

Marble Run—Part 1

Materials

- Three half pieces of copper pipe insulation (gray, spongy); each piece 1.83 meters or 6 feet
- Masking tape
- One marble
- Stopwatch
- Meter stick

Task

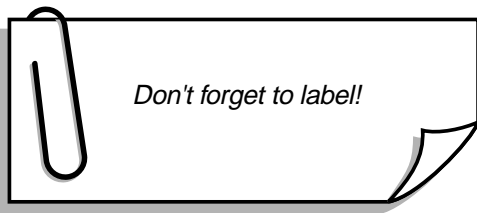
You will work as a group to build a roller coaster and to diagram the forces of motion and energy transformations that apply to the track.

Parameters

1. Use 5.49 meters (18 feet) of copper pipe insulation for the track.
2. Select any type of marble, but only one marble. You will be able to make one switch if you want to change marble type.
3. Avoid putting tape on the surface of the track on which the marble rides.
4. This is not a race, so take time to enjoy it.

Procedure

1. As a group, build a roller coaster that has
 - An initial hill and one additional hill
 - A complete loop
 - A gap where two pieces of track do not touch each other
 - A run that a marble can roll the entire distance of the track (except at the gap)
2. Time five complete marble runs.
3. Sketch the shape of the coaster below.
4. Label the forces that are present during the marble run (include gravitational, centripetal, and frictional).
5. Label energy transformations in your diagram where the potential energy and kinetic energy increases or decreases.



Roller Coaster Diagram

Average time for 5 trials _____



Marble Run—Part 2

Task

You will work as a group to calculate the average speed of a marble for the team’s roller coaster, and to draw the roller coaster to scale.

Parameters


1. Use 5.49 meters (18 feet) of copper pipe insulation for the track.
2. Select any type of marble, but only one marble. You will be able to make one switch if you want to change marble type.
3. Avoid putting tape on the surface of the track on which the marble rides.

Procedure

1. As a group, build a roller coaster that has
 - An initial hill and one additional hill
 - A complete loop
 - No gap
 - A run that a marble can roll the entire distance of the track
2. Draw a scale drawing of your roller coaster using the grid graph below.
3. Time the marble from start to finish five times and calculate the average time of travel.
4. Calculate the average speed of the marble.
($s = d/t$, where s = speed, d = distance, and t = time)

Materials

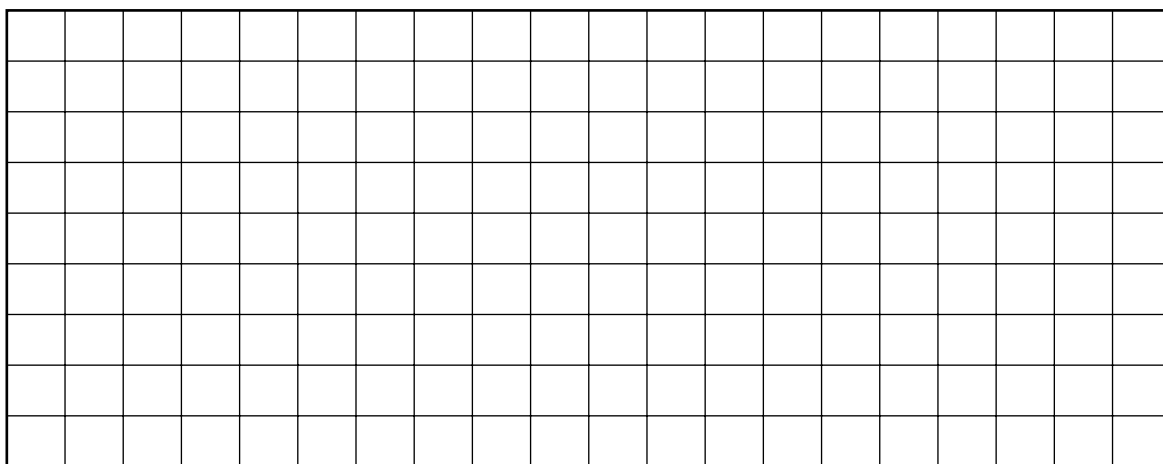
- Three half pieces of copper pipe insulation (gray, spongy); each piece 1.83 meters or 6 feet
- Masking tape
- One marble
- Stopwatch
- Meter stick
- Digital camera (optional)



Make sure you leave enough time to make the scale drawing and time five marble runs.

Scale drawing of roller coaster: 1 block = 20 centimeters

(Suggestion: Photograph your roller coaster with two meter sticks at right angles to represent the X and Y axes.)



Data and Calculations

Trial	Distance, m	Time, s	Speed, m/s
1	5.49		
2	5.49		
3	5.49		
4	5.49		
5	5.49		
Average	5.49		



Arranging the hill parameters for the marble run activities takes teamwork.



Students build a marble run roller coaster using copper pipe insulation. How is this for a total team effort?



Marble Run—Part 3

Task

You will build a roller coaster with a 4-foot hill where the marble stays on the track at all times and then calculate the average speed of the marble for five trials.

Parameters


1. The first hill must be at a height of 1.22 meters (4 feet) measured from the top of the first hill to the bottom of the first hill.
2. The two additional hills should be as tall as possible.
3. The marble must run the entire length of two pieces of track, 3.67 meters (12 feet).
4. You may add turns or any side motion to the track to increase speed.
5. You may try different types of marbles (small, big, heavy, and light).

Procedure

1. As a group, build a roller coaster that has
 - Three hills
 - Conditions to allow the marble to remain on the track for the entire run (the marble cannot leave the track at any point)
2. Use a stopwatch to time the marble from the beginning to the end of the track. Repeat for a total of five trials. Record the times below.
3. Calculate the average speed of the marble and record below. (speed = distance divided by time ($s = d/t$))
4. Draw your roller coaster on the following page and indicate the height of each hill.

Materials

- Two half pieces of copper pipe insulation (gray, spongy); each piece 1.83 meters or 6 feet
- Masking tape
- One marble
- Stopwatch
- Meter stick




Don't forget to return the marbles!

Data and Calculations

Trial	Distance, m	Time, s	Speed, m/s
1	3.67		
2	3.67		
3	3.67		
4	3.67		
5	3.67		
Average	3.67		



Draw your coaster and label the height of each hill in centimeters. Label the four items listed in the conclusion below.



Conclusion

1. What was the combined height of the three hills of your coaster? _____
2. Indicate on your diagram the one location where the potential energy (PE) of the coaster is the greatest (maximum PE). Note, there can only be one of these for the entire coaster.
3. Indicate on your diagram, the area of each hill where PE is decreasing and kinetic energy (KE) is increasing. (PE↓ KE↑)
4. Indicate on your diagram where the KE of the coaster is the highest (maximum KE). Note, there can only be one of these for the entire coaster. When you are finished with your drawing it should have each of the following things labeled:
 - Height of each hill
 - Maximum PE (one only)
 - Areas of PE↓ KE↑
 - Maximum KE (one only)



Marble Run—Part 4

One of the most exciting parts of a roller coaster ride is feeling weightless while traveling over a hill. If the coaster can simulate the path of a projectile (like a ball that rolls off a table) the riders will come close to experiencing free fall and will feel weightless.

Task

As a group, test three different hill formations to find out the optimal hill shape for a roller coaster.

Materials

- Two half pieces of copper pipe insulation (gray, spongy); each piece 1.83 meters or 6 feet
- Masking tape
- One marble
- Stopwatch
- Meter stick

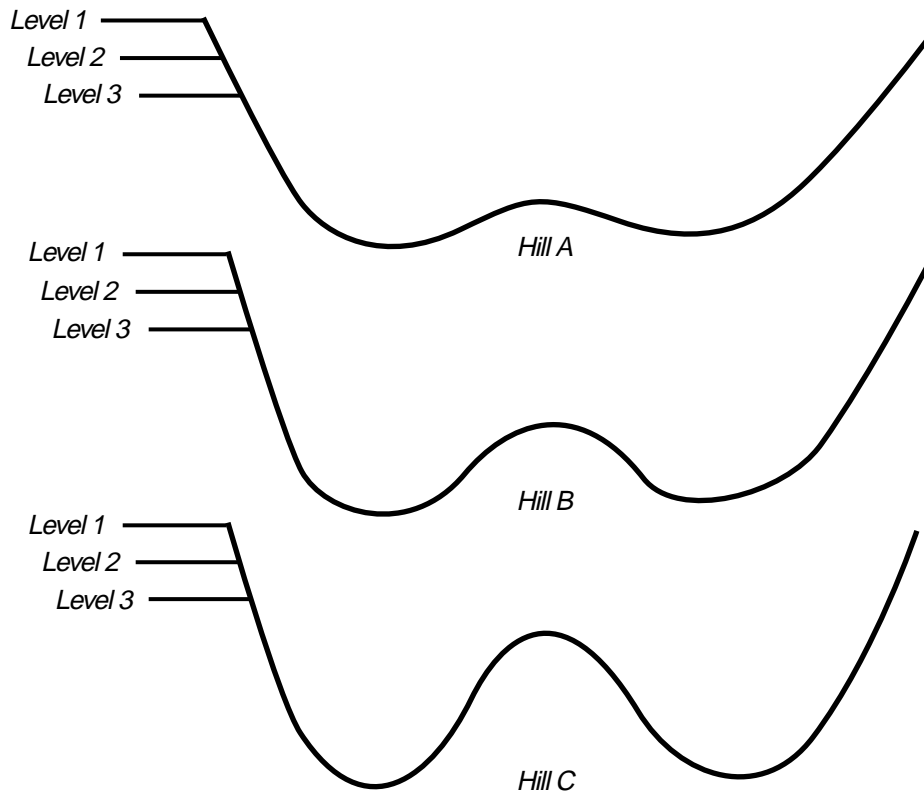
Parameters

1. Use two pieces of track. The marble must run the entire length of track.
2. The marble cannot leave the track at any time from start to finish.
3. You may try different types of marbles (small, big, heavy, and light), but you must use the same one for all three hills.

The starting heights will directly affect the speed of the marbles. Each hill shape is optimal for one starting level.

Procedure

1. Tape the two tracks together on the bottom.
2. Test three different types of hills (A, B, and C) from three different starting heights (levels 1, 2, and 3). Determine which hill shape is optimal for each starting height. Level 1 is 1.0 meter, level 2 is 0.8 meter, and level 3 is 0.6 meter above the lowest point of the hill (see diagrams below). Note, the heights of the middle hill shown in the diagrams are exaggerated for purposes of clarity.



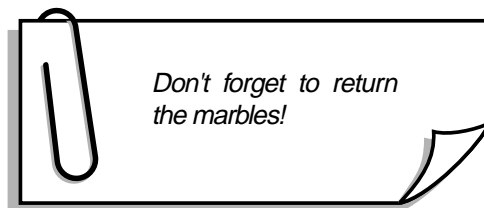
Fill in the table below according to the following descriptions:

Optimal hill—The marble is close to free fall for the longest period of time, and is softly caught at the bottom. This is the fastest ride while still staying on the track.

Safe hill—The marble stays on the track, but is not traveling as fast as it could, nor does it remain close to free fall for the maximum amount of time.

Unsafe hill—The marble leaves the track and possibly hits the other side of the track, or the marble doesn't have enough speed to go over a hill or complete a loop.

Starting height	Hill A	Hill B	Hill C
1			
2			
3			



Conclusion

1. Which hill type is optimal when starting the marble at level 1, and why do you think this is true?

2. Which hill type is optimal when starting the marble at level 2, and why do you think this is true?

3. Which hill type is optimal when starting the marble at level 3, and why do you think this is true?

4. When you ride down a roller coaster hill, does the angle of the slope of the track make a difference in the sensation that you get on the ride? Why? _____

