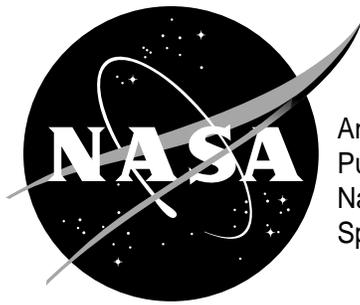
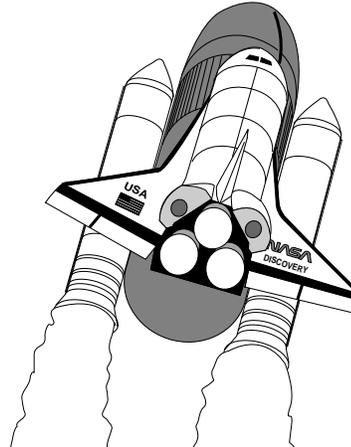


Educational Product	
Teachers	Grades K-8



An Educational  
Publication of the  
National Aeronautics and  
Space Administration

# Liftoff to Learning



## Go for EVA

### Video Resource Guide

VRG-003 10/91

**Application:** Life Sciences, Physical Science, Technology, History, Social Studies

**Video Length:** 13:48

#### Description

*Go for EVA* discusses the reasons for wearing spacesuits during spacewalking missions, how spacesuits work, and what kinds of jobs astronauts perform while spacewalking.

#### Shuttle Mission Facts

Most of the orbital scenes were taken during the STS-37 mission.

**Orbiter:** *Atlantis*

**Mission Dates:** April 5-11, 1991

**Commander:** Steven R. Nagel, Col., USAF

**Pilot:** Kenneth D. Cameron, Lt. Col., USMC

**Mission Specialist:** Linda M. Godwin, Ph.D.

**Mission Specialist:** Jerry L. Ross, Lt. Col., USAF

**Mission Specialist:** Jay Apt, Ph.D.

**Mission Duration:** 5 days 23 hours 32 minutes

**Distance Traveled:** 4,020,290 km

**Orbital Inclination:** 28.45 degrees

**Orbits of Earth:** 93

**Orbital Altitude:** 450 km

#### Payloads and Experiments:

GRO - Gamma Ray Observatory

EDFE- EVA Development Flight Experiment

PCG II - Protein Crystal Growth II

RME III - Radiation Monitoring Equipment III

AMOS - Air Force Maui Optical Site Calibration Test

BIMDA - Bioserve Instrumentation Technology

Associates Materials Dispersion Apparatus

SHARE II Middeck - Space Station Heat Pipe

Advanced Radiator Element II

SAREX - Shuttle Amateur Radio Experiment

## Background

When astronauts travel into space, they must carry part of Earth's environment with them. Air for breathing and for exerting pressure, food and water, and moderate temperatures are contained in a physical shell called a spacecraft. The shell also provides protection against high-speed micrometeoroid particles. On some space missions, the shell is deliberately opened and astronauts pass through an airlock to venture outside. When doing so, they must still be protected, but by a smaller and specialized version of their spacecraft called the Extravehicular Mobility Unit (EMU). This smaller spacecraft is composed of a spacesuit with a life-support system. It is different from the larger spacecraft by being anthropomorphic (human) in shape and flexible. Flexibility permits movement of arms and legs and operation of many types of scientific apparatus, taking pictures, assembling equipment and structures, piloting the Manned Maneuvering Unit (MMU), and repairing and servicing defective and worn-out satellites and other space hardware. All these tasks are called Extravehicular Activities, or EVAs.

## The Outer Space Environment

Outer space is just what its name implies. It is the space, or vacuum, that surrounds the uppermost reaches of the atmosphere of Earth and all other objects in the universe. Although it is a void,

outer space maybe thought of as an environment. Radiation and objects pass through it freely. An unprotected human or any other unprotected living being placed in the outer space environment would perish in a few brief, agonized moments.

The principle environmental factor of outer space is the vacuum, or nearly total absence of gas molecules. The gravitational attraction of large bodies in space, such as planets and stars, pulls gas molecules close to their surfaces, leaving the space between them virtually empty. Some stray gas molecules are found between these bodies, but their density is so low that they can be thought of as practically nonexistent. Air inside unprotected lungs would immediately rush out.

On Earth, the atmosphere exerts pressure in all directions. At sea level on Earth, that pressure is 101 kilopascals. In space, the pressure is nearly zero. Under virtually no pressure from the outside, dissolved gases in body fluids expand, pushing solids and liquids apart. The skin expands much like an inflating balloon. Bubbles that form in the bloodstream render blood ineffective to transport oxygen and nutrients to the body's cells. Furthermore, the sudden absence of external pressure, which balances the internal pressure of body fluids and gases, can rupture fragile tissues such as eardrums and capillaries. The net effect on the body is swelling, tissue damage, and a deprivation of oxygen to the brain that results in unconsciousness in less than 15 seconds.

The temperature range found in outer space provides a second major hazard for humans. At Earth's distance from the Sun, the sunlit side of objects in space may climb to over 120° Celsius, and the shaded side may plummet to lower than minus 100° Celsius. Maintaining a comfortable temperature range becomes significant.

Other environmental problems encountered in outer space include weightlessness, electrically charged particle radiations from the Sun, ultraviolet radiation, and micrometeoroids. Micrometeoroids are usually very small bits of rock and metal left over from the formation of the solar system and from the collisions of comets and asteroids. Though small in mass, these particles travel at very high velocities and can

easily penetrate human skin and thin metal. Equally dangerous is debris from previous space missions. A tiny paint chip, traveling at thousands of kilometers per hour, can do substantial damage.

## Spacesuit Design

Spacesuits were first used by the U.S. manned space flight program for EVAs during the Gemini missions. The suits were custom built to each astronaut's body size. In the Apollo program, for example, an astronaut had three custom suits—one for flight, one for training, and one for flight backup. Space Shuttle suits, however, are tailored from a stock of standard-size parts to fit astronauts over a wide range of individual variations.

In constructing the Shuttle spacesuit, developers were able to concentrate all their designs toward a single function—going EVA. Spacesuits in earlier manned spaceflight programs had to serve multiple functions. They had to provide backup pressure in case the cabin lost pressure, protection if ejection became necessary during launch, EVA in weightlessness, and EVA while walking on the Moon in one-sixth Earth's gravity. Suits were worn during lift-off and reentry and had to be comfortable under the high-G forces experienced during acceleration and deceleration.

Now, Shuttle suits are worn only when it is time to venture outside the orbiter cabin. At other times, crew members wear comfortable shirts and slacks or shorts. The Shuttle's EMU provides pressure, thermal and micrometeoroid protection; oxygen; cooling water; drinking water; food; waste collection (including carbon dioxide and perspiration removal); electrical power; light; vision; and communications. Maneuvering for traveling beyond the Shuttle can be added by fitting a gas-jet-propelled Manned Maneuvering Unit over the EMU's primary life support system.

## Many Layers

Protection of Shuttle astronauts on EVAs is accomplished with the 12 layers of the EMU. The first two layers, starting from the inside, make up the liquid cooling and ventilation garment. It is made of Spandex fabric and plastic tubing. Next

comes a pressure bladder layer of urethane-coated nylon and a fabric layer of pressure-restraining Dacron. This is followed by a seven-layer thermal micrometeoroid garment of aluminized Mylar, laminated with Dacron scrim, and topped with a single layer of fabric combining Gortex, Kevlar, and Nomex.

## Shuttle EMU Components

The Shuttle EMU consists of 19 major components. Fully assembled, it becomes a short-term spacecraft for one person. On Earth, the suit and all its parts weigh about 113 kilograms. Orbiting above the Earth, they have no weight at all. They do, however, retain their mass in space, which is felt as resistance to a change in motion.

### 1. Primary Life Support System (PLSS)

A backpack unit containing the oxygen supply, carbon dioxide removal equipment, caution and warning system, electrical power, water cooling equipment, ventilating fan, and radio.

### 2. Display and Control Module (DCM)

Chest-mounted control module containing all controls, a digital display, and the external liquid, gas, and electrical connections. The DCM also has the primary purge valve for use with the Secondary Oxygen Pack.

### 3. Electrical Harness (EH) (not shown)

A harness worn inside the suit to provide bioinstrumentation and communications connections to the PLSS.

### 4. Secondary Oxygen Pack (SOP) (not shown)

Two oxygen tanks with a 30-minute emergency supply, valve, and regulators. The SOP is attached to the base of the PLSS but it can be removed from the PLSS for ease of maintenance.

### 5. Service and Cooling Umbilical (SCU) (not shown)

Connects the orbiter airlock support system to the EMU to support the astronaut before EVA and to provide on-orbit recharge capability for the PLSS. The SCU contains lines for power, communications, oxygen and water recharge, and water drainage. The SCU conserves PLSS consumables during EVA preparation.

### 6. Battery (not shown)

Supplies electrical power for the EMU during EVA. The battery is rechargeable in orbit.

### 7. Contaminant Control Cartridge (CCC) (not shown)

Cleanses suit atmosphere of contaminants with an integrated system of lithium hydroxide, activated charcoal, and a filter contained in one unit. The CCC is replaceable in orbit.

### 8. Hard Upper Torso (HUT)

Upper torso of the suit, composed of a hard fiberglass shell. It provides structural support for mounting the PLSS, DCM, arms, helmet, IDB, EH, and the upper half of the waist closure. The HUT also has attachments for mounting a miniworkstation tool carrier.

### 9. Lower Torso

Spacesuit pants, boots, and the lower half of the closure at the waist. The lower torso also has a waist-bearing for body rotation and mobility and brackets for attaching a safety tether.

### 10. Arm

Shoulder joint and armscye (armhole) bearing, upper arm bearings, elbow joint, and glove-attaching closure.

### 11. Glove

Wrist bearing and disconnect, wrist joint, and fingers. One glove has a wristwatch sewn onto outer layer. The gloves have tethers for restraining small tools and equipment. Generally, crew members wear thin fabric comfort gloves with knitted wristlets inside.

### 12. Helmet

Plastic pressure bubble with neck disconnect ring and ventilation distribution pad. The helmet has a backup purge valve for use with the secondary oxygen pack to remove expired CO<sub>2</sub>.

### 13. Liquid Cooling and Ventilation Garment (LCVG) (not shown)

Long, underwear-like garment worn inside the pressure layer. Has liquid-cooling tubes, gas ventilation ducting, and multiple water and gas connectors for attachment to the PLSS via the HUT.

**14. Urine Collection Device (UCD)** (not shown)  
Urine collection device consisting of a roll-on cuff adapter and storage bag (for male crew members). The UCD is disposable after use.

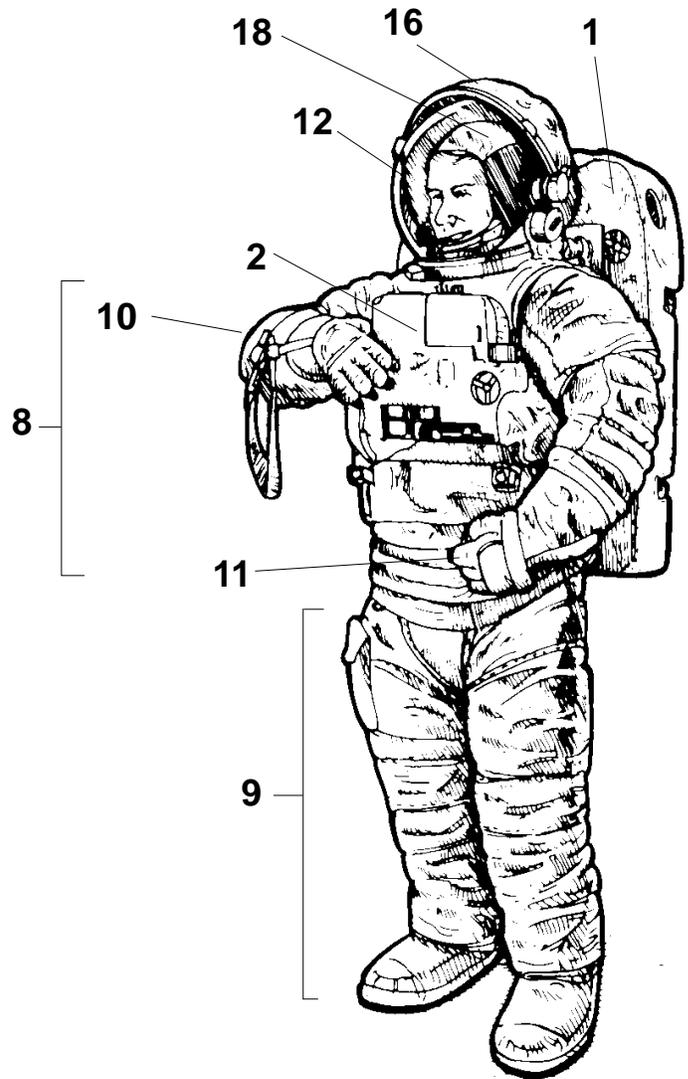
**15. Disposable Absorption Containment Trunk (DACT)** (not shown)  
Urine-collection garment consisting of a pair of shorts constructed from five layers of chemically-treated absorbent, nonwoven, fibrous materials (for female crew members)

**16. Extravehicular Visor Assembly**  
Assembly containing a metallic gold-covered sun-filtering visor, a clear thermal-impact-protective visor, and adjustable blinders that attach over the helmet. In addition, four small "head lamps" are mounted on the assembly, and a TV camera-transmitter may also be added.

**17. In-suit Drink Bag (IDB)** (not shown)  
Plastic water-filled pouch mounted inside HUT. A tube projecting into helmet permits crew member to drink as if with a straw.

**18. Communications Carrier Assembly**  
Fabric cap with built-in earphones and a microphone for use with the EMU's radio.

**19. Airlock Adapter Plate** (not shown)  
Fixture for mounting and storing the EMU inside the airlock and for donning the suit.



**Space Shuttle EMU**

## Terms

**Extravehicular activity (EVA)** - All tasks performed by astronauts outside their spacecraft.

**Extravehicular Mobility Unit (EMU)** - Spacesuit.

**Manned Maneuvering Unit (MMU)** - Backpack propulsion unit worn by astronauts for maneuvering in space.

**Micrometeoroids** - Tiny bits of naturally occurring rock and metal traveling through space at high velocities.

**Vacuum** - A space with nothing in it.

## Classroom Activities

The following hands-on activities demonstrate some of the concepts presented in this video tape.

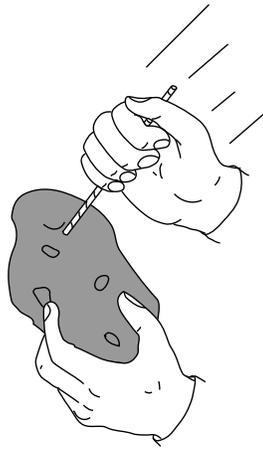
### Potato and Straw

#### Materials

Large potato  
Plastic straws (not flexible type)

#### Instructions

To illustrate why it is important to protect astronauts from high-velocity micrometeoroids in



space, show how easy it is to penetrate a potato with a straw. First, slowly press the end of a straw to the potato. The straw will bend or break. Take a second straw and sharply strike the potato with the end of it. It will penetrate completely through

the potato. Even though micrometeoroids have very low mass, they can cause severe injury to an astronaut because of their high velocities. **Caution: Be careful not to hit your hand.**

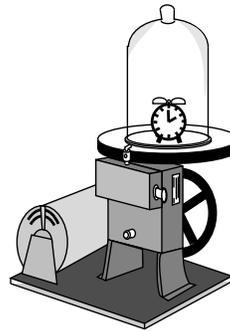
### Vacuum Pump Demonstrations

#### Materials

School vacuum pump, plate, and bell jar  
Balloon filled with water  
Windup alarm clock

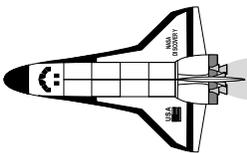
#### Instructions

Demonstrate why it is important to provide pressure for an astronaut in space by placing a balloon filled with water inside the bell jar and pumping out the air from the jar. As the pressure is lowered, water in the balloon begins to boil and the balloon



expands. The same thing could happen to human tissues exposed to the vacuum in space. A vacuum pump can also be used to demonstrate why radios are needed for communication between

space-walking astronauts. Start the clock's alarm ringing, and begin pumping out the air under the bell jar. Listen to the sound of the alarm diminish as the air is evacuated.



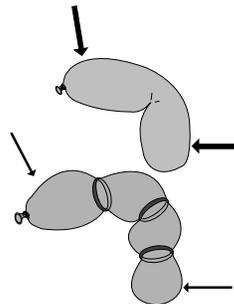
### Bending Under Pressure

#### Materials

Two long balloons  
Plastic or metal rings or heavy rubber bands

#### Instructions

To provide adequate pressure for astronauts on spacewalks, a flexible, but nonexpandable layer of the spacesuit contains oxygen. Oxygen is fed into this layer under pressure, and the pressure is



exerted on the astronaut. Unfortunately, the pressure makes the suit stiff. To illustrate this problem and what can be done about it, inflate a long balloon and let students try to bend it. Inflate a second balloon, but, when doing so, use rings or rubber bands to

pinch off the balloon like sausage links. The rings or bands provide joints that make bending easier.

## References

- Allen, J.P. with Martin, M. (1984), *Entering Space, An Astronaut's Odyssey*, Stewart, Tabori & Chang, New York.
- Challenger Center (1991), *Suited for Space Activity Book*, Challenger Center for Space Science Education, Alexandria.
- Compton, W. & Bensen, C. (1983), *Living and Working In Space, A History of Skylab*, NASA SP-4208, Scientific and Technical Information Branch, NASA, Washington, DC.
- Froehlich, W. (1971), *Apollo 14: Science at Fra Mauro*, EP-91, NASA.
- Machell, R. ed. (1967), *Summary of Gemini Extravehicular Activity*, NASA SP-149, Scientific and Technical Information Division, Office of Technology Utilization, NASA, Washington, DC.
- Mohler, S.R. & Johnson, B.H. (1971), *Wiley Post, His Winnie Mae, and the World's First Pressure Suit*, Smithsonian Institution Press, Washington.
- NASA (1970), *Apollo 12, A New Vista for Lunar Science*, EP-74.
- NASA (1970), *The First Lunar Landing As Told by The Astronauts*, EP-73.
- NASA (1971), *Apollo 15, At Hadley Base*, EP-94.
- NASA (1972), *Apollo 16 At Descartes*, EP-97.
- NASA (1973), *Apollo 17 At Taurus-Littrow*, EP-102.
- NASA (1973), *Apollo*, EP-100.
- NASA (1987), "The Early Years: Mercury to Apollo-Soyuz," Information Summaries, PMS 001-A (KSC).
- Vogt, G. & Haynes, R. (1990), *Spacesuit Guidebook*, PED-117, NASA.
- Vogt, G. (1987), *Spacewalking*, Franklin Watts, New York.
- Vogt, G. (in press), *Space Suit Activity Guide*, PED-000, NASA Educational Affairs Division, Washington, DC. (Available in 1992)

## STS-37 Crew Biographies

**Commander: Steven R. Nagel (Col., USAF).** Steven Nagel was born in Canton, Illinois, and received a Bachelor of Science degree in aeronautical and astronautical engineering from the University of Illinois. He also earned a Master of Science degree in mechanical engineering from California State University, Fresno. Nagel served as an Air Force pilot and first flew into space as a mission specialist on the STS-51G mission. He also flew as the pilot on the STS-61A West German Spacelab D-1 mission.

**Pilot: Kenneth D. Cameron (Lt. Col., USMC).** Kenneth Cameron was born in Cleveland, Ohio. He earned Bachelor and Master of Science degrees in aeronautics and astronautics from the Massachusetts Institute of Technology. Cameron is a Marine Corps aviator and test pilot. This was his first spaceflight.

**Mission Specialist: Linda Godwin (Ph.D.).** Linda Godwin's hometown is Jackson, Missouri. She received a Bachelor of Science in mathematics and physics from Southeast Missouri State. She also earned a Master of Science and a doctorate in physics from the University of Missouri. Godwin joined NASA in the Payload Operations Division before becoming an astronaut. This was her first flight into space.

**Mission Specialist: Jerry L. Ross (Lt. Col., USAF).** Jerry Ross was born in Crown Point, Indiana, and received a Bachelor of Science and Master of Science degree in mechanical engineering from Purdue University. Ross previously flew in space on the STS-61B and STS-27 missions. During his first mission he made two 6-hour spacewalks.

**Mission Specialist: Jay Apt (Ph.D.).** Jay Apt was born in Springfield, Massachusetts, but considers Pittsburgh, Pennsylvania, his hometown. Apt received a Bachelor of Arts degree in physics from Harvard College and a doctorate in physics from Massachusetts Institute of Technology. Apt began work for NASA in its Earth and Space Sciences Division at the Jet Propulsion Laboratory. This was his first space flight.

# *Go for EVA*

## Video Tape and Video Resource Guide Evaluation

The National Aeronautics and Space Administration would appreciate your taking a few minutes to evaluate the *Go for EVA* video tape and accompanying guide. Your feedback will be of great assistance in helping to develop new educational materials. When completed, please fold on the dotted line, staple or tape, and return to us by mail. Thank you.

SA - Strongly Agree  
 A - Agree  
 U - Undecided  
 D - Disagree  
 SD - Strongly Disagree

Please circle one

- |   |             |
|---|-------------|
| 1. <i>Go for EVA</i> is easy to integrate into the curriculum.  | SA A U D SD |
| 2. <i>Go for EVA</i> is appropriate for the grade level(s) I teach.   | SA A U D SD |
| 3. <i>Go for EVA</i> is just the right length for my students.  | SA A U D SD |
| 4. The video resource guide is a useful supplement to the video tape.   | SA A U D SD |
| 5. The instructions and background information in the video resource guide are complete and easy to understand. | SA A U D SD |

6. I teach \_\_\_\_\_ grade.

7. I teach the following subjects: \_\_\_\_\_

8. I showed *Go for EVA* \_\_\_\_\_ times to \_\_\_\_\_ students and teachers.

9. Please use the space below to comment on the video tape and the video resource guide. Feel free to elaborate on any of the questions above

---



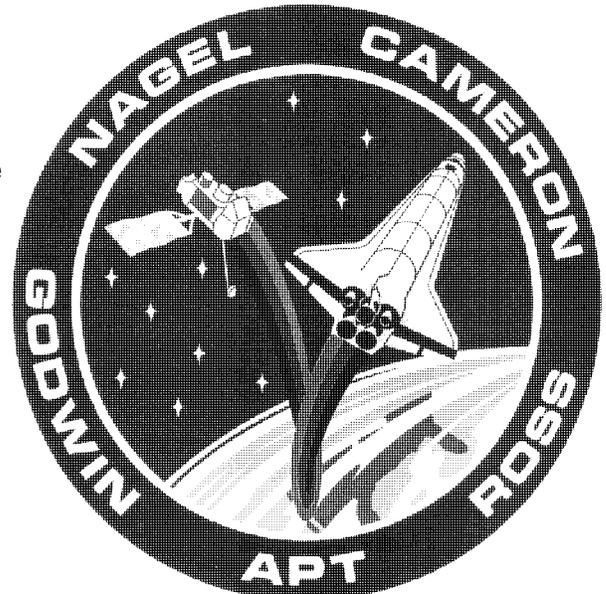
---



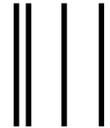
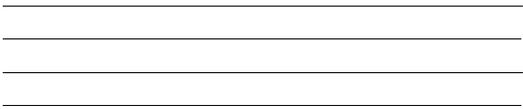
---



---



FOLD ALONG DOTTED LINE. TAPE OPPOSITE EDGE.



PLACE  
STAMP HERE  
POST OFFICE WILL  
NOT DELIVER  
WITHOUT PROPER  
POSTAGE

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
EDUCATION DIVISION  
CODE FET  
WASHINGTON, DC 20546-0001**

