

paper roller coaster

Lab

Background

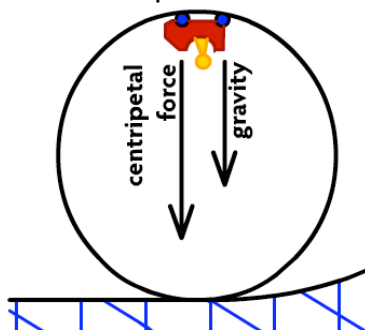
An object will travel in a straight line until a force acts to change its path of motion. This means that to travel in a circle (or a loop) the force must act on an object to push it sideways.



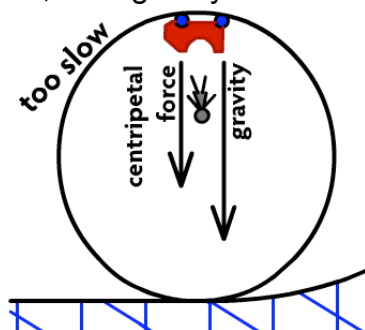
When the force acts to push the ball to the inside of a circle, the force is called a centripetal force. It is the centripetal force that keeps you from flying out of your seat in a loop on a roller coaster. It is that same centripetal force that spins your clothes in a circle in the clothes dryer. With this centripetal force there is also an acceleration. This acceleration is called a centripetal acceleration. The centripetal acceleration also points to the inside of a curve or circle and is calculated from,

$$a_c = \frac{v^2}{R}$$

Where “ a_c ” is the centripetal acceleration, “ v ” is the velocity, “ R ” is the radius. When you jump of a chair, it is gravity that pulls you down. If you were to get stuck upside down on roller coaster, gravity would also be pulling you down. But when the roller coaster is moving fast enough, the centripetal force pushes you towards the center with a greater force than or equal to the force of gravity. This is shown with the picture below.



This means that gravity does not have enough time to pull you out of your seat in the loop. If the roller coaster is traveling too slow, then gravity could win and pull you out of your seat.



(However, coasters are designed so this does not happen.)

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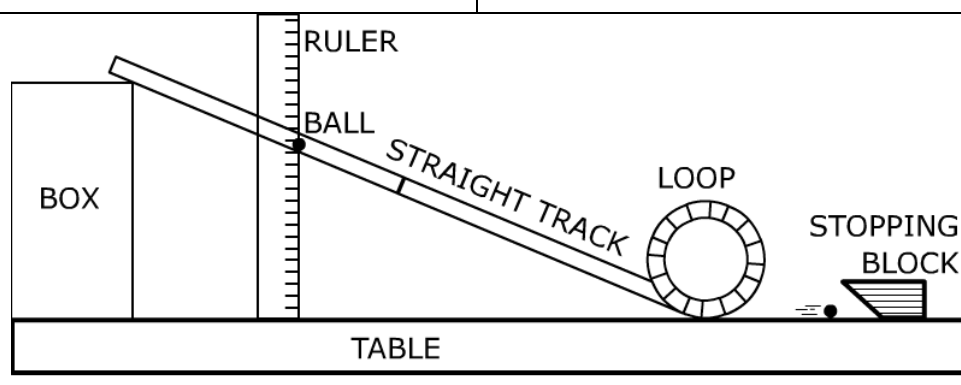
Lab

Objectives

- 1 To find the minimum height necessary to make it around the loop without falling out.
- 2 To investigate the effect of the entering straight track's angle on making it around the loop.
- 3 Calculate the minimum g's needed to stay safely inside the loop

Materials

1paper loop template	1ruler marked off in centimeters or meters
1paper track template	1calculator
1scissors	1marble or steel bearing
1roll of clear cellophane tape	




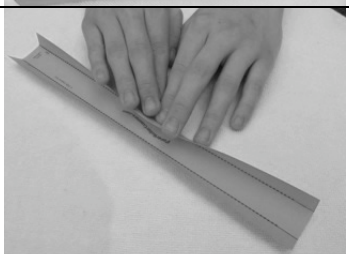
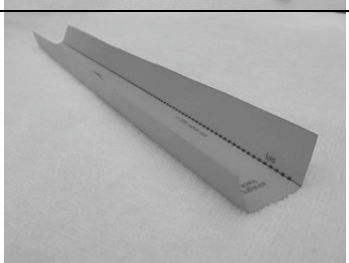
Procedure

- 1 You are to make two straight pieces of track and tape them together.
- 2 You are to make a loop and tape it to the straight piece of track.
- 3 Prop the end of the straight track on a box or ring stand cross bar. Make sure the end is at least twice as high as the loop's height.
- 4 Hold a marble at the top of the track.
- 5 Use a ruler to measure the vertical start height to the bottom of the track under the marble.
- 6 Release the marble from rest.
- 7 Listen to the marble as it travels around the loop. You will hear it make contact with the loop during its entire journey.
- 8 Move the marble lower; release it from rest, and listen to see if it makes contact the entire way around the loop. Repeat this process until you gone too far down the track. You will know you have gone too far when you hear the silence of the marble as it loses contact with part of the loop. Then back up until you've reached the point where the marble just barely keeps in contact with the track as it complete the loop.
- 9 Record this starting height on the data section of the lab.
- 10 Increase the angle of the straight piece of track. Do make the angle extremely steep.
- 11 Repeat the loop process until the marble just barely keeps in contact with the track as the marble makes it around the loop.
- 12 Record this starting height on the data section of the lab.
- 13 Answer the calculations and questions. (The "Challenge Questions" are optional.)


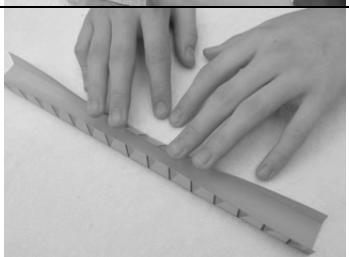
Track Construction Instructions

Straight Track

Video instructions can also be found on the website www.mrwaynesclass.com/project.

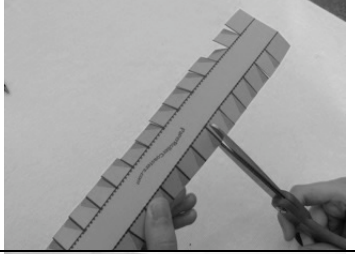
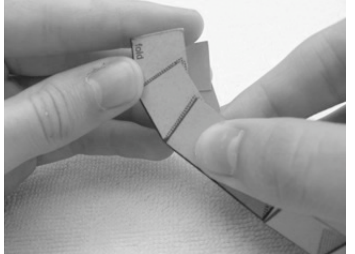
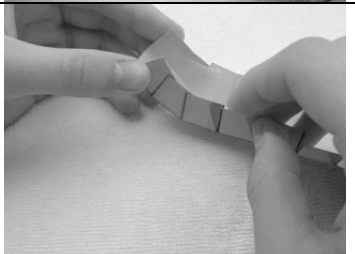
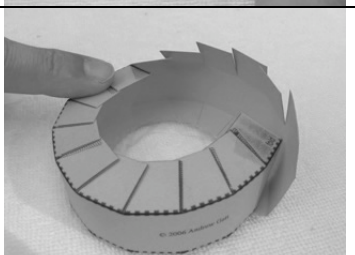
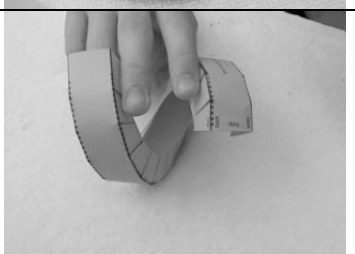
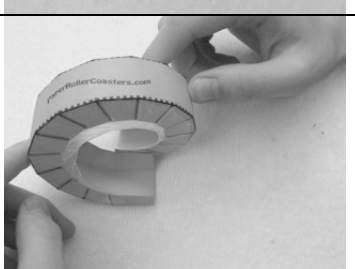
1 Take the card stock labeled, "Straight Track," and trace along the dotted lines with a ball point pen and a ruler. Press firmly with the pen. This will make a crease in the paper -which allows for the paper to be folded more easily. Also, lay the paper on top of a closed magazine. This will also help to define the crease.	
2 Fold along the dotted lines to make a sharp crease, keeping the lines on the inside. (fig. 36)	
3 Fold up the sides to make them vertical. <u>Finished.</u> These instructions are paraphrased from the Booklet <u>Step by Step Instructions for Building Incredible Roller Coasters</u> by Andrew Gait, www.paperrollercoasters.com , 2007.	

Loops

1 Trace along the dotted lines with a ball point pen to crease the paper. Firmly press the pen down. Doing this on top of magazine will help to define the crease.	
2 Fold along the dotted lines to make sharp creases. Keep the printed side on the outside. Much of the printing will be covered up in later steps.	

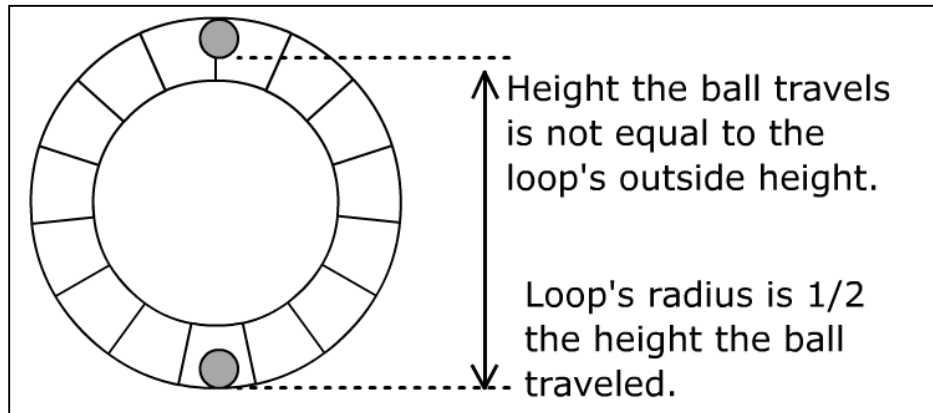
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Lab

<p>3 Cut along the short, solid, black lines. Cut all the way to the crease. If you don't cut to the crease. The folds you do later will not allow for a smooth looped track.</p>	
<p>4 Starting at one end, bring two flaps together so that the dotted pattern on one of them is just barely hidden.</p>	
<p>5 Use a small piece of tape to hold them in place. Use a small piece of tape on the inside too. Tape all the flaps on one side <u>before</u> starting the other side.</p>	
<p>6 After taping one side of the loop, it should hold its shape more easily thus allowing you to tape the other side.</p>	
<p>7 Tape the other side by placing small pieces of tape on the outside and then the inside of the loop. The loop should form a smooth circle.</p>	
<p>8 Stretch the loop side ways a bit. You can tape the sides together to make a solid loop. This will add stability to the loop. You can also connect several loops together make a cork screw. <u>Finished.</u> These instructions are paraphrased from the Booklet <u>Step by Step Instructions for Building Incredible Roller Coasters</u> by Andrew Gait, www.paperrollercoasters.com, 2007.</p>	

DATA SECTION

- 1 Loop diameter in meters: _____
- 2 Loop radius in meters: _____
- 3 Height the ball traveled in the loop in meters _____ (Use in calculations. This is different than the measurement in question 3. See the diagram below.)



- 4 Actual radius ball traveled in meters _____ (Use in calculations)

First track angle

- 5 Vertical starting height for successful loop the loop journey (in meters): _____

Second track angle

- 6 Vertical starting height for successful loop the loop journey (in meters): _____