a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Earth & Space Science

Exploration of Extreme Environments: Exploring Space

Science and Mathematics
Education Research Group

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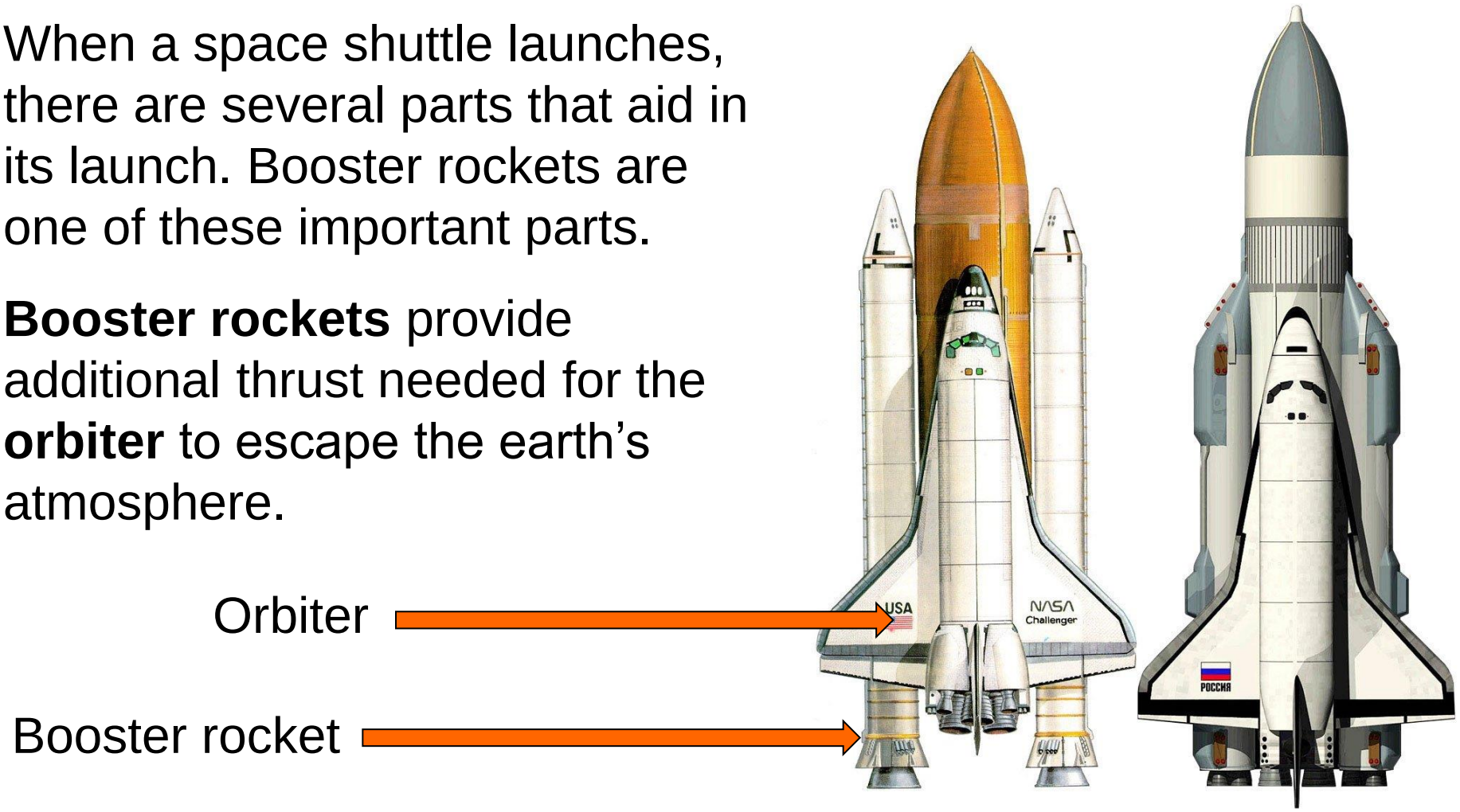
Exploring Space

Exploring Space I

When a space shuttle launches, there are several parts that aid in its launch. Booster rockets are one of these important parts.

Booster rockets provide additional thrust needed for the **orbiter** to escape the earth's atmosphere.



Exploring Space I Cont'd

What happens to booster rockets once they have used up all their fuel?

A. They stay attached and continue traveling with the orbiter
B. They remain attached to the launch pad after takeoff
C. They burn up in our atmosphere and disintegrate
D. They separate and descend on parachutes to land

Solution

Answer: D

Justification: Booster rockets (also called Solid Rocket Boosters, or SRBs) are required only for the first two minutes of launch. SRBs separate from the shuttle at an altitude of almost 45 kilometres. Once separated, they continue to travel upward (due to inertia) until they reach approximately 67 kilometres from the launch point on Earth.

Due to Earth's gravitational force, the SRBs then fall back through the atmosphere and are slowed down by a parachute system to prevent damage when they hit land. The rocket launch location is chosen to ensure SRBs will land in the ocean, away from humans.

Solution Cont'd

When objects travel from space back into the earth's atmosphere, they will likely burn and disintegrate due to friction. Because space is a vacuum, objects experience no drag when they travel through it. If an object in space travels close enough to earth, it will get pulled in by Earth's gravity. This force of gravity, combined with the lack of drag causes these objects to travel at extremely high speeds. When the object moves into Earth's atmosphere the friction they encounter travelling at such high speeds makes them catch fire.

Booster rockets do not escape Earth's atmosphere, so they do not experience enough friction for them to catch fire. Also, if the booster rocket remained on the launch pad after take-off, they would only power the initial release of the rocket, which would not be able to leave the atmosphere.

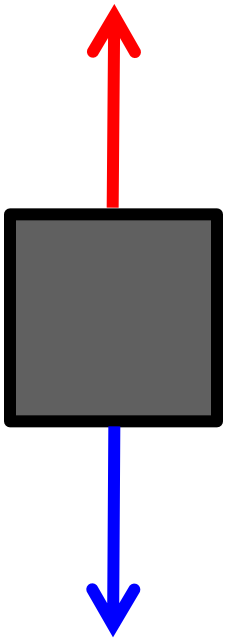
Extend Your Learning: Video

Title: Shuttle's Boosters Recovered in HD

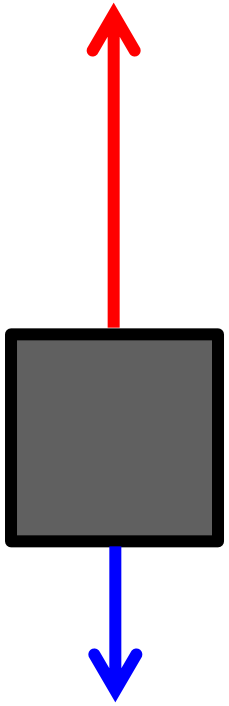
Exploring Space II

Which diagram correctly represents the magnitude (or size) of forces acting on a rocket immediately after it is launched?

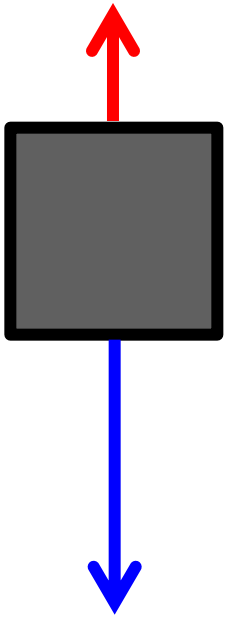
A.



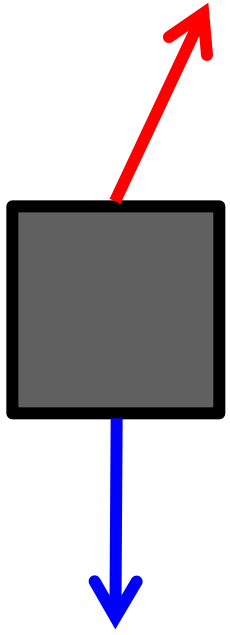
B.



C.



D.



Note: The grey square represents the rocket, the red arrow represents thrust and the blue arrow represents gravity (weight).

Solution

Answer: B

Justification: In order for a rocket to launch successfully, the thrust it experiences must be much greater than the force of gravity that it experiences.

Figure A: The two forces are equal;
the rocket will not be able to change speed.

Figure B: Thrust is greater than gravity (weight) and the rocket is able to take off.

Solution Cont'd

Figure C: Gravity (weight) is greater than thrust; the rocket will not move upward, and is unable to move down because it is positioned on the ground. The ground pushes up on the rocket with equal force, keeping objects from falling through the surface. If the rocket had been above the ground, it would fall.

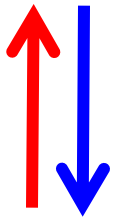
Figure D: The magnitudes (lengths) of both forces are equal, but the thrust force is acting on an angle; the rocket will move to the right.

Solution Cont'd

When two forces are acting on the same object, the **resultant force** is the sum of the two forces. The resultant force indicates the direction and speed of movement.

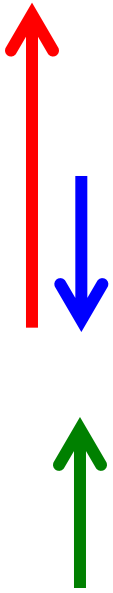
Below (in **green**) are the resultant forces for each of the scenarios in the question.

A.



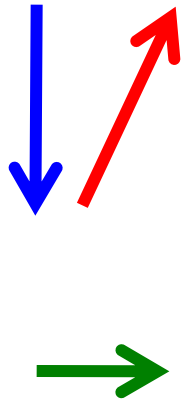
None – these two forces counterbalance each other

B.



C.

D.



Extend Your Learning: Take the Quiz

Title: Blastoff! The Big, Bad Space Launch System Quiz

Extend Your Learning: Video

Title: Discovery Launch Captured by Multiple Cameras

Exploring Space III

A **payload** refers to anything that is launched into space.

Which of the following would be the best example of a payload?

A. The moon

B. A booster rocket

C. A communication satellite

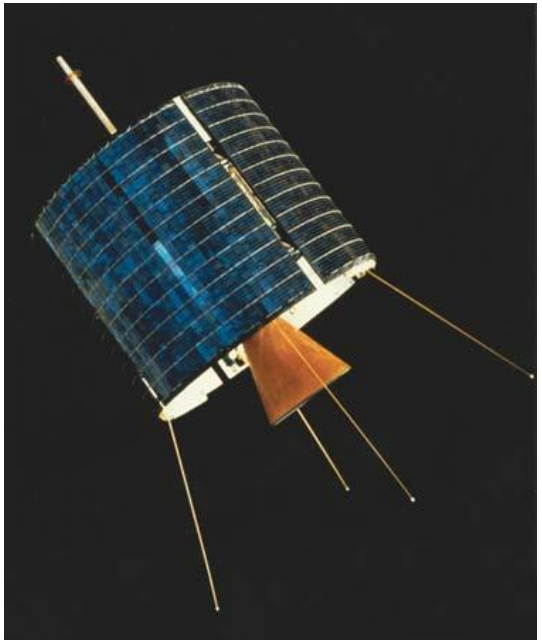
D. Radio waves

E. Global Positioning System (GPS)

Solution

Answer: C

Justification: Many communication satellites orbit Earth in order to provide various communication links across the globe. For example, these satellites increase the speed of television and telephone communication. These satellites are made on Earth and then launched into space as a payload.



These satellites must be able to withstand the shock of a launch into orbit at a speed greater than 28 000 km/h. Satellites must be small and made of lightweight materials in order to remain intact in an environment of high radiation and extreme temperature. Many satellites have an operational lifetime of up to 20 years.

Solution Cont'd

While the moon is a natural satellite of the Earth, it began and will remain in space as all natural satellites do.

Booster rockets assist a spacecraft to gain the thrust needed to escape the earth's atmosphere. Once they have used up all of their fuel, they detach and fall back to the earth's surface.

Radio waves are a type of electromagnetic radiation. They are invisible waves that travel through the Earth's atmosphere as well as the vacuum of space.

Global Positioning System (GPS) uses a number of satellites to operate. While these satellites would have been payloads launched into space at one point, the system itself is not one single payload that gets launched into space.

Exploring Space V

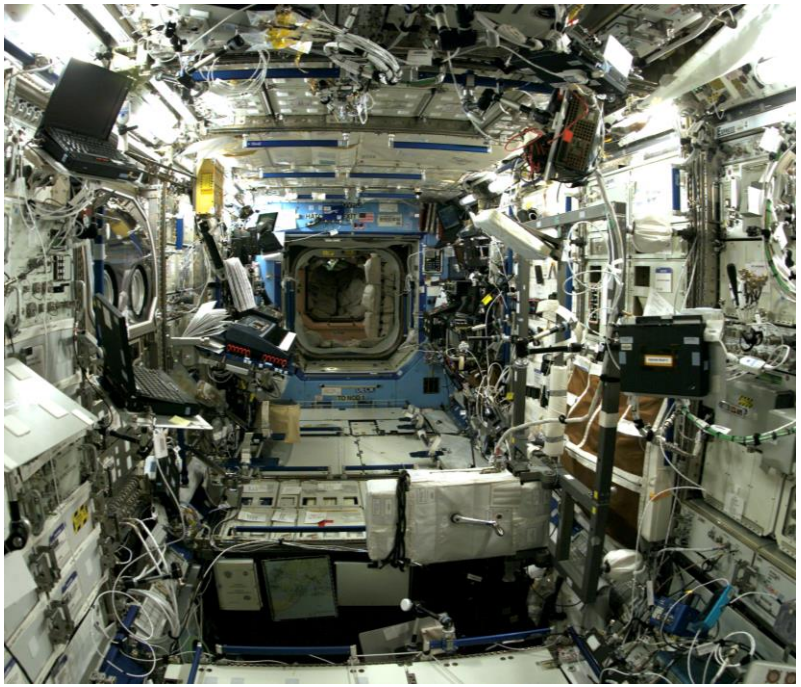
Which of the following statements is NOT true about the International Space Station (ISS)?

A. Astronauts on the ISS experience no gravity while working and living onboard

B. The ISS has astronauts from many different countries working in it at any given time

C. Astronauts carry out experiments on themselves while on the ISS

D. Astronauts use robots while on the ISS to repair other satellites orbiting Earth



Solution

Answer: A

Justification: Surprisingly, astronauts DO experience a gravitational pull in orbit on the ISS, just not a lot! We call this **microgravity**; the state that looks like astronauts are floating (sometimes called “zero gravity”). While objects in the space station appear to be floating, they are, in fact, free-falling at the same speed the spacecraft is orbiting the earth – 28 000 km per hour!

International astronauts come to the ISS from four agencies that have an agreement within NASA: European Space Agency (ESA), the Japanese Aerospace Exploration Agency (JAXA), the Brazilian Space Agency (AEB), and the Canadian Space Agency (CSA).

Solution Cont'd

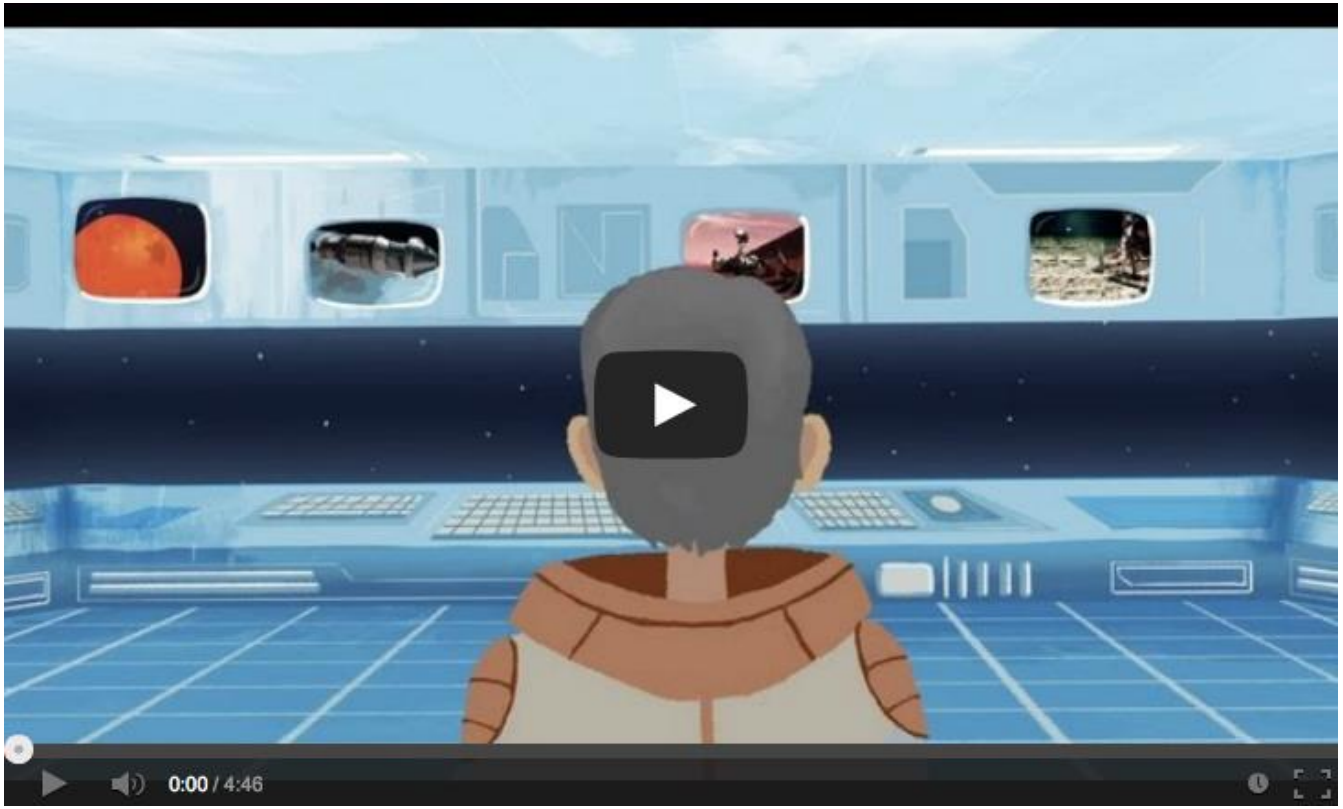
Among many others, some experiments on the ISS include vaccine development and exploring the strength in human bones and how exercise affects astronauts' performance. Experiments and research being carried out on the ISS are generally aimed at improving human health.

Click HERE to learn more about the Canadian-led experiments that are currently being carried out on the ISS.

Robots on the ISS are used to repair satellites and carry out tasks that would be too risky for humans to do while on space walks. These robots include the Canadarm2 and Dextre; both are part of Canadian's contribution to the ISS and space exploration!

Extend Your Learning: Video

Title: Gravity and the human body



Exploring Space VI

You now know that the ISS serves many purposes.

What is the **primary** reason for the ISS?

A. To make communication easier among the astronauts from different countries

B. For astronauts to carry out experiments and research that they would not be able to conduct on Earth

C. To gather images of planets, stars, and the earth from space

D. To fix other technology orbiting the earth such as the Hubble space telescope

Solution

Answer: B

Justification: Although all of the options include tasks that the ISS is necessary for, the reason that the ISS was first sent up into space (i.e. its primary purpose) is so that astronauts can carry out research in microgravity; something that they wouldn’t be able to do on Earth.

Experiments on the ISS include studies of plant and cell growth, and the strength in human bones.

Extend Your Learning: Fast Facts

The International Space Station (ISS) in Numbers:

Date of launch: November 20, 1998

Length: 51 metres

Mass: 419 455 kilograms

Number of orbits around the earth: 57 361

Continuous human occupation from: November 2, 2000

Total number of visitors: 204

Number of space walks for assembling ISS: 168

Number of computers to control all systems on the ISS: 52

Exploring Space VII

Canadarm2 has been used on missions to fix the Hubble space telescope and many communication satellites.

How is the Canadarm2 controlled?

A. Magnetic forces between objects in microgravity connect the parts to each other

B. Astronauts go on space walks and move the parts as needed

C. It is operated using a joystick from within the ISS

D. It is programmed from the control room within the ISS

E. It is controlled from Earth at the ISS Mission Control in Houston, TX

Solution

Answer: C

Justification: Somewhat like controlling a player in a video game, the Canadarm2 is controlled by astronauts on the ISS using a joystick. When fully extended, the Canadarm2 measures 17.2 metres, and astronauts require special training to operate its control in order to perform its functions.

The Canadarm2 was launched to the ISS in 2001, to replace the original Canadarm as a larger, more technologically advanced robotic “arm.” The Canadarm2 is capable of handling large payloads outside of the ISS and assists in station assembly and maintenance.

Extend Your Learning: Video

Title: Canadarm2: How It Works

Exploring Space VIII

There are limited resources available to astronauts on the ISS, but they must still have access to the basic needs for human survival; air, water, and food. As a result, life support systems have been developed to recycle these resources for astronauts' use.

Which of the following explains a life-support system on the ISS?

A. Air is recycled through vents to regulate the temperature in the ISS

B. A tether keeps astronauts connected to the ISS during space walks

C. Plants are used to purify waste water for astronauts to drink

D. Astronauts get nutrients from dried food and supplements

Solution

Answer: C

Justification: There are four basic needs for human survival – shelter, air, food, and water. Some can be dealt with on Earth and brought with astronauts to the ISS, but others require creative solutions on the ISS to recycle the limited resources.

Shelter is provided by the ISS structure itself.

Oxygen (air) is limited on the ISS, and with multiple astronauts on the space craft at all times it is used up quickly. NASA developed a system to remove carbon dioxide (the product we produce from using oxygen) and other toxins we breathe out, but astronauts still need a source of oxygen. This is done by using solar panels on the outside of the ISS as energy to create oxygen from water.

Solution Cont'd

Although air is cycled through the ISS, and the temperature of the ISS is regulated, this is not an example of a recycling mechanism created to provide a basic need.

Food is brought from Earth and is mostly dehydrated so that it doesn't take up too much space. It is specially designed to last for long periods of time and provide astronauts with the nutrients they need.

Water is more difficult to access because it takes up space and only so much can be brought to the ISS. NASA researchers realized they could use plants to clean waste water, allowing them to recycle the limited resource.

Finally, tethers are used to keep astronauts attached to the ISS, but this does not provide any of the basic needs for survival.

Exploring Space IX

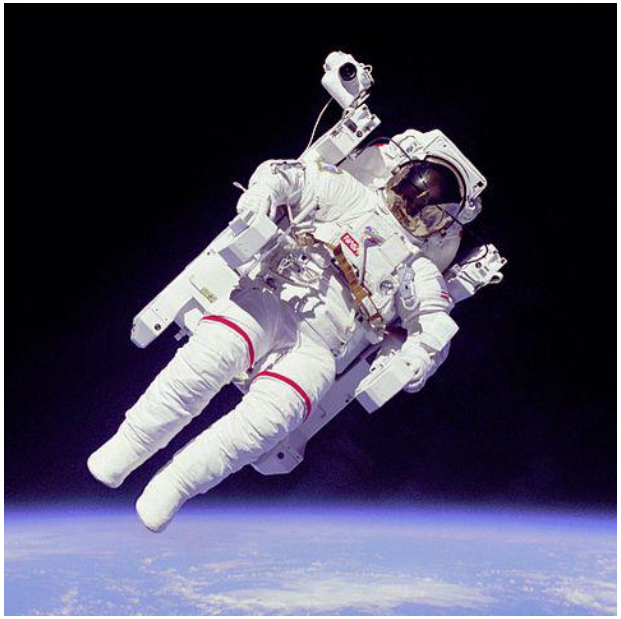
When might an astronaut require an **E**xtravehicular **M**obility **U**nit (EMU)?

1. When walking to a space shuttle for launch
2. When needing to move locations during a moon walk
3. When training for missions in the Neutral Buoyancy Laboratory
4. When in the space shuttle transitioning into microgravity
5. When an astronaut is required to work outside the spacecraft

A) 1, 4 B) 1, 2, 5 C) 2, 4, 5

D) 2, 3, 5 E) All of the above

Solution



Answer: D

Justification: The EMU is the space suit that astronauts wear when outside the spacecraft. This may be to go on a space walk, to fix something on the ISS, or during a moon walk. Astronauts also wear an EMU while training for space missions in the Neutral Buoyancy Laboratory (NBL), located at the Johnson Space Centre in Houston, Texas. The NBL is a large pool with life-sized parts similar to those on the ISS where astronauts may practice skills in a simulated microgravity environment.

Exploring Space X

What may be the greatest threat to an astronaut while wearing an EMU?

A. Keeping an astronaut’s body temperature regulated

B. Exposure to various types of radiation

C. Getting a tear in the outer layer of the suit

D. The danger of being hit with “space debris”

E. All of the above

Solution

Answer: C

Justification: The EMU is a 13 layer suit with a combination of soft and hard components designed for an astronaut's mobility and comfort. For an astronaut to take a space walk, and an EMU, they must go through a series of 30 steps before entering space. When worn properly, an EMU is essentially a spacecraft of it's own, completely self sufficient in space.

That said, there are several dangers when wearing an EMU on a spacewalk, the greatest of which would arguably be tear in the EMU. A tear would disengage the pressurized system of the EMU, and several things may happen which would result in death. For example, bodily liquids may boil and then freeze in space's extreme temperatures.

Solution Cont'd

The Liquid Cooling and Ventilation Garment (LCVG) is essentially a system of "long underwear" laced with plastic tubing in order to heat up and cool down an astronaut's body temperature.

Helmets in the EMU have coverings to reflect sunlight and tinted visors to reduce glare, just like one huge sunglass covering! The thick layers of the suit made out of strong materials such as Mylar, Gore-Tex and Kevlar (the same material as bullet-proof vests!) help protect an astronaut from micrometeorites traveling at fast speeds in space.

Extend Your Learning: Fast Facts

Fast facts about the Extra Mobility Unit (EMU):

Mass: 127 kilograms (on Earth)

Thickness: 0.48 cm, with 13 layers

Cost: $12 Million (per suit)

Some features:

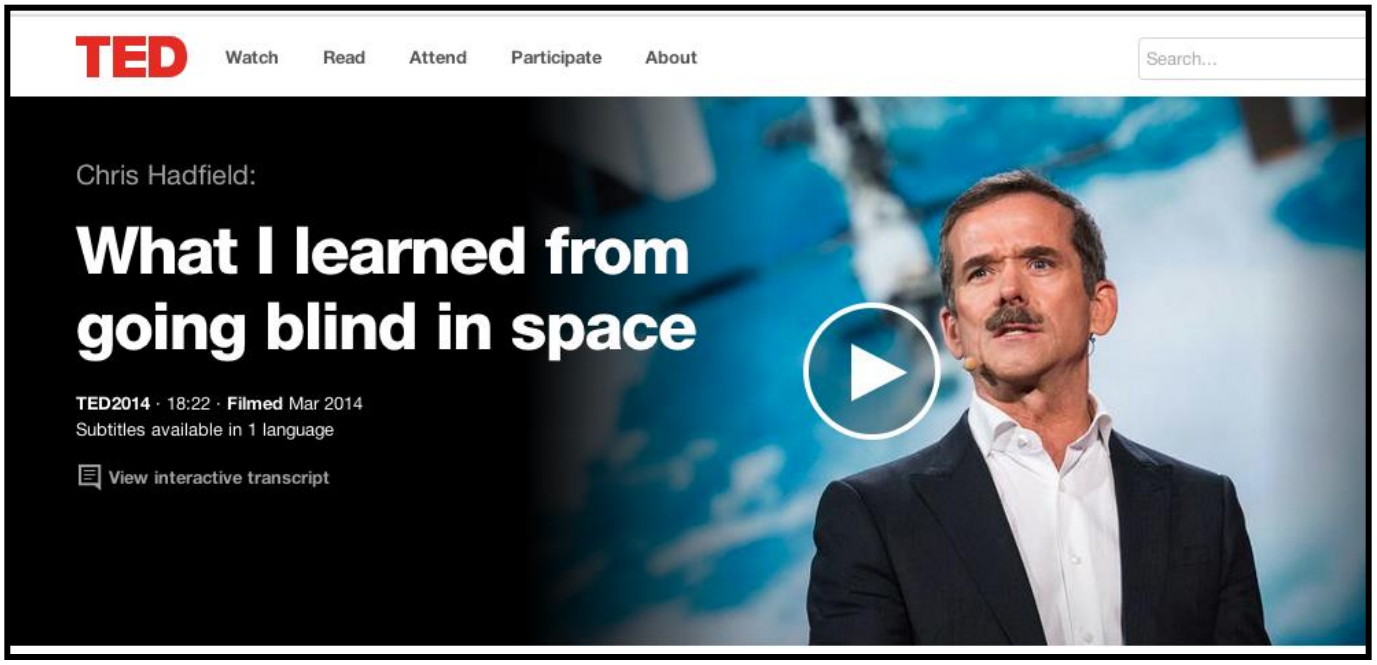
- In-Suit Drink Bag (IDB)
- Primary Life-Support Subsystems (PLSS)
- Secondary Oxygen Pack (SOP)
- Display and Control Module (DCM)
- Helmet Lights and Camera
- Sleeve-mounted Mirrors and Checklists

Extend Your Learning: Video

Title: Life of an astronaut

Extend Your Learning: Video

Title: What I learned from going blind in space



Exploring Space XII

Technology that was developed for use during space exploration is often adapted for new uses on Earth. This type of adaptation for a new use is called a **spinoff**.

What would an example of a spinoff be?

A. Astronauts using two different types of space suits

B. Dolphin echolocation inspiring the development of Sonar

C. Bar codes first being developed for keeping track of spacecraft parts

D. A rocket dispensing its payload and remaining in orbit as space junk

Solution

Answer: C

Justification: Exploration of extreme environments, in particular the exploration of the ocean and space, has developed many technologies that we use in our daily lives now.

Bar codes were developed by NASA to keep track of millions of space craft parts and now they are used in retail stores to keep track of groceries, clothes, and other items.

Other spinoffs include smoke detectors, cordless tools, freeze-dried foods, flame-resistant materials, laptops, digital watches, pacemakers, calculators, dental braces and motion sickness patches.