Level E Elementary | Grades K-4

SELTZER ROCKET LAB

Image credit: NASA

ACTIVITY: SELTZER ROCKET LAB

Big Idea

Students will learn about the engineering process while conducting and observing three launch altitudes using film canister seltzer rockets. The activity also provides a representation of LEO, MEO, and GEO orbits. LEO is Low Earth Orbit, MEO is Medium Earth Orbit, and GEO is Geostationary Earth Orbit. Students participate in a discussion with a Lockheed Martin engineer regarding rocketry and rocket scientists. The engineer explains Lockheed Martin's role in rocket technology development. The engineer explains the criteria for rocket scientists to consider as they design and launch rockets for specific orbits. Students conduct three film canister seltzer rocket launches and work through the engineering process by modifying their rocket's propellant to reach different desired launch altitudes. Students participate in a brief closing discussion to share observations about the success and altitude of each launch and discuss how they would continue to modify the propellant to better reach their altitude goals.

Guiding Question

How do rocket scientists design a rocket to launch for a specific mission?

Materials Gathered by Teacher

1. 1 cup per group of three students
2. 1 pitcher filled with tap water

Materials Provided in the EITC Kit

1. 10 film canisters per class or 1 per group of three students
2. 2 seltzer tablets split in half per group
3. 1 pair of safety goggles per group

Set Up

Communicate with the teacher at least one week before your scheduled classroom visit. Inform the teacher that this activity will require indoor and outdoor work spaces. For the indoor portion of this visit, desks should be arranged so students can alternate between small-group work and all-class discussions and demonstrations.

For the outdoor portion of this experience, ask the teacher to pre-select a launch area that will be available during your classroom visit. The launch area will require enough space for groups to launch side by side with a few feet between each group and with a clear space of at least 50 feet in front of the groups. An athletic field is ideal. The launch portion of this activity should not be done inside.

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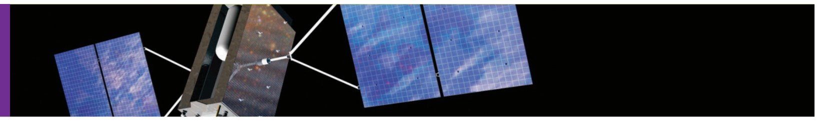

Introduction

Teacher introduces the engineer/classroom visitor.

Setting the Stage

- Show an Atlas V rocket launch video clip
- Tell students who you are, what you do, and what it's like to work in your career (3 minutes).
- Tell them a story about how you got interested in engineering/your career or something that happened in your work that was really exciting–something that truly made a difference in your life (3 minutes).

Hands-on Activity

Ask: *Have you ever wondered what makes rockets launch and how high they go?* Tell students that the whole science of rocketry is pretty cool and that they know more about it than they think they do.

Explain: Rockets are designed to launch payloads (satellites) into space. Rocket propellants used on current rockets combine a fuel and oxidizer that are burned inside a combustion chamber. Burning the propellants creates very high pressure gas, which then exits out the nozzle as rocket thrust. For this activity, the propellants are water and a seltzer (sodium bicarbonate) tablet. The pressure chamber is a white film canister with an inset cap. The propellants react in the chamber producing a gas that results in increasing pressure. The pressure eventually exceeds the capability of the film canister to hold together and thrusts the rocket (film canister body) skyward.

Ask: *Why do we have rockets that launch satellites into space?* Tell students that many things they use every day are possible because of satellites working in space.

Explain: Show the key image. Rockets are launched to three classifications of Earth orbits, Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Earth Orbit (GEO). For this activity, orbit describes how satellites move around Earth. This activity represents LEO, MEO, and GEO orbits by launching film canisters to three different altitudes. These altitudes are achieved by varying the amount of gas inside the film canister rockets.

Use the image of Earth orbits as a visual guide while you describe the differences between LEO, MEO, and GEO. If there is a globe in the classroom, use it as visual aide as you describe the orbits. Explain that Low Earth Orbit is the closest orbit to Earth. LEO is 99-1,200 miles above Earth's surface. Satellites that are circling Earth in LEO make a complete circle around Earth every 90-120 minutes; that is around the same amount of time it takes to watch a movie. Emphasize that these satellites travel really fast. Some satellites that are launched into this orbit are communication satellites, Earth observing satellites (commercial and spy satellites), the International Space Station, and the Hubble Space Telescope.

Medium Earth Orbit is the middle orbit between LEO and GEO. Satellites that travel in this orbit could be anywhere from 1,200 to 22,235 miles above Earth. Satellites in this orbit are often used for navigation purposes. The Global Positioning System (GPS) satellite array has 33 currently working satellites that are used to transmit location data to users around Earth. GPS Satellites are located 12,500 miles from Earth and orbit Earth about every 12 hours, which is around the same amount of time that kids sleep each night.

Geostationary Earth Orbit (GEO) satellites are located 22,236 miles above Earth. The satellites' positions in the sky in GEO remain the same for a stationary observer on Earth. Each satellite has a position directly above the Equator. As Earth turns, the satellites orbit Earth at the same time. This is important for communications satellites to successfully send information to satellite dishes.

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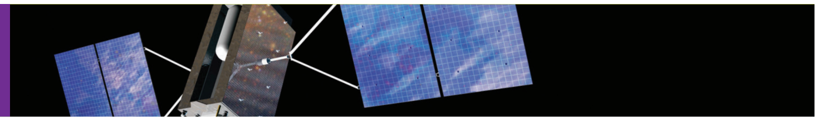

Ask students to raise their hand if they have or have ever seen a satellite dish on the roof or the side of someone's house. Explain that those satellite dishes are used to transmit TV signals. When they are installed, they are set in a permanent position pointing at a specific satellite. Satellite dishes in the United States are always pointing south because the United States is located north of the satellites that are in GEO directly above the equator. Ask: *Which direction would a satellite dish on a home in South America point? (North)*

The Seltzer Rocket Challenge

Explain to students that they are going to be engineers today. They are going to have to figure out how much propellant (fuel) that they will need to use to launch their rockets into different orbits. Explain that for the sake of this activity the orbits will be described as low (LEO), medium (MEO), and high (GEO). When they launch their rockets with different amounts of propellant, they will have to determine what orbit the rocket entered. Did the rocket go up just a little bit into LEO, a medium orbit into MEO, or really high and into GEO?

TIP: Have students use a nearby building or tree to help them judge the height their rockets achieve.

Ask the teacher to divide students into groups of three. Ask volunteers to carry the materials outside. As a safety precaution, make sure that you or the teacher carries the seltzer tablets. Let the teacher lead you and the class to a flat concrete launch area. Have each group of students line up behind each other with the line leader standing on a real or imaginary line. Space each group at least 5 feet from each other. Distribute one film canister, two tablets, one pair of safety goggles, and one cup filled with water to each group. Explain that engineers often test their rockets by securing them in one place and measuring their thrust using sophisticated machines; this is called static testing. For this activity, we will measure thrust by how high the rocket travels. Ask students to put their materials on the ground and focus their attention on you as you demonstrate one of the launches.

1. Follow these steps to guide students through the activity.
2. Put on a set of safety goggles.
3. Show students the open film canister.
4. Pour water into the canister until it is $\frac{1}{4}$ full.
5. Hold up half of a seltzer tablet.
6. Drop the $\frac{1}{2}$ tablet into the film canister.
7. Quickly put on the cap and turn over the canister so that the cap side is placed on the flat launch area.
8. The rocket should launch in one minute.

After the demonstration, tell students that it is their turn to launch rockets into orbit. Let students know that everyone will have a chance to launch a rocket. Each group will launch 3 rockets and each group member will complete all of the steps you showed in your demonstration. Ask everyone except for the first student in each line to take two giant steps back. Ask the first student in the group to put on safety goggles and pour water into the canister until it is $\frac{3}{4}$ full. Ask students to raise their hands when the canister has the proper amount of water. When all launchers have their hand raised, tell students to drop their $\frac{1}{2}$ tablet into the canister and quickly cap and turn over their canister so that cap side is placed on the flat surface. Instruct the other group members that it is their job to determine how high the rocket launched and what orbit they think it entered. Once all rockets have launched, repeat the process with the follow ratios of water to seltzer tablets listed for launches two and three.

Launch 1: $\frac{1}{2}$ tablet, $\frac{3}{4}$ canister water

Launch 2: $\frac{1}{2}$ tablet, $\frac{1}{2}$ canister water

Launch 3: $\frac{1}{2}$ tablet, $\frac{1}{4}$ canister water

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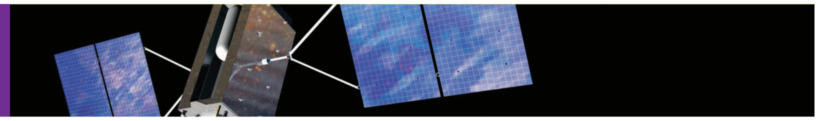

Wrap-Up

Collect all of the film canisters and left over seltzer tablets. Wrap up the activity with a closing discussion so that students can share their launch results and observations. Ask: *Which launch went the highest? Which launch went the lowest?* The expected results are increased altitudes from launch 1 to launch 3, with launch 1 representing a LEO mission; Launch 2, a MEO mission; and Launch 3, a GEO mission.

Ask: *Why did the rockets launch to different heights in the three tests? Shouldn't more propellant (water and seltzer tablets) make a higher launch?*

Explain: More isn't always better. A certain ratio of propellants for our particular rocket produces the best results. This is true in real rockets also. If engineers stuffed a rocket's combustion chamber full of propellants, it may not work as well as if they put in just the right amount. This is why they make tests. For our seltzer rockets, less water leaves more room for the pressurized gas that propels the rocket body so less water (to a point) leads to a higher launch.

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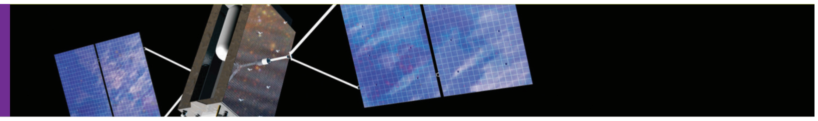

SUPPORT MATERIALS—FOR THE CLASSROOM VISITOR

Background Information

Rockets are designed to launch payloads (satellites) into space. Rocket propellants used on current rockets combine a fuel and oxidizer that are burned inside a combustion chamber. Burning the propellants creates very high pressure gas that exits out the nozzle as rocket thrust. For this activity, the propellants are water and a seltzer (sodium bicarbonate) tablet. The pressure chamber is a white film canister with an inset cap. The propellants react in the chamber producing gas that results in increasing pressure. The pressure eventually exceeds the capability of the film canister to hold together and thrusts the rocket (film canister body) skyward.

Why do we have rockets that launch satellites into space? Many things that we use every day are possible because of satellites working in space. Refer to the image of the satellite Earth orbits: rockets are launched to three classifications of Earth orbits: Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Earth Orbit (GEO). For this activity, orbit describes how satellites move around Earth. This activity represents LEO, MEO, and GEO orbits by launching film canisters to three different altitudes. These altitudes are achieved by varying the amount of gas inside the film canister rockets.

Low Earth Orbit is the closest orbit to Earth. LEO is 99–1,200 miles above Earth's surface. Satellites that are circling Earth in LEO make a complete circle around Earth every 90–120 minutes. Some satellites that are launched into this orbit are communication satellites, Earth observing satellites (commercial and spy satellites), the International Space Station, and the Hubble Space Telescope.

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National Standards Alignment

- National Science Education Standard: (K-4) Standard A-1: Abilities necessary to do scientific inquiry
- National Science Education Standard: (K-4) Standard E-2: Understandings about science and technology

Preparation For Your Classroom Visit

Once a classroom visit has been established, check in with the host educator to make sure students are prepared and have some prior knowledge about the topic you have selected to share with the class.

An educator guide has been created for you to share with the host educator before your classroom visit. This guide includes pre- and post-visit resources and suggested activities that support the content you will be presenting during your classroom visit. Some of the information in the educator guide has been provided in the "Support Materials–For the Educator" section at the end of this document. Share the educator guide for this activity with the classroom educator as soon as you have a date for your visit. The educator guide can be found in the educator version of the Engineers in the Classroom website (www.classroomengineers.org).

Prior Knowledge

Familiarize yourself and the educator with the following terminology: orbit, Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Earth Orbit (GEO), thrust, propellant, satellite, altitude, payload, criteria

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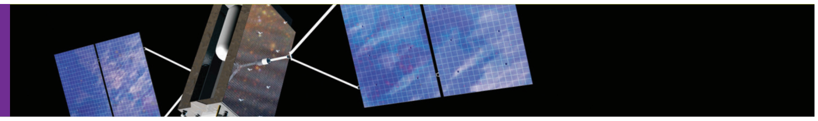

Other Resources to Explore

Article: NASA–Brief History of Rockets
http://exploration.grc.nasa.gov/education/rocket/TRCRocket/history_of_rockets.html

Article: NASA–Rocket Thrust
http://exploration.grc.nasa.gov/education/rocket/rockth.html

Image: NASA–Static Testing
http://www.nasa.gov/images/content/585437main_181889-03.jpg

Website: United Launch Alliance–Atlas V GPS IIF-4
http://www.ulalaunch.com/file-library.aspx?launchEventID=191

Classroom Management Tips

1. **Use a normal, natural voice:**

   The students will mirror your voice level, so keep it neutral and soft. If you want students to talk at a normal, pleasant volume, you must do the same. You also want to differentiate your tone. If you are asking students to put away their notebooks and get into their groups, be sure to use a declarative, matter-of-fact tone. If you are leading a classroom discussion, use an inviting, conversational tone.

2. **Use hand signals and other non-verbal communication:**

   Holding one hand in the air and making eye contact with students is a great way to quiet the class and get their attention on you. Have the students raise their hand along with you until all hands are up. Then lower yours and talk.

   Flicking the lights on and off is a helpful cue to let the students know a transition is coming up. At that point let them know they have 3-5 minutes to finish up their current task.

   Another helpful tool to gather attention is to clap or sing a certain rhythm for the students to repeat.

3. **Address attention needs quickly and wisely:**

   Always take a positive approach while addressing an interruption to your instruction. Say, “It looks like you have a question,” or, “Is there something that I might clarify for you?”

   When students have conflicts with each other, use neutral language as you guide the students to a solution.

4. **Use Reflective Questioning:**

   Paraphrase and restate comments. By repeating or reflecting the student’s statement in the form of a question, you will help them gain valuable insight and they will know you are listening to them.

5. **Emphasize Safety:**

   The most important component of any environment is safety. Let the students know it is your job to keep them safe and it is their job to help keep it that way.

   Review classroom safety rules:

   - Keep hands to self
   - Use the correct voice volume for the task (0-5 scale):
     0=silent, 1=whisper, 2=conversational, 3=small group, 4=presentation, 5=outside
   - Listen to the speaker
   - Share when it’s your turn

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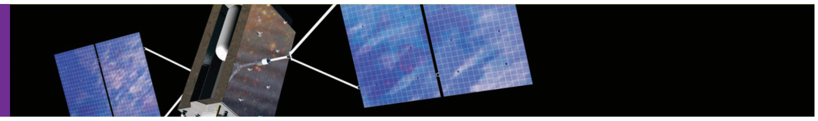

SUPPORT MATERIALS—FOR THE EDUCATOR

Tip

- Teachers may choose to incorporate a paper rocket covering that slips over the film canister body before launch. Paper rocket template:
  http://designwhatyoulove.blogspot.com/2012/08/alka-seltzer-rockets.html

Pre-visit Resources and Activities

- Pre-teach relevant vocabulary: orbit, Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Earth Orbit (GEO), thrust, propellant, satellite, altitude, payload, criteria
- Learn more about the December 2015, Lockheed Martin Orion rocket (this particular launch will be to LEO):
  http://www.lockheedmartin.com/us/products/orion/orion-status-updates0.html

Post-Visit Resources and Activities

- Learn more about rockets and find possible extension activities here:
  http://exploration.grc.nasa.gov/education/rocket/TRCRocket/history_of_rockets.html
- For students who want to know even more about rocket science:
  http://exploration.grc.nasa.gov/education/rocket/rockth.html
- Review relevant vocabulary: orbit, Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Earth Orbit (GEO), thrust, propellant, satellite, altitude, payload, criteria

For Further Exploration—Extending The Learning

Based on the knowledge students gained about orbit characteristics, task each group with the following engineering challenge:

An Internet company has hired you to propose a satellite system that will provide Internet service to all of India from space. Ask each group to choose an orbit for its satellite system and explain their reasons for choosing that orbit. All orbits are potential solutions. After the groups have explained their choices, discuss some of the factors that engineers would consider in designing such a system.

LEO: One satellite will zoom past India and there will be Internet service for about 5 minutes every 90 minutes; so to get continuous coverage, many satellites will be needed. The satellites will be closer to Earth so less powerful antennas are needed; also it takes less time for signals to go between the satellite and users on Earth.

MEO: The satellites will be in range longer so fewer satellites will be needed compared with a LEO system. The satellites will be farther from Earth so more powerful antennas will be needed' and there will be greater time for signals to go between the satellite and users.

GEO: One satellite could be in range all day. However, the satellite will be very far from Earth, so powerful antennas will be needed' and there will be the greatest lag (around 0.5 seconds!) for signals to go between the satellite and users.

The professional engineering team will consider the cost of each solution (more smaller satellites vs. fewer larger satellites), the quality of service (lag for communication between satellite and users), the reliability (if 1 out of 48 satellites break down, it may not affect your service, but if 1 of 10 or 1 of 1 satellites fail it could affect service) and other factors.