STEM in the lab

Inspiring Idaho's future STEM workforce

PERSEVERANCE: Rocketing to Mars with STEM

GRADE LEVELS

This activity is appropriate for grades 3-8.

MISSION

Design fins for a foam rocket.

VOCABULARY

LAUNCH VEHICLE: A launch vehicle provides the velocity needed by a spacecraft to escape Earth's gravity and set it on its course for space exploration.

TRAJECTORY: The path followed by a projectile flying or an object moving under the action of given forces.

MATERIALS

- 30 cm piece of polyethylene foam pipe insulation *(for 1/2" size pipe)*
- Rubber band (size 64)
- Duct tape
- Scissors
- Meter stick/ruler
- Two 4x6 index cards

ABOUT THIS ACTIVITY

On July 30, 2020, at 4:50 a.m., an Atlas V-541 rocket was launched from Cape Canaveral Air Force Station, Florida. The Atlas V is one of the largest rockets available for interplanetary flight and delivering things into space. The rocket departed Earth at a speed of about 24,600 mph (about 39,600 kph). Its launch was the start of the mission to deliver the Mars rover, Perseverance. After six-and-a-half months and about 300 million miles (480 million kilometers), the rover will reach Mars and land on the 28-mile-wide Jezero Crater (Feb. 18, 2021).

Once the rover reaches Mars, its mission will be to look for signs of ancient life and collect samples of rock and soil. However, the rover could not do all of this important data collection without an energy source to power it. Idaho National Laboratory is playing a major role in powering Perseverance. INL's Space Nuclear Power and Isotope Technologies Division assembles and tests Radioisotope Power Systems. The power systems they provide are then used in remote, harsh environments, such as Mars. The MMRTG will power Perseverance's movement and instruments, and help keep it warm while exploring the chilly Red Planet.

Your mission today is to design fins for a foam rocket. The purpose of fins on a rocket is to increase the rocket's stability and keep its trajectory on course. However, fins can also create aerodynamic drag that can slow down the rocket and affect its range. Your goal is to design fins to improve your rocket's performance (indicated by its ability to stay on course with little or no impact on the distance traveled).

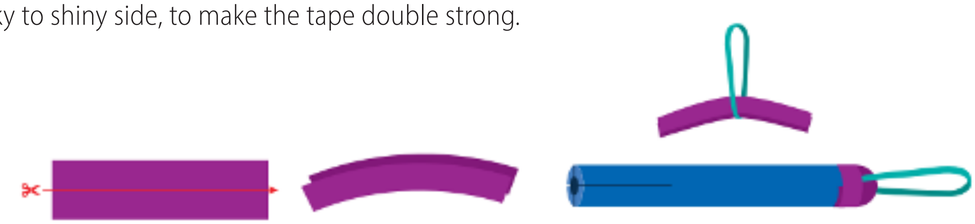
INSTRUCTIONS

1. 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.

2. Design fin pairs by drawing them on cardstock. Cut fin pairs from cardboard. 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. The shape of the fins is up to you. As you build your fins think about how the size, shape, weight or location of the fins on a rocket can affect its stability .

3. Carefully nest your fin pairs together and adjust them until they are even at right angles to each other. Then slide the nested fins into cuts in the rear end of the rocket. Wrap a piece of duct tape around the end of the foam tube to secure the fins.

4. 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.



5. Slip a rubber band over the tape and press the tape around the nose end of the rocket (opposite the end with the slits). Press the tape tightly and reinforce it with another length of tape wrapped around the tube.

6. Now your rocket is ready to launch. Loop the rubber band over the end of a ruler/meter stick. Pull back on the other end of the foam rocket and quickly release the rocket. Measure how far your rocket flew.

7. Repeat Step 6 five times. Make sure you pull back the rubber band to the same number on the ruler before every launch. Record the distance it flew each time. Make adjustments to your fins by making them a different size. Repeat Step 6. How does the adjustment affect the distance of the flight?

THE SCIENCE BEHIND IT

Like most engines, rockets burn fuel, turning fuel into hot gas. The engine pushes the gas out its back, making the rocket move forward. A rocket is different from a jet engine. A jet engine needs air to work, while a rocket engine doesn't need air. It doesn't need air to work because rockets travel in space, where there is no air. In the vacuum of space, an engine has nothing to push against. So how do rockets move? Rockets work by a scientific rule called Newton's third law of motion. The third law says that for every action, there is an equal and opposite reaction. When the rocket pushes out its exhaust, the exhaust also pushes the rocket forward. The foam rocket receives its entire thrust from the force produced by the elastic rubber band after the rubber band is stretched. When the rocket is released, the rubber band quickly returns to its original length, launching the foam rocket in the process. Technically, the foam rocket is a rocket in appearance only. The thrust of real rockets typically continues for several seconds or minutes, causing continuous acceleration, until all propellants are exhausted. The foam rocket gets a quick pull and then coasts. Furthermore, the mass of the foam rocket doesn't change in flight. Real rockets consume propellants, which diminish their total mass. Nevertheless, the flight of a foam rocket is similar to that of real rockets. Its motion and course are affected by gravity and by drag or friction with the atmosphere.

EXTENSIONS

» Watch this video to meet Phillip Hargrove, launch vehicle trajectory analyst: *www.nextgenstem.battelle.org/stem-stars-trajectory* (If you don't have time for the whole interview, watch at least 12:20-21:13) and consider the following questions:
   1. In what ways is planning a rocket's trajectory like planning a car trip?
   2. What are some of the projects that Phillip has worked on?
   3. What happens if the trajectory math for a mission is wrong?

» Learn more about how to add trajectory to your project by visiting: *https://nextgenstem.battelle.org/propulsion-with-foam-rockets*

» Try making rockets using different resources of varying size. How does size and weight affect the trajectory of the rocket?

RESOURCES

» https://www.nasa.gov/stem-ed-resources/beginners-guide-to-rockets.html
» https://www.ulalaunch.com/explore/rocket-science/fun-facts
» https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-a-rocket-k4.html
» https://nextgenstem.battelle.org/propulsion-with-foam-rockets
» https://https/www.jpl.nasa.gov/edu/teach/activity/foam-rocket/

LEARN MORE

Students + Parents + Educators

For information on grants, training and student opportunities, curriculum ideas and resources, please visit us at stem.inl.gov.