Life in Space

Build a mock space suit using everyday materials to learn about the challenges astronauts face to work in space.

Suggested grade level: 3-4

Activity length: 30-45 minutes

Required materials: Flexible

Relevant topics: Human factors, system design





Purdue Space Day, an educational outreach program of Purdue University's Department of Aeronautical and Astronautical Engineering, organizes the largest free STEM advocacy children's event in the Midwest, as well as myriad year-round outreach events throughout the surrounding metropolitan area. These activity write-ups are provided free of charge as an extension of Purdue Space Day's STEM programming.

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Questions? Comments? Contact Purdue Space Day via email at psd@purdue.edu.
We'd love to hear your feedback to help us improve our activities and write-ups.

Activity Summary

Students use ordinary household materials to design and build mock space suits.

Key Concepts: Human factors, instrumentation

NGSS Summary: The key concepts of this activity align with NGSS Disciplinary Core Ideas for third and fourth grade science education. Specifically, they meet the following Physical and Life Sciences standards:

- 3-LS4.C – Adaptation
- 3-ESS2.B – Natural Hazards
- 4-PS4.C – Information Technologies and Instrumentation
- 4-LS1.A – Structure and Function
- 4-LS1.D – Information Processing

This activity also connects to the following standards for Engineering, Technology, and Applications of Science:

- ETS1.A – Defining and Delimiting an Engineering Problem
- ETS1.B – Developing Possible Solutions
- ETS1.C – Optimizing the Design Solution

Learning Objectives

Students will be able to understand the fundamental requirements of human spaceflight and identify key components of a space suit. Students will be able to explain how engineers define and solve real-world problems.

Scientific Background

Human beings are able to accomplish much more in space than unmanned vehicles can. Astronauts are versatile and intelligent space travelers who can perform a wide variety of experiments, troubleshoot problems, and make critical observations during missions. However, it is also much more difficult to safely put humans into space than robotic equipment. Humans have a wide variety of specific needs and require a carefully-controlled environment in order to survive.

So, what makes living in space so difficult? Many things. The biggest ones are listed below:

- Vacuum conditions – space is virtually empty of everything, even air. Without air, there is nothing to breathe, but more importantly, humans can't survive without an atmosphere. Down here on Earth, we have about 10 miles' worth of air over our heads, and all that air weighs an awful lot. It might be strange to think about, but we are essentially living at the bottom of a giant ocean of air which is constantly pushing down on us. This "push" is what we

call pressure, and our bodies need it to function. In space, there is no air and no atmosphere, so there is no pressure. If you were in space, the liquids in your body would start to boil – from the blood in your veins to the saliva on your tongue. Of course, without air, you would also lose consciousness in about ten or fifteen seconds.

- Temperature extremes – on Earth, our planet maintains a relatively stable temperature. It might be cold in the winter and hot in the summer, but most of Earth is pretty temperate and stable, because the planet itself remains at a fairly constant temperature due to the energy it absorbs from the sun. However, none of this happens in space. If you are floating in direct sunlight in space, you would feel temperatures well over 38 degrees Celsius (100 degrees Fahrenheit) – but the real kicker comes in the shadows, where temperatures plunge to hundreds of degrees below zero.
- Radiation – The sun provides us with light which we need to survive, but this light is just one form of radiation, of which there are many kinds that are harmful to human beings. Some of them – microwaves, x-rays, and ultraviolet light – are probably familiar, but other more exotic forms of radiation like gamma rays and cosmic radiation are very prevalent in space and can cause real danger for astronauts. Radiation can cause people's bodies to start decaying, meaning that astronauts exposed to radiation can get very sick.
- Debris – believe it or not, there are lots of forms of space garbage flying through space! Small bits of old satellites, items discarded from prior space missions, and small bits of rock and dust can all cause big issues for astronauts in space. These bits of debris are pretty harmless here on Earth, but they travel through space at thousands of kilometers per hour meaning that they hit things with the force of speeding bullets.

Because of all these dangers, astronauts need a lot of protection in space. When they are inside, they are kept safe by the walls of their spacecraft, which are made of layers of metal. The spacecraft keeps an atmosphere inside, allowing the astronauts to breathe, and the walls of the spacecraft keep out flying debris and most radiation.

However, when the astronauts venture outside on a spacewalk, a more creative solution is needed. For any extra-vehicular activities, astronauts must put on space suits. These suits are effectively miniature spacecraft – they have their own atmospheres, their own temperature management, and their own shielding from radiation and debris. Some space suits even have jetpacks to allow astronauts to maneuver around. Unfortunately, being sealed into a small suit introduces a whole new set of problems. All the systems required to keep astronauts safe have to be miniaturized so that they can fit on an astronaut's back. Since the suits don't have much space inside them, it's critical that they have systems to keep the air breathable, converting carbon dioxide that humans inhale into the oxygen which they need to breathe. They also have to have excellent thermal management systems so that astronauts can work at a comfortable temperature, regardless of whether they are in the sun and the shadows. They also have to protect their wearers from small pieces of space debris, and on top of all of this, they have to remain dexterous and nimble so that astronauts can accomplish tasks requiring fine motor skills. In addition, they have to contain systems for the astronauts to communicate with each other and with Mission Control, and displays for the astronauts to look at important information as they work.

As you might imagine, space suits are very complicated systems. They usually consist of multiple parts which lock together to keep in pressure, a special water-cooled undergarment to help astronauts regulate their body temperatures, a helmet with a thick visor, a backpack with life support equipment, and a computerized display to help astronauts keep track of their suits' functions. Astronauts are sealed up in their suits from head to toe every time they leave the comfort of their spacecraft.

Suggested Activity Practices

- Explain the challenges involved with living and working in space.
- Describe some of the key components of space suits and why they are necessary – helmets, visors, gloves, displays, life support systems, etc.
- Challenge students to build the best space suits which they can with the given materials. Have them explain the design choices which they make and what problems they are trying to solve.
- Give the students tasks to accomplish once they are "suited up". For example, have them try to build some sort of structure or solve a puzzle.

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Assessment Techniques

Volunteers can observe participants for the following signs of comprehension or learning. For each, volunteers should assign a percentage to indicate how many of the students display an understanding of the concept.

- Students indicate an understanding of the vacuum environment of space by building a suit which seems reasonably well-sealed.
- Students demonstrate an understanding of the physical hazards of spaceflight by building a suit with some level of astronaut protection.
- Students display an understanding of the EVA process by building a suit which allows their astronaut to effectively move and perform tasks.
- Students are able to explain the purpose of different space suit components and to justify their design decisions.

Participant learning can also be assessed using the following pre-activity and post-activity questionnaires.

Pre-Activity Questionnaire

Draw the most important parts of a space suit.

Why is outer space dangerous?

Why do humans need an atmosphere?

Post-Activity Questionnaire

Draw and label the parts of your space suit.

What do the components of your space suit do? How do they protect the astronaut?

Why is it important that a spacesuit is airtight (meaning that it has no leaks)?

Construction Directions

Note: There are no real instructions for this activity as it is intended as a creative, free-form exercise. Students should be encouraged to design and build their own space suits according to what they have learned about space habitation and the dangers of spaceflight. Students should work in small groups to construct a single space suit which will be worn by one member of the group. This provides an effective way to embrace collaborative problem solving and the engineering design process by applying the concepts they have learned.

Suggested Materials:

- Cardboard boxes
- Cellophane/plastic wrap
- Masking or duct tape
- Bubble wrap
- Posterboard
- Hoses
- String
- Plastic gloves

Suggested activities

As mentioned above, you may find it illustrative to have students attempt one or more activities while wearing their space suit. These activities should emphasize how difficult a space suit can make ordinary tasks by impeding fine motor skills, flexibility, and coordination. Possible examples include:

- Solving a simple puzzle
- Building a structure out of cardboard boxes
- Navigating a set of obstacles on a playground