Kinetic and Potential Energy Cheat Sheet

AP Physics 1 · Unit 3 · g = 9.8 m/s² · air resistance neglected

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KINETIC ENERGY

- $K = \frac{1}{2}mv^2$, in joules: 1 J = 1 kg·m²/s².
- A scalar that is never negative. Direction does not change it.
- Twice the speed gives 4 times K. Twice the mass gives 2 times K.
- Speed from K: $v = \sqrt{(2K/m)}$.
- K depends on the observer's reference frame.

GRAVITATIONAL POTENTIAL ENERGY

- $\Delta U_g = mg\Delta y$, with up positive. $U_g = mgy$ above a zero level you choose.
- It belongs to the object-Earth system, not to the object alone.
- The zero level changes U_g but never ΔU_g. Below the zero level, U_g is negative.
- Only the vertical change counts. The path does not matter.

SPRING POTENTIAL ENERGY

- $U_s = \frac{1}{2}k(\Delta x)^2$, with Δx measured from the natural length.
- A stretch and a compression of the same size store the same energy.
- Twice the stretch gives 4 times U_s.
- Hooke's law: $F_s = -k\Delta x$. The area under a graph of holding force against Δx equals U_s.

FAR FROM EARTH

- $U_G = -Gm_1m_2/r$, with r between centers and $G = 6.67 \times 10^{-11}$ N·m²/kg².
- Zero at infinite separation and negative everywhere else. It rises toward 0 as r grows.
- Use $mg\Delta y$ only when Δy is small compared with the planet's radius.
- For more than two objects, add U_G for every pair.

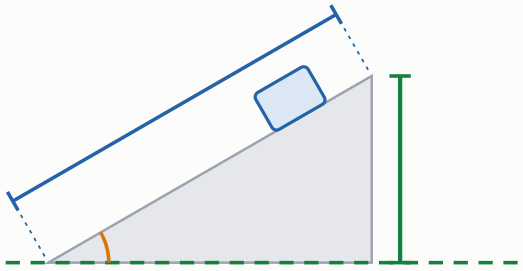
ENERGY BAR CHARTS

1. Name the system. Potential energy needs two interacting objects inside it.
2. Choose the zero level for U_g and say where it is.
3. Draw one bar per energy type at each moment, on one scale. With no friction and no outside work, every chart has the same total.

KINETIC AND POTENTIAL ENERGY TOGETHER

- No friction and no outside work: $K_i + U_i = K_f + U_f$.
- Dropped from rest through h: $v = \sqrt{(2gh)}$. The mass cancels.
- Starting at v_0 and dropping h: $v = \sqrt{(v_0^2 + 2gh)}$, for any launch direction.
- Rising h: $v = \sqrt{(v_0^2 - 2gh)}$. If $v_0^2 < 2gh$, it never gets there.

INCLINES



	Block, released from rest
I	Height h, used in mgh
⟷	Length of the slope, d = h / sin θ
◜	Ramp angle θ
- -	Zero level for U_g

- Frictionless: $v = \sqrt{(2gh)}$ at the bottom for every angle. A steeper ramp only takes less time.
- Use the height $h = d \sin \theta$ in mgh, not the slope length d.
- Kinetic friction: $\Delta E_{th} = \mu_k mg \cos \theta \cdot d$, and K at the bottom = $mgh - \Delta E_{th}$.

SPEED AFTER A DROP FROM REST

h (m)	0.50	1.0	2.0	5.0	10	20
v (m/s)	3.13	4.43	6.26	9.90	14.0	19.8

$v = \sqrt{(2gh)}$. Four times the height gives twice the speed.

FIVE CHECKS BEFORE YOU HAND IT IN

1. Is the speed squared in $\frac{1}{2}mv^2$?
2. Is h the vertical height, not the distance along a ramp?
3. Is Δx measured from the spring's natural length?
4. Is gravity counted once, as U_g or as work, not both?
5. Is every kinetic energy zero or positive?