Shuttle Spacesuits

Grade Level: 8
Time Required: 45 - 60 minutes

Countdown:
Several metric measuring tapes
Metric rulers
Cardboard calipers
Brass paper fasteners
Pencil and paper
Field-of-view measuring device: (plywood board 60 x 30 cm), white poster board, thumbtacks, marking pen, protractor

Ignition:
Like the shuttle itself, the new shuttle spacesuit Extravehicular Mobility Unit (EMU) is reusable. Spacesuits used in previous manned space flight programs were not; they were custom made to each astronaut’s body size. For example, in the Apollo program, each astronaut had three suits – one for flight, one for training, and one for flight backup. Shuttle suits, however are tailored from a stock of standard-size parts to fit male and female astronauts with a wide range of measurements.

Earlier suits had to serve multiple functions. In the Gemini mission, they had to provide backup pressure in case of cabin pressure failure and protection if ejection became necessary during launch. In the Apollo missions, they had to provide an environment for EVA in microgravity and walking on the moon. Suits were worn during liftoff and reentry and had to be comfortable under the high-g forces experienced during acceleration and deceleration.

Shuttle suits are designed to serve one function – going EVA (spacewalking). They are worn in their entirety only when it is time to venture outside the orbiter cabin. Otherwise, the crew wears comfortable shirts and slacks, or coveralls.

The suit is a pressure retention structure that, coupled with a life support system, provides a life-sustaining environment that protects the astronauts against the hazards of space. These hazards include the following:

1) temperature extremes of -300 degrees F
2) a vacuum environment, where low pressure would allow blood to boil
3) the impact of micrometeroids, which could rip through the spacesuit.

Twelve garment layers serve to protect astronauts from these hazards. The two inner layers, made of spandex fabric and plastic tubing, comprise the liquid-cooling and ventilation
garment. Next comes the pressure bladder layer of urethane-coated nylon and a fabric layer of pressure-restraining Dacron. This is followed by a seven-layer micrometeroid garment of aluminized Mylar, laminated with Dacron scrim topped with a single-layer fabric combination of Gortex, Kevlar, and Nomex materials.

Computer or Library Research

- Students will look up the characteristics of the following fabrics and their uses.
  - Dacron, Mylar, Gortex, Kevlar, Nomex
- Visit the following web site for additional information

Liftoff:

Spacesuit Parts

A. Discuss with students the 19 separate parts of an EVA shuttle spacesuit.

1. Primary Life-Support System (PLSS) -
   a self-contained backpack unit with an oxygen supply, carbon-dioxide removal equipment, caution and warning system, electrical power, water cooling equipment, ventilating fan, machinery, and radio

2. Displays and Control Module (DCM) -
   a chest-mounted control module with all controls, a digital display, and the external liquid, gas, and electrical interfaces; has the primary purge valve for use with the SOO

3. EMU Electrical Harness (EEH) -
   a harness worn inside the suit to provide bioinstrumentation and communications connections to the PLSS

4. Secondary Oxygen Pack (SOP) -
   2 oxygen tanks with a 30-minute emergency supply, valve, and regulators; it is attached to the base of the PLSS
5. **Service and Cooling Umbilical (SCU)** - connects the orbiter airlock support system to the EMU to support the astronaut before EVA and to provide in-orbit recharge capability for the PLSS; contains lines for power, communications, oxygen and water recharge, and water drainage

6. **Battery** - supplies electrical power for the EMU during EVA; is rechargeable in orbit

7. **Contaminant Control Cartridge (CCC)** - cleanses suit atmosphere of contaminants; is replaceable in orbit

8. **Hard Upper Torso (HUT)** - composed of a hard fiberglass shell; provides a structural support for mounting the PLSS, DCM, arms In-Suit Drink Bag, EEH and the upper half of the waist closure; can mount a mini-workstation tool carrier

9. **Lower Torso** - spacesuit pants, boots, and the lower half of the closure at the waist; has a waist bearing for body rotation and mobility, and brackets for attaching a tether

10. **Arms (left and right)** - shoulder joint and armscye (shoulder) joint and armscye (shoulder) bearing, upper arm bearings, elbow joint, and glove-attaching closure

11. **EVA Gloves (left and right)** - wrist bearing and disconnect, wrist joint, and fingers; one glove has a wrist-watch sewn onto the outer layer; both have tethers for restraining small tools and equipment; thin fabric comfort gloves with knitted wristlets are also worn underneath

12. **Helmet** - plastic pressure bubble with neck disconnected ring and ventilation pad; has a backup purge valve for use with the secondary oxygen pack to remove expired carbon dioxide

SpaceExplorers http://www.tsgc.utexas.edu/spaceexplorers/
Life Sciences: Shuttle Spacesuit
Texas Space Grant Consortium http://www.tsgc.utexas.edu/
13. Liquid Cooling and Ventilation Garment (LCVG) - 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 through the HUT

14. Urine Collection Device (UCD) - for male crewmembers consisting of a roll-on cuff and storage bag; discarded after use

15. Disposable Absorption and Containment Trunk (DACT) - for female crewmembers consisting of a pair of shorts made from 5 layers of chemically treated absorbent nonwoven fibrous materials; discarded after use

16. Extravehicular Visor Assembly (EVA) - contains a metallic-gold covered sun-filtering visor, a clear-thermal impact-protective visor, an adjustable blinder that attaches over the helmet; also, 4 small “head lamps” are used and a TV camera-transmitter may be added

17. In-Suit Drink Bag (IDB) - plastic water-filled pouch mounted inside the HUT; a tube projecting into the helmet works like a straw

18. Communications Carrier Assembly (CCA) - fabric cap with built-in earphones and a microphone for use with the EMU radio

19. Airlock Adapter Plate (AAP) - fixture for mounting and storing the EMU inside the airlock; also used to help put on the suit

When fully assembled, the shuttle EMU is a nearly complete short-term spacecraft for one person. It provides pressure, thermal and micrometeoroid protection, oxygen, cooling water, drinking water, food, waste collection (including carbon dioxide removal), electrical power, and communications. The only thing that the EMU lacks is manuvering capability, but this can be added by fitting a gas jet propelled Manned Maneuvering Unit (MMU) over the EMU’s primary life-support system.

On Earth, the suit fully assembled with all its parts (except the MMU) weighs about 113 kilograms. Orbiting above Earth, it has no weight at all. It does, however, keep its mass in space, which is felt as resistance to a change in motion.
Getting the Right Fit

1. Working in teams of 3 to 5, ask the students to design and build space helmets that can be used by anyone in the class.
2. Working in teams, the students should take four separate measurements of each member’s head in centimeters, and record the data. Measure the following:

- Head Circumference
- Head Breadth
- Head Depth
- Chin to Top of Head

Use calipers and a cloth tape measure for the actual measuring. Be sure the students check their work and record all data.

3. After the measurements are taken, the teams should calculate the average measurements for all members of the team.
4. Each group will report the average for each measurement to the class. The class will then calculate the classroom average for each measurement.

Field of View Measure

1. Construct a field-of-view measurement device out of wood and poster board. Cut a partial circle (220 degrees) with a radius of at least 30-cm out of plywood. Refer to the pattern on the next page for details. Tack or glue a strip of white poster board to the arc. Using a protractor and a marking pen, measure and mark the degrees around the arc as shown in the illustration.
2. Place the device on the edge of a table so that it extends over the edge slightly. Begin measuring the field of view by having a student touch his or her nose to the center of the arc and look straight ahead. Have a second student slide a marker, such as a small strip of folded paper around the arc. Begin on the right side of the 110-degree mark. The student being tested should say, “Now”, when he or she sees the marker out of the corner of the eye. Record the angle of the marker on a data table for the right eye. Repeat for the left eye.

3. Take the same measurements for the other students. When all the data have been collected, calculate the average field of view for all students.

Designing A Space Helmet

1. Working in the same teams as before, have the students draw sketches on graph paper of their ideas for a space helmet that could be worn by anyone in class. The students should determine a scale on the graph paper that will translate into a full-size helmet. In designing the helmet, three considerations must be met. First, it must fit anyone in the class. Second, it must provide adequate visibility. Finally, it must be made as small as possible to reduce its launch weight and make it as comfortable to wear as possible.

2. Students may wish to add special features to their helmet designs such as mounting points for helmet lights and radios.

Building a Space Helmet

1. Have each team inflate a large round balloon to serve as a form for making a space helmet. Tie the balloon with a string.
2. Using strips of newspaper and paper maché paste, cover the balloon except for the nozzle. Put on a thin layer of newspaper and hang the balloon by the string to dry.
3. After the first layer of paper maché is dry, add more layers until a rigid shell is formed around the balloon. Lights, antennas, and other appendages can be attached to the helmet as the layers are built up.
4. Using a pin, pop the balloon inside the paper maché shell. According to the design prepared in the earlier activity, cut out a hole for slipping the helmet over the head and a second hole for the eyes.
5. Paint the helmet, and add any designs desired.
6. When all helmets are completed, evaluate each one for comfort and utility. Have students try on the helmets and rate them on a scale that the students design. (Example: on a scale of 1 to 5, with 1 being the best, how easy is it to put the helmet on?)