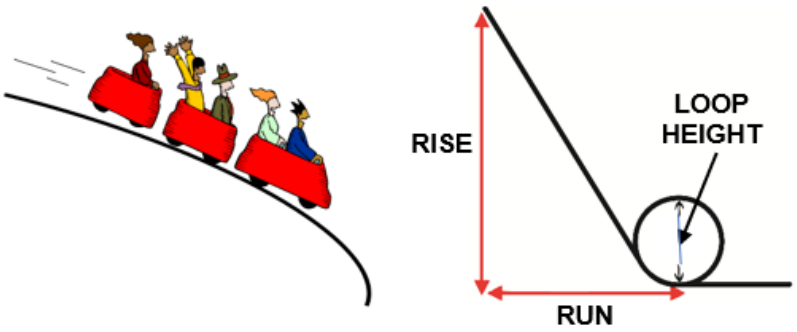
ROLLER COASTER MATH

Learn and apply math by designing a roller coaster



Curriculum topics

- Energy
- Friction
- Motion
- Momentum
- Simple Machines

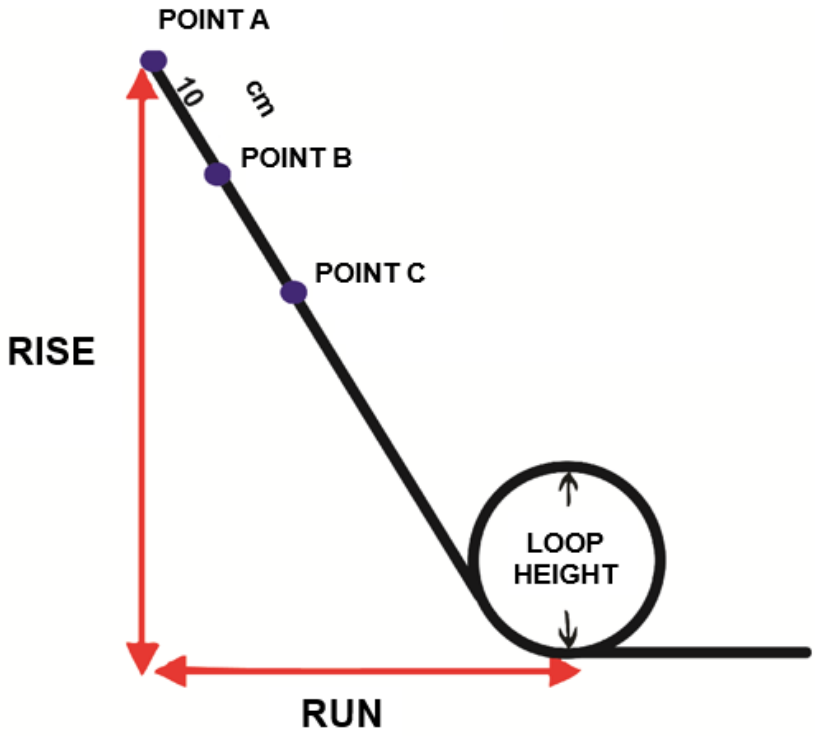
Subjects

- Engineering
- Mathematics
- Physical Science

Grade range: 6 – 8

Who we are: Resource Area for Teaching (RAFT) helps transform the learning experience by inspiring joy through hands-on learning.

What does math have to do with thrilling roller coaster rides? How high does a coaster need to be to successfully navigate through a loop and on to the end of the track? How is the speed of the coaster related to the height of the coaster's starting position? Answer these questions and more with this simple roller coaster investigation!



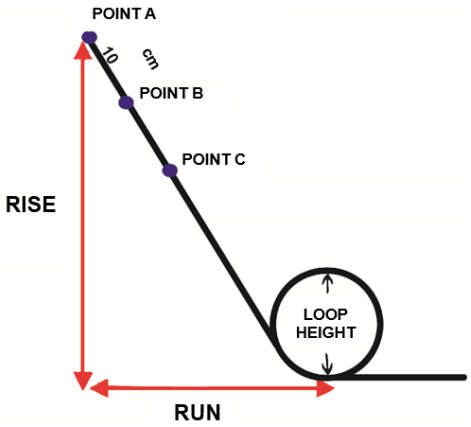
Share Your feedback!
http://bit.ly/RAFTkitsurvey

Materials

Materials in the kit may vary but generally, this kit contains the following:

- Marble or equal (1)
- Foam pipe insulation, 6'-8' (1)
- Stopwatch/timer (1)
- Measuring tape (1)
- Recording sheet (1)
- Not included: Calculator, tape

To Do and Notice



1 Measure and record the length of the foam insulation (L) in cm in the Roller Coaster Data Sheet. Tape one end of the foam insulation to the top edge of a table/chair or wall (U-channel faces up) (see below).

2 Configure the rest of the track, going toward the floor, with one vertical loop. Release the marble from the top of the track. Adjust the track as needed until the marble successfully reaches the end of the track. This may take several attempts.

3 Tape the underside of the loop to secure it in place. Avoid putting tape on the inside of the U-channel as it might block the path of the marble. Add other objects for track support as needed.

4 Measure and record the rise and the run (shown above right) in cm in the Roller Coaster Data Sheet (page 4). Compute and enter the track slope, refer to the length conversions box if needed.

5 Starting at the top of the track (**Point A**), conduct 3 trials. For each trial:

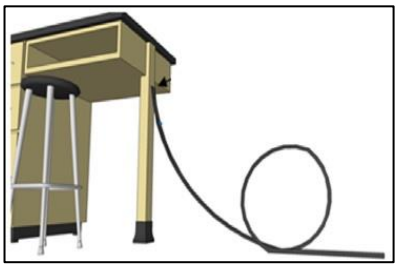
a. Measure and record the travel time (seconds) needed for the marble to complete the track. Start the timer when the marble is released; stop the timer when the marble exits the track.
b. Calculate the marble speed for each trial in cm/sec (see Data Sheet).
c. Calculate the average speed (add the 3 average speeds and then divide by 3).

6 Pick a new starting point, **Point B**, 10 cm from Point A. Calculate the new travel distance in the data sheet (new distance = L – 10 cm). Repeat step 5 for this new starting point.

7 Pick a third starting point, **Point C**, below Point B. Calculate and record the new travel distance for this point (L minus distance from Point A to Point C). If the marble does not make it around the loop, choose a slightly higher starting point and repeat the trials and calculations for Point C.

8 Observations: How did the slope of the roller coaster affect the speed of the marble? What differences in speed did you notice based on the starting points? What conclusions can you draw based on the data?

9 **Share** student learning with RAFT! Submit photos/video via email at education@raft.net or on social media (Facebook, Twitter, Instagram).



Core Content Skills:

Science & Engineering (NGSS)

Developing and Using Models, Planning and Conducting Investigations, Defining and Delimiting Engineering Problems, Developing Possible Solutions, Optimizing the Design Solution, Analyzing and Interpreting Data, Forces and Motion, Definitions of Energy

CCSS Mathematics

Ratios and Proportions, Expressions and Equations

Social Emotional Learning

- Self-awareness
- Self-management
- Responsible decision-making

The Content Behind the Activity

This project provides hands-on experience with several mathematical and physical concepts related to roller coasters. The roller coaster starts with an initial drop, usually a very high hill, so the coaster gains enough speed (and momentum) to keep itself on the track and to successfully navigate loops. The coaster reaches its greatest speed at the bottom of the track.

A roller coaster's **potential energy** (PE) is the energy that the coaster has at the top of the track (above the ground). The PE is converted into **kinetic energy** (KE, energy of motion) as the coaster goes downhill, "falling" towards the Earth's surface. As it moves closer to the ground, the roller coaster is also accelerating due to Earth's gravity, which is why its PE is often called **gravitational** potential energy.

The equation for calculating an object's gravitational PE is:

PE = mgh = mass of object x acceleration due to gravity x height above the ground

The equation for calculating an object's kinetic energy (KE) is:

$$\mathbf{KE = \tfrac{1}{2}mv^2} = \tfrac{1}{2} \times \text{mass of the object} \times (\text{velocity of object})^2$$

Velocity includes both the speed of an object (change in position over time) and the direction in which it is moving. **Acceleration** is the rate of change of velocity and occurs when either or both the object's speed and direction change. **Mass** is a measure of the amount of matter contained in an object. The average acceleration due to gravity (**g**) on Earth is 9.81 meters/second/second, or **9.8 m/s^2**.

Reuse

This kit uses 100% reusable materials designed for other uses. To continue making a positive impact in reducing waste, reuse these materials in other projects. Additionally, any unused materials can be collected and delivered back to RAFT.

Feedback

Please comment on this kit by taking this short survey: http://bit.ly/RAFTkitsurvey. Let us know of any material concerns (missing, broken, or poorly fitting parts) as well as any suggestions for improvement.

Visit https://raft.net to view related activities!

Marble Rollercoaster
Scaling the "g's"
Slipery Slopes
Slope on a Rope

Resources

- Interactive roller coaster lab - https://bit.ly/3biSERT
- Physics of roller coasters - https://bit.ly/34xdiee

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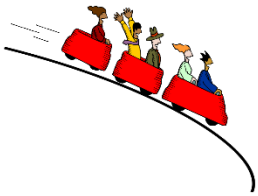
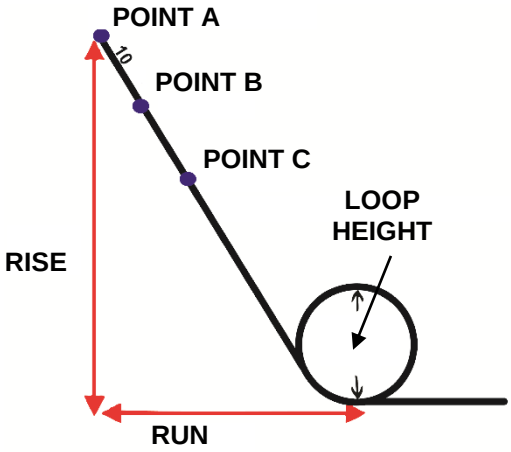
RESOURCE AREA FOR TEACHING

Length conversions:
1 ft = 12 in
1 in = 2.54 cm
1 ft x 12 in/ft x 2.54 cm/in ≈ 30.5 cm

Roller Coaster Math Data Sheet





Track length (L) = _____ft = _____in = _____cm

Track height (rise) = _____cm

Horizontal distance (run) = _____cm

Slope = Rise / Run = _____(cm) / _____(cm) = _____

Starting Point	Distance from top	Travel Distance	Trial	Travel Time (sec)	Marble Speed (cm/sec)
Point A	0 cm	L = _____cm	**1**		
			2		
			3		
Average Speed (A)	Add speeds from all three trials, then divide by 3				
Point B	10 cm	L – 10 cm = _____cm	**1**		
			2		
			3		
Average Speed (B)	Add speeds from all three trials, then divide by 3				
Point C	_____cm	L - _____cm = _____cm	**1**		
			2		
			3		
Average Speed (C)	Add speeds from all three trials, then divide by 3				