Physics LAB

HOW HOT ARE YOUR HOT WHEELS?

Application

Problem

How can you apply the conservation of energy concept to 1) predict from where to release a car on a loop-the-loop track to just retain contact with the track through the loop and 2) predict how far and how high a car will travel from a ramp inclined at some angle?

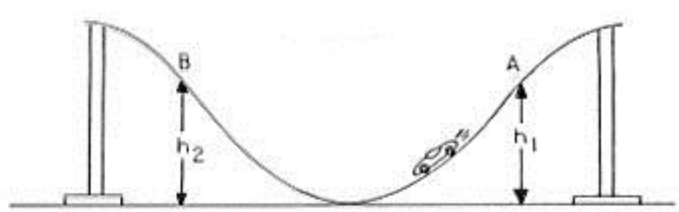
Materials

Hot Wheels set with loop-the-loop and ramp, small car, meter stick, timing device

Procedure

Part A: Loss of Energy Due to Friction

The illustration shows the track setup for Part A. Elevate both ends of the track to a height of about 1 m above the floor or lab table.



Release the car from the starting point A. Record this height (h_1) and the height to which the car rises (h_2) on the other end of the track. Please make several trials. It is important to secure the track to the floor so some of the car's energy is not transformed into motion of the track.

The ratio of the final height to the initial height is equal to the ratio of potential energy transferred back into the car going up the left ramp to the potential energy the car had at the top of the right ramp at point A. Call this ratio of (h_2 to h_1 the "efficiency" of the system for the car going from point A to point B on the track. The distance along the track from A to B is called the "standard length" so the ratio of (h_2 to h_1 (efficiency) represents the fraction of the initial energy the car will have when it reaches point B on the track. This ratio is used in later experiments to determine how high the car must start, so it will have a predictable total amount of energy when it reaches certain points on the track.

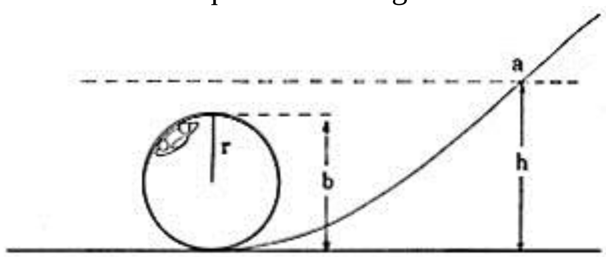
Summing Up

Part A

1. What is the average height ratio, or efficiency?
2. In what unit is efficiency measured?

Part B: Loop-the-Loop

The next illustration shows a loop-the-loop section placed in the track at about the **standard length** from the starting end of the track. The problem is to predict the minimum height from which the car must start, so it will successfully travel all the way around the loop without falling away from the track. In order for this to take place, there must be centripetal force acting on the car as it goes around the loop. This force Fc must be equal to the weight of the car.



The equations for centripetal force and weight appear below.

$$w = mg \qquad F_c = \frac{mv^2}{r} \qquad w = F_c$$

Combine these equations and solve for v^2.

What is the minimum speed the car can have at the top of the loop to perform a successful loop?

At the top of the loop, the car has both kinetic and potential energy. This energy total was supplied by the loss of potential energy the car had at point a. This means:

$$KE_b + PE_b = PE_a$$

or

$$\frac{1}{2}mv^2 + 2mgr = mgh$$

Substitute the value of v^2 you found above into the kinetic energy equation and then solve the total energy equation for h. This means that if there were no friction, the car should start from a height h to make it around the loop. Since the system does have friction, the car must start from a point just higher to make up for the frictional loss. Therefore the car must start from a height of

h divided by the efficiency of the system.

Write a report on your findings in this experiment.

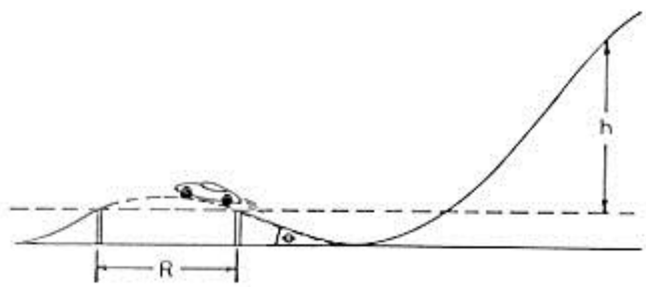
Summing Up

Part B

1.State in your own words the energy changes as you lift the car to point A, until it completes the loop-the-loop.
2.Do your results show that energy is conserved? Explain your answer.

Part C: The Dare Devil Jump (Optional)

The illustration below shows the jump-ramp set up. The problem here is to calculate the range of the car's jump when you release it from a chosen height (h) above the launch point of the ramp.



The starting point of the jump should be at about the "standard length" from the release point of the car. The kinetic energy of the car at the launch point on the ramp equals the loss in gravitational potential energy from the starting point on the track, or, mv^2 = mgh, assuming the track is 100% efficient. From this statement of conservation of energy, you can begin to solve the problem posed above. Calculate the loss in gravitational potential energy your car would undergo from the release point to the top of the launch ramp. Now calculate the actual energy at launch by using the efficiency factor you calculated in Part A. From this kinetic energy, you can calculate the launch velocity of the car. You can calculate or measure the initial launch angle of the car, and use this to calculate the vertical and horizontal components of the launch velocity. From your knowledge of projectile motion, you should now be able to calculate the total jump time and the jump range. Now try out your predictions! How did you do? If time permits calculate the maximum height of a "fence" the car could clear as it jumps from ramp to ramp.

Summing Up

Part C

1.Describe the energy changes as a car moves down the track and completes the jump.

2.Explain whether or not energy was conserved in this activity.
