



Lesson Activity

Title	Balloon Rocket Cars (2 sessions, 60-80 minutes)
ID Number	MS-S-C1
Sequence and Duration	<p>Session 1: Background and Exploration</p> <ul style="list-style-type: none"> • Lead In: 15-20 minutes • Initial Launch: 20-25 minutes • Investigation: 25-35 minutes <p>Session 2: Testing</p> <ul style="list-style-type: none"> • Testing: 30-40 minutes • Science Conference: 20-25 minutes • Closure: 10-15 minutes
Age Level	Middle School
Essential Question	What variables affect how fast and how far a balloon rocket car travels?
Learning Objectives	<ul style="list-style-type: none"> • TSW build a balloon rocket car to specs. • TSW design investigations to test variables related to the rocket's speed and distance. • TSW collect and analyze data from their investigation. • TSW communicate the results of their investigation to their classmates.
Other Objectives	<ul style="list-style-type: none"> • TSW develop a working plan with their group to develop a cooperative environment. • TSW communicate with their group by contributing their vocal input. • TSW write down the procedure they used to investigate the effect of their chosen variable. • TSW listen to their peers discuss the results of their investigation. • TSW contribute to a group discussion about the optimum characteristics of a balloon rocket car.
Key Terms	<ul style="list-style-type: none"> • Newton's 3rd Law: for every force, there is an equal force in the opposite direction. • Pressure: force per unit area. • Force: a push or a pull. • Chassis: body of a rocket. • Nozzle: opening from which gases to escape from a rocket. • Optimize: to make as effective or useful as possible.
Materials Needed	<p>Per Class:</p> <ul style="list-style-type: none"> • Extra materials: tape, straws, clay, bottle caps, skewers, balloons • Other materials students may want to try: tubing, larger bottle caps or lids, bottles of different sizes, other materials you have available • Meter sticks or tape measures • Stopwatches <p>Per Team (Include a set for teacher demo):</p> <ul style="list-style-type: none"> • Handout: Balloon Rocket Car Instructions • Handout: MESA Notebook • 1 plastic water bottle, 16-20 oz., empty • 5 drinking straws • 2 wooden skewers • 4 bottle caps • 1 balloon • roll of duct or masking tape • small nail

	<ul style="list-style-type: none"> • hammer • scissors • pea-sized ball of clay (optional) • scissors • ruler • small square of cardboard or foam board to protect surfaces
Session 1	Background and Exploration
Lead In	<ol style="list-style-type: none"> 1. Ask students what they remember about Newton's 3rd Law. When did they learn about this before? [If you have done the Newton's Scooters activity, students may remember learning about Newton's Laws then.] What does Newton's 3rd Law say about forces? [Every action has an equal and opposite reaction, or every force is paired with an equal force in the opposite direction.] What does this have to do with the motion of an object? [If an object pushes on an object, whatever it is pushing on pushes <i>back</i> in the opposite direction. Unbalanced forces cause acceleration, so the object will accelerate in the direction of the force.] Have students explain Newton's 3rd Law in their own words and write this in their MESA Notebooks. 2. Ask students what Newton's 3rd Law has to do with rockets. What makes rockets move through space? [The rocket's fuel exhaust is pushed out of the rocket by the pressure inside the rocket; the rocket pushes the fuel gases out and in turn, the gases push back on the rocket, causing it to accelerate.] Note: It is a common misconception that rockets push against the <i>ground</i> when they take off, and that the ground pushes the rocket up to space. If this were the case, rockets would not be able to accelerate in space, because there would be no ground to push off from. This activity, in which the rockets clearly are NOT pushing against the ground, can help students confront this misconception. 3. Tell the students that in this activity they will be building balloon rocket cars. What do they think will make these rockets move? [Letting out the air in the balloons will push the rockets forward.] What does this have to do with Newton's 3rd Law? [The balloon pushes out on the air, and the air pushes back against the balloon. If the rocket is attached to the balloon, it will move with the balloon.] 4. Explain that the air in the balloon is under <i>pressure</i>. What does it mean to be under pressure? Allow students time to explain and give examples in their own words. [Sample definitions: to be pressed on, to be pushed against from all sides. Possible examples: pressure cooker, geysers, deep-sea animals, a student whose parents want her to get really good grades!] When you blow up a balloon, the air you put inside pushes against the inside of the balloon, which expands as its skin stretches. [Note: If students are familiar with the concept, you could introduce this as an example of potential energy.] The balloon wants to go back to its un-stretched state, so it constantly pushes back against the air, putting the air under pressure. This is why the air comes out so quickly when a balloon is opened up, and why the balloon zooms around as the escaping air pushes it all over the place! 5. Ask the students what they might want to investigate about how their rockets move. [E.g. how fast they go, how far they go, how long a time they travel, how quickly they accelerate, how many empty water bottles they can knock over, etc.] Note: How quickly and how far the cars travel are the inquiries emphasized for the purposes of this lesson plan, but accept all answers and be willing to pursue any that seem viable. 6. Explain that there are a number of variables that can affect their rocket cars' performances. Their task as a class will be to investigate ways to <i>optimize</i> these variables - that is, to make them as beneficial as possible for the purpose chosen. [For instance, if the purpose was to travel the furthest, what are the optimal characteristics of the cars that make them travel the furthest?] Engineers conduct experiments to determine the optimal characteristics for the products they design.

Initial Launch	<ol style="list-style-type: none"> 1. State that in order to look at the variables that affect the cars' motion, each team needs a rocket car to examine. You will build your rocket cars together as a class, and launch one to observe its performance. 2. Get students into groups of 3 or 4 and hand out the supplies. Hand out the instructions for building the cars and walk through them with the students. Assist them as they build their cars. 3. Have the students gather their rocket cars and bring them to an open space clear of passers-by. Encourage students to ask questions, such as, what would happen if the cars had two balloons? What if the bottle had water in it? How many wheels are necessary? Tell students to keep these questions in mind for later. 4. Tell students to observe what happens as the rocket cars take off. Have one student from each group blow up the balloons and pinch the neck to keep the air from escaping. Have the other students fall back to a safe distance while the students with the rockets line up and launch their rocket cars. Draw students' attention to how far the rockets go and how fast they travel. If there are differences in terrain (i.e. some rockets launch on the pavement and some on the grass), have students make note of any differences in these rockets' performance.
Investigation	<ol style="list-style-type: none"> 1. Gather students back in the classroom. Allow time for a brief discussion of what students observed when the rockets launched. 2. Remind students of their ideas for investigations about the rocket cars, and solicit questions that the students came up with during the initial launch. Remind them that there are numerous variables affecting the rocket's journey, and that their mission as a class is to decide what the purpose of the rocket car should be and try to optimize those variables. What are some of the variables? [examples: size and shape of chassis, amount of air in balloon, width of nozzle, number of wheels, type of axle, roughness of launching surface, etc.] In what ways can the variables be varied? How can the class test the influence of those variables? 3. Tell the students that their class is a community of scientists studying the rocket car. Each group will work independently, but ultimately, in order to best understand the optimal rocket car, all groups will need to share their results with everyone else. The class will decide which variable(s) are the most important to investigate and each group will choose one (or more) and design their investigation. After all groups have completed their investigations, they will share the information they gathered by communicating their results to the whole class in a science conference setting. 4. Give the students the amount of time that they will have to run their investigations (e.g. half of the next class session). Guide a discussion in which students come to an agreement about the best way to make use of their time with the number of groups they have. Do they have a shared opinion of the purpose for the rocket car? How many variables will they test? How many investigations will each team have time to do? Do some investigations need more time than others? If necessary, lead students to an understanding that only one variable can be tested at a time or it won't be possible to know which variable is having the greatest effect on the dependent variable [the purpose of the rocket car as determined by the class or team]. 5. With the remaining class time, students should prepare their investigations. They must be completely prepared to begin testing in the next session, so they must come up with hypotheses, procedures, data sheets, and a plan for communicating the results of their investigation to the class (e.g. with graphs, charts or drawings). Students can use their MESA Notebooks to organize their investigations.
Session 2	Data Collection and Communication
Testing	<ol style="list-style-type: none"> 1. Allow students to make use of the allotted time to conduct their investigations. Ensure that proper safety precautions are taken every time a rocket car is launched.

	<ol style="list-style-type: none"> 2. Make sure students are faithfully collecting data. Remind them to record their units. 3. When a group is finished testing, they can begin organizing and analyzing their data and/or assisting other groups with their launches. No group should be without something to do. 4. Although groups will vary in the amount of time it takes them to complete their data collection, do not allow any group to linger too long over their investigation at the expense of preparing to report out to the class. When the time for testing is up, make sure that all groups move on to communicating their data.
Science Conference	<ol style="list-style-type: none"> 1. Give students sufficient time to pull their materials together, then have groups present the results of their investigations to the whole class. Allow the class to ask questions of the group. 2. After each group's presentation, write a conclusion statement on the board that reflects the group's results (provided by the group with the assistance of the rest of the class), for instance "Results indicate that ten breaths in the balloon is optimal for making the fastest rocket car." 3. Discuss the results of testing. Which rocket cars went the furthest or the fastest? What were the features of this rocket that made it so successful? What did other groups try? Allow time for discussion and debate, particularly if students' results seem to be in conflict with each other (e.g. if ten breaths is good for a fast car but 15 is better for knocking down obstacles). What features made these rocket cars successful or not so successful? 4. Ask groups to consider other variables that might be affecting the rocket's success that the class did not test. What kind of impact might these variables have on the groups' rocket cars? 5. Emphasize that all conclusions are tentative; the class' results are a good start, but further testing may lead to even better, more precise results. 6. Ask the students to consider, if they wanted to build the "best" rocket car, what features would it have?
Closure	<ol style="list-style-type: none"> 1. In their MESA Notebooks, have students respond to this conclusion question (or a similar question more aligned with the class' activities): <i>What variables affect how fast and how far a balloon rocket car travels?</i> 2. Students can use the remaining time to finish their Notebooks with their groups, or they can finish them as homework.
Informal Assessment	<ul style="list-style-type: none"> • Monitor students' understanding of Newton's 3rd Law through discussion and questioning. • Monitor students' understanding of experimentation and control of variables during the Investigation phase. • Monitor students' participation in discussions and group work.
Formal Assessment	<ul style="list-style-type: none"> • Completed investigation materials: hypothesis, procedures, data collection instruments, data charts, etc. • Presentations of groups' investigation results. • Completed balloon rocket cars. • Completed MESA Notebooks.
Trouble Shooting	<ul style="list-style-type: none"> • Start collecting and encouraging students to collect bottles and bottle caps for this lesson well ahead of time. You will need one bottle for the teacher demo and one for each group, as well as several extras in the case that the class decides to build additional rocket cars during their experimentation. You'll need an even larger number of bottle caps, roughly one for each student if you have groups of four, plus additional caps for experimenting. • Prior to class, build a rocket car yourself so you know how the components fit together before trying it with the students. • Have duplicate materials as well as additional materials with which the students can experiment. You may also want to prepare for the possibility that students will want to experiment with ramps (a plank and a stack of textbooks would work), knocking down obstacles (perhaps markers stood on their ends), or redesigning the rocket car's design (e.g. by using a 2-liter bottle instead of a

	<p>16 oz. bottle). As ever, feel free to improvise!</p> <ul style="list-style-type: none"> • Don't worry if a rocket car doesn't work the first time! Allow students to troubleshoot with you. Is the seal with the nozzle tight enough? Are wheels aligned properly? Is the rocket car's weight unbalanced for any reason? Mistakes are opportunities for learning. • Students may be at a loss to draw conclusions from their data. Encourage them to try different means of demonstrating the relationship between variables. Some students may find that their results do not follow a linear pattern; encourage them to consider other possible relationships - the data may more closely fit a parabola. 						
Extensions	<ul style="list-style-type: none"> • If students get excited about conducting more investigations about their rockets, consider adding an additional class period(s) for testing their ideas. Assess students' interest to decide if this lesson should be extended; there are a great number of investigations that students can conduct if they wish. 						
Citation	Home Training Tools, http://www.hometrainingtools.com/articles/balloon-rocket-car-project.html						
SEI Strategies Used							
<table border="0"> <tr> <td style="vertical-align: top;"> Preparation <input type="checkbox"/> Adaptation of Content <input type="checkbox"/> Links to Background <input checked="" type="checkbox"/> Links to Past Learning <input checked="" type="checkbox"/> Strategies incorporated </td> <td style="vertical-align: top;"> Scaffolding <input checked="" type="checkbox"/> Modeling <input checked="" type="checkbox"/> Guided practice <input checked="" type="checkbox"/> Independent practice <input type="checkbox"/> Comprehensible input </td> <td style="vertical-align: top;"> Grouping Options <input checked="" type="checkbox"/> Whole class <input checked="" type="checkbox"/> Small groups <input type="checkbox"/> Partners <input type="checkbox"/> Independent </td> </tr> <tr> <td style="vertical-align: top;"> Integration of Processes <input checked="" type="checkbox"/> Reading <input checked="" type="checkbox"/> Writing <input checked="" type="checkbox"/> Speaking <input checked="" type="checkbox"/> Listening </td> <td style="vertical-align: top;"> Application <input checked="" type="checkbox"/> Hands-on <input checked="" type="checkbox"/> Meaningful <input checked="" type="checkbox"/> Linked to objectives <input checked="" type="checkbox"/> Promotes engagement </td> <td style="vertical-align: top;"> Assessment <input type="checkbox"/> Individual <input checked="" type="checkbox"/> Group <input checked="" type="checkbox"/> Written <input checked="" type="checkbox"/> Oral </td> </tr> </table>		Preparation <input type="checkbox"/> Adaptation of Content <input type="checkbox"/> Links to Background <input checked="" type="checkbox"/> Links to Past Learning <input checked="" type="checkbox"/> Strategies incorporated	Scaffolding <input checked="" type="checkbox"/> Modeling <input checked="" type="checkbox"/> Guided practice <input checked="" type="checkbox"/> Independent practice <input type="checkbox"/> Comprehensible input	Grouping Options <input checked="" type="checkbox"/> Whole class <input checked="" type="checkbox"/> Small groups <input type="checkbox"/> Partners <input type="checkbox"/> Independent	Integration of Processes <input checked="" type="checkbox"/> Reading <input checked="" type="checkbox"/> Writing <input checked="" type="checkbox"/> Speaking <input checked="" type="checkbox"/> Listening	Application <input checked="" type="checkbox"/> Hands-on <input checked="" type="checkbox"/> Meaningful <input checked="" type="checkbox"/> Linked to objectives <input checked="" type="checkbox"/> Promotes engagement	Assessment <input type="checkbox"/> Individual <input checked="" type="checkbox"/> Group <input checked="" type="checkbox"/> Written <input checked="" type="checkbox"/> Oral
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Arizona Math Standards Addressed	<ul style="list-style-type: none"> • S2C1: TSW understand and apply data collection, organization and representation to analyze and sort data. 						
Arizona Science Standards Addressed	<ul style="list-style-type: none"> • S1C1: TSW formulate predictions, questions, or hypotheses based on observations and evaluate appropriate resources. • S1C2: TSW design and conduct controlled investigations. • S1C3: TSW evaluate experimental design, analyze data to explain results and propose further investigations. • S1C4: TSW communicate results of investigations. • S5C2: TSW analyze relationships between forces and motion, using Newton's 3rd Law to explain forces as interactions between bodies. 						

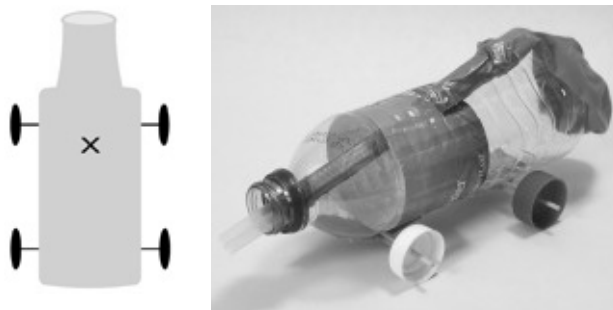
Balloon Rocket Car - Instructions

Materials:

Plastic water bottle
5 drinking straws
2 wooden skewers
4 bottle caps
Balloon
Piece of cardboard
Clay
Tape
Nail
Hammer
Scissors
Rule

Instructions:

1. The water bottle will be the *chassis*, or body, of the car. The wheels and rocket engine (balloon) will be attached to the chassis.
2. Next, you'll add two tubes, made from straws, that your car's wheel axles will go through. Measure the width of your water bottle. Cut two lengths of straw as long as the width of your water bottle. (You should be able to use one straw to make two axles.) Use strips of tape to attach the straws to the chassis, one at the front and one toward the back. Make sure you line them up as straight as possible so your wheels won't be crooked!
3. The bottle caps will be your wheels. Tap a hole through the center of each bottle cap using the hammer and nail. Use the cardboard to protect the table by placing it under the bottle cap you're working with.
4. The skewers will be your axles. Cut two lengths of skewer about 1.5 inches longer than you cut the straws. Thread the skewers through the straws and attach the wheels to the ends. If the caps don't fit snugly on the skewers, add a little modeling clay to hold them in place.
5. Make sure your car rolls smoothly. Make adjustments if necessary.
6. Prepare the balloon by stretching it out with your hands and blowing it up and deflating it a few times.
7. Create a *nozzle*, or opening, for the balloon out of straws. Tape 4 straws together in a bundle and insert them into the mouth of the balloon. Create a seal of tape around the balloon's mouth so air can only escape through the straws.
8. Next you'll need to mount the balloon on the car. *Carefully*, cut an "X" on the top of the car about 4 inches from the bottle's mouth. Poke the nozzle through the "X" and out the mouth of the bottle. Leave about an inch of the nozzle sticking out of the bottle. If necessary, tape the nozzle around the "X" to secure it.



Your rocket car is ready for testing