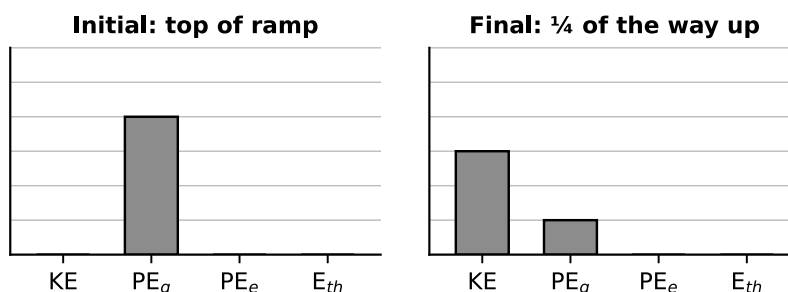


Part A: Energy Changes Form

Ignore friction and air resistance on this worksheet. Use $g = 9.8 \text{ m/s}^2$.

- Nia swings on a playground swing. Describe the energy at each point using KE and PE_g .
 - at the highest point of the swing, where she stops for an instant
 - at the lowest point of the swing
 - halfway between them
 - Is her total mechanical energy bigger at any of these points? Explain.
 - All PE_g and zero KE (she is momentarily at rest at maximum height).
 - Maximum KE and minimum PE_g (zero if the low point is the reference level).
 - Some of each: $KE + PE_g$ adds up to the same total.
 - No.** With no friction the system is closed, so TME is the same at every point. Energy only changes form.
- A skateboarder starts from rest at the top of a ramp. The initial energy bar chart is shown. Complete the final bar chart for the moment she reaches a point one quarter of the way up from the bottom ($h = 0$ at the bottom). Explain how you chose the bar heights.



Final: $PE_g = 1$ unit (one quarter of the height), **$KE = 3$ units**, $PE_e = 0$, $E_{th} = 0$.

PE_g is proportional to height, so $\frac{1}{4}$ of the height leaves $\frac{1}{4}$ of the 4 units. With no friction, the total must still be 4 units, so the other 3 units are KE .

Part B: Using Conservation of Energy

Pick initial and final points, write $TME_i = TME_f$, cross out zero terms, and solve.

- Ethan's phone slips off a balcony railing 4.9 m above the ground. How fast is it moving just before it lands?

Set up: initial: at rest at $h = 4.9 \text{ m}$. Final: at the ground, $h = 0$

Conservation: $PE_{gi} = KE_f$: $mgh = \frac{1}{2}mv^2$, so mass cancels and $v = \sqrt{2gh}$

Substitute: $v = \sqrt{2 \times 9.8 \text{ m/s}^2 \times 4.9 \text{ m}} = \sqrt{96.04 \text{ m}^2/\text{s}^2}$

Answer: **$v = 9.8 \text{ m/s}$** (downward). The mass of the phone is not needed.

4. Gabi tosses her keys straight up at 4.2 m/s. How high above her hand do they rise?

Set up: initial: at her hand, $h = 0$, $v = 4.2$ m/s. Final: top, $v = 0$

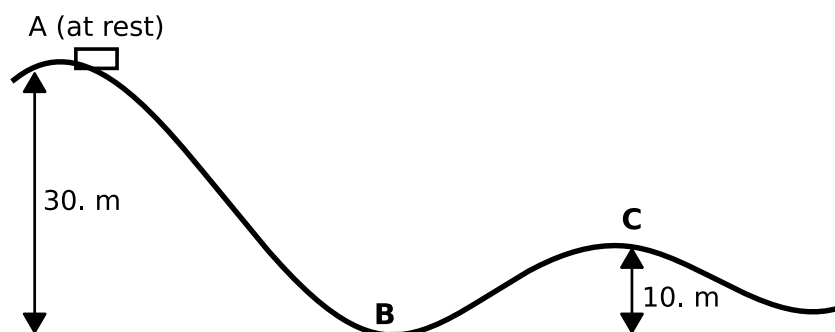
Conservation: $KE_i = PE_{gf}$: $\frac{1}{2}mv^2 = mgh$, so $h = v^2/(2g)$

Substitute: $h = (4.2 \text{ m/s})^2 / (2 \times 9.8 \text{ m/s}^2) = 17.64 / 19.6 \text{ m}$

Answer: $h = 0.90 \text{ m}$

Part C: Multi-Step Problems

5. A 600. kg roller coaster car starts from rest at point A and rolls along the track shown.



- a. Find the car's total mechanical energy at point A ($h = 0$ at the ground).

- b. How fast is the car moving at point B, the bottom of the track?

- c. How fast is the car moving at point C, the top of the 10. m hill?

a. At rest, so $TME = PE_g = mgh = (600. \text{ kg})(9.8 \text{ m/s}^2)(30. \text{ m}) = 176,400 \text{ J} \approx \mathbf{1.8 \times 10^5 \text{ J}}$

b. $mgh_A = \frac{1}{2}mv_B^2$, so $v_B = \sqrt{2gh} = \sqrt{2 \times 9.8 \text{ m/s}^2 \times 30. \text{ m}} = \sqrt{588 \text{ m}^2/\text{s}^2} = 24.2 \text{ m/s} \approx \mathbf{24 \text{ m/s}}$

c. $mgh_A = \frac{1}{2}mv_C^2 + mgh_C$, so $v_C = \sqrt{2g(h_A - h_C)} = \sqrt{2 \times 9.8 \text{ m/s}^2 \times 20. \text{ m}} = \sqrt{392 \text{ m}^2/\text{s}^2} = 19.8 \text{ m/s} \approx \mathbf{20. \text{ m/s}}$

The mass cancels in parts b and c; only the drop in height matters.

6. A toy launcher has a spring with $k = 500. \text{ N/m}$. It is squeezed 0.10 m and launches a 0.20 kg ball along a level floor. The ball then rolls up a ramp.

- a. How much elastic potential energy is stored in the squeezed spring?

- b. How fast is the ball moving on the level floor after it leaves the spring?

- c. How high up the ramp does the ball roll before it stops?

a. $PE_e = \frac{1}{2}kx^2 = \frac{1}{2}(500. \text{ N/m})(0.10 \text{ m})^2 = \mathbf{2.5 \text{ J}}$

b. $PE_{ei} = KE_f$, so $v = \sqrt{2KE/m} = \sqrt{2 \times 2.5 \text{ J} / 0.20 \text{ kg}} = \sqrt{25 \text{ m}^2/\text{s}^2} = \mathbf{5.0 \text{ m/s}}$

c. $PE_{ei} = PE_{gf}$, so $h = PE_e/(mg) = 2.5 \text{ J} / [(0.20 \text{ kg})(9.8 \text{ m/s}^2)] = 2.5 \text{ J} / 1.96 \text{ N} = 1.28 \text{ m} \approx \mathbf{1.3 \text{ m}}$