Challenger Center

In Partnership with

Minecraft Education

Photo Credit: NASA/Joel Kowsky

It’s Just Rocket Science

LESSON OVERVIEW

NASA’s Artemis program plans to put the first woman and first person of color on the Moon. In 2022, the first Artemis mission went to the Moon without any humans onboard. In 2024, we will send the first Artemis mission with humans and there are many more missions planned through the year 2040.

But how do the rockets even get there? The basic science is surprisingly simple. In this lesson, students become Propulsion Engineers as they explore the scientific forces of motion that send rockets up, up, and away! Students will perform hands-on explorations to collect data and see how Newton’s Laws (specifically Newton’s 2nd Law) influence rocket launches.

LEARNING OBJECTIVES

Students will . . .

- observe Newton’s Laws in action,
- conduct hands-on investigations with partners, and
- understand how Newton’s Laws apply to the launch of a large rocket, like those of the Artemis missions.

TEACHER NOTES AND PREP

Background

The last time humans went to the Moon was in 1972 as part of NASA’s Apollo program. But recently, NASA was charged with taking the first woman and first person of color to the Moon in a new program named Artemis. In 2022, NASA launched Artemis I, an uncrewed mission to test the rocket. In 2024, the Artemis II mission will be the first crewed Artemis mission.

Student Ages

8-13

Subjects

Math
Science

Skills

Collaboration
Data Analyzing and Interpretation
Planning and Investigation

Estimated Time

45-50 minutes *(can be broken into two lessons, one for each challenge)*

Educational Settings

Classroom
Informal *(museums, science centers, and camps)*

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Whether you’re launching a rocket to the Moon, all the way to Mars, or just targeting an orbit around Earth, there are straightforward principles of physical science at play. Engineers use special principles called Newton’s Laws (named after Sir Isaac Newton who first formally wrote the principles) to help rockets fly properly.

Preparation

In the *Artemis: Rocket Build* world, students will see Newton’s Laws written out in relation to the rocket they’re building. In this lesson, students will get hands-on experience with a balloon “rocket” to experience Newton’s Laws for themselves. They will also be introduced to the career of a Propulsion Engineer (those who deal with engines, propulsion systems, and more for rockets) through this activity. Newton’s Laws can be stated as follows:

First Law

An object at rest stays at rest or an object in motion stays in motion, until acted upon by an outside force. Basically, objects like to stay still or keep moving until something else makes them change. In a rocket, this can be easily seen when it is stationary on the pad, until the outside force of the fuel exploding sends it flying upward.

Students will experience this when their balloon hangs stationary on the flight line or moves until it hits the end.

Second Law

This law is an equation (F=ma) mathematically explaining that how fast an object changes speed or changes direction depends on how heavy it is and how hard it is pushed. In a rocket, we see this in the delicate balance of fuel (pushing power for liftoff), rocket weight, and the speed the rocket will reach.

Students will experience this by altering the amount of force and/or weight in their balloon rocket and comparing the differences in flight.

Third Law

Every action has an equal and opposite reaction. In a rocket, this is most easily seen when the explosion of fuel fires out the bottom of the rocket, forcing the rocket upwards in the opposite direction.

Students will experience this when they release their balloons, forcing the balloon to travel in the opposite direction of the rapidly exiting air.

STUDENT ACTIVITIES

Supplies

Arrange all supplies in a central location, or in a bag/bin for each group. For each group of 2-4 students (for younger students, working in pairs is best), you’ll need:

- One 8-10 ft (~2.5-3m) string that fits smoothly through a drinking straw (e.g., twine, thin yarn, fishing wire)
- One drinking straw
- One balloon
- Tape
- Soft measuring tape, or ~2 ft (~0.5m) piece of string and a ruler
- Handful of small “weights” (e.g., metal washers, coins, large paperclips)
- Stopwatch or clock
- Pencil
- Copy of *Student Handout*
  [EDUCATOR NOTE: Be sure to familiarize yourself with the procedures in the Student Handout ahead of time.]

Warm-Up and Introduction (5 minutes)

- If possible, show students the image of Propulsion Engineer John Sayres (link in External References section) on a projector screen. Tell students that today, they will become Propulsion Engineers like John.
  [EDUCATOR NOTE: For the rest of the lesson, refer to students as "engineers" to drive it home!]
- Ask students what they think a propulsion engineer works on. If desired, record a few student answers.
- Explain that propulsion engineers work on all aspects of the rocket related to its engines, propulsion systems, etc. They're focused on what makes the rocket *go*.

Introduce Group Challenges (5-7 minutes)

- Explain that students will work in teams as propulsion engineers to complete tests on a balloon "rocket." They will be looking for evidence of three scientific principles at work called Newton's Laws.
- Ask if students can name any of Newton's Laws.
  [EDUCATOR NOTE: You do not need to list them all at this time.]
- Explain only that Newton's Laws are a series of laws that describe how objects move, and there are three you will be uncovering and working with today.
  [EDUCATOR NOTE: If students have experienced Minecraft Education's Artemis: Rocket Build world already, they will have seen all three laws.]
- Divide students into "engineering groups" and give a Student Handout to each group. Propulsion engineers can only learn from their tests if they make notes, so teams will be expected to record data from their tests as they go.

Investigative Challenge (25 minutes)

- Tell students they will have 25 minutes to read through the instructions on their Student Handout and record their data. If students are younger and need more supervision, demonstrate the balloon rocket assembly from the Student Handout in front of the entire class, and set a timer in the front of the room or on the projector.
- As students begin, circulate throughout the room to guide procedures, ask questions, and answer student questions. If not all groups finish Challenge #2 in time that is okay, but they will want to complete Challenge #1.

Regroup and Final Discussion (10-15 minutes)

When time's up, gather the class's attention. Ask one group to summarize Challenge #1. Then, ask each group to share:

- Responses to Box #1. Have students use their data to explain or back up their conclusions.
    - Ask: What do you think your observations have to do with the Artemis rocket?
    - Discuss Newton's First Law of Motion and how it connects to the balloon and real rockets.
- Responses to Box #2. Have students use their data to explain or back up their conclusions.
    - Ask: What do you think your observations have to do with the Artemis rocket?
    - Discuss Newton's Third Law of Motion and how it relates to the balloon and real rockets.
- Responses to Box #3 (and Box #4 if complete). Have students use their data to explain or back up their conclusions.
    - Ask: What do you think your observations have to do with the Artemis rocket?
    - Discuss Newton's Second Law of Motion and how it relates to the balloon and real rockets.
    - Ask: What would we have to change if we wanted to launch a heavier rocket to the moon?

Finally, explain that these laws were named for Sir Isaac Newton, but students don't have to be famous scientists to uncover them and interact with them on their own. These are the kinds of things propulsion engineers like John Sayres work with every single day. Science is for all of us!

GUIDING IDEAS AND QUESTIONS

- What are Newton's Laws of Motion?
- How are we seeing Newton's Laws of Motion at work in our balloon rockets?
- How do you think Newton's Laws apply to the Artemis rocket launches?

PERFORMANCE EXPECTATIONS

Students will develop an understanding of how Newton's Laws work through hands-on investigation and observation. They will apply these observations to their understanding of large-scale rockets.

Students will gain social-emotional experience by working together in teams to conduct their investigations.

NGSS SCIENCE AND ENGINEERING PRACTICES

For educators based in the United States, the Next Generation Science Standards (NGSS) Science and Engineering Practices in this lesson are:

- planning and carrying out investigations;
- analyzing and interpreting data; and
- using mathematics and computational thinking.

EXTERNAL REFERENCES

Beakers and Ink | How to Teach Claim, Evidence, and Reasoning (CER) Like a Pro (*For Extension Activity)*
https://beakersandink.com/how-to-teach-claims-evidence-and-reasoning-cer-like-a-pro/

ENGRE | What Is a Propulsion Engineer? Definition, Skills, and Salary
https://engre.co/blogs/articles/what-is-a-propulsion-engineer/

NASA | How We Are Going Back to the Moon
https://youtu.be/_T8cn2J13-4

NASA | I Am Artemis: John Sayres
https://www.nasa.gov/feature/i-am-artemis-john-sayres

Seeker | NASA's 2024 Artemis Moon Landing Mission Explained
https://youtu.be/B2lA3Uu29KI

Time Me | Countdown Timer
https://www.timeme.com/countdown-timer.htm

SUPPORTING FILES

- Vocabulary List
- Student Handout

EXTENSIONS

LANGUAGE ARTS / WRITING EXTENSION

Create a Claim, Evidence, Reason (CER) report to help a group of propulsion engineers building a balloon rocket decide how to make their heavier rocket go faster. This can be left in simple CER format, or written up into a cohesive paper, depending on grade level. Divide a paper into three sections:

- Claim: State a claim (e.g., “Blow your balloon rocket up more to make it go faster.”)
- Evidence: Use evidence (data) from your own trials to support your claim.
- Reason: Explain the reasoning for why this evidence supports your claim.

MATH EXTENSION

Have groups use their data to calculate the average (mean) time their balloon flew for each flight in Challenge #1. Then, have everyone place their averages on a central bar graph to compare the entire class’s data. What patterns emerge when comparing the larger data sets?

STEAM EXTENSION

Create a poster that explains Newton’s Three Laws of Motion in relation to a rocket. Show them off in a poster gallery!