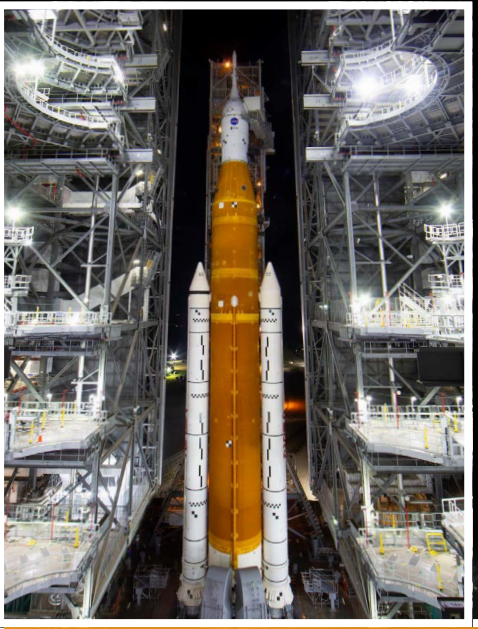
National Aeronautics and Space Administration



Light but Strong

A Lesson in Engineering

engineering is out of this world

Light but **Strong**

teacher notes

Next Generation Science Standards:

Structure and Properties of Matter

2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

5-PS1-3. Make observations and measurements to identify materials based on their properties.

Engineering Design

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

3-5-ETS1-1. Define a simple problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Dr. Erin Hayward — Lightweight materials are essential for spaceflight missions as they reduce the mass of spacecraft and enable efficient launches from planetary bodies such as Earth, the Moon, and Mars. However, launching is just the first step for a lightweight spacecraft material. When the spacecraft reaches orbit and begins its journey, it must survive the harsh space environment. The material will encounter extreme temperatures, intense ultraviolet radiation from the Sun, galactic cosmic rays, and all while being immersed in a vacuum environment that makes dissipating heat incredibly challenging.

My focus as a materials engineer is to help ensure a successful mission by recreating the space environment in the laboratory and verifying the lightweight materials selected for a specific mission will meet the demanding requirements set by the system designers. Every test I conduct adds to the development of even stronger and lighter materials that have the potential to be used in the exploration of the most remote areas of our solar system.

As much as possible, I like to share my testing experiences with other engineers at conferences and through technical publications. This way I can play a role in the success of many missions, not only within NASA, but also through universities and the commercial spaceflight industry.

An Introduction to Materials Engineering

Lesson Duration: 1 hour

THE CHALLENGE

Design and build a mobile launcher that is light enough to be moved to the launch pad, but strong enough to hold the weight of the rocket.

Be prepared

1. Read the teacher notes and student journal page.
2. Gather materials for the activity listed on the teacher notes page.
3. Count the straws ahead of time for each group.
4. Draw a spacecraft on the side of the small cup to represent the crew vehicle.

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Background information on materials engineering

Materials engineers are involved in the development, processing, and testing of the materials used to create a range of products. A materials engineer at NASA would develop lightweight, strong, heat resistant materials for use in space.

Introduce the challenge (5 minutes)

1. Students should develop an understanding of the word material. A material is a substance out of which a thing is or can be made.Choose an object in your classroom and hold it up in front of the class. Ask the class what materials make up the object. (Example: a pencil is made of wood, lead, metal, and rubber for the eraser.) Do this several times with different objects until the students understand the word “material.”

2. **Discuss with the class what the role of a materials engineer is at NASA.**

   A materials engineer selects the materials to build rockets, spacecraft, and launch pads. Sometimes they have to make new materials to meet the needs of the rocket. Read Todd Schneider’s description of a materials engineer to the class. Show the class an image of the SLS (Space Launch System) rocket (image on page 8).

3. **Introduce the activity to the students.**

   Tell your students they have been challenged by a NASA materials engineer to use a lightweight material to build a mobile launcher that is light enough to move, but also strong enough to hold the weight of the rocket. The students should brainstorm ideas, design the launcher platform, and estimate how many astronauts (pennies) their platform will hold. Put students into groups of 3-5 to build the platform.

   Even though a real mobile launcher must roll to the launch pad, this activity does not have the requirement to roll. Make sure the students know their mobile launcher will not require wheels/tracks/etc. to move it.

   After each group completes their mobile launcher, set a 3" by 3" piece of cardboard on top of the launcher platform with a cup sitting on top and drop one penny at a time into the cup (rocket) to test the strength of the platform until the platform collapses. Explain that mobile launcher has to be light enough to roll out to the launch site, but also strong enough to hold the weight of a rocket and crew. The SLS Block 1 rocket will weigh 5.75 million pounds fully fueled.

Materials (per group):

- Plastic drinking straws (30)
- Scissors (1 pair)
- Pennies (50)
- One small paper or Styrofoam cup
- One 3” by 3” piece of cardboard
- Scale (optional)
- Ruler/measuring tape/ etc. (needed for enhanced activity)
- Various materials such as clay, tape (recommended for younger students), or playdough to connect the straws together.

The Mobile Launcher (ML) at Kennedy Space Center was originally constructed for transporting the Saturn V rocket. The base alone is 25-feet high.

Light but **Strong**

Think it over and design (15 minutes)

1. Distribute the challenge instructions and journal page to each student.
2. What kind of mobile launcher can you make from the supplies provided? (Straws can serve as the walls. The tape or clay could be used to hold the straws together.)
3. Instruct students to answer the questions on the journal page about two items that they think are light but strong. (Examples: aluminum, cardboard, plastic, and more)
4. Have the students get together with their assigned groups and discuss how they will build their mobile launcher. Have each student draw a picture of the group's proposed mobile launcher on their individual journal page.

Build and test (30 minutes)

1. Distribute materials to the groups.
2. Explain that each group's mobile launcher will be tested by placing a 3" by 3" piece of cardboard on top of the platform. A cup representing the rocket will be placed on the cardboard. One penny at a time will be placed in the cup to see how much weight the mobile launcher will hold. The mobile launcher must be 6" high. Give each group 20–30 minutes to build.

Discuss activity (10 minutes)

1. Have the students share how they designed their mobile launcher platform and the results.
2. What features helped your platform withstand the weight of the pennies?
3. Would you make any changes if you could rebuild the platform?
4. Did any materials work better than others?

Change it up!

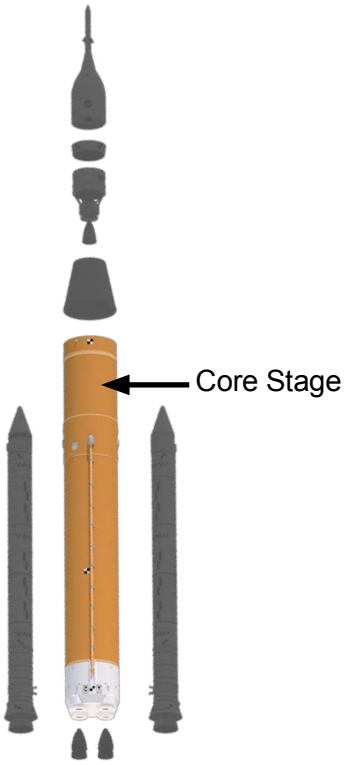
There are many ways to enhance the activity!

- Specify a weight limit for the mobile launcher
- Have different groups use different materials to build the mobile launcher and compare
- Require a hole in the center of the launch pad (cardboard) for the rocket "flame"
- Make this a multimedia project by having the students record (phone/camera/etc.) their process and test then present to the class

Dr. Erin Hayward inspecting a beta cloth sample in the accelerator lab at NASA's Marshall Space Flight Center in Huntsville, Alabama, prior to conducting a radiation test on the material.

Light but **Strong**

student journal notes



Your Challenge

To design and build a mobile launcher that will hold as much weight as possible but built as light as possible.

Think it over

Your mobile launcher must be both light and strong.

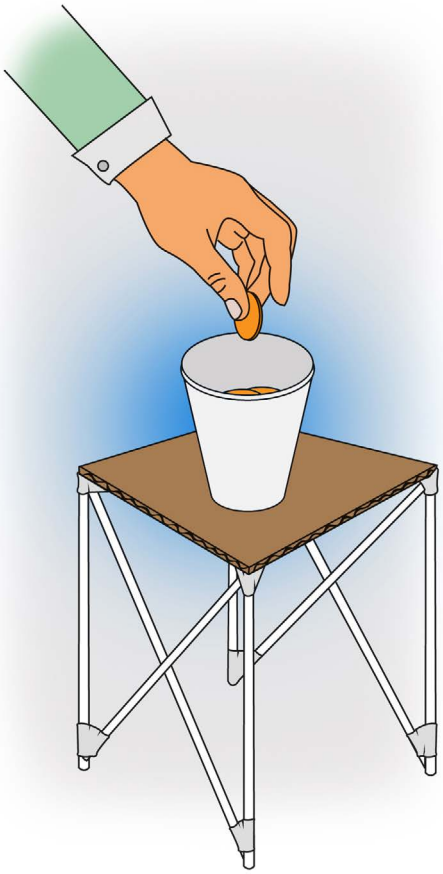
Discuss with your group:

- What does it mean for something to be lightweight?
- What does it mean for something to be strong?

The core stage of the SLS will be made from a light and strong material called aluminum.

Name one thing that you know is made of aluminum.

_____



Name two items that are light but also strong.

_____

_____

Plan and design

Your mobile launcher must hold the rocket (a cup) six inches above the ground. It must also be able to be moved (by hand) to the testing site and hold a 3” by 3” piece of cardboard.

Discuss with your group how you will build your mobile launcher.

- Which materials will you use?
- What will your design look like?
- What type of material will you use to hold the mobile launcher together?

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Draw a picture of your proposed mobile launcher:

Build

Collect all of the materials to begin building your mobile launcher.

Did you use all of your materials? Yes ____No____

Did you change your original design as you were building? Yes ____No____

Why?_____

How much does your mobile launcher weigh? _____

Testing and results

Now that you have finished building your mobile launcher, it is time to test how much weight your platform can hold.

Move your platform to the testing area.

Estimate how many pennies your mobile launcher will hold.	**How many pennies did your mobile launcher hold?**

If you did this activity again, would you change your design? Yes ____No____

Why?_____

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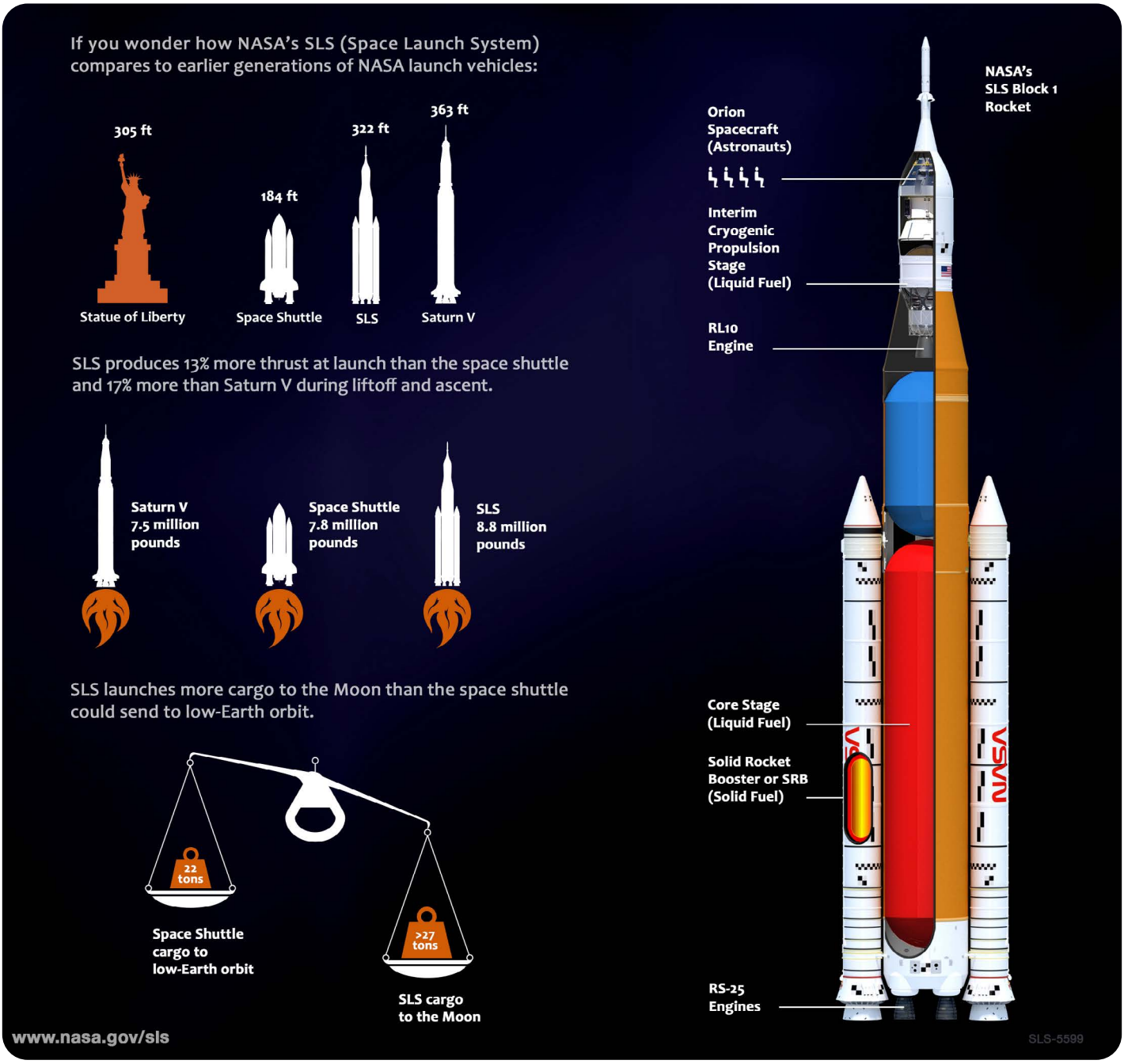

SLS Fun Facts

- The average cow weighs 1,200 lbs. – SLS Block 1 can lift the equivalent weight of 49 average cows to the Moon
- The SLS Block 1 will weigh more than 7 fully-loaded 777 jumbo jets, and produces more thrust than 76 of the engines used on that jet

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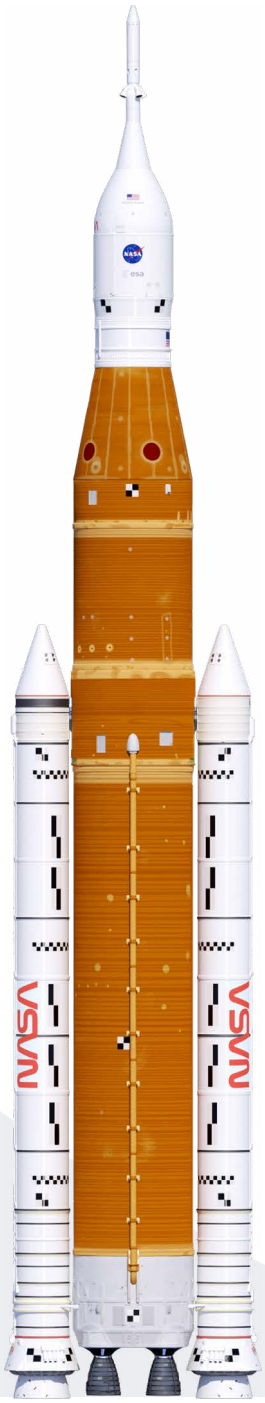
Space Launch System
Block 1 Crew



National Aeronautics and Space Administration

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SLS-5560-2025

For more information about SLS, visit:

https://www.nasa.gov/Artemis
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