

Coaster Designer

Mission: The park wants a coaster with three hills and no motor after the first hill. Design hill heights so the car makes it all the way, with and without friction.

Big question: How does energy decide whether a coaster can make it over a hill?

★ Warm-up: Real-world riddle

Answer with energy words.

Why is the first hill of a coaster always the tallest? ✓ **It gives the car all its energy.**

Could a coaster car climb a hill taller than where it started (no motor)? ✓ **No: it doesn't have enough energy.**

Key vocabulary

Potential energy	Stored energy from height.
Kinetic energy	Energy of motion.
Friction	A force that turns motion energy into heat.
Design constraint	A rule your design must follow.

1 Box 1

Break the rule

In the simulator: Make hill 2 TALLER than the start hill and launch.

What happened, and why?

- ☐ The car rolled back: it didn't have enough energy to climb higher than the start ☐ It went faster
☐ It flew off the track

✓ **The car rolled back: it didn't have enough energy to climb higher than the start**

2 Box 2

Add friction

In the simulator: Set hills to 30, 30, 20 with **Some friction** and launch.

Hill 2 was the same height as the start, but the car still didn't make it. Why?

- ☐ Friction turned some energy into heat, so it had less than it started with ☐ The car got heavier ☐ Hill 2 moved

✓ **Friction turned some energy into heat, so it had less than it started with**

3 Box 3

Design a winner

In the simulator: With **Some friction**, design hills so the car makes it all the way.

Describe your winning design (the three heights) and why it works.

Look for: Later hills are lower; Explains with energy or friction; a number from the simulator

4 Box 4

Rank the designs

With friction, sort each design (start / hill 2 / hill 3).

Sort: 40 / 30 / 20 · 30 / 35 / 20 · 35 / 30 / 25 · 25 / 25 / 25 · 40 / 20 / 38

Makes it	Rolls back
40 / 30 / 20 35 / 30 / 25	30 / 35 / 20 25 / 25 / 25 40 / 20 / 38

5 Box 5

Legend: energy math Legend only

A 500 kg car starts at 40 m ($PE = m \times 9.8 \times h$). What is its PE at the top in joules?

Answer: _____ | ✓ 196000

Show your thinking:

6 Box 6

Design memo (CER)

What rule should the park follow when designing hills?

Claim

Look for: States the design rule; at least 6 words

Evidence

Look for: Uses test results; a number from the simulator; at least 12 words

Reasoning

Look for: Explains using energy; Accounts for friction; at least 12 words

Exit ticket: answer the big question in your own words

How does energy decide whether a coaster can make it over a hill?

Look for: A coaster car's total energy comes from the height of the first hill. It can only climb a hill if it has enough energy to reach that height. Friction turns some energy into heat, so later hills must be lower than the first one by a safe margin.

Completion codes

Students see a code like **ABC-I3** when they finish. The first part must match below. The letter is the level (E = Explorer, I = Investigator, L = Legend), and the number at the end is how many stars they earned.

Level	Code starts with
 Explorer	ZLG-E

 Investigator

36Y-I

 Legend

1FJ-L

 Watch for these misconceptions

- "Cold moves into things." Heat moves; objects feel cold because heat leaves your hand.
- "Only moving things have energy." Stored (potential) energy counts too.
- "Radiation needs air to travel." Radiation crosses empty space, which is how sunlight reaches Earth.