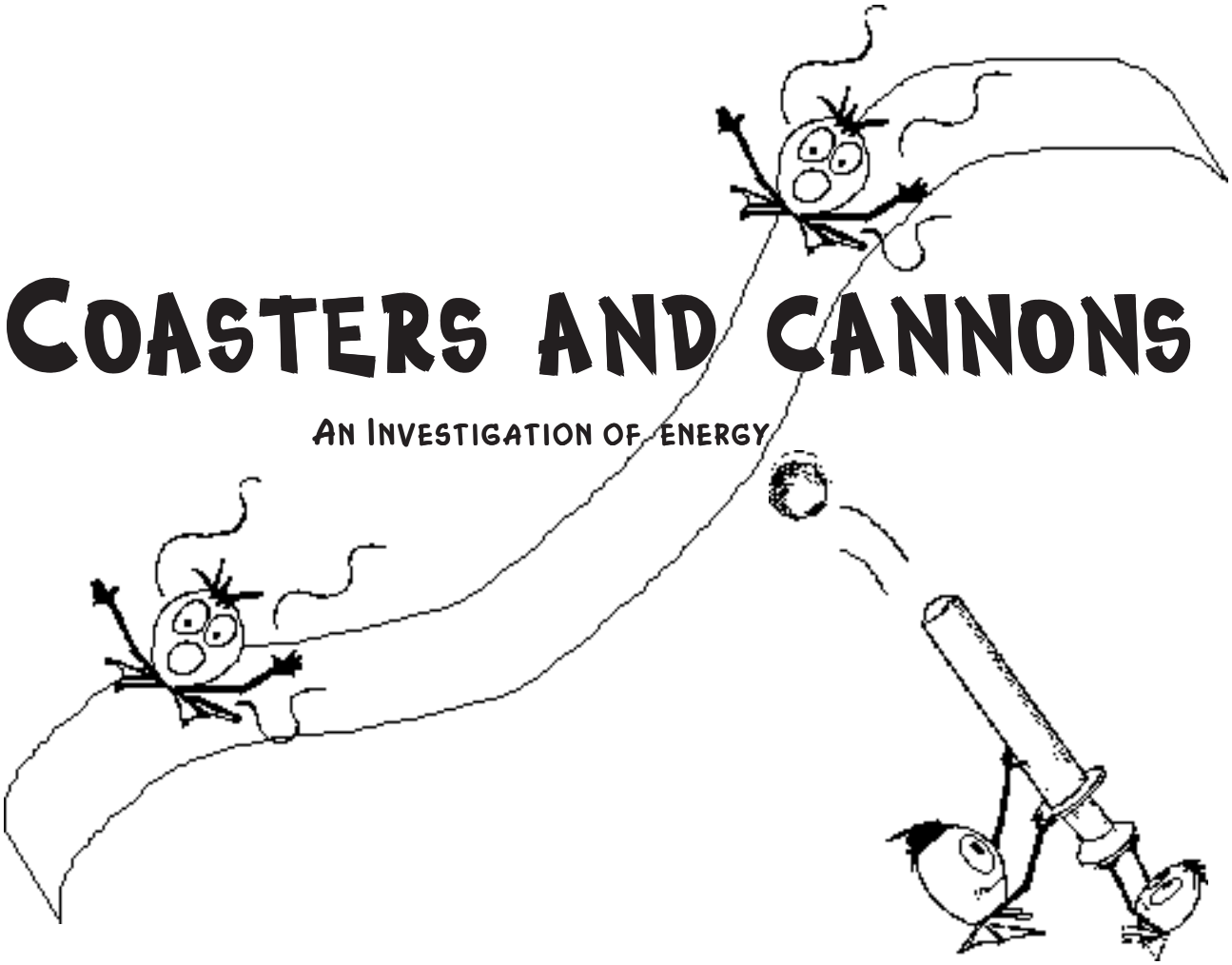


Coasters and Cannons

An Investigation of Energy

Written by
Sandy Yaras

Illustrations by Gary Russell

An Active Classroom™ Publication

Table of Contents

Teacher's Notes 1
Frame Dimensions 10

Teacher Directed Activities

Coasters
1. Speed Demon 2
2. Speed Demon Too 3
3. Over the Hill 4
4. Over the Hill Again 5
5. Hill after Hill 6
6. Defying Gravity 7
7. Hill and Loop 8
8. Free Form 9

Cannons
9. Cannon Power 23
10. The Right Angle 24

Student Worhsheets

Coasters
1. Speed Demon 11
2. Speed Demon Too 13
3. Over the Hill 15
4. Over the Hill Again 17
5. Hill after Hill 19
6. Defying Gravity 20
7. Hill and Loop 21
8. Free Form 22

Cannons
9. Cannon Power 25
10. The Right Angle 27
11. Hit the Target 29

Teacher's Notes

The following activities are designed as an inquiry into kinetic and potential energy. Students should discover that:

1. Gravity pulls all things at the same rate.
2. The size or weight of the ball used does not determine the speed it will travel.
3. The slope of the track determines the speed.
4. The higher the ball is from the ground, the greater potential energy it has.
5. The greater the mass of the ball, the greater potential energy it has.
6. Centripetal force will cause a ball to travel around a loop.
7. The amount of force used on a projectile will determine the distance it travels.
8. The angle of a projectile will determine the distance it travels.
9. The optimum angle of a projectile is 45°.

Terms

Centripetal force: Center seeking force that causes an object to move in a circle.
Kinetic energy: Energy that is being used.
Momentum: The product of mass and velocity of an object in motion
Parabola: The path of a projectile.
Potenial energy: Stored energy.
Trajectory: The curved path of a projectile.

Material

The material needed for these activities can be found in most hardware stores. You will need 1/2 inch schedule 40 pvc pipe, 90° elbows, tees, couplings, 3/8 inch tubing insulation for 1/2 inch copper tube, marbles (plastic balls supplied in Active Classroom Kit), steel balls, masking tape, rubber bands, bottle caps, 1/2 inch dowel and something to cut into rings.

Each group will need 10 elbows, 5 tees, 1 coupling, and pipe cut into the following lengths:
2 - 1 1/2 foot lengths 2 - 1 foot lengths 2 - 6 inch lengths 10 - 2 inch lengths.

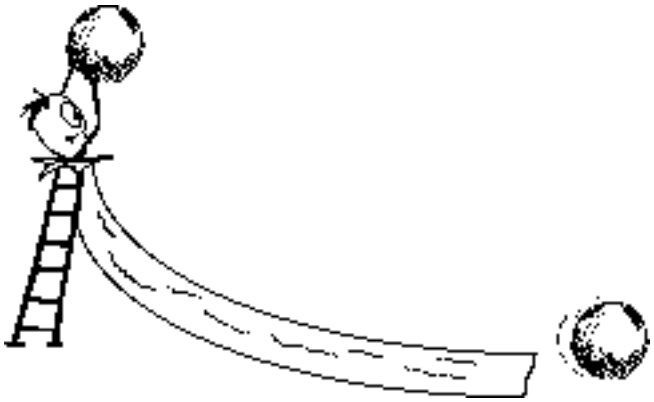
The insulation is split down the middle and 1/2 is given to each group.

The rings are used to secure the insulation to the pipe and fittings without having to put tape on the insulation. Removing the tape from the insulation can destroy it. Rings can be cut from 2 oz. polyethyene bottles (glue bottles) or a flanged tailpiece (pvc drain pipe) or anything with a 1 3/8 inch inside diameter.

SPEED DEMON

MATERIALS:

PVC pipe and fittings
Support rings
Pipe insulation tube
Marbles
Masking tape
Stop watch



PROCEDURE:

1. Have students assemble the stand and stop as shown on the Speed Demon Worksheet. Use a six inch riser for the stand.

2. Tape a support ring to the stand and use it to connect the insulation tube to the stand.

3. Stretch the tube out as far as it will go and place the stop at the end to catch the marbles.

4. Release a marble at the top of the track and time how long it takes to hit the stop.

5. Repeat this three times and get an average time.

6. Replace the six inch riser with a one foot riser and repeat steps 4 and 5.

7. Replace the one foot riser with a one and a half foot riser and repeat steps 4 and 5.

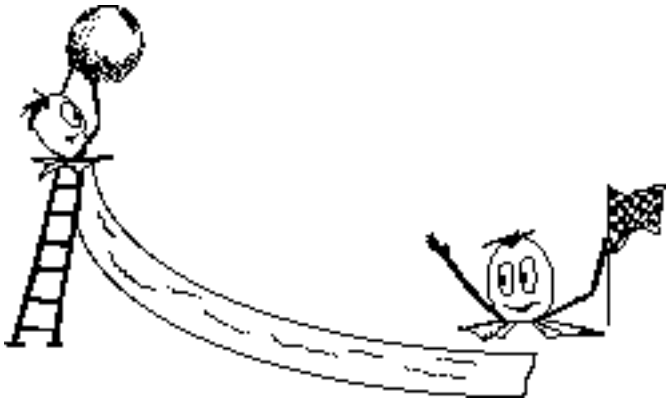
8. Record the data on the Speed Demon Worksheet.

9. Does the height of the coaster affect the speed of the coaster?

Speed demon too

Materials:

PVC pipe and fittings
Support rings
Pipe insulation tube
Marbles and steel balls
Masking tape
Stop watch



Procedure:

1. Have students assemble the stand and stop as shown on the Speed Demon Too Worksheet. Use a six inch riser for the stand.

2. Tape a support ring to the stand and use it to connect the insulation tube to the stand.

3. Stretch the tube out as far as it will go and place the stop at the end to catch the marbles and steel balls.

4. Release a marble at the top of the track and time how long it takes to hit the stop. Release a steel ball at the top of the track and time it.

5. Repeat this three times and get an average time for marbles and an average for steel balls.

6. Replace the six inch riser with a one foot riser and repeat steps 4 and 5.

7. Replace the one foot riser with a one and a half foot riser and repeat steps 4 and 5.

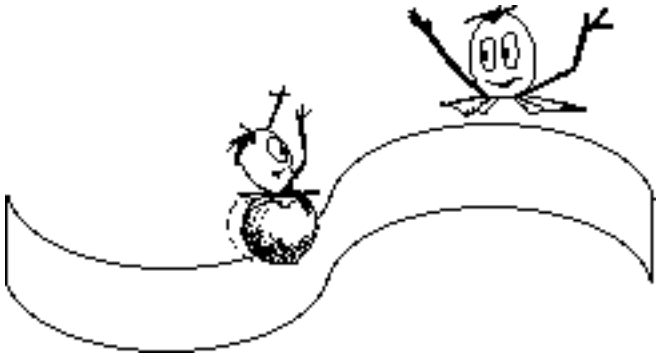
8. Record the data on the Speed Demon Too Worksheet.

9. Does the weight of the coaster affect the speed of the coaster?

OVER THE HILL

MATERIALS:

PVC pipe and fittings
Support rings
Pipe insulation tube
Marbles
Masking tape



PROCEDURE:

1. Have students assemble the stands and stop as shown on the Over the Hill Worksheet. Use six inch risers for the stands.

2. Tape three support rings to the stands and use it to connect the insulation tube to the stands.

3. Adjust the stands to create the hill and place the stop at the end to catch the marbles.

4. Release a marble at the top of the track and see if it can go up and over the hill.

5. Replace the six inch riser on stand #1 with a one foot riser and repeat step 4.

6. Replace the six inch riser on stand #2 with a one foot riser and repeat steps 4.

7. Replace the one foot riser stand #1 with a one and a half foot riser and repeat step 4.

8. Replace the one foot riser stand #2 with a one and a half foot riser and repeat steps 4.

9. Record the data on Over the Hill Worksheet.

10. Does the height of the coaster affect the momentum of the coaster?

Activity four

Over the Hill Again

Materials:

PVC pipe and fittings
Support rings
Pipe insulation tube
Marbles and steel balls
Masking tape

Procedure:

1. Have students assemble the stands and stop as shown on the Over the Hill Worksheet. Use six inch risers for the stands.

2. Tape three support rings to the stands and use it to connect the insulation tube to the stands.

3. Adjust the stands to create the hill and place the stop at the end to catch the marbles and steel balls.

4. Release a marble at the top of the track and see if it can go up and over the hill. Release a bearing at the top of the track and see if it can go up and over the hill.

5. Replace the six inch riser on stand #1 with a one foot riser and repeat step 4.

6. Replace the six inch riser on stand #2 with a one foot riser and repeat steps 4.

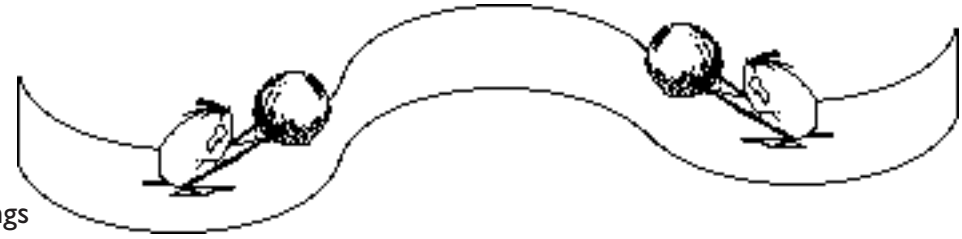
7. Replace the one foot riser stand #1 with a one and a half foot riser and repeat step 4.

8. Replace the one foot riser stand #2 with a one and a half foot riser and repeat steps 4.

9. Record the data on Over the Hill Worksheet.

10. Does the weight of the coaster affect the momentum of the coaster?

HILL AFTER HILL



MATERIALS:

PVC pipe and fittings
Support rings
Pipe insulation tube
Marbles and steel balls
Masking tape

PROCEDURE:

1. Give students the Hill After Hill Worksheet.

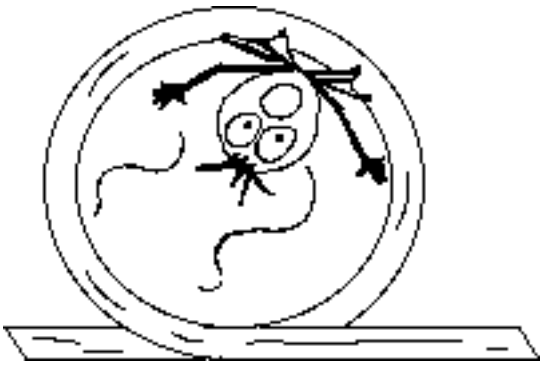
2. Tell them to experiment as they try to assemble the hill after hill coaster.

3. Tell them that the drawing is not to scale and they will have to find the correct sizes for the pipe lengths to make the coaster work.

4. When a marble is released at the top of the track it should go up and over both hills and hit the stop.

5. Have students mark the pipe length dimensions on the Hill After Hill Worksheet.

DEFYING GRAVITY



MATERIALS:

PVC pipe and fittings
Support rings
Pipe insulation tube
Marbles and steel balls
Masking tape

PROCEDURE:

1. Give students the Defying Gravity Worksheet.

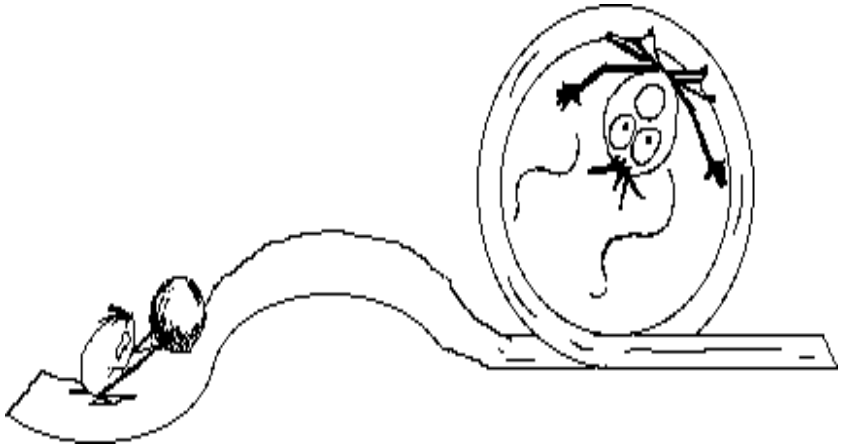
2. Tell them to experiment as they try to assemble the defying gravity coaster.

3. Tell them that the drawing is not to scale and they will have to find the correct sizes for the pipe lengths to make the coaster work.

4. When a marble is released at the top of the track it should go up and around the loop and hit the stop.

5. Have students mark the pipe length dimensions on the Defying Gravity Worksheet.

HILL AND LOOP



MATERIALS:

PVC pipe and fittings
Support rings
Pipe insulation tube
Marbles and steel balls
Masking tape

PROCEDURE:

1. Give students the Hill And Loop Worksheet.

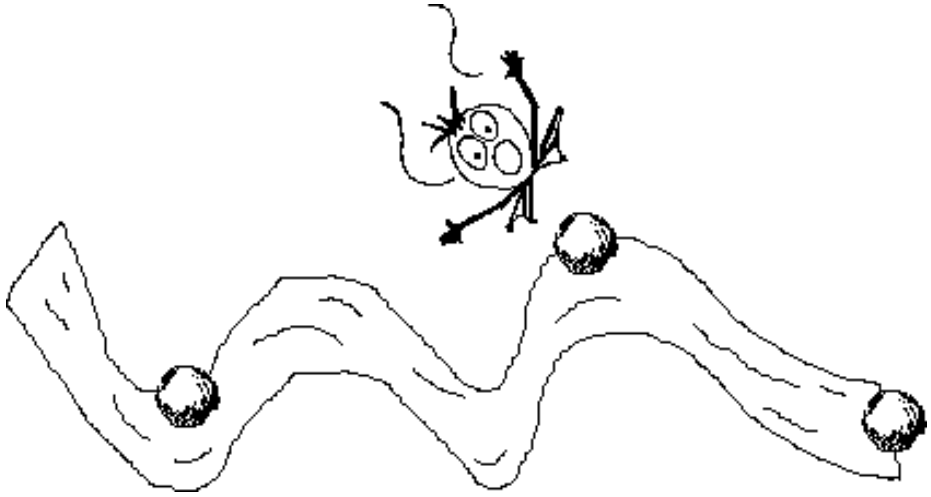
2. Tell them to experiment as they try to assemble the hill and loop coaster.

3. Tell them that the drawing is not to scale and they will have to find the correct sizes for the pipe lengths to make the coaster work.

4. When a marble is released at the top of the track it should go up and around the loop, over the hill and hit the stop.

5. Have students mark the pipe length dimensions on the Hill And Loop Worksheet.

FREE FORM



MATERIALS:

PVC pipe and fittings
Support rings
Pipe insulation tube
Marbles and steel balls
Masking tape

PROCEDURE:

1. Give students the Free Form Worksheet.

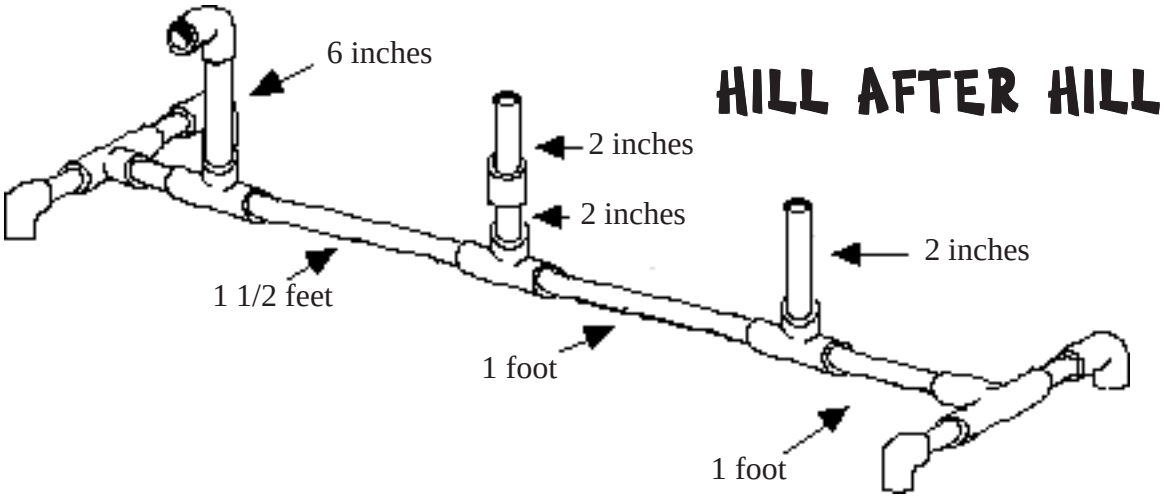
2. Tell them to use what they have learned about roller coasters to design and assemble their own coaster.

3. Tell them to experiment until they are happy with their design.

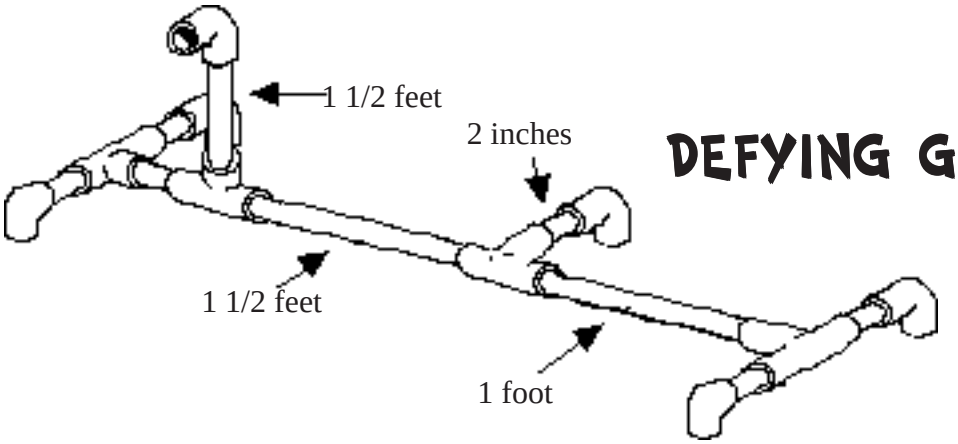
4. Draw the design and dimensions on the Free Form Worksheet.

5. Discuss the designs and reasons for the designs.

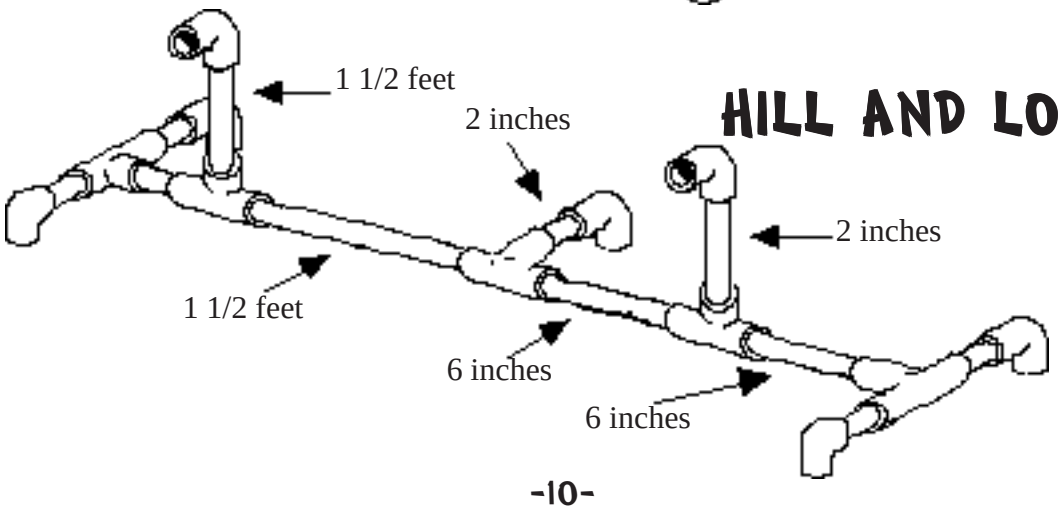
Frame dimensions



Hill after hill



Defying gravity

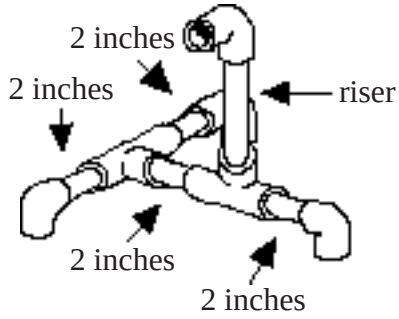


Hill and loop

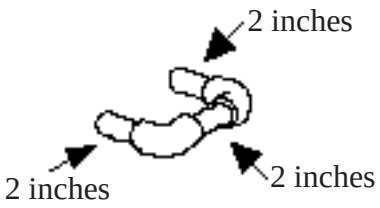
Speed Demon

Assemble the stand and stop as shown. Use a six inch riser for the stand.

STAND

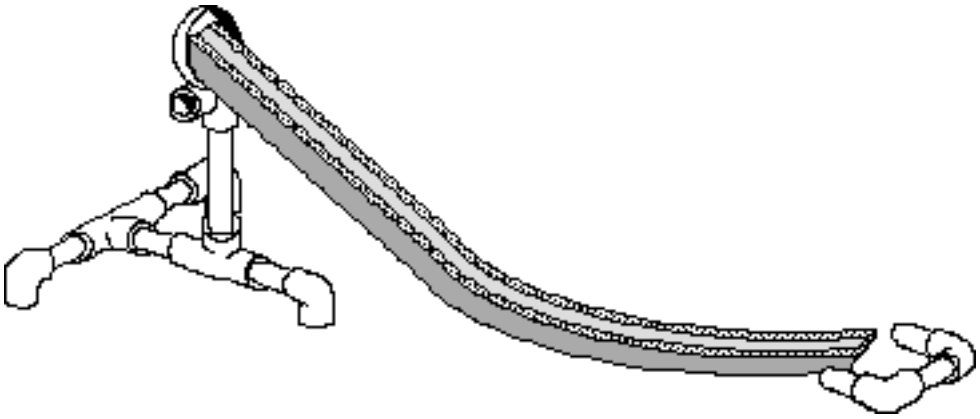


STOP



Tape a support ring to the stand and use it to connect the insulation tube to the stand.

Stretch the tube out as far as it will go and place the stop at the end to catch the marbles.



Release a marble at the top of the track and time how long it takes to hit the stop.

Repeat this three times and get an average time. Record the data on the next page.

Replace the six inch riser with a one foot riser and repeat the procedure.

Replace the one foot riser with a one and a half foot riser and repeat the procedure.

Does the height of the coaster affect the speed of the coaster?

_____

_____

SPEED DEMON

SHEET TWO

Does the Height of the coaster affect the speed of the coaster?

What do you think? What is your hypothesis?

HYPOTHESIS: I think _____

_____

_____

Riser	Test 1	Test 2	Test 3	Average	Speed ft/second
6 inch					
1 foot					
1 1/2 feet					

What did you find out?

CONCLUSION: _____

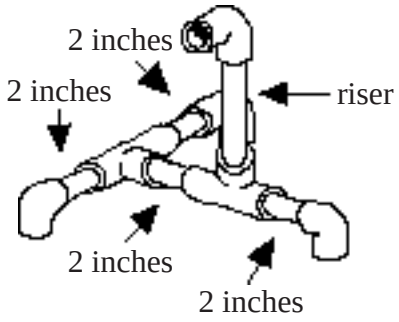
_____

_____

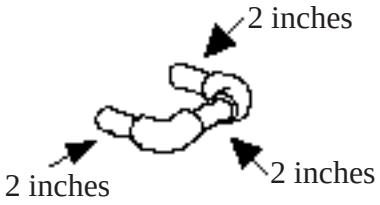
Speed Demon Too

Assemble the stand and stop as shown. Use a six inch riser for the stand.

STAND

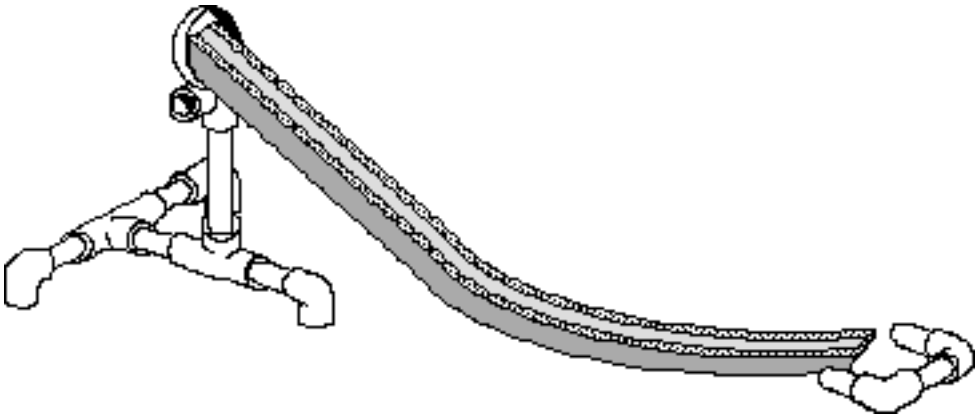


STOP



Tape a support ring to the stand and use it to connect the insulation tube to the stand.

Stretch the tube out as far as it will go and place the stop at the end to catch marbles and steel balls.



Release a marble at the top of the track and time how long it takes to hit the stop.

Release a steel ball at the top of the track and time how long it takes to hit the stop.

Repeat this three times and get an average time. Record the data on the next page.

Replace the six inch riser with a one foot riser and repeat the procedure.

Replace the one foot riser with a one and a half foot riser and repeat the procedure.

Does the weight of the coaster affect the speed of the coaster?

_____

_____

SPEED DEMON TOO

SHEET TWO

Does the Weight of the coaster affect the speed of the coaster?

What do you think? What is your hypothesis?

HYPOTHESIS: I think _____

_____

_____

MARBLE

Riser	Test 1	Test 2	Test 3	Average	Speed ft/second
6 inch					
1 foot					
1 1/2 feet					

STEEL BALL

Riser	Test 1	Test 2	Test 3	Average	Speed ft/second
6 inch					
1 foot					
1 1/2 feet					

What did you find out?

CONCLUSION: _____

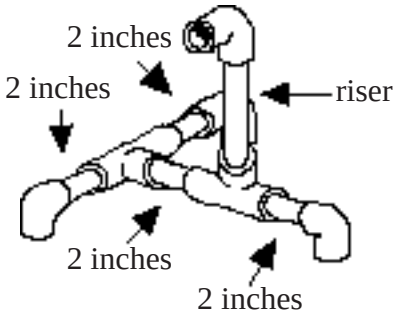
_____

_____

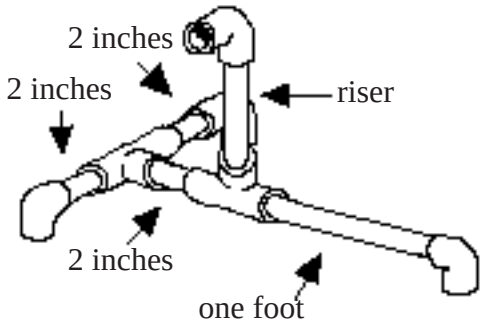
OVER THE HILL

Assemble the stands and stop as shown. Use six inch risers for both stands.

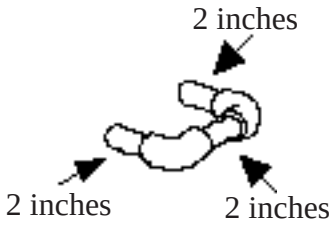
STAND 1



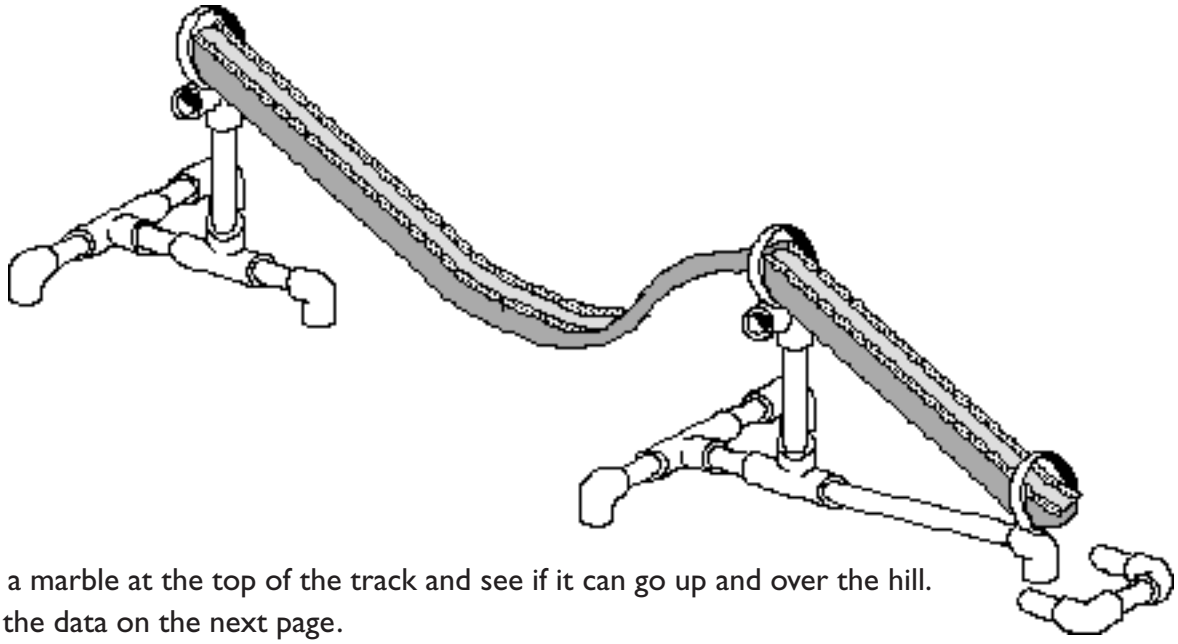
STAND 2



STOP



Tape three support rings to the stands to connect the insulation tube to the stands.
Adjust the stands to create the hill and place the stop at the end to catch the marbles.



Release a marble at the top of the track and see if it can go up and over the hill.
Record the data on the next page.
Replace the six inch riser on stand #1 with a one foot riser and repeat the procedure.
Replace the six inch riser on stand #2 with a one foot riser and repeat the procedure.
Replace the one foot riser stand #1 with a one and a half foot riser and the one foot riser on stand #2 with a six inch riser and repeat the procedure.
Replace the six inch riser stand #2 with a one foot riser and repeat the procedure.
Replace the one foot riser stand #2 with a one and a half foot riser and repeat the procedure.
Does the height of the coaster affect the momentum of the coaster?

_____

_____

OVER THE HILL

SHEET TWO

Does the Height of the coaster affect the momentum of the coaster?

What do you think? What is your hypothesis?

HYPOTHESIS: I think _____

_____

_____

Riser 1	Riser 2	Over the Hill?
6 inch	6 inch	
1 foot	6 inch	
1 foot	1 foot	
1 1/2 feet	6 inch	
1 1/2 feet	1 foot	
1 1/2 feet	1 1/2 feet	

What did you find out?

CONCLUSION: _____

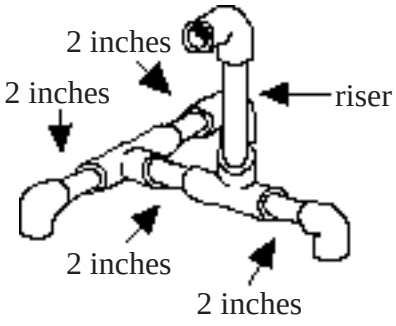
_____

_____

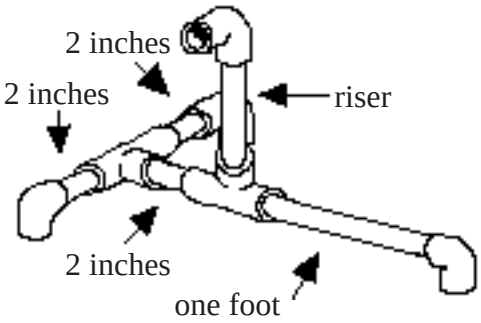
OVER THE HILL AGAIN

Assemble the stands and stop as shown. Use six inch risers for both stands.

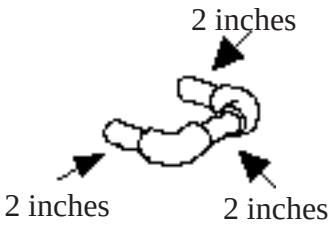
STAND 1



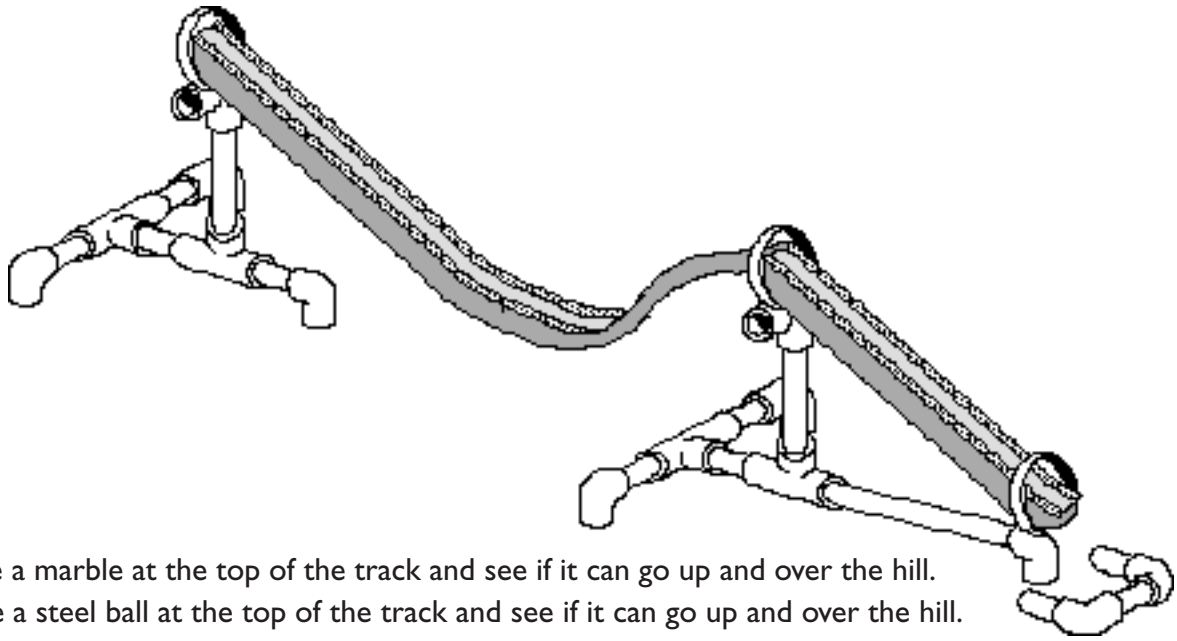
STAND 2



STOP



Tape three support rings to the stands to connect the insulation tube to the stands.
Adjust the stands to create the hill and place the stop at the end to catch the marbles.



Release a marble at the top of the track and see if it can go up and over the hill.
Release a steel ball at the top of the track and see if it can go up and over the hill.
Record the data on the next page.
Replace the six inch riser on stand #1 with a one foot riser and repeat the procedure.
Replace the six inch riser on stand #2 with a one foot riser and repeat the procedure.
Replace the one foot riser stand #1 with a one and a half foot riser and the one foot riser on stand #2 with a six inch riser and repeat the procedure.
Replace the six inch riser stand #2 with a one foot riser and repeat the procedure.
Replace the one foot riser stand #2 with a one and a half foot riser and repeat the procedure.
Does the weight of the coaster affect the momentum of the coaster?

_____

_____

OVER THE HILL AGAIN

SHEET TWO

Does the Weight of the coaster affect the momentum of the coaster?

What do you think? What is your hypothesis?

HYPOTHESIS: I think _____

_____

_____

MARBLE

Riser 1	Riser 2	Over the Hill?
6 inch	6 inch	
1 foot	6 inch	
1 foot	1 foot	
1 1/2 feet	6 inch	
1 1/2 feet	1 foot	
1 1/2 feet	1 1/2 feet	

STEEL BALL

Riser 1	Riser 2	Over the Hill?
6 inch	6 inch	
1 foot	6 inch	
1 foot	1 foot	
1 1/2 feet	6 inch	
1 1/2 feet	1 foot	
1 1/2 feet	1 1/2 feet	

What did you find out?

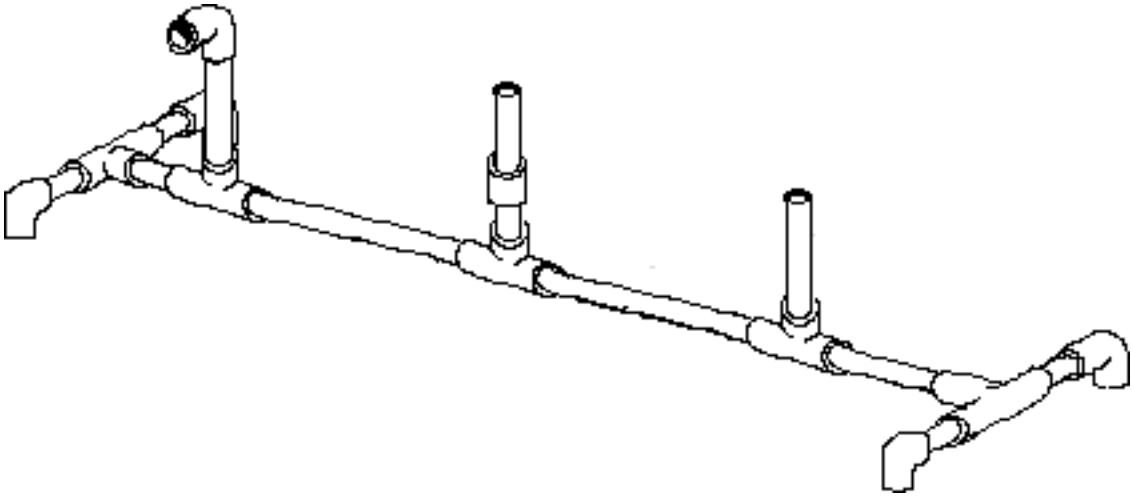
CONCLUSION: _____

_____

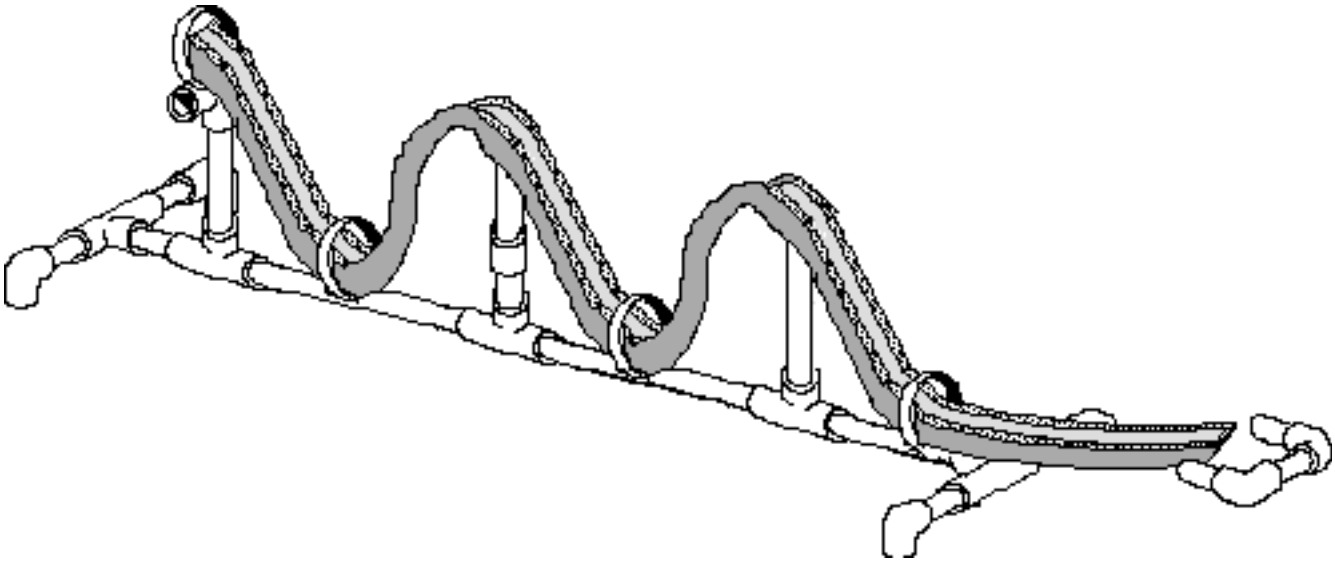
_____

HILL AFTER HILL

Experiment as as you assemble the hill after hill coaster. The drawing is not to scale so you will have to find the correct sizes for the pipe lengths to make the coaster work.

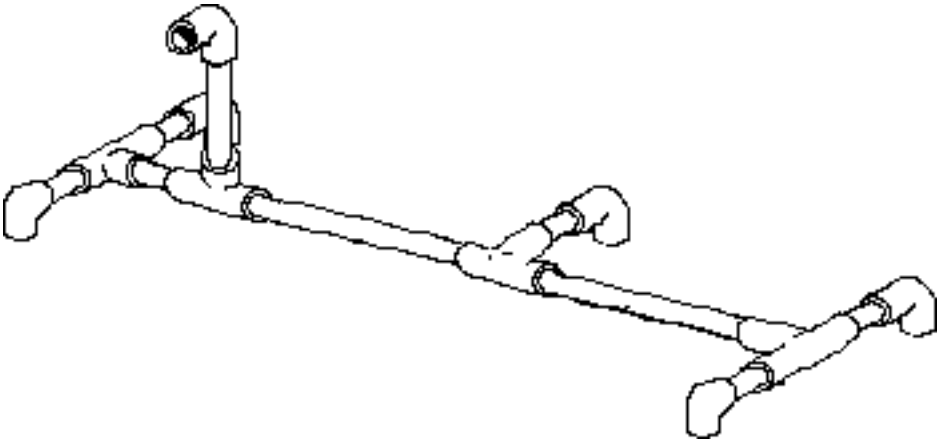


When a marble is released at the top of the track it should go up and over both hills and hit the stop. Mark the pipe length dimensions you used to build the coaster on the Worksheet.

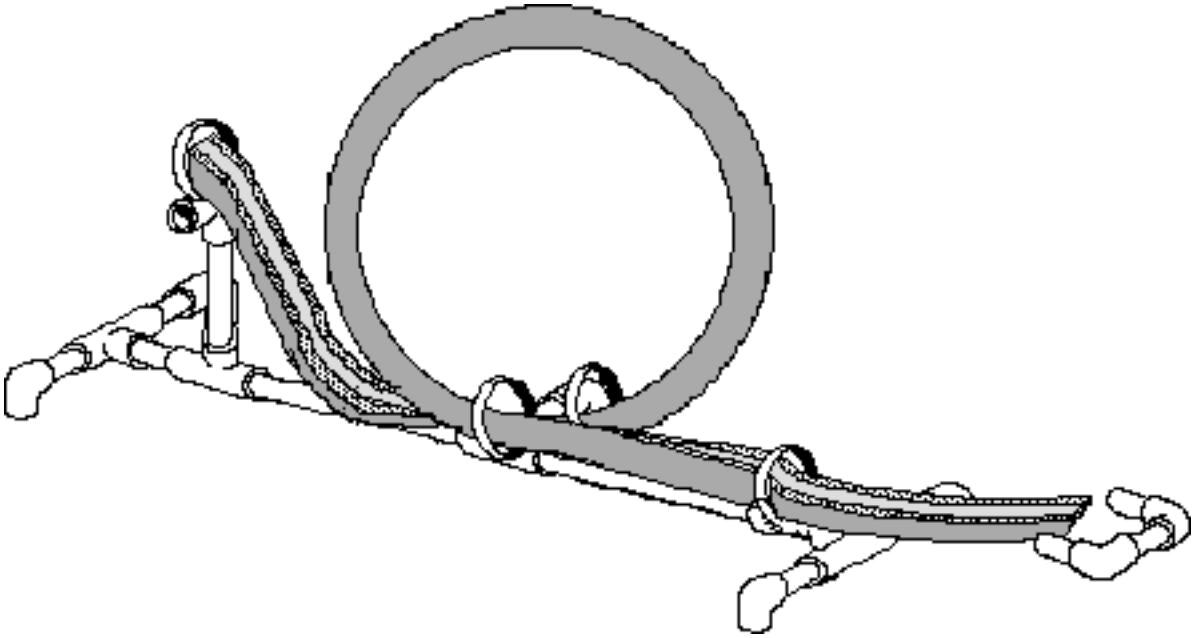


DEFYING GRAVITY

Experiment as as you assemble the defying gravity coaster. The drawing is not to scale so you will have to find the correct sizes for the pipe lengths to make the coaster work.

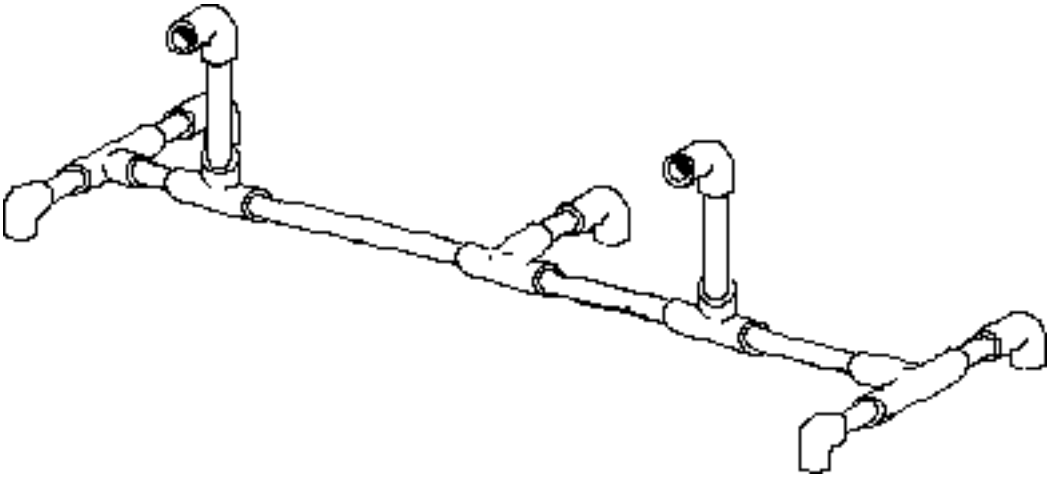


When a marble is released at the top of the track it should go up and around the loop and hit the stop. Mark the pipe length dimensions you used to build the coaster on the Worksheet.

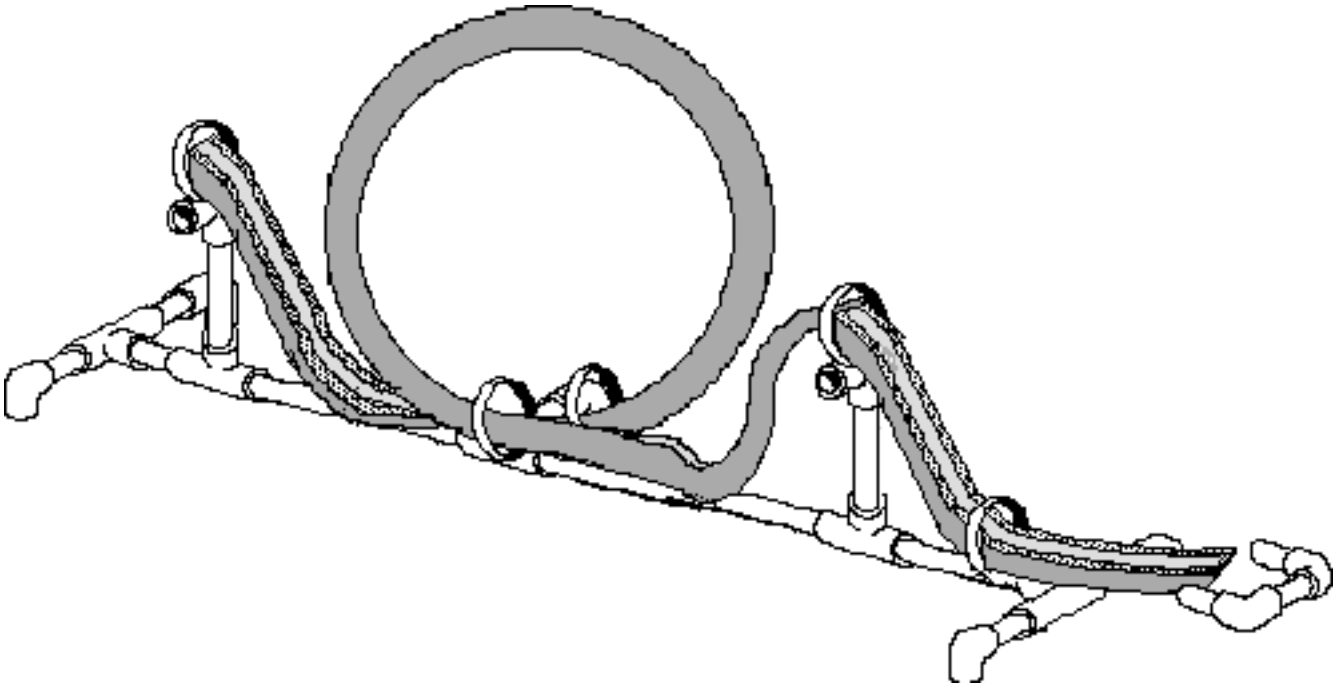


HILL AND LOOP

Experiment as as you assemble the hill and loop coaster. The drawing is not to scale so you will have to find the correct sizes for the pipe lengths to make the coaster work.



When a marble is released at the top of the track it should go up and around the loop, over the hill and hit the stop. Mark the pipe length dimensions you used to build the coaster on the Worksheet.



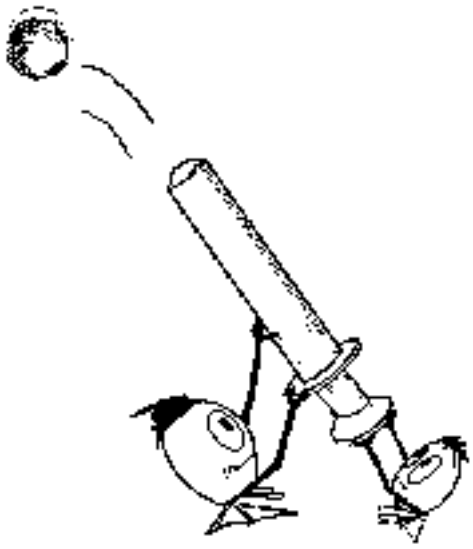
FREE FORM

Use what you have learned about roller coasters to design your own coaster. Experiment until you are happy with your design. Draw your design (both frame and coaster) on the worksheet. Give dimensions for all pipe lengths.

MY COASTER FRAME DESIGN

MY COASTER DESIGN

CANNON POWER



MATERIALS:

PVC pipe and fittings
Plastic bottle cap
Rubber bands
Marble and steel ball
Masking tape
Hammer
nail
Screw
Screw driver
1/2 inch dowel 6 inches long

PROCEDURE:

1. Have students assemble the cannon as shown on the Cannon Power Worksheet.

2. Have students use the marble and steel ball as cannon balls.

3. One student should fire the cannon while others watch to see how far the cannon ball travels.

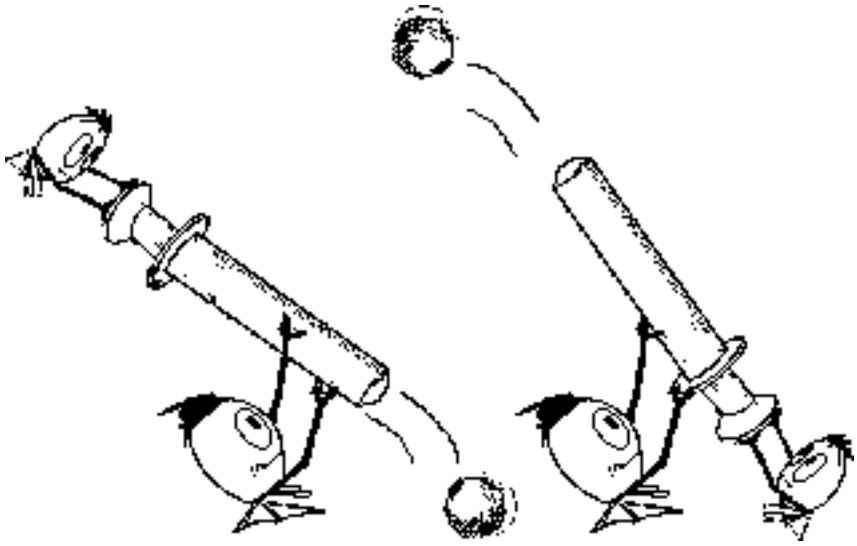
4. Release cannon balls from each power mark on the dowel.

5. Record the results on the worksheet.

6. Does the mass of the cannon ball effect the distance it travels?

7. Does the amount of force used on a cannon ball affect the distance it travels?

THE RIGHT ANGLE



MATERIALS:

PVC Cannon
Transparent tape
Scissors
Rubber bands
Marble and steel ball

PROCEDURE:

1. Have students add the angle markings to the cannon stand as shown on the Right Angle Worksheet.

2. Have students use the marble and steel ball as cannon balls.

3. One student should fire the cannon while others watch to see how far the cannon ball travels.

4. Release cannon balls from each angle marked.

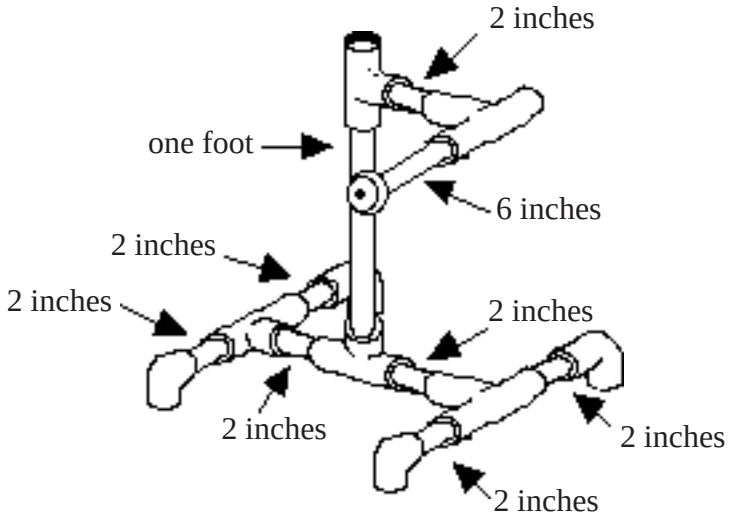
5. Record the results on the worksheet.

6. Does the angle of the cannon affect the distance the cannon ball travels?

7. Can the cannon hit the same spot from different angles?

CANNON POWER

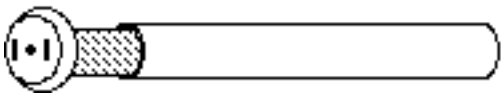
Assemble the cannon stand and cannon as shown.



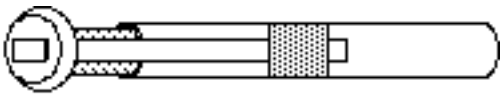
Use a hammer and nail to put a hole in the center of the bottle cap and the 1/2 inch dowel. Mark 8 lines on the dowel, one every 1/2 inch starting from the end without the hole. Number the lines one through eight. Use a screw driver to put slots in the bottle cap 1/4 inch either side of the hole. Screw the bottle cap on to the dowel. Cut a rubber band open and push the ends through the slots in the cap. Place the dowel inside a six inch piece of pipe. Stretch the ends of the rubber band to the end of the pipe. While holding the ends, tape the rubber band to the middle of the pipe.

Hole in center of bottle cap | Hole in center of dowel | Hole and slots in bottle cap

1/2 inch dowel 6 inches long with eight 1/2 inch marks



Dowel with bottle cap attached inside pipe



Complete assembly with rubber band

Make different size cannon balls by rolling pieces of clay. Make sure they fit inside the cannon.

One person fires the cannon while others watch to see how far the cannon ball travels.

Release cannon balls from each power mark on the dowel. Record the results on the worksheet.

CANNON POWER

SHEET TWO

Does the mass of the cannon ball affect the distance it travels?
Does the amount of force used on a cannon ball effect the distance it travels?

What do you think? What is your hypothesis?

HYPOTHESIS: I think _____

_____

_____

Ball	Force 1	Force 2	Force 3	Force 4	Force 5	Force 6	Force 7	Force 8
marble								
steel								

What did you find out?

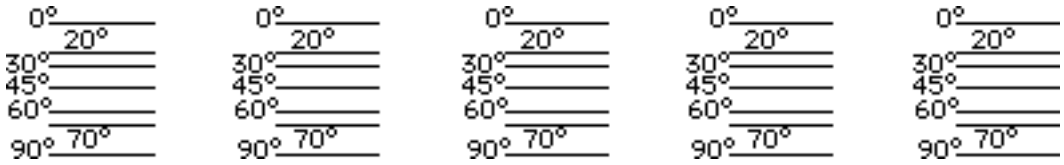
CONCLUSION: _____

_____

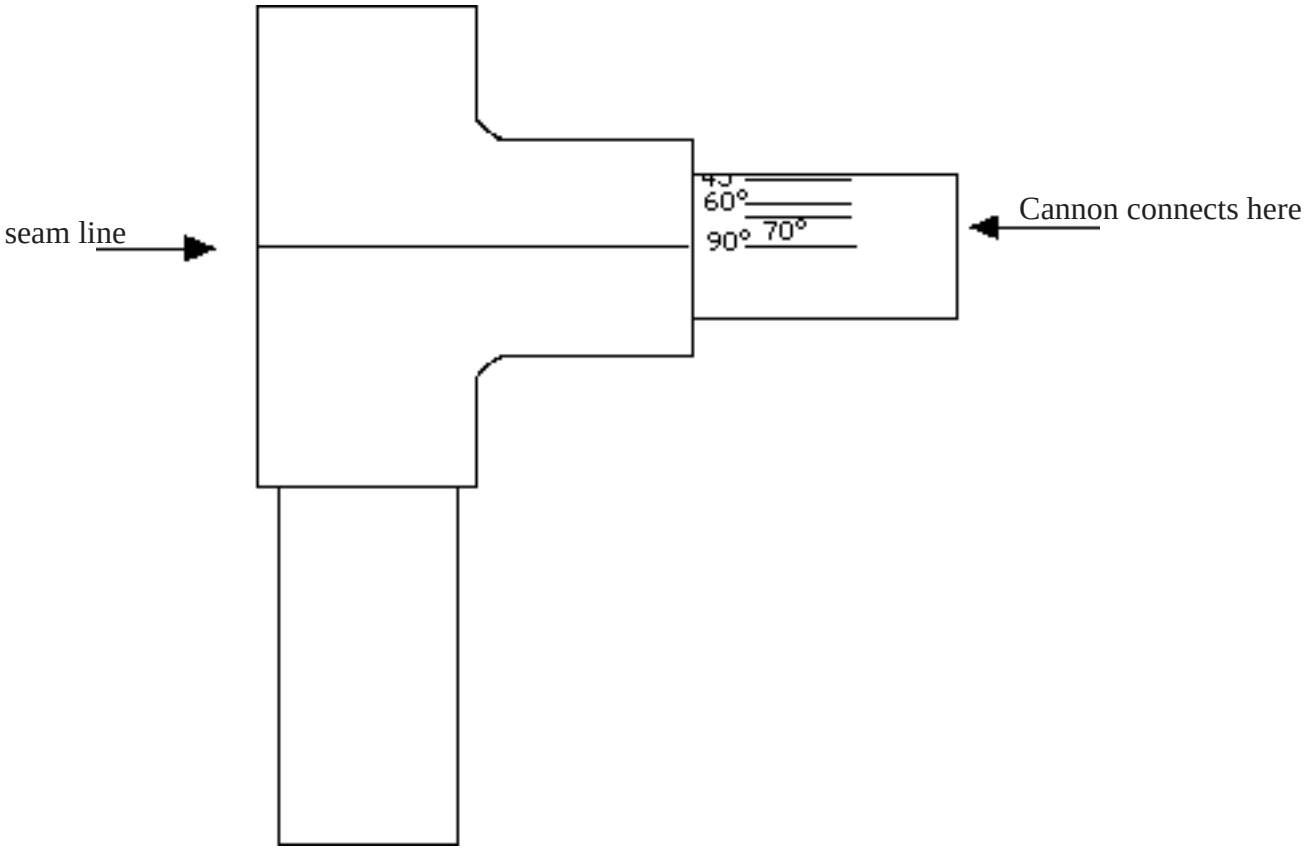
_____

THE RIGHT ANGLE

Add the angle markings to the cannon stand.



Cut out one of these angle markings and use transparent tape to tape it to the stand. Tape it to the two inch piece of pipe connectin the cannon to the stand. Make sure that the 90° mark is even with the seam line on the tee.



Use the marble and steel ball as cannon balls.

One person fires the cannon while others watch to see how far the cannon ball travels.

Release cannon balls from each power mark on the dowel and each angle on the stand. Use the seam line on the cannon's tee to mark the angle. Record the results on the worksheet.

THE RIGHT ANGLE

SHEET TWO

Does the angle of the cannon affect the distance the ball travels?
Can the cannon hit the same spot from different angles?

What do you think? What is your hypothesis?

HYPOTHESIS: I think _____

_____

_____

Angle	Force 1	Force 2	Force 3	Force 4	Force 5	Force 6	Force 7	Force 8
0 degrees								
20 degrees								
30 degrees								
45 degrees								
60 degrees								
70 degrees								
90 degrees								

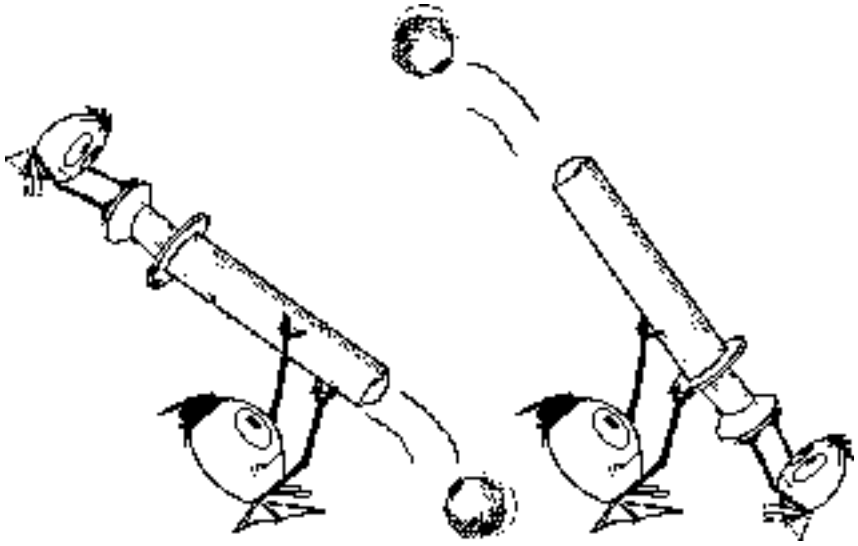
What did you find out?

CONCLUSION: _____

_____

_____

HIT THE TARGET



Now that you have experimented with your cannon, can you hit a target?
Place a cup about three feet from the cannon. Take a practice shot to see how far the cannon ball travels. Now adjust angle and force to get the cannon ball to land in the cup. How many shots will it take to hit the target? Record your data below.

Try	Short	Long	Hit
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Try	Short	Long	Hit
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Active Classroom™

239 South Wilton Place
Los Angeles, CA 90004
(323) 634-0848