18 Rotational Mechanics
Loop the Loop

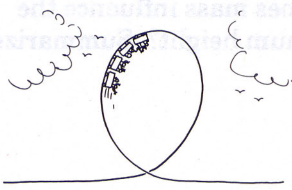
Purpose

To discover what effect(s) rotational energy has on the minimum height required for a car or sphere to loop-the-loop.

Required Equipment and Supplies

Hot Wheels car and track or equivalent
steel balls (solid) of various sizes
ring stand
tape

Discussion



Release a block and a ball from the top of an incline to see which one reaches the bottom first. If the block slides freely and the ball rolls, the block wins. All of the block's potential energy is converted to translational kinetic energy. The ball's potential energy, however, is converted to both rotational and translational kinetic energy. The ball's translational kinetic energy is less than it would have been if it had simply slid down the incline. A rolling wheel similarly takes energy that otherwise would go into translational motion. To reduce this energy-taking effect, racing cars have lightweight wheels. In this activity you will investigate the role of rotational kinetic energy in rolling things.

Procedure

Step 1. Set up the toy car track as shown is Figure 18.1. Make the track as sturdy and smooth as possible to minimize the effects of friction.

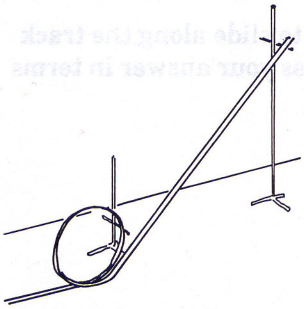


Figure 18.1

Step 2. Find the minimum height on the incline of the track that barely enables the toy car to loop-the-loop without leaving the track at the top of the loop. Mark this point with a a felt-tip pen or a tiny piece of masking tape. Record the height.

height (car) = _______

1. How great a force does the track exert on the car at the top of the loop?

Step 3. Predict what will happen when you release the steel ball at the same place on the track. Will it make the loop without leaving the track? Can it make the loop when released from a higher or lower elevation on the track? Record your predictions.

Step 4. Release the ball to test your prediction. To be sure of your results, repeat several times. Record your findings.

height (ball) = ______

2. How great a force does the track exert on the ball at the top of the loop?

3. Did the steel ball make the loop when released from the minimum height required for the car to make the loop?

4. Since both the car and the ball are going in a circle at the top of the loop, what force is providing the centripetal acceleration at the top of the loop?

Step 5. Repeat the experiment with ball-bearings and toy cars of different sizes and masses. How do your results compare? Does mass influence the results? Does the radius of the ball affect the minimum height? Summarize your findings.

Analysis

5. Find the theoretical minimum height for a block to slide along the track (with no friction) without leaving the track. Express your answer in terms of the radius of the loop, *r*. Show your reasoning.

h = ________

6. How does this theoretical height compare to the actual height required to make the loop?

7. Find the theoretical minimum height a solid ball can be released and make the loop without leaving the track. Express your answer in terms of radius of the loop, *r*. Assume the ball rolls down the track. Show your reasoning.

8. The amount of rotational *KE* of the steel ball can be estimated by comparing the results in Steps 2 and 4. If the ball bearing slid down the track without rolling, it would make the loop from the same minimum height as the car. However, if the balls rolls, it has energy of rotation as well as translation. The total energy of the ball is the sum of the *KE*, KE_{rot}, and *PE*. Since the ball has the same *PE* at the top of the loop regardless of whether or not it's rolling, estimate what percent of the ball's *PE* goes into rotational *KE* for it to just make the loop without leaving the track.