

CEIRP design project: roller coaster challenge

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Learning standards:

This exercise was developed for high school physics students and is also suitable for middle school physics students with some modifications. It addresses the following standards:

- Physical science standard: motion and forces
- Science and technology standard: abilities of technological design
- Science and technology standard: understanding about science and technology

Learning objectives for students:

This project was designed with the intention of bringing an engineering design challenge into the classroom. The students are asked to work as if they are part of an engineering design firm. Their project has five different design criteria that must be optimized to win the “contract”. A design rubric is provided to assist in this process. They must also build a working scale model of their design. This project is set up to let the students decide how best to meet the different criteria. A final presentation to the prospective buyer requires the students to explain their design choices and demonstrate their concept using their model. To complete and present their designs the students must master the concepts of forces, momentum, energy and friction. They must also learn to work in groups as they plan, design and construct their model. The final presentation works on their professionalism and communication skills.

Background information:

There is a memo from the company to propose the project to the students which treats them as a design firm. Groups were required to calculate the total energy, work due to friction, potential energy, kinetic energy, velocity, centripetal force, seat force and force factor at critical points along the length of their ride such as the first hill, dips, tops of loops and horizontal curves. A generous timeframe for the project is:

- Introduction (1 class period)
 - pose challenge
 - show materials
- Design (1-2 class periods)
 - weigh design factors
- Construction (10-12 class periods)
- Presentation (2-3 class periods)
 - calculations for design

Ways to limit the time required for this project are:

- set a height limit
- reduce foam board size
- limit total cost of design
- increase group size (2-4)
- use whole tubing (don't cut it in half to make u-shaped track – keep it o-shaped)

Memo: Roller coaster design

To: HS-Design

From: SmileCorp

SmileCorp has built a chain of amusement parks across the country over the last 30 years. In order to remain competitive we are continuously looking for ways to keep the rides and attractions at our parks new and exciting. With this in mind we have decided to build a new roller coaster at our largest and oldest park. We would like you at HS-Design to come up with five design proposals. Each design team should build and test a scale model of their design. A panel from SmileCorp will visit HS-Design to hear a proposal from each design team. The best design will be built and featured at our park. Presentations should include the force factor at critical points along the length of the ride such as the first hill, dips, tops of loops and horizontal curves. Research from our marketing department indicates that the following criteria are crucial to the success of a new ride:

- Thrill factor
- Theme
- Length of ride

However, our funds are not unlimited and we would like to avoid any legal repercussions due to rider injury. Therefore the other criteria that we at SmileCorp consider crucial are:

- Ride safety
- Construction cost

Naturally we will be expecting each design team to address these five criteria in their design process and explain their reasoning in their presentation. Materials to build scale models will be provided by SmileCorp. Outside materials may be incorporated but they must be accepted and the cost to the design approved by a SmileCorp representative or the president of HS-design.

Design Criteria

Thrill factor

- vertical loops
- turns
- hills
- g forces felt by riders

Theme

- creativity
- aesthetics

Length of ride

- ride time
- ride must be at least 30 seconds long

Ride safety

- must prove that ride will not injure riders

Design cost

- list and price all materials used (a price list for materials provided by SmileCorp will be provided)

Design Rubric:

In order to select the best design each team must determine the advantages and disadvantages of each alternative. One way to do this is to use the design rubric provided or design a rubric to arrive at numeric scores for each alternative. Once this has been done the totals for each design can be compared to determine which alternative best meets the criteria.

Design Rubric

Numeric scale – description

1- poor

2- acceptable

3- good

<i>Alternative</i>	Thrill	Theme	Length	Safety	Cost	<i>Total</i>

Materials price list
(based on scale model dimensions)

<u>Material</u>	<u>Price US \$</u>
Tubing/track (u-shaped:cut in half)	100,000/ft
Doweling	50,000/ft
Skewers	30,000/ft
Toothpicks	500/pick
Wire	1,000/inch
Glue stick	500/stick
Elmer's glue	100/ml
Construction paper	500/sheet
Saran wrap	1,000/ft
Aluminum foil	5,000/ft
Pipe cleaners	500/stick