Teacher Instruction

Phase 1
Design: Graphics and Layout

QuickView
The students review car designs that they like and draw multiple thumbnail sketches to generate ideas for their own cars. After creating at least three designs, the students select one and do a more detailed multiview drawing.

Time Required
45-135 minutes

Content Areas
Primary: Engineering
Secondary: Math

Vocabulary
- brainstorming
- scale
- thumbnail

Materials
"Thumbnail Drawing Sheet"
"Multiview Design Sheet"

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

   The Design Loop

   A. Research.

   B. Brainstorm possible solutions.

   C. Formulate a solution to implement.

Procedure
Before this activity, encourage students to bring photos of cars they like to class. These can include concept cars, race cars, drag racers, or any car with a design the student admires. You may also choose to provide a set of your own photos for students to peruse. Also provide several photos of CO_2 dragster cars to show students the typical form of these vehicles. The images will stimulate imagination and dialogue.

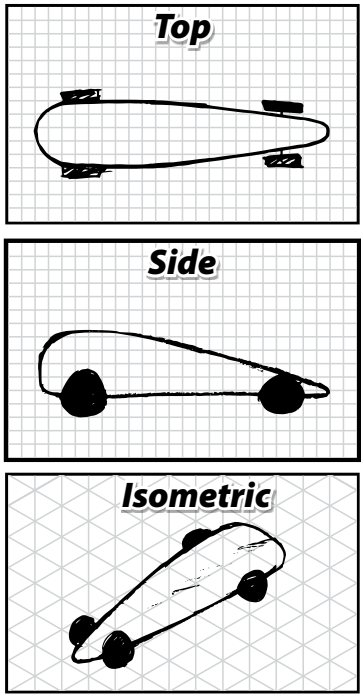
It is recommended that students do their sketching and drawing by hand, at least at first. If you have the resources, you may have students each create a CAD version of their multiview design after they have settled on a design. They could then make adjustments to the CAD file and save each updated draft with a new name.

Teacher Instruction

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).

   This is one of those times when extreme attention to detail is not desired. If students are being too perfectionistic about their drawings, you may urge them to speed their sketching process a little. Consider doing some preliminary sketches with a very short time limit, such as one or two minutes, to get students used to the idea that these are quick sketches, not detailed sketches.



(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.

   Watch students as they sketch to ensure they are not just continually erasing their vehicles and redrawing them. A little bit of erasing is fine, but it is good for them to have a record of the way their ideas have changed. Emphasize that this is an important part of the design process.

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.

   The "Multiview Design Sheet" has outlines of the body blank that should help students understand the concept of multiple views. However, it might take a little more explanation to convey the concept. One technique is to use blocks as manipulatives. These can be arranged in ways that clearly and comprehensibly demonstrate the difference between the different views. An Ortho-Box™, available from Hearlihy, is a product that can help explain the concept in a powerful way.

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.

   Some teachers might still wish to use blank sheets of 11" x 17" graph paper instead of the "Multiview Design Sheet" for more advanced students. If you take this route, it is doubly important to emphasize sticking to the specifications.

6. You will do a side-view, a top-view, and a rear-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.

In the next activity, students will be assessing their vehicle drawings to make sure they are within the specified ranges. It is not necessary that they get everything right at this point because they will have time to make corrections.

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 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.)

   Providing the available dragster wheels for your students to trace and instructing them to place the center of the wheel where they imagine the axle to be might help them visualize their designs and save time during the measurement and redesign stage.

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.

   If there is time, a rear-view drawing in particular is helpful. It prompts students to think about the safe space around the cartridge hole. Students will also have an easier time with the rear view. The front view is considerably more difficult technically.

10. Save all your work in your portfolio.

Student Instruction

Phase 1
Variable Balloon Staging: Part 1

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

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

Procedure

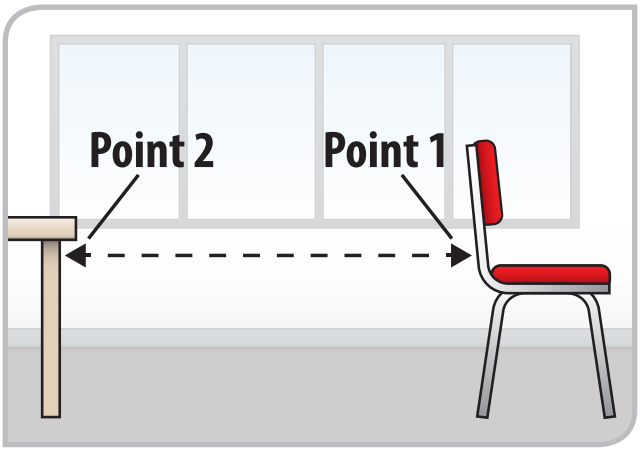
1. Find two points above the ground that are at least six meters apart to which you can connect a string (or monofilament). Point 1 and Point 2 should be the same height above the ground (at least 0.6 meter). There should be no slope to the string track. The backs of two chairs might work well (Figure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

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.

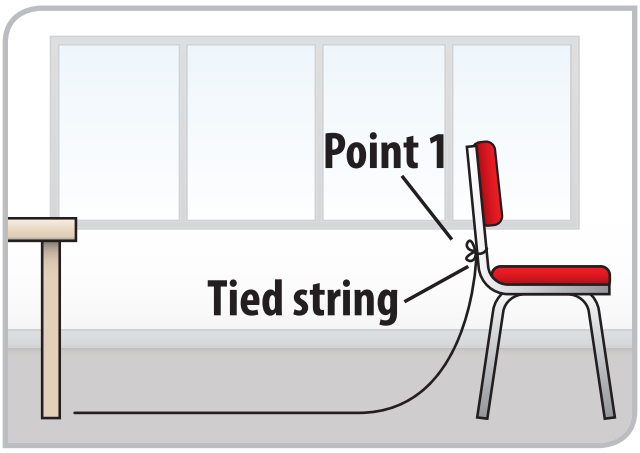
3. Cut a length of string a little longer than this length and either tape or tie one end of the string to Point 1 (Figure 2).

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.

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 1)



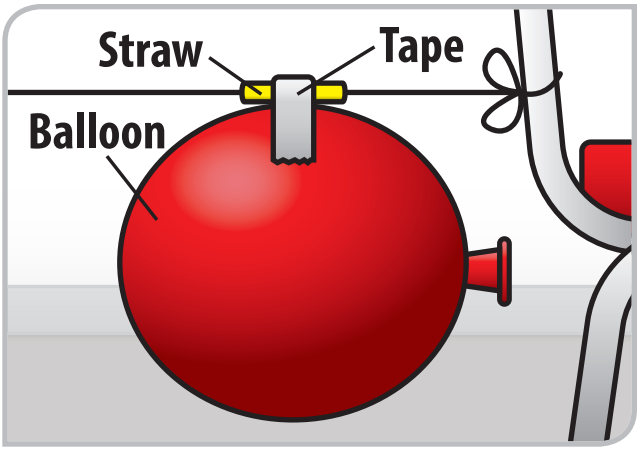
(Figure 2)

Student Instruction

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.

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.



(Figure 3)

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.

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.

Balloon Racer Worksheet

Student Designer/Engineer: _____

Teacher: _____

Date: _____ Class Period: _____

Setup 1

String length: _____

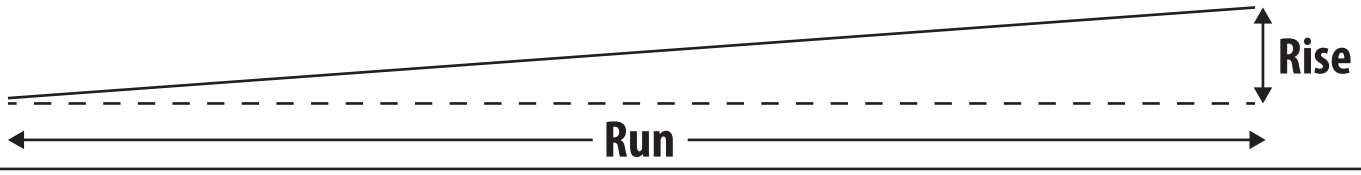
Balloon circumference: _____

Slope* = $\frac{\text{Rise}}{\text{Run}}$ ⟶ _____ = _____

	Trial 1	Trial 2	Trial 3	Average
Distance				
Time				
Speed**				

*The formula for calculating slope is rise over run, written as a fraction. Measure the difference in height between Point 2 and Point 1. This is your rise. The run is the length between the two points. This can be measured in centimeters or meters, but your units should be the same for both measurements. Reduce the fraction to lowest terms.

**To find the speed, divide the distance (in meters) traveled by the time (in seconds) taken. Write the answer in mps, or meters per second.



Setup 2

String length: _____

Balloon circumference: _____

Slope = $\frac{\text{Rise}}{\text{Run}}$ ⟶ _____ = _____

	Trial 1	Trial 2	Trial 3	Average
Distance				
Time				
Speed				

Setup 3

String length: _____

Balloon circumference: _____

Slope = $\frac{\text{Rise}}{\text{Run}}$ ⟶ _____ = _____

	Trial 1	Trial 2	Trial 3	Average
Distance				
Time				
Speed				