

Designing and Building A Rocket Car: The Distance Challenge



Overview

Using new and recycled materials, students construct rocket cars that use a balloon and straw “rocket” to move. Students will “race” the cars to see which can go the farthest before revising their design and “racing” again.

What’s the point?

This is a demonstration of Newton’s third law of motion (every action has an equal and opposite reaction). This is the same principle rockets use to move. By burning fuel, mass, in the form of exhaust, exits the rocket engine and pushes the rocket forward. In this case, the air from the balloon is the mass that exits the straw that propels the car forward. If the air does not provide enough force (thrust), the car will not go very far. The same is true with a rocket!

Engineers, when considering how to design something, need to define their goals and constraints. In this activity, the goal is for the rocket car to go in a straight line as well as very far with the limited thrust provided by the balloon and air. The constraints will vary with the design, however, everyone will be constrained by: 1) Gravity which pulls everything down; 2) Friction between the race track and the wheels; 3) Friction experienced by the car’s axle rubbing against the bushing (to be explained later); 4) Air friction that drags on the car (from the air around us!); and 5) The amount of air in the balloon. Minimizing the effects of these constraints is the key! For example, having very smooth wheels will create less friction, or maybe the shape of the car will reduce the friction of the air around it etc.

Engineers always test, test, and re-test, and then revise their designs and test them again before they settle on a finished product. They may have to re-design over and over again, so we call it the engineering cycle. There is always room for improvement and innovation. It’s okay to start something over again if it doesn’t work the first time.

Learning goals

After doing this activity, students will be able to:

- Define the parts of his/her car and how they work.
- Explain Newton’s third law and how it applies to a rocket car.
- Identify how the design could be improved.

Time

1-1.5 hours

Materials

Materials to share:

- Masking tape
- Clear tape
- Children's scissors (several pairs)
- Rulers
- Sharp pencils
- (Optional) Modeling clay or sticky tack
- Measuring tape to measure the race course
- Glue sticks

Materials for every group of two or three:

- One bendy straw
- One 4-or 5-inch round balloon

Materials for instructor and/or requiring instructor assistance:

- An awl to make holes in plastic bottle caps or jar lids
 - OR alternately, a block of wood, a hammer and thick nail
- (Optional) Hobby knife or box cutter (X-acto or similar)
- (Optional) Hot glue
- White glue, distribute sparingly (ensure students are not gluing down a part that should spin)
- Sandpaper
- Black sharpie

Materials for Car parts:

Note: In the spirit of the maker's movement, cars can take almost any shape! Be sure to have choices of materials to encourage exploration. We recommend using mostly found and recycled items. If available locally, consider visiting a store for recycled materials such as the Resource Area for Teaching (RAFT). Soliciting donated materials from parents or coworkers is highly encouraged! Suggested materials are on the following page.

For Chassis (body) of car, one per group:

- Styrofoam food trays (ask for donations from the supermarket, 3/16” work best)
- Styrofoam plates (heavy duty)
- Rectangular scraps of cardboard
- Shoe boxes
- Small boxes
- Paper towel tubes
- Foam core board
- Stiff paperboard
- Plastic food storage containers
- Berry baskets
- Egg cartons
- Empty plastic bottles, various sizes
- Foam packing material

For axles, two per group:

- Round plastic stir sticks (sip stirrers)
- Wooden skewers
- Wooden dowels (pre-cut)
- Pencils

For bushings, two per group:

- Plastic or paper straws (straight)
- Narrow cardboard tubes (found in shipping for objects such as glass thermometers)

For wheels, four per group:

- Plastic bottle caps, various sizes
- Circular packing foam
- CDs or DVDs
- Jar lids, various sizes
- Plastic container lids (like those for oatmeal, baking powder, yogurt etc.)
- Large wooden beads

- Spools, various sizes, plastic, wood, or paperboard (with hole or opening in the center like those for thread, ribbon, fishing line, or wire)
- Thick metal or foam washers
- Styrofoam food trays, plates, or cardboard cut into circles of various sizes, either pre-cut or student-cut, template provided

Preparation (45 minutes)

- Gather and set out materials
- Pre-cut cardboard or Styrofoam wheels (if desired) using the template provided.
- Pre-puncture holes in the center of the lids (for wheels) by using the awl or with a block of wood, a hammer and thick nail. Use the diameter(s) of the axles as a guide to the desired width of the hole. Before forming the hole, mark the center using a ruler and sharpie. Secure lids to the wood using masking tape before hammering the nail into the mark to the desired width. Students may do this step themselves with supervision (see “Safety” section).
- Make copies of student sheets
- Find a suitable area for the car races. Cars are not likely to travel more than 20 feet. Mark out a racetrack about 2 feet wide (about 60 cm) and around 20 feet (about 6 meters) long using masking tape (place a mark every couple of feet or every 60 cm or so). Note that students may be excited, so choose an area where noise is acceptable.
- Make and test your own car!

Alternate ideas

- If time allows, have students modify the car more than once and re-race. Students could, for example, add an additional rocket engine to see how that changes the motion/speed/distance of the car.
- If short on time, omit the “Redesign” pages of the student sheets. Students can revise their designs without them.
- Show “Some Spectacular Failures of Unmanned Rockets” or similar: <https://www.youtube.com/watch?v=RY1cEOzaf78>
- Provide large chart paper for students to use in the design process.
- To explore more about Newton’s laws, visit a website such as: <http://teachertech.rice.edu/Participants/louviere/Newton/>

- Visit the NASA Space Launch System page and explore with students: <http://www.nasa.gov/launching-science-and-technology.html>
- Watch the launch of the New Horizon’s Spacecraft, the fastest spacecraft ever to launch, and explain that New Horizons visited the dwarf planet, Pluto: <https://www.youtube.com/watch?v=KNJNaloa5Hk>
 - Explore more about the New Horizons mission: <http://pluto.jhuapl.edu/>
- This is a great activity for a family day or night!

Procedure

1. Tell students they will need a chassis (body for their car), axle (where the wheels attach), bushing (where the axle sits), and will need to be able to attach a bendy-straw with the balloon as shown in the diagrams on the student sheets.
2. Give a tour of the materials.
3. Stress that the car can be as creative as the students want. The diagram shown is a simple car without a body, and only shows the major parts.
4. In groups of two to three, students will discuss their design, draw their cars, and make a materials list.
5. Have each group choose a team name.
6. Once students are engaged, display your car for them to explore. Be sure to tell students not to copy your design!
7. Remind students to actively test designs as they build.
8. To stretch the balloon, have students inflate and slowly let out the air. Do not tie off the end of the balloon.
9. Show how to slip the nozzle of the deflated balloon over the end of the straw and tightly seal with masking tape so there are no leaks.
10. Have students test for leaks and assist with the seal if necessary. To prevent the spread of germs, only one student from each team will be in charge of blowing up the balloon.
11. When finished with the cars, individual teams will “race” down the track one at a time (only one car will be on the track at a time).
12. A student will inflate the balloon through the end of the straw and pinch it off to hold in the air.
13. With the end of the straw still pinched off, one student will place the car on the track.
14. On the mark (“Ready, set, Go!”) the racer will release the straw.

15. No one should touch the car as it is traveling.
16. Measure the distance it travels with a tape measure. If it leaves the track, measure from the starting line to the point where it exited.
17. Record distances of each team.
18. Ask: How could your design be improved? (Note: Students can consider which cars went the farthest and how those cars were designed.)
19. Have students revise designs and repeat the race.
20. Remind students that engineers always strive to improve their designs, they make mistakes sometimes, but they don't give up. They learn from their mistakes and try to improve the design the next time, and often have to start over again.
21. Discussion: What provided the thrust that pushed the car forward? (Ans: The air from the balloon traveled through the straw and exited at the back of the car. This pushed the car forward). Remind students that Newton, a famous physicist in the 1600s developed three laws of motion. Students may have heard of Newton's laws, so ask if students know what the third law states and how it applies to the design of the cars. (Ans: The air being pushed out the back of the car was the action, and the reaction was that the car moved forward.)
22. Discussion: Were all races the same for each car? Why/why not? (Examples: the balloons may not have been equally inflated (different amounts of thrust/time for thrust), the wheels are not the same for each car (different amounts of friction, different sizes have the car go different distances)).
23. Open discussion: What worked and didn't work with your cars? How could you improve the design?
- 24.

Safety

- Instruct children in appropriate ways to use tools prior to conducting the activity.
- Children should be aware they should never use a tool toward their bodies or the bodies of other children, and to never play or roughhouse while using tools.
- Have a first-aid kit available.

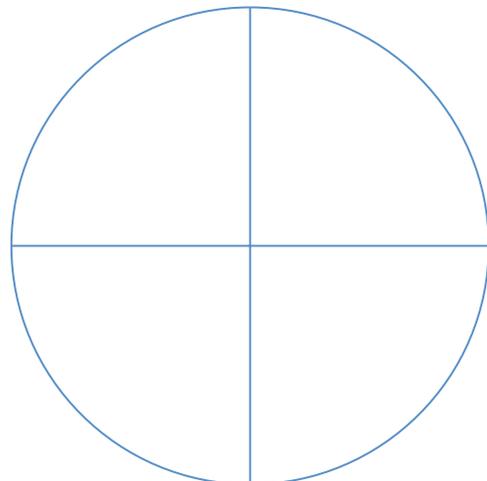
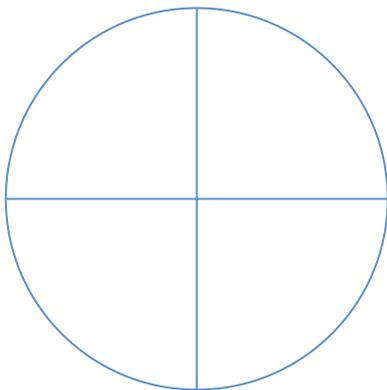
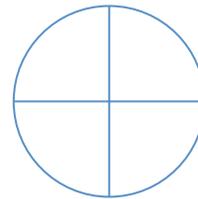
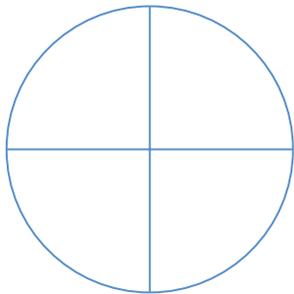
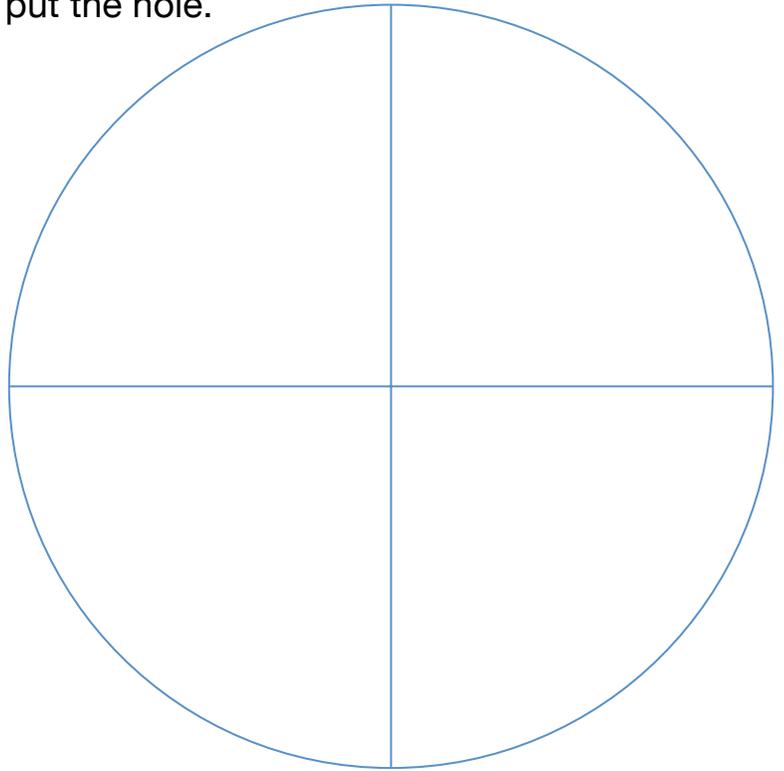
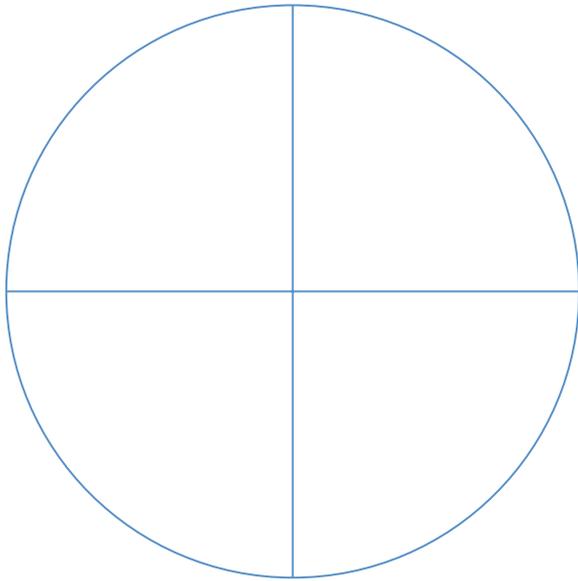
Inspiration/Credits for this activity:

Activity adapted from Rocket Activity Rocket Races, NASA Educational Resources,
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rocket_Races.html#.VkDNqINVhBd

Inspiration for modification of the activity provided by The Scrap Box News Creative Recycling website's entry from August 29, 2013, Build a Race Car with Scraps!
<https://a2scrapbox.wordpress.com/2013/08/29/build-a-race-car-with-scraps/>

Wheel Template

Cut out wheel patterns to pre-cut Styrofoam and cardboard wheels.
The central mark is where you put the hole.



Student Sheets

This is a diagram of a car, but how you actually build it is up to you! Think about your design in teams of two or three. The goal is to have your team's car go the farthest!

A basic car has:

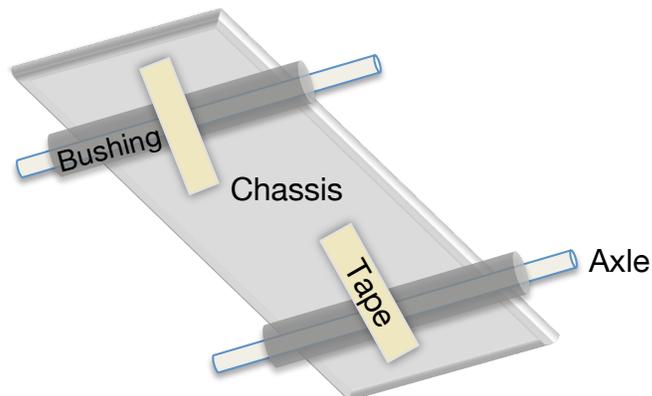
Two Axles with Bushings—

The bushing slips over the axle to help it spin. The wheels attach to the axle.



Chassis (cha-see)—Base of the car

The bushings attach to the chassis as seen in the image below.

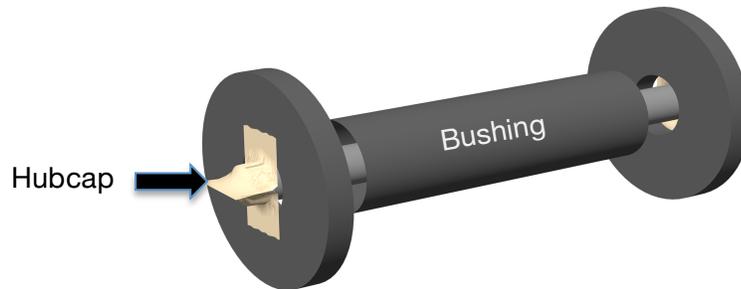


Wheels—

Something round! The wheels attach to the axle.

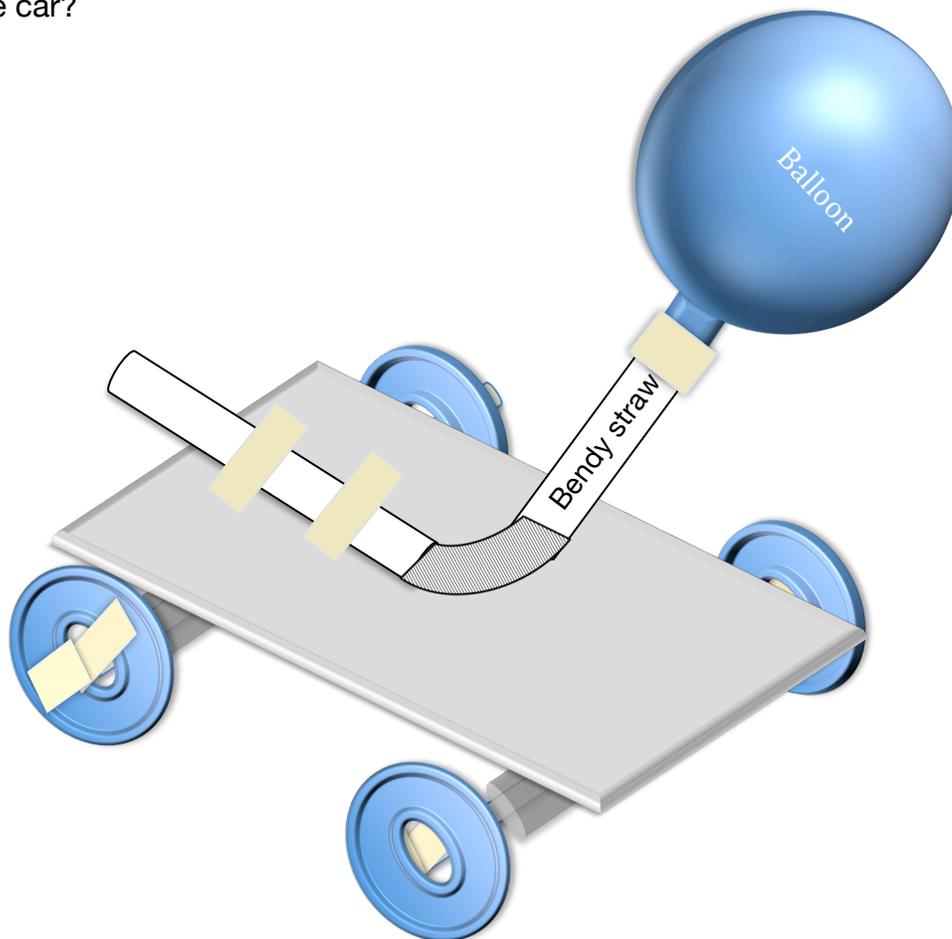
Hubcap—

Keeps the wheels from falling off! This can be a piece of tape, putty, clay, or something else. Here, the wheels attach to the axle using masking tape for a hubcap. Your design might have the wheels spin as the axle spins, or the wheels and axle could both spin.



Car Body—

This could look however you want, as long as you are able to attach the rocket engine (balloon with straw). See how the straw nozzle extends past the end of the car?



Design your car!

Team Name:

Draw a picture of your design



What materials will you use?

Material	What will you use it for?

Race #1

Team Name	Distance

Redesign: Things to think about

What worked well about your first design?

What needs to be changed?

What will you change to make your car go farther?

Redesign Page

Draw a picture of your design and label the changes you made.

Redesign Page

Did you choose different materials?

Material	What will you use it for?	What did you use before?

Race #2

Team Name	Distance