a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Earth & Space Science Exploration of Extreme Environments: Technology in Extreme Environments

Science and Mathematics
Education Research Group

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Technology in Extreme Environments

Technology I

Extreme environments have fascinated humans for a long time, but we are unable to survive in many of these places. Therefore, scientists have developed special tools to allow us to explore and learn about them.

What is the general name given to these tools?

A. Robots

B. Contraptions

C. Discoveries

D. Inventions

E. None of the above

Solution

Answer: E

Justification: Technology is the general name given to all tools that scientists use to make it possible for humans to survive in and explore challenging environments. Technology includes both traditional means, such as Inuit snowshoes, as well as more modern technological advances such as the Mars rover, *Curiosity*.

Inventions was a difficult answer to rule out in the previous question. Consider this – many inventions are considered technology, but not all inventions are technologies. For example, a toy manufacturer may invent new board games, stuffed animals, or figurines, but these inventions are not technologies. However, technology was most likely used to produce them.

Extend Your Learning: Video

Title: Mars Science Laboratory (Curiosity Rover) Mission Animation

Technology II

Which of the following statements is true about the use of technology to explore extreme environments?

A. People would be unable to explore extreme environments without technology

B. Technology will soon replace all human presence during exploration

C. Technology makes it easier for humans to explore extreme environments

D. Technology is not necessary for the exploration of extreme environments

E. Newer technology is only necessary when exploring the deep ocean and space

Solution

Answer: C

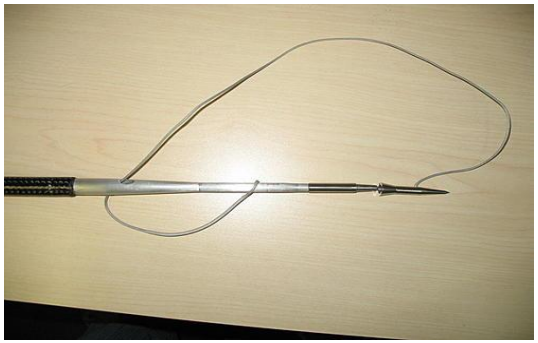
Justification: Although scientists would be able to explore extreme environments without technology, it certainly makes exploration easier, safer, and more accessible. As you may be able to imagine, only an extremely small fraction of the ocean can be explored from the shore. In fact, you may have gone exploring for sea stars and urchins in tide pools. However, in order to see, breathe and survive for a short time underwater, technology such as scuba gear, submarines and underwater submersibles are necessary.

It's interesting to think that, even with these technologies, there is still over half of the ocean left to be explored!

Technology III

Which of the following is NOT a form of technology developed and used by the Inuit peoples to survive in the harsh Arctic conditions?

A.



B.

C.

D.

Solution

Answer: A

Justification: The Inuit peoples invented tools, or technology (such as early forms of sunglasses) that have allowed humans to withstand the challenging conditions in the northern parts of Canada, the Arctic.

While the Inuit peoples are mainly hunters, this is more difficult for them during the winter months due to the thick ice and snow cover that blankets the Arctic. The spear fishing rod pictured in the previous slide is used for divers when underwater. On the other hand, Inuit peoples do not hunt underwater. Instead, they would usually use harpoon guns when hunting for fish and larger marine mammals such as the ringed seal and narwhal.

Technology IV

Consider traditional snowshoes developed by aboriginal peoples.

How does wearing snowshoes prevent people from sinking deep in the snow?

A. Snowshoes are lighter than your shoes

B. Snowshoes spread weight over a larger area

C. The snow escapes through the holes in-between the pieces of animal hide

D. All of the above

Solution

Answer: B

Justification: Aboriginal peoples invented snowshoes so that they were able to travel on top of the snow rather that sinking deep into the snow when they step. Snow can only handle so much weight before it compacts. The snowshoes spread the wearer's weight over a larger surface area than boots would, keeping the snow from compacting. This allows humans to walk on top of the snow.

Extend Your Learning: Compare & Contrast

Extension: Compare and contrast aboriginal people's snowshoes and modern day snowshoes.

How are they similar?

How are they different?

Technology V

The Newt Suit is a Canadian-made specialized diving suit used to explore ocean depths of up to 305 metres below sea level.

What advantage does the Newt Suit provide scientists over traditional scuba gear?

A. Scientists have more dexterity (ability to move) in order to collect samples of plants and animals

B. Scientists are able to travel faster and escape danger quickly in the Newt Suit

C. Scientists are able to better communicate with others when wearing the Newt Suit

D. Scientists are able to spend more time underwater when wearing the Newt Suit

Solution

Answer: D

Justification: When deep sea explorers wear the Newt Suit, they are able to remain underwater for over 8 hours. This is because the Newt Suit has a supply of breathable air much greater than the supply in a scuba tank.

While the Newt Suit allows scientists to remain underwater for long periods at one time, they don't have much dexterity or ability to move around at fast speeds. There is a motor on the back of the suit, allowing explorers to move from one location to another, as well as moving up and down in water, but it cannot travel faster than 5.5 km/hr.

Extend Your Learning: Fast Facts

Fast facts about Canada's latest contribution to deep sea exploration technology, the EXOSUIT:

Designer: Phil Nuytten & Nuytco Research

Place of Design: North Vancouver, British Columbia, Canada

Mass: 272 kilograms

Material: aluminum alloy metal

Features: communication device, high-definition camera, SONAR, lights, oxygen monitors and pincer-like claws for dexterous tasks

Use: For scientists to discover new species of plants and animals, oil rig maintenance

Technology VI

Sonar (SOund Navigation And Ranging) is a technology used to navigate, communicate and detect objects underwater.

How does Sonar work to detect objects in the ocean?

A. It emits (sends out) a pulse of sound and measures the angle of reflection to determine distance of an object

B. It emits a pulse of sound that gets absorbed into an object, which determines distance

C. It emits a pulse of sound and determines distance by the time it takes the pulse to reflect back

D. It emits a pulse of sound waves that bounce back in larger or smaller quantities, which determines distance

Solution

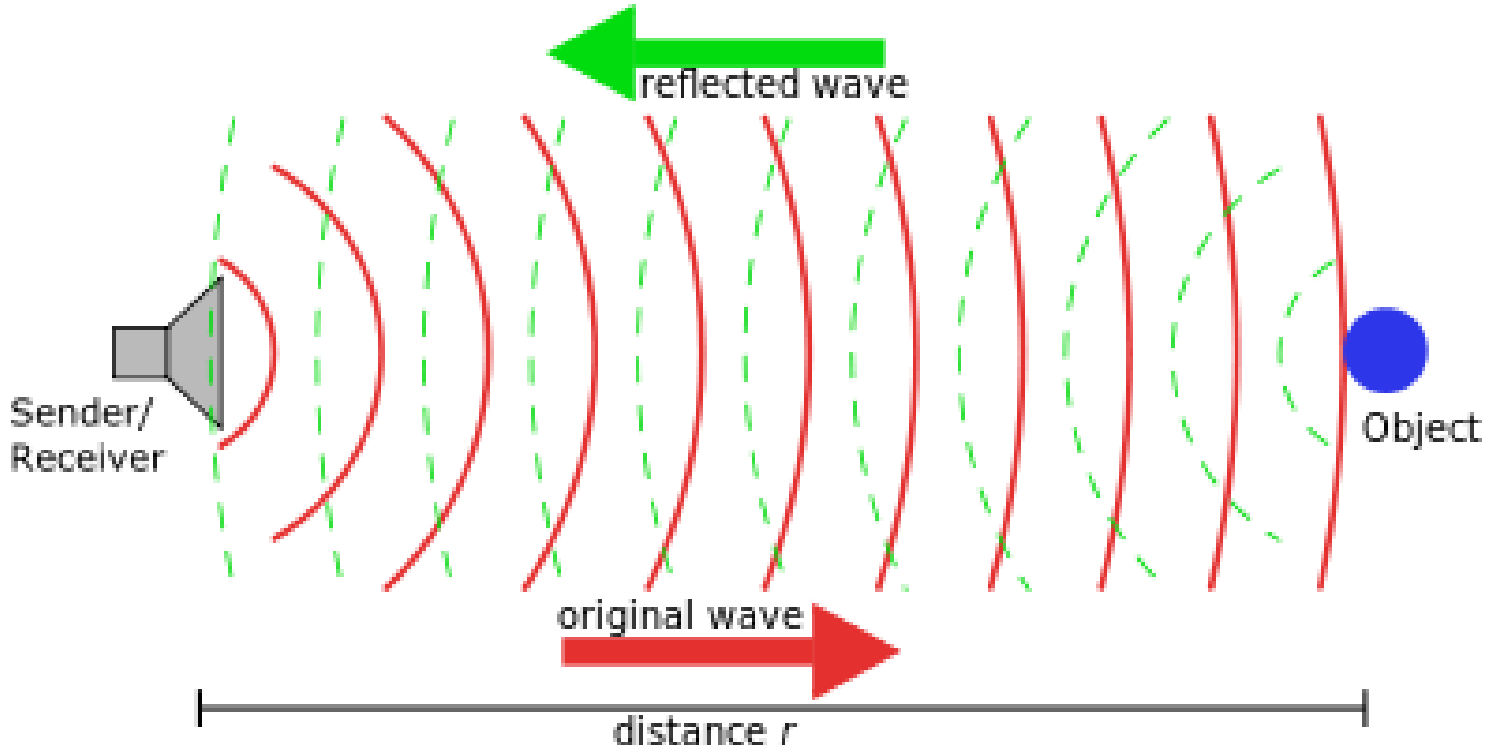
Answer: C

Justification: As the name indicates, Sonar uses the echoes of sound waves to determine the distance of objects underwater. This will also allow ships to navigate properly, by avoiding objects that may cause some danger. The pulses of sound that are emitted (sent out), often called “pings,” bounce back from an object. The time it takes a pulse to bounce back enables the receiver to determine the distance of an object underwater. For example, a ping that comes back quickly indicates something is closer than a ping that comes back slowly.

A small Sonar device that you may be familiar with is a “fishfinder.” This may be used to determine where schools of fish are located underwater.

Solution Cont'd

The diagram below is a basic representation of how sonar sends and receives sound waves underwater.



Extend Your Learning: Discussion

You may have already made this connection, but there are some animals that use something similar to Sonar called “echolocation.” These include bats, toothed whales, shrews and cave dwelling birds.

What do you know about these animals? What characteristics do they have in common?

Why might these animals require echolocation to survive?

What barriers might echolocation pose to these animals?

Technology VII

Why would Sonar not be able to determine the distance of objects in space?

A. Sonar transmitters are unable to be sent into space

B. Objects in space are too far apart from one another to determine distance

C. Space is a vacuum so sound waves would not be able to travel through it

D. Sonar would be able to determine the distance between objects in space

Solution

Answer: C

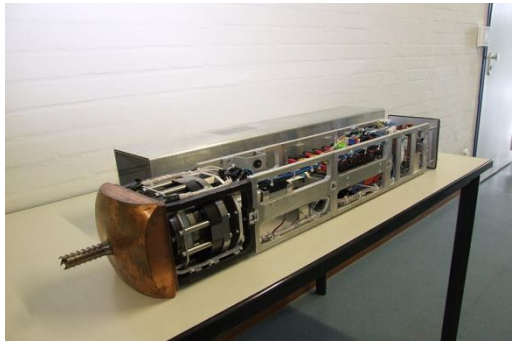
Justification: Space is a vacuum, meaning it does not contain solids, liquids or gases (matter). Sound can only travel through these mediums and because space lacks any matter, sound cannot travel through it.

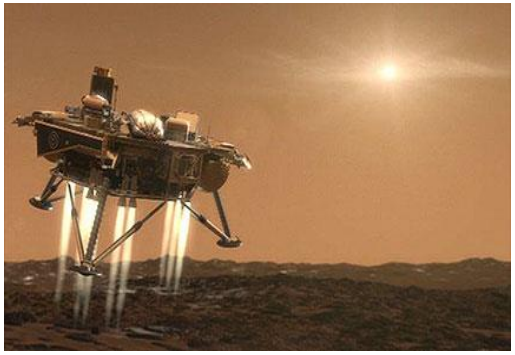
You may however, be thinking that there is matter in space, such as planets, stars and asteroids. This is true, but since space is so vast, the emptiness between these objects is called interstellar space. Since most of space is made up this interstellar space, it is considered a vacuum.

Technology VIII

Which of the following forms of technology would be best suited for helping scientists understand weather patterns in the Sahara Desert?

A. 

B. 

C. 

D. 

Solution

Answer: A

Justification: The Nomad rover is an unmanned vehicle, operated by remote control. It was developed and funded by NASA in order to explore deserts, and potentially explore other planets one day.

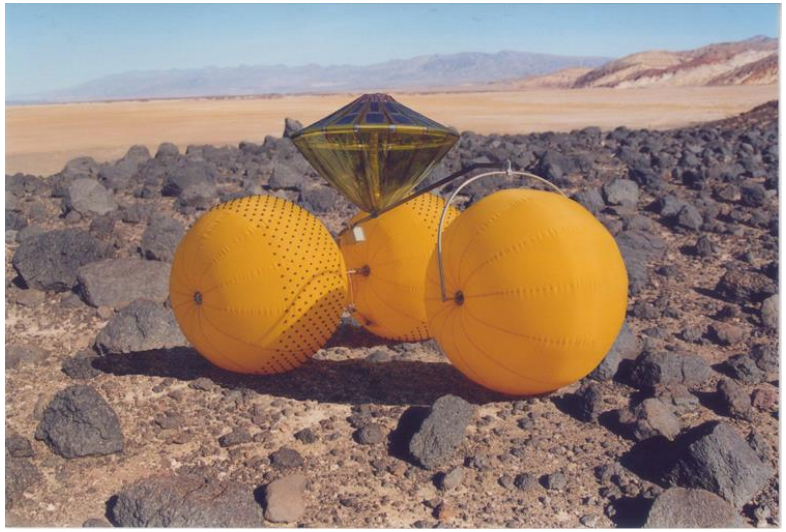
Solution Cont'd

The Phoenix Mars Lander (C) appears as if it is landing in a desert. This is a stationary sampling lab that was sent to Mars to help us determine more about the composition of Martial soil and gases.

A cryobot (B) uses heat to drill in ice and ROPOS (D) is a Canadian-made Remotely Operated Vehicle (ROV) that has allowed us to conduct research on the bottom of the ocean floor.

Extend Your Learning: Points of Interest

Another interesting technology that was developed to explore the desert is called a Tumbleweed Rover; named after the desert's famous tumbleweed plant that uses wind to roll and spread its seeds (pictured below right). These rovers lack wheels and are powered by the wind. Researchers at NASA's Jet Propulsion Laboratory are working on getting this rover to Mars someday.



Technology IX

Radar is used on planes and rockets to navigate properly in the air and space. It sends out invisible radio waves through the air towards an object, and they bounce back to the radar receivers once they hit that object.

What does the radar receiver determine about the object when this happens?

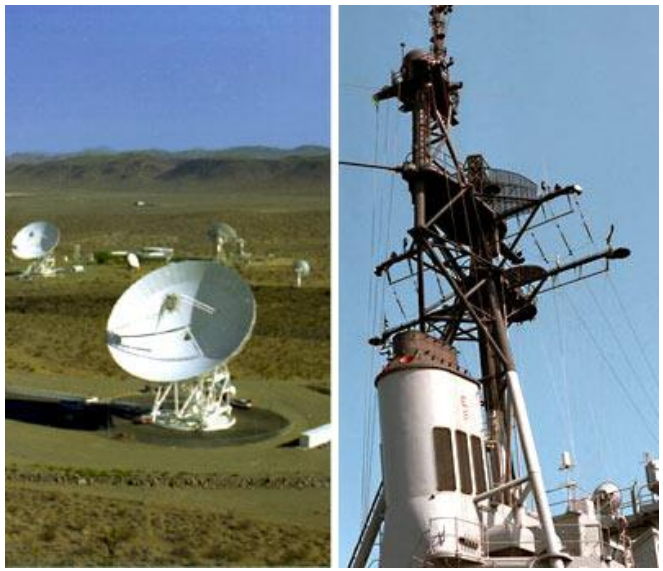
A. Distance, speed, mass & shape

B. Speed, mass, shape & direction

C. Mass, shape, direction & distance

D. Distance, speed, direction & mass

E. Distance, speed, shape & direction



Solution

Answer: E

Justification: Mass is the only measurement among the choices that radar is unable to determine about an object. When radar waves bounce off an object, information about an object's shape, direction of travel, distance away, and traveling speed is available.

For example, police use speed radar guns in order to determine a vehicle's (the "object") speed; whether or not it is traveling faster than the speed limit.

Technology X

Robots have helped tremendously in exploration; in particular, space exploration.

Which of the following is NOT a characteristic of a robot?

A. Robots may either be programmed or controlled using a remote control

B. Rovers are types of robots that explore beyond our earth; on our moon and Mars

C. Robots may travel into the poisonous gases in a volcano and under huge water pressure on the ocean floor

D. Exploration of deserts would be impossible without robots

E. Simple robots include household appliances such as a dishwasher

Solution

Answer: D

Justification: Although the exploration of deserts is significantly advanced by the use of robots (or, by association, rovers such as Nomad and tumbleweed rovers), robots are not always necessary to explore the desert. Humans are able to make certain accommodations in order to survive the extreme range of desert temperatures. These may include their choice in wearing light, protective clothing and an ability to make shelter to protect from the scorching sun.

Scientific research and exploration may still be carried out; perhaps traveling by foot, dune buggy, or on camel. In this case, exploring, collecting samples and capturing images occurs without the use of robots.

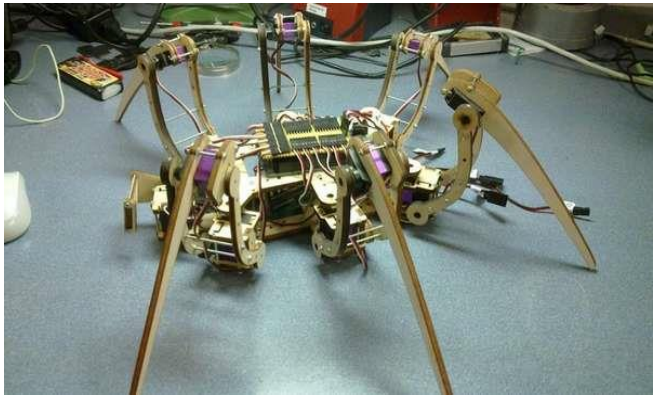
Technology XI

Which of the following robots may be used to investigate in pipes under city streets?

A. 

B. 

C. 

D. 

Solution

Answer: C

Justification: As you may have gathered by its shape, the snakebot is able to investigate and take pictures in pipes under city streets and other places underground.

A cryobot (A) uses heat to drill in ice in order to explore underwater in the polar regions. A frogbot (B) is able to hop around in order to explore the uneven terrain of the desert, and hopefully on other planets in the future. Finally, a spiderbot (D) is able to crawl into tight spaces and is designed to chart terrain, perhaps on Mars one day.

Technology XII

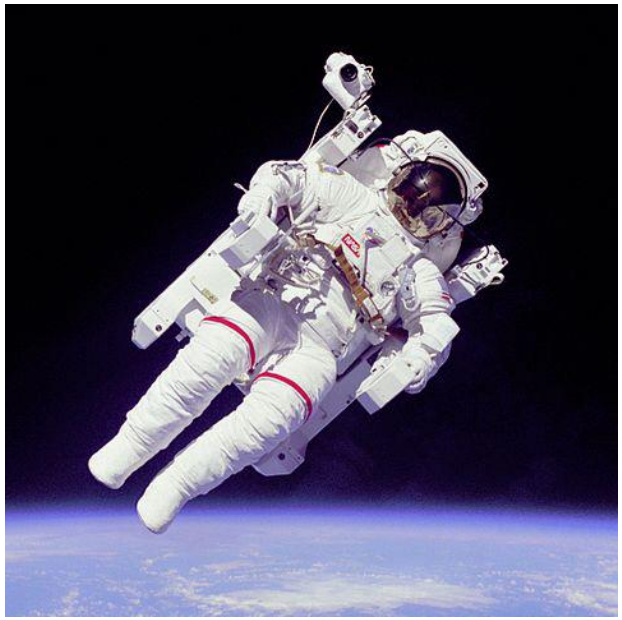
When might an astronaut require an Extravehicular Mobility Unit (EMU)?

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.

Technology XIII

The International Space Station (ISS) serves many functions.

What is the **primary** purpose 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 strength in human bones.

Extend Your Learning: Fast Facts

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

Technology XIV

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

Technology XV

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 spacecraft 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.