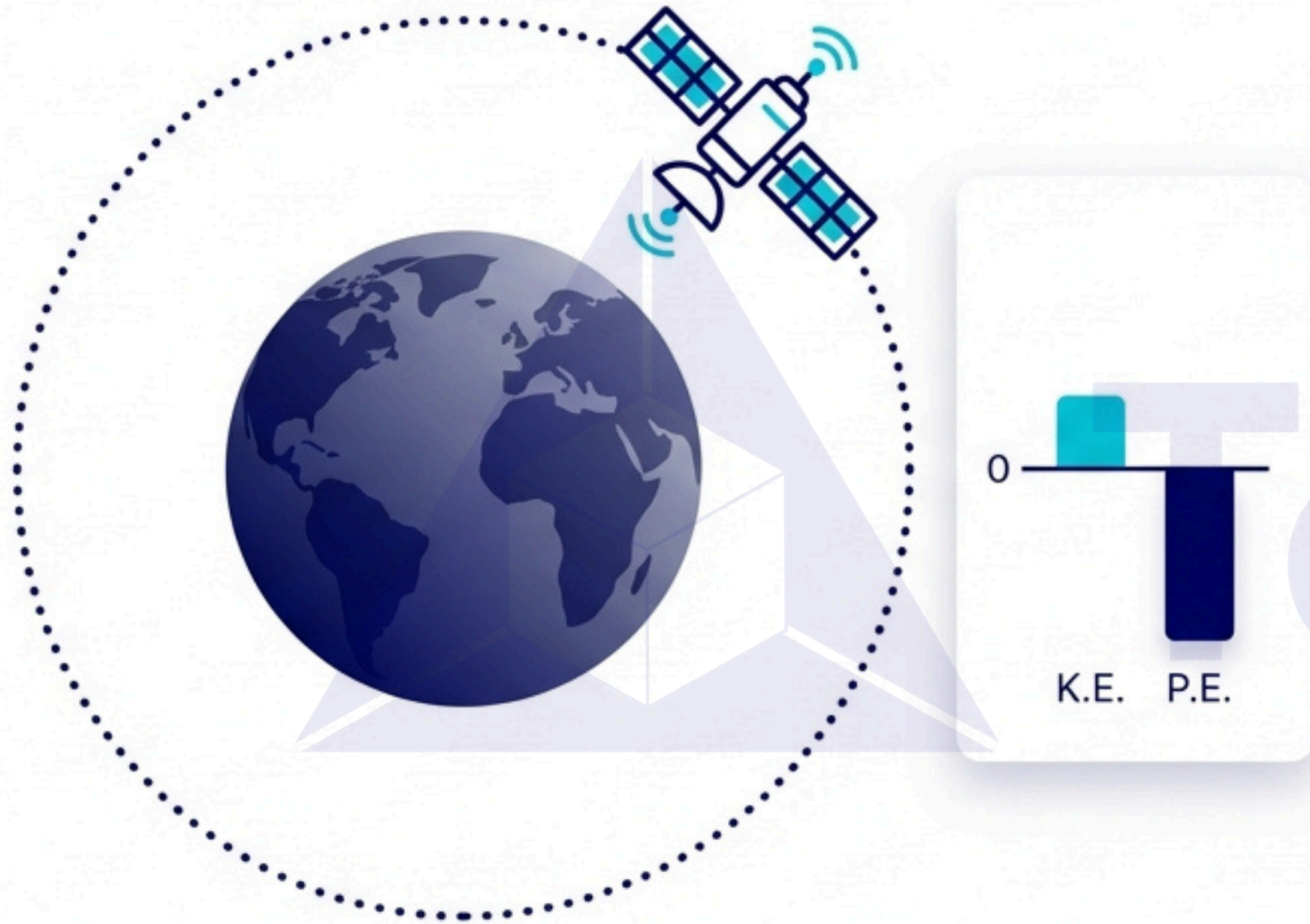
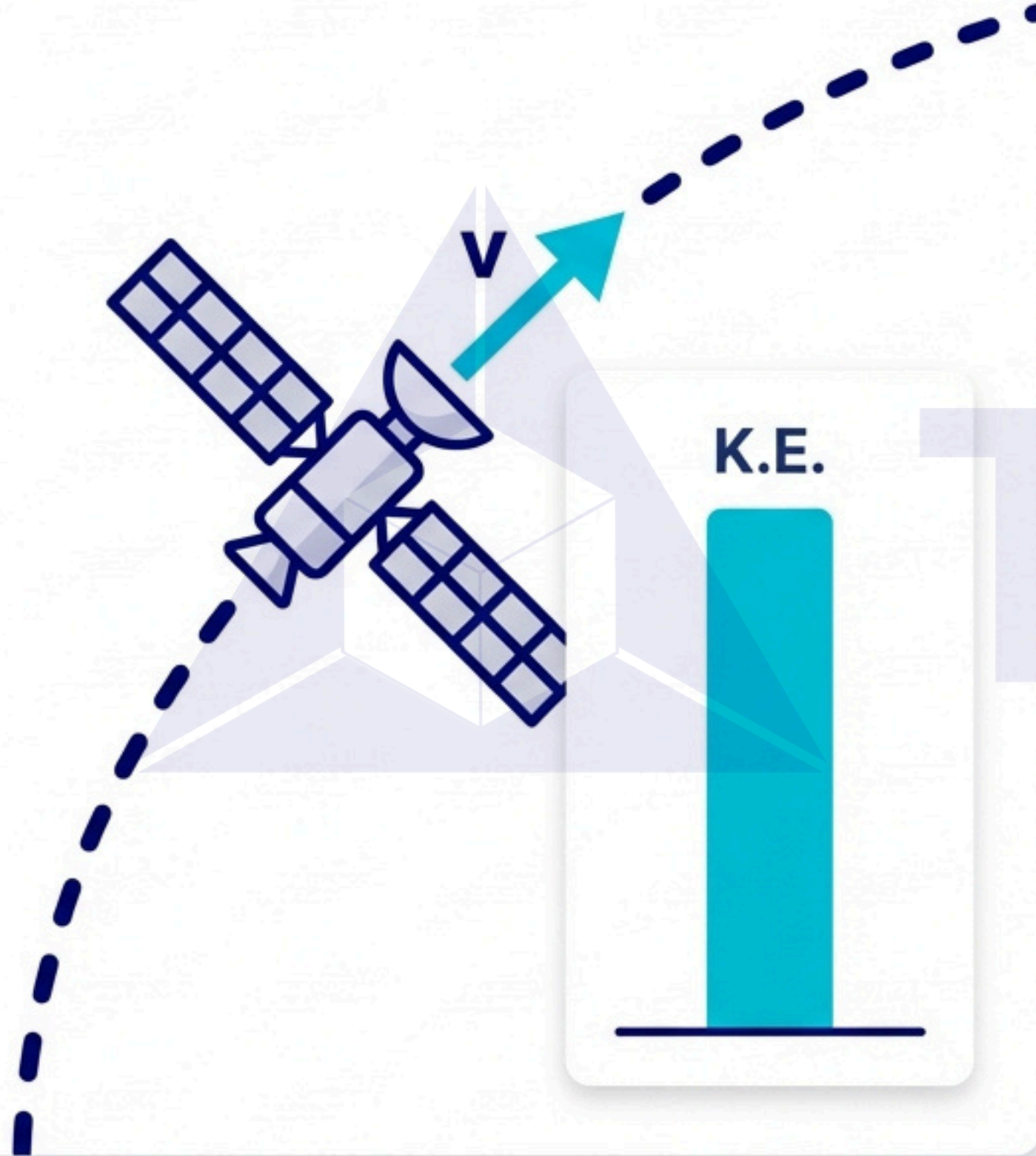




Energy of an Orbiting Satellite

Why total energy is negative in a bound orbit.

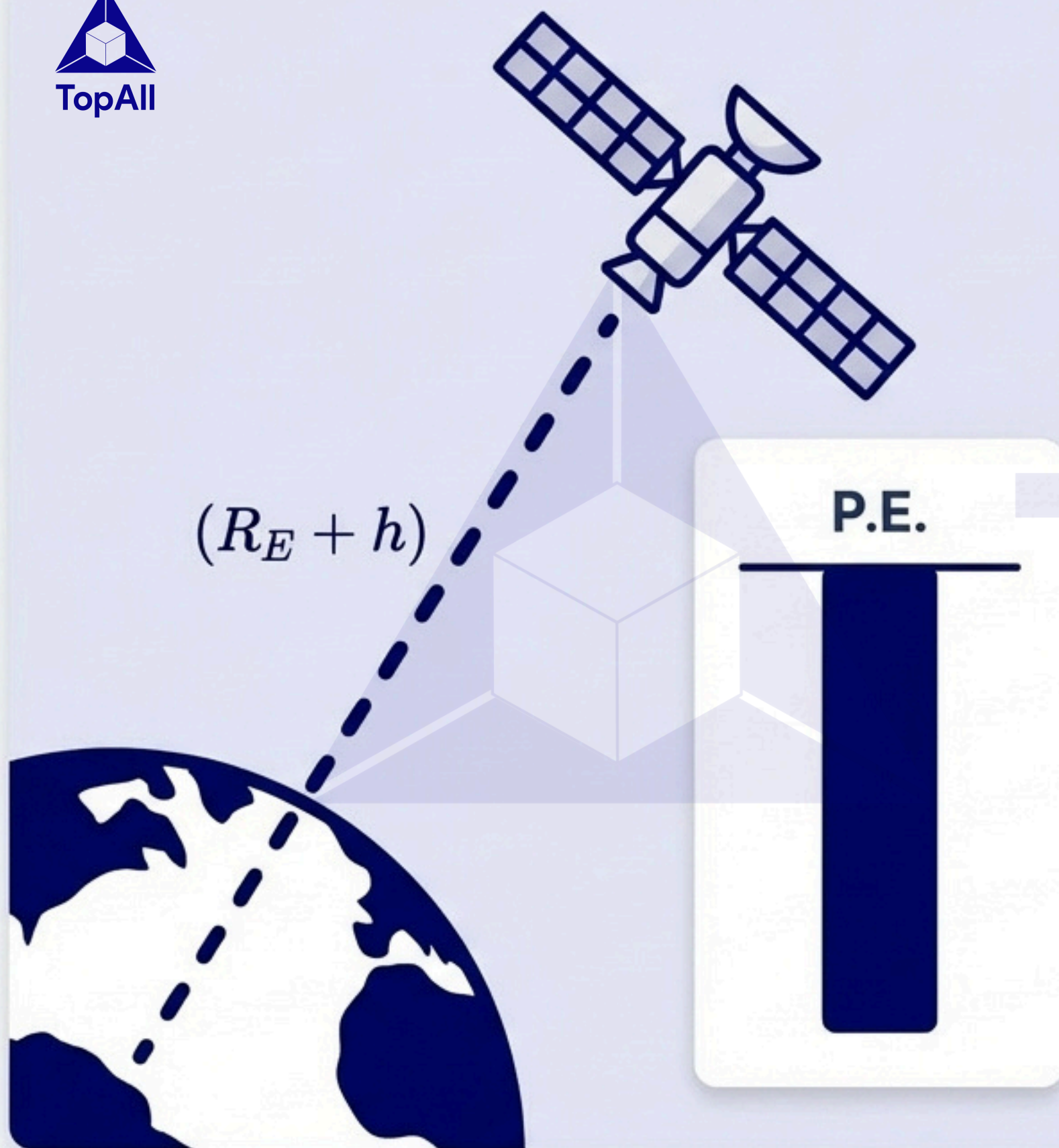


Kinetic Energy (K.E.)

A satellite of mass m orbiting at altitude h (orbital radius $R_E + h$) requires a specific orbital speed v .

$$K.E. = \frac{1}{2}mv^2 = \frac{GmM_E}{2(R_E + h)}$$

Notice that Kinetic Energy is inherently a positive value. It represents the satellite's active motion.



Gravitational Potential Energy (P.E.)

Assuming potential energy at infinity is zero, the energy at a finite distance is the work done by the gravitational field.

$$P.E. = -\frac{GmM_E}{R_E + h}$$

Watch the sign. P.E. is always negative for a mass in Earth's gravitational field, and its magnitude is exactly twice that of the K.E.



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Key Highlights

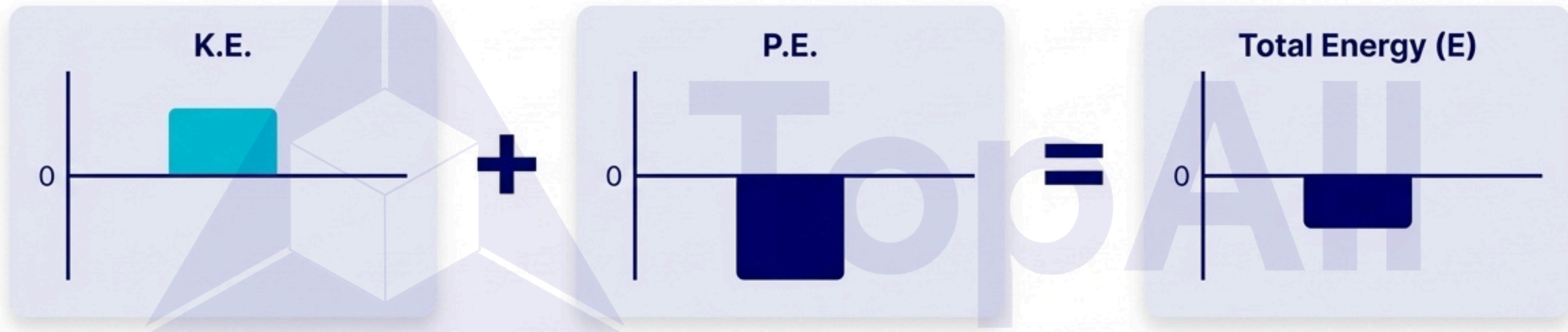
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Total Energy ($E = K.E. + P.E.$)

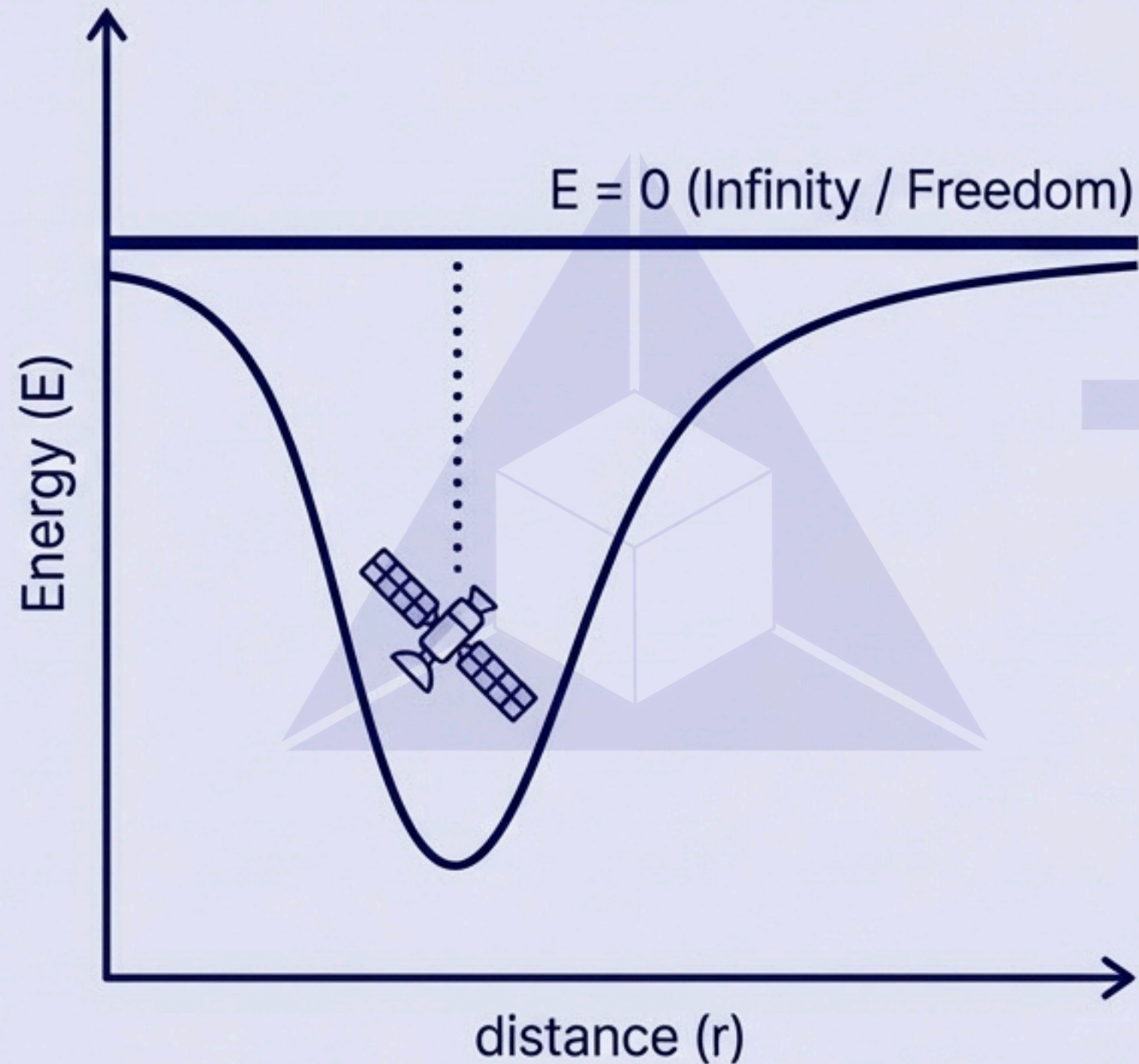
When we add the positive kinetic energy to the larger negative potential energy, the net result remains negative.

The Math Becomes Visual



$$E = \frac{G m M_E}{2(R_E + h)} - \frac{G m M_E}{R_E + h} = - \frac{G m M_E}{2(R_E + h)}$$

Gravity Well



The Meaning of a Bound Orbit

If total energy (E) is negative, the satellite is trapped in Earth's gravitational well. It is a bound system.

- To escape Earth entirely ($r \rightarrow \infty$), the satellite needs $E \geq 0$.
- Because E is currently negative, it does not have enough energy to fly away. It must stay in orbit.

Orbiting Satellite Energy Summary

Kinetic Energy (K.E.)



Sign: Positive (+)

Formula: $+ (GmM_E) / 2r$

Meaning: Energy of orbital motion.

Potential Energy (P.E.)



Sign: Negative (-)

Formula: $- (GmM_E) / r$

Meaning: Energy of position in gravity field.

Total Energy (E)



Sign: Negative (-)

Formula: $- (GmM_E) / 2r$

Meaning: Satellite is bound to Earth.

(Note: $r = R_E + h$)

Exam Tip: $E = -K.E.$ and $E = P.E. / 2$



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