A Frictional Roller Coaster

Constructing from Design

Troy Roller Coaster, Toverland, Netherlands | height = 104 ft | speed = 54 mph | Cost = ????

Do you have any idea of the cost of roller coaster projects?


El Toro
Six Flags Great Adventure, Jackson, NJ
Height: 181 ft
Speed: 70 mph
Length: 4,400 ft
Guess
the cost…


Thunder Dolphin
Tokyo Dome City Attractions, Tokyo, Japan
Height: 260 ft
Speed: 81 mph
Length: 3,497 ft
Guess
the cost…


Millennium Force
Cedar Point Park, Sandusky, OH
Height: 310 ft
Speed: 93 mph
Length: 6,995 ft
Guess
the cost…

Roller coasters are expensive and complex projects…

Have you ever worked a school roller coaster project?

Steel Dragon 2000, Mie Prefecture, Japan | Height = 318 ft | Speed = 95 mph | Cost = $52M


Ideate
Rollercoaster Building
Process [redacted]


Are you ready for a school roller coaster project?
...and to have a lot of fun?

Your Engineering Challenge

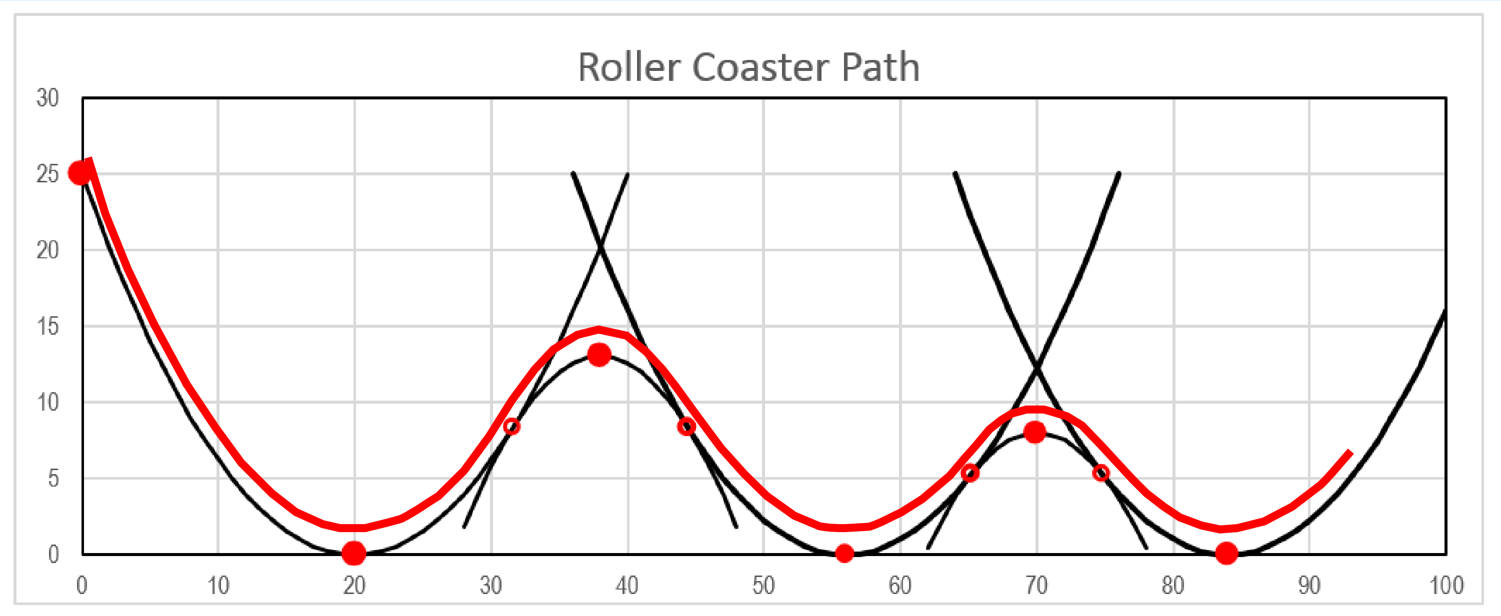
Project requirements and constraints:

- Work as real-world professional engineers do—from design to final product
- Use the physics you learned in the previous lesson, *A Tale of Friction*
- Define your roller coaster's path as a differentiable function
- Do the necessary calculations to prove that your coaster *is going to work*, before building it

Are you ready for all this fun?

Project Guidelines

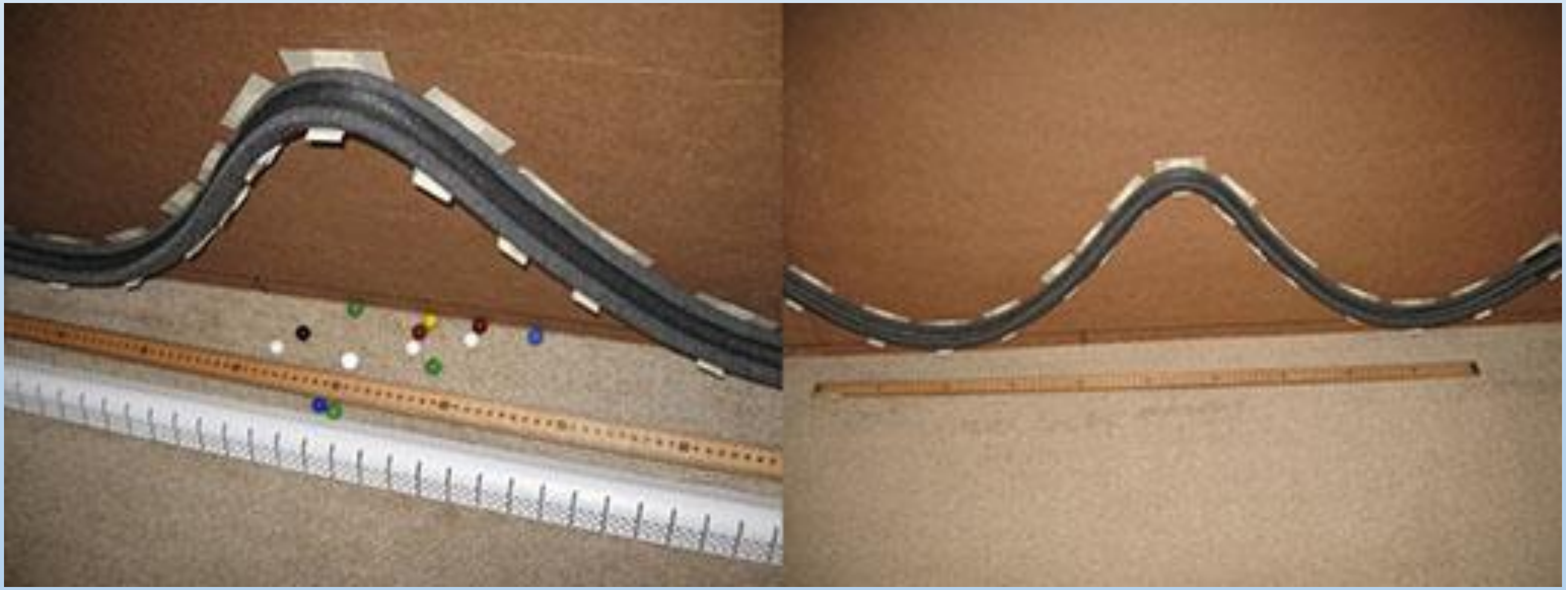
- Work in teams of 3 or 4 members
- Design your coaster's path using at least 5 differentiable functions; to simplify the calculations, use parabolas



- The piecewise function produced must be differentiable

Project Guidelines

- Your design dimensions must be appropriate to the flexibility of the material you use to build the model: foam pipe insulation
- 1.5-in external diameter pipe insulation material is suggested
- That means, no very sharp curves or loops



- Mount the roller coaster on a big enough flat surface; a 3 x 4-ft cardboard sheet is recommended

Project Guidelines

- **Use this formula**

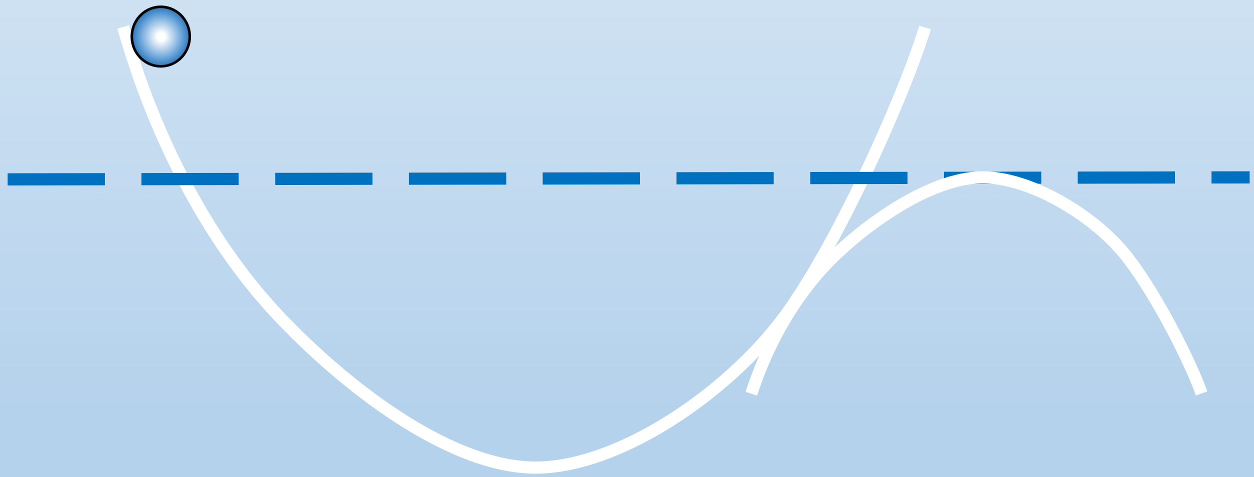
$$v_f = \sqrt{v_i^2 - 2g \cdot (f(x_f) - f(x_i)) - \frac{4}{7} \cdot g \cdot |f(x_f) - f(x_i)|}$$

to determine the maximum height the marble will reach after rolling from a high point on the upward-opening parabolas

(The velocity of the marble at this maximum height is zero)

Project Guidelines

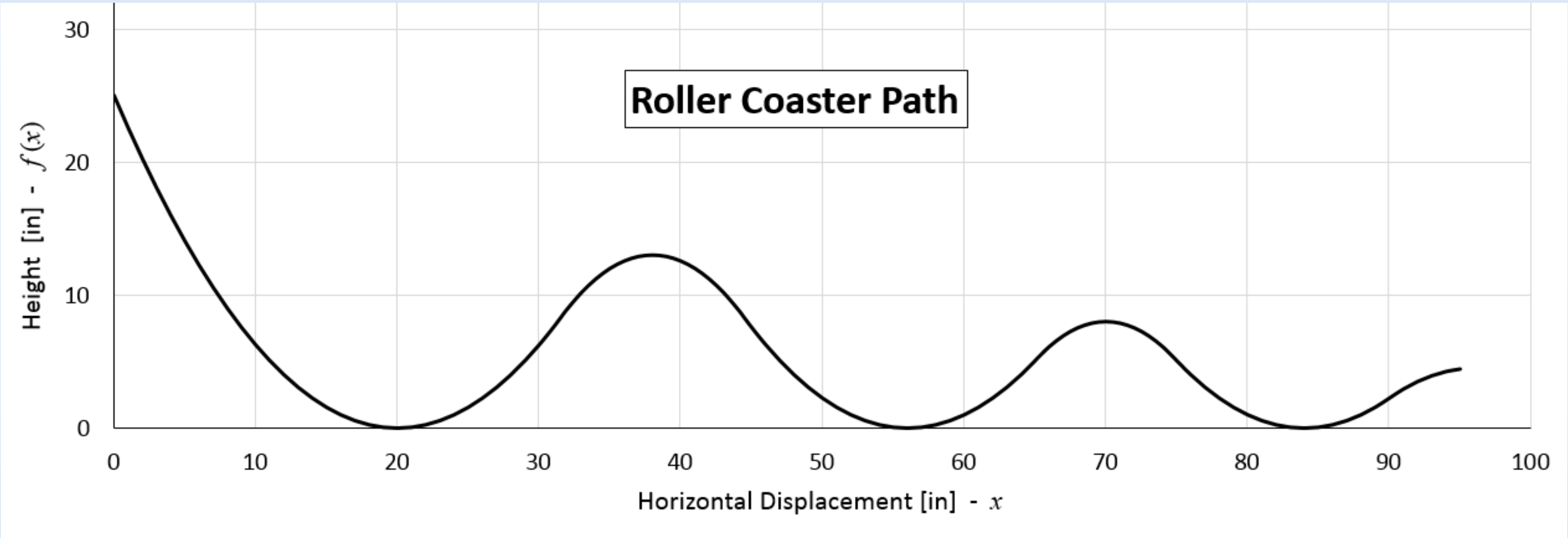
- **Use the height the marble reaches at the end of an upward-opening parabola to determine the height of the vertex for the next downward-opening parabola**



- **At path beginning, the initial marble velocity must be zero**
- **At path end, the final velocity must also be zero (or almost)**

Project Guidelines

- **Use Excel to make the required computations and produce a graph of the designed path**



- **Use the velocity formula to test the functionality of the entire designed path; the velocity must be greater than zero at every point on the path, except at the ends**

Project Guidelines

- **Find the piecewise function for the designed path**

$$f(x)=\begin{cases} \frac{1}{16}\cdot(x-20)^2 & 0\le x<\frac{284}{9} \\ 13-\frac{13}{116}\cdot(x-38)^2 & \frac{284}{9}\le x<\frac{400}{9} \\ \frac{1}{16}\cdot(x-56)^2 & \frac{400}{9}\le x<\frac{456}{7} \\ 8-\frac{2}{17}\cdot(x-70)^2 & \frac{456}{7}\le x<\frac{534}{7} \\ \frac{1}{16}\cdot(x-84)^2 & \frac{534}{7}\le x<90 \\ 5-\frac{5}{64}\cdot(x-96)^2 & 90\le x<96 \end{cases}$$

- **Use points from this function to build your model**

Project Guidelines

- **Test your model. Then make conclusions about your design and your model:**
  - Is it behaving as expected? If not, why?
  - What were the failures?
  - What problems did you have during construction?
  - How did you solve them?

- **Make a class presentation** of your model, design process, computations, construction process, and conclusions
  - Support your presentation with a slide show or video.
  - A standalone presentation earns extra points.
  - See details in rubric handout

Have fun with this real-world engineering challenge project!