# Engineering Activity 2

## Mass and Speed:
### Protecting Space Suits from Orbital Debris

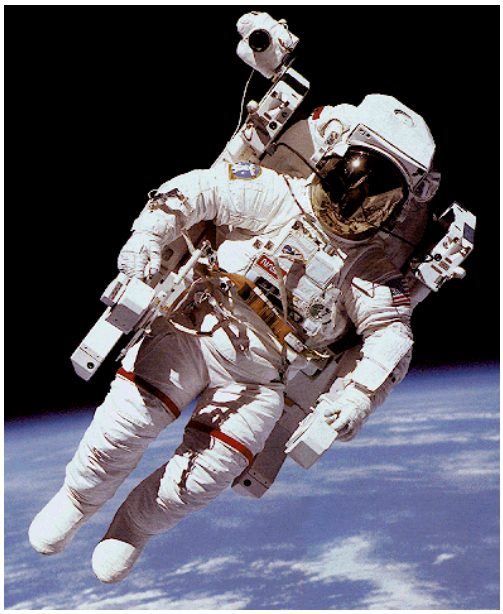

**Figure 1.** Extravehicular Mobility Unit (EMU) outside of the International Space Station.

**Objective**
To investigate the relationship between mass, speed, velocity, and kinetic energy. To apply an engineering design test procedure to determine impact strength of various materials.

**NASA Challenge**
You are a NASA Space Suit Engineer and you need to select the best material to be used on your space suit. You need to pick a material that can survive an impact (hit) by a piece of space debris the size of a marble traveling at different speeds.

**Background**
The International Space Station (ISS) orbits about 400 kilometers (250 miles) above the surface of the earth. The ISS is surrounded by human-made debris (trash) which can impact (hit) the ISS or the astronauts in space suits outside of the ISS at speeds up to about 7 kilometers per second (16000 miles per hour). Debris traveling at high speeds can cause life threatening damage to the ISS the space suits. Data collected by the International Space Station helps to track these objects.

**Grade Level:** 5th, 6th, 7th, 8th

**Key Topic:** Mass and Speed

**Prep Time:** 1 hour

**Class Time:** 50 minutes

**Materials per Group**

- 1 empty tissue box
- 1 pair of scissors
- 1 roll of cellophane tape
- 10 napkins
- 10 paper towels
- 1 small marble
- 1 large marble
- 1 meter stick

**National Science Content Standards:**

- Physical Science
  - Motion and Forces
- Science and Technology
  - Abilities of Technological Design
- Science in Personal and Social Perspectives
  - Personal Health

**National Mathematics Content Standards:**

- Measurement
  - Apply appropriate techniques, tools, and formulas
- Data Analysis
  - Develop and evaluate inferences and predictions based on data
- Problem Solving
- Connections
- Representations

**Vocabulary:**

- Debris
- Force
- Kinetic Energy
- Mass
- Speed
- Velocity

**Management**
This activity can be conducted in a classroom environment. Ideally, have three (3) students per team.

Other materials like tissues, aluminum foil, etc. may be used in the place of the napkins and paper towels. Marbles can be replaced with other objects if desired. A student handout with answer key is provided.

## Additional Information for Teachers

### Types of Orbital Debris

1. **Natural Debris.** This comes from asteroids and comets that pass near Earth. It is usually smaller and harder to observe than human-made debris.
2. **Orbital Debris.** This means all human-made space objects that aren't being used. These are caused by pieces from rockets and satellites.

Both types of debris are called Micrometeoroid and Orbital Debris (MMOD).

**How much orbital debris is in Earth orbit?**
In Earth orbit there are about 19,000 objects bigger than 10 cm, about 500,000 objects between 1 and 10 cm, and millions of objects smaller than 1 cm.

**How is the International Space Station protected from orbital debris?**
The ISS is the most heavily shielded space craft ever flown. Important areas like the modules (sections) where the astronauts live can survive hits from orbital debris less than 1 cm in diameter. The ISS can also move to avoid larger objects.

**How are astronauts protected when they need to go outside of the ISS?**
Astronauts sometimes need to go outside of the ISS to do repairs and inspections. These are called Extravehicular Activities (EVAs). The astronauts use a space suit to protect them, called the EVA Mobility Unit (EMU).

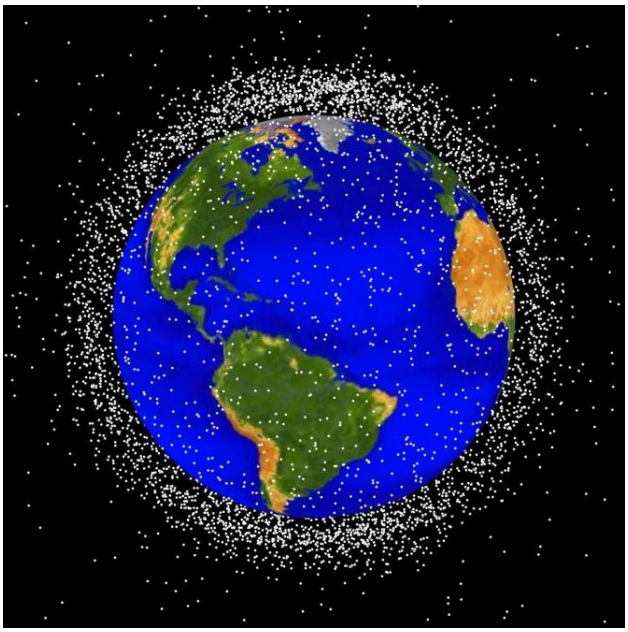

**Figure 2.** The white dots in this image show the orbital debris that is currently circling the Earth.

### Space Suit Layers

This activity focuses on the engineering design and testing process used to select the best materials to protect the astronauts while they are in their space suits. The space suit is protected by multiple layers of materials with each layer serving a different function. The layers of the suit from inside to outside are:

1. **Pressure garment bladder**. This is a urethane coated nylon oxford material (kind of like a rubber balloon) which keeps all the breathing air inside the space suit.

2. **Pressure garment restraint layer.** This layer is made of Dacron (a material commonly found in tents). This gives the pressure garment bladder a human shape and holds it close to the body of the astronaut.

**The next layers of the suit are called the Thermal Micrometeoroid Garment (TMG).**

3. **TMG Liner.** The inside layer is made of Neoprene (a material found in wetsuits). It protects astronauts from the temperature extremes in space.
4. **TMG Insulation.** This is made of about 6 layers of aluminized Mylar (a material commonly found in metallic balloons), and insulates the astronauts to keep them at the tight temperature.
5. **TMG cover.** The outside layer is made of Nomex, Kevlar, and Teflon. These are the same kinds of materials used in a bulletproof vest, even though the space suit is not bulletproof. It protects against micrometeoroid impacts in space. It is also white because white tends to reflect more heat energy than it absorbs which prevents the space suit from getting too hot. The TMG cover layer is the focus of this engineering activity.

**How does NASA test space suit materials?**

NASA has a Hypervelocity Impact Testing Facility (HITF) located at White Sands Test Facility in New Mexico. The HITF is home of a light gas gun.

NASA has to use a light gas gun in order to accelerate small objects to speeds of up to 7 kilometers per second (16,000 miles per hour) into a space suit material sample.

A failure is defined as an impact that completely penetrates the pressure garment bladder, damages the inner liner of the pressure garment bladder, or causes the bladder to leak air or oxygen.

**Websites**

Links to more information can be found at the end of this educator guide.