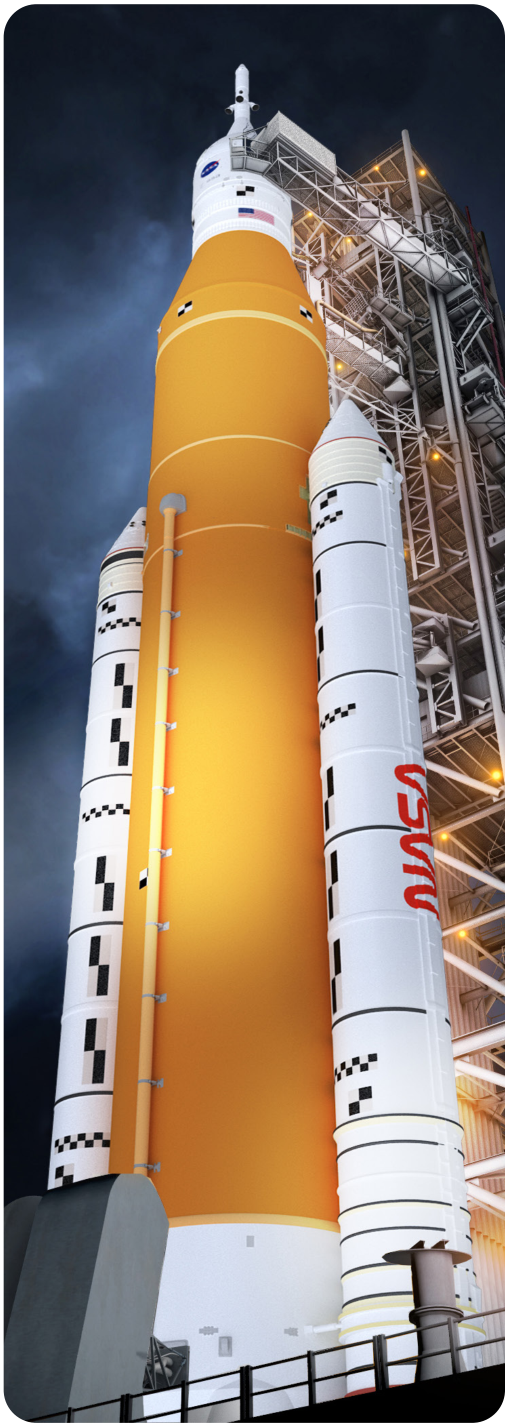
National Aeronautics and Space Administration

ARTEMIS CAMP
EXPERIENCE



Totally Artemis Camp

Systems of Artemis and How They Work Together

NASA's Artemis mission will land the first woman and first person of color on the Moon! Using new technologies, NASA will explore regions of the Moon never visited before and establish a long-term human presence on the Moon. Astronauts will live and work there for weeks to months at a time. They will test technologies, conduct science experiments, mine resources, and learn how to live in extreme environments. This knowledge will help NASA take the next giant leap–sending astronauts to Mars.

Activities

1. Design a Crew Module
2. Design Stabilizing Fins
3. Build a Space Module Structure
4. Build a Heat Shield

Sample Camp Schedule

8–8:10am	Welcome - We Are Going Video
8:10–8:30am	Icebreaker - Docking Activity
8:30–9:30am	Activity 1
9:35–9:50am	Break
9:55–10:55am	Activity 2 - How We Are Going Video
10:55–11:55am	Lunch/Recess
12–1:00pm	Activity 3
1:05–1:20pm	Break
1:20–2:20pm	Activity 4
1:25–2:55pm	Wrap up
2:55–3:00pm	Artemis - We Go as the Artemis Generation Video

We Are Going Video

Docking Activity

How We Are Going Video

We Go as the Artemis Generation Video

Activity 1: Design a Crew Module

Prep time: 15 min **Activity time:** 60 min

Summary: Upon returning from the Moon, the Orion crew module enters Earth's atmosphere at around 25,000 mph and, with the aid of parachutes, splashes down at 25 mph. During the launch and landing of the Orion crew module, the astronauts are safely secured in specially designed seats. Engineers at NASA Langley Research Center test the seats and other parts of Orion by loading sensors into a mock spacecraft to measure the forces acting on the test article during splashdown.

Learning Objective: Participants will understand that parachutes help slow the rate of re-entry significantly. Even with the slower speed, astronauts must be secured and safe in their seats during reentry.

Outcome: The participants will build an Orion crew module that will keep "astronauts" seated and secure through a series of drop tests.

Activity 2: Design Stabilizing Fins

Prep time: 15 min **Activity time:** 60 min

Summary: Rocket stability is an important issue for rocket engineers. All rocket components are tested in a variety of ways before they are verified for flight. Scale models of rockets are tested in wind tunnels, which allow engineers to visualize and gather data on how air moves around the nose, body, and fins of the rocket. The nose, cone, and fins of a rocket are designed to minimize drag and provide stability and control. Rocket fin shapes vary; they can be triangular, rectangular, elliptical, and trapezoidal to name a few. The fin shape contributes to the rocket's center of mass and how much drag it faces during flight.

Learning Objective: Fins affect a rockets stability during flight.

Outcomes: Participants will create a fin that keeps their rocket stable.

Activity 3: Build a Space Module Structure

Prep Time: 15 min **Activity Time:** 60 min

Summary: NASA is working with the industry on the critical elements required to support early Gateway missions. The Power and Propulsion Element (PPE) and the Habitation and Logistics Outpost (HALO) are the first two components that will launch to lunar orbit. The HALO and PPE will be integrated on Earth and launched together. Other Gateway modules will follow on separate launches, including cargo ships that will deliver supplies for Gateway and lunar surface operations. Because each of the components must be lifted into space, NASA materials engineers select materials like aluminum, titanium, Kevlar, and high-grade steel to make sure Gateway components are lightweight, yet strong enough to withstand the loads of launch and the hazards of space.

Learning Objective: Participants will understand that building an ideal space module structure is both light weight and strong.

Outcome: Participants will work together as a team to design and create a structure from spaghetti that will protect the inside cylinder and support increasing amounts of mass.

Activity 4: Build a Heat Shield

Prep time: 15 min **Activity time:** 60 min

Summary: The heat shield is one of the most critical elements of the Orion spacecraft. When returning home from the Moon, Orion will exceed speeds of 25,000 mph. The friction between Earth's atmosphere and the surface of Orion will generate temperatures near 5,000 F. That is about half as hot as the surface of the Sun! The heat shield uses an ablative material called AVCOAT. The AVCOAT blocks "burn off" as they heat up, removing thermal energy away from the capsule while keeping the astronauts safe from the intense heat. NASA engineers conduct non-destructive tests to look for gaps between the AVCOAT blocks and run thermal tests before the heat shield is certified for flight.

Learning Objective: Heat shields are necessary to protect astronauts and their flight equipment from thermal energy sources.

Outcome: Participants will use common items to make heat shields that are able to keep payload (a candy bar) from melting under the heat of a hair dryer.

MISSION BRIEFING

ACTIVITY: Design a Crew Module

PREP TIME: 15 min

ACTIVITY LENGTH: 60 min

TASK: Participants will design, build, and test a crew module that will secure two 2cm sized astronaut figures during a drop test.

Orion will serve as the exploration vehicle that will carry the crew to space, provide emergency abort capability, sustain astronauts during their missions and provide safe re-entry from deep space return velocities.

Scan the QR code with your smartphone for an instructional video of this activity.

By the end of this activity participants will

- Know that crew modules must be tested for safety, impact force, and damage to the crew module.
- Understand that the quantitative and qualitative data collected is used to make improvements.
- Be able to use data to improve crew module design.

Materials

- 2-cm plastic figurines, 2 per team
- Tape (tape cannot be used to keep the astronaut in place)
- Scissors
- Metric scale
- Meter stick
- Paper and pencil for brainstorming
- Mailing tube, oatmeal canister, or small coffee can (used as a size constraint)
- Paper or foam cups
- Paper or foam plates
- Index card
- Aluminum foil or plastic wrap

Preparation

1. Gather and prepare all supplies listed on the materials list.
2. Divide the participants into teams (three to five participants per team).

Procedure

1. Provide each group with sheets of graph paper.
2. Participants should sketch their crew module designs, and then agree on a design.
3. AFTER participants agree on a design, one participant should gather desired materials.
4. Participants construct, and improve their crew capsules. (Participants should be able to test crew capsules as they build.)
5. Gather ALL participants in one area for the drop test. (Height=1m)

MISSION GUIDANCE...

DO

- Set up a "testing site" for participants to use as they build.
- Encourage student groups to sketch crew designs before building.

MAYBE

- Conduct a "building brainstorm" time.
- Show a video of Orion "drop" tests.

DON'T

- Make unrequested suggestions
- Provide step-by-step instructions.

Crew Module Constraints

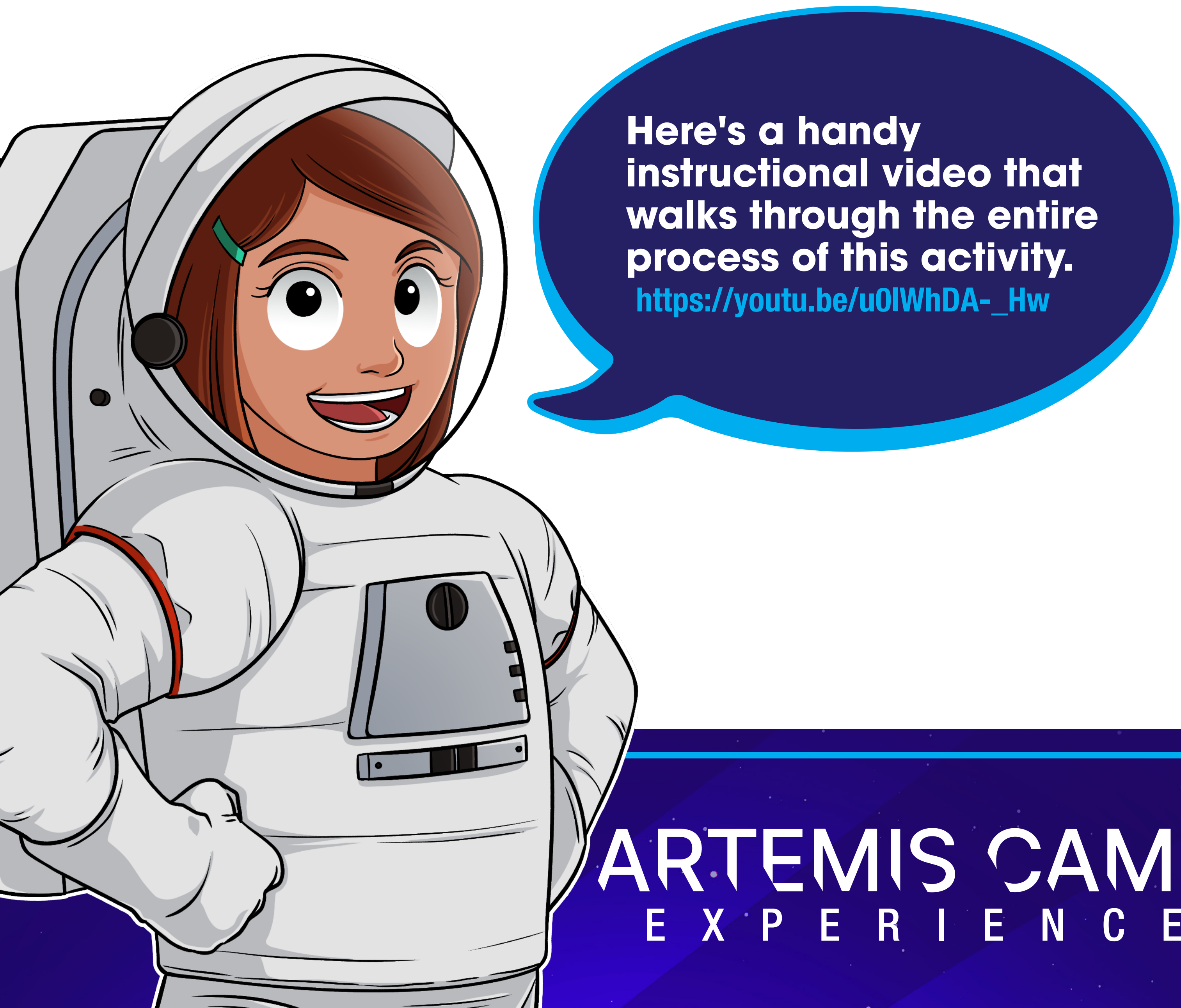
- The crew module must safely carry two astronauts. Each team must design and build secure seats for the astronauts without gluing or taping the astronauts in place. The astronauts must stay in their seats during each drop test.
- The crew module must fit into the constraint container provided. This item is simply a size constraint; the crew module will not be dropped while inside the container.
- The crew module must have at least one hatch that opens and closes easily. The hatch must remain closed during all drop tests.

Extension

- Ask participants to calculate the area of their self-designed crew module by identifying smaller shapes, and calculating the area of each shape.
- Provide participants a "budget" to maintain.
- Provide size and mass constraints.

Challenge Questions

- How can the force of impact on the crew module and astronauts be reduced?
- What are some safety devices used to protect passengers on or near Earth? Will these devices be useful in space?
- What design features will allow a hatch that can open and close after splashdown?



ARTEMIS CAMP
EXPERIENCE

MISSION BRIEFING

ACTIVITY: Design Stabalizing Fins

PREP TIME: 15 min

ACTIVITY LENGTH: 60 min

TASK: Create fins for a foam rocket that lands downrange, and follows a desired pathway.

NASA's Space Launch System (SLS) will be the most powerful rocket NASA has ever built. When completed, SLS will enable astronauts to begin their journey to explore destinations far into the solar system.

Scan the QR code with your smartphone for an instructional video of this activity.

By the end of this activity, participants will

- Know that fins can alter the stability of a rocket.
- Understand the relationship between a rocket's stability and its trajectory.
- Be able to improve rocket stability.

Materials

- Polyethylene foam pipe insulation for 13-mm (1/2-in.) size pipe (one 30-cm piece per group)
- Foam food trays, cardboard, or stiff poster board
- Long tape measures and/ or rolling measure wheel (used to indicate the horizontal rocket range and to measure distances to where the rocket landed)
- Launcher quadrant template printed on cardstock (see page 9)
- Rubber bands (size 64)
- Safety glasses
- Duct tape
- Scissors
- Meter stick
- Masking tape
- Zip ties
- Binder clip
- Pushpin
- 75cm string

Safety

Remind participants that rockets should never be launched at anyone. Safety glasses should be worn during launch.

Preparation

Watch "DIY Space: Build a foam rocket" video tutorial for instructions on building the rocket and conducting activity

Build it (example illustrations below)

1. Using scissors, cut one 30-cm length of pipe foam for each team.
2. Cut four equally spaced slits at one end of the tube. The slits should be about 12 cm long. The fins will be mounted through these slits.
3. Cut a 12-cm length of duct tape down the middle to make two pieces. Place one piece over the other, sticky to shiny side, to make the tape double strong.
4. Slip a rubber band over the tape and press the tape around the nose end of the rocket (opposite the end with the slits).
5. Press the tape tightly and reinforce it with another length of tape wrapped around the tube.
6. Cut fin pairs from the foam food tray or stiff cardboard.

MISSION GUIDANCE...

DO

- Keep a protractor nearby to help participants with launch angles.
- Allow participants to design and build unique fins.

MAYBE

- Create the launcher ahead of time.
- Mark the launch pathway ahead of time.

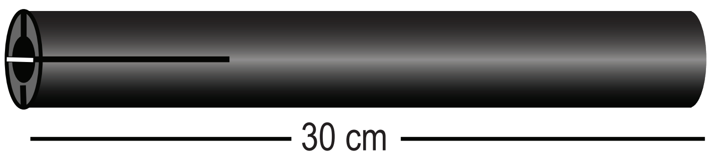
DON'T

- Give participants templates for fins.
- Let participants launch the rockets toward one another.

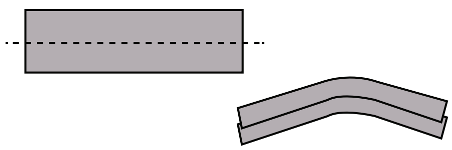
Refer to the fin diagram. Both fin pairs should be notched so that they can be slid together as shown in the diagram. Different fin shapes can be used, but they should still “nest” together.

7. Slide the nested fins into the slits cut in the tube. Close off the slits with a piece of duct tape wrapped around the foam tube. The rocket is finished.

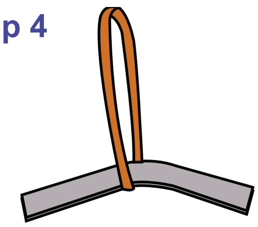
Steps 1 and 2



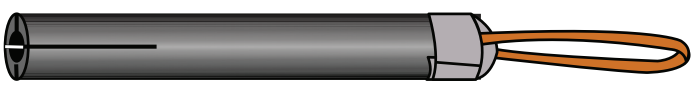
Step 3



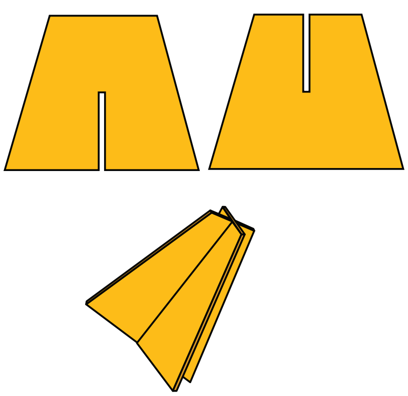
Step 4



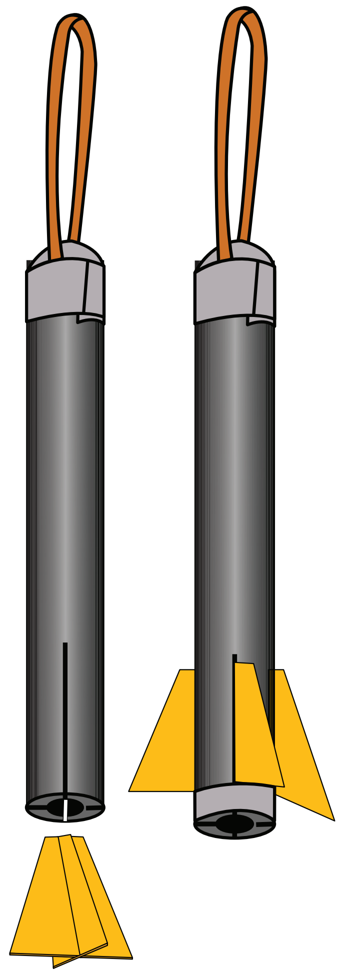
Step 5



Step 6



Step 7

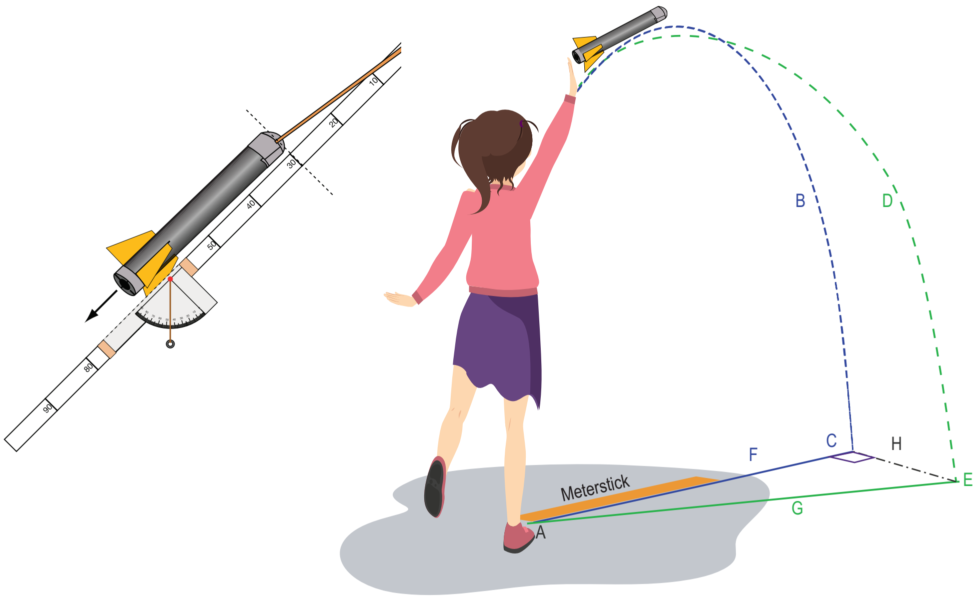


Quick Tips and Tricks

1. Some participants may struggle with “nesting fins,” assist them with fins that nest/slide together.
2. To ensure that vertical launch height is unchanging, place the bottom edge of the launcher on a table.
3. Participants should measure two distances ONLY: downrange distance, and distance off course.

Test it

1. Build the model rocket launcher (pattern included at the end of this activity).
2. Put a piece of string or tape on the ground in a straight line directly in front of the launcher. This line will be used to measure the distance that the rocket flew from the launcher, and how far off course the rocket traveled.
3. Have the participants launch the rockets at a specified angle using the rocket launcher.
4. After they have launched, the participants will record the distance that the rocket traveled (line segment F) and how off course the rocket went (line segment H).



A. Launch site
B. Ideal or planned trajectory
C. End point of planned trajectory
D. Actual trajectory of launched rocket
E. Point where rocket landed
F. Downrange distance traveled
G. Straight line from launch site to point where rocket landed
H. Distance off course

Improve

1. Give each team additional supplies to redesign and build another set of fins. Ask them to consider the stability and trajectory of their first set of launches and think of what improvements could be made to their fin design.
2. Discuss different variables that may impact their results, including the elasticity of the rubberband.
3. The goal is to increase the stability of their rocket, which is measured by how close they are to landing near the tape measure or meterstick without a significant decrease in the range of their rocket or how far the rocket traveled from the launch site.
4. Teams will repeat steps 4 to 6 of the rocket building procedure, conduct three launches, and then compare the results of their redesigned fins with the results of their original design.

Extension

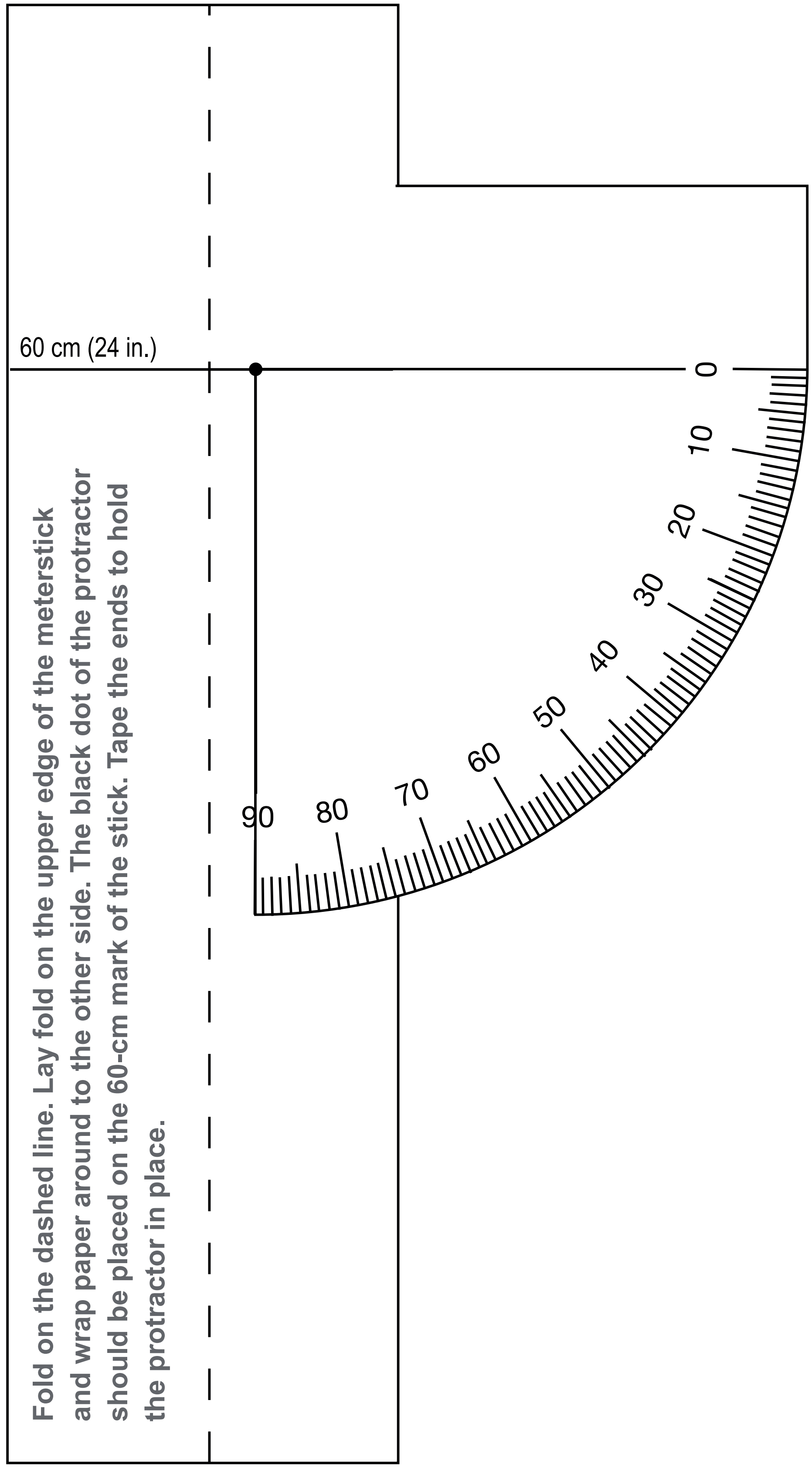
- Ask participants to add weight to their rockets by taping pencils to them. Give participants a limited number of pencils they can use. Consider also limiting where they can add the weight.
- Ask participants to consider center of mass and investigate how it impacts rocket stability.
- Ask participants to measure the dimensions of each fin and use geometry to find the area. Gather data from the entire class. Plot a graph comparing area of a fin with horizontal distance traveled by each rocket.
- For advanced participants, apply the rules of sine, cosine, or tangent to find angle CAE (in degrees) between the planned path of travel and the actual path of travel for the rocket. By finding angle CAE, teams can compare results across different fin designs, launch angles, and so forth.
- For advanced participants, capture video of the launch and use the open-source Tracker Video Analysis and Modeling Tool (https://physlets.org/tracker) to collect data about position, velocity, or acceleration.

Challenge Questions

- How does rocket stability affect it's trajectory
- Why was it important to launch from different angles?
- How do you think the size, shape, weight, or location of fins on a rocket can affect its stability?

Launch Quadrant Pattern

(Actual size)



Making the Launcher

1. Print the quadrant pattern on card stock paper.
2. Cut out the pattern and fold it on the dashed line.
3. Tape the quadrant to the meter stick so that the black dot lies directly over the 60-cm mark on the stick.
4. Press a pushpin into the black dot.
5. Tie a string to the pushpin and hang the binder clip on the end of the string. The weight should swing freely.

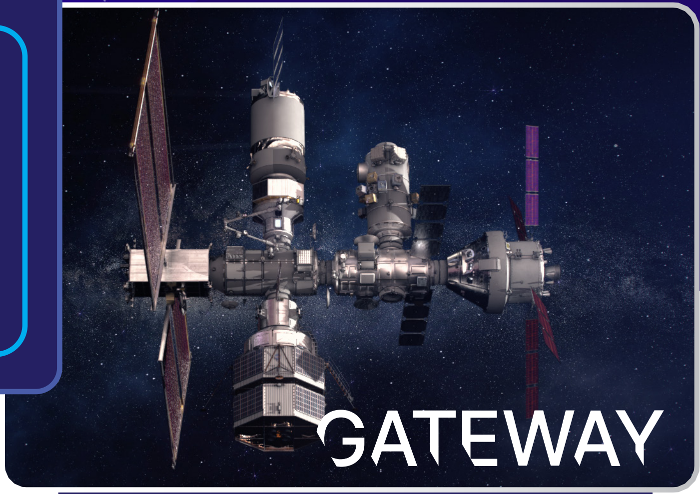
MISSION BRIEFING

ACTIVITY: Build a Space Module Structure

PREP TIME: 15 min

ACTIVITY LENGTH: 60 min

TASK: Participants will design, build, and test their own space module.



Gateway, a vital component of NASA's Artemis program, will serve as a multipurpose outpost orbiting the Moon. It will provide essential support for long-term human return to the lunar surface and serve as a staging point for deep space exploration.

Scan the QR code with your smartphone for an instructional video of this activity.

By the end of this activity participants will

- Know that space modules must be lightweight to make liftoff less difficult, but sturdy enough to withstand conditions in space.
- Understand the relationship between mass and weight.
- Be able to construct a space module that is sturdy and lightweight.

Materials

- Cardboard tubes (10 cm), aluminum cans, or similar lightweight cylinders (1 per team for use as an inside cylinder)
- Mass (lead weights, coins, large washers, or similar)
- 30 pieces of uncooked spaghetti for each team
- Clear tape or low-temperature glue gun with cool-melt glue
- Index cards
- Paper and pencils
- Scissors
- Metric scale
- Rulers

Preperation

1. If using a glue gun, even with cool-melt glue, setup a glue gun station for safety and supervision.
2. Determine the internal volume constraint for the space module in advance of the lesson. Any lightweight cylinder ranging in size from a toilet paper tube to a 12-oz aluminum can will work.

Procedure

1. 1.Provide each team 25 pieces of dry spaghetti noodles and 50 cm of one-sided tape (or one small glue stick).
2. When building is done, teams will test their structures (record the mass held).
3. After testing, provide 5 additional spaghetti noodles and 10 cm of tape for improvements.
4. Participants should test a second time and record the new mass held.

MISSION GUIDANCE...

DO

- Provide all teams the same number of spaghetti noodles.
- Discuss challenge constraints.

MAYBE

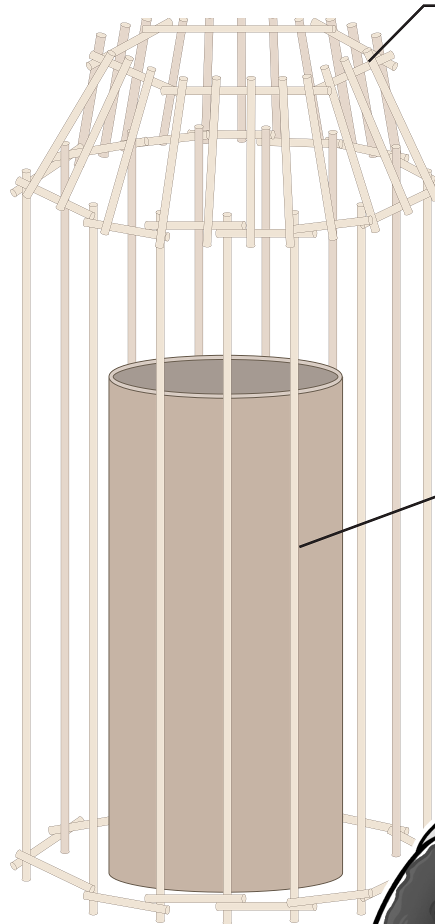
- Have participants build again with a different fragile material.
- try spaghetti with a different thickness to manipulate difficulty.

DON'T

- Allow participants to use materials that are not provided.
- Give participants structural suggestions or show examples.

Design Constraints

- The volume constraint cylinder must fit completely and securely within the spaghetti structure each team builds.
- Teams are only allowed to use the supplies provided. If they make a mistake, they must reuse materials.
- Test the module frame standing upright on its end (oriented like a soda can), and there should be a gap between the top of the volume constraint cylinder and the spaghetti structure.



Test

Teams will test their designs by increasing the mass on the top of the design. The test stops if one (or more) of these three things happen:

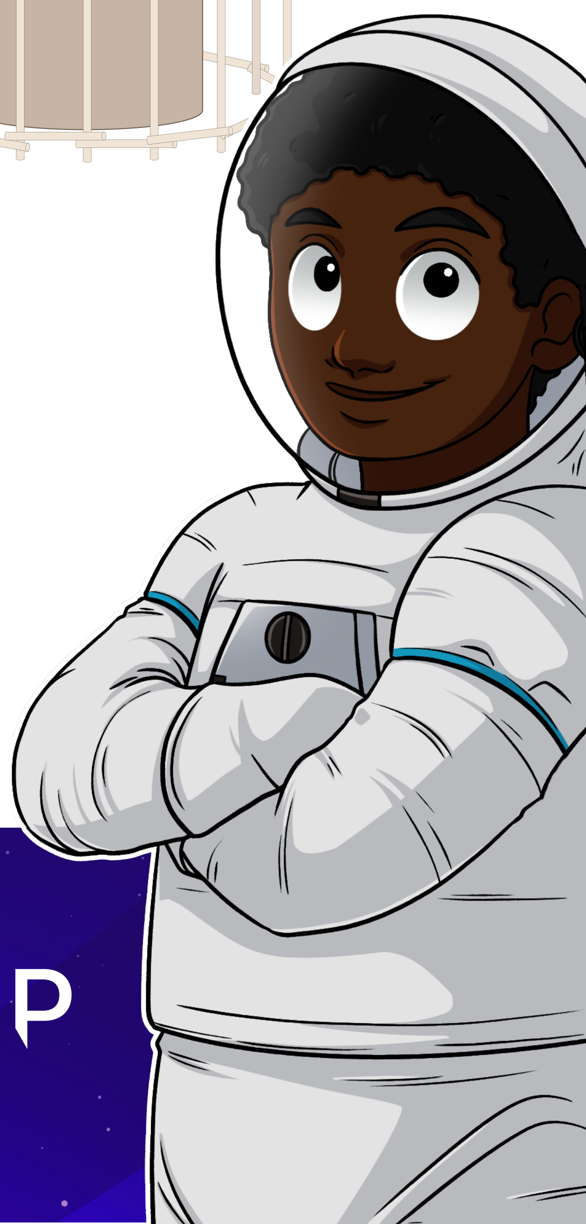
1. One of the pieces of spaghetti breaks/snaps.
2. The end of one of the pieces of spaghetti is detached from the tape or glue.
3. Any of the spaghetti pieces bend to the point of touching the top of the cylinder.

Extension

- Ask the participants to build a new structure to protect a taller cylinder.
- Add a cost constraint to the challenge and create a budget for the participants to "purchase" materials. Assign cost to each piece of spaghetti and centimeter of tape. Challenge participants to create the most efficient design (smallest ratio of cost to mass supported).
- Repeat the challenge using different materials for the structure.

Challenge Questions

- Which was most difficult: Keeping the spaghetti from bending, breaking, or becoming detached?
- Would this challenge be more difficult with a larger or smaller cylinder used as a size constraint? Why?
- What was the purpose of the design constraints? Why were you limited in how much the spaghetti could bend?



MISSION BRIEFING

ACTIVITY: Build A Heat Shield

PREP TIME: 15 min

ACTIVITY LENGTH: 60 min

TASK: Participants will build a heat shield that will protect crew module contents from simulated atmospheric re-entry.

The Orion heat shield, will protect the Orion crew module during re-entry after the spacecraft's first uncrewed flight test with NASA's Space Launch System rocket.

Scan the QR code with your smartphone for an instructional video of this activity.

By the end of this activity participants will

- Know that some materials better resist heat than others.
- • Understand that crew modules can be damaged upon reentry due to exposure to extreme heat.
- Employ methods of thermal resistance.

Materials

- Cardboard scraps (shoe boxes, milk cartons)
- Foam scraps (packing peanuts, plates, food trays)
- Infrared thermometer (recommended)
- Paper
- Unwrapped candy bars without nuts
- Scissors
- Tape
- Metric rulers
- Newspaper
- 5-oz paper cups
- Hair dryer
- Digital scale or balance
- Tongs
- Stopwatch
- Eye protection
- Construction paper
- Cotton balls
- Bubble wrap
- Index cards
- Oven mitts/gloves
- Electrical tape
- Pens
- Steel Wool

Preperation

1. Gather and prepare all listed supplies.
2. Set up testing stations with safety equipment, hair dryer, tongs, infrared thermometer (recommended), scale, and a metric ruler. At most, allow three teams per testing station.

Quick Tips and Tricks

- If presenting videos or web-based resources, test the links and the classroom technology ahead of time.
- Wire or mesh cloth (also known as hardware cloth or welded wire fabric) can be purchased online. It should be strong enough to provide structure for the design.

MISSION GUIDANCE...

DO

- Ask probing questions to prompt participants creativity.
- Allow groups to test individual materials prior to building.

MAYBE

- Carry out sample "tests" as a demonstration.
- Have participants document the results of their tests.

DON'T

- Critique participant designs.
- Tell participants which items you think repel heat the best.

Procedure

1. Ask participants to develop a list of building materials, then allow one participant from each group to gather materials.
2. Participants build their heat shield to fit over the open end of the cup.
3. Load the candy bar astronaut into the cup, and then use a rubber band to attach the heat shield to the front of the cup.
4. Hold the hairdryer 10 cm away from the cup.
5. Turn the hairdryer on (facing the heat shield) for 1 min.
6. Check to see if the candy bar has melted.
7. Repeat steps 5 and 6 (do this 7 times total).
8. Give participants 15 min to alter their heat shield based on observations.
9. Repeat steps 3 to 7 using the new design.

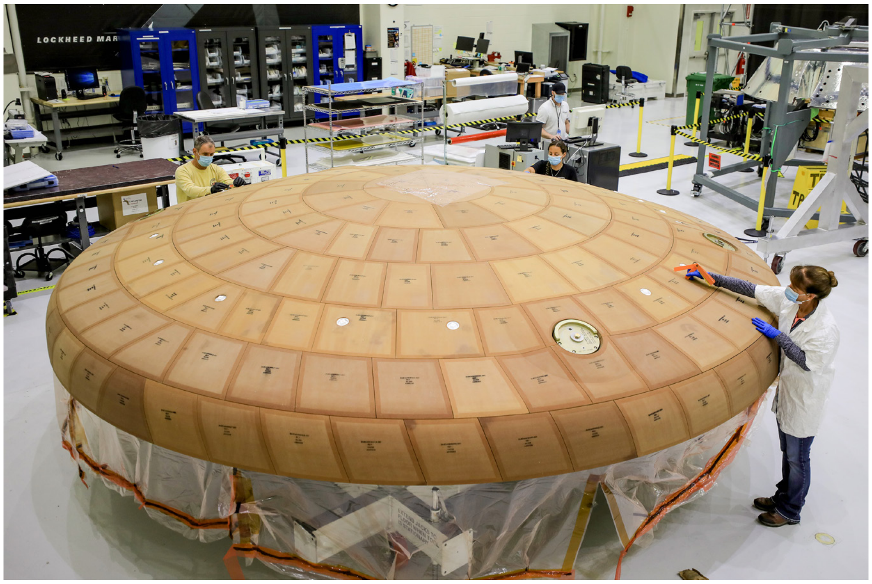
Note: A heat shield is properly designed when the candy bar remains solid after 7 minutes of heating (steps 3-7).

Extension

- Use an alternative substance as an astronaut, such as wax or ice.
- Provide participants with an engineering budget and assign a price to each piece of building material.

Challenge Questions

- Which design characteristics provide the most protection to the crew on board?
- What information could engineers working on this project learn from your team's results?
- What other tests or calculations would you do before making recommendations to NASA for their heat shields?



Technicians at NASA's Kennedy Space Center in Florida meticulously applying more than 180 blocks of ablative material to the heat shield for the Orion spacecraft.

National Aeronautics and Space Administration

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