CHAPTER 4

Thrills and Chills

Chapter Overview

Chapter Challenge

Whether you are a roller-coaster fanatic or someone who anticipates a roller-coaster ride as much as a trip to the dentist, there is a thrill in watching the riders shriek as the coaster whips around turns and riders flip upside down. *Thrills and Chills* challenges students to modify a roller-coaster design for a select group of riders. The roller-coaster ride has to produce the most thrills with the least danger. Students are asked to present a model of their design and a written report or poster that includes their calculations of the energy and power required to get the roller coaster started, the energy dissipated to stop the roller coaster at the end of the ride, and a spring system to stop the roller-coaster cars in case the brake system fails. Students are expected to apply their knowledge of physics to provide safety data on the height, speed, and acceleration of the roller coaster at five required locations that occur at the top of two hills, top of a loop, back curve, and a horizontal loop.

Some students will immediately want to build the roller coasters for daredevils. Others, however, may choose to design a roller coaster for children. Others may choose to provide a ride for physically challenged individuals. Another group may work on the roller coaster for senior citizens. The roller coaster has been used quite extensively to illustrate the conservation of mechanical energy. The thrill of the roller coaster, however, has little to do with energy conservation and everything to do with forces and accelerations. In this chapter, students view the roller coaster as both an energy-transformation device and as a force and acceleration ride. When they are asked to create new roller coasters, the demands of safety provide a constraint on their imagination and help them to learn more physics than they would otherwise.

Designing a roller coaster begins with being able to draw a schematic design of the coaster. Since the coaster is a three-dimensional ride, the students learn how to create pairs of drawings to show both the hills and the horizontal turns. They then learn about gravitational potential energy and kinetic energy through inquiry exercises. After a synthesis of the concepts of work, energy, and energy conservation, students turn their attention to forces and vectors. Finally, students look specifically at the required safety aspects of all roller-coaster rides.

Chapter Summary

Students investigate and apply ideas involving vectors, kinematics, the gravitational force, the force of a spring, Newton's laws, kinetic and potential energy, including gravitational potential energy and the potential energy stored in a spring, conservation of energy, circular motion, work, and power. Students

- define, measure, and calculate displacement, acceleration, and velocity.
- describe vectors and scalars, calculate kinetic energy and gravitational potential energy, and apply the conservation of energy to solve problems.
- apply kinetic energy, gravitational potential energy, and conservation of energy to roller-coaster rides and calculate spring potential energy.
- map out Earth's gravitational field, explore Newton's law of universal gravitation and apply it to solve problems and describe inverse square relationships.
- describe the difference between mass and weight, calculate spring constants, describe Hooke's law and apply it to solve problems.

- explore the difference between rest weight and apparent weight using Newton's laws, calculate apparent weight on a roller coaster, and analyze forces on a mass at rest and under acceleration.
- recall Newton's second law and explore how the centripetal acceleration depends on the radius of the curve and the velocity of the roller coaster and recognize the safety limit of acceleration for a roller coaster.
- define work in terms of force and displacement, calculate the work done by a force acting in the direction of the displacement, and define power.
- apply conservation of energy to solve problems and use the force and energy approach to understand different aspects of a roller-coaster ride.
- apply concepts of centripetal force and energy to determine the forces acting on roller-coaster riders constrained by the safety criteria, and how to add thrills in a roller-coaster design.

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