EDUCATOR'S GUIDE

# Blast Off!

## Preparation

**Overview and Objectives**
This lesson is geared toward students in grades 3-8.

Participants will learn about the physics behind launching a space shuttle orbiter into space. Furthermore, participants will be able to identify Newton's laws of motion and will be able to demonstrate the relationship between mass, acceleration, and force. Sense-making activities will help foster an understanding of how Newton's laws work around us, in addition to how they apply to a spacecraft launch. Finally, participants will inflate a balloon that will generate enough thrust to reach an assigned target. This challenge is a chance to relate the missions represented by the spacecraft in our museum's collection to a hands-on experience.

### Standards

Next Generation Science Standards

**3-PS2-1**
**3-5-ETS1-2**
**MS-PS2-2**
**MS-ETS1-4**

Disciplinary Core Ideas

PS2.A: Forces and Motion
ETS1.A: Defining and Delimiting Engineering Problems

This lesson includes a slideshow in which an instructor can lead participants through various activities to gain deeper knowledge of Newton's laws of motion before introducing the thrust challenge as the culminating activity. By the end of this lesson, participants will be able to identify and apply Newton's laws of motion to an engineering challenge.

**Instructional Modalities**

This activity was designed for synchronous instruction.

For **synchronous instruction**, we recommend a platform that allows both for whole class discussion and for students to interact in small groups.

**Materials**

- **Blast Off! Slideshow**
- **3...2...1...Launch! Worksheets** (pp. 6-8)
- Paper to crumple into a ball
- Rubber band
- Backpack (full of materials)
- Space for running and exploring

- String, or yarn, cut 5-6 ft in length (1 piece per group)
- Straw (1 per group)
- Tape
- Scissors
- Balloons (1 balloon for each group)
- Measuring tape to record distance

## Lesson

1. **Introductory Activity**
    - **How do we get spacecraft to space?** Have participants discuss their ideas during turn and talks. Create a list of their ideas through a whole-group share out.
    - Follow the discussion with another reflection question:
        - **How do force and motion work in a launch?**
    - Ask participants to write down and discuss ideas as a whole group.
    - Show the video (4:06-24:58)
        - **What did you discover?**
        - **What are Newton's laws of motion, and how are they working to launch a space shuttle orbiter?**
2. **Core Activity**
    - Explain to participants that in order to better understand these three laws of motion, they were explore the ideas by investigating with the forces and motions of the following objects:
        - Exploring inertia with a soccer ball. Allow students to note inertia of the ball at rest and compare it to the inertia of the ball when it is kicked. Allow time for a brief game of soccer to illustrate inertia.
    - **Newton's first law: What did you notice about the ball at rest or in motion?**
        - Reiterate facts from the video. Explain how the soccer ball remained at rest until acted upon by an outside force: participants kicking the ball. This also means that we have to apply a force to get the soccer ball off the ground and into the air toward the goal, or else it is just going to sit on the ground like the straw rocket.

  - Similarly, the ball remained in motion until acted upon by an outside force to stop it. In this case, it could be the goalkeeper preventing the score, for example.
- **Newton's second law: What changed between running with the backpack on and without the backpack?**
  - You needed to generate more force to move yourself with the backpack. The greater amount of mass requires a greater amount of force to accelerate or move the backpack. However, when you run without the backpack, you may have noticed the mass changed, so the amount of force needed to move yourself was less. This is the idea behind Newton's second law.
- **Newton's third law: What did you notice about the direction of force while testing the sling shot?**
  - According to Newton's third law, for every force in one direction, there will be an equal force in the opposite direction. With the sling shot, the pulling back of the object you tossed results in the object launching forward.

- Ask students if they can figure out how all three laws are working together by viewing the video of a shuttle launch.

3. **Design Challenge**
   - Explain that participants will inflate a balloon that will generate enough thrust to reach, but not overshoot, an assigned target. They will adjust the amount they inflate their balloon to reach their target. Over the course of multiple trials participants will use trial and error to get the desired result.
   - Provide the following materials and visual instructions for this challenge:

<u>Materials:</u>

- String, or yarn, cut 5-6 ft in length (1 piece per group)
- Straw (1 per group)
- Tape
- Scissors
- Balloons (1 balloon for each group)
- Measuring tape to record distance


Set up:

Use the visual instructions in the activity handout to set up and conduct the challenge.

Wrap-up (5 minutes):
Ask students what they learned as they kept testing their designs. What did these tests teach them about rocket design/ aircraft design? How did the four forces of flight come into play? In what ways did they see Newton's laws of motion working in the challenge?

## Extension Activities

To deepen student engagement with this content, you may choose to add the following activities :

### Getting to Mars

Have participants discuss and list the challenges in getting the rover Perseverance to Mars. Participants can examine the infograph from NASA.

## Additional Resources/ References

**Background Information**

- Mercury Redstone
  - On May 5th, 1961, Mercury 3, the first manned American spacecraft, used the Redstone rocket to leave Earth's atmosphere. This rocket was 69' 4" tall and weighed in at more than 61,000 Lbs. It basically just went straight up and then back down to earth, but it was the very first.
- Mercury Atlas
  - During this NASA was working on an upgraded rocket, the Atlas. With the Atlas, which was 94' tall, and fully loaded with fuel, weighed more

than 260,000 lbs, NASA went even higher and actually achieved orbit. The Intrepid participated in this part of Project Mercury by picking up Scott Carpenter and the Aurora 7 capsule.

- Gemini Titan II
    - After Project Mercury came Project Gemini which used the much larger Titan rocket. It was 109 feet tall, and with payload and fuel could way 340,000 Lbs. With all that power and fuel we could go even farther, allowing NASA to perform some of their most advanced experiments as far as 850 miles off the surface of the planet. Now the first manned Gemini mission Gemini 3, which was recovered by the Intrepid only went 140 miles. *So with each program the rocket gets bigger, and we go farther from the Earth. What do you predict is NASA's next step? Why?*
- Saturn V
    - With these massive Saturn V rockets, astronauts could travel the almost 240,000 miles to the moon! The Saturn V was 363 feet tall, and filled with fuel, the module weighed 6.2 million pounds.
- Space Shuttle
    - *What do you notice about the shuttle? Why is the space shuttle so much smaller than the Saturn V?* The Space Shuttle program aim was to create a reusable module, that could transport crews and cargo into orbit, not go to the moon. This is our 1:100 model of the Enterprise, which achieved altitudes of 26,000 feet! Well that's because it was the prototype but Enterprise paved the way for the other orbiters that would travel out to almost 400 miles.
- Hubble Space Telescope
    - The Space Shuttle Program was responsible for launching and servicing the Hubble Space Telescope. This telescope was launched into space in 1990 aboard the Space Shuttle Discovery and was placed as high as the shuttle could safely travel. The Hubble Space Telescope currently orbits 353 miles above Earth's surface.

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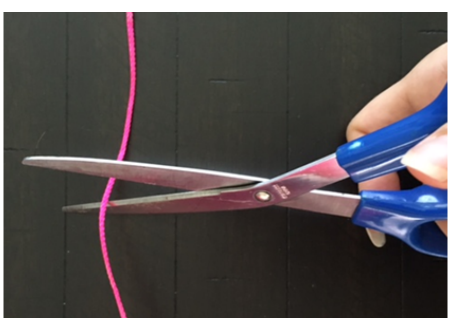
# ACTIVITY: 3...2...1...Launch!

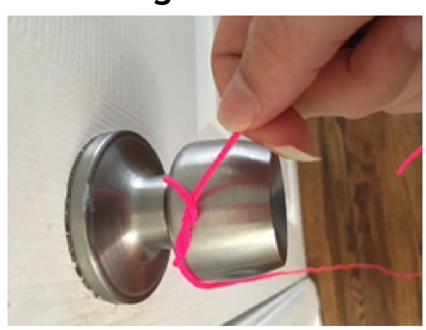
Directions:
Inflate a balloon so that will generate enough thrust to reach an assigned target. You will adjust the amount you inflate the balloon to reach your assigned target. Over the course of multiple trials you will use trial and error to get the desired result.

1. **First, you will need these materials:**

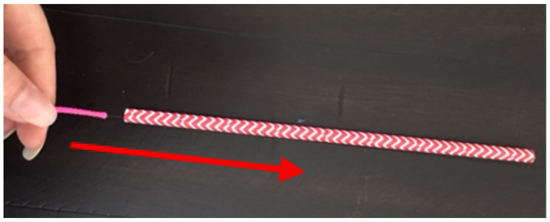
   - String, or yarn, cut 5-6 ft in length (1 piece per group)
   - Straw (1 per group)
   - Tape
   - Scissors
   - Balloons (1 balloon for each group)
   - Measuring tape to record distance


2. **Cut some string so that it is about 5-6 ft long. Tie one end to a door knob.**





3. **Push the string through the straw.**




4. **For your first trial, lightly blow up the balloon. Pinch the balloon's opening so that no air comes out.**


5. **Tape the balloon onto the straw.**

6. **When you are ready, let the balloon go for your first trial. What happened to the balloon? How far did it travel along the string?**

7. **You have a total of three attempts to reach your target**. Now test the balloon by half-way inflating it and then fully inflating it. Be sure to measure the distance traveled for all three trials.

8. Record your three trials and outcomes in the table:

| | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|
| Distance traveled | | | |
| Amount of inflation (light, medium, fully inflated) | | | |
| Target not reached, reached, too short, too far? | | | |

What did these tests teach you about rocket design/ aircraft design?

How did the four forces of flight come into play?

In what ways did you see Newton's laws of motion working in your challenge?