Teacher Instruction

Phase 1
Variable Balloon Staging: Part 1

QuickView
Students work in small groups to construct balloon racers and test the effect of pressure on speed and distance.

Time Required
90 minutes (will vary with class size)

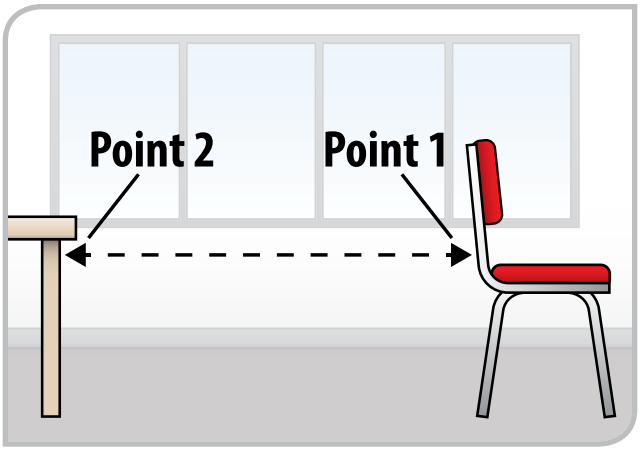
Content Areas
Primary: Science
Secondary: Math; technology

Vocabulary
- circumference
- pascals
- pressure
- psi
- volume

Materials
Kite string (or monofilament)
3 balloons
Stopwatch
Straws
Tape measure
"Balloon Racer" worksheet
Scissors
Transparent tape

Procedure
1. Find two points above the ground that are at least six meters apart to which you can connect a string (or monofilament). Point 1 and Point 2 should be the same height above the ground (at least 0.6 meter). There should be no slope to the string track. The backs of two chairs might work well (Figure 1).

   Groups of two to three students will probably work best for this activity, though the number of groups might be limited by the amount of space available to set up the experiment.



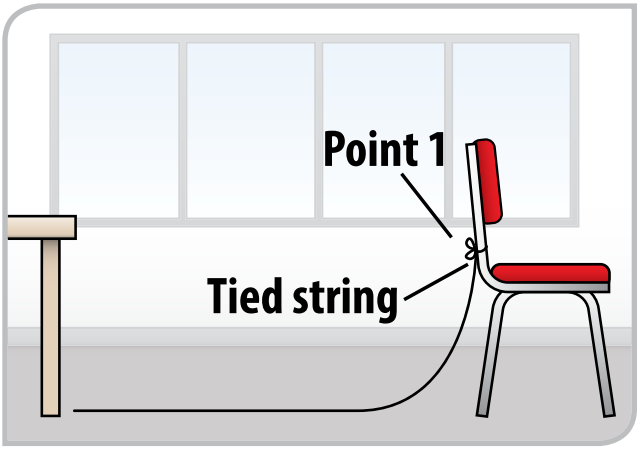
(Figure 1)

Teacher Instruction

2. Using the tape measure, measure the distance between these two points. Record this length on your "Balloon Racer" worksheet in the Setup 1 section. Record the slope as 0.

   Though an explanation of calculating slope is given on the worksheet, they might benefit from going over this as a class. Be sure to explain the terms rise *and* run.

3. Cut a length of string a little longer than this length and either tape or tie one end of the string to Point 1 (Figure 2).

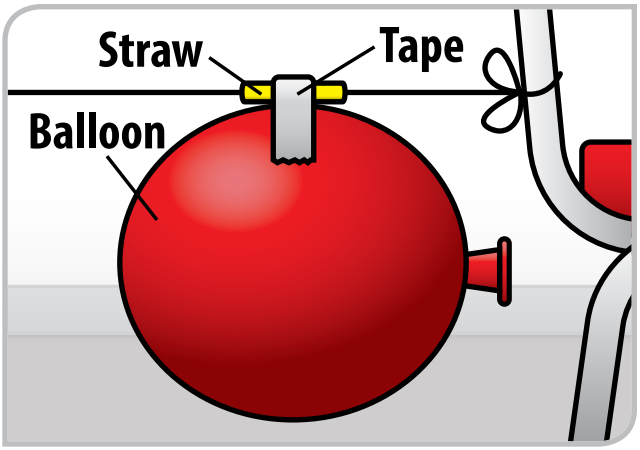


(Figure 2)

4. Thread the other end of the string through a straw and slide the straw all the way down the string to Point 1. Now, connect the loose end of the string to Point 2. Make sure the string is taut – stretched tightly between the two points.

   Though not strictly needed, a small piece of wire can be used to make the process of threading the string a little easier.

5. Cut two lengths of string. The first should be 60 centimeters. The second should be 75 centimeters. These pieces of string will be used to measure the amount of inflation.



(Figure 3)

6. Blow up one of the balloons until it is just large enough that the 60-centimeter piece of string goes around its circumference (the distance around the outside of a circle). The ends of the string should touch with no overlap.

   Students might need guidance on where to measure the balloon and measuring it at the same place each time.

7. Pinching the mouth of the balloon so that the air doesn't escape, tape the balloon to the straw at Point 1. The mouth of the balloon should be pointed at Point 1 (Figure 3).

8. Let go of the balloon. Time it with the stopwatch as it travels from Point 1 to whatever spot it stops at.

   You might want to have students practice using the stopwatch before actual data collection.

9. Write down the time on your "Balloon Racer" worksheet in the Trial 1 column. Measure how far it traveled and write that down as well.

10. Calculate meters per second using the method on the worksheet.

11. Repeat the experiment two more times, doing everything exactly the same way. This time, record your measurements and calculations in the Trial 2 and Trial 3 columns. Find the averages of the distance, time, and speed for Trial 1, Trial 2, and Trial 3 and record them.

12. Now, it is time to perform the experiment again with a different setup. This time, inflate the balloon until the circumference is 75 centimeters. Perform three trials with this setup and record the results.

    At this circumference, it is possible that a few balloons will be accidentally popped. Having a few spare balloons handy is strongly advised.

    If your class has access to a 3-D printer, there is a great optional enrichment activity here that emphasizes design and data gathering. Have the students design and print nozzles that will stay in the balloon to control the size of the opening that releases the air. You can have students track the effects of different sizes of openings. Does wider correlate to faster and farther?

13. For Setup 3, inflate the balloon to 60 centimeters. Change the slope of the string track. Lower Point 2 at least 0.3 meter. Calculate the new slope using the formula on your worksheet. Perform three trials with this setup and record the results.

14. On the worksheet, answer the question about Newton's third law. Leave the rest of the worksheet blank for now.

Student Instruction

Phase 1
Design: Graphics and Layout

QuickView
Review car designs you like and draw multiple thumbnail sketches to generate ideas for your own car. After creating at least three designs, select one and do a more detailed multiview drawing.

Materials
"Thumbnail Drawing Sheet"
"Multiview Design Sheet"

Engineering Design Process
1. Determine the problem or the opportunity (idea).
2. Determine the specifications.

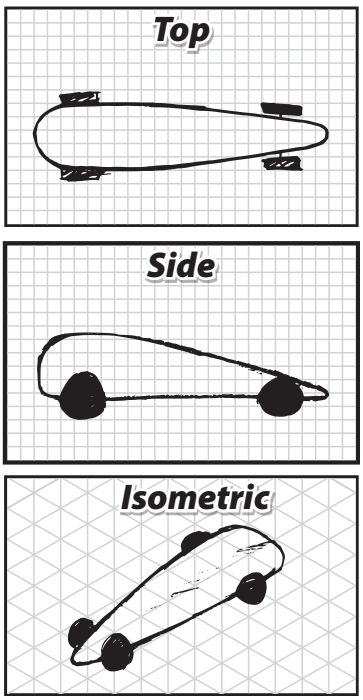
   The Design Loop

   A. Research.

   B. Brainstorm possible solutions.

   C. Formulate a solution to implement.

Procedure
1. Look through the collection of vehicle photos, both the real-world cars and the CO_2 dragsters. You will notice that many CO_2 cars are inspired by features of real cars but that they have a form all their own. Pick out several photos of cars that you like.
2. Sketch at least three car designs on your "Thumbnail Drawing Sheet." You can sketch more than three if you like. Each design should have a top, side, and isometric drawing. The designs you make do not need to look exactly like the cars in your chosen photos. In fact, they do not need to look like them at all. The photos are only for inspiration and ideas. The drawings you are making are only quick sketches. The point is to capture an idea, not to make a polished, perfect drawing (Figure 1).
3. After you have drawn three thumbnail sketches, decide whether you like any of these well enough to use it as a final design. If not, keep making more sketches. If one is close to being satisfactory but not quite where you want it to be, make another sketch of that design but with modifications that make it to your liking. Do not just erase sketches you have already made. Instead, create new sketches. Stop when you have at least three sketches and one that you really like.
4. When you have created all your thumbnail sketches, choose the one that you like the most. Study it and imagine how it will look from the side, from the top, from the front, and from the back.



(Figure 1)

Student Instruction

5. You will now transform your sketch into a series of detailed full-size drawings. Fill out the information at the top of the "Multiview Design Sheet." For Design Number, write the numeral 1. If you do another detailed drawing later, you will redraw it on another sheet with your changes and keep track of the number of designs you've made.
6. You will do a side-view and a top-view drawing. Before you begin drawing, however, look at the specifications indicated on the "Multiview Design Sheet." These tell you such things as how long or short the car may be and how far apart the wheels may be. When you make your drawings, make sure that you follow these specifications.
7. Make a detailed side-view drawing of this sketch on the "Multiview Design Sheet." You will make your drawing full scale, which means that your drawing will be the same size that you want your car to be. If your car will be 220 millimeters inches from front to back, so will your drawing. When making a side-view drawing, show only the side. You should not show any of the top, bottom, back, or front. Include the placement of the screw eyes on this drawing. (These should not be placed below the axles.)
8. Make a top-view drawing on the "Multiview Design Sheet." Just as before, the drawing will be at full scale. Show only the top of the vehicle. To do this, imagine that you are standing directly over your vehicle and looking down at it. Use the graph lines to make sure that the two drawings are aligned.
9. If time remains, you may also draw a front-view drawing and a back-view drawing. You may also add details to your car such as decals and painting ideas.
10. Save all your work in your portfolio.

Thumbnail Drawing Sheet

Student Designer/Engineer: _____

Teacher: _____

Date: _____ Car Name: _____

THE SCIENCE of Speed 2

1	Top	Side	Isometric
2	Top	Side	Isometric
3	Top	Side	Isometric