BioEd℠

Think like an Engineer

TEACHER'S GUIDE

Rocket Cars

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Baylor College of Medicine

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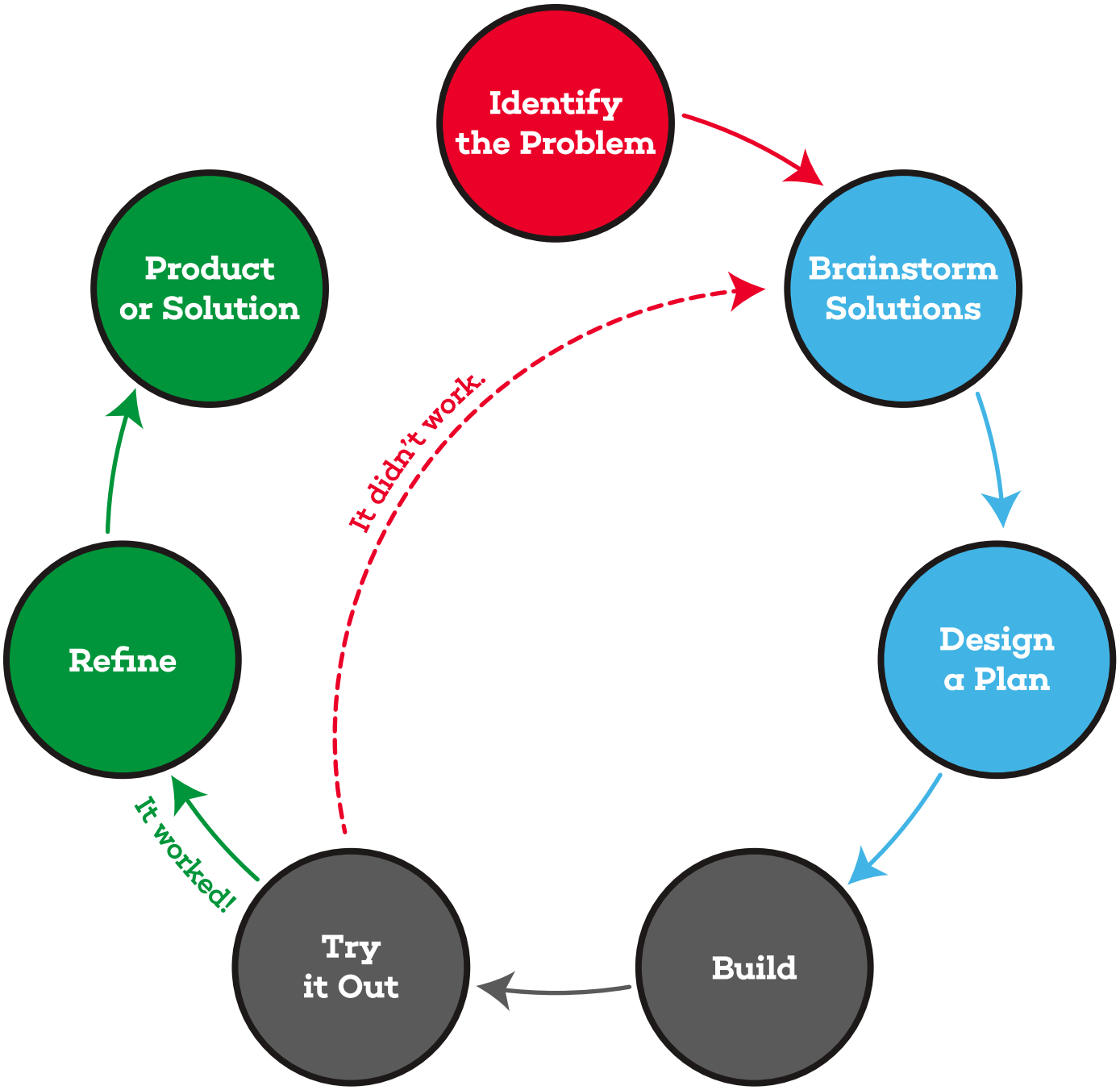
An Engineer's Approach



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Rocket Cars
Off to the Races

Time
3 sessions to build, test and modify/retest

Before You Start
Construct a sample rocket car to demonstrate to students how to operate their vehicles.

Create a "racetrack" with a 10-meter strip of masking tape. Use a marker to indicate one-meter intervals on the course.

Obtain 24 Styrofoam™ trays (no sections).

Make 24 copies of the "Wheel Patterns" page on card stock for students to use as templates when cutting wheels from the Styrofoam™ tray.

Optional: Obtain 26 plastic drink covers (4 per student) to serve as wheels.

You Need This Stuff
Teacher Materials
- 10-meter strip of masking tape
- Meterstick

Per Student
- 2 coffee stirrers (axles)
- 2 non-bending straws (sleeves for axles)
- 2 round, 12.7 cm (5 in.) size balloons
- Flexible straw
- Masking tape
- Pair of scissors
- Sandpaper
- Sharp pencil
- Styrofoam™ tray (large, no sections)
- Copy of "Design Plan," "Build a Rocket Racer," and "Rocket Racer Data" pages
- Copy of the "Wheel Patterns" page on card stock

What It's About
All vehicles, whether designed for land, sea, air or space, are governed by the scientific principles stated in Isaac Newton's Laws of Motion. In brief, the laws are as follow.

First Law: An unbalanced force is required to cause an object to change its state of motion or rest. Once in motion, an object will continue moving in a straight line until acted upon by an unbalanced force. Imagine two people pushing on each other. If they are equally strong, neither will move because the opposing forces are balanced. If one person is stronger than the other, the forces are unbalanced and the weaker person will be pushed backward.

Second Law: An object's acceleration is directly proportional to the force exerted on it and inversely proportional to its mass. In other words, the less mass an object has, the more that object will accelerate when it is acted upon by an unbalanced

On May 23, 1928, Fritz von Opel (known as "Rocket Fritz") drove the OPEL RAK2 at 238km/h. The car was powered by 24 powder rockets (ignited by a foot pedal), and had wings to compensate for uplift, which kept the car on the ground.

OPEL RAK2: Public domain. (http://www.mad4wheels.com/webpics/hires/00008282%20-%201928%20Opel%20Rak2%20-%20race%20car/1928_Opel_Rak2_-_race_car_001_0938.jpg)

force. Acceleration also can be increased if the force is increased (f=ma).

Third Law: Every action is accompanied by an equal and opposite reaction. When force is applied to an object, the object exerts an equal opposing force. Consider what happens when someone fires a shotgun. The pellets fly out of the barrel and the shooter is pushed back by a strong "kick."

Shown above is the fully electric Formula Student car developed and built by 60 students at Eindhoven University of Technology, The Netherlands. The annual engineering competition is run by the Institution of Mechanical Engineers, UK.

Rockets are an excellent example of the Laws of Motion at work. This activity demonstrates all three laws. Students construct and test a lightweight "rocket" car propelled by the action/reaction force of air escaping from an inflated balloon. The escaping air exerts an unbalanced force on the car, shifting it from a state of rest to a state of motion. The force of the balloon squeezing on air inside accelerates the car when the air is released. Because the car's mass is very low, it impedes the acceleration minimally. If the car were heavier, it would accelerate more slowly. Finally, the balloon's wall exerts an action force on the air, causing it to shoot out the nozzle. This creates an equal and opposite reaction force that propels the car. When the balloon's air runs out, there is no more force to push the car, which coasts until friction brings it to a stop.

What's the Question?

How can a balloon propel a race car?

What to Do

1. Announce to your class that this is the day of the big rocket car race. Each student will design and build a rocket car, and race his/her car on the track in the hall. Show your students a sample race car. Explain that this is only one possible design, and that their cars could look very different.
2. Demonstrate how the car works. Inflate the balloon by blowing through the straw. Pinch the straw and set the car on the floor. Release the straw and away the car goes!
3. Distribute the student sheets. Have students brainstorm design ideas as a group. Then have each student plan a car and draw pictures of what he/she wants his/her car to look like on the "Design Plan" sheet. Finally, have students begin construction on their cars.
4. Give each student a large Styrofoam™ tray, explaining that the car and its wheels must be made from the tray. Show students how to cut the pieces for their designs. If you are not using scissors, demonstrate the pencil trick: outline the pieces by punching the Styrofoam™ with a sharp pencil tip. When the outlines are completely punched, break out the pieces. Smooth the rough edges by rubbing them against a hard surface. It is especially important to smooth the edges of the wheels. Have students use sandpaper to refine the edges. (Optional: Obtain plastic drink covers from a restaurant to use as wheels.)
5. Show students how to create sleeves for the axles by cutting the non-bending straws. The sleeves should be shorter than the coffee stirrers.
6. When students have drawn and cut out all their car pieces, show them how to create wheel sets. Press one end of a coffee stirrer (axle) through the center of a wheel. Extend the end of the stirrer about a centimeter through the other side, and hold it in place with a small piece of masking tape. Slip a non-bending piece of straw over the stirrer. Then attach the other wheel to the opposite end of the stirrer. The

wheels should turn freely when you hold the axle by the straight straw covering the stirrer. Repeat this process for the second pair of wheels.

7. When both wheel sets are complete, mount them on the bottom of the car platform. Use masking tape to hold them in place. Make sure the wheels are not pressed against the platform and that they turn freely.
8. Pre-inflate the balloon once to make it easier to re-inflate when the car is finished. Insert the short end of a flexible straw into the balloon nozzle. Use masking tape to attach the balloon securely to the straw. Squeeze the tape around the straw to seal any leaks.
9. Mount the straw and balloon to the upper surface of the car's platform with masking tape. Be sure the long end of the straw extends off the back of the platform.
10. Have students test their cars, and explain that they may not perform as well as expected. Allow time for students to make needed design improvements before the "official" race. Mention that wheels that are not round, don't turn freely, or not mounted straight will affect speed and direction.
11. When all rocket cars are ready, organize races on the track in the hallway. For each trial, have two entrants inflate their balloons and hold their cars just behind the starting line. After a short countdown, have students release their straws. The fastest, straightest-running car wins!

Wrapping Up

1. Conduct a post-race talk show, during which racers explain their accomplishments. What worked? What didn't? How did they solve problems? What's the best rocket racer design?
2. Ask students how they would redesign their rocket cars to improve performance.
3. Lead a class discussion about the impact of friction on the performance of students' rocket cars. Ask, *What are some possible sources of friction?* (Wheels not round or rubbing on the frame, rough "track" surfaces, balloon touching the floor or front wheels, etc.)

Extra

Have students design their ultimate rocket race cars.

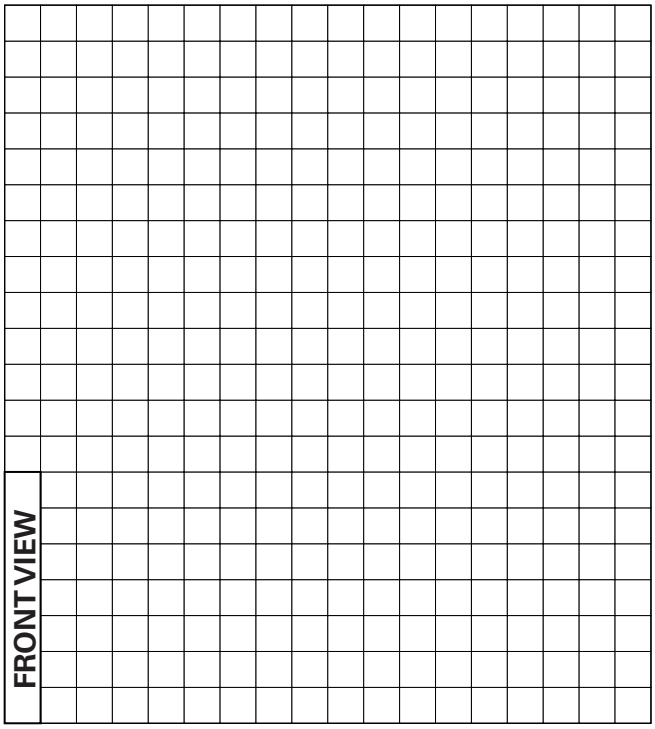
Design Plan

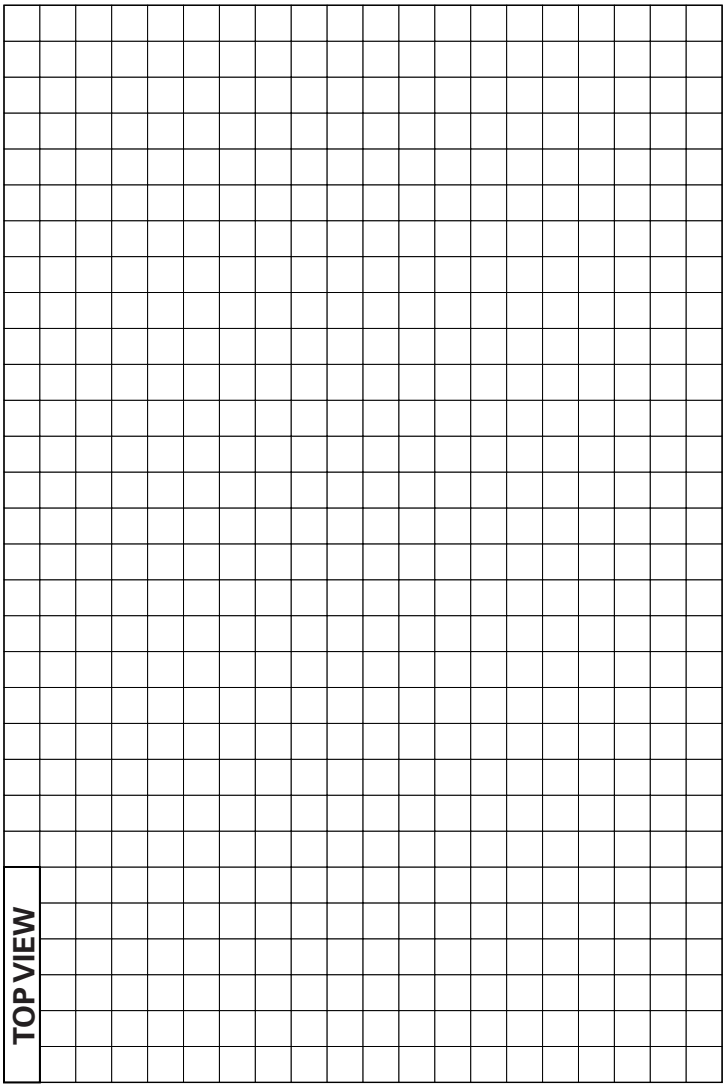
Name

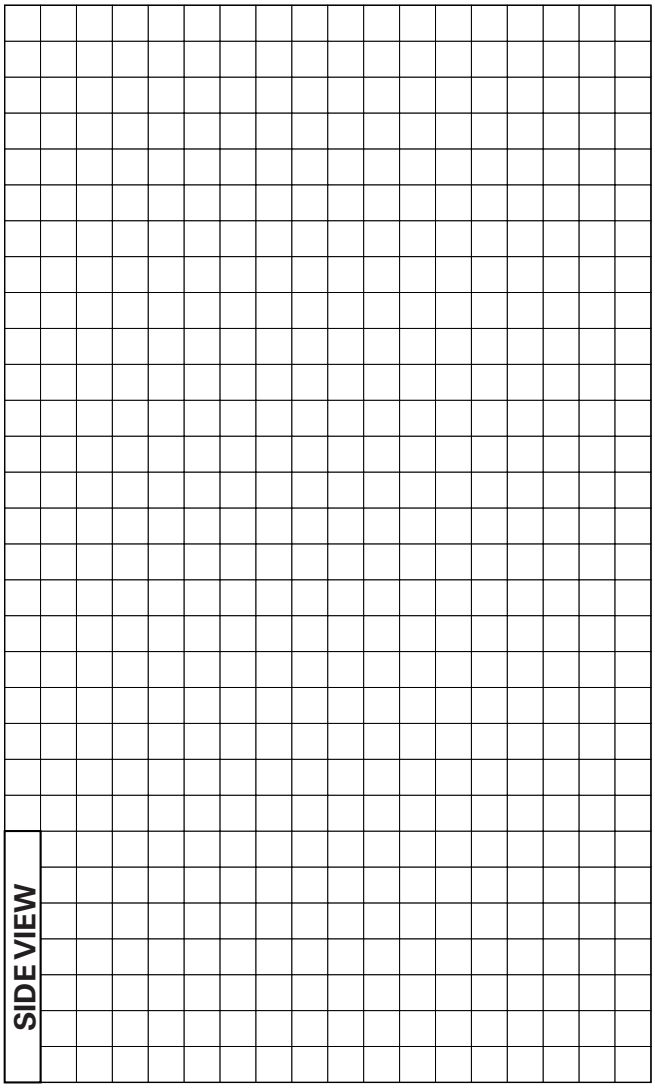
1. Draw your best design for a rocket racer. Show the racer from three views: top, side and front.

2. Use the following scale.

   Each square represents 1 cm.



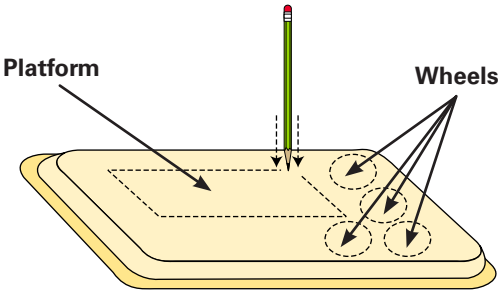




Build a Rocket Racer

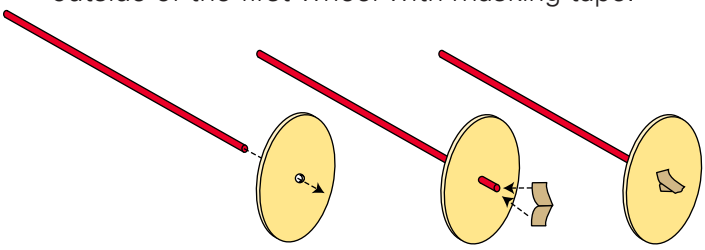
Read the instructions below and refer to the illustrations to build a rocket racer. Keep in mind that your racer does not have to look exactly like this one. *Try different numbers of wheels and different shapes for the racer's frame!*

1. Use a sharp pencil and wheel templates to punch out wheel patterns on the Styrofoam™ tray. Punch out a pattern for the racer's platform. Break the pieces out of the tray. Use sandpaper to make sure the wheels are smooth and round.

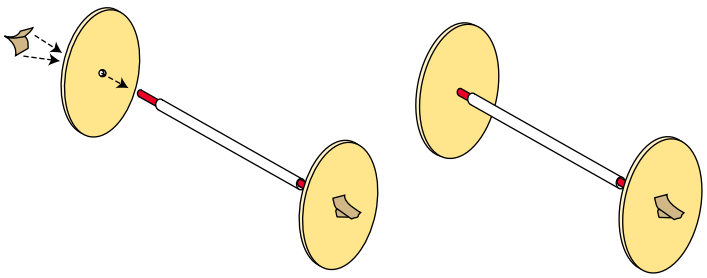


2. Cut two non-bending straws so that they are a bit shorter than a coffee stirrer.

3. Use a coffee stirrer (axle) to punch a hole in the center of one wheel, then punch another hole in a second wheel. Push the tip of the axle just a little bit through the wheel. Secure the axle to the outside of the first wheel with masking tape.

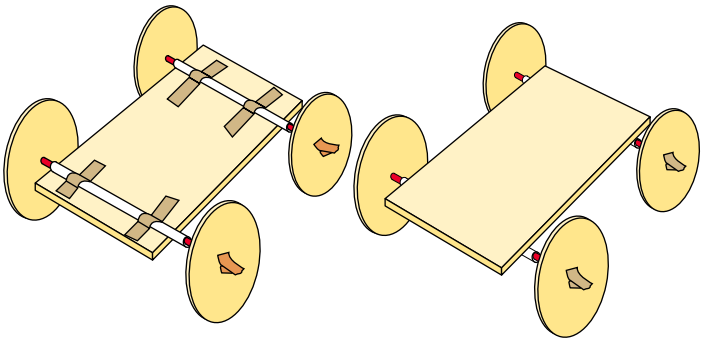


4. Slip a shortened straw (sleeve) over the axle. Attach a second wheel to the other end of the axle. This is one wheel assembly. *Tip:* Leave a bit of room on the inside of the wheels so that you can see the axle inside of the sleeve.

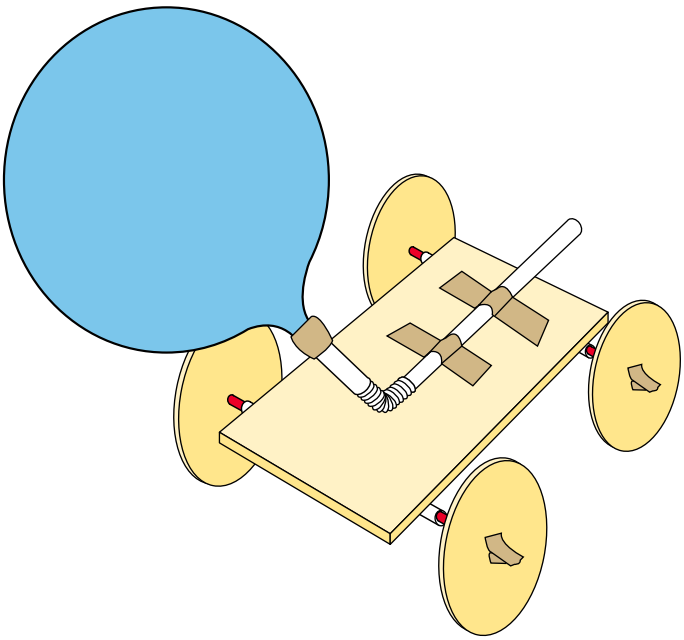


5. Repeat the steps above to create at least one more wheel assembly.

6. Tape the sleeves of both wheel assemblies to the racer's frame.



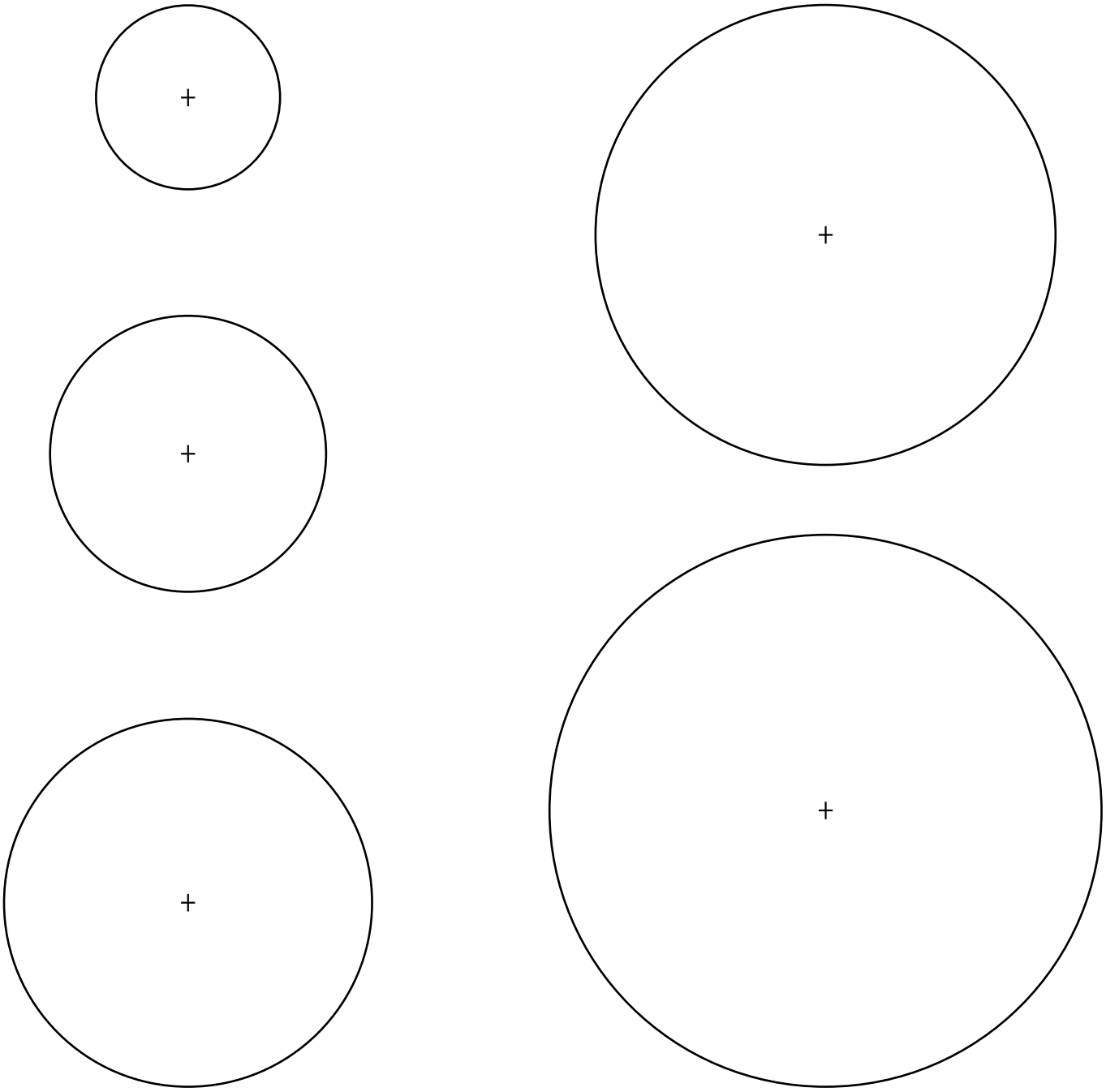
7. To complete the race car, insert the shorter part of a flexible straw into the end of a round balloon. Secure it with tape. Bend the straw and tape its longer end to the racer's platform.



Wheel Patterns

1. Select the wheel size for your rocket racer. Cut out the shape you wish to use as a template for your wheels. *You may use more than four wheels for your racer, as well as different shaped-wheels.*

2. Notice the "+" in the center of each pattern. This is where you should use a coffee stirrer to punch a hole in the Styrofoam™ wheel. (See instructions and illustrations on the "Build a Rocket Racer" sheet.)

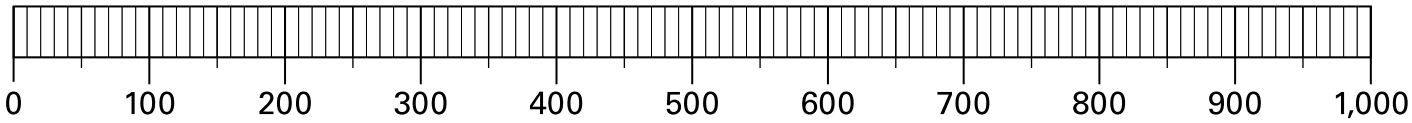


Rocket Racer Data

_____
Name

For each trial, color in the graph to show how many centimeters your rocket racer traveled. Then answer the questions below on the back of this sheet or on a separate sheet of paper.

TRIAL 1: Initial Design



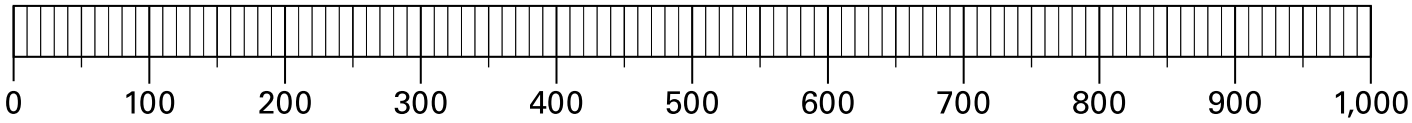
1. How did your rocket racer run (straight, curved, circles, stuck, etc.)?

2. Did your racer perform as well as you hoped? Explain why or why not.

TRIAL 2: Modifications 1

1. How did you improve your rocket racer?

2. Predict how far your modified racer will run. _____ cm.



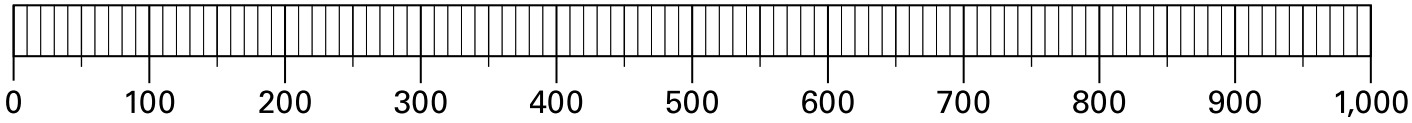
3. How did your modified rocket racer run (straight, curved, circles, stuck, etc.)?

4 Did your improvements work? Explain why or why not.

TRIAL 3: Modifications 2

1. How did you improve your rocket racer?

2. Predict how far your modified racer will run. _____ cm.



3. How did your modified rocket racer run (straight, curved, circles, stuck, etc.)?

4 Did your improvements work? Explain why or why not.