Roller Coasters

In this computer simulation, you will construct two types of looping roller coasters, a circular loop and a clothoid loop. These are shown in **Figure 8** on page 131, and discussed in the case study. The purpose of this simulation is to compare the speeds required by each coaster in order to have the same force act on the riders when the coaster reaches the top of the loop.

Question

How must the speed of a circular looping roller coaster compare with the speed of a clothoid loop to achieve the same force on the rider?

Hypothesis/Prediction

(a) Which roller coaster will require less speed at the bottom of the loop to achieve the same normal force acting on a passenger at the top of the loop?

Materials

a computer simulation program for uniform circular motion, such as *Interactive Physics*

Procedure

1. Use the computer simulation program to construct two roller coasters that have the same height. One roller coaster should have a circular loop; the other roller coaster should have a clothoid loop. The radius of curvature for the circular roller-coaster track should be approximately twice that of the clothoid roller-coaster track at the top of the loop.

2. Place a roller coaster on each track. Give the coaster on the clothoid track enough speed at the bottom of the loop so that the net force acting on it at the top of the loop is three times the force of gravity exerted on it at that position.

3. For the coaster on the circular track, determine the speed required at the bottom of the loop so that the net force acting on the coaster at the bottom and top of the loop is the same.

4. Determine the minimum speed at the bottom of the loop for both coasters to complete the loop, with the net force acting on the coaster at the top of the loop equal to the force of gravity exerted on it at that position.

(continued)

Analysis

(b) Which coaster required a greater speed to achieve the same force at the top of the loop? Why?

(c) How do the speeds for the two types of track compare when the net force at the top of the loop is equal to the force of gravity on the object?

(d) Assuming that the riders and cars are securely attached, are different speeds required at the bottom of the loop to get to the top of the loop for these types of coasters? Explain.

Roller Coasters, Solution

In this computer simulation, you will construct two types of looping roller coasters, a circular loop and a clothoid loop. These are shown in **Figure 8** on page 131, and discussed in the case study. The purpose of this simulation is to compare the speeds required by each coaster in order to have the same force act on the riders when the coaster reaches the top of the loop.

Question

How must the speed of a circular looping roller coaster compare with the speed of a clothoid loop to achieve the same force on the rider?

The circular looping roller coaster requires a greater speed than the clothoid looping roller coaster.

Hypothesis/Prediction

(a) Which roller coaster will require less speed at the bottom of the loop to achieve the same normal force acting on a passenger at the top of the loop?

The clothoid roller coaster requires less speed at the bottom of the loop.

Materials

a computer simulation program for uniform circular motion, such as *Interactive Physics*

Procedure

1. Use the computer simulation program to construct two roller coasters that have the same height. One roller coaster should have a circular loop; the other roller coaster should have a clothoid loop. The radius of curvature for the circular roller-coaster track should be approximately twice that of the clothoid roller-coaster track at the top of the loop.

2. Place a roller coaster on each track. Give the coaster on the clothoid track enough speed at the bottom of the loop so that the net force acting on it at the top of the loop is three times the force of gravity exerted on it at that position.

3. For the coaster on the circular track, determine the speed required at the bottom of the loop so that the net force acting on the coaster at the bottom and top of the loop is the same.

4. Determine the minimum speed at the bottom of the loop for both coasters to complete the loop, with the net force acting on the coaster at the top of the loop equal to the force of gravity exerted on it at that position.

(continued)

Analysis

(b) Which coaster required a greater speed to achieve the same force at the top of the loop? Why?

The circular roller coaster required a greater speed. It has a larger radius of curvature and, therefore, a smaller centripetal force.

(c) How do the speeds for the two types of track compare when the net force at the top of the loop is equal to the force of gravity on the object?

The speed of the circular loop is 1.4 times the speed of the clothoid loop.

(d) Assuming that the riders and cars are securely attached, are different speeds required at the bottom of the loop to get to the top of the loop for these types of coasters? Explain.

No. If the riders and cars are attached, the speeds at the bottom of the loop for these coasters are the same. The law of conservation of energy implies that this must be the case.