Rocket Staging

Objective:
To demonstrate how rockets can achieve greater altitudes by using the technology of staging.

Background Information:

Good morning/afternoon, I am ______________ and I will be your Mission Team Leader for An Introduction to Rockets and Rocket Staging.

Opening Question: The first thing we should know is that we’re not going to the Moon without a rocket. So, what are rockets? What do they do? (allow Members a few open responses to get them thinking)

Today we get to learn what rockets are, a little about who invented them, and how they work..

Brief History of Rockets

The Chinese created the first real rockets in the 1st century A.D. as fireworks to celebrate special events. They filled bamboo tubes with gunpowder and tossed them into fires. When the gunpowder was heated up it burned and produced fire, smoke, and the gas that escaped from the bamboo tube caused the tube to launch in the air. These early rockets were very small and did not travel very far. They were used primarily as fireworks and later used as weapons in wars.

This history of rocketry really began in the early 20th century, around the same time the Wright Brothers flew the first airplane. The key pioneer in American rocket design was Robert Goddard. He figured out much of the science behind rockets and launched the first small rockets ever fired, all during the 1930’s, the years of the Great Depression and World War II. However, America was not the only country designing rockets. In Germany, a man named Werner von Braun worked for the German government and helped design the first ever large rocket, the V-2. Unfortunately, the V-2 was used as a weapon during WWII and terrorized the citizens of Great Britain, killing thousands of British citizens. The V-2 foreshadowed the use of rockets by both American and Soviet forces during the Cold War as a means of launching nuclear bombs.

On a brighter note, rockets are the only reason we have been able to explore space and visit the moon during the last 40 years. The Soviets were the first to design rockets suitable for getting to space. In 1957, they launched a rocket that carried the first ever satellite, Sputnik, into orbit. Additionally, the Soviets were the first to launch
human astronauts, with Yuri Gagarin the first ever human being launched into space. The United States was also successful in rocket design. The United States began a program around 1960, called the Mercury program (named after the planet Mercury) that took a small group of United States Air Force and Navy airplane pilots and trained them to operate rockets. Among this first class of American astronauts (a word which means “space voyagers” in Greek) were Alan Shepard, the first American to reach space, and John Glenn, the first American to orbit the earth.

**Perhaps the most exciting moment in the history of rockets and space exploration happened on July 20, 1969, when Neil Armstrong and Buzz Aldrin landed their spacecraft, Eagle, on the surface of the moon, marking the first time mankind had stepped foot on ground that was not Earth.** Rockets have known no greater purpose than the exploration of space.

Okay now we know a little history; so now let’s look at how rockets work.

Sir Isaac Newton, in the late 17th century studied how objects move and developed the basis for how rockets work and why they can fly through the air and far into outer space. He developed Newton’s three scientific laws. **Newton said that for every action there is an equal and opposite reaction.** What does that mean? (Hand out balloons to the Mission Team Members to demonstrate Newton’s Third Law of Action-reaction) Hold the balloon in your hand. The balloon does not move because we have not done anything to it, or given it a **force**. Now, blow air into your balloon and then release it. Does the balloon move? Why do you think it moves? It moves because there is air escaping the balloon. **The air escapes one direction and the balloon moves in the opposite direction. The same thing happens in rockets.** The rocket’s engine produces gas that escapes one end of the rocket and it causes the rocket to move in the opposite direction, just like your balloon!

**Practical Rocketry**

Show them pictures of different types of rockets (in the attached slideshow) and discuss what they would be used for.

What were the first modern rockets that were used? Ask them who the first person who ever went into space was – Yuri Gagarin – and show them a picture of his rocket. Then ask them who the first American in space was – Alan Sheperd – and who the first American to orbit the earth was – John Glenn – and show them pictures of the Mercury rockets. You might also show them a picture of the V-2 rocket used by Germany in WWII, which was designed by the same man – Werner von Braun – who designed the Saturn V, which sent the first humans to the moon.

Why did we design big rockets (Saturn V)? We designed big rockets to send large objects into space – first people and their living quarters to the moon, then big satellites that are used to transmit communications through cell phones, television sets, and radios.
Why is the space shuttle a different shape than earlier rockets? The space shuttle is a different shape because it is the first rocket that was intended to be used over and over again. The Saturn V and all other rockets are only used once and then they are thrown away. The space shuttle has been used many, many times. You’ll also notice that the space shuttle, unlike other rockets like Saturn V, looks like an airplane. This is because, in order to get the astronauts back to earth safely and be used again, the shuttle has to land like an airplane on a runway. Since it has to land like an airplane, it has to look like an airplane.

Why are rockets different sizes? Today, the size of the rocket depends on how big the object is that you want to send into space. The bigger the object, or payload, the bigger the rocket. The biggest determinant in the size of the rocket is the amount of fuel it has to carry – fuel is often 90% of the total weight of the rocket! The bigger the payload, the more fuel you need, and thus the bigger the rocket. So, if you want to get a really big satellite into space, you need a really big rocket. At this point, show the Mission Team Members a picture of several types of rockets – the original Gemini and Mercury rockets, Saturn V, the space shuttle, and modern Atlas rockets – next to a person, or something well-known like the Statue of Liberty, and show them the size comparison.

What kind of rocket would we need to explore far away planets? The rocket would have to be really big since it would have to carry a lot of fuel for the large distances. Even though we could send people to other planets without a lot of fuel by using the earth’s gravity as a slingshot (have them thing of a real slingshot and the distance you can throw a pebble with one – the earth’s gravity is the sling and the rocket would be the pebble) we would need fuel to get them back to earth. Also, this rocket would have to be big enough to send people with enough food, water, medicine, and personal items on a long journey. (Ask them how long they think it would take to get a rocket to Mars, the planet right next door. The answer is almost 9 months)

What kind of rocket would we need to send humans into space? We have sent people into space on two types of rockets – Saturn V-type rockets and the space shuttle. One of the key differences is what the astronauts’ living quarters look like in each case (show pictures of the re-entry pod for the Apollo missions and the space shuttle main cabin). The biggest concern for NASA today is the safety of the astronauts. So, we need a really safe rocket. One of the key drivers is re-entry. When humans re-enter the atmosphere, there is a lot of heat generated because of the friction generated by the high speeds – the space shuttle re-enters the earth’s atmosphere at over 18,000 miles per hour! The astronauts need to be kept safe from this heat, so there is a lot of protective shielding put on the space shuttle, just as there was a lot of shielding on the Apollo space module.

Now, we have learned that getting into space takes a big rocket. But, there is a way we can use fuel efficiently to get higher into the atmosphere. That is by using separating the rocket into different stages. When a lower stage has exhausted its load of propellants, the entire stage drops away, making the rocket lighter and the upper stages more efficient in reaching higher altitudes. In typical rocket, the stages are mounted one on top of the other. The lowest stage is the largest and heaviest. In the Space Shuttle, the stages attach side by side. The solid rocket boosters attach to the side of the external tank. Also
attached to the external tank is the Shuttle orbiter. When exhausted the solid rocket boosters jettison. Later, the orbiter discards the external tank as well.

Mission Team Leader’s Note: Divide the Mission Team into groups of 4 Mission Team Members. This activity should be done as a competition between groups and then Mission Teams. Groups are judged by distance.

**Materials and Tools for each group:**
- 2 Long party balloons
- Nylon monofilament fishing line (two or three lines per Mission Team)
- 2 Plastic straws (milkshake size)
- Styrofoam coffee cup
- Masking tape
- Scissors
- 2 Spring clothespins

**Procedure:**
1. Thread the fishing line through the two straws. Stretch the fishing line snugly across a room and secure its ends. Make sure the line is just high enough for people to pass safely underneath.
2. Cut the coffee cup in half so that the lip of the cup forms a continuous ring.
3. Stretch the balloons by pre-inflating them.

Inflate the first balloon about three-fourths full of air and squeeze its nozzle tight. Pull the nozzle through the ring. Twist the nozzle and hold it shut with a spring clothespin. Inflate the second balloon. While doing so, make sure the front end of the second balloon extends through the ring a short distance. As the second balloon inflates, it will press against the nozzle of the first balloon and take over the clip's job of holding it shut. It may take a bit of practice to achieve this. Clip the nozzle of the second balloon shut also.
4. Take the balloons to one end of the fishing line and tape each balloon to a straw with masking tape. The balloons should point parallel to the fishing line.
5. Remove the clip from the first balloon and untwist the nozzle. Remove the nozzle from the second balloon as well, but continue holding it shut with your fingers.
6. If you wish, do a rocket countdown as you release the balloon you are holding. The escaping gas will propel both balloons along the fishing line. When the first balloon released runs out of air, it will release the other balloon to continue the trip.
7. Distribute design sheets and ask campers to design and describe their own multistage rocket.

**Assessment:**
Collect and display student designs for multistage rockets. Ask each Mission Team Member to explain their rocket to the Mission Team.

**Extensions:**
- Encourage the Mission Team Members to try other launch arrangements such as side-by-side balloons and three stages.
- Can Galaxy Explorers fly a two-stage balloon without the fishing line as a guide? How might the balloons be modified to make this possible?