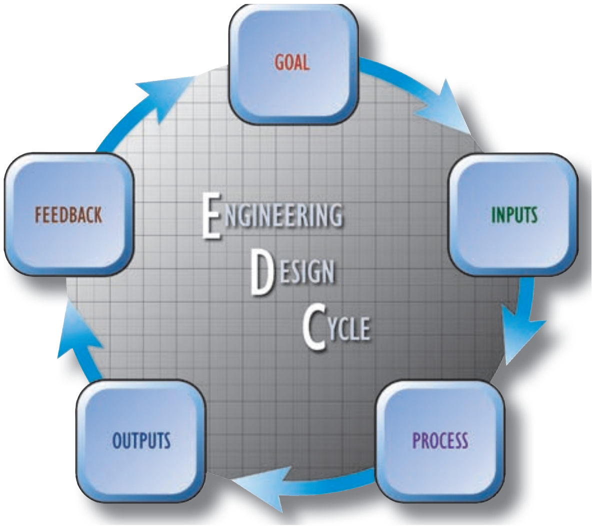
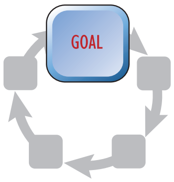
Physics

Chapter Challenge

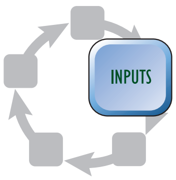
You will be completing a second process of the *Engineering Design Cycle* as you prepare for the *Chapter Challenge*. The goals and criteria remain unchanged, however, your list of *Inputs* has grown.





Goal

Your challenge for this chapter is to modify the design of a roller coaster to create the optimum thrills and chills for your target audience. Review the *Goal* as a class to make sure you are familiar with all the criteria and constraints.



Inputs

You now have additional physics information to help you identify and address the different physics concepts that apply to the design of a roller coaster. You have completed all the sections of this chapter and learned the content you will need to complete your challenge. This is part of the *Input* phase of the *Engineering Design Cycle*. Your group needs to apply these physics concepts to build your presentation. You also have the additional *Input* of your own personal experience with roller coasters as well as the feedback you received following your *Mini-Challenge* presentation.

Section 1 You determined the best method for drawing a model of a roller coaster. You also calculated velocities and accelerations. You discovered that acceleration can be more thrilling than high speed.

Section 2 You investigated gravitational potential energy and its impact on velocity for objects going down a ramp. This is important information for calculating the safety limitations of speed.

Section 3 You explored kinetic energy and the conservation of energy. These concepts are critical for determining the height of the "hills" in your roller-coaster design and how fast the roller coaster can go.

Section 4 You investigated the force of gravity. You may wish to explain how your roller-coaster design would work on the Moon!

Section 5 You explored the weight of objects and how a spring scale works. What if you had a spring for a seat?

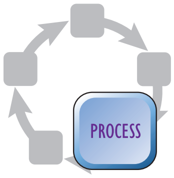
Section 6 You investigated apparent weight, or the force acting to hold you up. You will use this to construct hidden thrills in your ride and to calculate how much "up" force a passenger will need to stay safely in the seat at all times.

Section 7 You calculated centripetal force and learned an important safety factor in roller-coaster design. You discovered that a roller coaster must never exceed forces of 4 *g*'s in its turns, which may be too high for some passengers.

Section 8 You calculated work and compared that value to potential energy. This is significant in determining how much work is needed to start your roller coaster.

Section 9 You used scalar and vector quantities to analyze speeds and energies in your roller-coaster ride. You also learned a way to compare and explain different slope designs for your model.

Section 10 You completed the safety calculations for the height, speed, and acceleration of your roller coaster. You learned to pay special attention to the design criteria that are specific to your target audience.



Process

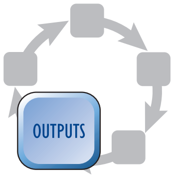
In the *Process* phase, you need to decide what information you will use to meet the *Goal*. Defining your target audience is a good way to start. Your target audience is a specific group of potential riders with similar thrill tolerances. Also, it is important to clearly identify what types of "thrills and chills" you intend your ride to deliver, which will help your audience assess how successful you were.

You can either construct a physical model or create a design poster to explain the twisting path of your roller coaster. This model is part of the criteria and is a powerful tool for explaining design concepts clearly to an audience. Make sure your design contains all of the required features as defined in the criteria.

To maximize the thrills of your ride, you will need to figure out the optimum size for your roller coaster's hills, loops, and turns. For this, you may need to perform an *Iterative Analysis*, repeating analysis steps. You can start by calculating the potential and kinetic energy associated with each hill in your roller-coaster design. You can also calculate the forces involved with different accelerations. Your results will be important for determining if you are pushing the 4-*g* limit or maintaining a low-*g* experience for riders. Once you complete the calculations, you should be able to deduce what changes will move you closer to the results you want in your design. Alternatively, you could use a programmable calculator or a spreadsheet program to perform repetitive calculations and simply try various different values until you are satisfied with the result. Both are valid approaches and each has its advantages.

You will need safety calculations for at least five points on the ride. You should include them for each major feature in the ride, even if there are more than five. Be sure to add one or two examples of safety calculations to your poster or model so that the class can follow your explanations. In many cases, you will have to repeat calculations as you use the results to optimize the sizes of hills, loops, and turns.

Your poster should include all the required data and highlight the information you want your audience to know. Make sure you identify all of the key features of your design along with example calculations and results for all of your safety analyses. You should also clarify how your design addresses the particular needs of your target audience.



Outputs

Presenting your information to the class is your design cycle *Output*. You should offer a clear description of your target audience and explain how the features of your roller coaster are designed for that audience. You will need to present your *PE*, *KE*, and velocity calculations and explain the factors that determine how much work must be done on the system to get it started. This will effectively be the energy bill for your design. While this is not one of the design criteria, minimizing energy consumption is an added bonus to almost any situation.

Feedback

Your classmates will give you *Feedback* on the accuracy and the overall appeal of your presentation based on the criteria of the design challenge. This feedback will likely become part of your grade, but could also be useful for additional design iterations. No design is perfect; there is always room for optimization or improvement no matter how slight. From your experience with the *Mini-Challenge,* you should see how you could continuously rotate through the design cycle to refine almost any idea.