Science Museum of Minnesota

SciEd.

SciEd is science education support and programs for teachers. Working with teachers, we strive to advance science literacy through dynamic resources: field trips to the museum, in-school visits, curriculum support, Science House lending library, and professional development.

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SPACE

FEBRUARY 20 – SEPTEMBER 7, 2015

Teacher and Chaperone Guide

Classroom and Museum Activities

Connections to Minnesota Education Standards

smm.org/fieldtrips

In This Guide

What does the future hold for humans and space travel? *Space* is a one-of-a-kind exhibition that seeks to answer that question and more by exploring the challenges of living and working in space. Unlike traditional space exhibits that focus on the history of space travel, *Space* looks into current and future exploration.

Take a journey to space through interactive exhibits, whole body experiences, and authentic artifacts that will engage you and your students with the unparalleled adventure of human space exploration.

Your students will have the opportunity to:

1. Immerse themselves in the sights, sounds, and smells that astronauts experience while traveling and living in space;

2. Engage as problem solvers with some of the unique engineering challenges that must be solved to support living and working in space;

3. Experience what life is like in space through the voices of engineers, scientists and astronauts.

Space was produced in partnership with the International Space Station Office of NASA's Johnson Space Center, the California Science Center and the partner museums of the Science Museum Exhibit Collaborative.

Special thanks to Minnesota teachers who served as Guide advisors: Jill Jensen, Kim Atkins, Dee McLellan, Lynn Spears, Kate Watson, Brandi Hansmeyer.

Field Trip Information

Plan your trip today with one of our field trip specialists for best availability. Visit www.smm.org/fieldtrips or call (651) 221-9444.

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Don't miss these complementary Science Museum programs!

OMNITHEATER

Journey to Space

Experience where we have been and where we will go. Learn how the space shuttle program of the past has shaped our approach to the future's space hurdles, including the exploration of Mars with the new Orion space craft.

SCIENCE LIVE!

Destination Outer Space

Put on your moon boots and experience an action-packed demonstration exploring the obstacles and challenges of a journey to space. And yes, there will be rockets launched!

To reserve a spot or for further information, visit www.smm.org/fieldtrips **or call (651) 221-9444.**

Before you visit the *Space* exhibition:

- Consider your goals for this field trip. What are important outcomes? Inspiration, motivation, opportunities for hands-on experiences with this topic, connections with science or engineering curriculum? Will your students be expected to take notes, do sketches, answer questions, or explore their own interests?
- When you make your reservations, ask about a free teacher pass to preview the exhibition.
- Do some preparation activities before your visit. Use suggestions in this guide and the resource list for more ideas.
- Review this guide for connections to your curriculum. Choose activities that best meet your needs.
- Review At the Museum pages (pp. 22–30). Use these as inspiration for your museum visit, print them for students to use, or add your own page(s). Use journals or notebooks if you use these in classroom work. Bring clipboards or sturdy cardboard to write on if you plan to use single pages during your field trip.
- Share expectations, plans and schedules for the visit with students and chaperones. Give chaperones copies of any activities students will do.
- Encourage students to spend time in *Space* beyond simply answering questions. There are many opportunities for hands-on experiences in *Space*. Plan time for students to share what they did and learned.

During your visit to the *Space* exhibition:

- Encourage students to make their own observations and ask their own questions in the exhibition.
- Photography is permitted and encouraged. Consider using photography as a way for students to document their experiences or to support their ideas for further use in classroom follow-up.
- Students must be with their chaperones to enter the exhibition, and should stay with the chaperone throughout.
- Divide your class into small groups to work together in the exhibition.
- Consider using the At the Museum pages as guiding questions for students to gather information and sketches instead of as worksheet handouts.

Exhibition Overview

Humans are engaged in an exciting journey of exploration and discovery in space. The environment of space presents many challenges, but engineers are working to make traveling to and through space safer, faster, and cheaper. It is no longer a question of IF humans will reach Mars, but WHEN. *Space* explores the challenges and solutions that will shape our future in space.

Introduction theater

A four-minute video introduces you and your students to the idea that our journey to space is an ongoing one. Beginning with the excitement of a rocket launching into space, the video weaves together news clips to provide a brief look back at the last 60 years of space exploration before turning our attention towards the future. Our accomplishments to date are impressive, but there is much, much more yet to be done. Where do you want to go?

Space can kill you

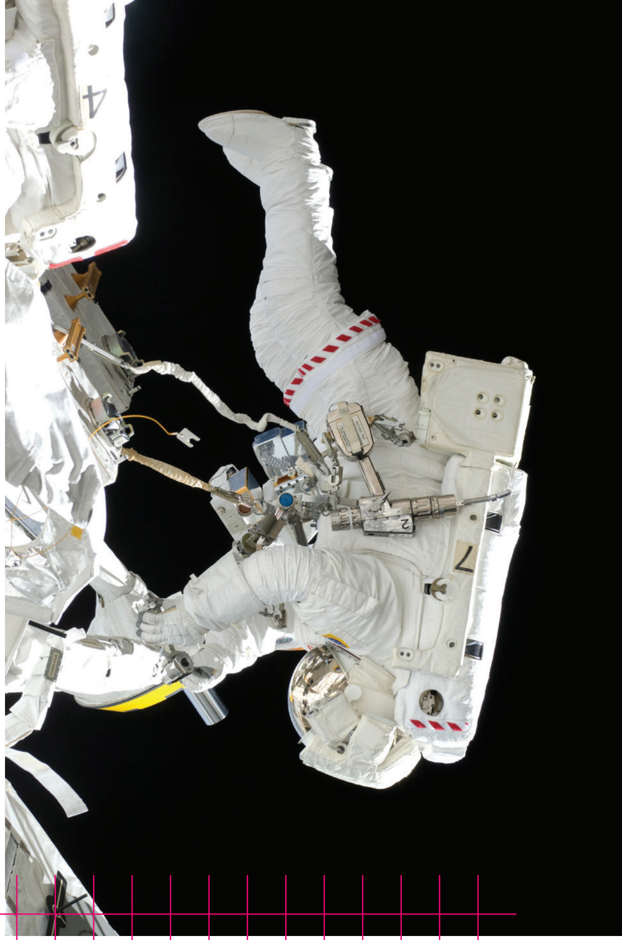
Space is not a friendly place. The environment just beyond our atmosphere can hurt you in any number of ways. If the extreme temperatures don't get you, the radiation will. Your spacecraft can protect you from the vacuum, but watch out for the meteoroids! Explore the dangers of space and protections that engineers have devised for astronauts.

- Experiment with a vacuum chamber to see how common objects behave in zero pressure. Does a fan create a breeze in a vacuum? Can you hear a bell ring?
- See the hole blown through a thick metal plate by a simulated meteoroid and watch slow motion video of the impact.
- See a spacesuit arm cut open to reveal 10 layers of protective materials and an x-ray image of a real space suit that protected astronauts on the moon.

Traveling to and in space

Getting to space isn't easy and the huge distances between destinations make travel a challenge. Explore technologies that will take us where we want to go.

- Launch a water rocket. Experiment to find out how much water it takes to reach maximum height.
- Turn on an ion engine and marvel as it moves forward propelled by ionized air molecules. A video of a NASA engineer provides an accessible explanation of the technology.
- Gaze at the beauty of Earth as astronauts see it with images of Earth taken from orbiting spacecraft.



You're weightless in space

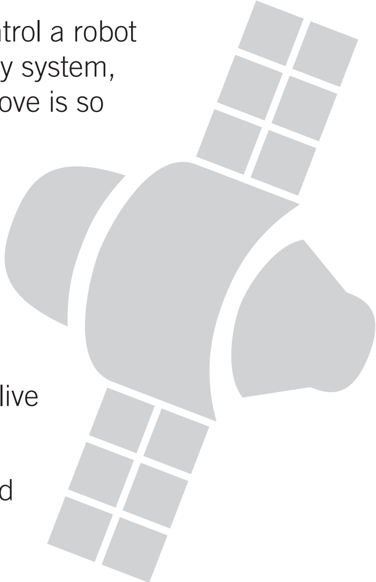
Astronauts look like they're floating, but they're actually falling. Freely falling objects are weightless. Gravity pulls at objects everywhere in space, but when something—like a spacecraft—moves fast enough, it falls around a planet or star, never hitting the ground. Explore why astronauts are weightless in space.

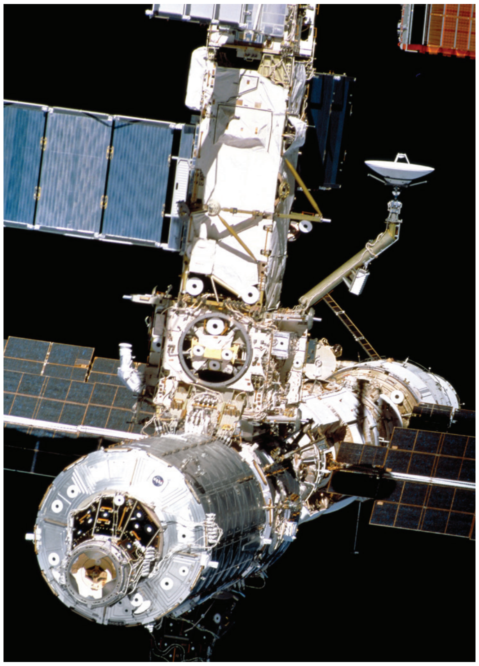
- Use a 16-foot drop tower equipped with slow motion instant replay video to explore effects of weightlessness on common objects.
- Explore orbital mechanics as you launch a puck into orbit around a planet on a circular air hockey table.
- Watch astronauts in a large video projection somersault, float, and fly as they work and play in space.
- Don't really understand why astronauts float? Select questions and view short animations that help explain the amazing physics of orbital flight.

Living and working in space

Planet Earth makes life easy. Air and water? Taken care of. Using the bathroom? Gravity practically does the work for you. But in space nothing is "normal." From work and exercise to eating and breathing, everything requires new solutions. Learn some ways that living and working in space is different from (and similar to) life on Earth.

- Do the work of astronauts as you control a robot arm, manage a space station's energy system, and discover why wearing a space glove is so challenging.
- Experiment with centripetal force, a method of creating artificial gravity, which might one day change the way we live in space.
- Play with a space station "dollhouse" and imagine what it would be like to live in space.
- Sit on a mock-up of a space toilet and examine real space food.





Destiny rotating lab

Get a taste of the disorientation experienced by first-time astronauts when you enter a full-sized mock-up of the International Space Station's U.S. Destiny lab module. As you stand on a platform, the module will slowly rotate around you, giving you the sensation of 'floating' in space. As features of Destiny come into view, lighting effects and narration highlight the vital equipment of the module, from life support systems to the Canadarm2 robotic controls, telling the story of a research station orbiting 250 miles above the Earth.

Destiny is the primary research laboratory for U.S. payloads, supporting a wide range of experiments and studies contributing to health, safety and quality of life for people all over the world. Science conducted on the Station offers researchers an unparalleled opportunity to test physical processes in the absence of gravity. The results of these experiments will allow scientists to better understand our world and ourselves and prepare us for future missions, perhaps to the moon and Mars.

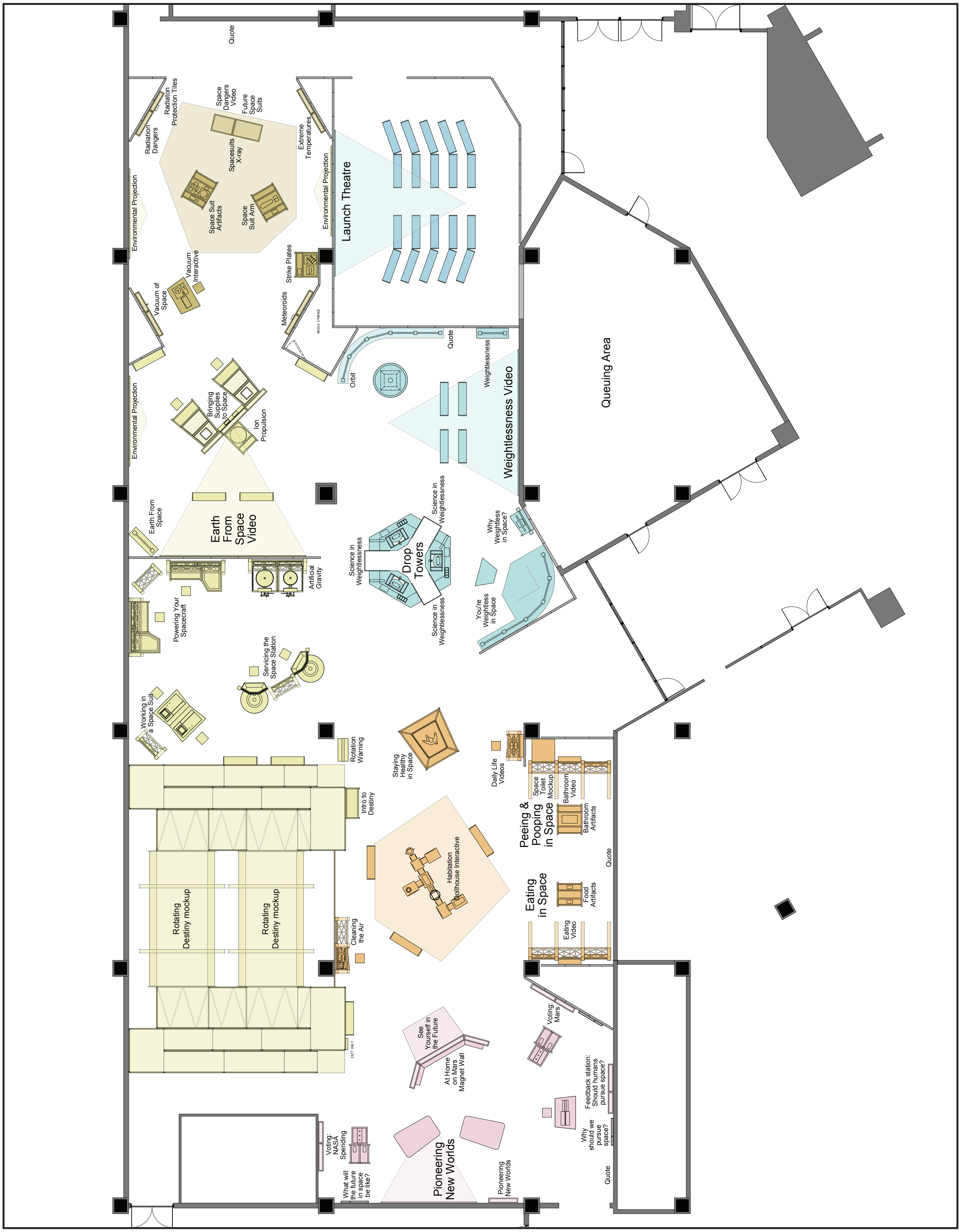
Future

We're on a journey to space. It didn't stop at the moon, and it won't stop at the Space Station. We're looking farther out, overcoming challenges, and asking, "Where to next?" Explore many different visions of what our future in space might be like.

- Share your opinions with questions like, "Would you want to be on the first spaceship to land on Mars?" "How much should the U.S. spend on space exploration?" "Should humans pursue a future in space?" Videos of new space entrepreneurs and NASA insiders answering the same questions inform the conversation.
- Imagine life on Mars to construct a colony.
- Glimpse into the imaginations of artists and engineers and their view of the future of humans in space.

A floor plan of the exhibition is shown on page 7.

Exhibition Floor Plan



Misconceptions About Space

Have you heard (or thought) any of these statements about space travel?

- Gravity does not exist in space.
- Space is empty, a *complete* vacuum.
- The USA is no longer doing space exploration. NASA has been closed.
- Space exploration costs a lot and has little value for everyday life on Earth.
- Humans can hear explosions and other sounds in space, just like in the science fiction movies.
- Astronauts have no weight in space.

These are all common misconceptions that your students may hold too. Take a closer look at each statement by reviewing the comments below that explain each concept and why the misconceptions just don't fit the facts.

Misconception: Gravity does not exist in space.

The Facts:

- Gravity is everywhere; it governs motion throughout the universe. It holds us to the ground.
- Gravity keeps the moon in orbit around Earth and Earth in orbit around the sun.
- Gravity is a natural phenomenon by which all physical bodies attract each other.
- Satellites, spacecraft, astronauts do not experience zero gravity. Orbiting spacecraft, like the space station, are kept in orbit around Earth by gravity.

Misconception: Space is empty, a *complete* vacuum.

The Facts:

- There is a danger to humans in space because of the lack of air and atmospheric pressure. Space is *almost* a vacuum, but it is not completely empty.
- Space is filled with gas, dust, magnetic fields, and charged particles. And here is more from NASA:

  Space is filled everywhere by plasma, the fourth state of matter (solid, liquid, gas, and plasma). Plasma is a gas in which electrons have been separated from their atoms (ions), making it electrically charged. Plasma is extremely rare on Earth; you can only find it in candle flames, lightning, and fluorescent lights. But in fact, 99% of the universe is made up of plasma.

- Because the distances between objects visible to the human eye, even with telescopes, are so vast, it may "look" empty. Other technologies have been developed to probe, measure and understand more about the interstellar medium, the space between stars and planets.

Misconception: The USA is no longer doing space exploration.

Or the other variation: NASA has been closed.

The Facts:

- NASA came into existence on July 1, 1958, following extensive hearings by a joint congressional committee. It is still in existence, with no prospect of NASA closing. You can read descriptions of its current and planned activities on the NASA website: www.nasa.gov
- Confusion about closing may stem from the retirement of the space shuttle program. NASA is using other methods of transporting astronauts to the International Space Station, and is supporting development of alternative technologies by a combination of government projects and private firms. NASA has been working with private industry from the beginning. Some of the firms that are currently developing technologies to use in space exploration are SpaceX, Blue Origin, Orbital Sciences, and Boeing, among others. (For information about current developments in partnerships with private companies, visit nasa.gov/exploration/commercial/)
- Learn more about future expeditions to the International Space Station here: nasa.gov/mission_pages/station/expeditions/ These are multi-national teams from Japan, Russia, Italy, and, of course, the United States.
- NASA's satellites, scientists and engineers also track Earth systems, for example, tornado systems, rainfall, ozone layers, iceberg movements, and temperature data.
- Here are other leading space agencies:
  – ROSCOSMOS (Russian Federal Space Agency) federalspace.ru/
  – CSNA (China National Space Administration) cnsa.gov.cn/n615709/
  – JAXA (Japan Aerospace Exploration Agency) iss.jaxa.jp/kids/en/
  – ISRO (Indian Space Research Organization) isro.org
  – ESA (European Space Agency) esa.int/esaKIDSen
  – Canadian Space Agency asc-csa.gc.ca/eng/

Misconception: Space exploration has little value for everyday life on Earth.

The Facts:

- Although many millions of dollars have been spent on space exploration, there are many other human endeavors that have cost as much or more.
- Funding for NASA has never been a large percentage of the US budget. The budget for NASA has been in the range of 0.5–1% of the entire Federal budget throughout NASA's history, with a bump up to almost 5% during the middle 1960s.
- Work in space exploration has supported development of satellite communications that allow not only radio and television, but also telemedicine, GPS navigation, weather forecasts, and defense. There have been thousands of space-related inventions that became products or services, including kidney dialysis machines, CAT scanners, telescope technology that aids in eye surgery, and freeze-dried food. NASA administration estimates that each dollar of NASA spending creates $10 of benefit in the economy.

Misconception: Humans can hear explosions and other sounds in space, just like in the science fiction movies.

The Facts:

- Sound travels by making molecules vibrate. On Earth, sound travels to your ears by vibrating air molecules. In deep space, between stars and planets, there are few molecules to vibrate. Because interstellar gas clouds are much less dense than the Earth's atmosphere, only a few atoms per second would strike our eardrums. We wouldn't be able to hear the sound because our ears aren't sensitive enough.

Astronauts have no weight in space.

The Facts:

Actually, this one is mostly true, but may challenge student ideas about weight and mass and the difference between the two.

- As in other examples of everyday language and scientific language, we often interchange the ideas as well as the terms *weight* and *mass*, in common conversation. *Weight* is not the same as *mass*.
- An object's mass is always the same, but an object's weight depends upon where it is and the forces acting on it.

  A brick with a mass of one kilogram will have a weight of 9.81 newtons (2.2 pounds) on Earth, a weight of 1.62 newtons on the Moon (0.36 pounds), and a weight of zero newtons (0 pounds) on the International Space Station. But in all cases its mass will be the same: one kilogram.
- Weight is a measure of force. Gravity is one of those forces. On Earth, we experience the feeling of weight because of gravity's force.
- On the International Space Station, astronauts experience weightlessness because they are in free fall, much like on the down cycle of an amusement park ride, not because there is no gravity. While you are falling back to Earth, you would be weightless. Gravity is pulling you, but there is nothing for it to press you *against*. So you weigh nothing, and you *feel* like you are floating.
- What prevents the ISS and all of its contents, including astronauts, from crashing into the Earth? They are actually moving to the side *very, very fast* as they fall. Gravity is still pulling them down, but they move so fast that they never hit the ground. This works because of the shape of the Earth. When a spacecraft flies fast to one side as it falls, it travels around the curve of the planet.

  Isaac Newton proposed a "thought experiment" using a cannon to launch a cannonball into orbit with a certain amount of force. Try it here: spaceplace.nasa.gov/how-orbits-work/en/
- Astronauts do not experience "zero gravity" (no gravity), but rather weightlessness. The term "0 g" (zero G) actually describes the *forces* in this situation.

Misconceptions can be frustratingly difficult for students (and adults!) to give up. Many are reinforced by popular media or misleading information sources. Take some time to discuss these in your classroom, and identify classroom and field trip experiences that will provide your students with opportunities to confront their own misconceptions. Many of the Connecting with the Classroom and At the Museum activities will allow students to dig into these ideas.

For more resources to examine misconceptions about space, see page 31 (Resources Section).

Connecting with the Classroom

Field trips are most effective when integrated with your curriculum. Below are activities that can be used to introduce topics included in the *Space* exhibition. Many can be used after your trip or as ongoing topic explorations.

For the following suggestions, use strategies that best complement your class. Include drawing, think-pair-share, open discussion, small groups, as well as project-based learning. If you are already incorporating engineering projects in your classroom, use your engineering process to include problems to solve about space travel.

While we provide suggestions, background information, and materials lists for many of these activities, we have left the suggested length of time for each activity open-ended. Every teaching situation is unique; modify these activities to suit your students' needs as well as yours, i.e. reading levels, English language learners, differentiated instruction, and amount of class time available for group work. Some of these activities could be completed in one 45-minute class period, while others could be extended to one or two weeks, depending on students' interest.

Engage your students in inquiry and design challenges that inspire them to learn about living and working in space!

Pre-Visit: All Grades

As an introduction to the idea of traveling to space, ask students to think about moving to another place on Earth.

For older students, ask students to compare moving to another Earth location with traveling to space. What would be the same, what would be different? How?

Discuss: If you were to move to another part of the world that is very different from your home, what kinds of preparation would you need?

Brainstorm and list some ideas (Think-pair-share)

Possible ideas could include:

- Research weather for new location – what clothing would you need, special equipment (e.g. umbrellas, snow boots, warm clothes)
- Site-specific accommodations, e.g. earthquake prone, poisonous or other dangerous creatures (insects, spiders, reptiles), rocky, sandy
- What kinds of homes or living spaces are available? Or what resources are available to build?

Review what you already have in your current home, that you will need in your new place.

Investigate sources for materials you need.

- Should you take them along?
- Construct them in new location?
- Find sources for what you need in new location?
- Where can you get them?
- Are they expensive?

Transportation: how can you get there? What is the route? Use maps or online resources.

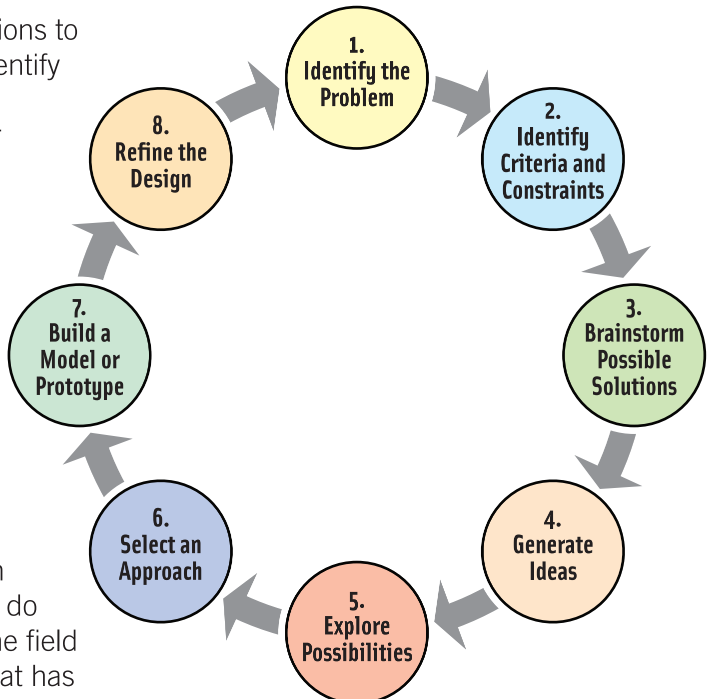
Will you need special transportation modes? (e.g. ship, plane, dogsled) How does the transportation mode affect what you can bring? (size, weight, materials)

Ask: If you were going to space, what would you take along? Why would it be important to you?

Students can respond by whole class discussion, in small groups, or by drawing/writing, as most appropriate.

Be an engineer!

Engineering is the systematic practice of designing solutions to human problems. Engineers use a design process to identify problems to solve, consider possible solutions, test one, analyze what happened and make recommendations for further work. One design process that NASA uses to introduce students to the process is pictured here.



There are other design process models, but all have similar steps. A simple one, appropriate for elementary students, is Ask, Imagine, Plan, Create, and Improve, developed by Engineering is Elementary®. Note: both of these are used in the classroom activity descriptions. You may use others in your classroom.

What are the challenges in space travel? Ask students to imagine, or do some research, to identify a problem in space travel. How would they solve this problem? What do they need to know before they design a solution? Use the field trip to learn about various challenges in space travel, what has already been designed to solve a problem, and what challenges still need new solutions. These are first steps in the design cycle. Complete the cycle after your visit in your school, by creating, testing, and improving prototypes, and proposing solutions to these problems.

Grades K–2

Essential focus question: What is it like to travel to space?

- Ask students: When you look at the sky, what can you see?

  As students respond, make a list. If appropriate, have students make their own lists in their journals, or on a separate piece of paper. Ask them to circle the objects that are part of nature and draw a line under the ones that humans made.

- Ask students to complete this statement: An Astronaut is…

- Ask students to share ideas, or draw a picture, of what or who they think astronauts are. Read a book about astronauts to the class, such as *Mousetronaut* by Mark Kelly or *Astronaut Handbook* by Meghan McCarthy. Share photos of astronauts.

- Ask students: What is space like? What do you think is the same as here on Earth, what might be different?

- Share your plans about your field trip to *Space* and what students should look for and what they will do.

Grades 3–5

Essential focus question: What do astronauts do?

- Ask students to share ideas, or draw a picture, of what they think astronauts do in space. Read a book about astronauts to the class, such as *What Do Astronauts Do?* By Carmen Bredeson. This book is set up as series of questions and answers, so students could brainstorm their own answers to the questions, before you reveal them from the book.

- Good communication is very important for a space mission to be successful. Astronauts, engineers, and scientists must communicate ideas clearly, accurately, and promptly in order to solve problems and complete their daily tasks during a mission. Simulate mission communication by having students partner up and complete a mission together.
  - One student will be the "engineer" at mission control and the other will be the "astronaut" on the space mission.
  - Have students sit back to back.
  - Provide two matching bags of materials (linking cubes or other common construction material) for each pair of students.
  - Have the engineer build a structure using the materials provided.
  - Tell the students:
    - *Astronauts:* You are out in space on a mission and you need to communicate to the engineer at the Mission Control Center. Listen carefully to the engineer as s/he tells you how to build a structure that will complete the repair for the satellite.
    - *Engineers:* communicate with your astronaut and explain how to use the materials to re-create the structure you have built.
    - One mistake in communication could stop your mission from being successful!
  - Have students discuss the outcome of this communication activity. They can brainstorm why communication between astronauts and mission control is so important. How could the communication be improved?

How do space vehicles get their names?

Review past USA missions and spacecraft names. What do students notice about the names? Ask students to research ones they may not know. (www.nasa.gov/missions/)

Below are a few of the names. What kind of name would students use for their own spacecraft or mission?

MERCURY 3 / FREEDOM 7	APOLLO	MAGELLAN
MERCURY 4 / LIBERTY BELL 7	GEMINI	PHOENIX
MERCURY 6 / FRIENDSHIP 7	SATURN	PIONEER
MERCURY 7 / AURORA 7	GALILEO	ODYSSEY
MERCURY 8 / SIGMA 7	CLEMENTINE	CHALLENGER
MERCURY 9 / FAITH 7	JUNO	

Grades 6–8

Essential focus question: What is it like to live and work in space?

- Ask students what they think it is like to live in space. What might be different than on Earth? Do movies show what it is actually like in space? Students can write their ideas in a journal, or short essay, and review after the field trip.

Space Travel Challenges

Ask:

- What dangers could traveling to space include?
- What do you think a microgravity environment might be like?
- What do you think might be the biggest challenges to humans in traveling in space?
- Record ideas and discuss what kinds of dangers these challenges might provide.

  Answers may include:
  - Vacuum / low pressure
  - Temperature
  - Meteoroids
  - Radiation

  Explain to students that they will be able to see more about all of these in the "What is Space Like" section of the *Space* exhibition.

For additional foundational knowledge, have students try "Surviving in Space" activities in your classroom; see page 37.

CHALLENGE: VACUUM (LOW PRESSURE)

Students may have personally experienced high and low temperatures, but the effects of lack of atmospheric pressure might be difficult to understand.

Demonstrate the importance of a pressurized spacesuit by observing what happens to a balloon when atmospheric pressure is removed from a bottle.

1. Obtain an empty clear wine bottle and a wine pump, available from most liquor or kitchen supply stores.
2. Put a tiny amount of air into a small balloon, tie off, and insert the balloon into the bottle.
3. Explain to the students what atmospheric pressure is, and that there are equal amounts of atmospheric pressure inside the bottle, as there is in the room.
4. Explain that the pump removes the air (which provides atmospheric pressure) from the bottle, and begin pumping. Tell the students to keep their eyes on the balloon.
5. Ask students what they notice about the balloon. Why does this happen?
6. Discuss the importance of a pressurized suit for a human body in space.

(Adapted from an activity from the Canadian Space Agency)

Grades 9–12

Essential focus question: What will future space travel look like?

Space travel: past, present and future

Divide students into groups of 3-5. Provide the following writing and discussion prompts:

- Write down past milestones in space travel. Consider both successes and setbacks.
- What features of space have been explored?
- What would future space travel look like?
- What would you like to see explored or researched?

Provide time for students to share their ideas within their groups, and brainstorm further ideas as a group.

For class discussion, ask each group to share 2-3 interesting comments from their group, and add at least one idea for future space travel.

List future space travel ideas, which can be used as a base for discussion, journal prompts, or continued small group work to consider for each proposed idea:

- Potential positive and negative consequences
- Are there any current prototypes or models for this idea? (include science fiction!)
- What are some constraints in designing for this type of idea? (e.g., development and building time, money needed or available, current scientific knowledge, available technology, etc.)

Allow students time to research goals for future space travel:

- What are current projects at NASA? What is in development?
- How are private aerospace companies working on space exploration?
- Are any of these similar to class ideas?

When students visit *Space*, they can add additional details and information by exploring the Pioneering the Future section of the exhibition (see floor plan on page 7). Students will see and hear interviews about the future of space travel, cast votes based on desirability of travel to Mars, and consider Mars habitats.

Students can think about and choose one or more of the following questions to answer:

- What are the benefits of continuing to explore space?
- Do the benefits of future space travel outweigh the costs?
- What are safety concerns of space travel in the future?
- What would it take to arrive safely and sustain life on Mars?
- Would you be interested in traveling to Mars?

Connecting with the Classroom: Post-Visit

All Grades

Review student pages to discuss field trip experiences.

Share observations, questions, new ideas.

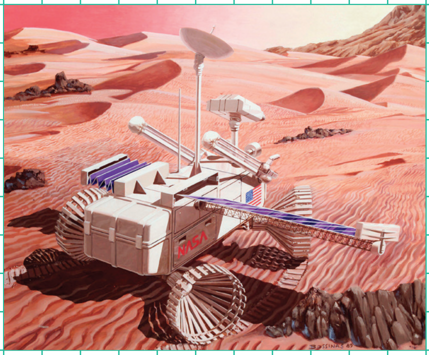
Careers in space exploration

What do astronauts do? What other jobs and careers are part of space exploration projects?

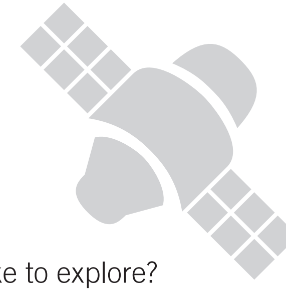
Ask students to think about these questions, and do appropriate research to find out more. For example, at Jet Propulsion Laboratory, some careers are:

- *Planetary geologists* study the terrain of other planets
- *Volcanologists* study volcanoes
- *Software engineers* program computers for spacecraft
- *Mechanical engineers* design systems including the spacecraft and instruments
- *Business people* design strategies to plan for and support projects

Find others using the resources on page 31. See also: www.jpl.nasa.gov/education/?page=131



Grades K–2



Focus question: What is it like to travel to space?

Review student answers to “An Astronaut is…” (pre-visit suggestion, page 13).

Add or revise any statements, based on student experiences at the exhibition.

Would they like to travel in space? Where would they like to go? What would they like to explore?

Students can draw a detailed picture of themselves as an astronaut.

Be an engineer!

Introduce young students to the engineering design process with a simple activity using only 2 materials, index cards and tape.

Discuss what a *model* is, and examples of models from their experience (for example, toy cars, dollhouses, globes, etc.). Engineers may design and build models to test their ideas.

Tell students that they will work in pairs to design and build a model “launch tower” that will hold a space vehicle above the ground before launching into space. Show them the vehicle (this could be any small toy that might be considered a space vehicle), and their materials.

The Engineering Design Process: Designing a Launch Tower

GOAL: Design a tower that will hold a space vehicle.

ASK: How can materials (index cards) be changed to fit together and hold something?

IMAGINE: Students will try out various shapes based on provided materials.

PLAN: Students will choose one design they will build.

CREATE: What are the criteria for this design? What shapes are best to hold a weight? Students will test their design with the “space vehicle,” observe and describe results.

Communicate the Solution: Students will share their design and result with the class.

IMPROVE: Students will consider what changes they would make based on their experience and hearing about others’ solutions.

Discuss other things they would like to include in their design based on what they saw in *Space*. How would they improve the model space vehicle you used? What changes would they make?

(This activity is adapted from *Engineering Adventures,* www.eie.org/engineering-adventures. The activity guide for “Prep Adventure 1: What is Engineering? Tower Power” guides you through the steps in this beginning engineering activity.)

Grades 3–5

Focus question: What do astronauts do?

Using their experiences at *Space*, and images of the ISS or other spacecraft (you can find many images at the NASA website: nasa.gov), ask students to design their own space vehicle, to include spaces and devices for working, sleeping, leisure and other activities they saw on their field trip.

Have them write a “day in my space trip” description, based on their notes from the visit, referencing the different parts of their vehicle and how they would use them.

Provide materials to have students make a 3-D scale model of their space vehicle design. Find detailed directions at spaceplace.nasa.gov/build-a-spacecraft/en/.

After their field trip to *Space*, students will have a deeper understanding of what astronauts do in space. How do astronauts return to Earth, and what safeguards do engineers need to consider for their return?

Be an engineer!

Provide opportunities to use their experiences and creativity by designing a landing system for a spacecraft.

The Engineering Design Process: Designing a Parachute Landing System

GOAL: Design and construct a parachute landing system for an Orion spacecraft (aka egg astronaut) to land safely on land or water.

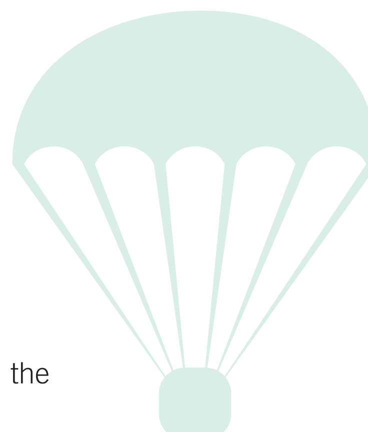
ASK: What designs have been successful?
What are the parts of a parachute?
What size and shape are best?
What materials are available?
How far must the spacecraft travel with the parachute system?

IMAGINE: Students will brainstorm and discuss various ideas using available materials.

PLAN: In small groups, students will choose one design, sketch and label the plan, test with simulated (e.g., plastic) eggs.

CREATE: Students will finalize and construct their design, and test an “egg astronaut” inside the capsule.

IMPROVE: Based on observations of all class designs and outcomes, each team will analyze their plan, and suggest changes for improved performance.



For full details of this activity, refer to “Splashdown!” in the Kennedy Space Center Educator Guide, Grades 3–5. www.kennedyspacecenter.com/~/media/Files/6-Education%20Files/2012KSC_Field_Trip_Guide_3-5.pdf

Grades 6-8

Focus question: What is it like to live and work in space?

Create an Explorers' Guide

Using their experiences during the field trip, and questions in the Student pages, students can highlight what they have learned about living and working in space by creating a guide for current (or future!) space travellers.

International Space Station and "Your Day in Space"

Provide time and materials for students to build a model of the ISS. A full lesson plan is available from NASA. classroomclips.org/sites/classroomclips.org/files/ancilliary_materials/International%20Space%20Station%20Study%20Guide_3.pdf

Ask the class to share space travel challenges they saw in Space

- Which one(s) were mentioned most?
- What are current solutions to these challenges?
- What challenge would students like to solve?

Provide time and materials for students to design and prototype a possible solution.

Designing solutions for space challenges

Below are a few experiments to guide design ideas.

Solar Hazards

Design an experiment to test protection against ultraviolet (UV) radiation, using UV detecting beads with varying types of fabric, sunglass lenses with different tinting, sunscreens of varying SPFs, etc. How would you use this information to design a spacesuit? Other applications? www.mrsec.psu.edu/education/nano-activities/vision/uv_beads/uv_beads.pdf

Design a menu for astronauts

Choose the best foods for space. Full explanation of activities can be found in NASA's Space Food and Nutrition Educator Guide: www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Space_Food_and_Nutrition_Educator_Guide.html

- Test the rate of browning or spoiling of fruits with a chemical inhibitor and air to see which fruits they would recommend get taken to space and which they would not recommend. Factors to consider: spoiling rates, inedible parts, weight of fruits, etc.
- Test out a variety of breads and tortilla types to see which type is best for spaceflights.
- Weigh unshelled nuts vs. shelled nuts, fruits with skin or a peel vs. fruits without and calculate percentages of edible vs. waste of each food.

Design Proposal

Ask students to write a journal entry, a sample memo or letter to NASA or an engineering company, such as SpaceX, proposing a solution to a challenge in space travel, why this solution would be important, and what the solution could contribute to life in the future.

The Engineering Design Process: Designing Spacesuits

Synthesize new understanding of space travel and student experience in Solar Hazards (see above) and Surviving in Space activities (page 37) by having students design a spacesuit.

Identify the Problem	Design a spacesuit for an astronaut that is the most effective at diminishing the effects of solar radiation, and other space travel hazards.
Identify Criteria and Constraints	Research solar radiation and describe its benefits and disadvantages. Review experiment results from Solar Hazards, and other Surviving In Space activities. What might be effective materials for protection?
Brainstorm Possible Solutions	Students will brainstorm/draw possible space suit designs that will provide optimal protection, given the provided materials.
Generate Ideas, Explore Possibilities, and Select an Approach	Students will select the solution they think will be the most successful in protecting against identified hazards.
Build a Model or Prototype	Students will use materials to construct their astronaut space suit. Students will test out their design and determine the effectiveness of their solution.
Refine the Design	Students will redesign their space suit either to achieve a solution to the problem, if their first prototype was unsuccessful, or make modifications to their prototype in order to make it more successful.

Additional support materials available from Northeastern University, Center for STEM Education: www.stem.neu.edu/programs/k-12-school-field-trips/space-suit-design/

Students can also construct a scale-model space station designed to deal with the challenges of living in space. Find detailed directions at: spaceplace.nasa.gov/build-a-spacecraft/en/

Grades 9–12

Focus question: What will future space travel look like?

Review Student pages completed during the visit to *Space*. Students can synthesize what they have learned about future space travel by engaging in a Mission to Mars task. Students identify a problem to which they would like to design a solution. For example:

- How do we safely launch a rocket to Mars?
- How long does it take to efficiently and effectively travel to Mars?
- How will we land safely on Mars?
- How will we survive on Mars once we get there?
- How will we transport equipment and materials to and from Mars?

Students will be in charge of pinpointing their own problem and then generating their own goals around how they will solve this problem. Teachers could give budget or materials limitations if desired.

The Engineering Design Process: Mission to Mars

Identify the Problem	Students will identify their own problem for their Mission to Mars.
Identify Criteria and Constraints	The topics to research will depend on the problem they identify. Outline the most significant criteria for the solution, and describe constraints.
Brainstorm Possible Solutions	Students will brainstorm and draw possible design solutions for solution, consider how to construct a prototype to test, and how to test based on the identified criteria.
Generate Ideas, Explore Possibilities, and Select an Approach	Students will select the solution they think will best meet identified criteria.
Build a Model or Prototype	Students will use materials to construct and test their design, and determine the effectiveness of their solution, according to identified criteria.
Refine the Design	Students will analyze and redesign their prototype to make it more successful.

The activities in these linked documents do not provide the students the opportunity to identify and choose their own problem, but can be useful references for this Mission to Mars Design Challenge:
marsed.asu.edu/sites/default/files/stem_resources/Marsbound_Lesson_High_School_4_14.pdf

The accompanying materials for designing a mission can be found here:
marsed.asu.edu/sites/default/files/stem_resources/Marsbound_Design_Mat_v200.pdf
marsed.asu.edu/sites/default/files/stem_resources/MarsboundCardsv300.pdf

See also: mars.jpl.nasa.gov/participate/marsforeducators/soi/MarsSOI2012_Lesson13.pdf

Communicate Findings

Students can present persuasive essays about the value of their design solution by using digital technology, such as creating an iMovie, a Prezi, or a PowerPoint or use more traditional methods, such as a poster or visual display.

Understanding space and space travel

Research past outcomes, products, processes generated by space exploration. Describe the impact of any of these on life today. What might be future applications of technologies being currently tested?

Investigate some of the current scientific experiments on board the ISS. What are the goals for these experiments? What would students propose as future experiments on the ISS?

At the Museum: Chaperone Guide

What is Space Like?

Dangers, challenges

- Why do astronauts need spacesuits? Use exhibits to find some examples of the dangers of space.
- What do spacesuits do?
- How would you create a spacesuit? What would you need?

Weightlessness

- Describe what you think it would be like to be weightless in space.
- What would be hard to do? Easy? Fun?
- Why are astronauts weightless in space but not on Earth?
- Are there ever times you can be "weightless" on Earth? Where? How?
- Try an experiment that shows weightlessness. What was it? What did you find out?

TIPS FOR CHAPERONES

- Encourage students to interact with exhibits, share their discoveries and ideas with the rest of the group.
- Enjoy the exhibits with your group! Share your own discoveries, questions, and "I wonder…"
- Allow time for student exploration. These suggested questions are guides that encourage exploration of each area of Space. Use questions to help students find ideas in exhibition sections or at individual exhibits. Share with each other when you come back together in groups.

Learning to Live in Space

How is life in space different than your life on Earth? Find and share examples with your group.

International Space Station - A stepping-stone to deeper space

Compare your house or school to the ISS. How are they alike? What is different?

Who brought the batteries?

- What things on the ISS need power?
- If you go camping or if the power goes out in your house, you look for flashlights or extra batteries. What do you do in space for power?

HOW FAR AWAY IS THE ISS?

About 220 miles (350 km) above Earth.

(This is like the distance from St. Paul to Fargo, ND or Cedar Rapids, IA… or the distance between Los Angeles and Las Vegas. Madison, WI and Des Moines, IA are farther away from St. Paul than the ISS!)

Future exploration in space…

- Look around to see what next steps in space travel might be. What ideas do you have for future space travel?
- Imagine yourself working on space travel in the future. What kind of project would you like to work on?

YOUR TRIP TO SPACE

Use the exhibits to spark your imagination!

Find some things you would ***need*** in space. Or, find ideas about what you would ***do*** if you were traveling in space. Draw 2 ideas below and write about them on the lines.

Living in Space

You will see ***models*** of parts of The International Space Station (ISS). There is a big model of one part of the station, and a small model of the whole space station.

Talk with people in your group. What words would you use to describe the models? Circle the words you would use.

smaller than the real thing	huge	simple
place to work	cylinder	soft
round	white	just like the real thing
moving	place to play	purple

Add some words of your own!

______________ ______________ ______________

______________ ______________ ______________

Space Travel in the Future

What would you like to explore in space?

Describe where you would go, and what you would need to explore space. Find ideas in the exhibits and add your own ideas. Draw yourself as a future space explorer.

Preparing for your Journey to Space

Use the exhibits to get ideas about what YOU would need to do if you were traveling to space. Use these pages to write some notes, make some sketches and add your own ideas about this exciting possibility.

You will need to know about some of the challenges of traveling and living in space.

Find an example of a challenge that you might have being outside the Earth's atmosphere. Choose one of these or use your own idea:

- no air to breathe
- weightlessness
- extreme heat or extreme cold
- radiation
- very low pressure (vacuum)

Draw (or describe) what dangers this challenge might have for you:

How can you protect or prepare yourself? Write some ideas here.

1. __________

2. __________

3. __________

Your Day in Space

It's time for lift-off!

T-minus 15 seconds... 10... 9... 8... 7... Ignition sequence starts, engines are on... 4... 3... 2... 1...

Main engine start... 0... **And we have lift-off of** ______________________________ **!**

(Add your own idea for the name of your space vehicle)

And you're heading to space!

Look at the exhibits and use your imagination.

Describe your day in space. Write your ideas here. Add some sketches to help you remember details.

There are still problems to solve in traveling and living in space.

As an engineer, you could design a solution to one of the problems. What problem would you like to solve?

Describe a journey that you would like to take into space.

What is your destination? ______________________________

What would you need to take with you? List some ideas here. If you find something like it in the exhibition, make sketches or notes about it next to your list.

To take along: *Notes & details:*

What new object or system would you design for your journey to space?

You will need to know about some of the challenges of traveling and living in space.

Find an example of a challenge that you might have being outside the Earth's atmosphere. Choose one of these or use your own idea:

- no air to breathe
- weightlessness
- extreme heat or extreme cold
- radiation
- very low pressure (vacuum)

Draw (or describe) what dangers this challenge might have for you:

How can you protect yourself or prepare yourself? Write some ideas here.

1. ______

2. ______

3. ______

Your Day in Space

Investigate how you would do activities in space. For each one, write down one thing you would like about doing the activity "space-wise" and one thing you would not like about doing it this way.

(Example: for "Sleeping," you could write "Like: cozy strapped-in sleep sack" and "Don't like: can sleep only in sleep sack.")

	Like	Don't like
Sleeping		
Eating		
Doing experiments		
Leisure *(for example, reading, playing an instrument or something else you do for fun)*		
Washing		
Other activity?		

Living in Space

The International Space Station (ISS) is a home to astronauts, an orbiting research laboratory and a stepping-stone to future journeys in space. Engineers have designed many systems to keep the ISS safe and complete the mission for studying space.

Circle the ***systems*** you notice in the ISS models, the signs about the ISS, or in the exhibits.

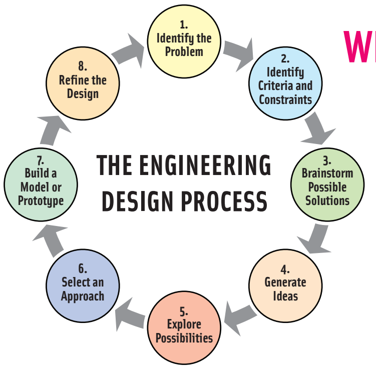
AIR CIRCULATION	COMMUNICATION	HEATING
WARP DRIVE	KARAOKE	WATER RECYCLING
COMPUTER	LIGHTING	FANTASY FOOTBALL

Choose a system that you think is **most** important.

Give 2 reasons why you think so.

1. ______

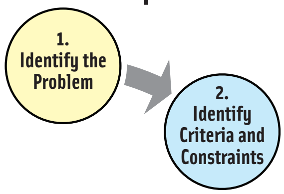
2. ______



What is Space Like?

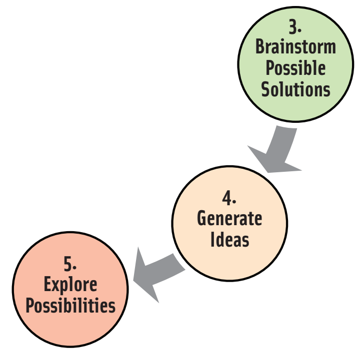
As an engineer designing for a space travel project, you would need to know about challenges of traveling and living in space.

Find **examples of challenges** that are part of human space travel.



1. ________________________________
2. ________________________________
3. ________________________________

Choose one of these challenges and propose a solution. Review technologies already designed and suggest an alternative or improvement.



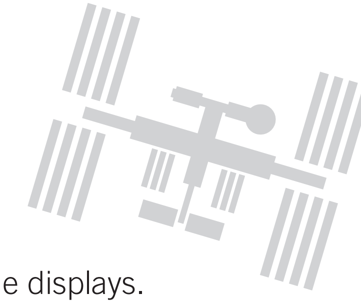
Learning to Live in Space

Investigate how astronauts do the following activities in the International Space Station. What are the pros and cons of each solution?

	Technology to support this activity	Advantage of solution	Drawbacks
Sleeping			
Eating			
Doing experiments			
Washing			
Leisure			
Activity of your choice			

*Note: **Technology** is anything human-made that is used to solve a problem.*

Living in Space



The International Space Station (ISS) is a home to astronauts, an orbiting research laboratory and a stepping-stone to future journeys in space. Engineers have designed many systems to keep the ISS safe and complete the mission for studying space.

Circle the systems you notice in the ISS models, the signs about it, or in the displays.

AIR CIRCULATION	COMMUNICATION	HEATING
WARP DRIVE	KARAOKE	WATER RECYCLING
COMPUTER	LIGHTING	FANTASY FOOTBALL

Choose one system. What are the parts of this system? What does this system need to be able to function? (needed=input) What is the result of a functioning system? (result=output)

If inputs are limited — for example, the loss or lack of energy — which systems would be most important to keep operating?

Which system could be limited/shut down?

Pioneering New Worlds

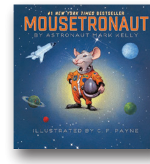
Choose one of the questions below to answer. Take notes at the museum, complete your ideas back at school.

- What are the benefits of continuing to explore space?
- Do the benefits of future space travel outweigh the costs?
- What are the safety concerns of space travel in the future?
- What would it take to arrive safely and to sustain life on Mars?
- Would you be interested in traveling to Mars?

Resources for Teachers & Students

Books

For students



Kelly, Mark (2012). ***Mousetronaut***. Simon & Schuster/Paula Wiseman Books.
ISBN-10: 1442458240.

Written by retired astronaut Kelly, this story uses the real mice companions in the space shuttle flights as characters in a fictionalized account of a problem encountered during a flight, in which Meteor Mouse solves the problem and saves the day. (Grade Level: Preschool–2)

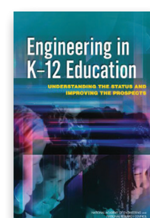
McCarthy, Meghan (2008). ***Astronaut Handbook***. Knopf Books. ISBN -10: 0375844597.

This charmingly illustrated book highlights important stages in astronaut preparation and provides a look at different jobs for astronauts. The shuttle program is no longer in operation, but most of the book will still give young students a better idea of what it takes to become an astronaut. (Grade Level: Preschool–2)

Stott, Carole (2014). ***DK Eyewitness Books: Space Exploration***. Dorling Kindersley.
ISBN-10: 1465426167.

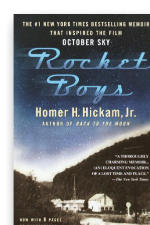
An informative guide that touches on a multitude of space-exploration topics, from the early history of rocketry to animals in orbit, space stations, astronaut underwear, and probes to the outer planets includes actual photos of spacecraft, scale models, toys, portraits of people and selected heavenly bodies, all with detailed captions. Wide-ranging information includes international space agencies, not just American or Russian. (Grade Level: 3–7)

For teachers



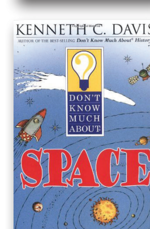
Linda Katehi, Greg Pearson, and Michael Feder, Editors (2009). ***Engineering in K-12 Education: Understanding the Status and Improving the Prospects***. Committee on K-12 Engineering Education; National Academy of Engineering and National Research Council. Available at nap.edu/catalog/12635.html.

For students and teachers



Hickam, Homer (1998). ***Rocket Boys (October Sky)***. Delta. ISBN-10: 0385333218.

Kids of the late 1950s, stuck in a coal camp and enthralled by the space race, the author and his friends built rockets. They kept working and learning until they had designed sophisticated rocket engines, capable of flying for miles into the sky. The author of this memoir became an engineer at NASA. It inspired the movie October Sky, and is inspiring for following and achieving your dream. The book has a very teacher-friendly website: homerhickam.com/books/rb.shtml



Davis, Kenneth C., (2001). ***Don't Know Much About Space***. HarperCollins.
ISBN-10: 0064408353.

Using a lively question-and-answer format, Davis provides remarkable information about the sun, stars, planets, and the universe, and encourages readers to contemplate such issues as humans' ability to travel to and live in other worlds. Easy to understand and good for both adults and students, reading level grade 3+.

Websites

Science Museum of Minnesota

Educator resources for the *Space* exhibit: smm.org/space/educators & spaceexhibit.org

NASA Wavelength

A search engine of all NASA educational products, and additional external resources. All have been peer-reviewed: nasawavelength.org/

Search criteria include: age of audience; activity time; cost of materials. There are sub-fields under each choice: e.g., topics, instructional strategies, AAAS Strandmaps

NASA's "teacher area"

www.nasa.gov/audience/foreducators/teachingfromspace/home/

The Destiny Laboratory

Considered the centerpiece of the International Space Station, Destiny, the U.S. Laboratory module, supports scientific and technological research conducted aboard the International Space station (ISS): www.nasa.gov/mission_pages/station/structure/elements/destiny.html

Other leading space agencies (*includes pages for kids)

ROSCOSMOS (Russian Federal Space Agency): www.federalspace.ru/
CSNA (China National Space Administration): www.cnsa.gov.cn/n615709/
JAXA (Japan Aerospace Exploration Agency): iss.jaxa.jp/kids/en/ *
ISRO (Indian Space Research Organization): www.isro.org/
ESA (European Space Agency): www.esa.int/esaKIDSen/ *
Canadian Space Agency: www.asc-csa.gc.ca/eng/

Misconceptions

NASA budget: www.washingtonpost.com/wp-srv/special/politics/presidential-budget-2015/

No sound in space: curious.astro.cornell.edu/question.php?number=8

NASA impacts: spinoff.nasa.gov/

Weightlessness and "zero gravity": education.jlab.org/qa/gravity_01.html & www.universetoday.com/95308/why-are-astronauts-weightless-in-space/

NASA career information (Grades 5-12)

What does it take to become an astronaut? What other kinds of careers are possible at NASA?: www.nasa.gov/audience/forstudents/careers-index.html

Can we make it to Mars?

Video from PBS, as part of the NOVA series; 53 min., first aired in 2011: http://video.pbs.org/video/1752557302/

The first half is about the challenges of space. At about the 30-minute spot, it is about the challenge of distance to Mars and how to make the trip faster, to minimize the fuel and weight, and the other challenges that go along with spending more time in space, on a planet with features very different from Earth. Final section is about Mars rovers and other robots.

Engineering Adventures Liftoff: Aerospace Engineering

Free lesson plans for engineering rockets and rovers to explore several planets and moons in our solar system. Grades 3-5. Developed for out of school programs: http://www.eie.org/engineering-adventures/curriculum-units/liftoff

Minnesota Academic Standards

The Science Museum of Minnesota provides a field trip destination that allows teachers and students to reinforce Minnesota Academic Standards. Use of the materials in this guide in combination with a field trip to *Space* will help you link learning experiences to the following content standards.

Grades K–2

Science

Kindergarten

Nature of Science and Engineering

0.1.1.2.1 Use observations to develop an accurate description of a natural phenomenon and compare one's observations and descriptions with those of others.

0.1.2.1.1 Sort objects in to two groups: those that are found in nature and those that are human made.

Earth and Space Science

0.3.2.2.2 Identify the sun as a source of heat and light.

Grade 1

Nature of Science and Engineering

1.1.1.1.1 When asked "How do You Know?", students support their answer with observations.

1.1.1.1.2 Recognize that describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.

1.1.3.2.1 Recognize that tools are used by people, including scientists and engineers, to gather information and solve problems.

Grade 2

Nature of Science and Engineering

2.1.1.2.1 Raise questions about the natural world and seek answers by making careful observations, noting what happens when you interact with an object, and sharing the answers with others.

2.1.2.2.1 Identify a need or problem and construct an object that helps to meet the need or solve the problem.

Physical Science

2.2.1.1.1 Describe objects in terms of color, size, shape, weight, texture, flexibility, strength and the types of materials in the object.

English Language Arts

Kindergarten

0.6.8.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question

0.8.1.1 Participate in collaborative conversations with diverse partners about kindergarten topics and texts with peers and adults in small and larger groups.

0.8.5.5 Add drawings or other visual displays to descriptions as desired to provide additional detail.

Grade 1

1.6.8.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

1.8.1.1 Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

1.8.5.5 Add drawings or other visual displays to descriptions when appropriate to clarify ideas, thoughts, and feelings.

Grade 2

2.6.8.8 Recall information from experiences or gather information from provided sources to answer a question.

2.8.1.1 Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups.

Grades 3–5

Science

Grade 3

Nature of Science and Engineering

3.1.1.2.3 Maintain a record of observations, procedures and explanations, being careful to distinguish between actual observations and ideas about what was observed

3.1.1.2.4 Construct reasonable explanations based on evidence collected from observations or experiments.

3.1.3.2.2 Recognize that the practice of science and/or engineering involves many different kinds of work and engages men and women of all ages and backgrounds.

Earth and Space Science

3.3.3.2.2 Recognize that the Earth is one of several planets that orbit the sun, and that the moon orbits the Earth.

Grade 4

Nature of Science and Engineering

4.1.2.2.1 Identify and investigate a design solution and describe how it was used to solve an everyday problem

4.1.2.2.2 Generate ideas and possible constraints for solving a problem through engineering design.

Grade 5

Nature of Science and Engineering

5.1.1.1.4 Understand that different models can be used to represent natural phenomena and these models have limitations about what they can explain.

Physical Science

5.2.2.1.2 Identify the force that starts something moving or changes its speed or direction of motion.

English Language Arts

Grade 3

3.2.7.7 Use information gained from illustrations (e.g. maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when why, and how key events occur).

3.6.8.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.

3.8.7.7 Locate and use information in print, non-print, and digital resources, and identify reasons for choosing information used.

Grade 4

4.6.8.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

4.8.7.7 Locate and use information in print, non-print, and digital resources, and identify reasons for choosing information used.

Grade 5

5.2.7.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

5.6.8.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

5.8.7.7 Locate and use information in print, non-print, and digital resources, and identify reasons for choosing information used.

Grades 6–8

Science

Grade 6

Nature of Science and Engineering

6.1.2.1.2 Recognize that there is no perfect design and that new technologies have consequences that may increase some risks and decrease others.

6.1.2.1.4 Explain the importance of learning from past failures, in order to inform future designs of similar products or systems.

6.1.3.1.1 Describe a system in terms of its subsystems and parts, as well as its inputs, processes and outputs.

Physical Science

6.2.2.2.3 Recognize that some forces between objects act when the objects are in direct contact and others, such as magnetic, electrical, and gravitational forces can act from a distance.

Grade 8

Nature of Science and Engineering

8.1.3.3.1 Explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigations.

8.1.3.3.2 Understand that scientific knowledge is always changing as new technologies and information enhance observations and analysis of data.

8.1.3.3.3 Provide examples of how advances in technology have impacted how people live, work and interact.

Earth and Space Science

8.3.3.1.2 Describe how gravity and inertia keep most objects in the solar system in regular and predictable motion.

8.3.3.1.3 Recognize that gravitational force exists between any two objects and describe how the masses of the objects and distance between them affect the force.

English Language Arts

Grades 6–8

6.7.1.1; 7.7.1.1; 8.7.1.1 Write arguments to support claims with clear reasons and relevant evidence.

Reading/Science

6.13.4.4 Determine the meaning of symbols, equations, graphical representations, tabular representations, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

6.13.8.8 Distinguish among claims, evidence, reasoning, facts, and reasoned judgment based on research findings, and speculation in a text.

Writing for Science

6.14.7.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

6.14.8.8 Gather relevant information from multiple data, print, physical (e.g., artifacts, objects, images), and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Grades 9–12

Science

9.1.1.1.2 Understand that scientists conduct investigations for a variety of reasons, including: to discover new aspects of the natural world, to explain observed phenomena, to test the conclusions of prior investigations, or to test the predictions of current theories.

9.1.1.1.6 Describe how changes in scientific knowledge generally occur in incremental steps that include and build on earlier knowledge.

9.1.1.2.2 Evaluate the explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the scientifically acceptable evidence, and suggesting alternative scientific explanations.

9.1.2.2.1 Identify a problem and the associated constraints on possible design solutions.

9.1.3.2.2 Analyze possible careers in science and engineering in terms of education requirements, working practices and rewards.

9.1.3.4.1 Describe how technological problems and advances often create a demand for new scientific knowledge, improved mathematics, and new technologies.

9P.1.3.3.1 Describe changes in society that have resulted from significant discoveries and advances in technology in physics.

English Language Arts

9.7.7.7; 11.7.7.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

11.12.7.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, spatially, aurally, physically as well as in words) in order

9.14.7.7; 11.14.7.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize ideas from multiple sources on the subject, demonstrating understanding of the subject under investigation.

9.14.8.8; 11.14.8.8 Gather relevant information from multiple authoritative data, print, physical (e.g., artifacts, objects, images), and digital sources using advanced searches effectively; assess the usefulness of each source in answering the research question

Next Generation Science Standards Alignment Matrix

Science & Engineering Practices

	K–2: Designing a Launch Tower	K–2: At the Museum	3–5: Communication Activity with Mission Control	3–5: ISS Model	3–5: Designing a Parachute Landing System	3–5: At the Museum	6–8: Surviving in Space	6–8: Designing Spacesuits	6–8: At the Museum	9–12: Mission to Mars	9–12: At the Museum
Ask Questions & Define Problems	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔
Developing & Using Models	✔	✔	✔	✔	✔		✔	✔		✔	✔
Planning & Carrying out Investigations	✔	✔			✔	✔	✔	✔		✔	
Analyzing & Interpreting Data	✔	✔	✔		✔		✔	✔		✔	
Using Mathematics & Computational Thinking	✔			✔			✔			✔	
Constructing Explanations & Designing Solutions	✔			✔	✔	✔	✔	✔	✔	✔	✔
Engaging in Argument from Evidence	✔			✔	✔		✔	✔		✔	✔
Obtaining, Evaluating, & Communicating Information	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Crosscutting Concepts

	K–2: Designing a Launch Tower	K–2: At the Museum	3–5: Communication Activity with Mission Control	3–5: ISS Model	3–5: Designing a Parachute Landing System	3–5: At the Museum	6–8: Surviving in Space	6–8: Designing Spacesuits	6–8: At the Museum	9–12: Mission to Mars	9–12: At the Museum
Patterns		✔		✔	✔		✔	✔		✔	✔
Cause & Effect	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔
Scale, Proportion, & Quantity	✔	✔		✔	✔			✔		✔	
Systems & System Models	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔
Energy & Matter	✔						✔	✔		✔	✔
Structure & Function	✔			✔	✔		✔	✔	✔	✔	✔

Surviving in Space

This activity provides experiences with five hazards of space for humans: lack of air, micrometeoroids, radiation, extreme temperatures, and microgravity. As a wrap-up activity after visiting the Space exhibition, students can construct a scale-model space station designed to deal with the challenges of living in space:

- **Lack of Air:** The human body evolved within Earth's atmosphere and cannot survive without it. However, air does not exist in space. Lack of air means that humans do not have any breathable oxygen and that there is no air pressure. Without a spacecraft and space suits to supply pressurized, breathable air, astronauts would suffocate and endure the effects of depressurization. Depressurization can kill by causing liquids in a person to turn into gases, which will bubble inside the body. These bubbles can block blood flow and cause tissues to expand, damaging organs.

- **Micrometeoroids:** Micrometeoroids are tiny bits of comets, asteroids, dust – even leftover junk from previous missions – which travel through space, sometimes at very high velocities. These fast-moving particles can puncture spacecraft and space suits leading to loss of air and air pressure. They also can kill an astronaut by flying through them faster than a bullet. Strong spacecraft hulls and tough fabric layers in spacesuits protect against deadly micrometeoroids.

- **Radiation:** Space contains many sources of radiation, including our sun and, more dangerous, exploding stars in our galaxy and beyond. Some radiation such as X-rays, gamma rays and high-energy particles can kill cells in the body. Earth's atmosphere blocks most harmful solar radiation, and Earth's magnetic fields block most harmful cosmic radiation; but in space, where there is no atmosphere, spacecraft and spacesuits must provide protection against this danger. In addition, to minimize the astronauts' exposure to radiation, spacewalks are kept short and crews stay in the spacecraft during sun storms that send out very intense radiation.

- **Extreme Temperatures:** Space is an environment of temperature extremes. Different factors affect temperature – proximity to the Sun, location in shadow or light, and composition of a planet. In the shade, the temperature can dip to -250°F, in sunlight it can soar to 250°F. A spacecraft and a spacesuit must be able to both insulate and reflect heat to maintain a comfortable environment for astronauts.

- **Microgravity:** Gravity is a property of mass. However, the force of each object's gravity depends on its amount of mass. The less mass an object has, the weaker the effect of its gravity. Space is a microgravity environment, not zero gravity, because it is filled with mass such as planets, moons, astronauts and space capsules. The human body builds bone and muscle mass and strength based on resistance, such as the force of gravity on Earth. Because space is a microgravity environment, the body does not have to do as much work, and reacts by decreasing the mass and strength of bones and muscle. The longer an astronaut is in space, the more bone and muscle is lost. Once an astronaut returns to Earth, she or he can have a difficult time adjusting to the resistance of gravity. The effects of microgravity are not immediately fatal but are felt by an astronaut for a long time after the completion of a mission. Exercise in space helps to combat these effects.

To Do:

1. Your students will work in small groups, exploring and researching one particular hazard of space travel. The five groups are as follows:

    - Group 1: The Pressure is Off!
    - Group 2: Micrometeoroids
    - Group 3: Radiation
    - Group 4: Extreme Temperatures
    - Group 5: Microgravity

2. Each group will go to their related station in the classroom, which has been set up in advance. At each station they engage in an activity that simulates that hazard. Each station can include a computer or tablet cued to a related video (video links listed below). Finally, each station should have a corresponding card with instructions and discussion questions. Allow students about 20 minutes to explore at their station. By the end of the 20 minutes, they should be able to explain to anyone else in the class about that hazard and what space engineers have done to protect from that hazard.

Wrap-up:

After students have experienced their station, they will present to the class, demonstrating the simulation and describing how humans could be protected from that hazard while in space. Encourage them to share a fun fact or anecdote that they learned in the exploration process.

Station 1: The Pressure is Off!

There is a danger to humans in space because of the lack of air. Why is there no air in space? How would the lack of air affect astronauts? Try this demonstration to see one way that astronauts (and other objects!) could be affected by the near vacuum of space.

YouTube video: https://www.youtube.com/watch?v=pm6df_SExVw

Materials

- Modeling clay
- Plastic syringes
- Mini marshmallows

Procedure

1. Remove the plunger from the syringe and place a mini marshmallow in the barrel.
2. Replace the plunger and push it down close to the marshmallow.
3. Place a small piece of modeling clay on the end of the syringe to prevent air from flowing in.
4. Slowly pull up on the plunger while observing the effect on the marshmallow.
5. Now, slowly push the plunger back in. Observe the marshmallow.
6. Discuss with your group about what you observe. Answer the discussion questions below in your science notebooks.
7. Finally, come up with 1–2 questions of your own that were inspired by this station.

Discussion Questions

- What do you notice happening to the marshmallow?
- Why does this happen?
- How do you think other objects would be affected by removing air?
- What conclusions can you make from this activity?
- How does this activity relate to space and the lack of air in space?
- What could you design to protect humans from this hazard? Brainstorm or discuss possibilities.

Station 2: Micrometeoroids

You may think space is empty, but actually it's filled with stuff – lots of stuff! Some of this matter is large, like a planet, and some is tiny, like a speck of dust from a comet. These tiny specks of dust and debris are called micrometeoroids. Try this activity to see how micrometeoroids affect space suit material in space.

YouTube video: https://www.youtube.com/watch?v=fhBT-zIZdVQ

Materials

- Coffee cans
- Projectiles (marbles, washers, or nuts)
- Tissue paper
- Tape
- Pen/Pencil
- Paper
- Meter stick

Procedure

1. Cut tissue paper into squares large enough to cover the opening of a coffee can.
2. Tape one square of tissue paper over the opening of a coffee can.
3. Using the meter stick, drop a projectile onto the paper-covered coffee can from a certain distance and record the distance and your observations on a piece of paper. Did the tissue paper break? Design a simple table where you can record your data for this activity.
4. Continue adding layers of tissue paper over the coffee can until your observations change. Be sure to keep the drop distance in each try the same as Step 3.
5. Repeat the activity, but this time change the distance the projectile is dropped over several trials and keep the number of tissue layers constant.
6. Repeat the activity once more, but design a way to provide some airspace between each layer.
7. Engage in a discussion with your group about what you observe. Answer the discussion questions below in your science notebooks.
8. Finally, come up with 1–2 questions of your own that were inspired by this station.

Discussion Questions

- What do you notice happening when you increased the distance from which you dropped the projectile?
- What do you notice happening when you increased the number of layers of tissue?
- What happened when you added space between each layer?
- What conclusions can you make from this activity?
- How does this activity relate to space and the importance of space suits?
- What could you design to protect humans from this hazard? Brainstorm or discuss possibilities

Station 3: Radiation

The Sun is a star at the center of our solar system that provides heat and light for its eight orbiting planets. The giant, mostly hydrogen, ball also emits ultraviolet radiation, which is a form of energy we cannot see directly, but that we can see the effects of, such as when you get sunburn. Try this activity to see how radiation affects light sensitive paper.

YouTube video: https://www.youtube.com/watch?v=803Oa0CpJ4s

Materials

- Sunprint kit or plain solar photo paper
- Paper
- Foil
- Timer
- Sunlight

Procedure

Because the radiation from the sun is important to completing this activity, find a sunny spot outside or near a window to experiment.

1. Follow the directions for using Sunprint paper. Notice how the paper changes when it is exposed to the sun.
2. Cut sheets of plain paper into strips. Lay the strips over another piece of Sunprint paper at various thicknesses. Record your observations in a simple data chart.
3. Lay down 4 strips of paper side by side so that they cover a new piece of Sunprint paper. Remove one strip every 30 seconds. Record your observations in your data chart.
4. Place a layer of foil over another piece of Sunprint paper. Record your observations.
5. Engage in a discussion with your group about what you observe. Answer the discussion questions below in your science notebooks.
6. Finally, come up with 1–2 questions of your own that were inspired by this station.

Discussion Questions

- What do you notice about the intensity of the color under different layers of paper?
- What do you notice about the intensity of the color as the paper is exposed for different lengths of time?
- What conclusions can you make from this activity?
- How does this activity relate to space and the dangers of radiation?
- What could you design to protect humans from this hazard? Brainstorm or discuss possibilities.

Station 4: Extreme Temperatures

Space is an extreme environment – in direct sunlight temperatures can soar to 250°F, while in the shadows the temperature will plummet to -250°F. Space suits and spacecraft must be designed to withstand these quick and drastic changes in temperature. Try this activity to see how different materials react to temperature changes.

YouTube video: https://www.youtube.com/watch?v=6QE3oHoTgUQ

Materials

- 3 Empty jars
- 3 Thermometers
- Black & white paper
- Tap water
- Tape
- Scissors
- Clock or stopwatch
- Sunlight or heat lamp

Procedure

1. Cut the black paper so that it wraps around and covers a jar. Secure it with tape.
2. Repeat step 1 using the white paper and another jar.
3. Leave the third jar uncovered.
4. Fill all three jars with the same amount of tap water and place them in the sun. Allow the jars to sit for 2 minutes to equalize their temperatures.
5. Using a thermometer for each jar, record the initial temperature of the three quantities of water.
6. Continue recording the temperature of the water in each jar every three minutes for about 20 minutes. Graph temperature versus time for all three jars.
7. Engage in a discussion with your group about what you observe. Answer the discussion questions below in your science notebooks.
8. Finally, come up with 1–2 questions of your own that were inspired by this station.

Discussion Questions

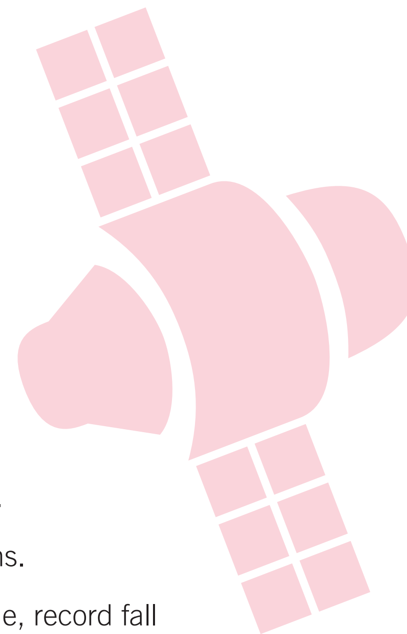
1. What do you notice about the temperature of the water in the different colored jars?
2. What can you infer about how direct sunlight affects different colors?
3. What conclusions can you make from this activity?
4. How does this activity relate to space and extreme temperatures?
5. What could you design to protect humans from this hazard? Brainstorm or discuss possibilities.

Station 5: Microgravity

Microgravity can make performing even the simplest of tasks very difficult, such as eating, sleeping, or using the bathroom. What does microgravity look like?

YouTube video: https://www.youtube.com/watch?v=kwEjFznfZ0c

Materials



- 2-liter clear plastic bottle
- Colored tape or marker
  - Prepare bottle by adding a broad stripe on the bottle with tape or a marker, in the upper $\frac{1}{4}$–$\frac{1}{3}$ of the bottle
- Cardboard astronaut (see link for download); add string to astronaut as shown.
  - How to Demonstrate Microgravity in Your Classroom: http://spaceflightsystems.grc.nasa.gov/DIME_Documents/SEEC/docs/HowToDemo-2013.pdf

Procedure

1. Hold string in neck of bottle with finger so “astronaut” is even with the line.
2. Release the string while holding the bottle. Observe and record observations.
3. Reset and release string and bottle together. Observe and record. If possible, record fall on video to observe in slow motion.

Discussion Questions

- What do you notice when the astronaut falls?
- How are the two falls different? What happens to the astronaut in relationship to the bottle in each case?
- What conclusions can you make from this activity?
- How does this activity relate to microgravity?
- Why do you think microgravity is a challenge for humans?
- What could you design to alleviate any problems related to microgravity for humans? Brainstorm or discuss possibilities.