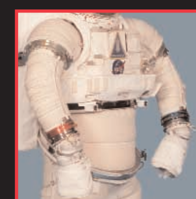
Build It With Spacewalks

Small, water-filled, plastic tubes laced through the liquid cooling and vent garment keep the astronaut cool inside a spacesuit.

When pressurized, spacesuits become stiff. Suit gloves need many joints to permit finger dexterity. A small wrist mirror permits reading control settings on the front of the suit.



With the outer suit fabric removed, bearings for mobility are visible in the shoulders, wrist, and waist.
The astronaut enters the suit by pulling on the lower torso (pants), slipping into the upper torso, and snapping the waist bearing rings together.

The lower torso has boots attached.Red stripes on some suits help mission controllers identify which astronaut they are looking at in their television screens.

With oceans and continents sliding by hundreds of kilometers below, space-suited astronauts help construct the International Space Station. The eyes and hands of astronauts are needed in the many intricate tasks that have to be performed. Keeping astronauts alive in the hostile space environment and able to perform hands-on work is the job of a spacesuit.

Fully suited, the astronaut is ready for a space walk. Refer to the other side of the poster for more suit details.

Build it with Spacewalks

2005 AD

Just after sunset, an exceptionally bright star-like object glitters in the southwestern sky. Unlike its stellar background, the object moves quickly and sets in the northeast a few minutes after it first appeared. It is a scene that is repeated over many parts of Earth 16 times each day. The object is the International Space Station, a huge orbital space platform constructed by the United States, Russia, Canada, Japan, Brazil, and 11 European nations. Inside interconnected cylindrical laboratories scientists probe the states of matter, combine chemicals, grow crystals, monitor the reactions of the human body, grow plants, raise animals, and study Earth below and the universe above.

The Present

Planned to be the largest structure ever erected in Earth orbit, construction on the International Space Station (ISS) will take place over the next several years. Components of the Space Station will be brought to Earth orbit by the Space Shuttle and Russian Proton rockets. Modules, truss beams, air locks, solar panels, antennas, and radiators will be joined together in Earth orbit. When finally completed, the ISS will be nearly 110 meters long and 80 meters wide or almost the size of two side-by-side football fields.

Spacewalks

The International Space Station will be built with spacewalks. Assembly operations will be complex because there is much more to do than just docking pieces together. For example, electrical connections will have to be made and fluid transfer lines will have to be joined. Antennas will need positioning. Locking bolts for solar panels will have to be removed to permit the panels to open, and other bolts will have to be driven tight to firmly attach components to the truss beam that serves as the Space Station's backbone. Completing each of these tasks calls for a space version of a hard hat worker. The hard hat will be a space helmet and the worker, a highly trained astronaut, will be decked out in a spacesuit.

Spacewalking astronauts will move about the outside of the International Space Station using various translational aids such as rails fixed to modules that serve as hand holds. They will also use a mobile robot arm with a work platform at its end that moves along the truss beam. With each new component delivery from Earth, spacewalkers will perform dozens of jobs as they make new connections and reconfigure previous ones.

By the time the International Space Station is completed, astronauts and cosmonauts will don their spacesuits many times and accomplish hundreds of hours of spacewalks.

Please take a moment to evaluate this product at:
http://ehb2.gsfc.nasa.gov/edcats/educational _wallsheet
Your evaluation and suggestions are vital to continually improving NASA educational materials. Thank you.

Extravehicular Mobility Units

Spacesuits, or extravehicular mobility units (EMUs), are complex multi-layered garments that protect spacewalkers from the hazards of outer space. These hazards include:

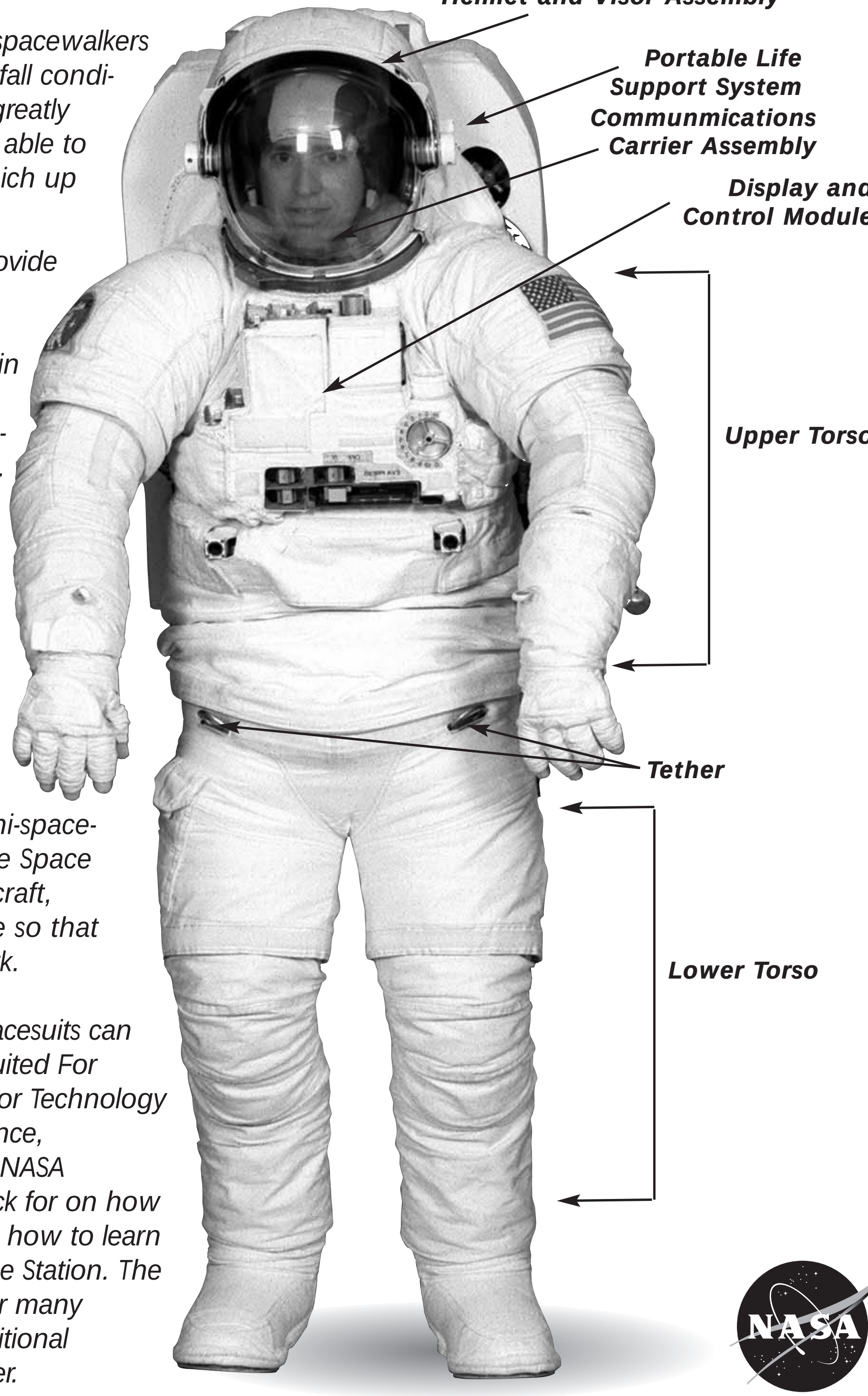
- *vacuum (no atmosphere for breathing and pressure)*
- *boiling hot temperatures in sunlight*
- *shattering cold temperatures in shade*
- *high-speed micrometeoroids and other space debris*
- *radiation*

In addition to these hazards, spacewalkers also function in microgravity (free-fall condition in which gravity's effects are greatly reduced). Suit systems have to be able to function in an environment in which up and down is not apparent.

The many layers of the suit provide different services to the astronaut inside. Some layers hold in a breathable atmosphere and contain pressure needed to sustain body tissues. Other layers provide insulation against temperature extremes. Still other layers provide protection against micrometeoroid impacts. Additional equipment is contained in a backpack including oxygen, cooling water, electrical power, gas circulation, and radio communications.

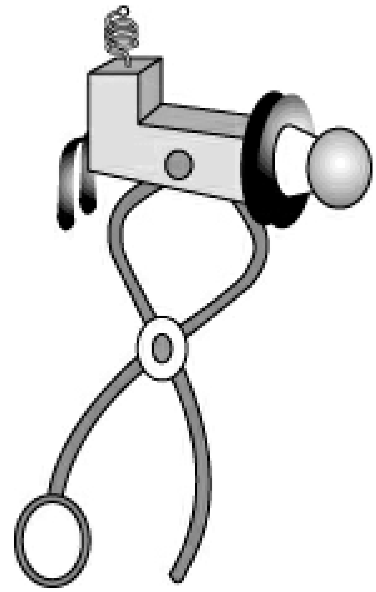
All of the thousands of spacesuit parts are integrated into a system that serves as a mini-spacecraft for astronauts. But unlike the Space Shuttle and Russian Soyuz spacecraft, spacesuits also have to be flexible so that the astronauts inside can do work.

The complete story of U.S. spacesuits can be found in the latest edition of Suited For Spacewalking - An Activity Guide for Technology Education, Mathematics, and Science, EG-1997-01-112-HQ. Refer to the NASA resources section of the poster back for on how to obtain a copy of the guide and how to learn more about the International Space Station. The guide provides the lesson plans for many hands-on classroom activities. Additional activities are included on this poster.



Right Tool for the Job

Objective: *To design and construct a prototype tool for spacewalkers to use to complete a specific job while assembling the International Space Station.*



Standards:

Science Content Standards
- *Motions and forces*
- *Abilities of technological design*

Universals of Technology
- *Physical Systems*
- *Linkages*
- *Utilizing Technological Systems*

Materials *(one set for the class):*
- *Paper*
- *Pencil or marker*
- *Miscellaneous materials for making prototypes such as sticks, springs, paperclips, tape, straws, etc.*

Background:

A good workshop contains many tools. Each tool has a specific function. Using the right tool for a job guarantees success. Using the wrong tool often leads to damaging the object on which the tool is being used. Spacewalkers need tools to complete their jobs in space but the cost of sending a complete tool shop to space is prohibitive. Furthermore, the tools have to be accessible while astronauts are scrambling outside the Space Station. Where would the tools be placed when they were not being used? A tool chest would work great until it is opened. In microgravity, wrenches, pliers, hammers, and screwdrivers would all start floating away. A lost tool is hazardous because it is traveling at high speed in Earth orbit. Someday it might collide with a future spacecraft and cause extensive damage.

Spacewalkers are limited in the number of tools they can carry in space and they have to be carried in such a way that the tools can never escape the spacewalker's control. In this activity, students are challenged to design and construct a prototype tool to do a job during a spacewalk.

Procedure:

1. *Discuss the tool problem with your students.*
2. *Select a particular job an astronaut needs to do on a spacewalk such as:*
   - *cut and splice a wire*
   - *connect fluid lines end-to-end*
   - *remove bolts to reposition an antenna and reinstall and tighten the bolts*
   - *straighten a metal strut that got bent during docking operations*
   - *remove machine screws to open a panel, etc.*
3. *Have students work in small groups to design a tool to do the selected job. The tool must meet a few criteria:*
   - *cannot get loose from the astronaut's control*
   - *sharp edges and pointed structures are protected so that they don't accidentally puncture the spacesuit*
   - *the tool will not be damaged by the temperature extremes of outer space*
   - *are able to successfully complete the required job.*
4. *Have students demonstrate their tool to the rest of the class.*

Extensions:

- *Bring in a variety of standard tools for students to examine. Ask them how the tools might be modified for space use.*

Bending Under Pressure

Objective: *To examine ways to make spacesuits flexible.*

Standards:

Science Content Standards
- *Motions and forces*
- *Abilities of technological design*

Curriculum and Evaluation Standards for School Mathematics
- *Geometry*
- *Computation and Estimation*

Universals of Technology
- *Physical Systems*
- *Linkages*
- *Designing and Developing Technological Systems*

Materials (per student group):

2 liter soft drink bottle
Balloons
Flexible aluminum clothes drier duct (available at hardware store)
Metric ruler

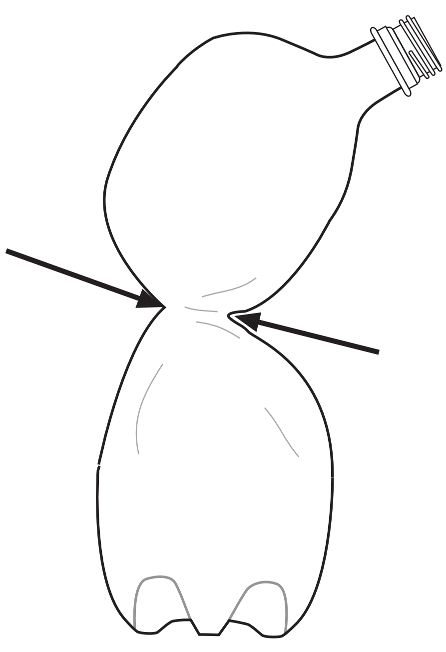
Background:

Making a spacesuit out of flexible material isn't sufficient to make the suit flexible when it is worn. Air under pressure must be contained inside the suit and this stiffens the suit regardless of what materials it is composed. To experience the stiffness factor, compare the flexibility of an uninflated balloon with an inflated one. Some sort of joint system in a spacesuit is necessary to permit it to bend in strategic places (elbows, wrists, fingers, knees, ankles, and waist).

Making a spacesuit bendable is only part of the problem. When an arm or a leg is bent, the bend can reduce the interior volume of the suit and this causes the pressure inside the suit to increase. Consequently, the suit becomes stiffer than before.

This two-part activity shows first how bending a suit arm increases suit pressure and then shows one strategy for solving the problem. An empty 2-liter soft drink bottle is used as a model of a suit arm. With the bottle cap off, the bottle is very easy to bend. The bottle is much harder to bend with the cap on. To see what is happening, stretch a balloon over the bottle's neck. Bending decreases the volume of the bottle, causing the pressure inside to increase. The balloon acts like a pressure gauge to show the increase.

In the second part of the activity, a length of aluminum clothes drier duct is bent. Measurements of the diameter of the hose will show that no crimping has taken place. Consequently, if a suit were constructed with aluminum vent hose, pressure inside the suit would not increase as it is bent. The vent hose is constructed with small tucks that expand on the outside of the bend and contract on the inside of the bend. A similar system is used in spacesuits but arm and leg cylinders are made out of fabric with expansion tucks sewn into them.



Uncapped Bottle

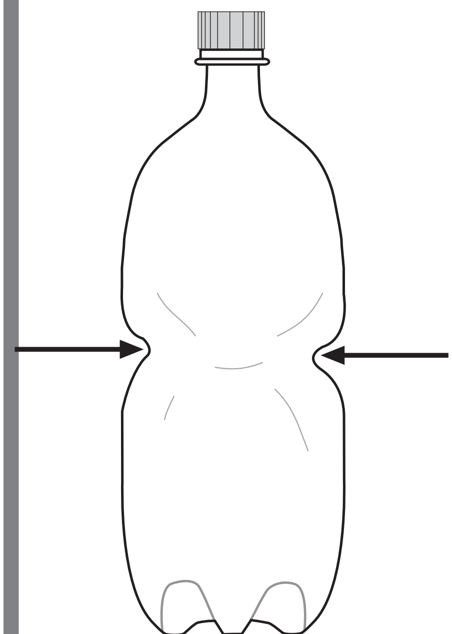
continued on next page

Procedure:

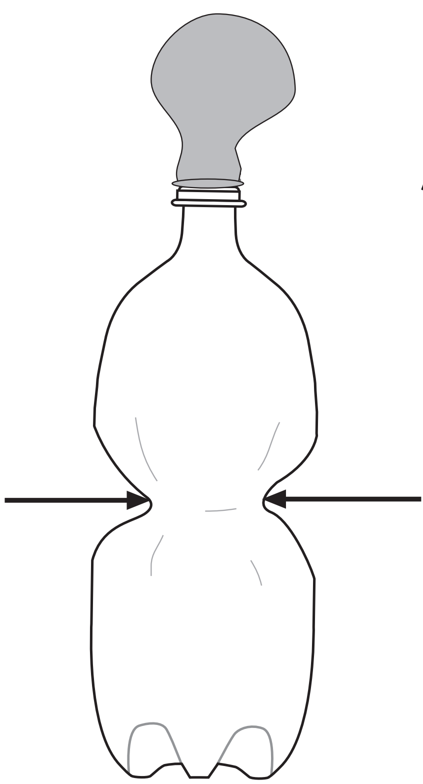
1. *Remove the cap from an empty 2-liter bottle. Bend the bottle in half. Observe how hard this is to do.*
2. *Straighten out the bottle and put the cap back on the bottle. Try to bend the bottle again and observe how hard this is to do. Why is the bottle harder to bend?*
3. *Stretch a small balloon over the bottle mouth and repeat the bending activity. What happens to the balloon?*
4. *Examine the aluminum vent hose. Measure its diameter at several points.*
5. *Bend the hose. Measure the diameter of the hose at the same points. Does the volume of the hose change when it is bent? How can you confirm this mathematically?*

Extensions:

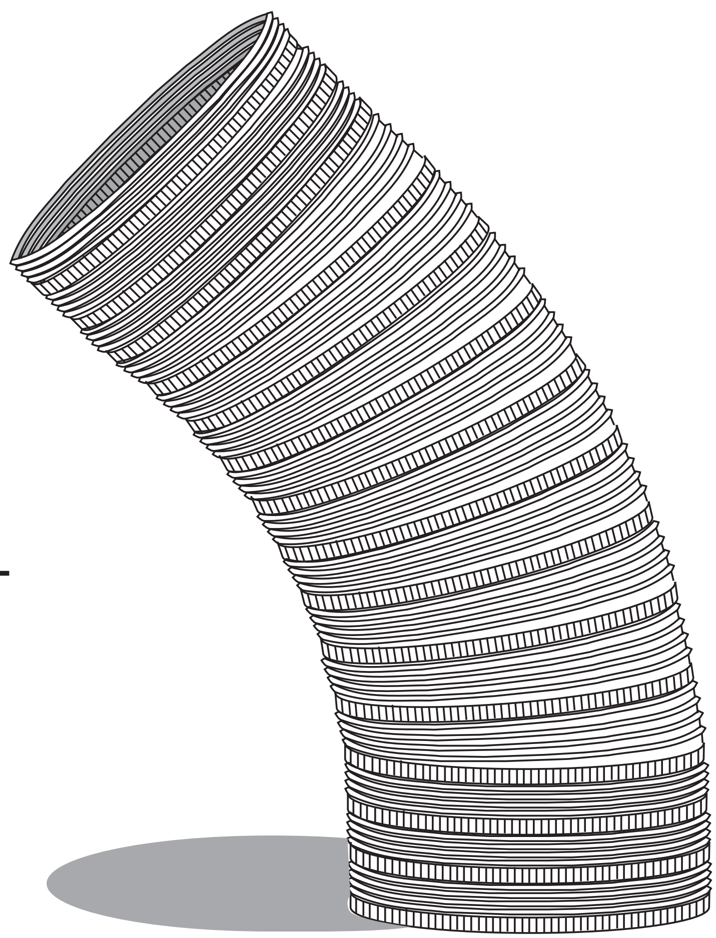
- *Discuss other ways a spacesuit can be made to be flexible.*
- *Try making an inflated long balloon flexible by adding some sort of joint system to it.*
- *Collect other materials that can be bent without crimping such as vacuum cleaner hose and swimming pool filter hose. Compare how flexible the different materials are and how effective they are at bending without crimping.*



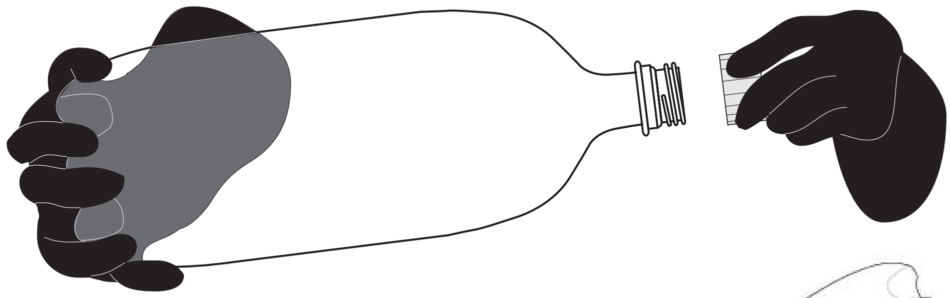
Capped Bottle



Bottle With Balloon



Get A Grip!



Objective: *To model the problems spacewalkers have when doing jobs that involve finger dexterity and to look for solutions to the problems.*

Standards:

Science Content Standards

Motions and forces

Universals of Technology

Physical Systems

Linkages

Utilizing Technological Systems

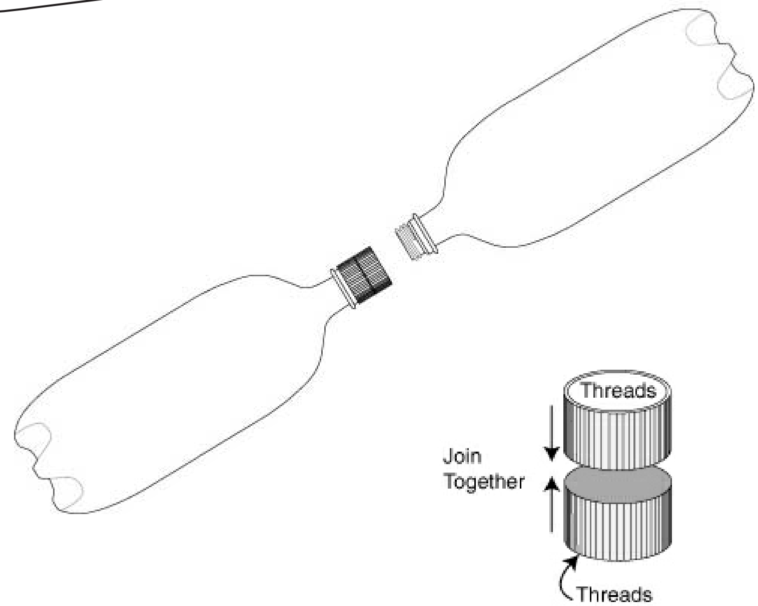
Materials (one set for the class):

2 soft drink bottles (2-liter size) with caps

Duct tape

Scissors

Heavy duty (rubber-coated) work gloves



Background:

The greatest challenge in making space suits flexible is to construct flexible gloves. When a spacesuit is pressurized, the glove fingers tend to pop out and become stiff. Although it is possible for the astronaut inside to bend the fingers to grab things, fingers get very tired in time, causing the astronaut's efficiency to diminish.

In this activity, students will don heavy-duty rubber-coated work gloves and try to join two 2 liter soft drink bottles together. The caps of the bottles are fastened together with duct tape. The object is to then connect the bottles to each other. This activity gives students experience with large and small objects at the same time.

At the completion of the activity, discuss with your students their observation of the problems they encountered trying to join the bottles together. Ask them to come up with ideas on how the problems could be solved.

Procedure:

1. *Remove the caps from two empty 2-liter bottles. Tape the caps together with duct tape so that the screw ends point outward in opposite directions.*
2. *Have a student put on heavy work gloves and try to assemble the two bottles and the joined caps into a single structure. Also have the student try the job without gloves. Which assembly operation was easier? Which one took less time?*

Extensions:

- *Obtain a pair of rubber surgical gloves and inflate and tie them. What happens to the fingers and palms of the gloves? Ask students to come up with ways to make the gloves flexible. Test the ideas on the surgical gloves.*
- *Play games of skill with and without gloves. Compare completion times. Do students improve their scores with practice?*

Let Your Fingers Do the Walking

Objective: To develop strategies for moving about the International Space Station.

Standards:

Science Content Standards
- Motions and forces
- Abilities of technological design

Universals of Technology
- Physical Systems
- Linkages
- Designing and Developing Technological Systems

Materials (for the entire class):

Swivel office chair with castors

Background:

When astronaut Edward White made the first American spacewalk, he discovered that moving in space was exhausting. His problem was finding hand holds. Although an astronaut can exert a force on an object in space and propel it away, the astronaut will move away from the object in the opposite direction at the same time. This is explained by Isaac Newton's Third Law of Motion: For every action there is an opposite and equal reaction.

If a spacewalker is not touching any part of the spacecraft, it is impossible for the spacewalker to do anything but turn in circles. To get about, the spacewalker needs to be able to push or pull against an object or have some sort of rocket system for propulsion. Once moving, the spacewalker has to able to exert another force to stop. This is explained by Newton's First Law of Motion: An object at rest will remain at rest and an object in motion will travel in a straight line unless acted upon by an unbalanced force.

Spacewalkers working on the International Space Station will wear a self-propelled rescue device called the Simplified Aid for Extravehicular activity Rescue (SAFER). SAFER is a clip-on unit that is worn around the backpack life support system. If a spacewalker should get loose from the Station, gas jets in the SAFER unit can propel the spacewalker back to the Station.

In this activity, a student will be placed on a swivel office chair. The student will attempt to move the chair without touching the floor. The chair becomes a simplified microgravity simulator that shows students the necessity of exerting a force in order to be able to change locations.

Procedure:

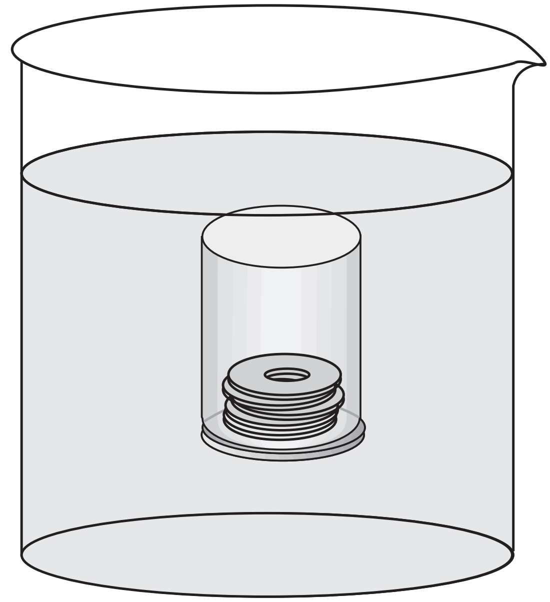
1. Place a student on a swivel office chair. Tell the student to move the chair without touching feet to the floor. The student will be able to get the chair to rock and spin but the motion will stop when the student stops moving. The student will not be able to get the chair to move off its spot on the floor.
2. Conduct a discussion with your students about ways to enable an astronaut to move about the International Space Station. Let students study the front side of this poster for ideas on how to get about.

Extensions:

- Present an emergency situation to your students and discuss possible answers. "You are spacewalking outside the International Space Station and become separated from it. How can you get back to the Station?" For additional information on transitional aids for spacewalking, refer to the background information section in the Suited For Spacewakling publication (see the panel on NASA resources on this side of the poster).

Remaining Neutral

Objective: *To load a plastic film canister with enough weight so that it will become neutrally buoyant.*



Standards:

Science Content Standards

- *Structure and properties of matter*
- *Abilities of technological design*

Curriculum and Evaluation Standards for School Mathematics

- *Geometry*
- *Computation and Estimation*

Universals of Technology

- *Physical Systems*
- *Linkages*

Materials (per group of students):

Plastic film canister
1000 ml beaker of water (large jar can be substituted)
Weights (washers, nuts, small nails, sand, etc.)

Background:

Before an astronaut gets to do a spacewalk, the astronaut receives extensive spacesuit training. One of the most important forms of training is to practice spacewalks under water. With the spacesuit properly weighted, the astronaut is immersed in an indoor swimming pool that holds nearly 25 million liters of water. The weights on the suit make the astronaut neutrally buoyant. That means when the astronaut is pulled under water by a couple of safety divers, the astronaut will be able to hover at any level in the pool without moving. This makes for a good simulation of a spacewalk. To make the simulation more effective, replicas of Space Station modules are present in the pool and the astronaut will practice making connections and turning bolts on the modules.

In this activity, students attempt to make a plastic film canister neutrally buoyant. They fill the canister with weights so that it can hover below the surface inside of a beaker

Procedure:

1. *Have students add weights to the film canister and then immerse it in water. If the canister floats at the surface, more weights must be added. If it sinks to the bottom, some weights have to be removed. The canister is weighted properly when the canister hovers in the middle of the beaker or jar.*

Extensions:

- *Increase the challenge to this activity by balancing an object of irregular shape and unevenly distributed mass for neutral buoyancy. One such object might be a small hammer. The hammer head will be much denser than the wooden handle. Weights will have to be added to the handle while small floats have to be added to the head to achieve neutral buoyancy. Styrofoam peanuts make good floats. Weights and floats are added to space-suited astronauts in underwater training facilities to achieve neutral buoyancy. Be sure to thoroughly dry the hammer after the activity.*

NASA Resources for Educators

NASA's Central Operation of Resources for Educators (CORE) *was established for the national and international distribution of NASA-produced educational materials in audiovisual format. Educators can obtain a catalogue and an order form by one of the following methods:*

- NASA CORE
  Lorain County Joint Vocational School
  15181 State Route 58
  Oberlin, OH 44074-9799
- Phone (440) 775-1400
- Fax (440) 775-1460
- E-mail nasaco@leeca.esu.k12.oh.us
- Home Page: http:/core.nasa.gov

Educator Resource Center Network

To make additional information available to the education community, the NASA Education Division has created the NASA Educator Resource Center (ERC) network. ERCs contain a wealth of information for educators: publications, reference books, slide sets, audio cassettes, videotapes, telelecture programs, computer programs, lesson plans, and teacher guides with activities. Educators may preview, copy, or receive NASA materials at these sites. Because each NASA Field Center has its own areas of expertise, no two ERCs are exactly alike. Phone calls are welcome if you are unable to visit the ERC that serves your geographic area.

A list of the centers and the regions they serve includes:

AK, AZ, Northern CA, HI, ID, MT, NV, OR, UT, WA, WY
NASA Educator Resource Center
Mail Stop 253-2
NASA Ames Research Center
Moffett Field, CA 94035-1000
Phone: (650) 604-3574

CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT
NASA Educator Resource Laboratory
Mail Code 130.3
NASA Goddard Space Flight Center
Greenbelt, MD 20771-0001
Phone: (301) 286-8570 MS

CO, KS, NE, NM, ND, OK, SD, TX
JSC Educator Resource Center
Space Center Houston
NASA Johnson Space Center
1601 NASA Road One
Houston, TX 77058
Phone: (281) 244-2129

FL, GA, PR, VI
NASA Educator Resource Center
Mail Code ERC
NASA Kennedy Space Center
Kennedy Space Center, FL 32899
Phone: (407) 867-4090

KY, NC, SC, VA, WV
Virginia Air & Space Center
Educator Resource Center for
NASA Langley Research Center
600 Settler's Landing Road
Hampton, VA 23669-4033 Phone:
(757) 727-0900 x 757

IL, IN, MI, MN, OH, WI
NASA Educator Resource Center
Mail Stop 8-1
John H. Glenn Research Center at Lewis Field
21000 Brookpark Road
Cleveland, OH 44135
Phone: (216) 433-2017

AL, AR, IA, LA, MO,TN
U.S. Space and Rocket Center
NASA Educator Resource Center for
NASA Marshall Space Flight Center
One Tranquility Base
Huntsville, AL 35758
Phone: (205) 544-5812

MS
NASA Educator Resource Center
Building 1200
NASA John C. Stennis Space Center
Stennis Space Center, MS 39529-6000
Phone: (228) 688-3338

NASA JPL Educator Resource Center
Village at Indian Hill
1460 East Holt Avenue, Suite 20
NASA Jet Propulsion Laboratory
Pomona, CA 91767
Phone: (909) 397-4420

AZ and Southern CA
NASA Educator Resource Center for
NASA Dryden Flight Research Center
45108 N. 3rd Street East
Lancaster, CA 93535
Phone: (661) 948-7347

VA and MD's Eastern Shores
NASA Educator Resource Center
Visitor Center Building J-17
GSFC/Wallops Flight Facility
Wallops Island, VA 23337
Phone: (757) 824-2298

Regional Educator Resource Centers (RERCs) *offer more educators access to NASA educational materials. NASA has formed partnerships with universities, museums, and other educational institutions to serve as RERCs in many states. A complete list of RERCs is available through CORE, or electronically via NASA Spacelink at http://spacelink.nasa.gov/ercn*

NASA's Education Home Page

NASA's Education Home Page serves as a cyber-gateway to information regarding educational programs and services offered by NASA for the American education community. This high-level directory of information provides specific details and points of contact for all of NASA's educational efforts, Field Center offices, and points of presence within each state.

Educators and students utilizing this site have access to a comprehensive overview of NASA's educational programs and services, featuring a search-able database that has cataloged each of NASA's educational programs. In addition the Education homepage features access to NASA Education News Releases, NASA's Education Calendar of Events, and schedules for NASA educational Internet and television broadcasts. The site highlights direct access to NASA's on-line resources specifically designed for the educational community, as well as access to home pages maintained by NASA's four areas of research and development (including the Aero-Space Technology, Earth Science, Human Exploration and Development of Space, and Space Science Enterprises). Visit this resource at the following address:
http://education.nasa.gov

NASA Spacelink

NASA Spacelink is one of NASA's electronic resources specifically developed for the educational community. Spacelink is a "virtual library" in which local files and hundreds of NASA World Wide Web links are arranged in a manner familiar to educators. Using the Spacelink search engine, educators can search this virtual library to find information regardless of its location within NASA. Special events, missions, and intriguing NASA web sites are featured in Spacelink's "Hot Topics" and "Cool Picks" areas. Spacelink may be accessed at: http://spacelink.nasa.gov

NASA Spacelink is the official home to electronic versions of NASA's Educational Products. NASA educator guides, educational briefs, lithographs, and other materials are cross-referenced throughout Spacelink with related topics and events. A complete listing of NASA Educational Products can be found at the following address: http://spacelink.nasa.gov/products

"Educator Focus" is comprised of a series of Spacelink articles, which offer helpful information related to better understanding and using NASA educational products and services. Visit" Educator Focus" at the following address: http://spacelink.nasa.gov/focus

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NASA Television (NTV) features Space Shuttle mission coverage, live special events, interactive educational live shows, electronic field trips, aviation and space news, and historical NASA footage. Programming has a 3-hour block—Video (News) File, NASA Gallery, and Education File—beginning at noon Eastern and repeated five more times throughout the day.

NTV Weekday Programming Schedules (Eastern Times)

Video File	NASA Gallery	Education File
12–1 p.m.	1–2 p.m.	2–3 p.m.
3–4 p.m.	4–5 p.m.	5–6 p.m.
6–7 p.m.	7–8 p.m.	8–9 p.m.
9–10 p.m.	10–11 p.m.	11–12 p.m.

Live feeds preempts regularly scheduled programming. Check the Internet for program listings at: http://www.nasa.gov/ntv

NTV Home Page http://www.nasa.gov/ Select "Today at NASA" and "What's New on NASA TV?"

http://spacelink.nasa.gov/NASA.News/ Select NASA "TV Schedules"

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For more information on NTV, contact: NASA TV
NASA Headquarters, Code P-2
Washington, DC 20546-0001
Phone: (202) 358-3572

How to Access Information on NASA's Education Program, Materials,and Services EP-1999-06-345-HQ *This brochure serves as a guide to accessing a variety of NASA materials and services for educators. Copies are available through the ERC network, or electronically via NASA Spacelink.*

Please take a moment to evaluate this product at
http://ehb2gsfc.nasa.gov/edcats/educational_wallsheet
Your evaluation and suggestions are vital to continually improving NASA educational materials. Thank you.

EW-1999-12-02-JSC