Straw Rocket Crafting Instructions

In Commemoration of the 50th Anniversary of the Apollo 11th Mission, the Louisiana Space Grant Consortium (LaSPACE) invites you to celebrate the mission that resulted in the first moon landing. Apollo 11 launched from Cape Kennedy on July 16, 1969 at 9:32 AM EDT, carrying Commander Neil Armstrong, Command Module Pilot Michael Collins, and Lunar Module Pilot Edwin "Buzz" Aldrin on top of a Saturn V rocket. Before Neil Armstrong could make his "...one small step for a man, one giant leap for mankind," thousands of NASA scientists, engineers, and technicians worked meticulously to craft the vehicle that would get them there. To celebrate this event, LaSPACE has adapted instructions and compiled materials so that Louisiana participants can craft and launch paper rockets from straw and stomp launchers. These instructions were adapted from the US Space & Rocket Center. Don't forget to launch your rocket on July 16th to help break a world record! More info at the website below.

Materials

SLS rocket pattern printed on 8.5 x 11 paper
Cellophane tape
Colors (crayons, markers, pencils)
Scissors
Drinking straws

Objective

Participants will learn about rocket stability as they construct and fly small paper rockets.

Description

Participants will construct small "indoor" paper rockets, determine their flight stability, and launch them by blowing air through a drinking straw.

Management

Hold on to the straws until participants have completed decorating their rockets. Select a clear space for the launches. Depending upon participant lung power, rockets may fly 22-32 feet! Be sure participants aim away from other people. Although the rockets have little mass, pointed nose cones could injure eyes. Make sure participants understand that the rockets are not to be launched toward anyone.

Join LaSPACE, the U.S. Space & Rocket Center, and the rest of the world by participating in the Global Launch attempt to break the current Guinness World Record by launching your rocket at any time on July 16!

If launching individually, register at https://www.rocketcenter.com/apollo50/GlobalLaunch/Info .

Instruction kit adapted from U.S. Space & Rocket Center "Rocket Activity 3...2...1...PUFF!" at https://www.rocketcenter.com/apollo50/GlobalLaunch

Background

Rocket stability is an important issue for rocket scientists. The success of a space launch depends upon "pinpoint" accuracy. If a future NASA Space Launch System rocket arrives in space in the wrong orbit, it may not have enough fuel or supplies to make rendezvousing with the International Space Station or an asteroid possible. The crew would have to return to Earth and "chalk off" a failed mission.

Stability means making sure the rocket follows a smooth path in flight. If it wobbles, the ride will be rough and extra fuel will be burned to get back on course. If it tumbles, it's time to push the destruct button! An unstable rocket is dangerous.

Fortunately, it is relatively easy to ensure stability when traveling through the atmosphere if two things are kept in mind. These two things are center of mass and center of pressure.

Center of mass (COM) is easy to demonstrate. It is the balance point of a rocket. Think of it like balancing a meter stick on an outstretched finger. If the stick rests horizontally, the COM is directly over your finger. If the COM is to the right of your finger, the stick will tip to the right. If to the left of your finger, the stick will tip to the left.

An object, tossed into the air, rotates around its COM. Rockets also try to rotate around their COM while in flight. If this rotation is allowed to happen, the rocket becomes unstable. This is where center of pressure (COP) comes to the rescue.

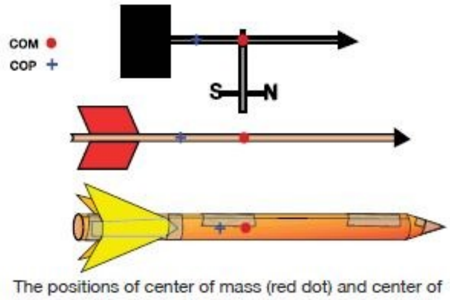
COP is also a balance point. It is the balance point of the pressure exerted on the rocket surface by air molecules striking it as it flies through the air. Like COM, there is a midpoint for the air pressure on the rocket body. This is the COP. For a stable rocket, the COP is located to the rear of the rocket and the COM is to the front. To understand why the rocket is stable, let's take a look at a couple of devices that also depend upon the placement of COM and COP.

A weather vane pivots on a vertical axle (COM) when the wind blows. One end of the vane is pointed and the other end has a broad surface. When the wind blows, the broad end of the vane catches more air (more air pressure) and is blown downwind. The narrow end of the vane has less pressure exerted on it and points into the wind.

One end of an arrow is long, narrow, and pointed while the other end has large feathers (or plastic fins). In flight, greater air pressure is exerted on the feathers than on the narrow end. This keeps the arrow from tumbling around its COM and on course to its target.

In both examples, there was more surface area on one side of the COM than on the other. Both devices were stable. Stability of a rocket is the same thing.

In this activity, participants will build paper rockets and may test them for stability using a drop test.

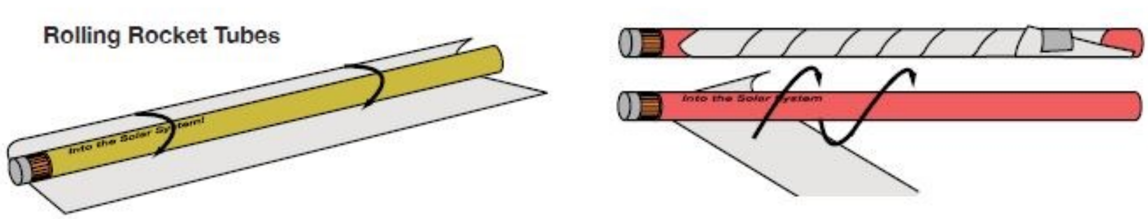


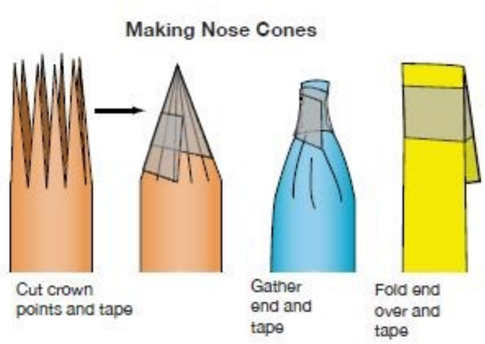
The positions of center of mass (red dot) and center of pressure (blue +) are shown for a weather vane, arrow, and rocket. The center of pressure is to the rear of the center of mass in each device. This enables them to point into the wind.

Instructions for Event Participants

1. Personalize your rocket.
2. Cut out the rocket pattern strip. 1 SLS Rocket Pattern sheet includes 2 rocket strips.
3. Use the straw and roll the strip around the straw. (See diagrams below.)
4. Tape the long seam. Avoid taping the top area that says Fold 1, Fold 2, Fold 3, Fold 4.
5. After forming the rocket body, the upper end of the tube is folded four times and taped down. (See the yellow rocket in the "Making Nose Cones" diagram below.)
6. (Optional) After the rocket is constructed, perform a drop test to check for stability. Hold the rocket horizontally at eye level and drop it to the floor. If the nose of the rocket hits the floor first, the rocket is stable and ready for flight. If the rocket falls horizontally or the fin end hits first, the rocket is unstable.
7. Stand at one end of your launch range. Insert a straw into the rocket body. Aim the rocket down range and puff strongly into the straw. Liftoff!
    - Remember, aim the straw away from others and wait until the range is clear before launching your own rocket.

8. (Optional) Improve your rocket design by holding distance trials. Launch your rocket three times and find the average distance the rocket travels. Try to improve your rocket design to get greater distance. The Paper Rocket Test Report outlines the procedures and provides space to jot down and analyze data. Consider using the other nose cone ideas shown in the diagram below.





 Instruction kit adapted from U.S. Space & Rocket Center "Rocket Activity 3...2...1...PUFF!" at https://www.rocketcenter.com/apollo50/GlobalLaunch

Paper Rocket Test Report

Name: ______________________

1. Launch your rocket three times at the same launch angle. Each time, measure how far it flew. Record your measurements in the data sheet below under the space labeled “Rocket 1.” Calculate the average distance for the three flights.

2. *What can you do to improve the distance your rocket travels? Can you think of any improvement for your rocket?* Design and build a new rocket. Predict how far it will fly. Record your answer below in the space labeled “Rocket 2.” Launch your second rocket three times and measure its distance. Record your data below. What is the difference between your predicted and actual distance? Did Rocket 2 fly farther than Rocket 1? Write your answers below.

3. *Did your changes in the rocket improve its flight?* Design and build a third rocket. Fly it the same way you did for Rockets 1 and 2. Did Rocket 3 fly farther than Rocket 2?

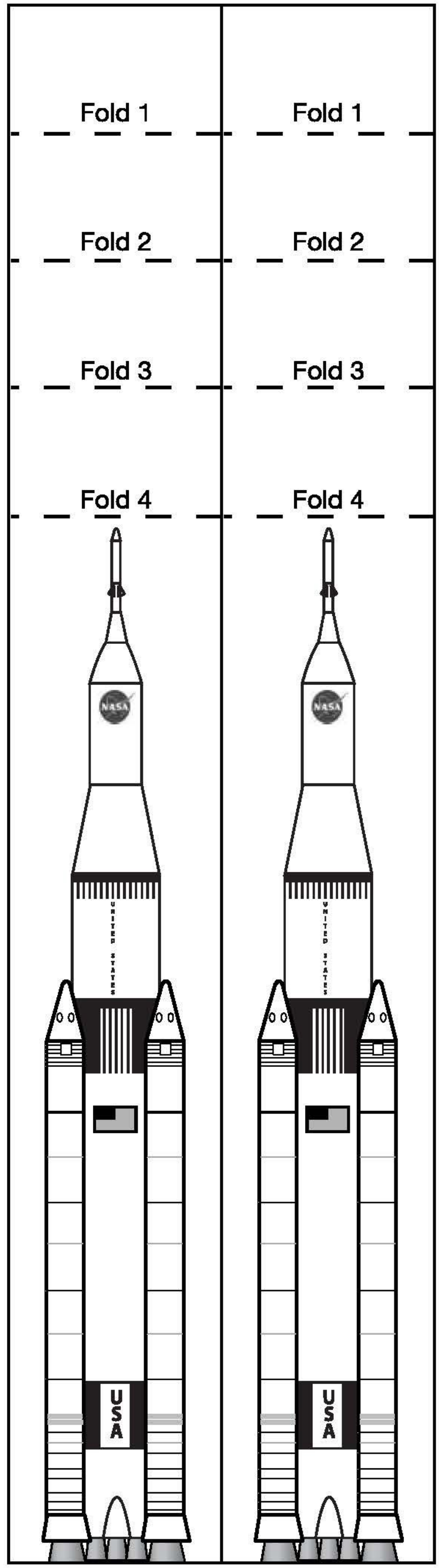
4. On the back of this paper, write a short paragraph describing the improvements you made to yo rockets, how well they flew, and what you can conclude from your experiments. Draw pictures t illustrate how each rocket looked.

ROCKET 1	Flight Distance (in cm)		Make notes about the flights here.
	Flight 1		
	Flight 2		
	Flight 3		
	Average Distance		

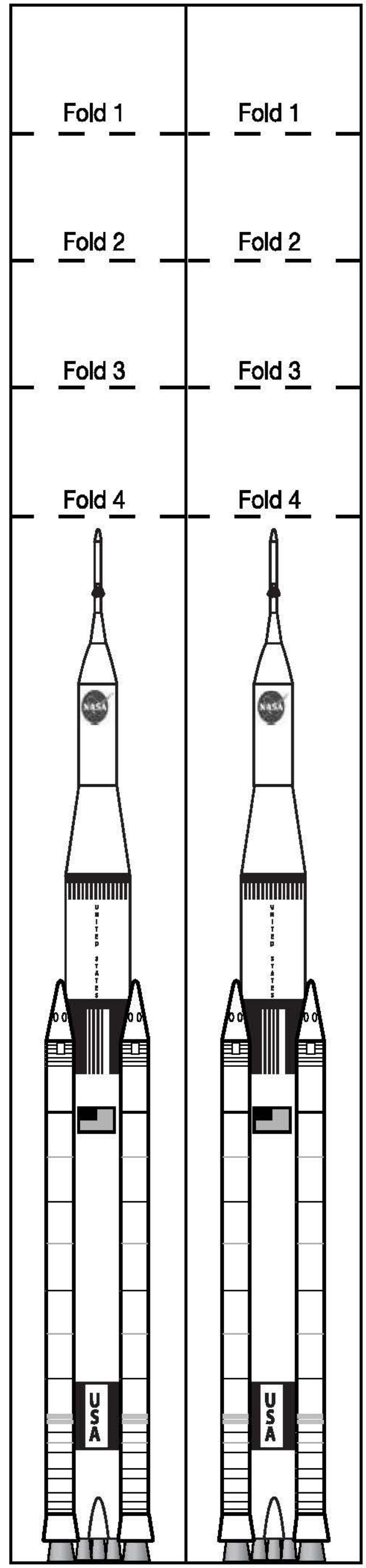
ROCKET 2	Flight Distance (in cm)			Make notes about the flights here.
Distance Prediction		Flight 1		
		Flight 2		
Difference between your prediction and the average flight distance		Flight 3		
		Average Distance		

ROCKET 3	Flight Distance (in cm)			Make notes about the flights here.
Distance Prediction		Flight 1		
		Flight 2		
Difference between your prediction and the average flight distance		Flight 3		
		Average Distance		

SLS Rocket 1



SLS Rocket 2



Procedure for Event Leaders / Volunteers

1. **<u>Demonstrate the construction technique</u>** for making paper rockets. Encourage participants to personalize their rockets. (Refer to the SLS rocket pattern; Each participant should receive 1 white paper and 1 colored paper with the patterns.)

a. Cut out the rocket pattern strip. 1 SLS Rocket Pattern sheet includes 2 rockets.

b. Use the straw and roll the strip around the straw.

c. Tape the long seam. Avoid taping the top area that says Fold 1, Fold 2, Fold 3, Fold 4.

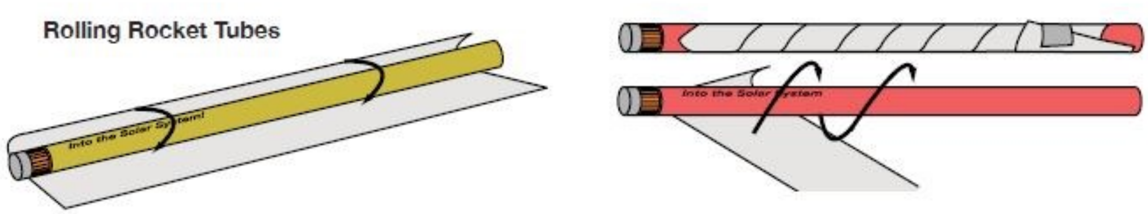
d. After forming the rocket body, the upper end of the tube is folded four times and taped down. (See the yellow rocket in the "Making Nose Cones" diagram below.)

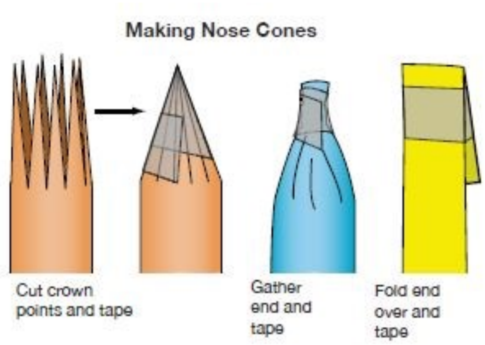
2. (Optional) After participants have constructed their rockets, show them how to perform drop tests to check for stability. Hold the rocket horizontally at eye level and drop it to the floor. If the nose of the rocket hits the floor first, the rocket is stable and ready for flight. If the rocket falls horizontally or the fin end hits first, the rocket is unstable.

3. Finally, **<u>demonstrate the launch procedure</u>** for the rocket. Stand at one end of your launch range. Insert a straw into the rocket body. Aim the rocket down range and puff strongly into the straw. Liftoff!

4. Talk over ideas for safety. Discuss aiming the straw away from others. Ask participants what should be done when they retrieve their rockets for another launch. (Other participants should wait until the range is clear before launching.)

5. (Optional) Have participants improve their rocket design by holding distance trials. Participants will launch their rocket three times and find the average distance the rocket travels. They will then try to improve their rocket design to get greater distance. The Paper Rocket Test Report outlines the procedures and provides space to jot down and analyze data. Have participants consider using the other nose cone ideas shown in the diagram below.





Additional Materials for Event Leaders / Volunteers

Discussion

• *Why is the SLS rocket stable even though it doesn't have any fins?*

Folding the paper makes the nose cone end of the rocket heavier than the tail end. Run a balance test with a finger. The balance point (center of mass) is far forward. The center of pressure is to the rear. This combination stabilizes the rocket for flight. The stability control for the paper version of the SLS rocket is similar to the control used by the Chinese for their fire arrows (See pictorial history section.) The actual SLS rocket will employ steerable engines to maintain stability.

• *How do paper rockets work?*

Unlike traditional rockets, paper rockets do not carry their own propellants. Instead, a sharp puff through the straw momentarily fills the rocket tube with "high pressure" air. The tube directs the air back through the opening, producing an action force. The rocket launches because of the equal and opposite reaction force (Newton's third law).

Assessment

• Have participants write and illustrate a paragraph that describes their improvements to their rockets and how these improvements affected their experimental results.

Extensions

• Hold a rocket flight contest. See whose rocket flies the furthest or whose rocket is the most accurate (make a target).

• In a gym or other room with a high ceiling, launch rockets straight up next to a wall. Have other participants estimate the altitudes reached by the rockets. Count the number of concrete blocks the rocket reached and multiply by the height of one block.

• Place a target at the far end of the launch range. An empty box makes a good target and rockets that land within the box are a "bull's eye."

Additional Content for Educators

National Science Content Standards

Unifying Concepts and Processes

• Evidence, models, and explanation

Science as Inquiry

• Abilities necessary to do scientific inquiry

Physical Science

• Position and motion of objects
• Motions and forces

Science and Technology

• Abilities of technological design

National Mathematics Content Standards

• Number and Operations
• Geometry
• Measurement
• Data Analysis and Probability

National Mathematics Process Standards

• Connections
• Representations