Civil Air Patrol's ACE Program

Paper Rocket
Grade 2 Academic Lesson #5

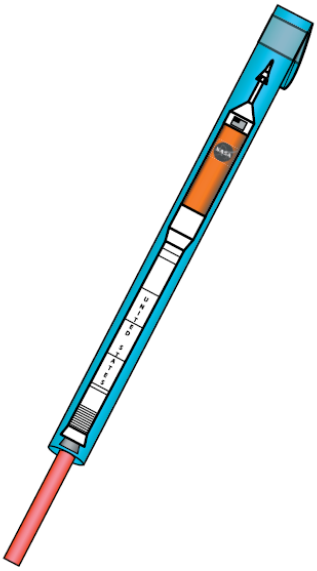
Topic: rockets, motion, force, action, reaction (science, math)

Length of Lesson: 45-60 minutes

Lesson Reference: NASA's Rockets Educator Guide

Objectives:

- Students will be able to identify the main parts of a rocket.
- Students will construct and launch a rocket.
- Students will apply Newton's Laws of Motion.



National Standards:

Next Generation Science Standards:

- Analyze data from tests of an object or tool to determine if it works as intended. (K-2-ETS1-3)
- Ask questions based on observations to find more information about the natural and/or designed world. (K-2- ETS1-1)
- The shape and stability of structures of natural and designed objects are related to their function(s). (K-2- ETS1-2)

CCSS Math:

- CC.2.MD.1 - Measure and estimate lengths in standard units. Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.

Background Information:

Sir Isaac Newton (a scientist and mathematician in England in the 1600s) described rocket science principles in his three laws of motion. His third law of motion states that for every action, there is an equal and opposite reaction. This law can be applied to rockets by a rocket expelling fuel or propellant out of its engine causing the rocket to move in the opposite direction. The rocket pushes the propellant out, and the propellant then pushes the rocket in the opposite direction. The propellant comes out of the engine. This is the action. The rocket lifts off the launch pad in the opposite direction. This is the reaction.

Materials:

- paper rocket pattern copies
- straws (Consider asking a fast food restaurant to donate straws.
- tape

NOTE: Tailor the information provided to accommodate your available time and student ability. You may wish to watch this video (or share it with your class): "Ultimate Straw Rocket!."

Lesson Presentation:

1. Tell students that they are going to do a rocket activity today, and to start, you want to teach them a song. Help students learn the "I'm a Little Rocket" song. Sing it to the tune of "I'm a Little Teapot."

   I'm a little rocket tall and thin. (Stand straight with your arms at your side.)
   Here is my nosecone (bring your fingertips together above your head, bending arms as little as possible)**; here are my fins.** (Place your hands on your hips.)
   When I get all fired up (stomp in place); **launch begins.**
   Watch me rise (jump), **and see me grin** (smile).

2. To engage students, Show images of rockets. For initial engagement, you can also begin with "Mars in a Minute: How Do You Get to Mars?" as a cartoon teaser for more in-depth content. Research video and images of rockets that NASA sends into space. (NASA Launch Services Program).

3. Ask students what they know about rockets. They can refer to the song to give them some clues. (Possible responses: Rockets are tall and thin. The top of the rocket is called a nosecone. The parts that look like "wings" are called "fins." It doesn't launch until the smoke and fire begin coming from the bottom of it. It shoots into the air. It is capable of transporting people and equipment into space.)

4. Help students understand how a rocket works by explaining Newton's third law of motion, which states that for every action, there is an equal and opposite reaction. Tell students that Sir Isaac Newton was a scientist who lived a long, long time ago. Through some of his experiments, he realized some important information about how things move, and one reason things move the way they do is because of action and reaction. For example, the action of you pedaling your bicycle causes a chain to move that causes the wheels to move. The reaction is that the bicycle moves forward.

   - Demonstrate Newton's action-reaction law using a balloon. Blow up the balloon and release it. Ask them why the balloon flew around the room. Air coming out of the balloon caused the balloon to move. The reason the balloon flies in many directions is because there is nothing to control the air coming out of the balloon. The balloon is made of flexible material, and as air comes out of the balloon, the balloon changes in size. There is nothing firm in place to control the direction of the air coming out of it.

- Explain to students that the reason rockets are able to launch into the sky is because of the gases and smoke that are moving down quickly out of the rocket. (This is an extremely simplified explanation.) The burning gases being forced quickly out of the rocket cause the rocket to move upward.

5. **Aerodynamics:** *Aerodynamics is how easily an airplane moves through the air.* -Simple aerodynamic demonstration - Ask the students to hold one of their hands in front of their body with the palm facing sideways so that the thumb is on top and pinkie is facing the floor (like they're reaching out to shake someone's hand). Have the class swing their hands back and forth. Notice the amount of air pushing against the hand? - Now ask your students to turn their palm so their hand is horizontal and parallel to the floor. Then ask them to swing their hands back and forth like they're slicing it through the air. They should still be able to feel the air, but now their hands are able to move more smoothly than when the hand is positioned the other way.

6. **Drag & Gravity:** *Drag is when air resists the forward motion of the plane.* - There are many factors that affect the amount of drag. The shape of the paper airplane is one of them. In order to reduce drag and allow the plane to fly as far as possible, you want a plane that creates as little drag as possible, so it moves through the air just like the students' hands did when their palms were parallel to the floor. Gravity is the force that will be pulling a paper airplane to the ground. -In order to make a paper airplane fly as far as possible and help fight against gravity, they must keep their plane as light as possible. • Simple in-class gravity demonstration - Slip a paper clip on the edge of a sheet of paper and see how quickly the sheet falls to the floor. Now remove the paper clip and watch how long it takes the paper to float back and forth before finally landing on the floor. The lighter your paper is, the less it will need to fight against gravity pulling it to the ground.

7. **Thrust & Lift:** *Thrust is the forward motion of a plane.* - For full-size airplanes, the engine is what generates the thrust. For paper airplanes, thrust is created by the forward launch of the thrower's arm. To overcome gravity and the weight of a paper airplane pulling it to the ground, all airplanes create an opposing force called lift. - Lift is created when the air below the airplane wing is pushing up harder than the air above it is pushing down. The wings are doing the lifting, not the engines or thrust. The wings of a plane are usually curved slightly so that the air can move more quickly over the top of the wing than the air moves below the wing. This creates an upward push on the wing which generates lift.

8. Tell students that they will make a rocket today. Unlike the balloon demonstration, they will make a rocket out of a sturdy material (paper), that will not change shape while the rocket is in flight. The air coming out of their rocket will be directed in one direction only, and there will not be a steady stream of air coming out of their rocket, as with the balloon. Like the balloon, it will continue moving until the force of gravity causes it to return to the ground.

9. Distribute a paper rocket pattern to each student. Guide students through the following procedures in order to make the rocket:
    1) Cut out the rocket pattern.
    2) Have students wrap the paper around the straw and tape it in place, but do not tape the paper to the straw!
    3) After forming the rocket body, students should remove the straw and fold the top down four times and tape it in place.

10. Tell students that the reason that this rocket does not have fins is because it was designed to have steerable rocket engines to keep it stable (flying straight) during flight. (If you would like to allow students to make little paper triangles to place on the paper rocket body for fins, that is fine.)

11. Once students have constructed their rocket, go over any safety rules that are appropriate for the class such as: not aiming the rocket at anyone, wearing safety goggles, launching in a particular order, waiting for a certain signal before launching, launching in a designated direction, etc.

12. Allow students to practice launching their paper rocket, then pass out the "Paper Rocket Test Report" and have them launch their rocket three times, measuring the distance in centimeters.

13. Bring the class back together and discuss why their rocket launched. Confirm that it is because of Newton's third law of motion, which states that for every action, there is a reaction. (simplified statement) In this case, there were no hot gases shooting out of the end of their rockets as in a real rocket, but rather, air was coming out of their rocket tube. Explain or lead a student to explain that when they blew through the straw, the air slammed into the nosecone of their rocket (which pushed it forward) and the reaction of the air traveling back away from the nosecone and out of the rocket tube (body of the rocket) caused the air to go one way and the rocket to go the other.

Summarization:
Ask students to explain things they know about rockets. Ask a volunteer if he/she can explain why real rockets fly. Which rockets flew the farthest distance and why? Which rockets flew the fastest and why?
Think about one new thing that you learned in today's lesson.
- Tell your partner
- Tell your parents tonight
- Write a journal entry

Character Connection: Remind students that in life, we react to things. Sometimes people do things that are not right or not fair, but that does not mean that our reaction should "equal" their wrongdoing. We do not need to do the same bad thing that someone

else does. We must try to think about the best way to handle a problem, and then react appropriately. With Newton's Laws of Motion, the reaction occurs quickly, almost instantly after the action. Remind students that we do not have to react quickly in all situations. We need to stop, think, and find a good solution to react appropriately.

Assessment:

- teacher observation
- rocket construction
- paper rocket test report
- answers to class discussion questions

Additional activity ideas to enrich and extend the primary lesson (optional):

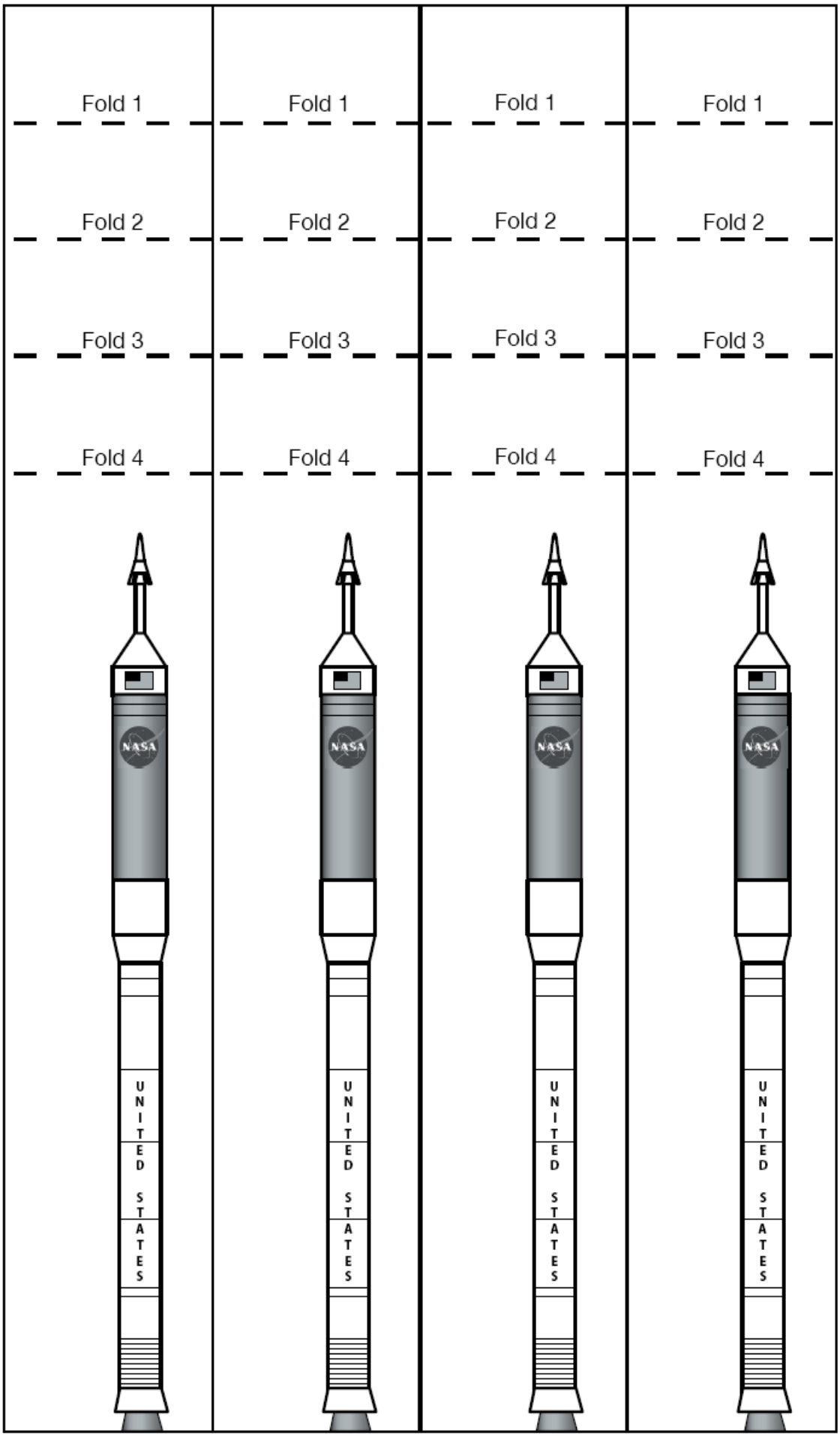
- Allow students to continue to experiment with their rocket. Allow them to make changes. Will their rocket fly better if fins (or more fins) are added? Allow them to shape their nosecone like a regular pointed nosecone. What will happen if students change the size or shape of fins that are added to the rocket? Will a paper rocket that is shorter in length fly farther than a paper rocket that is longer in length?

- Set up a target at which students can shoot their paper rockets.

- Allow students to measure how far their rocket travels. Have a contest to see whose rocket can go the farthest.

Associated Websites:

- Rockets Educator Guide "3....2....1 PUFF!"
- NASA "A pictorial history of rockets"
- ESA Kids "How Does a Rocket Work?"
- NASA "What is a Rocket?"
- NASA Kids' Club Rocket Builder
- NOVA/PBS Build a rocket
- "Rocket Science: How Rockets Work" (You may wish to watch ahead of time (or share with your class.)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Paper Rocket Test Report

Names: _____

_____

1. Launch your rocket three times. How far did it fly each time. What is the average distance your rocket flew? Write your answer in the spaces below.
2. Build and fly a rocket of a new design. Before flying it, predict how far it will go. Fly the rocket three times and average the distances. What is the difference between your prediction and the actual average distance?
3. Build a third rocket and repeat step 2.
4. On the back of this paper, write a short paragraph describing each rocket you built and how it flew. Draw pictures of the rockets you constructed.

Rocket 1

		Make notes about the flights here.
How far did it fly in centimeters?	1. _____ 2. _____ 3. _____	
Average distance in centimeters?	_____	

Rocket 2

		Make notes about the flights here.
Predict how many centimeters your rocket will fly.	_____	
How far did it fly in centimeters?	1. _____ 2. _____ 3. _____	
Average distance?	_____	
Difference between your prediction and the average distance?	_____	

Rocket 3

		Make notes about the flights here.
Predict how many centimeters your rocket will fly.	_____	
How far did it fly in centimeters?	1. _____ 2. _____ 3. _____	
Average distance?	_____	
Difference between your prediction and the average distance?	_____	