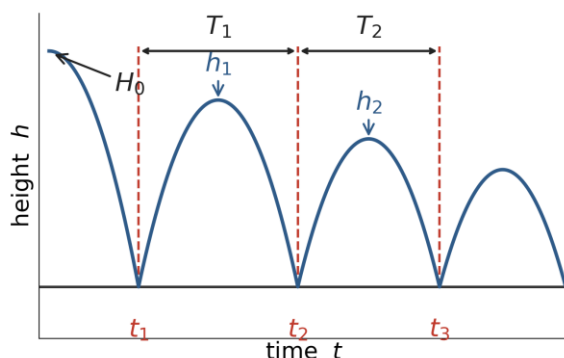


Characterizing Collisions — Self-Check • INSTRUCTOR KEY

Model answers shown in **red**. Worked with $g = 9.81 \text{ m/s}^2$ and the example data of Part 3.

1. Formulas

Flight interval: $T_n = t_{n+1} - t_n$	Rebound speed: $w_n = \frac{1}{2} g T_n$
Peak height: $h_n = \frac{1}{8} g T_n^2$	COR from flight times: $e_n = \frac{T_n}{T_{n-1}}$
COR from rebound heights: $e_n = \sqrt{\frac{h_n}{h_{n-1}}}$	Fraction of energy lost: $1 - e^2$



2. Calculations

Given: $t_1 = 0.45 \text{ s}$, $t_2 = 1.25 \text{ s}$, $t_3 = 1.97 \text{ s}$

(a) $T_1 = 1.25 - 0.45 = \mathbf{0.80 \text{ s}}$ $T_2 = 1.97 - 1.25 = \mathbf{0.72 \text{ s}}$

(b) $e = \frac{T_2}{T_1} = \frac{0.72}{0.80} = \mathbf{0.90}$

(c) $w_1 = \frac{1}{2} (9.81)(0.80) = \mathbf{3.92 \text{ m/s}}$

(d) $h_1 = \frac{1}{8} (9.81)(0.80)^2 = \mathbf{0.785 \text{ m}}$

(e) $1 - e^2 = 1 - (0.90)^2 = 0.19 = \mathbf{19\%}$

(f) $e = e^{-0.105} = \mathbf{0.90}$ (same e as part b — a good consistency check)

3. Explanations (model answers)

(a) Why is the peak at the midpoint of a flight interval?

Gravity has the same constant magnitude on the way up and on the way down, so the time to rise equals the time to fall. The ball therefore reaches its highest point at the midpoint of the interval, $t = \frac{T_n}{2}$.

(b) Why is the log-plot slope a more reliable value of e than one pair of times?

The slope is fit to all of the bounces at once, so random timing error in any single bounce is averaged out. A value from just one pair of times depends entirely on the error in those two measurements, so it is far noisier.

Challenge. What would a flat (zero-slope) $\ln T_n$ vs. n graph mean?

A flat line means $\ln T_n$ — and therefore T_n — is constant. Then $e = \frac{T_n}{T_{n-1}} = 1$: no energy is lost and the collisions are perfectly elastic; the ball would bounce forever to the same height.