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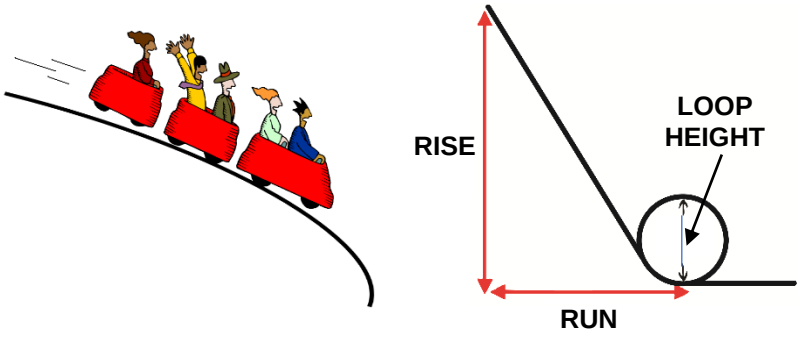
RESOURCE AREA FOR TEACHING

ROLLER COASTER MATH

Study math by designing a roller coaster!



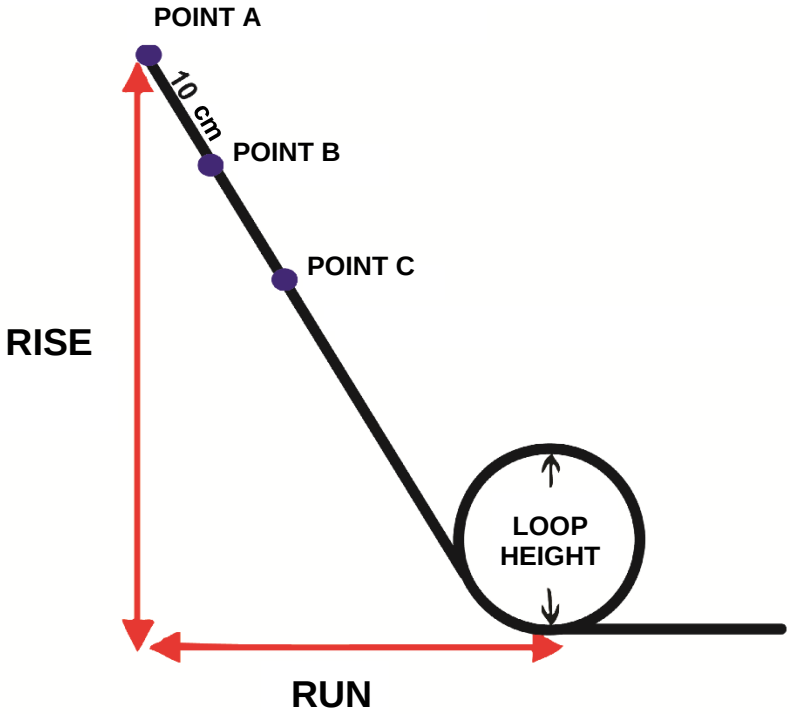
Curriculum topics:

- Velocity and Speed
- Slope
- Rates
- Ratios
- Algebraic Formulas
- Roller Coasters

Subject:
Mathematics, Physical Science

Grade range: 6 – 12

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?



Who we are:

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

For more ideas visit
https://raft.net

Materials required per student or group

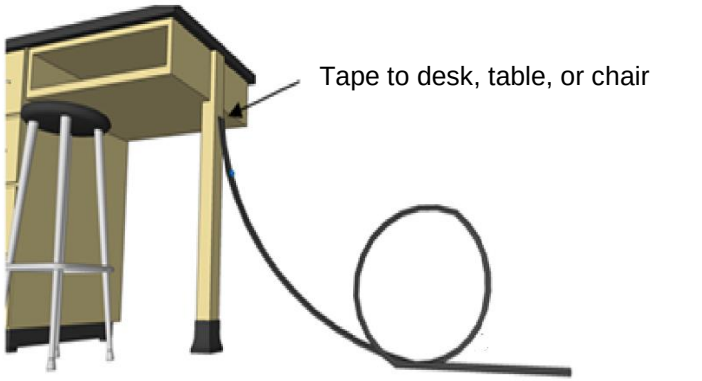
- Marble or equivalent (x1)
- Foam pipe insulation, 6-8 ft length (x1)
- Stopwatch or equivalent
- Measuring tape
- Calculator (not included)
- Tape (not included)
- Recording Sheet (x1)

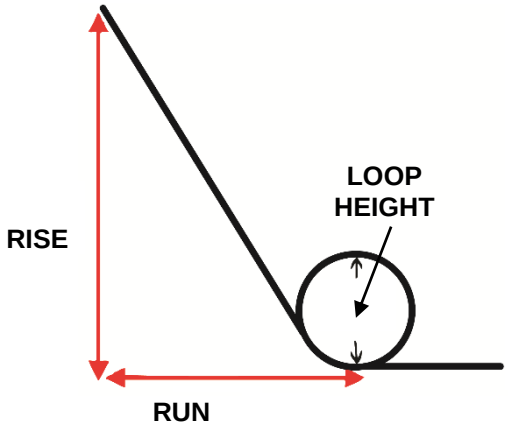
Set Up

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 or chair so the U-channel faces up.

2. Configure the rest of the track, going toward the floor, with one vertical loop (see below). Release the marble at 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.





To do and notice

1. 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.

2. 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).

3. 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 2 for this new starting point.

4. 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.

5. Observations: How did the slope of the roller coaster affects 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?

Content Standards:

NGSS

Kinetic & Potential Energy:
MS-PS3-2
MS-PS3-5

Engineering:
3-5-ETS1-3
MS-ETS1-2
MS-ETS1-4

CCSS MATH

Ratios & Proportions:
6.RP.A.2.B
6.RP.A.2.D

Expressions and Equations:
6.EE.C.9

The science behind the activity

This activity gives students hands-on experience with several mathematical and physical concepts in the development of a safe roller coaster. 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.

Students gain experience collecting data on then performing calculations to determine the average speed for each trial/test using the roller coaster. The progression of construction, testing, observation, and evaluation reinforces the integration of math and science in this real-world roller coaster challenge.

A roller coaster's **potential energy** (PE) is the energy that the coaster has at the top of the track. 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 potential energy (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: **KE = ½mv^2** = ½ x mass of the object x (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 or direction change. Mass is the amount of matter contained in an object. The average acceleration due to gravity on Earth is 9.81 meters/second/second, or 9.8 m/s^2.

Learn more

- Create a longer track out of similar or different materials.
- Test heavier marble-like objects on the track and compare findings.
- Research older roller coasters made primarily out of wood, and newer types made from steel and other materials.

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

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

Resources

- Interactive roller coaster lab - https://bit.ly/3biSERT
- YouTube video (3:38), Physics of roller coasters - https://bit.ly/34xdiee

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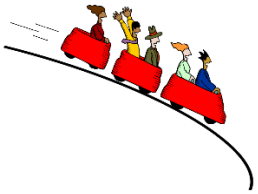
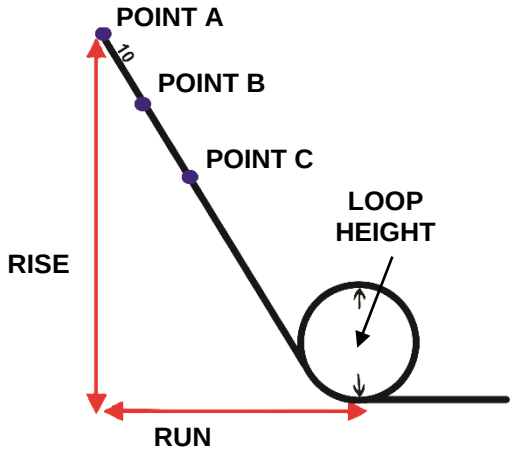
Length conversions:
1 ft = 12 in
1 in = 2.54 cm
1 ft x 12 in/ft x 2.54 cm/in ≈ 30.5 cm

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				