Day 5
Space Exploration

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Introduction

People have been observing what's out there in space since before recorded history. **Astronomers** first focused their eyes and then their **telescopes** on stars, comets, and planets. But to really get out there and look around, a practical way to escape the Earth's **gravity** had to be invented.

Advancements in rocket technology made leaving the Earth, to better understand it and our place in the solar system, possible. The ability to **accelerate** objects to the **velocity** needed to escape Earth's gravity and travel away from the planet made space exploration a reality.

Questions to guide explorations and experiments

- How can humans observe and explore space?
- What is gravity? How do we experience gravity on Earth? Is there gravity in space?
- How does a rocket get into space?
- What else revolves around the Sun?
- What kinds of challenges and work are involved in getting people into space?

Books and activities

- **Books:** fiction, nonfiction and poetry all about telescopes, gravity, rockets, astronauts, and exploring space
- **Activities:** explore and make tools for observing and getting to space; discover the challenges of becoming and being an astronaut

Children's Books

Fiction

- *CatStronauts: Space Station Situation* by Drew Brockington (Ages 6-9)
- *Commander Toad* series by Jane Yolen (Ages 6-9)
- *El Mundo de Copocuqu: La Reina Gravedad y el Rey Masa (The World of Copocuqu: Queen Gravity and King Mass)* by Adriana C. Ocampo Uria (Ages 6-9)
- *Just Right: Searching for the Goldilocks Planet* by Curtis Manley (Ages 6-9)
- *Maria's Comet* by Deborah Hopkinson (Ages 6-9)
- *Max Goes to Jupiter: A Science Adventure with Max the Dog* by Jeffrey Bennett (Ages 6-9)
- *Max Goes to the Space Station* by Jeffrey Bennett (Ages 6-9)
- *Mousetronaut* by Mark Kelly (Ages 4-8)
- *Tiny Little Rocket* by Richard Collingridge (Ages 4-8)

Poetry

- *Galileo's Universe* by J. Patrick Lewis (Ages 9-12)
- *Out of This World: Poems and Facts About Space* by Amy Sklansky (Ages 6-9)

Biography

- *Almost Astronauts: 13 Women Who Dared to Dream* by Tanya Lee Stone (Ages 9-12)
- *Chasing Space* by Leland Melvin (Ages 9-12)
- *Counting on Katherine: How Catherine Johnson Saved Apollo 13* by Helaine Becker (Ages 6-9)
- *Mae Among the Stars* by Roda Ahmed (Ages 4-8)
- *Path to the Stars: My Journey from Girl Scout to Rocket Scientist* by Sylvia Acevedo (Ages 9-12)
- *To Space and Back* by Sally Ride (Ages 9-12)
- *Starry Messenger: Galileo Galilei* by Peter Sis (Ages 6-9)
- *What Miss Mitchell Saw* by Hayley Barrett (Ages 4-8)
- *Who Was Neil Armstrong?* by Roberta Edwards (Ages 9-12)

Children's Books

Nonfiction

- *Astronaut Academy* by Steve Martin (Ages 6-9)
- *Astronaut Handbook* by Meghan McCarthy (Ages 6-9)
- *Astronaut in Training* by Catherine Ard (Ages 6-9)
- *To Burp or Not to Burp: A Guide to Your Body in Space* by Dave Williams (Ages 6-9)
- *Exploring Space: From Galileo to the Mars Rover and Beyond* by Martin Jenkins (Ages 9-12)
- *Floating Home* by David Getz (Ages 6-9)
- *Floating in Space* by Franklyn Branley (Ages 4-8)
- *Gravity* by Jason Chin (Ages 9-12)
- *Gravity Is a Mystery* by Franklyn Branley (Ages 4-8)
- *How to Be a Space Explorer* by Lonely Planet (Ages 9-12)
- *I Fall Down* by Vicki Cobb (Ages 4-8)
- *I Want to Be an Astronaut* by Byron Barton (Ages 4-8)
- *The International Space Station* by Franklyn Branley (Ages 4-8)
- *Mighty Mission Machines: From Rockets to Rovers* by Dr. Dave Williams and Loredana Cunti (Ages 9-12)
- *Professor Astro Cat's Space Rockets* by Dominic Walliman (Ages 6-9)
- *Science Comics: Rockets: Defying Gravity* by Anne Drozd (Ages 9-12)
- *Rockets and Spaceships* (DK Readers) by Dr. Karen Wallace (Ages 6-9)
- *Rocketry: Investigate the Science and Technology of Rockets and Ballistics* by Carla Mooney (Ages 9-12)
- *Space Exploration* by Dan Green and Simon Basher (Ages 9-12)
- *Spacewalk: The Astounding Gemini 4 Mission* by Carl R. Green(Ages 9-12)
- *Star Spotters: Telescopes and Observatories* by David Jefferis (Ages 9-12)

Space Words

Accelerate
To increase the speed or rate of something.

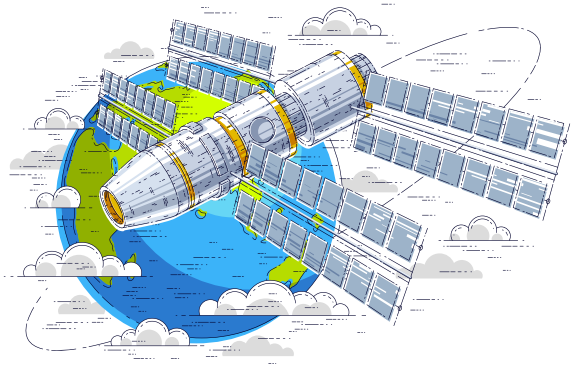
Astronomer / Astronomy
A scientist who studies space and the Universe beyond Earth. Astronomy is the branch of science that studies space.

Eyepiece
The lens closer to your eye in a telescope, through which you view objects in the sky.

Force
Power, energy, or physical strength. The strength or power applied to an object.

Gravity
A force that pulls matter together; a force that pulls people and objects toward the ground.

International Space Station
A large spacecraft in low orbit around Earth. It serves as a home and science laboratory for crews of astronauts from around the world. It orbits Earth every 90 minutes.



Lens
A piece of clear material such as glass that bends light rays passing through it. The surface of a lens is curved to bend light rays toward or away from a central point.

Magnify
To make something appear larger.

Mission
An important task that one is sent out to do. A space mission is a journey into space (unmanned or with a crew) for a specific reason — usually to gather scientific information.

Objective lens
The lens that gathers light from the object being looked at and focuses the light rays to produce an image.

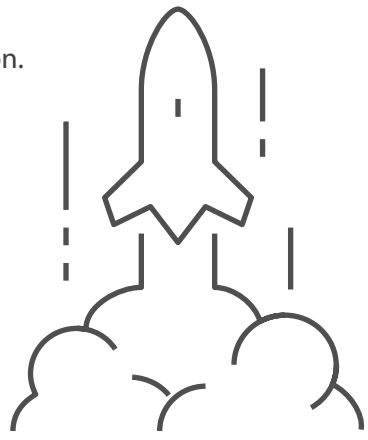
Refract
To bend as you move from one medium to another. Example: The movement of air and dust in the atmosphere bends, or *refracts,* a star's light in different directions.

Rocket
A flying device, shaped like a tube, that is pushed by hot gases released from engines in its rear. Rockets are used to launch spacecraft.

Telescope
An instrument that uses lenses and mirrors to make far away objects look larger and closer to us.

Thrust
To push or drive something with force.

Velocity
The rate of speed or motion.



Activity 1: DIY Telescopes

Introduction

Telescopes take our eyes beyond Earth to the stars and planets of the night sky. The curves of a telescope's glass or plastic lenses make this possible. The curved surface bends light — or **refracts** it — and the light changes direction. This change in direction makes objects seen through the telescope's lenses seem bigger than they really are.

The refracting telescope uses **lenses** to bring more light rays to a focus in your eye. Kids can make a simple refracting telescope with a tube that contains two lenses: one at the front end which gathers light, called the **objective lens**; and another that is closest to the user's eye, called the **eyepiece.** The objective lens collects the light. The eyepiece lens takes the collected light and **magnifies** what you are looking at.

Supplies (for each telescope)

- A pair of weak reading glasses — the kind you can get from the drugstore
- A small, strong magnifying glass
- Heavy cardstock or cardboard tubes, about 10-12 inches long, with a diameter slightly larger than your magnifying glass lens
- Masking tape
- Scissors

If kids working will be working in small groups, be sure to have enough of items 1-3 for each group.

Get kids thinking

To observe objects in space, you need to get a closer look! **Ask kids:** Why can't you see things that are very far away? What can you do to observe things that are far, far away? What kinds of tools or technology do you know about that can help you take a closer look at objects that are very distant?

Kick off discussion with older kids with this TED-Ed video: *The Story Behind Your Glasses*
https://ed.ted.com/lessons/the-story-behind-your-glasses-eva-timothy

Activity 1: DIY Telescopes

Let's get started!

Have kids look at the supplies you've provided for making a refracting telescope. Explain what the lenses are. Talk about how a telescope works and discuss what kinds of information telescopes provide about the solar system and beyond.

Let kids play a role in engineering their telescope. Explain that the tube that holds the lenses is really two tubes — one that fits inside the other — that need to have openings that can hold the lenses. **Ask kids:** Will the lenses fit into the bottom of the cardboard tube? How can they make them fit?

Experiment together to either narrow a tube by cutting along its length, making the tube smaller as it is fitted around the lens and then taped into shape, or to create a larger tube by rolling cardstock to the diameter of the lens and taping it into shape.

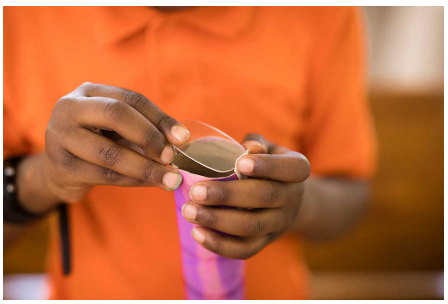
Warning: Never, under any circumstances, should kids point their telescope at the sun. The ultraviolet (UV) rays from the sun will permanently damage their eyes.

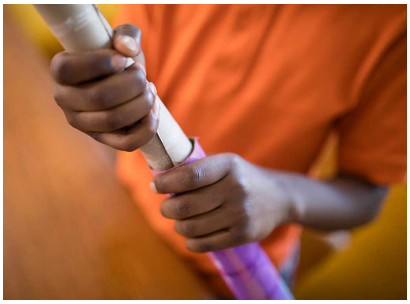
Once everyone understands how to make tubes and safe use of the telescopes, provide these instructions for making the telescope:

1. Form a tube for the stronger lens (your magnifying glass). The lens should be at the bottom of the tube and with the edges of the lens taped neatly to the tube to keep it secure. This is the telescope's eyepiece.

2. Form a tube for the objective lens that is either bigger or smaller in diameter than your first tube. Tape the lens neatly to the end of the tube.

3. Insert the empty end of one tube into the empty end of the other tube. Look through the eyepiece and point the other end of the telescope at a distant object. Slide the two tubes in and out until the object comes into focus. If it is difficult to focus the telescope, experiment with lengthening the tube.





Activity 1: DIY Telescopes

Ask kids: What do you see? Are you surprised to find things upside down?

To help kids think more about why images appear upside down, have them look at their reflection in a spoon and talk about the similarities between the curve of the spoon and the way light is curved through the lens of their telescope.

Do kids have ideas for how they could make their telescope more effective or powerful? Not show upside-down images?

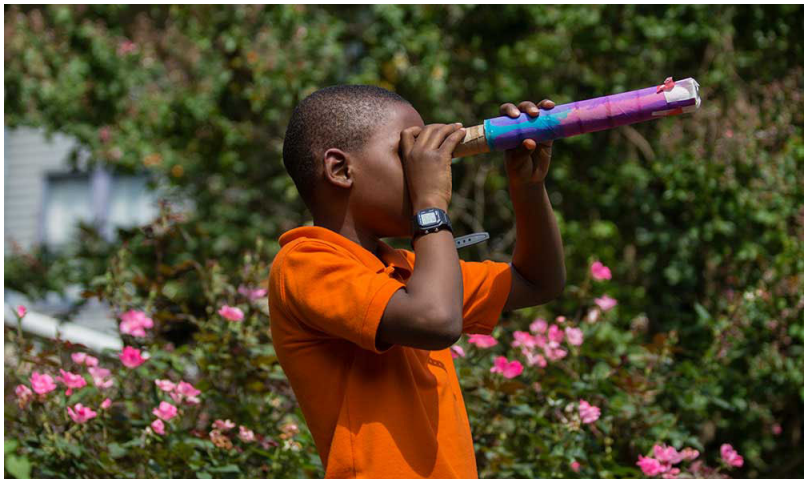


Photo © National Geographic Kids

More telescope and astronomy activities

Make Your Own Hand-Held Hubble
http://hubblesite.org/the_telescope/hand-held_hubble/

Observing with NASA
https://mo-www.cfa.harvard.edu/OWN/index.html

Activity 2: Exploring Gravity

Introduction

Gravity is an invisible force that pulls objects toward each other. On Earth, gravity continuously pulls us and everything on Earth (and in Earth's orbit) down towards the ground. The closer an object is to Earth, the more its gravity pulls on it. To explore space, spacecrafts have to overcome Earth's gravity, have kids build a model rocket to explore the **force** and **thrust** needed to launch a real rocket into space.

Supplies

- Straight, jumbo size (smoothie) straws
- Flexible drinking straws, standard size (standard straws need to slide inside the jumbo straws easily without too much extra space)
- 2 adhesive labels, 1" x 2.5" (for each rocket)
- Modeling clay (small ball to fill the end of the smoothie straw)
- Scissors
- Small stuffed animal (optional)
- Masking tape
- Tape measure

You'll need some space for launching the rockets!

Get kids thinking

Check kids understanding of gravity. Do they think things just naturally fall? They should understand that objects and people "fall" towards Earth because of gravity.

Watch this Crash Course Kids video: Defining Gravity (https://youtu.be/ljRlB6TuMOU) or try a demonstration:

Activity 2: Exploring Gravity

Hold up a small stuffed animal. Drop it on the floor and **ask kid**s: What happened? Talk about how the force of gravity continuously pulls things down towards the ground. Next, toss the stuffed animal up into the air and then let it fall to the ground and **ask kids** how the toy fell to the ground this time. Talk about the force you used to toss the stuffed animal up and the force of gravity that pulled it down to the ground.

Let's get started!

Have kids jump straight up as high as they can. **Ask kids:** how do you feel? How much energy did you use to jump? Were you able to jump very high? How does a rocket get so high? Why can't you jump as high?

Talk about the incredible amount of energy it takes to launch a rocket to overcome Earth's gravity. In a rocket engine, when ignited rocket fuel heats up, rapidly expanding gases are forced out of the tail of the rocket. This generates the upward **thrust** which pushes the rocket into the air.

In this activity, kids use moving air blown through a straw to provide the thrust.

Provide kids with a jumbo straw, small clay ball, and labels. Have kids use the clay to stop up one end of the straw. This is the nose of the rocket. Have them fashion a nose cone by cutting one of the labels in half and wrapping it around the top of the straw, covering the clay.

Kids should cut the remaining label in half. They should use those halves along with the half label left over from the nose cone to make fins. Fins are at the opposite end of the rocket's nose. Kids should attach one end of the label to the straw, fold and crease the piece in half, and attach the remaining bit of label to the straw. The should position 3 fins around the base of the straw. (See photo at right).

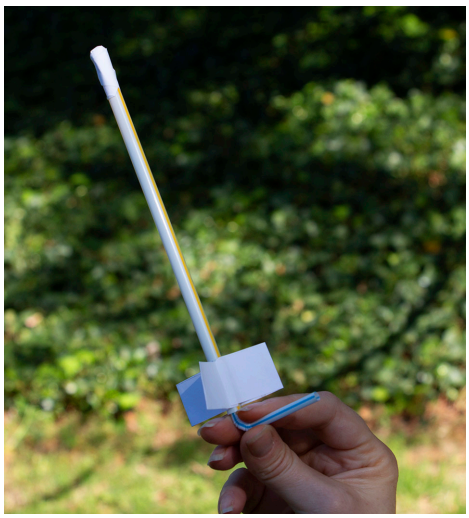


Photo © Breece Walker

Activity 2: Exploring Gravity

Now kids are ready to launch! Have them bend the neck of the flexible drinking straw to a right angle. Next, they should slide the long end of the straw into the base of the rocket. Before anyone blows into the short end of the drinking straw to launch, make sure everyone has plenty of room and that no one is in the way of an incoming rocket.

Count down 10-9-8-7-6-5-4-3-2-1, blast off!

Photo © Breece Walker

After this initial test flight, measure out a flight zone with masking tape so kids can see how far their rockets travel in future flights. Have them launch again. Encourage kids to make observations about their rocket launch. Ask kids: Where did it go? How high? How far down the flight zone? What could you change about your rocket or your launch to make it go higher or travel farther? Talk about how the clay prevents the air from escaping from the rocket and is pressurized, producing a force — thrust.

Give kids a chance to modify their rockets, try different launch angles, blow harder, or redesign something different to test. Let them keep launching and revising and then discuss how their ideas and changes worked or didn't work.

Activity 2: Exploring Gravity

Launch	Launch Angle	Air Output	Distance	Observations
1				
2				
3				
4				
5				

More rocket activities

Simple Rocket Science
https://www.jpl.nasa.gov/edu/teach/activity/simple-rocket-science/

Up, Up, Up! Build and Launch Your Own Rockets
https://www.esa.int/Education/Teachers_Corner/Up_up_up!_Build_and_launch_your_own_rockets_Teach_with_space_PR23

Activity 3: Moving and Working in Space

Introduction

Getting ready to live and work in space takes a lot of preparation. It can take up to two years of training to become an astronaut and get assigned to a **mission**. Astronauts face challenges from how to deal with weightlessness to dangers from space debris and malfunctioning technology when they travel and live in space (at the **International Space Station**). In these activities, kids learn about the space environment and some of the physical challenges faced by astronauts.

Supplies

- Timer
- Work gloves (2 pairs)
- Winter gloves (2 pairs)
- 4 carabiners or binder clips
- 50 feet of thin rope or heavy string
- 2 empty plastic jars with screw-on lids, such as a peanut butter jar
- LEGO® bricks (10 bricks in a container with a lid)
- 4 chairs
- Stopwatch

This allows two "astronauts" to go on a spacewalk at one time.

Get kids thinking

Ask kids: If you are an astronaut who lives and works in space, where do you sleep? And eat? And work?

Share a quick overview of What It's Like to Live on the International Space Station with kids: https://www.businessinsider.com/what-its-like-to-live-on-the-international-space-station-2015-9

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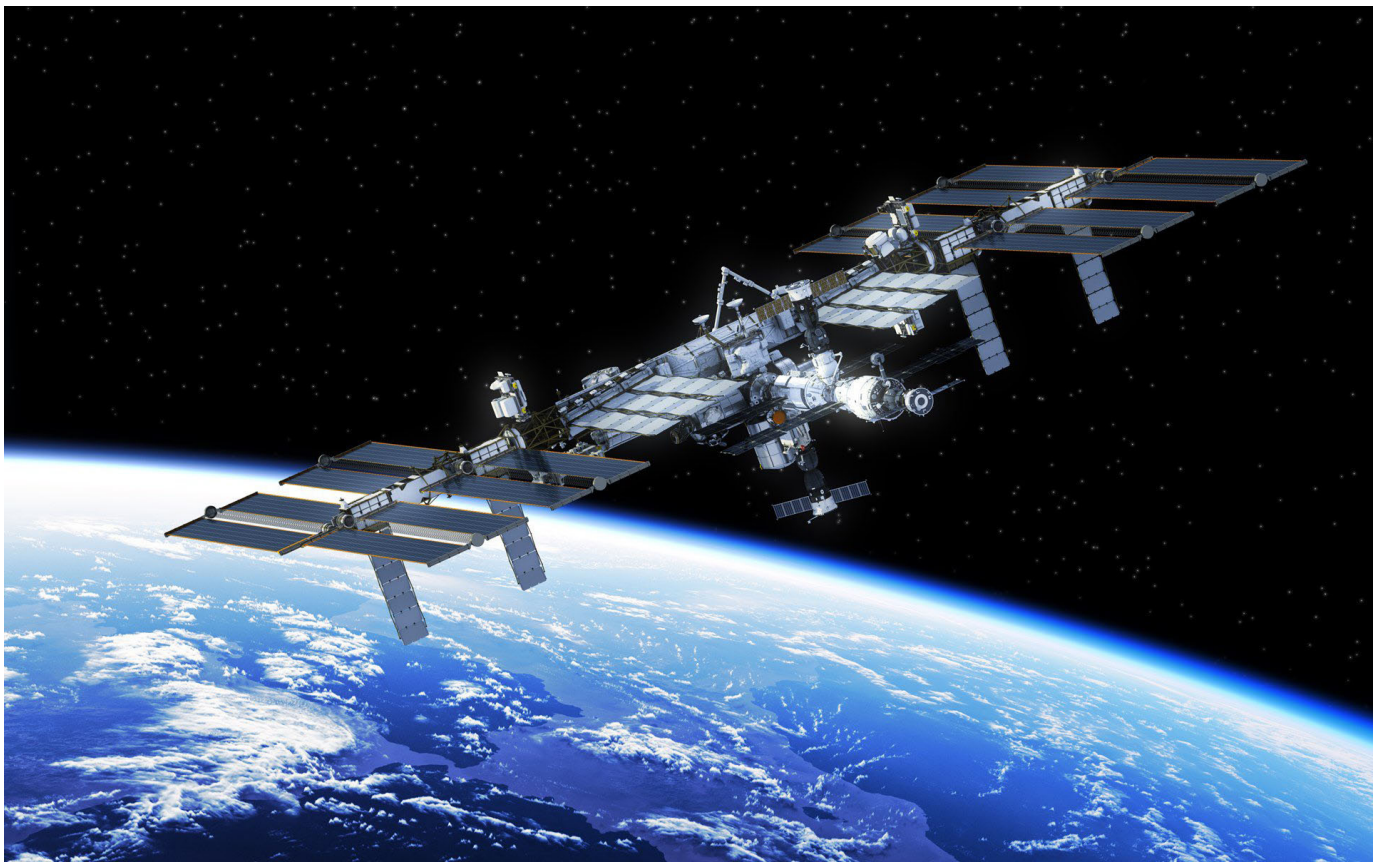
The International Space Station



The International Space Station. Photo © NASA

Activity 3: Moving and Working in Space

Or follow astronauts on the International Space Station in a series of videos as they explain their daily routines: https://www.nasa.gov/audience/foreducators/stem-on-station/dayinthelife

To get to live and work on the space station, astronauts train to improve their overall physical fitness. **Ask kids:** Why is that important? What kinds of work do astronauts do that require good strength and balance? How does living in space affect an astronaut's body? How would you get prepared to go to space?

Let's get started!

When exploring space, astronauts complete many physical tasks and must be able to twist, bend, lift, and carry massive objects to do their work. Even "walking" takes different physical effort in the reduced gravity environment of space, with astronauts pushing and pulling themselves from one place to another.

Flight Engineer Karen Nyberg exercising in the International Space Station. Photo © NASA

And being physically fit and continuing regular exercise (2 hours a day on the International Space Station!) is the most effective way to counteract the effects of weightlessness on the human body to maintain muscle strength and good bone health.

Lead kids through this **Astronaut Workout** and get them talking about how these exercises would benefit them when training to work and live in space.

Astronaut workout

Stretch

In the reduced gravity environment of space, NASA has found that the height of astronauts increases approximately 3% over the first 3 to 4 days in space. Everybody's body stretches in space! Stretch with your arms high above your head and hold for 30 seconds. Repeat 4 times.

Activity 3: Moving and Working in Space

Balance

How long can you balance on one leg? Try to balance on your right leg for 60 seconds. Now try to balance on your left leg for 60 seconds. Try each leg again, this time with eyes closed.

Extra challenge: Pass a ball back and forth with a friend while balancing on one leg.

Float

Get used to the position of floating in space. Lie on your stomach and stretch your arms out like an airplane. Hold for 30 seconds. Relax, then repeat 4 times.

Extra challenge: Raise your chest up and move your arms like you are swimming using the breaststroke.

Bear Crawl

Get down on your hands and feet (facing the floor) and walk on all fours like a bear, without your knees touching the ground. Try to go 20 feet [to where I am standing]. Rest for a minute. Bear crawl back to where you started. Repeat.

Crab Walk

Sit on the ground and put your arms and hands behind you, with you knees bent and feet on the floor. Lift yourself off the ground (facing upwards). Try to go 20 feet [to where I am standing]. Rest for a minute. Crab walk back to where you started. Repeat.

Jump

Jump as high off the floor as you can, and land lightly. Keep jumping for 30 seconds.

Extra challenge: Start your jump in a squat position and return to squat when you land. Jump for 30 seconds.

Breathe

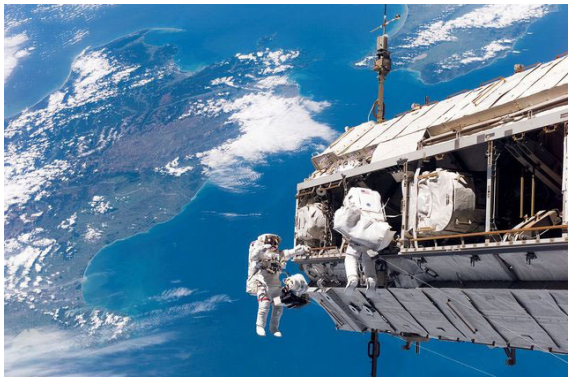
Life in space can be stressful. Breathing exercises can relax you. Take a deep breath in as you raise your arms over your head. Let the breath out as you drop your arms down. Repeat for one minute or more.

Activity 3: Moving and Working in Space

Work in space

Now that everyone is warmed up, have kids put balance and agility to use as they see what it might be like to have to repair something on the outside of a spacecraft.

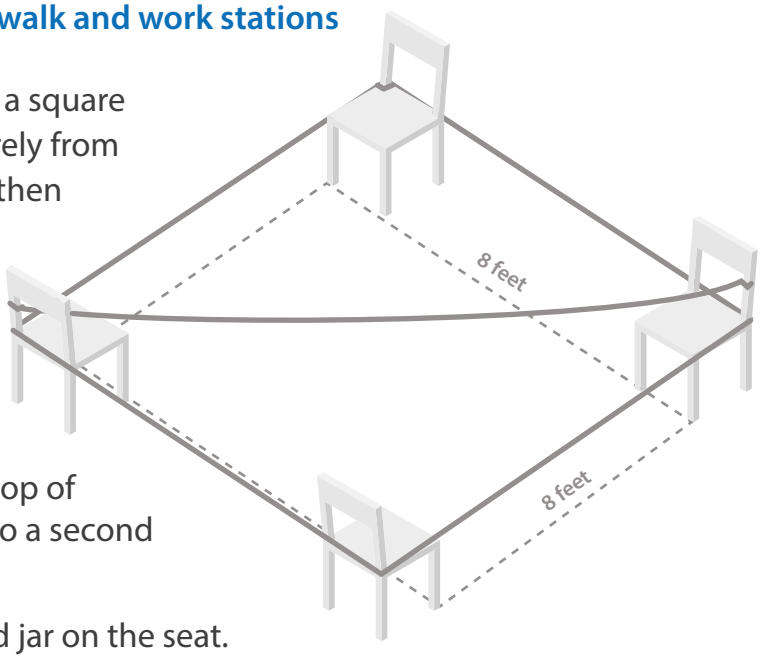
Ask kids: Have you ever had to wear something that made it hard to move around? Like lots of layers of clothes or a costume? Something that was too big or too small?



Spacewalk outside the International Space Station. Photo © NASA

Talk about the challenges for an astronaut having to work in a space suit to complete tasks while out in space. You may want to have kids explore NASA's Interactive Spacesuit Experience: www.nasa.gov/audience/foreducators/spacesuits/home/clickable_suit.html

While they explore, you can set up the spacewalk and work stations



- To create the spacewalk area, set 4 chairs in a square about 8 feet apart. Tie lengths of rope securely from one chair to the next to form a square, and then cross the rope diagonally across the middle of the square and secure to the chairs to create slide wires for astronaut tethers. There should be some slack.
- To prepare a tether, cut 2 feet of rope and tie one end to a carabiner or to the metal loop of a binder clip. Tie the other end of the rope to a second carabiner or binder clip.
- On one chair, set an opened jar and a closed jar on the seat.
- At the opposite chair, set the box of LEGO bricks.
- On a remaining empty chair, place sets of gloves.

Activity 3: Moving and Working in Space

Get your astronauts ready to go! **Ask kids:** Why do astronauts go on spacewalks? How do they stay safe during spacewalks?

Talk about how spacewalks let astronauts work, do science, test new equipment or repair satellites or spacecraft that are in space. Explain that the spacewalk today includes:

- Opening one "vent" (opening a closed jar) and closing another "vent" (closing an open jar)
- Increasing the length of a robotic arm (connecting 5 LEGO® bricks)

As part of their spacewalk, kids must remain attached to their tether and slide wire. In order to get to both work stations, they must slide their carabiners/clips to an adjacent rope and then attach themselves to that rope.

And to protect against the hostile environment of space, kids need to wear gloves. Astronaut gloves have multiple layers, so kids should put on 2 pairs of gloves.

Two astronauts can spacewalk at a time, but for safety reasons, should not pass each other. Have kids look for a different route.

Astronauts can spacewalk for many, many hours. But this spacewalk is a race against the clock. See how quickly all your astronauts can complete the tasks.

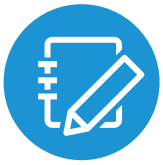
After the spacewalk, **ask kids:** What was the spacewalk experience like? What things were challenging about it? How did the tethers work? Are there other ways to keep astronauts in place?

[Adapted from the Canadian Space Agency's activity "Moving and Working in Space"]
http://www.asc-csa.gc.ca/eng/educators/resources/working.asp

More astronaut training activities

Train Like an Astronaut: Adapted Physical Activity Strategies
https://www.nasa.gov/sites/default/files/ape_all_as_one_tla.pdf

Train like an astronaut
https://www.stem.org.uk/missionx/resources



Writing About Space Exploration

Writing helps kids process and solidify new knowledge and gives them an opportunity to use new vocabulary and concepts. Offer one or more of these prompts or questions to get your Space Rangers writing.

Writing prompts

- Imagine you are a journalist getting ready to interview an astronaut. Write your questions. Then, imagine you are an astronaut. Research and write answers to your questions!
- Write an essay about how a telescope can be like a time machine.
- Choose an astronaut you admire or want to learn more about. Write and illustrate a picture book biography which shares the childhood experiences, struggles, and accomplishments of your astronaut.
- Write a story about how our lives on Earth would be different if the rocket had never been invented.
- Think about how gravity affects your everyday life. Write a story about how life on Earth would be different if there was much less gravity.
- Write a letter to a friend explaining why you think they should or should not become an astronaut.

Story Time from Space

Story Time from Space features videos of astronauts reading books aloud from the International Space Station. Watch a story at: https://storytimefromspace.com/. Write a review of the book and of the reader's performance.

Writing About Space Exploration

Be a cosmic poet

Write poetry about the tools and technologies we've used to make discoveries about the universe: https://www.jpl.nasa.gov/edu/teach/activity/planetary-poetry/

Mission to ...

Invent a space-themed board game that puts players through the challenges of astronaut training, mission planning, and traveling to the space station (or the Moon or Mars). First astronaut back on Earth wins! Don't forget to write down the directions for how to play!

Kid-friendly Websites and Apps

Websites

Telescopes from the Ground Up (Amazing Space)
http://history.amazingspace.org/resources/explorations/groundup/

Galileo history lesson, or why you shouldn't smart off to those in charge
https://adventuresinmommydom.org/galileo-unit-study/

Video: Gravity Compilation (Crash Course Kids)
https://youtu.be/EwY6p-r_hyU

Gravity in Orbit (Smithsonian National Air and Space Museum)
http://howthingsfly.si.edu/flight-dynamics/gravity-orbit

Rocket Lab (Smithsonian National Air and Space Museum)
http://howthingsfly.si.edu/activities/rocket-lab

Video: How Do You Get a Rocket to Land Back on Earth? (NOVA)
https://www.pbs.org/wgbh/nova/video/how-do-you-get-a-rocket-to-land-back-on-earth/

Space Exploration Timeline (Sea and Sky)
http://www.seasky.org/space-exploration/space-timeline-menu.html

Living and Working in Space (PBS Learning Media)
https://www.pbslearningmedia.org/collection/living-and-working-in-space/

NASA Kids' Club
https://www.nasa.gov/kidsclub/index.html

Kid-friendly Websites and Apps

Educational apps

Gravity Launch (Apple and Android)
http://sciencenetlinks.com/gravity-launch/

NASA (Apple)
https://www.commonsensemedia.org/app-reviews/nasa

Globe Oberver (Apple and Android)
An international citizen science initiative to understand our global environment. Start submitting cloud observations today!
https://observer.globe.gov/about/get-the-app

This is my Spacecraft – Rocket Science for Kids (Apple) $
https://www.commonsensemedia.org/app-reviews/this-is-my-spacecraft-rocket-science-for-kids

Simple Rockets (Apple and Android) $
https://www.commonsensemedia.org/app-reviews/simplerockets

SMART Adventures Mission Math 1: Sabotage at the Space Station (Apple and Android) $
https://www.commonsensemedia.org/app-reviews/smart-adventures-mission-math-1-sabotage-at-the-space-station

NASA: Space Science Investigations: Plant Growth (Apple and Android)
https://www.commonsensemedia.org/app-reviews/space-science-investigations-plant-growth