ARTEMIS
SPACE ADVENTURE
WITH LEGO® BRICKS

EDUCATOR GUIDE

PRODUCED BY FLYING FISH

IN COLLABORATION WITH SCIENCE WORLD

ARTEMIS SPACE ADVENTURE WITH LEGO® BRICKS

K-1 Activity Guides

PRODUCED BY FLYING FISH
IN COLLABORATION WITH SCIENCE WORLD

Space Weather

Objective:

Investigate how weather on Earth compares to weather on other worlds in our solar system.

NGSS Standards:
ESS3.B: Natural Hazards (K-ESS2-1, K-ESS3-2)

Materials:

- Images or symbols of weather such as these
- Full-page printed images of the Earth, Moon, Sun, and Mars (recommended photo gallery)
- Photos depicting space weather

Introduction:

What's the weather like today? Is it cloudy, sunny, rainy, windy, or stormy? How do you find out what the weather is like outside? Sometimes experts who study the weather will forecast, or tell us what the weather might be like tomorrow or even next week.

Now, imagine that you're standing on the Moon. Do you notice any weather on the Moon? What about on the Sun, or on Mars? Other worlds sometimes have weather, but it's different from the weather we notice on Earth. Mars and the Sun can have storms, while the Moon is always calm. Let's be weather explorers today and discover what the weather is like in space!

Activity:

1. Gather students in a circle, and select four volunteers to sit in the center.
2. Assign each of the four students a role, so that the Earth, Moon, Sun, and Mars are all represented. Students may hold up the image representing their assigned role.
3. Provide remaining students with the weather image cards (examples might include dust storms, lightning, solar flares, rain, clouds, hurricanes, etc).
4. Begin with the Earth: Anyone who is holding a card that represents weather we see on our own planet will place the card on the floor near the student representing the Earth. The "Earth" may choose to accept or argue against any of the cards placed by them.
5. Continue with the Moon, Sun, and Mars, until all the weather cards are placed. These students may also accept or argue against any cards they receive.

6. Lead the class in a discussion of the final card placements, beginning with the Earth. Examples of correct placement might include:

- Earth: lightning, rain, clouds, hurricanes, dust storms
- Moon: none
- Sun: solar flares
- Mars: dust storms

7. Wrap up by sharing images and videos of space weather such as these.

Discussion Questions:

- What do you think causes storms on the Sun? What about on Mars?
- Why doesn't the Moon have weather like the Earth?
- What do you think it would feel like to stand on the Moon?
- Imagine that a student from Mars moves to our neighborhood on Earth. What do you think they'd like about the weather here? What would they dislike?

Extension:

Students create a space weather report for a location of their choice (Mars, the Sun, the Moon, Jupiter, etc) and present it like a space meteorologist. They can draw, act out, or present their forecast using weather symbols. Martians may depend upon your students' dust storm forecasting!

Did you know?

The planet Saturn has a mysterious, six-sided storm at its north pole! Scientists call this storm Saturn's hexagon and are still working to find out what causes it. Maybe you can be the one to figure out why this storm exists!

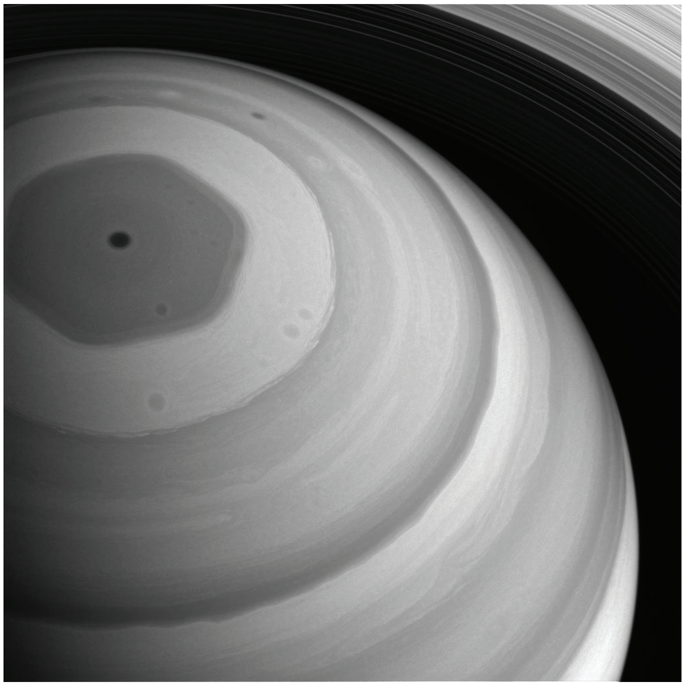


Image source: https://www.jpl.nasa.gov/images/pia20513-basking-in-light/

ARTEMIS SPACE ADVENTURE WITH LEGO® BRICKS

Lunar Living

Objective:

Create a drawing or simple model of a house designed for living on the Moon, justifying design choices such as shape and structure.

NGSS Standards:
ETS1.B: Developing Possible Solutions (K-2-ETS1-2)

Materials:

White and construction paper
Pencils, crayons, markers

If building models:

- Cardboard
- Glue sticks
- Clay
- Safety scissors
- Recycled materials such as toilet paper rolls and foil
- Decorative stickers

Introduction:

Would you ever want to live on the Moon? Why or why not? Today, let's imagine that we have just landed on the Moon, and it's your job to design the perfect place to live. What would your house need in order to keep you safe and comfortable?

Remember, there's no air to breathe on the Moon. The nights are really cold, and the days can become really hot. There are also no restaurants or grocery stores on the Moon (yet) to provide your food! Let's learn about the surface of the Moon and then design your perfect living space!

Activity:

1. Using images on slides, show students pictures of the Moon's surface and discuss what it's like (extreme temperatures, lack of air, dusty). You may also wish to show videos of astronauts hopping around due to the decreased gravity compared to Earth.
2. Ask students to contribute ideas about what they'd need in order to live on the Moon. How could you build these ideas into a physical structure, like a house?

3. Provide students with paper and drawing materials so they may begin to sketch their ideas for a Moon house (or other type of dwelling). Guiding questions to assist in their drawings might include:
   a) What shape should the roof be?
   b) How will you and other astronauts enter and exit? Is there a special door?
   c) How will it stand up on the bumpy surface of the Moon?
   d) What will you do for food? Can you grow it inside?
   e) Are there any rooms you'd like to add for fun, once your needs are met?
4. After students complete their drawings, hold a Moon living showcase where they share their creations with their peers.
5. Optional: Keep the creativity flowing by building 3D structures of the Moon dwellings out of cardboard, glue, and any other age-appropriate craft materials. You may also provide stickers or other decorative items that students can add for visual appeal.

Discussion Questions:

- What would your Moon house be made out of?
- How does your house keep astronauts safe from the heat and cold?
- Why did you choose the shape of your house?
- After seeing your classmates' houses, what would you like to add to yours?

Extension:

Explore some proposed designs of lunar habitations such as this Artemis Base Camp Concept. Compare and contrast the features included here with those that your students chose.

Did you know?

The Moon is a place of extreme temperatures. It can get as hot as 260°F (127°C) during the day and as cold as -280°F (-173°C) at night. Your lunar house needs to handle temperatures as hot as an oven, and much chillier than Antarctica!

Image source: https://www.asc-csa.gc.ca/eng/astronomy/solar-system/moon.asp

ARTEMIS SPACE ADVENTURE WITH LEGO® BRICKS

Faces and Phases

Objective:

Observe, describe, and visually represent the pattern of the Moon's phases.

NGSS Standards: ESS1.A: The Universe and its Stars (1-ESS1-1), (1-ESS1-2)

Materials:

- Blank construction or printer paper
- Pencils, crayons, or markers
- Optional: printable Moon phases
- Optional: glue or tape

Introduction:

You all make different faces when you have different feelings, right? What does your face look like when you're happy? How does it look when you're sad? Now, can you show me your surprised face? Well, did you know that the Moon makes different faces too? The Moon doesn't make excited or sad faces, but it does change the way it looks in the sky.

Sometimes the Moon looks like a bright, round circle. Other times it might look like a half-circle or a thin sliver, and sometimes we can't see the Moon at all! When the Moon changes how it looks, we call those changes "phases". Doesn't "phases" sound a lot like "faces"? Today, we are going to learn about all of the Moon's different phases and then create a picture of them!

Activity:

1. Provide each student with a Moon phase template, explaining that the middle circle is the Earth and that the eight circles around it will be the different Moon phases.
2. Option A: Together as a class, color in each phase, one at a time. Introduce each new phase using descriptive phrases to explain the appearance of each phase (for example, the Crescent Moon looks like a smile in the sky—maybe the Moon makes happy faces after all)! Encourage students to describe what each phase resembles.

   Option B: Together as a class, cut and paste the pre-filled Moon phases in the correct order. Consider allowing students to place the Moon phases in whatever order they choose, and then compare their results with a neighbor, before gluing.
3. Guide students to label the images with the name of each phase, or provide pre-written labels that can be pasted.
4. After the drawings are completed or while the glue dries, hand each student a separate paper with one Moon phase drawing on it.

5. Encourage students to arrange themselves in a line or in a circle such that the phases are in the correct order. This activity can be performed whole-class or in small groups; it can also be completed in total silence using only nonverbal communication.

Discussion Questions:

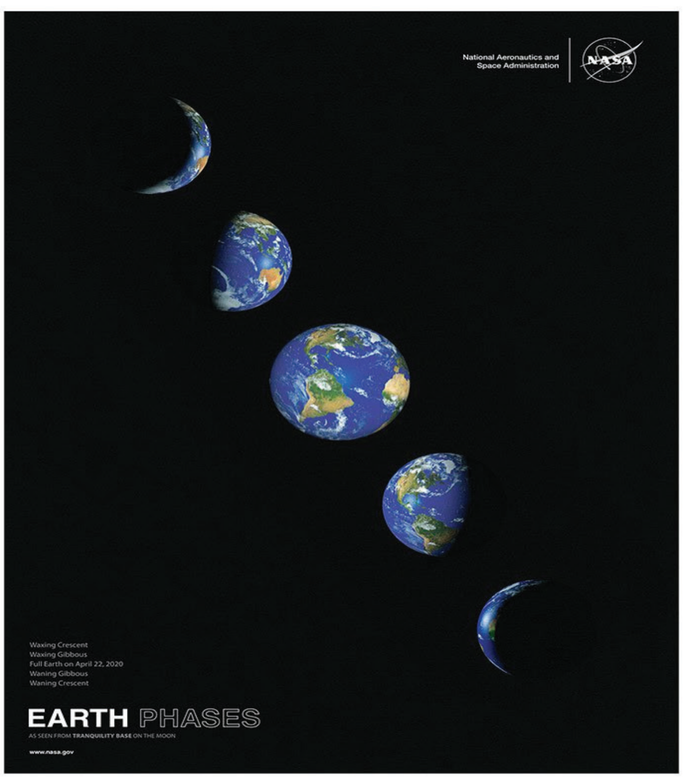
- What do you notice about the way that the Moon's shape changes?
- During the New Moon phase, is the Moon still there?
- Does the Moon get bigger or smaller after the Full Moon phase?
- Why do you think the Moon changes the way it looks at different times?

Extension:

Encourage students and their caregivers to observe the Moon every night for a month, to draw what they see, and to try to name the phase. At the end of the month, students should share their journals with classmates and compare (template/example here).

Did you know?

If you were standing on the Moon, you would see the Earth showing different phases! Sometimes you'd see the full, bright circle of the Earth, while at other times you might see a crescent, half-illuminated, or "new" Earth.



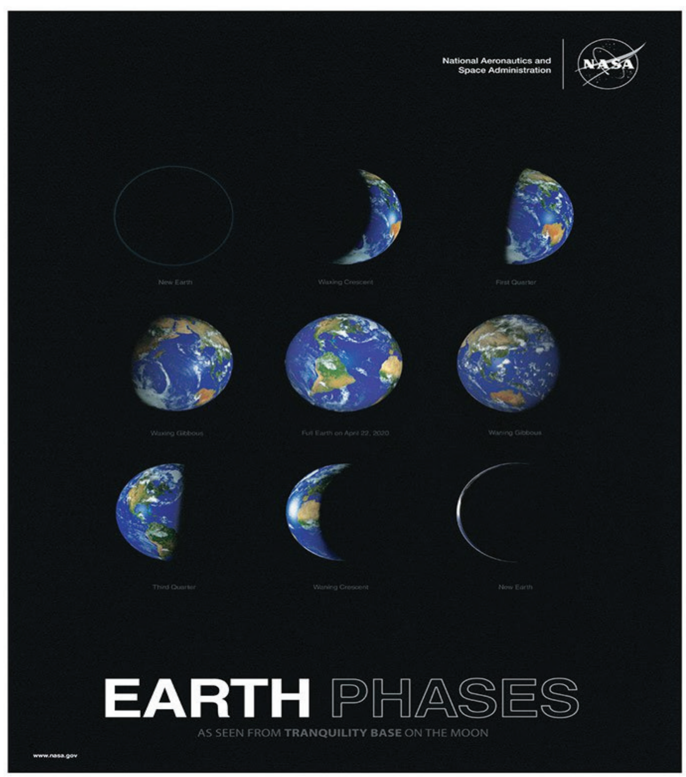


Image source: https://www.jpl.nasa.gov/news/nasa-observes-earth-day-with-downloadable-art/

Moonlight Messages

Objective:

Explore how we see the Moon, basic properties of reflection, and how light can be used by humans for communication.

NGSS Standards:
PS4.B: Electromagnetic Radiation (1-PS4-3)
PS4.C: Information Technologies and Instrumentation (1-PS4-4)

Materials:

- White foam ball
- Flashlight
- Mirror
- Colorful translucent materials such as cellophane sheets, one additional flashlight per group

Introduction:

Do you think the Moon makes its own light, like the Sun or a lightbulb? The Moon actually reflects sunlight, similar to the way a mirror reflects light in this room. Astronauts have even placed mirrors on the Moon so that we can learn more about it using light!

Today, we are going to explore how light helps us to see and understand the Moon, and then we will demonstrate how light can also be used to send secret signals!

Activity:

1. Choose a volunteer or assign one student to be the sun (holding a flashlight) and another student to be the Moon (holding the foam ball). Inform the rest of the class that they are playing the role of Earth. Then, dim or turn off the classroom lights.
2. Ask students how easy or difficult it is to see the Moon in the absence of light. Now, ask the student with the flashlight to illuminate the Moon. Much easier to see, right? If not for sunlight, we would not be able to see the Moon, as the Moon does not produce its own light. It only reflects sunlight, which allows us to see it. This means that all moonlight is also sunlight!

3. Now, provide a mirror to a third volunteer, and have them place it in the flashlight beam (taking precautions to protect the eyes of the flashlight holder!). Encourage students to share what they notice. How is the light reflecting off of the mirror similar to how it illuminates the Moon? How is it different?
4. Provide each student group with a flashlight and, optionally, a colorful translucent material such as cellophane. Students will explore ways that they could use these materials to send a message (for example, switching the flashlight on and off, or shining the light with and without cellophane covering the beam).
5. Encourage students to invent their own secret code for communicating nonverbally using light. This may include anything from "two blinks for yes" to "blue light means it's time to board the spaceship". Creativity is encouraged!

Discussion Questions:

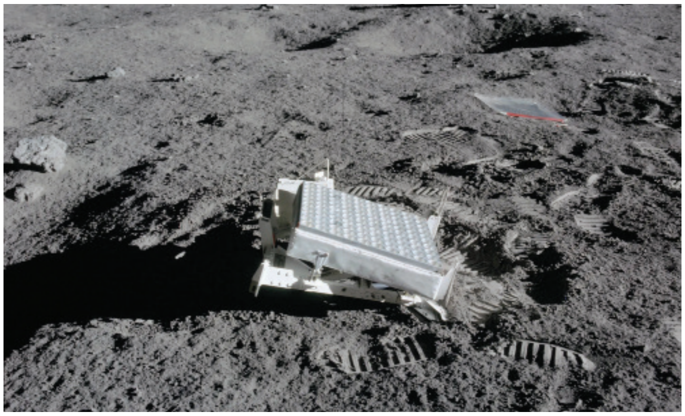
- If we can only see the Moon because of sunlight, does that mean that people on the Moon can only see the Earth because of sunlight? Why or why not?
- Why would scientists or astronauts use mirrors in space? Can you think of any reasons that we didn't mention?
- Is it easier to see the Moon at night, or during the day? Why do you think that is?
- If the Moon is reflecting sunlight, why is it less bright than the sun?

Extension:

Together, explore photos of the Earth from space (such as the famous Earthrise photo) as well as images of other planets (such as those taken by the Hubble Space Telescope). Facilitate a class discussion on how we are able to see the Earth and other planets. Do they make their own light, or do they reflect sunlight just like the Moon?

Did you know?

When astronauts visited the Moon during the Apollo missions, they left mirrors behind. This isn't because they packed up to leave in a hurry and left them by mistake! They placed mirrors on the moon so that we can shine lights on it from Earth in order to learn about it (specifically, how far away it is). Light can also allow us to send messages and communicate with one another!



A close-up photograph of the laser reflecting panel deployed by Apollo 14 astronauts on the Moon in 1971.

Image source: https://www.nasa.gov/missions/laserbeams-reflected-between-earth-and-moon-boostscience/

ARTEMIS SPACE ADVENTURE WITH LEGO® BRICKS

Grades 2-3 Activity Guides

PRODUCED BY FLYING FISH

IN COLLABORATION WITH SCIENCE WORLD

Astronaut Garden

Objective:

Conduct an experiment to determine the effect of sunlight and water on plant growth, and design an astronaut garden that demonstrates how plants can be grown in space.

NGSS Standards:
LS2.A: Interdependent Relationships in Ecosystems (2-LS2-1)

Materials:

- Clear plastic cups
- Ziploc bags
- Paper towels
- Potting soil
- Bean seeds
- Water
- Rulers
- Permanent markers or labels
- A sunny windowsill or grow lights

Introduction:

How many of you can see a plant from where you're sitting right now? Are there more plants inside the building or outside the building? Why might that be?

Now, let's think about the world beyond our building and even beyond our neighborhood. The Earth is covered in a wide variety of plants, but what do they need to grow? Turn and tell the person next to you one thing plants need. Many of us know that plants on Earth require sunlight, water, and soil in order to grow.

What happens if we take plants to another planet in our solar system, or into a space station? Can they still grow? Let's become plant scientists and space engineers in order to find out!

Activity Part 1: Growing on Earth:

1. Soak bean seeds in water overnight to help them sprout. Be sure to leave enough for the "space" experiment that follows!
2. Fill cups with potting soil, leaving about an inch at the top.
3. Create a small hole in the soil using your finger or a pencil.
4. Place bean seed into the hole and gently cover it with soil.
5. Water the soil lightly to keep it damp, but not soaked.

6. Place the cup in a sunny spot, like a windowsill.
7. Draw or photograph the seed every day to track its growth, measuring height with a ruler.

Activity Part 2: Growing in "Space":

1. Now, let's simulate some of the differences between growing plants on Earth and in other environments away from Earth. Since there's no atmosphere in space, your astronaut garden needs to be fully enclosed and sealed.
2. Fold a paper towel and line the sides and bottom of a plastic bag.
3. Scrunch up another paper towel and fill the middle of the bag to hold the seeds in place.
4. Dampen the paper towels with water.
5. Place a few bean seeds between the paper towel and the sides of the bag, ensuring they're visible.
6. Tape the bag in a sunny spot (like directly on a window).
7. Draw or photograph the seed every day to track its growth, measuring height with a ruler.

Discussion Questions:

- Why does using a paper towel make sense for the astronaut garden, as opposed to using soil?
- What would happen to a plant if it didn't get enough water or sunlight?
- Can you imagine any helpful tools or materials that astronauts might need to grow plants in space?

Extension:

Explore the Tomatosphere project, in which K-12 classrooms can learn about plants in space by growing "space" tomato seeds!

Did you know?

Astronauts perform experiments in low gravity to figure out the best way of growing plants in space. They study water-based and air-based methods of supporting plant growth without using Earthlike soil.

Image source: https://www.nasa.gov/missions/station/ways-the-international-space-station-helps-us-study-plant-growth-in-space/

Orbital Outfits

Objective:

Brainstorm and evaluate designs for space suits based on criteria and constraints in order to determine the best solution.

NGSS Standards:
ETS1.B: Developing Possible Solutions (3-5-ETS1-2)

Materials:

- Slides with photos and videos of astronauts in suits
- Paper and writing utensils
- Assorted craft materials: construction paper, aluminum foil, pipe cleaners, foam, tape, scissors

Introduction:

Astronauts face some interesting challenges when they travel into space. Temperatures can be extreme, there's no air to breathe, and dangerous rays from the sun can cause health issues. This is why we cannot simply send an astronaut to space dressed the same way as we like to dress when we attend school!

Our mission today is to learn about what astronauts need in order to survive in space and then develop creative solutions for safe (and maybe even stylish) space suits! We will consider the availability and "cost" of materials just like real space suit engineers, and then we'll vote on the best design for protecting our future astronauts– which may include some of you!

Activity:

1. Together as a class, review images and videos of astronauts in space suits (these images from the CSA of spacewalks are a good start).
2. Discuss some of the challenges astronauts face, such as: extreme hot and cold temperatures, lessened gravity, lack of breathable air, and harmful solar radiation. Encourage students to rank these concerns from most to least important when it comes to designing their space suits.
3. Divide students into small groups; provide drawing and writing materials. Ask students to draw and label their initial space suit designs, paying careful attention to how the suit features will solve the challenges they ranked as most important.
4. Present the craft materials to the class and set expectations about how much of each material can be used for one prototype design. You may optionally choose to assign students an imaginary budget in order to model this real-world constraint (for example, your total suit design can cost "$100", and each piece of foam that you use is worth $20; therefore, a suit using 6 pieces of foam would exceed your budget).

5. Each group will select a spacesuit model and build the wearable prototype around them, ensuring that they are being safe– that's the whole point of space suits!
6. Groups present their designs to the class and explain how their particular design is both functional and safe for their astronaut model.
7. Students vote on the "best" suit– you can divide this into further categories, such as "best suit for Mars" and "most fashionable suit".
8. Encourage students to provide constructive feedback on how designs could be improved, based on the challenges astronauts face.

Discussion Questions:

- What did you determine is the most important function of a space suit?
- How did building your prototype suit help you think of improvements?
- What parts of this process do you think real engineers follow?

Extension:

Provide online and print resources on the history of space suits over time (Mercury, Apollo, Artemis generation Axiom suits). Students work together in groups to create a timeline of space suit evolution. This infographic on 50 Years of Spacewalking can be used for inspiration.

Did you know?

Space suits have special screens that help astronauts keep track of important information like how much oxygen or power they have left. Engineers who design these suits have to figure out the best place to put the screen. Having a screen directly inside your helmet may be convenient when you're standing still, but not if you need to see where you're going so you can avoid falling into a lunar crater!

Image source: https://www.esa.int/ESA_Multimedia/Images/2013/12/Alexander_Gerst_spacesuit_check_at_NASA

Space Matter Explorers

Objective:

Investigate and classify materials based on a variety of observable properties, while learning about how similar materials might be used in space exploration.

NGSS Standards:
PS1.A: Structure and Properties of Matter (2-PS1-1)

Materials:

- Containers to hold materials at each station
- Station 1: Sand, flour, gravel, potting soil
- Station 2: Aluminum foil, foam, rubber, cloth
- Station 3: Ice cubes, liquid water
- Station 4: Wooden blocks, metal, plastic, stone
- Magnifying glasses
- Paper and writing utensils for recording student observations

Introduction:

Have you ever imagined what it would be like to walk around on the surface of another world? There are some planets, like Jupiter, which are made of swirling gas– you couldn't stand on the surface, because you'd sink right through the clouds! Other planets, like Mars, have a solid surface similar to some locations on Earth. However, you'd need to wear a protective suit made of special materials in order to keep yourself safe on Mars.

Today, we'll investigate some special materials to decide which ones work best for space suits, building homes on another planet, and even for helping astronauts practice what it's like to stand on another world. I hope you're ready to use your skills of observation so we can discover which materials will best support our adventures in space!

Activity:

1. Set up the four themed stations, or prepare materials in such a way that the class can explore each station together as a whole (see "Materials").
2. For each of the four investigations, encourage students to record notes and drawings representing their observations and conclusions about the best-suited materials.
3. Guide the exploration of each station as follows:

Station 1: Sand, flour, gravel, potting soil

- Here, we have materials to simulate different types of soil you might encounter on Earth, the Moon, or Mars.
- How are these soils similar? How are they different? Pay special attention to features like the color and texture.
- Which soil types would you expect to find on Earth? What about the Moon or Mars? Is there anywhere on Earth that resembles the Moon, or Mars?
- The Moon, for example, contains rocks and boulders like Earth, but it's also covered with a surface layer of fine dust grains (as seen in this photo of a boot print on the Moon's surface).

Station 2: Aluminum foil, foam, rubber, cloth

- At this station, we will explore different materials that could be used in a protective suit for an astronaut to wear on their mission.
- Which of these materials would be best for protecting astronauts from extreme hot and cold temperatures?
- Optional: Allow students to test the best materials for insulation from the cold by using ice cubes, borrowed from Station 3.
- Which material would be best for protecting astronauts from sharp rocks?
- Which material would you find most comfortable to wear for a long journey through space? Why?

Station 3: Ice cubes, liquid water

- Everyone should already be familiar with the materials at this station– it turns out that these are simply two different versions of the same material!
- Can you describe the differences between liquid water and ice verbally or through drawings? Which one is able to change shape? How do they feel? What are their temperatures like?
- Earth contains both liquid water and ice.
- Scientists have confirmed that water exists on the moon, primarily in shadowed areas near the poles. Most of the water on Mars is frozen in ice caps near the planet's poles. Why do you think it's easier for water to exist there?

Station 4: Wooden blocks, metal, plastic, stone

- These are all materials we use to build structures on Earth, but which one would be best for building a house on another world?
- When would flexibility be important in a building material? Which of these materials is the most flexible?
- Sometimes we want to use the hardest and sturdiest material possible due to the harsh conditions of space. Which materials feel strongest?
- Which materials would be easiest to transport in a rocket and carry around while wearing a spacesuit?

Discussion Questions:

- Did you notice anything surprising about any of the materials we observed?
- Why is it important for scientists to test materials before using them in space?
- Did you notice any patterns in what materials worked best for certain purposes?

Extension:

Read about the history of investigating whether water exists on the Moon. Encourage students to work together in groups to propose a future Moon mission with the goal of understanding the Moon's water once and for all!

Did you know?

When scientists develop new materials for space and air travel, they often find their way into everyday life on Earth! Memory foam is used in many couches, mattresses, shoes, and even helmets, but it was first created by NASA researchers designing seats that could better protect test pilots during flights.

Image source: https://spinoff.nasa.gov/Spinoff2019/cg_4.html

Classroom Space Station

Objective:

Design, build, and assemble components of a model space station in order to explore how larger objects can be created from smaller constituent pieces.

NGSS Standards:
PS1.A: Structure and Properties of Matter (2-PS1-3)

Materials:

- Rulers
- Paper and writing utensils
- Assorted craft materials (cardboard, tape, pipe cleaners, construction paper, etc)
- Optional: building blocks such as LEGO® bricks or other interlocking pieces
- Slides with images of the International Space Station and Gateway

Introduction:

How many people do you think are in space right now? Thanks to an international collaboration called the International Space Station (ISS), there are always people orbiting around the Earth while learning more about how to live and work in space!

The International Space Station contains six sleeping spaces, two bathrooms, a gym, science laboratories, and more. In order to build a space station where astronauts can live and work for extended periods of time, many of the pieces were built separately and later combined. We call these parts "modules", and each module needs to connect perfectly to the others–sort of like giant LEGO® bricks in space.

Today, each of you will design and build your own miniature space station module. It could be a bedroom, a science lab, or even a movie theatre where astronauts can relax after all their hard work. The most important thing is that your module fits together with everyone else's so that we can combine them all into one big space station at the end. Let's get started on designing our new Classroom Space Station!

*The number varies, but you can check a website like this to be certain.

Activity:

1. Together as a class, explore a variety of examples and images of modular space station features, including the International Space Station and Gateway.
2. Introduce the concept of modules called nodes which connect parts of the station to each other, and of docking ports which allow visiting spacecraft to connect to the station.
3. Provide students with paper and drawing

materials to sketch their individual module designs. Creativity is encouraged, but one requirement is that each module contains a connector that allows it to fit with other modules.

4. Review designs and provide feedback (educator-led and peer-led), especially on ideas for connecting different components.
5. Encourage students to build their modules using provided craft materials, providing frequent reminders to check that their component will fit with those others are creating! LEGO® bricks or other interlocking pieces may be incorporated into designs to allow for better connections.
6. Assemble the space station– either in small groups or as a whole class. Experiment with different ways to test connections and rearrange components in order to create the best experience for astronauts living in this station.

Discussion Questions:

- Why is it helpful to build a space station in smaller pieces instead of one continuous structure all at once?
- If you could add one more module to our classroom space station, what would you add and why?
- What is the biggest challenge to creating a modular space station?
- Did your design change at all as you started building? What changes were necessary?

Extension:

Write a short story about the life of an astronaut living in your classroom space station. Use the experiences of this astronaut to help plan future improvements to the space station design and arrangement of components.

Did you know?

The cupola is a special module on the ISS that offers spectacular views of Earth through its seven windows. Astronauts use it to watch spacewalks, observe spacecraft coming to visit, and enjoy the beautiful sights of our planet below. The cupola just might be the best window seat in space!

Image source: https://www.nasa.gov/image-detail/gmt274_17_51_for-esa_samantha-cristoforetti_water-playing-and-portraits_610h-2/water-playing-and-portraits_610h-2/

ARTEMIS SPACE ADVENTURE WITH LEGO® BRICKS

Grades 4-5 Activity Guides

PRODUCED BY FLYING FISH IN COLLABORATION WITH SCIENCE WORLD

ARTEMIS SPACE ADVENTURE WITH LEGO® BRICKS

Gravity Games

Objective:

Investigate evidence for the downward (toward the center of the planet) direction of objects under gravity's influence on Earth, and consider how gravity varies on other worlds.

NGSS Standards:
PS2.B: Types of Interactions (5- PS2-1)

Materials:

- Basketball
- Balloon
- Tennis ball (optional)
- Paint (or water/other liquids mixed with food coloring)
- Large sheets of paper
- Small beanbags
- Feathers or tissues
- Paper for helicopters (optional template here)
- Scissors
- Paper clips
- Video of the Apollo 15 feather and hammer drop

Introduction:

(Hold the basketball in one hand and the balloon in the other)

Despite the fact that I am holding a basketball, I assure you that you are, in fact, in science class rather than PE class! These two objects can be used to help us explore a fundamental property of nature. What will happen if I drop the basketball and the balloon at the same time? Who thinks the basketball will hit the ground first? Who thinks the balloon will hit the ground first? (Drop the objects and discuss why the basketball hits the ground first)

Now, imagine if we did this experiment on the Moon. What do you think would happen?

The force that pulls both of these objects to the ground is gravity, but there is more to the science of gravity than meets the eye! Today, we are going to visit four different activity stations to explore this fascinating force.

Activity:

Station 1: Gravity Art

- Drip paint or colored water onto a vertical paper surface (with a tarp or other easy-to-clean surface underneath).
- Observe how gravity affects the flow of the paint– it always moves downward, rather than sideways or up.

- Compare what happens with thicker vs. thinner liquids. Is gravity still pulling on both liquids in the same way? What is the reason the liquids behave differently?

Station 2: Gravitational Target Toss

- Set up different "target areas" at various heights and distances. These can optionally be labeled with the names of planets or other celestial bodies.
- Encourage students to experiment with different throwing angles for reaching each target.
- Compare what happens when the beanbags are thrown with a steeper initial angle versus a lower initial angle. Gravity always pulls the beanbags back down, so steeper angles may result in shorter horizontal distance traveled.

Station 3- Paper Helicopter Experiment

- Fold paper helicopters (simple strips of paper with two flaps at the top).
- Drop helicopters from the same height and record observations: Does gravity pull the helicopters straight down, or do they spin as they fall?
- The helicopters fall because of gravity, but air resistance slows them down and causes them to spin.
- What happens if you attach a paperclip and add mass? What if you add multiple paperclips?

Station 4- Earth and Moon Gravity Comparison

- Drop a feather and a beanbag simultaneously, in order to confirm the findings from the introductory demonstration with the basketball and balloon.
- Now, watch the famous feather & hammer drop experiment from Apollo 15.
- Without air, both objects fall at the same rate!

Discussion Questions:

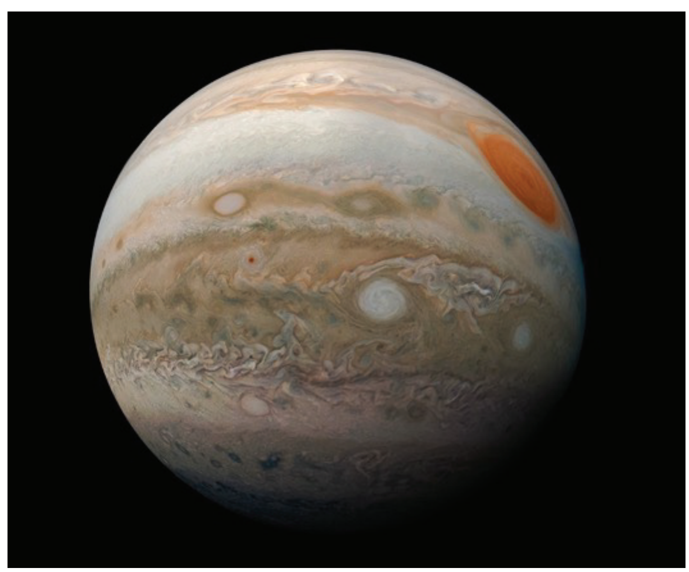
- Why do astronauts appear to bounce when they walk on the Moon?
- How do you think gravity would be different if Earth were bigger or smaller?
- Can you think of something in your daily life that only works because of gravity?

Extension:

Watch videos such as this of astronauts on the International Space Station (ISS) floating in microgravity. The ISS orbits around the Earth, so why do we say "microgravity" instead of "zero gravity"? This is because the ISS is still under the influence of Earth's gravity, but it's moving at incredibly high speeds. The astronauts are in a constant state of freefall as they zoom around the Earth, which creates the feeling of floating or weightlessness!

Did you know?

Jupiter's gravity is so strong that it actually changes the path of asteroids! We are lucky to share a solar neighborhood with such a powerful gas giant helping to protect Earth from dangerous collisions.



Source: https://www.asc-csa.gc.ca/eng/astronomy/solar-system/jupiter.asp

Balloon Rocket Blast-Off

Objective:

Build and launch balloon rockets to explore how tiny, invisible gas particles create thrust that propels an object forward.

NGSS Standards:
PS1.A: Structure and Properties of Matter (5-PS1-1)

Materials:

- Balloons (party-sized, or a variety)
- Binder clip
- String
- Plastic or paper straws
- Scissors
- Tape
- Optional: measuring tape
- Optional: LEGO® bricks

Introduction:

(Begin by blowing up a balloon and sealing it with your hand)
What will happen when I let go of this balloon?

(Release the balloon)
Why did it fly around the room when I let go? This is because of tiny particles of air moving at high speeds. Even though we can't see them, the release of gas particles makes the balloon move forward. This is similar to how real rocket thrusters work, though usually, we try to aim rockets a little more precisely than how I just aimed the balloon. Today, we will build our own miniature balloon rockets and test how gases help them blast off!

Activity:

1. If you have access to LEGO® bricks or other building materials, provide time for students to create a small Artemis-style rocket. Be sure to keep the design lightweight, or else it may not move very far in space!
2. Each pair or group of students may cut the straw into small segments and tape a piece to their rocket model. This will help guide the rocket along the string.
3. Run a long piece of string through the straw, tying one end to a handle or chair.
4. Inflate the balloon but leave it unsealed; students can use a binder clip to temporarily seal it if desired.
5. Tape the balloon to the side of the "rocket", ensuring that the open end of the balloon faces in the direction considered "backward".
6. Now, the other end of the string can be held freely by one of the students or attached to a surface across the room.

7. Begin your launch countdown, and at zero, release balloon rockets!
8. Encourage students to observe how the LEGO® rocket moves. Did it zoom forward? Did it not move as far as you thought?
9. Iterate! Repeat the experiment with different balloon sizes, altered rocket components, or adjusted string angles to see how they affect the rocket's distance.

Discussion Questions:

- Why did the rocket move in the forward direction?
- How does this experiment prove that gases are made of moving particles too small to see?
- What would happen if we performed this experiment in space, outside of Earth's atmosphere?

Extension:

Astronauts don't use a string to control the direction of their spacecraft; instead, they may use thrusters to fire in different directions. The Orion spacecraft changes direction by using features called reaction control system (RCS) thrusters. Experiment with taping multiple balloons of different sizes and inflation levels to the rockets in order to "steer" them through the air.

Did you know?

Even though outer space is considered a vacuum (completely empty of matter), there are still small amounts of particles floating around in the space between star systems. We refer to the energy and particles that exist between stars as the interstellar medium.

Image source: https://www.utoledo.edu/nsm/astro/research/dust-interstellar-medium.html

How Far to the Stars?

Objectives:

Build a conceptual understanding of cosmic scale using a simple model of the Earth, Moon, and Sun.

Explore the relationship between distance and brightness of stars.

NGSS Standards:
ESS1.A: The Universe and its Stars (5-ESS1-1)

Materials:

- 1 cm diameter ball or marble to represent the Earth
- ~0.3 cm diameter spherical object like a peppercorn or sprinkle to represent the Moon
- Tape measures or meter sticks
- Optional: Rope measuring 117 m

Introduction:

Have you ever looked up at the night sky and wondered how far away the stars are? What about the Moon, which can appear so close that you almost feel like you can reach out and touch it? Our Sun appears so bright that it lights up our entire daytime sky, but it's just one of billions of other stars in our galaxy.
Let's explore the distances between objects in space using something called a scale model, in order to understand one aspect of why the night sky looks the way that it does.

Activity:

1. Provide each student (or group of students) with the 1 cm diameter object (the Earth) and the 0.3 cm object (the Moon). Students should be careful not to lose these, as they are literally holding the fate of the planet in their hands!
2. Ask students to demonstrate how far they think the Moon should be from the Earth.
3. Reveal that the true scale distance should be 30 cm between the Earth and the Moon– have them measure this out and discuss what surprises them.
4. Next, take students outdoors or into a long hallway. Alternatively, you can determine in advance a notable feature that is 117 m away.
5. Ask students to predict or place themselves where they think the Sun would be based on a model of this scale.
6. Reveal the true distance of the Sun in this model: 117 m away. Students may optionally stretch the rope across an open space to help visualize the distance.
7. Now, explore examples of distant stars that have similar sizes to our Sun (such as Alpha Centauri A, Tau Ceti, and Kepler-452). While you can see Alpha Centauri A and Tau Ceti in the night sky, depending upon where you live, they appear quite different from our Sun despite having similar properties. Kepler-452 is far too

dim to see using our eyes, as it's located over 1800 light-years away from the Earth.

8. Finally, you can introduce stars of different sizes to demonstrate the range of possibilities (for example: Proxima Centauri, much smaller and dimmer than the Sun, or Betelgeuse, which is hundreds of times larger than the Sun). Challenge students to use online resources to determine how stars like these look in the night sky.

Discussion Questions:

- Why do distant stars appear dimmer than the Sun, even if they are the same size or larger?
- If the Sun is 117 m away in this model, how far do you think the next closest star would be? What does this suggest about the possibility of humans traveling to other stars?
- If two stars appear to have the same brightness from Earth, but one is farther away, what does that tell you about how those stars might be different?

Extension:

Constellation Creation: Have students design their own constellation using different-sized stars to represent their brightness. They can name their constellation and explain its story or myth. You can even require them to explain the sizes and distances of their invented stars and how that affects their appearance!

Did you know?

The largest known star observed thus far is called UY Scuti. If you replaced our Sun with UY Scuti, it would extend out beyond the orbit of Jupiter!

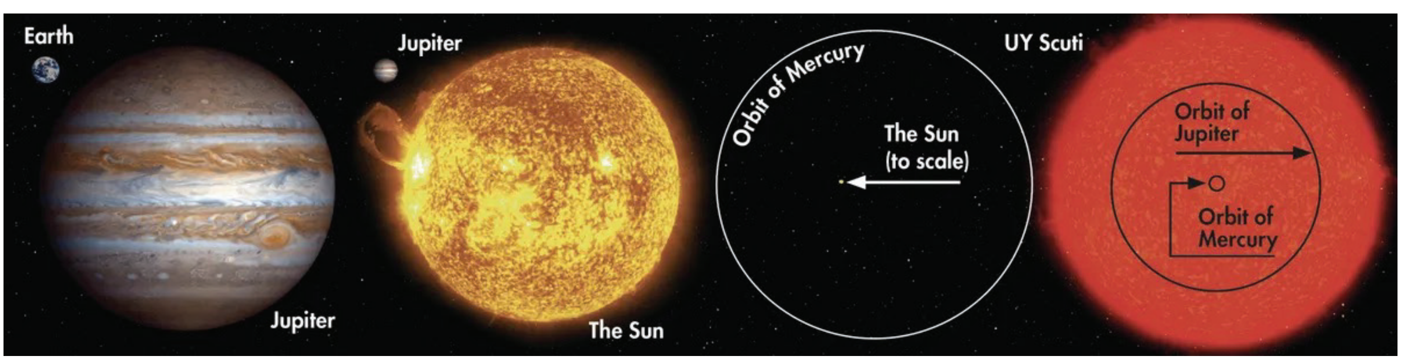


Image source: https://www.skyatnightmagazine.com/space-science/uy-scuti

Cosmic Clocks

Objective:

Investigate how observable patterns in celestial bodies are used to create calendar systems and methods of timekeeping.

NGSS Standards:
ESS1.B: Earth and the Solar System (5-ESS1-2)

Materials:

- Sidewalk chalk or small stones
- Measuring tape or meter stick
- Writing utensils and paper
- Compass
- Sunny outdoor space
- 1 printable sundial template per student
- Optional: 1 sturdy piece of cardstock per student

Introduction:

How do you know what time it is right now? Most of us tell time digitally using the clock on an electronic device such as a phone or computer. Did you know that before we had clocks, people used the Sun to tell time? The movement of neighboring bodies in the sky– like the Sun, Moon, and stars– was the original clock for Earthlings. Let's step back in time (ha!) and use the Sun to make our own cosmic clocks.

Activity:

1. Bring the class to a sunny spot outside– either a paved area that can be marked with sidewalk chalk, or an unpaved area where you can place small stones as markers (being sure to remove or replace them afterward).
2. Divide the class into small groups– each group must choose one person to stand still while the others trace their shadow's outline with chalk or stone markers. One group member should then measure the extent of the shadow (from their standing teammate's feet to the shadow's tip) and mark down the time of measurement.
3. Be sure to label the shadow tracing with a signature or design that helps you remember whose shadow it is and where exactly they were standing!
4. Return outside at the end of class or later in the school day so that each group can trace the same person's shadow from the same location.
5. Note how the shadow moves and changes in length– what patterns do you notice?
6. Congratulate students on the fact that they just effectively created a giant sundial, using a human as the gnomon (the stick which casts the shadow).
7. Now, provide each student with this printed sundial template and follow the instructions together as a class. It is helpful to create an

example ahead of time so that students can witness the finished product.

8. Encourage students to test their sundials the next day and to report back on their findings.

Discussion Questions:

- Why does your shadow length change throughout the day?
- How do you predict that your shadow length might change throughout the year? Why?
- The Sun appears to move across our sky throughout the day. What is really causing this apparent motion?

Extension:

Hold onto your sundial creations, or keep one as a classroom decoration. Compare sundial shadows at different times of the year to see how Earth's tilt changes the Sun's angle.

Did you know?

Many cultures around the world developed complex and intricate structures with astronomical alignments. The Medicine Wheel located in Bighorn National Forest is just one such example of a site that could be used for both ceremony and cosmic timekeeping.

Image source: https://www.wyohistory.org/encyclopedia/medicine-wheel

ARTEMIS SPACE ADVENTURE WITH LEGO® BRICKS

Middle and High School Activity Guides

PRODUCED BY FLYING FISH
IN COLLABORATION WITH SCIENCE WORLD

Elemental Origins

Objective:

Investigate how stars create elements through nuclear fusion and supernovae while reflecting on our personal connection to the cosmos.

NGSS Standards:
ESS1.A: The Universe and Its Stars (HS-ESS1-2), (HS-ESS1-3)

Materials:

- Printed cards with element names
- Nucleosynthesis periodic table (example)
- Signs for each "stellar formation zone"
- Devices with internet access
- Paper and writing utensils

Introduction:

Where did you come from? Correct– you just walked in from the hallway or another classroom. Let's go back much further and ask a different question, then. Where did the atoms in your body come from? Some of them were formed in the hearts of massive, ancient stars and then flung across space in powerful supernova explosions. Some of the atoms in your body even trace back to the Big Bang itself. Today, we will track where these elements originated and learn how we are all connected to the universe itself.

Activity:

1. Provide each student with a printed element card (Carbon, Oxygen, Gold, etc).
2. Use a printed or digital version of a nucleosynthesis periodic table tool to investigate where their element was formed.
3. Once identified, students should share their element's origin with the class. Alternatively, you can set up labels on the board and have students affix their element to the correct section (main sequence star, red giant, neutron star merger, etc).
4. Next, students will rotate through "stellar formation zone" stations, which can be set up around the room or visited virtually from their seats. Stations should be selected from the nucleosynthesis periodic table and may include categories such as Big Bang fusion, exploding massive stars, and merging neutron stars. Additional printed resources or internet access can augment the learning at each station.
5. For each station, students will record their answers to the following:

- Briefly describe the nucleosynthesis process featured here.
- What elements are formed through this process?
- How are these elements used in your body or in your life?

6. Conclude by watching this clip of Carl Sagan discussing how intimately we are connected with the stars, as distant as they may seem.

Discussion Questions:

- What is the most surprising elemental origin you learned about today?
- Why are elements like Hydrogen and Helium so common compared to elements like Gold and Platinum?
- Describe what evidence exists to support the following claim: "By understanding stellar nucleosynthesis, we aren't just learning about space– we're learning about ourselves."

Extension:

Create a classroom periodic table of the cosmos: each student chooses an element and creates a one-page poster about its origins and role in human life.

Did you know?

There are still mysteries in our understanding of elemental origins! One famous example is known as the Cosmological Lithium Problem. Theoretical predictions based on our understanding of the Big Bang suggest that the element Lithium should be more abundant in certain stars than what we actually observe. Maybe you'll be the astrophysicist to finally solve this cosmic conundrum!

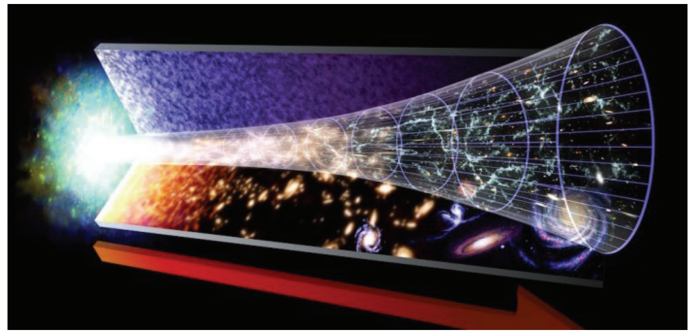


Image source: https://aasnova.org/2017/02/15/fixing-the-big-bang-theorys-lithium-problem/

Fossils of the Solar System

Objective:

Apply scientific reasoning to the story of Earth's earliest history and the solar system's formation.

NGSS Standards:
ESS1.C: The History of Planet Earth (HS-ESS1-6)

Materials:

- Images and/or samples of:
  - Terrestrial rocks (granite, basalt, or sedimentary rock)
  - Lunar rocks (Apollo sample image or replica)
  - Martian meteorites such as NWA 7034
  - Carbonaceous chondrite meteorites
- Printed or digital "Cosmic Case Files"
- Large poster paper or whiteboard for a class timeline
- Paper and writing utensils

Introduction:

Earth's surface has continually reshaped itself through plate tectonics, erosion, and volcanism. However, space is full of time capsules– objects that have remained largely unchanged for billions of years. Meteorites, lunar rocks, and even ancient Earth minerals are like "fossils" of the early solar system. Today, we will engage in astronomical fossil investigations to reconstruct the story of our planet's earliest history.

Activity:

1. Display examples (images, or samples if available) of terrestrial rocks, lunar rocks, Martian meteorites, and carbonaceous chondrite meteorites.
2. Ask students: Which of these rocks do you think came from Earth? Which could be from the Moon? What about Mars, or beyond? How do you think scientists tell the difference?
3. Space rocks often have unique compositions not found on Earth. Scientists can analyze everything from a rock's texture to the ratio of certain isotopes to determine its origins.
4. Divide students into groups and assign each a "Cosmic Case File" focused on a real-world sample that scientists have used to understand the formation of Earth and the conditions of the early solar system. Each case file contains a brief description and image of the object along with other basic information about its discovery. Case file examples may include:

- The Innaanganeq Meteorite
- The Campo del Cielo Meteorite
- Carbonaceous Chondrites

- Apollo Moon Rocks
- Terrestrial Zircon Crystals
- Acasta Gneiss
- Martian Meteorites

5. Each group should create a one-page display about their case file and add it to a large class timeline, starting from 4.6 billion years ago to today.
6. Once complete, analyze the full timeline together as a class and discuss how different pieces of scientific evidence tell the story of Earth's past.

Discussion Questions:

- What challenges do scientists face when trying to determine the origins of a rock sample?
- How does radiometric dating help us determine the age of samples?
- Why does the Moon appear so cratered while Earth does not?
- What other places in the solar system might hold important clues about Earth's past?

Extension:

Take a virtual tour of the Antarctic Meteorite Lab and then write a brief reflection on why Antarctica is considered one of the best places on Earth to find meteorites.

Did you know?

NASA's Lucy mission is the first ever spacecraft designed to study the Trojan asteroids which share an orbit with Jupiter. In the same way that the Lucy fossil transformed our understanding of human origins, the Lucy spacecraft will revolutionize our understanding of the solar system's origins!

Image source: https://science.nasa.gov/mission/lucy/

Galactic Journeys

Objective:

Create and refine a galaxy classification system while learning about the properties and motions of galaxies in our universe.

NGSS Standards:
ESS1.A: The Universe and Its Stars (MS-ESS1-2)

Materials:

- Images of various galaxies (printed or digital)
- Markers and poster paper
- Print or digital reference materials about galaxies

Introduction:

We all know that the Earth and other planets revolve around the sun. Did you know that our Sun, and therefore our entire solar system, is also on an orbital journey around the center of our Milky Way Galaxy? Even galaxies are constantly on the move. Today we will observe many types of galaxies in our universe and then learn about some of their journeys through the wider cosmos.

Activity:

1. Distribute images of galaxies such as these to students without revealing their official classifications.
2. Ask students to observe the galaxies closely and note any distinctive features such as shape, color, and size.
3. In groups, students discuss their observations and devise a system to categorize galaxies based on the features they noted; creativity is encouraged– there are no wrong answers!
4. Each group presents their classification system to the class in the form of a poster, explaining the criteria and reasoning they used. A whole-class discussion on the diversity of approaches to this activity may follow.
5. Next, share the standard classifications used by astronomers. How did students' own systems compare?
6. Together as a class or in small groups, explore concepts like galaxy clusters and the expansion of the universe. Relate this content to what students already know about gravity.

Discussion Questions:

- What surprised you about the standard way in which galaxies are classified? Do you think astronomers could improve their galaxy classification system?
- Can you think of any challenges astronomers may face when classifying galaxies using distant images?
- How do you think some galaxies stay bound together, while the universe itself is expanding?

Extension:

Complete a hands-on activity to model the expansion of the universe, using balloons with dot stickers to represent galaxies. Students can even draw waves to represent light between galaxies, which becomes stretched (redshifted) as the balloon inflates!

Did you know?

In the grand, complicated dance of the cosmos, our Milky Way is on a collision course with the neighboring Andromeda Galaxy! Luckily, we don't have to worry about this for billions of years. Meanwhile, interacting spiral galaxies NGC 2207 and IC 2163 offer a sneak peek at what such a galactic merger might look like for us in the distant future.

Image source: https://hubblesite.org/contents/media/images/2004/45/1627-Image.html

LEGO® Brick Physics

Objective:

Observe the relationship between mass, ramp angle, and unbalanced forces, through experiments with a LEGO® brick car.

NGSS Standards:
PS2.A: Forces and Motion (MS-PS2-2)

Materials:

- LEGO® bricks (including wheels and building components)
- Books, boards, or other flat objects to create ramps
- Rulers
- Stopwatches or timers
- Small masses or weights (coins, washers, etc)
- Optional: sandpaper or felt

Introduction:

When engineers design a Mars rover, they need to make sure it can move across different kinds of surfaces, climb hills, and carry onboard scientific experiments. They must have a solid understanding of how changes in mass, terrain, and friction will affect the rover's movement. Today, we will experiment with LEGO® cars to understand how all of these factors affect a vehicle's movement. Only once we understand these forces on Earth can we then feel confident sending our creations to other worlds!

Activity:

1. Provide students with the materials to construct simple cars out of LEGO® bricks and/or other building materials, ensuring the cars have room to later add additional weights.
2. Set up ramps using books or boards, marking a starting point on the ramp so that every initial trial begins from the same height.
3. Students should conduct their first trial by releasing their cars at the starting mark without pushing. Time how long it takes to reach the bottom and measure how far it travels after leaving the ramp.
4. Experiment with changing the ramp incline, adding small masses to the car and taping sandpaper or felt to the ramp in order to simulate rough terrain. How do these variables affect the car's speed and distance?
5. Encourage students to conduct multiple trials with different combinations of ramp angle, mass, and friction. Record data, compare results, and analyze patterns.

Discussion Questions:

- Can you identify all the balanced and unbalanced forces acting on your car?
- How did adding or removing mass to the car affect its motion?
- Why does friction reduce the car's speed?
- What would happen to the car's motion if we performed this experiment on the Moon or Mars?

Extension:

Students use their recorded time, distance, and speed data for different trials to create a graph. Each group then presents their findings to the class, providing additional recommendations for engineers planning to adapt their design for Mars exploration.

Did you know?

Wheels on Mars rovers need to be tough enough to handle the rocky, dusty, and uneven terrain of the Red Planet. The Curiosity rover, which landed on Mars in 2012, has wheels that have been damaged by sharp rocks and rough surfaces. NASA engineers learned from this experience and designed wheels differently for future rovers, like Perseverance.

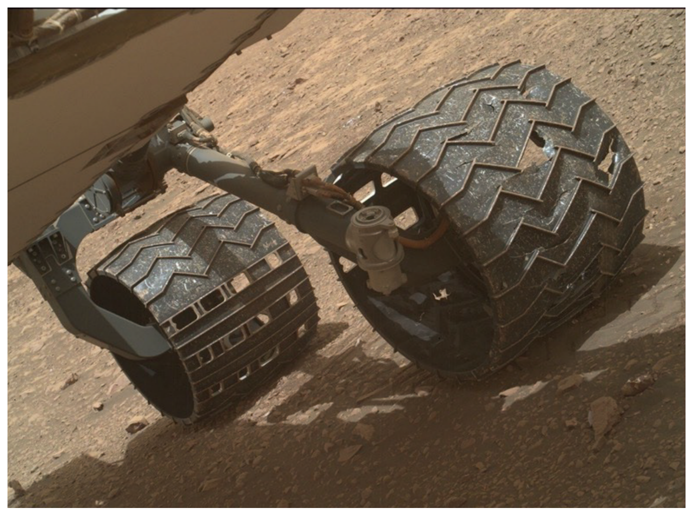


Image source: https://science.nasa.gov/blog/sol-2032-2033-the-rocks-vs-stone-cold-aluminum-wheels/

ARTEMIS SPACE ADVENTURE WITH LEGO® BRICKS

Additional Classroom Resources

PRODUCED BY FLYING FISH IN COLLABORATION WITH SCIENCE WORLD

Additional Classroom Resources

Extend the Artemis-inspired educational adventure in your classroom with these resources for engaging lessons and interactive experiences.

LEGO® Education
LEGO® themed classroom resources divided into Pre-K & Kindergarten, Elementary, and Middle

NASA Next Gen STEM For Educators
Lesson plans and inquiry-based experiments to engage students with NASA missions

NASA's Eyes
Interactive web-based 3D visualizations using real NASA data

STEMonstrations
Educational STEM demonstrations filmed by astronauts aboard the International Space Station

Canadian Space Agency
Lesson plans and hands-on experiments for the classroom

Teach with Space
Space-themed classroom resources from the European Space Agency, for elementary and secondary students

Lunar and Planetary Institute
K-12 Earth and space science resources and planetary science news for students

Zooniverse
Anyone can contribute to research projects on topics ranging from black holes to dark energy

Stellarium
A free, open-source planetarium that can be downloaded or run in the web browser

Minecraft Education: Artemis Missions
Classroom activities on Newton's Laws, coding, and more, set in the world of Minecraft