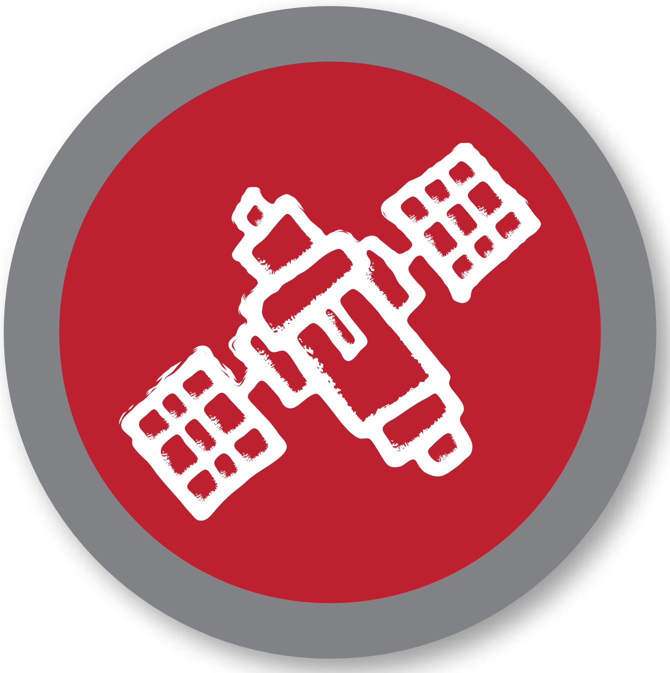
STEM | Science | Technology | Engineering | Mathematics

SPACE EXPLORATION KIT FOR CUB SCOUTS

Background Information and Scouter Manual



A Collaboration between Scouts Canada and Canada Science and Technology Museum

CANADA SCIENCE AND TECHNOLOGY MUSEUM

SCOUTS CANADA

It starts with Scouts.

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Introduction

The Space Exploration Kit is the product of a collaboration between Canada Science and Technology Museum and Scout Canada's STEM program. The kit provides activity cards and materials for six STEM projects that can be done over the course of a few weeks in Pack meetings, or in a weekend camp. The kit contains:

- **Activity cards:** These cards include some background information, instructions on how to Plan, Do, and Review the activities. They also list the materials that are needed for each activity, and the approximate amount of time it takes to complete each part of the activity.
- **Activity materials and equipment:** Most of the materials and equipment needed for completing the activities are in the kit. In some cases, materials will need to be provided, those items are specified on the activity cards.
- **Background information and Scouter manual:** This document includes more detailed information about the STEM concepts behind each activity, supporting documents for each activity, and some alternative additional activities that complement the package.

The activities in the kit are designed around the theme of space exploration. They focus on different aspects of space technology and life on the International Space Station. Cubs can review the description of the activities and choose which ones they would like to work on. The activities are:

1. **Piloted and Unpiloted Space Exploration:** Cubs will learn the pros and cons of human space exploration by studying a far-away object first with their eyes, then with mini telescopes (or binoculars) and finally by sending a human "probe."
2. **Rockets and Spacecraft:** Cubs will understand the basic principles of rocketry by constructing and launching rockets made from pop bottles. They will also learn how pressure developed from chemical reactions can produce the thrust needed to power a rocket.
3. **Astronaut Training:** Cubs will circulate through a series of activity stations to discover various aspects of life in space.
4. **Robotic Hand:** Cubs will build a robotic hand and learn more about Canada's contributions to the International Space Station.
5. **Inflatable Space Station:** Cub Scouts will identify the various components of a space station, will gain an understanding of their separate functions and will build and inflatable space station that they can walk through.
6. **Designer Space Station:** Cubs Scouts will explore the decision-making process required to build a space station like the International Space Station by participating in a team effort to design a model space station.
7. **Mission Patch Design:** Cubs will analyze and describe personal and team mission patches from Canadian space missions. Teams of Cubs will create mission patches to visually communicate their teams' background and imaginary mission to the International Space Station.

Activity #1: Piloted and Unpiloted Space Exploration

Description of the activity

Cub Scouts will learn the pros and cons of human space exploration by studying a faraway object first with their eyes, then with mini telescopes (or binoculars) and finally by sending a human "probe."

Background information

Piloted space explorations are the space missions that have crew abroad the spacecraft. In these missions, the spacecraft can be directly operated by the crew and does not need to be remotely controlled from the Earth. There are however known and unknown safety risks from radiation, microgravity and isolation that can endanger the crew members.

In unpiloted missions, there are no crew abroad the spacecraft and the mission is controlled from the Earth. These missions are usually much cheaper to complete than piloted missions as the spacecraft is less complex and therefore less expensive. The spacecraft does not have to carry the weight of the crew and the life support equipment and materials that are needed on piloted space missions.

Votosk 1 was the first piloted spacecraft, launched by USSR in 1961. The duration of the flight was 1 hour and 48 minutes and Yuri Gagarin was the astronaut onboard the spacecraft. In that same year, the United States launched two manned spacecraft into orbit (Mercury-Redstone 3 and Mercury-Redstone 4). Each flight lasted about 15 minutes. Alan Shepard was onboard in the first mission and Virgil Grissom in the second one. Since 1961, 12 spacecraft have been used for launching 303 human spaceflights. These spacecraft have been developed by the United States, the former Soviet Union/Russian Federation, and the People's Republic of China.

Since the construction of the International Space Station, humans have been continuously in space for more than 13 years now. But the advances in robotics technology have made it possible to complete more sophisticated missions with unpiloted spacecrafts.

Activity #2: Rockets and Spacecraft

Description of the activity

Cub Scouts will understand the basic principles of rocketry by constructing and launching rockets made from pop bottles. They will also learn how pressure developed from chemical reactions can produce the thrust needed to power a rocket. As an optional activity, Cubs can calculate the maximum altitude of a rocket during its flight. Altitude tracker templates are provided in this document.

Background: A Brief History of Rockets

3-2-1 blast-off! Who among us does not recognize these famous words, signalling the launch of a rocket high up into the sky? It takes just a little imagination to begin dreaming of flights to distant galaxies and missions to new and unexplored worlds!

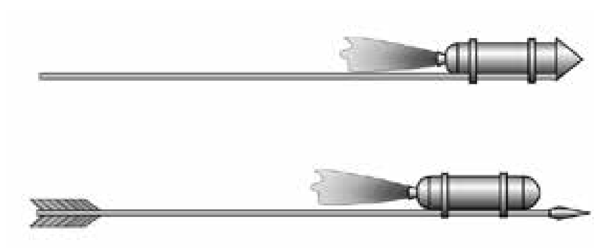
Today, rockets are remarkable machines that are the result of thousands of years of experimentation, research and development. But who invented the first rocket? How have they changed throughout time and how do they work?

Historically speaking, it is difficult to determine when the first, recognizable rockets were used, but evidence suggests that they have been around for a very long time. By the first century AD, the Chinese had created a primitive form of gunpowder using saltpeter, sulphur and charcoal dust. At first, this mixture was packed into bamboo tubes, which were then tossed into a fire, making explosions during religious festivals. Eventually, they began experimenting with the gunpowder-filled tubes. They attached these bamboo tubes to arrows and launched them with bows. They soon discovered that these gunpowder tubes could launch themselves just by the power produced from the escaping gas.

The commonly accepted date for the use of the first true rocket is 1232. At this time, the Chinese and the Mongols were at war with each other. During the battle of Kai-Keng, the Chinese repelled the Mongol invaders using "arrows of fire." These fire-arrows were a simple form of a solid-propellant rocket.

It wasn't until the 17th century that scientists finally had the tools they needed to begin to understand the science behind rocketry. An English scientist, Sir Isaac Newton, expressed his understanding of physical motion using three scientific laws, which explain how rockets work and why:

1. Every object stays at rest or in motion at a constant speed in a straight line unless a force acts on it.
2. When a force acts on an object, that object accelerates. The acceleration depends on the force and the object's mass. The formula is: f=ma (i.e. force=mass x acceleration).
3. For every action, there is an equal and opposite reaction.



Chinese Fire Arrow

Towards the end of the 18th and early 19th century, while crude rockets continued to be used as weapons of war, scientists began to conceive an alternate use for them.

In 1898, a Russian schoolteacher, Konstantin Tsiolovsky (1857-1935), proposed the idea of space exploration using liquid fuel-propelled rockets that would allow rockets to go faster and higher.

In the early 20th century, American Robert H. Goddard (1882-1945) conducted practical experiments in rocketry using various types of solid and liquid propellants. His first successful launch of a liquid propellant rocket occurred in 1926; the rocket flew for only 2.5 seconds, climbing a mere 12.5 metres.

In 1937, a number of German scientists (including Hermann Oberth and Wernher von Braun) gathered to design and build rockets. By 1945, von Braun's team had developed what was then the most advanced rocket, the V-2 (also known as the A4 rocket). The V-2 was a long-range liquid-fuel rocket used by the Germans as a ballistic missile in World War II. When the war ended, many German scientists were relocated to the United States or the Soviet Union to continue their work in the field of rocketry and realize their dream of reaching space.

These efforts culminated in the successful launch of the first artificial satellite in 1957. The Soviet Sputnik 1 became the first artificial satellite to orbit the Earth. The first human being soon followed; in April 1961, **Yuri Gagarin**, aboard the Soviet spacecraft, Vostok 1, became the first human being to orbit the Earth.

A few months after the first Sputnik, the United States followed the Soviet Union with a satellite of its own. Explorer I was launched by the U.S. Army on 31 January 1958. In October of that year, the United States formally organized its space program by creating the ***National Aeronautics and Space Administration*** (NASA). NASA became a civilian agency with the goal of "peaceful exploration of space for the benefit of all humankind".

Soon, many people and machines were being launched into space. As the demand for more and larger payloads increased, a wide array of powerful and versatile 2- and 3-stage rockets had to be built. Astronauts orbited the Earth and landed on the Moon. Robot spacecraft traveled to the planets. Space was suddenly opened up to exploration. Satellites enabled scientists to investigate our world, forecast the weather and communicate conveniently around the globe.

Since the earliest days of experimentation and development, rockets have evolved from simple gunpowder devices into giant vehicles capable of traveling into space. Through rockets, human beings have gained access to the universe.

What Is a Rocket?

A rocket, in its simplest form, is a chamber enclosing a gas under pressure. A small opening at one end of the chamber allows the gas to escape, and in doing so creates a **thrust** (a propulsive force) that propels the rocket in the opposite direction.

The basic principle driving a rocket engine is Newton's Third Law of Motion: "For every action there is an equal and opposite reaction." As the propellant burns, hot gases are produced, creating pressure, which forces the exhaust gases out of the nozzle at the back of the rocket. This is the action part in Newton's terms. The reaction causes the body of the rocket to be pushed by the same gas pressure in the opposite direction.

This principle can be illustrated using a balloon. When a balloon is blown up and released it flies about the room. Because the air inside is under pressure, some of it is pushed out through the nozzle. Again, this is the action from Newton's third law. The same air pressure pushes against the inside of the balloon in the opposite direction, propelling it forwards. The balloon is therefore acting as a simple rocket.

All rockets contain the same basic elements, but as their designs have become more complex so have their components. Let's keep our definition of a modern rocket simple by identifying some key rocket parts.

Rockets consist of a case (body tube), which generally has a pointed nose. This reduces the aerodynamic drag acting on the rocket, making it easier for the rocket to cut through the atmosphere and achieve an orbit.

Rockets also need to be stable when in flight. Various types of stabilizing fins can be used to help stabilize the rocket.

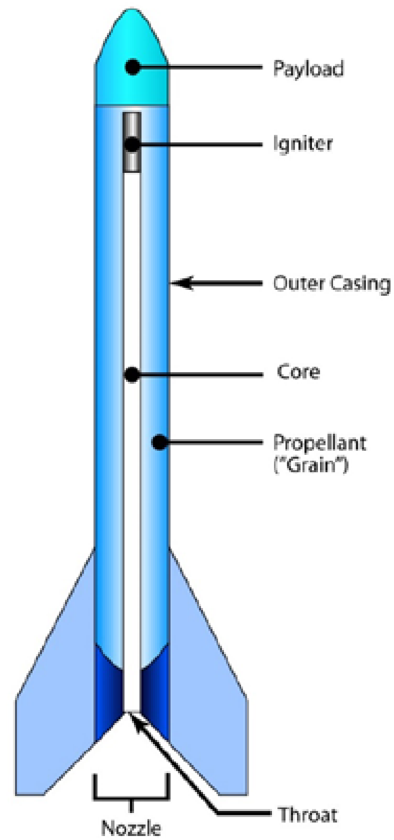
Rockets require both a fuel (the chemical that the rocket burns) and an oxidizer (a substance providing oxygen). The fuel cannot burn without oxygen. Since there is no oxygen in space, rockets must carry their oxygen source with them. Together, these substances are called the rocket's propellants, which may be in the form of liquids or solids.

Therefore, three essential components of any rocket are its propellants, the combustion chamber inside the engine and the nozzle through which the gas is forced out.

There are two basic types of modern rocket; one type fuelled by solid propellants and the other by liquids.

Solid-Fuel Rockets

Solid rocket propellants contain both the fuel and oxidizer mixed together.



Solid-Fuel Rocket

A solid-propellant rocket has the simplest form of engine. It has a nozzle, a case (which is the combustion chamber), propellant and an igniter.

The nozzle is an opening at the back of the rocket that permits the hot expanding gases to escape. Its purpose is to increase the acceleration of the gases as they leave the rocket, thereby maximizing thrust.

Solid-propellant rockets have three important advantages:

- Simplicity
- Low cost

- Can be stored for long periods and used immediately

They also have two disadvantages:

- Thrust cannot be adjusted while the rocket is in flight.
- Once ignited, the engine cannot be stopped or restarted

Solid rockets are often used as additional boosters to augment the power of liquid propellant rockets. The Space Shuttle is the best known spacecraft to use auxiliary solid rocket boosters.

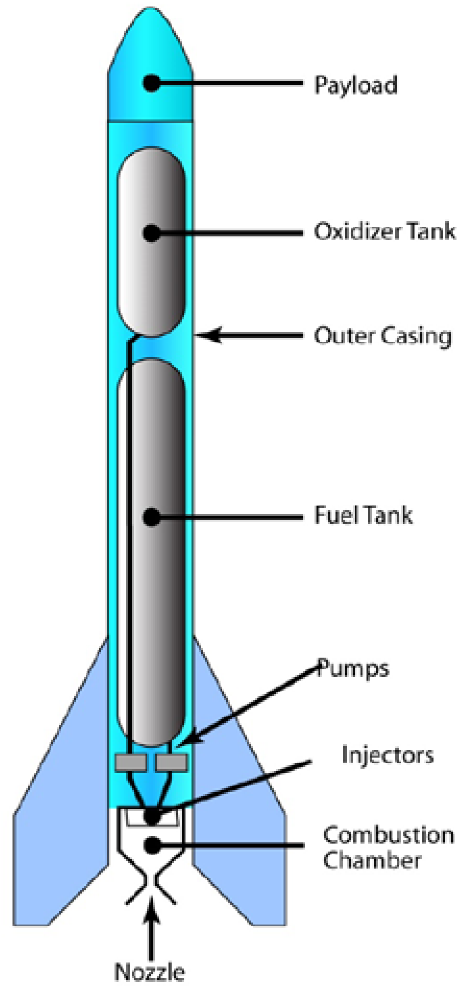
Liquid-Fuel Rockets

Liquid propellant rockets have much more complicated engines. Liquid propellants, which are often gases that have been chilled until they turn into liquids, are kept in separate containers; one for the fuel and the other for the oxidizer.

Just before firing, the fuel and oxidizer are mixed together in the combustion chamber. There they burn to create a high-pressure, high-velocity stream of hot gases. These gases flow through the nozzle at the tail of the rocket, which accelerates them further, and then leave the engine.

Liquid-propellant rockets have the following advantages:

- Liquid propellants can contain more energy than the same weight of solid propellant. This makes them more attractive for use in large and powerful rockets.
- Can be stopped and/or restarted
- Thrust can be varied in flight



Liquid-Fuel Rocket

Their disadvantages are:

- Complexity
- High cost
- Take time to prepare for launch
- Cannot easily be stored ready for launch
- Propellants can be difficult to handle (poisonous, corrosive or very cold)

Suggestions for a Successful Activity

- The water automatically makes this an outdoor activity.
- Have Cubs practise putting on the caps of their rockets.
- **Use only Black's or Fuji film canisters.** Kodak film canisters are made differently and will leak.
- Antacid tablets can be re-used until they are dissolved entirely.

Optional Activity: Altitude Tracker

If Cub Scouts want to be able to calculate the exact altitude of the rocket, they can use the below instructions to build an altitude tracker and altitude calculator. Samples of these are available in the kit and can be used as models. To begin the process, copy the pattern for the ***altitude tracker*** and ***altitude calculator*** onto heavyweight paper for each Cub.

Part 1: Constructing the Altitude Tracker

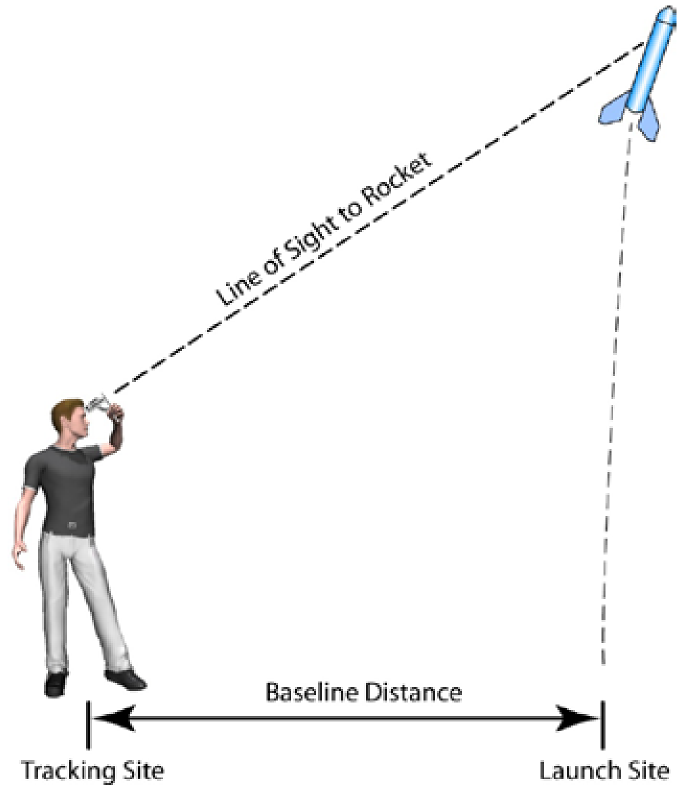
- Cut out the pattern on the dark outside lines.
- Tape a drinking straw onto the altitude tracker. Be careful to align the straw with the outline on the altitude tracker template.
- Punch a small hole through the apex of the protractor quadrant on the pattern.
- Slip a length of light-weight string through the hole. Knot the string on the back.
- Complete the tracker by hanging a paper clip from the other end of the string.

Part2: Constructing the Altitude Calculator

- Cut out both patterns on the dark outside line.
- Place the top pattern on a cutting surface and cut out the window.
- Join the two patterns together where the centre marks are located. Use a brass paper fastener to hold the pieces together. The pieces should rotate smoothly.

Part 3: Determining the Rocket's Maximum Altitude

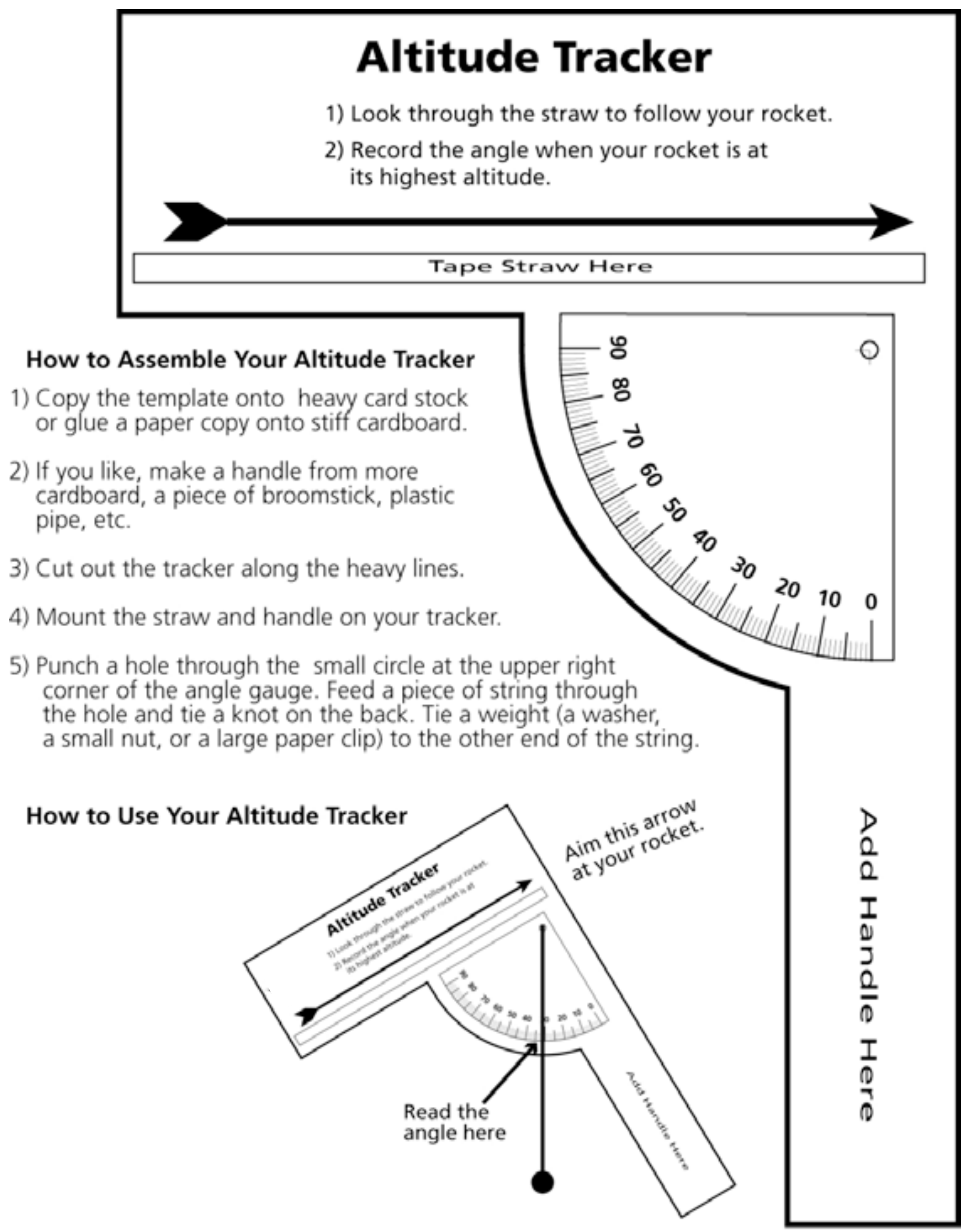
1. Set up a tracking station location a short distance away from the rocket launch site. Depending on the expected altitude of the rocket, the tracking station should be 5, 15, or 30 m away. Generally, a 5 m distance is sufficient for antacid-powered rockets, a 15 m distance is sufficient for water rockets and a 30 m distance is sufficient for model rockets.



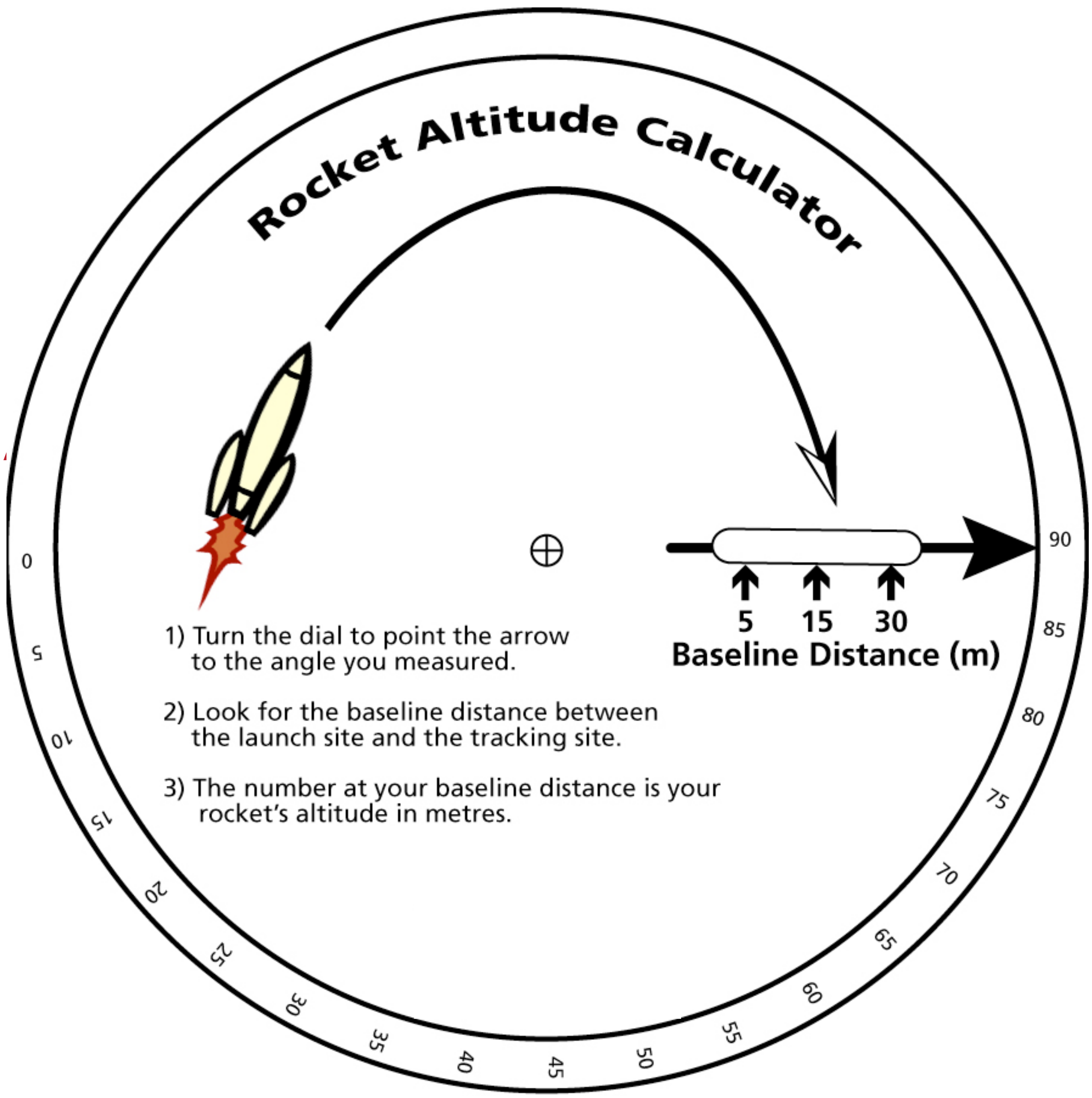
2. As a rocket launches, follow the flight with the sighting tube on the tracker. The tracker should be held like a pistol and kept at the same level as the rocket when it is launched. Continue to point the tracker at the highest point the rocket reaches in the sky, as shown in the illustration. Ask another Cub to read the angle the weighted string makes with the angle gauge. Record the angle.
3. Use the altitude calculator to determine the height the rocket reached. To do this, rotate the inner wheel of the calculator so that the large arrow is aimed at the angle you measured in Step 2.
4. Read the altitude of the rocket by looking in the window. For example, if you use a 5 m baseline, the altitude the rocket reached will be at the arrow marked "5." To achieve a more accurate measurement, add the height of the person holding the tracker to calculate altitude.

Activity Documents for Altitude Tracker

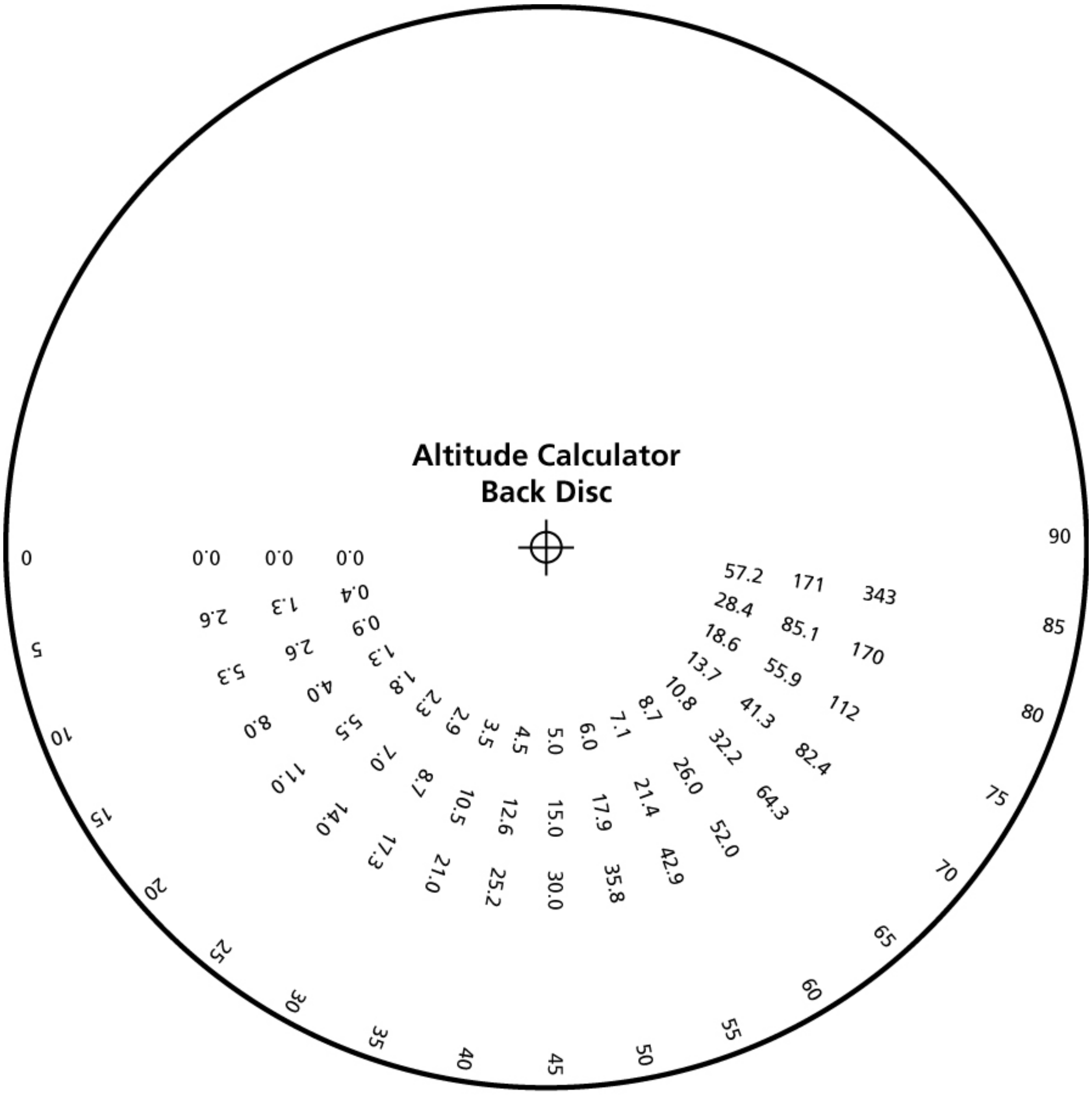
Altitude Tracker Template



Altitude Calculator Template – Front Disk



Altitude Calculator Template – Back Disk



Activity #3: Astronaut Training

Description of the activity

Cub Scouts will circulate through a series of activity stations to discover various aspects of life in space.

a. Water-Cooled Underwear: Cubs will experience and describe how the cooling system in Extravehicular Mobility Units (EMU) woks.

b. Bottle Vacuum: Cubs will predict what would happen to an unprotected human being placed in the environment of space and demonstrate the results by simulating an astronaut in the vacuum of space using a balloon and a kitchen pump.

c. Space Gloves: Cubs will follow a set of written and/or verbal instructions while wearing simulated space gloves. Cubs will describe and discuss some of the challenges of working in the microgravity environment wearing a spacesuit or Extravehicular Mobility Unit (EMU).

d. Disorientation Maze: Cubs will discover how simple tasks can become difficult after experiencing some form of disorientation.

Background

Space: microgravity, no pressure, no air, no sound, extreme temperatures, solar flare particles, cosmic rays and space debris. Oh my! Space is a very unnatural and hostile environment for human beings.

The principal environmental factor of space is the vacuum, or virtual absence of gas molecules. This means that there is almost no air or other matter in space. Atmospheric pressure in space is measured at nearly zero, compared to the sea-level pressure of 101 kilopascals (kPa) we experience here on Earth. With virtually no pressure exerted from the outside, air inside an unprotected human's lungs would immediately rush out in the vacuum of space. Dissolved gases in body fluids would expand, pushing solids and liquids apart. Bubbles would form in the bloodstream and render blood useless as a transporter of oxygen and nutrients to the body's cells. Furthermore, the sudden absence of the external pressure that balances the internal pressure of body fluids and gases would result in the rupturing of fragile tissues such as eardrums and capillaries. The net effect on the body would be swelling, tissue damage and a deprivation of oxygen to the brain causing unconsciousness in less than 15 seconds.

The lack of air in space even makes identifying day and night a difficult process for astronauts! We generally associate "day" with the notion of a blue sky or sunlit clouds and the scattering of light in all directions — visual confirmation of the sun's presence is not necessary. Out of the direct light of the sun, outer space is a complete blackness out of which the countless stars shine.

Contrary to common science-fiction movie representations, space is a very quiet place. Sound is a wave of vibrations transmitted through a medium (such as air, water, etc.). Humans are capable of detecting waves with frequencies in the range of 20 to 20,000 hertz. Because space is a vacuum, there is no medium for sound waves to pass through; therefore, sound does not exist in space. Even the noisiest cannon could not be heard in space.

The dramatic temperature range found in space provides a second major obstacle to would-be space-travelers. In Earth's orbit, the temperature rises to over 120°C in direct sunlight and plummets to lower than -100°C in the shade!

Other environmental factors in space that are hostile to life include: electromagnetic radiation (i.e. UV and X-rays), particle radiation (i.e. cosmic rays, solar flare particles, and high-speed neutrons), energetic plasma, low-energy plasma, micrometeors (tiny meteoric particles about the size of a grain of sand) and the tens of thousands of pieces of space junk that orbit the Earth.

Spacesuits

Chris Hadfield working outside Endeavor during the STS-100 mission

Space is a hostile place. To make it possible for humans to survive there, we must carry an Earth-like environment with us. Inside a spacecraft, the environment is controlled so that special clothing is not necessary, but when it is necessary to leave the spacecraft, humans require the protection of a spacesuit. The basic functions of a spacesuit or Extravehicular Mobility Unit (EMU) are:

- To protect the human body
- To provide necessary life support
- To enable astronauts to perform necessary work in space

EMUs must provide: a pressurized atmosphere, oxygen, temperature control, protection from debris and radiation, mobility, electrical power, communications, food, drink, and waste management of both urine and carbon dioxide. When fully assembled, a spacesuit becomes a short-term spacecraft for one person.

The EMU worn by modern space walking astronauts is the result of more than 60 years of development and testing of pressure suits in the U.S., Russia, Canada, France, Italy, Germany and other countries. Spacesuit engineers have been working steadily on creating better, more efficient and more comfortable spacesuits. Gone are the days when spacesuits were custom built to a specific astronaut's body size and used only once. Today, modern spacesuits used on the ISS are tailored from a stock of standard-sized parts to fit astronauts with a wide range of measurements and are reusable for twenty-five Extra-Vehicular Activities (EVAs, commonly called "spacewalks"). Historically, astronauts received their oxygen via an umbilical cord from the spacecraft, but today's modern spacesuit includes a Portable Life Support System (PLSS). The PLSS provides oxygen, power, carbon dioxide removal, cooling water, and radio equipment.

Getting Suited

Megan McArthur, wearing the LCVG, puts on the EMU's upper torso section

Because of the complexity of modern spacesuits and the potential dangers of spacewalking, all of the crewmembers are involved in making sure that each spacewalker is safe and that each EVA is successful. A detailed EVA checklist with over 160 pages outlines the step-by-step procedure of preparing for, putting on **(donning)** and taking off **(doffing)** the spacesuit. This elaborate procedure includes:

- Testing equipment and checking valves and controls.
- Depression of atmospheric pressure inside the entire orbiter cabin.
- Prebreathing of pure oxygen.
- Donning either a **Maximum Absorbency Garment (MAG)** (imagine an adult-sized diaper) or a leg bag. Both are urine collection systems needed during

long EVAs. Most astronauts prefer the leg bag over the MAG.

- Donning the **Liquid Cooling and Ventilation Garment (LCVG)**, which looks like long underwear. This one-piece spandex suit has a zippered front, and is lined with 91.5 m of plastic tubing through which chilled water flows to control the temperature within the suit.
- Inserting a food bar (compressed fruit, grain, and nuts, wrapped in edible rice paper) and a water-filled **In-Suit Drink Bag (IDB)** inside the front of the helmet.
- Rubbing an anti-fog compound on the inside of the helmet.
- Placing a wrist mirror, which ensures that the astronaut can see EMU controls that are out of his/her visual range. The settings and numbers on these knobs are written backward so they can be read in the mirror.
- Connecting the **Communications Carrier Assembly (CCA)**, or "Snoopy cap."
- Pulling on the lower torso, or suit-pants, and diving into the hard upper torso.
- Donning the helmet and finally, gloves. The helmet is equipped with built-in lights.

Background on the Water-Cooled Underwear Activity

Spacesuit insulation technologies protect the astronaut from the extreme high and low temperatures of the space environment. However, the same insulation technology also works to keep heat released by the astronaut's body inside the suit; thus, the spacesuit has an active cooling system. To get an idea of what this might be like, imagine walking around on a hot day wearing a plastic bag.

The Space Shuttle Extravehicular Mobility Units (EMUs) have a cooling system called the Liquid Cooling-and-Ventilation Garment (LCVG). This long underwear-like garment is worn under the pressure layer and is made up of a network of small diameter water circulation tubes held close to the body by a Spandex® body suit. Heat released by the astronaut is transferred to the water where it is carried to a refrigeration unit in the suit's backpack. The wearer of the suit controls the operating rates of the system through controls on the display and control module mounted on the chest area of the EMU.

Background on the Bottle Vacuum Activity

The principal environmental factor of space is the vacuum, or near-total absence of gas molecules. This means that there is almost no air or other matter in space. Human beings live on Earth and are constantly under the weight of the atmosphere, pushing down on us all the time (sea-level pressure is 101 kPa). In the absence of atmospheric pressure, dissolved gases in body fluids would expand, pushing solids and liquids apart; the body would swell and tissue would rupture. The brain would be deprived of oxygen resulting in unconsciousness in less than 15 seconds.

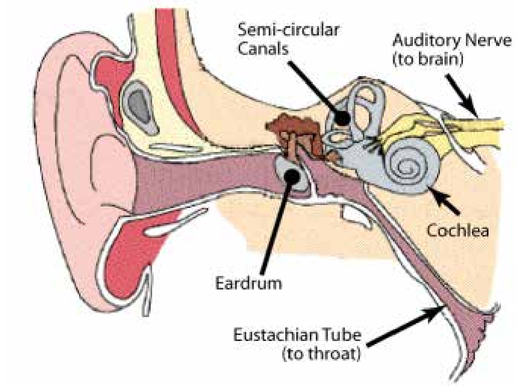
Background on the Space Gloves Activity

In April 2001, Canadian astronaut Chris Hadfield served as Mission Specialist on STS-100 where he performed two spacewalks to install the Canadarm2 on the ISS. He described the hardest part of astronaut training as remembering everything you need to know and keeping the information fresh in your mind for when you need it. To help astronauts remember everything they must accomplish on an EVA, spacewalking astronauts wear a checklist of duties on the arm of their spacesuit and maintain constant communication with the crew inside the station.

Background on the Disorientation Maze Activity

Space Adaptation Syndrome (commonly called ***space sickness***) occurs in approximately 40% of astronauts who have gone into space. The problem, contrary to popular belief, is not with the stomach, but with the inner ear!

The vestibular apparatus of the inner ear consists of three



semi-circular canals, one for each of the directions in which we can move (i.e, up and down; left and right; forward and backward). A rotation of the head rotates the semi-circular canals, but the fluid (called ***endolymph***) inside the canals responds more slowly to the motion because of its inertia. The relative motion of the fluid and the walls of the canals is picked up by little hairs which are connected by nerve fibers to the brain. A signal reports the angular motion to the brain.

In addition to the three semi-circular canals, there are two otolith organs, which send information to the brain about linear movements and the direction of gravity relative to the head.

Of course, the vestibular organs are not the only sensors sending information to the brain. If the eyes and receptors in muscles, tendons and bones (mechanoreceptors) or other sense organs send conflicting information, the brain has to decide which is correct and what to do to fix the problem.

For example, the vestibular system is part of a poison-detection system in humans. Toxins common in certain poisonous substances interfere with the inner ear's motion detection mechanisms, which respond by sending incorrect signals to the brain. However, the eyes and mechanoreceptors don't send corresponding signals. The brain concludes that the body has been poisoned and triggers vomiting in an attempt to get rid of the poison.

The semi-circular canals and otolith organs are very sensitive receptors and are extremely accurate for the activities of pre-technological humans. As higher performance vehicles were developed, the speeds and forces humans could experience began to exceed the limits of the vestibular system. In cases like this, the overtaxed vestibular system sends signals that do not correspond with the signals from the eyes or mechanoreceptors. The effects resemble the symptoms of poisoning and we feel nauseated or even vomit.

In space the same phenomenon occurs. However, once the body adjusts to the new environment, the symptoms disappear.

Activity Documents

Space Gloves Job Cards

Job Card-Space Gloves Activity "A"

Working in space is not as simple as it looks, especially when you have to wear big bulky spacesuits.

Astronauts spend many hours on the ground training to learn how to work while wearing their spacesuits. The space gloves that they have to wear pose particular problems because of their size and bulk.

Try the following challenges while wearing the simulated space gloves.

Activity

1. Put on the simulated space gloves.
2. Pick up the Lego from the table and snap together all of the blocks.
3. With the simulated space gloves still on, disassemble the Lego blocks and put them on the table.

What would make these tasks easier? How would you design better space gloves?

Job Card-Space Gloves Activity "B"

Working in space is not as simple as it looks, especially when you have to wear big bulky spacesuits.

Astronauts spend many hours on the ground training to learn how to work while wearing their spacesuits. The space gloves that they have to wear pose particular problems because of their size and bulk.

Try the following challenges while wearing the simulated space gloves.

Activity

1. Put on the simulated space gloves.
2. Pick up the thread and needle from the table.
3. Thread the needle.

What would make these tasks easier? How would you design better space gloves?

Job Card-Space Gloves Activity "C"

Working in space is not as simple as it looks, especially when you have to wear big bulky spacesuits.

Astronauts spend many hours on the ground training to learn how to work while wearing their spacesuits. The space gloves that they have to wear pose particular problems because of their size and bulk.

Try the following challenges while wearing the simulated space gloves.

Activity

1. Put on the simulated space gloves.
2. Pick up the paper and pencil from the table.
3. Write your name on the piece of paper and then a brief message.

What would make these tasks easier? How would you design better space gloves?

Job Card—Space Gloves Activity "D"

Working in space is not as simple as it looks, especially when you have to wear big, bulky spacesuits.

Astronauts spend many hours on the ground training to learn how to work while wearing their spacesuits. The space gloves that they have to wear pose particular problems because of their size and bulk.

Try the following challenges while wearing the simulated space gloves.

Activity

1. Put on the simulated space gloves.
2. Pick up the chopsticks and sponge from the table.
3. The goal is to pick up the sponge with the chopsticks and place it in the container.

What would make these tasks easier? How would you design better space gloves?

Job Card-Space Gloves Activity "E"

Working in space is not as simple as it looks, especially when you have to wear big, bulky spacesuits.

Astronauts spend many hours on the ground training to learn how to work while wearing their spacesuits. The space gloves that they have to wear pose particular problems because of their size and bulk.

Try the following challenges while wearing the simulated space gloves.

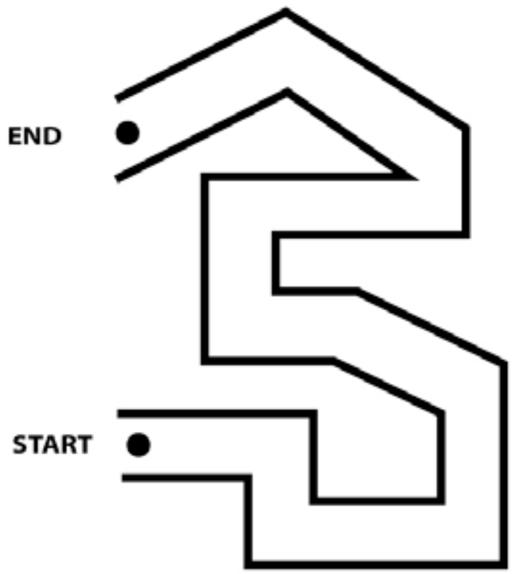
Activity

1. Put on the simulated space gloves.
2. Pick up the marbles from the table and put them into the container.

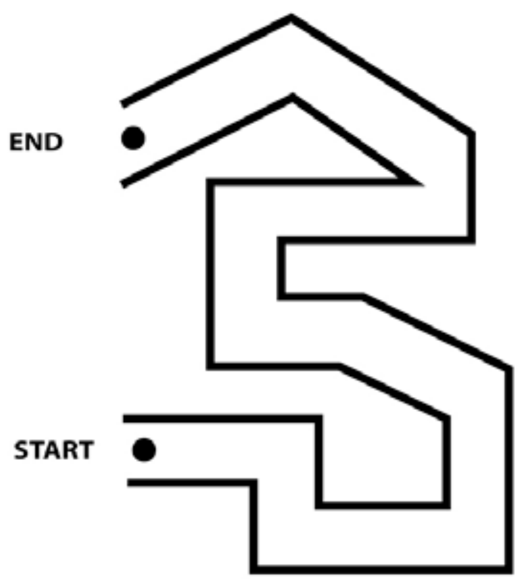
What would make these tasks easier? How would you design better space gloves?

Disorientation Maze Template

Disorientation Maze "A"

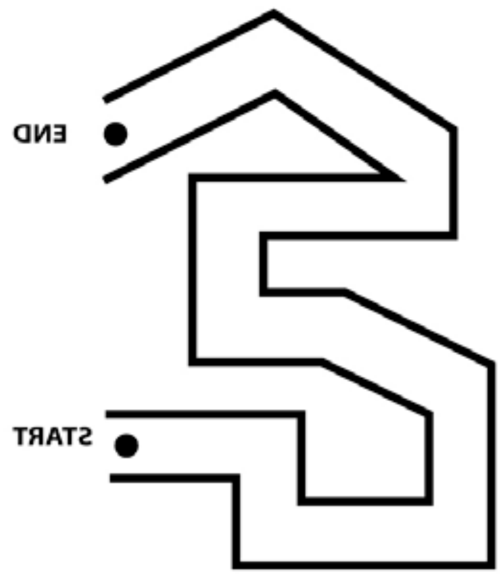


Bumps on the wall: ____

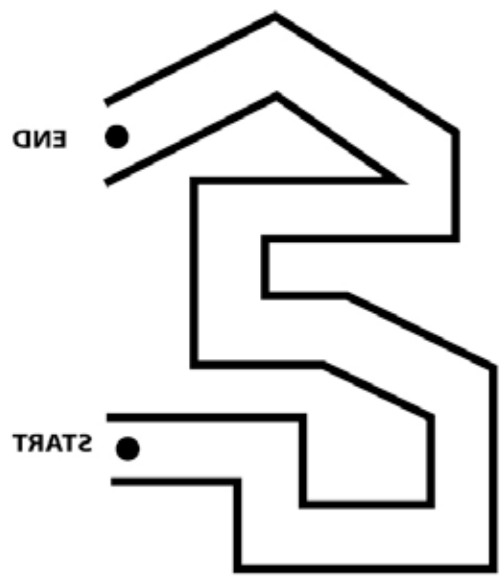


Bumps on the wall: ____

Disorientation Maze "B"



Bumps on the wall: ____



Bumps on the wall: ____

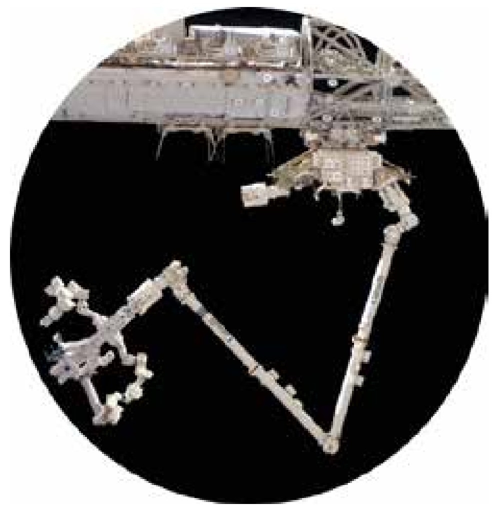
Activity #4: Robotic hand: A model hand in action

Description of the activity

Cub Scouts learn about Canada's contribution to the International Space Station. They build a robotic hand that simulates the Canadarm and experience some of the challenges of working with a remotely controlled robot.

Background: The Canadian Mobile Servicing System (MMS)

Canada's contribution to the International Space Station is the Mobile Servicing System (MSS), a sophisticated robotics system comprised of three main elements:



1. The new generation Canadarm2 (the SSRMS)
2. The base (a mobile platform to support the SSRMS/MBS)
3. Its "hand" (called the SPDM)

All of these systems together are called the Mobile Servicing System. It is critical to the assembly, maintenance and servicing of the Space Station. Without this Canadian technology, the ISS could not have been built.

The Space Station Remote Manipulator System

Officially known as the **Space Station Remote Manipulator System (SSRMS)**, the 17 m long robotic arm can manipulate objects weighing up to 116,000 kg. It is similar to the space shuttle's Canadarm, but is longer, larger, stronger and more flexible, and has more advanced control features. The Canadarm2 can handle and move a fully loaded space shuttle. The SSRMS can relocate itself, independent of the other Canadian components, moving end-over-end (like an inchworm) using various grapple fixtures located on the structure. This was the first complete Canadian component installed on the Space Station in (April 2001). Astronauts use the arm to move massive equipment around the outside of the ISS.

Mobile Remote Servicer Base System

The Mobile Remote Servicer Base System (MBS) serves as both a storage location and work platform for astronauts.

Special Purpose Dexterous Manipulator

The **Special Purpose Dexterous Manipulator (SPDM)**, known as the "hand," is an essential tool for maintaining and servicing the Space Station. Its two-handed design allows it to remove and replace smaller components on the Station's exterior when precise movements are required.

In many ways, the SPDM can be compared to an astronaut. It has cameras for vision, a body with a rotating waist and two arms that can hold equipment or tools. It operates independently from a Station grapple fixture, or at the end of the SSRMS - like an operator at the end of a crane. It has been designed so that it can perform activities such as replacing defective equipment, which would otherwise require an astronaut to undertake a space-walk. By using a robot whenever possible in the hazardous environment of space, crew safety is greatly increased. The SPDM loads and unloads objects, uses robotic tools, attaches and detaches covers, installs various units of the Space Station and provides the crew inside the ISS with camera views of exterior work areas.

Suggestions for successful implementation of the activity

The Cubs will probably need some one-on-one instruction or help for this activity. Parents can be invited to volunteer. This can also be turned into a linking activity with Scouts.

To save some time, it is best if working stations for each group of 3-4 Cubs is prepared ahead of time. Group Cubs together so that younger and older Cubs will have a chance to work together. This makes it easier for each group to finish the job. Older Cubs can take responsibility for jobs that need more dexterity. Younger Cubs can work on easier parts of the project. At the end, each Cub should have one finished product to take home.

When you prepare the materials, consider the following:

- Make sure that the masking tape is of good enough quality; extremely inexpensive brands tend to not stick well enough.
- The use of ribbon instead of rope will provide an easy way to pass it through the straws.
- Test the quality of the straws before buying a large quantity. Some straws tend to split in the hole-punching process.

Preparation tools

The best tool to use for making the finger joints is an adjustable hole-punch with three punches. You need to find one with a wide enough opening so that you can squish in a straw. This provides the quickest and best result.

If you use a single, make sure you buy a good quality one. Cheap ones tend to tear the straw, rather than cut it.

Also, with the single ones, some of them tend to over punch and crush the straw, causing splits. Modify the punch with some paper as a spacer and tape to prevent the punch from cutting too deeply, as seen above with the red.

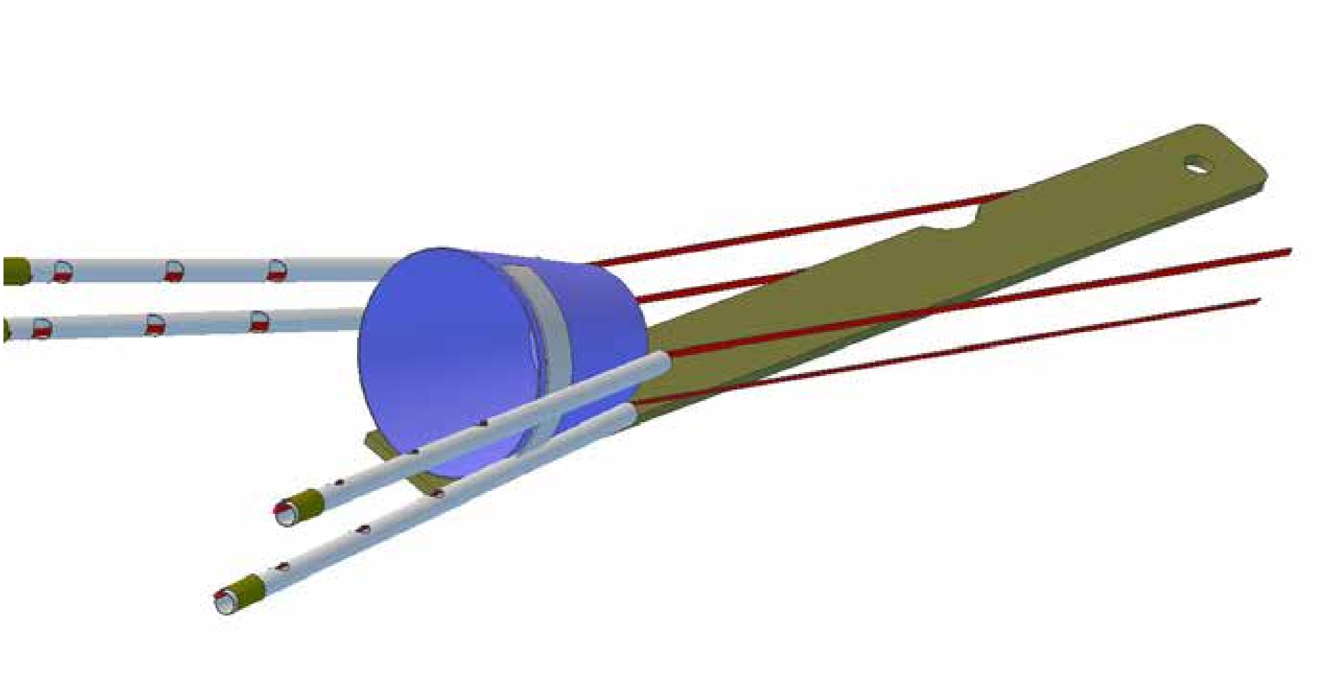


Preparation of the Fingers

- Cut three aligned notches in the straw to create a finger joint. The notch should be almost half-way through the straw.
- If you notch too deeply, the finger will not have enough strength to straighten after it was retracted.
- If you notch too shallowly, the bend will not be straight
- If your alignment from hole to hole is off, the fingers will curl. This is good if you are creating a witch/skeleton hand for Halloween.

Extended instructions for Leaders

- When taping the ligament (ribbon) to the finger tip, make sure that the youth tapes it to the side where the fingureprint would be. This will aid in the bending process of the finger tip.
- When testing the finger for the first time, there will be some resistance. After the bends are created in the straw, the function of the finger will be much easier.
- When attaching the straws to the cup, take your time in aligning each finger before they are taped down. If you are doing cup stacking, it is best to have the figure work opposite of the thumb. This is so that when the hand is open, it can grab the cup easily.
- If you want to make it more robot-like, use only two straws on each side. Have them work like parallel grabbers.

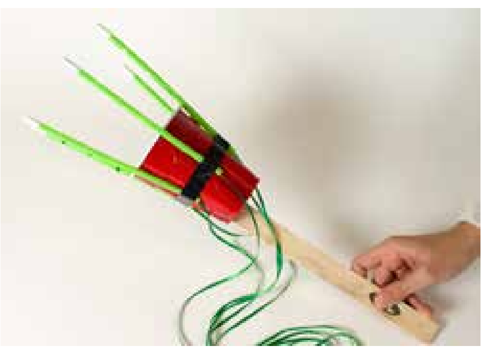


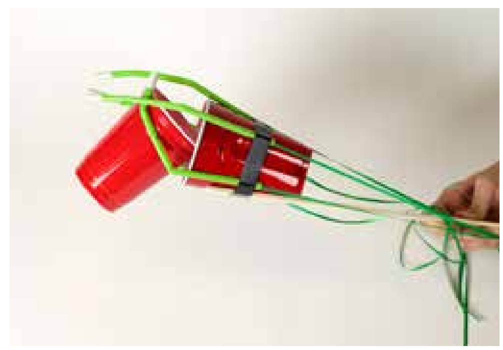
Suggestions for successful implementation of Games

To build the structures, get some solid plastic cups. If the cups are too light, the youth will have trouble stacking them. They will tend to fall over too easily.

- **Cup Stacking Race**
  - Set a pyramid height that is accessible and based on the age of the youth.
  - Set up team groups. They, must work together on building their teams pyramid. A single builder is easy, but having multiple arms working at the same time on the same pyramid will require teamwork.

- **Cup Stacking Robot with Wireless Controls.**
    - Each team will select a robot and a controller.
    - The robot will be blindfolded and the controller can only direct the robot with commands.
    - The team must build its cup structure before the other teams.
    - It is best for the leaders to demonstrate communication techniques to the team members so they have a better grasp of how to direct their robots.
    - Choose more complicated structures for older youth.
- **Highest Structure in Allotted Time**
    - This is a free for all. Each team will need to build the highest structure in a predetermined amount of time, with whatever design it can figure out.
- **Relay Race**
    - This is an optional activity you can do if you have time.
    - Use the arms in a relay race. The youth must pass objects to each other, robot hand to robot hand. Use different objects that will provide different strategies on how to grab, such as small water balloons, Ping-Pong balls, and so on.





Activities #5 and #6: Inflatable Space Station and Designer Space

Description of the inflatable space station activity

Cub Scouts will identify the various components of a space station, will gain an understanding of their separate functions and will build and inflatable space station that they can walk through.

Description of the designer space station activity

Cubs Scouts will explore the decision-making process required to build a space station like the International Space Station by participating in a team effort to design a model space station.

Background

The International Space Station (ISS) is an amazing engineering project involving work contributions from 16 nations (the United States, Russia, Japan, Canada, Italy, Belgium, the Netherlands, Denmark, Norway, France, Spain, Germany, Sweden, Switzerland, the United Kingdom and Brazil). The ISS is the largest spacecraft in history, measuring 88 m in length, 109 m wide, and weighing nearly 450,000 kg when originally completed. The ISS currently circles approximately 400 km above the Earth at 27,358 km/h, completing one orbit every 92 minutes and provides 1218 cubic metres of research and living space.

The ISS is unique in that it offers astronauts the opportunity to do something quite special: live and work longer than ever before possible in the microgravity environment of space (often incorrectly called weightlessness or zero gravity). Because the space shuttle has a very limited supply of consumables (food, fuel, etc.), missions normally last less than two weeks. On the ISS, astronauts are able to remain in orbit for up to six months at a time, giving them the opportunity to study the long-term effects of microgravity on biological and material samples. This type of research has never been possible on a space shuttle.

ISS and its Parts

The ISS is like a modern research building in that it has a frame, labs, living areas, water systems, power systems and parking. Cylindrical shaped facilities called modules are the main building blocks of the station. A bridge-like linear structure called a ***truss*** acts as the track of attachment point for the Canadian Mobile Servicing System, which includes Canadarm2 and the Special Purpose Dexterous Manipulator. Solar arrays provide electricity for the station.

You can find the description of the Canadian Mobile Servicing System (MSS) in the background section of the "Building a robotic hand" activity. The following is a description of the others parts that together, with the MSS, form the International Space Station.

Scientific Laboratories

The International Space Station is a world-class, state-of-the-art, multipurpose laboratory. It provides astronauts with a continuous shirtsleeve environment, meaning they do not have to work in their spacesuits. In this environment, astronauts can comfortably perform research in many areas including life sciences, microgravity sciences, Earth sciences and space science.

Trusses

The backbone of the International Space Station is made up of five large truss segments measuring 109 m. Canadarm2 installed the first of these segments in 2002.

Wires and cables snake through the truss to carry energy, coolant and information throughout the station. The truss is also the site of the Canadian Mobile Servicing System.

Solar Arrays

The Space Station uses solar arrays supplied by both the United States and Russia to convert sunlight into electricity for the crew and experiments. The American solar arrays consist of a group of eight panels, 34 m by 12 m. They are mounted in groups of four at each end of the truss. Because the Space Station is orbiting Earth, the relative position of the sun constantly changes. The solar arrays are mounted on rotating motors that allow them to follow the sun for maximum efficiency. The combined output of this system is 110 kilowatts (roughly equal to the electricity used by 55 average houses). When the Space Station is in the shadow of Earth, it relies on surplus electricity that has been stored in rechargeable batteries.

Nodes

A ***node*** is a passageway that connects the living and working modules of the International Space Station. The nodes are cylindrical and each one has six hatches that serve as docking ports to the other modules. Unity, the first node, was launched in 1998 and connects the Russian Zarya service module to the American Destiny laboratory and the Quest airlock. The second node connects the Destiny laboratory to the Japanese Experiment Module, Kibo, and the European laboratory module, Columbus.

Radiators

The ISS radiator system is used to maintain the temperatures of the various systems and elements on ISS.

Each radiator uses an ammonia flow system to cool the rest of the Space Station. The ammonia collects heat from the Space Station's electronic equipment and module cooling components and transfers it to the radiator panels so the heat can be dissipated into space. Ammonia was selected because it was found to be the best heat transport fluid that meets all of NASA's thermal performance and safety requirements (i.e. toxicity, flammability, freeze temperature, stability, cost and successful commercial and industrial use).

Living on the International Space Station

Microgravity (the absence of the effects of gravity) presents some interesting situations for astronauts living in space. Eating, sleeping, recreation and yes, even going to the bathroom are necessities that astronauts have to deal with while they are in space.

Let's explore what it's like for astronauts to live on the International Space Station.

On Tonight's Menu

Astronauts have an astonishing selection of food choices. The kinds of foods they eat are not mysterious concoctions, but foods prepared here on Earth, many of which are commercially available on grocery store shelves. Most of the food aboard the ISS is frozen (i.e. entrees, vegetable and dessert items), dehydrated or thermostabilized (heat-processed, canned, and stored at room temperature) and does not require the addition of water before consumption. Many of the beverages are dehydrated. In addition to the standard food selections, astronauts get a special treat whenever they are visited by a Space Shuttle.

Visiting astronauts usually bring an assortment of fresh fruits and vegetables that cannot normally be stored on the Space Station. For a few days, ISS astronauts can enjoy fresh produce from Earth.

Astronauts select their menus approximately five months before their flight. The menus are analyzed for nutritional content by a dietician and recommendations are made to correct any nutrient deficiencies based on the recommended dietary allowances of vitamins and minerals necessary to live and work each day in space.

Although the astronauts select their favourite foods, they often find that their sense of taste changes in space. If they no longer enjoy their selections, they will sometimes trade with other crew members.

Once the selection is complete, meals are individually packaged and stowed for easy handling in microgravity. Meals are stowed in special transparent pullout drawers so that all of the contents may be seen at once. Food and other items are restocked every 90 days.

Food Preparation

Astronauts prepare all of their meals in the galley — a kitchen area containing a hot and cold water dispenser and an oven. When it's time to eat, astronauts select which packages of food need to be warmed and place them in the oven.

During a typical meal in space, Velcro is used to hold food and beverage containers onto trays. This tray can be attached to a table or the astronaut's legs — again using straps fitted with Velcro. The meal tray becomes the astronaut's dinner plate, enabling him or her to choose from several foods at once, just like a meal at home.

Conventional eating utensils, such as knives, forks and spoons, are used in space. They are magnetized so they stay attached to the metal food tray. The only unusual eating utensil is a pair of scissors used for cutting open some of the heated meal packages. When the meal is finished, eating utensils and food trays are cleaned at the hygiene station with pre-moistened towelettes. All the trash is collected into containers to be burned up in the atmosphere or brought back to the Earth for disposal.

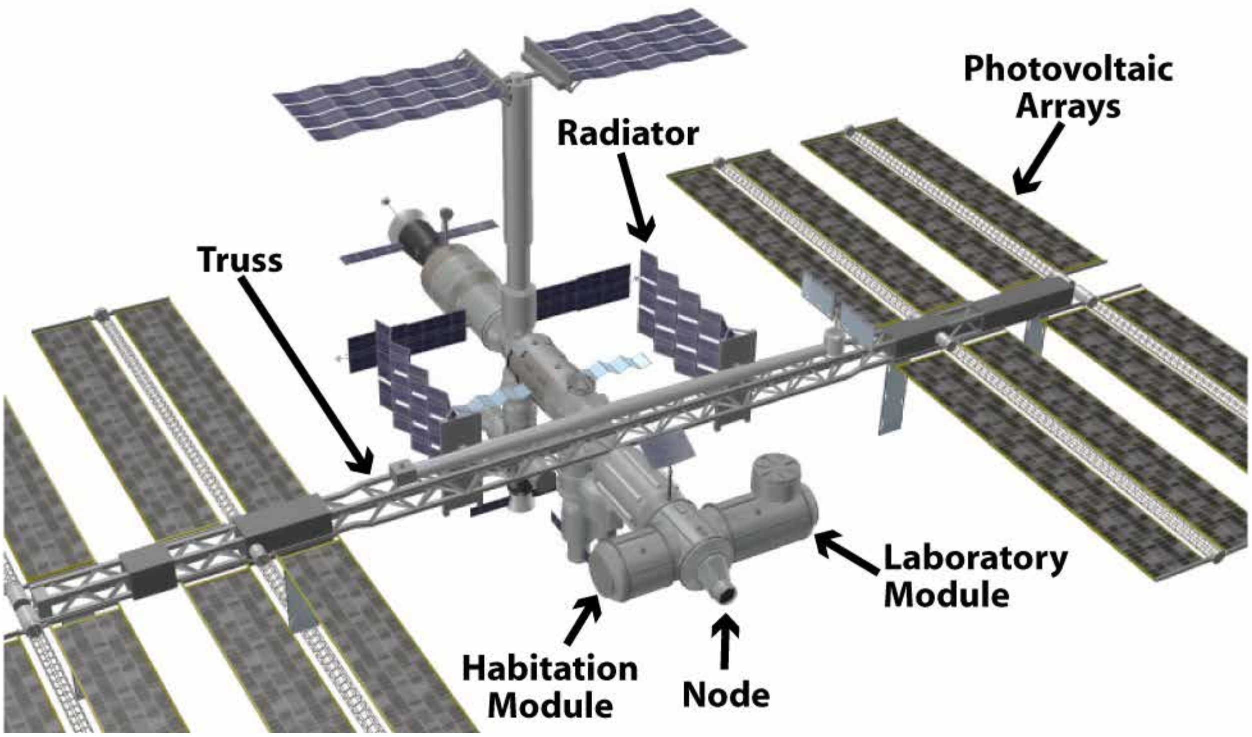
A typical series of steps involved in the preparation and consumption of a meal on the ISS includes:

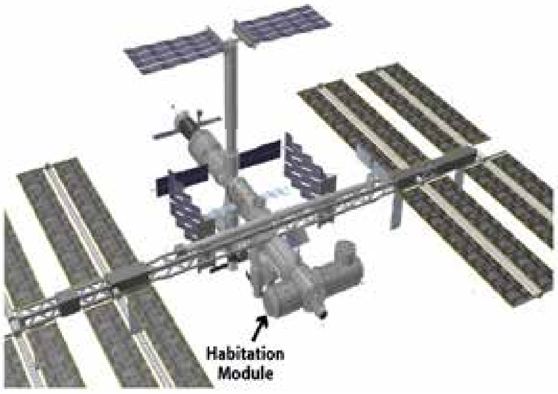
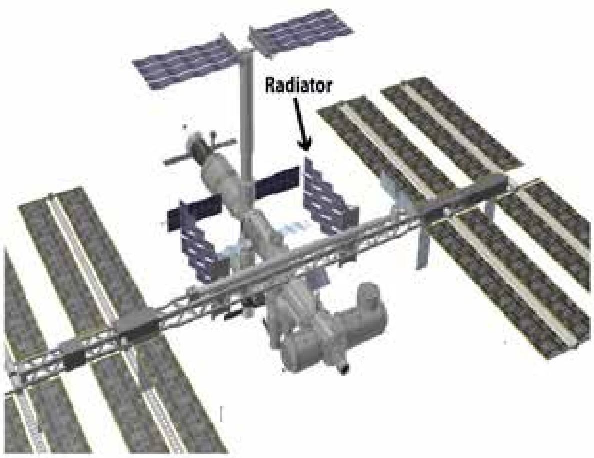
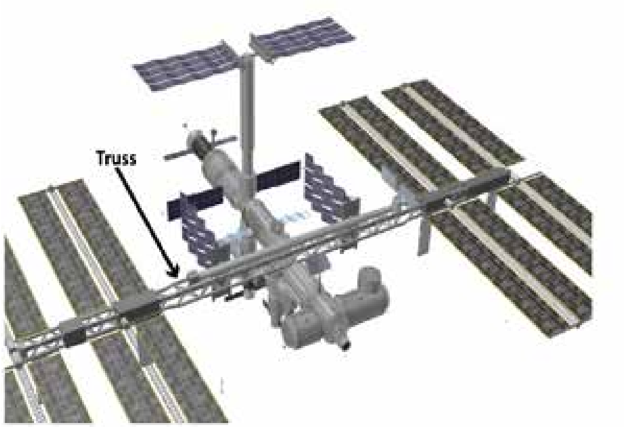
1. Collect meal tray and utensils
2. Prepare food items for heating
3. Place items to be heated in oven
4. Enter cook control codes and press “start”
5. Re-hydrate beverages
6. Place beverages on meal tray
7. Retrieve refrigerated foods
8. Place refrigerated food on meal tray
9. Retrieve items from oven
10. Place heated foods on meal tray
11. Eat meal
12. Place used containers in trash
13. Clean and stow meal tray and utensils.

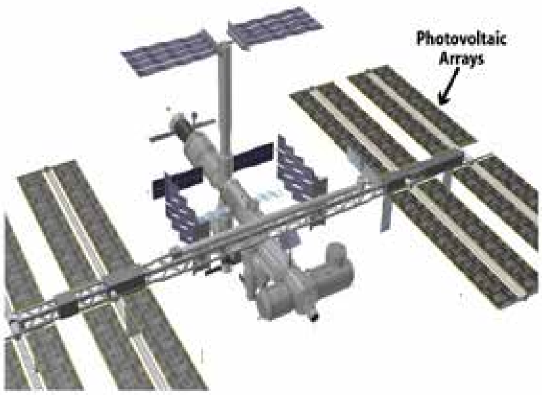
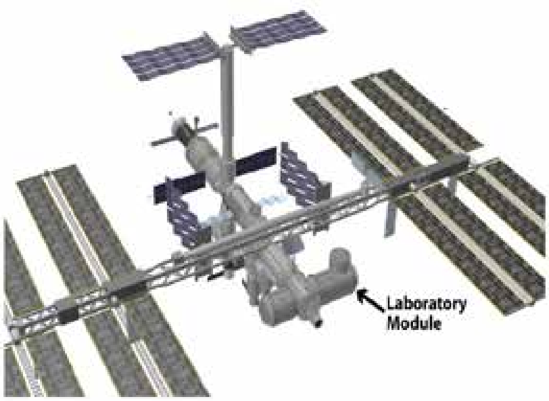
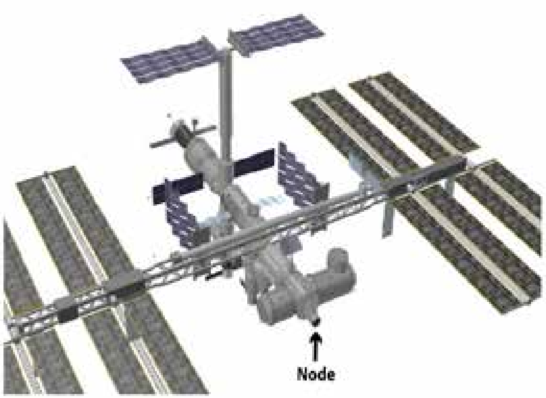
Canadian astronaut Chris Hadfield displays a variety of food selections for space flight

Activity Documents

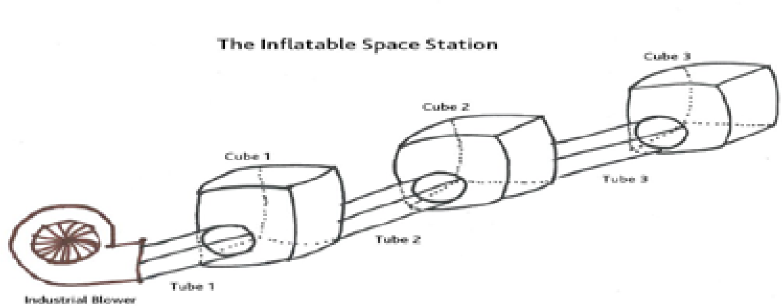
International Space Station Function Challenge



The part	The function
	The place where astronauts eat, sleep, bathe, cook and relax.
	Removes heat from the space station so it will not be too hot to live in.
	The backbone of the space station, used to attach all the parts together.

The part	The function
	The part of the space station that makes electricity to run machines and equipment.
	The space station crew spends 8-12 hour a day working here.
	A part of the space station that serves as a passageway between parts.

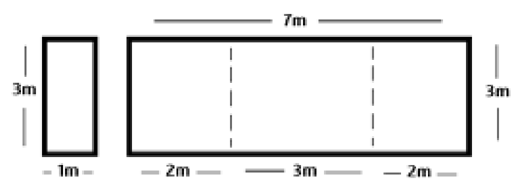
The Inflatable Space Station Construction Guide



* The dimensions below are suggested dimensions for a space station model that easily accommodates 20 Cubs. You can make a bigger or smaller space station depending on the number of Cubs in the Pack.

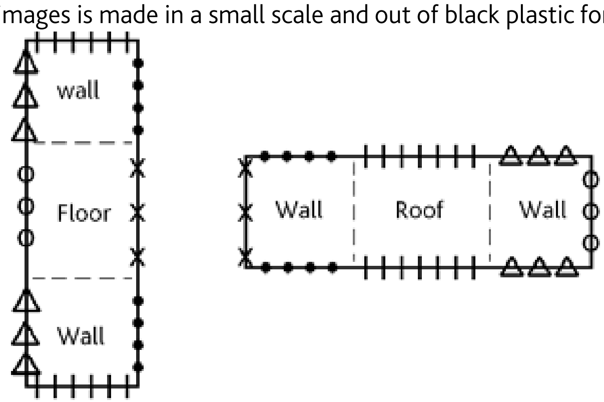
Cutting the plastic

1. Cut 6 sections of plastic sheet, 6m x 2m.
2. Cut three other sections, each 3m X 1m.



Connecting the pieces to make the cube

*The cube in the below images is made in a small scale and out of black plastic for demonstration.



1. Join pieces A and B along the seams marked x x x x

2. Join pieces A and B along the seams marked • • • • •

3. Join pieces A and B along the seams marked I I I I I I

4. Join pieces A and B along the seams marked Δ Δ Δ

5. Join pieces A and B along the seams marked o o o o

Pieces A and B should now resemble a Cube (more like a ball when it is not inflated.)

* When the first cube is done, one group of Cubs can move on to make the tunnels and the other can build the remaining two cubes needed.

Making the tunnels

1. To make the tunnels, Join the sides of each 3m x 1m section along the seams marked x x x x
2. This will give you tubes that are about 1m in diameter (large enough to crawl through).

Building the station

1. Attach the end of one tube to the industrial blower.
2. Cut a circle of about 30cm in diameter in one of the sides of one of the cubes. Make sure the hole is close to the ground and easily accessible to Cubs.
3. Place the other end of the first tube (the one connected to the fan) around the hole and attach it to the cube with duct tape.
4. Repeat step 2 and 3 to connect the two other cubes to the first one.
5. Start the fan and prepare to tape any holes.
6. When the cube is close to fully inflated, cut a slit into the front wall of the laboratory. Line this slit with duct tape so it doesn't rip as Cubs go in and out.

Space Station Materials Price List

Materials Price List

*This is just a suggested list. You can create your own materials price list based on what you can easily collect for the cubs.

Item	Quantity	Price
Bowl	1	$75
Clothes Pins	2	$25
Cups (Paper or Foam)	2	$100
Egg Carton	1	$100
Elastic Bands	3	$25
Masking Tape	1 metre	$25
Paper clips	5	$25
Paper Plate	1	$50
Pipe Cleaner	1	$25
Popsicle Sticks	2	$25
Straws	2	$50
String	50 cm	$25
Tin Foil	50 cm	$25
Toothpicks	4	$25
Toilet Paper Tubes	1	$100

Space Station Design and Budget sheet

1. You must have an approved design and budget for your space station, before construction may begin.
2. You will be given $1500.00 *Space Dollars* to finance your project.
3. Use of scissors and pencils is free.

Design and Budget Sheet

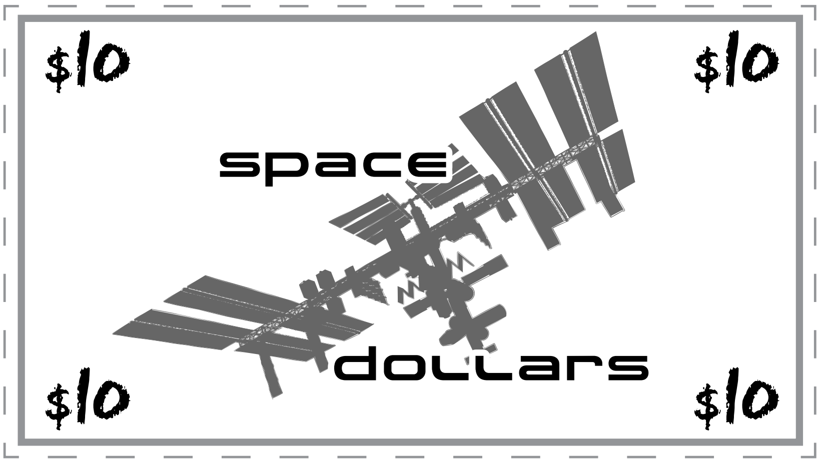
Proposed Budget

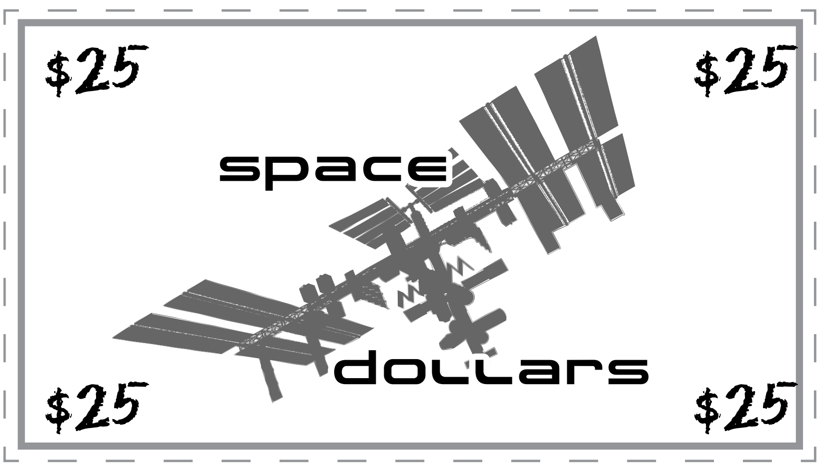
Item	Amount	Cost

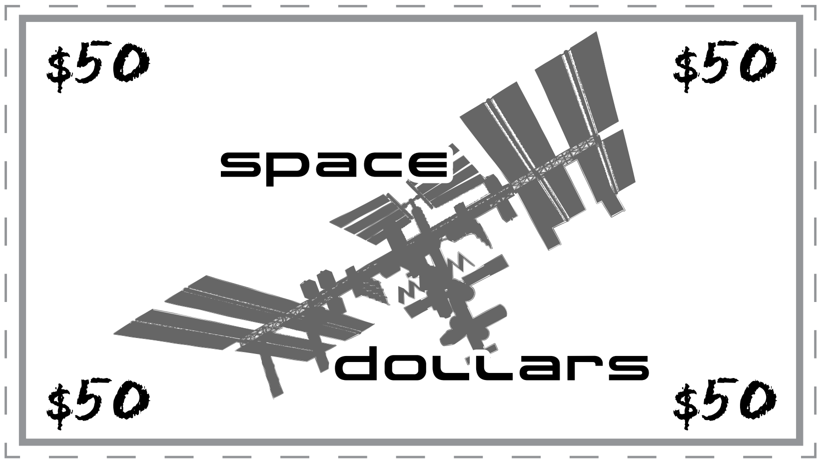
TOTAL $ ____________

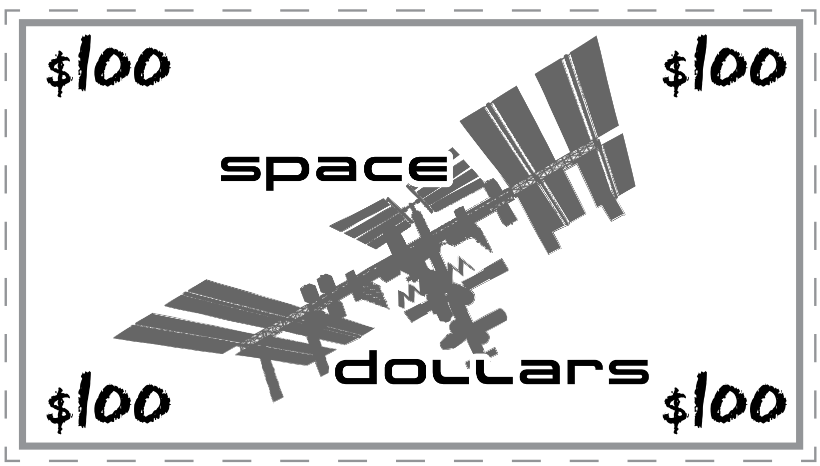
Space Dollars

Carefully cut along the dotted lines to make the Space Dollars you need for this activity.






$50
$50
space
dollars
$50
$50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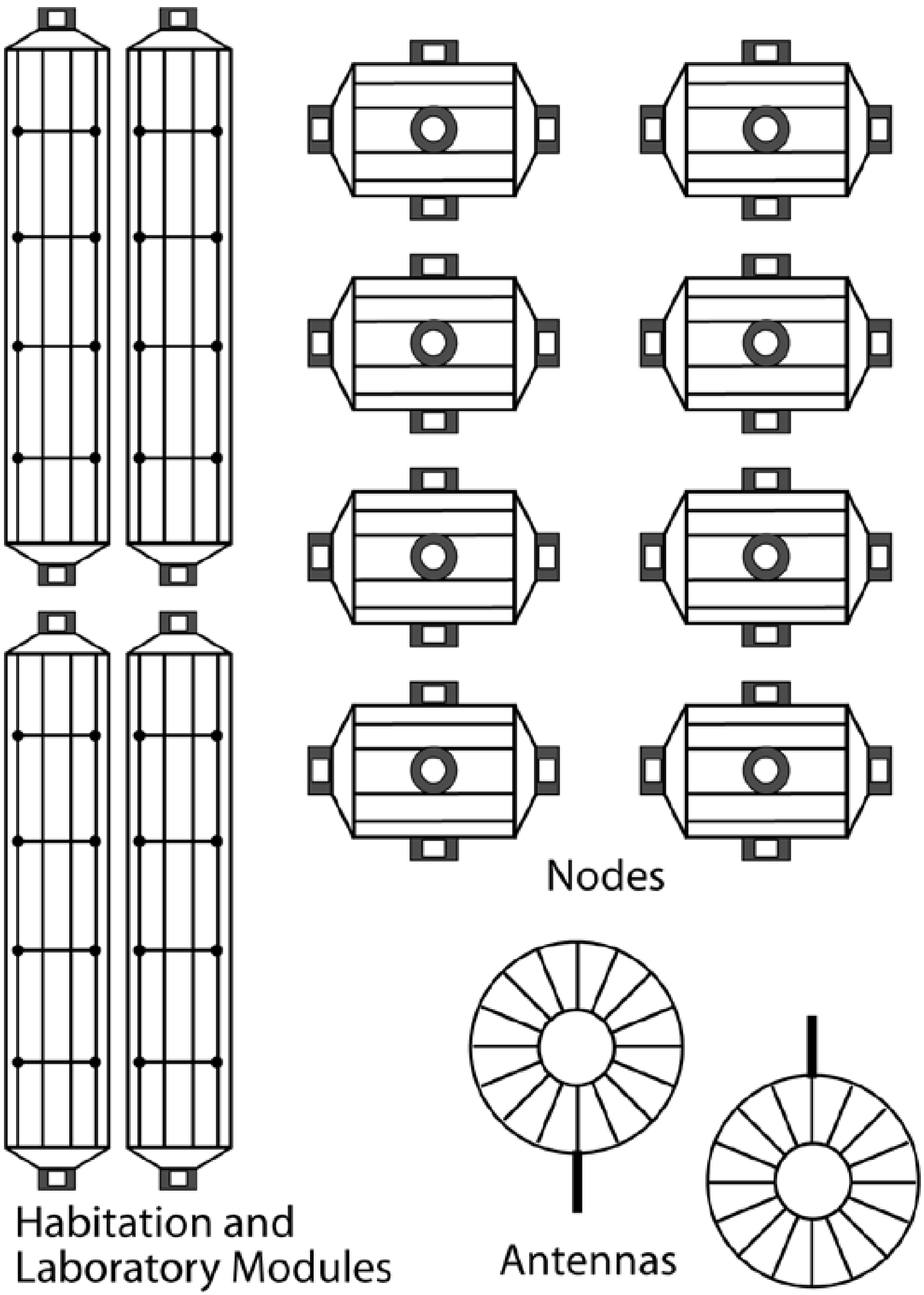
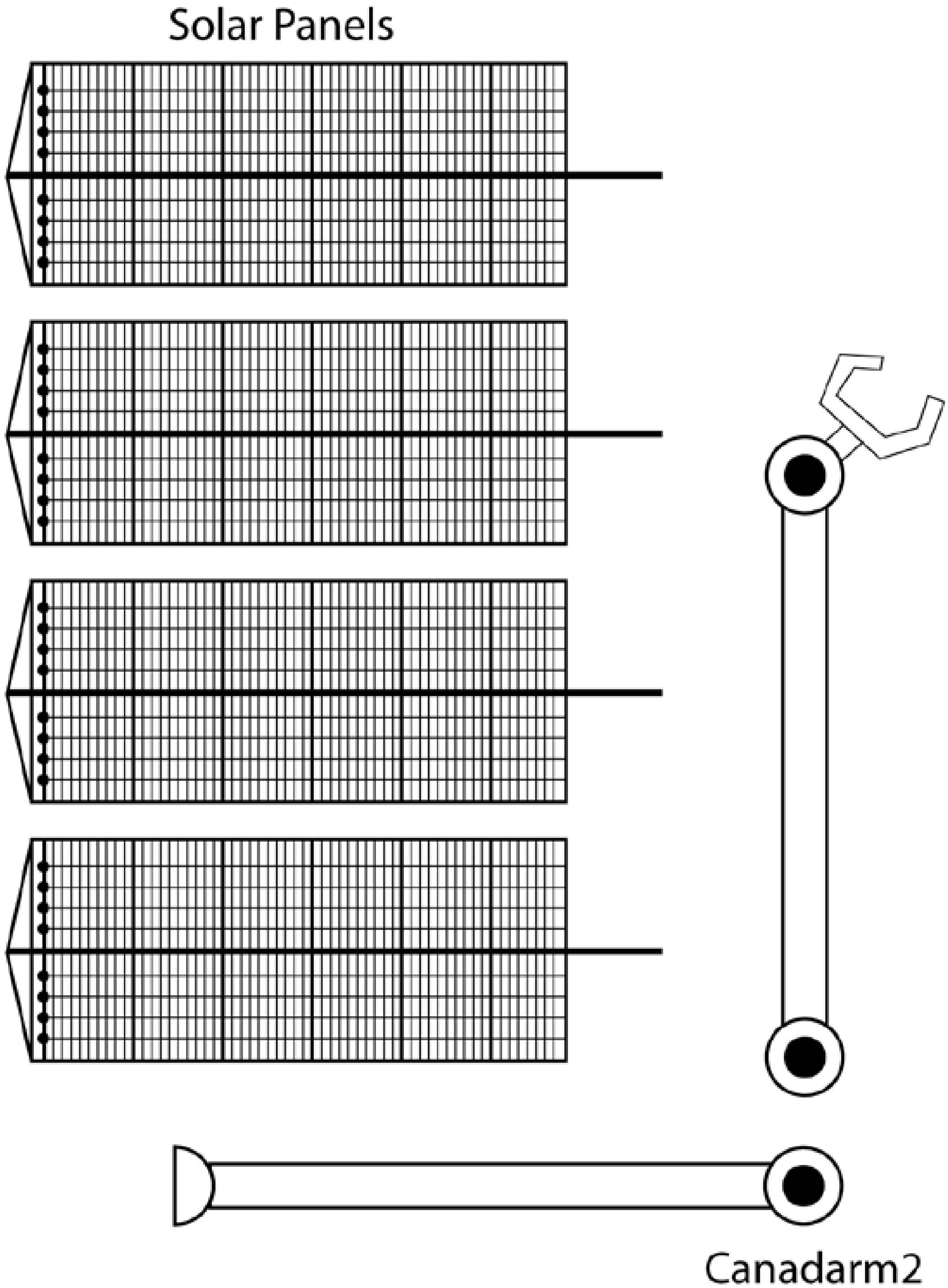
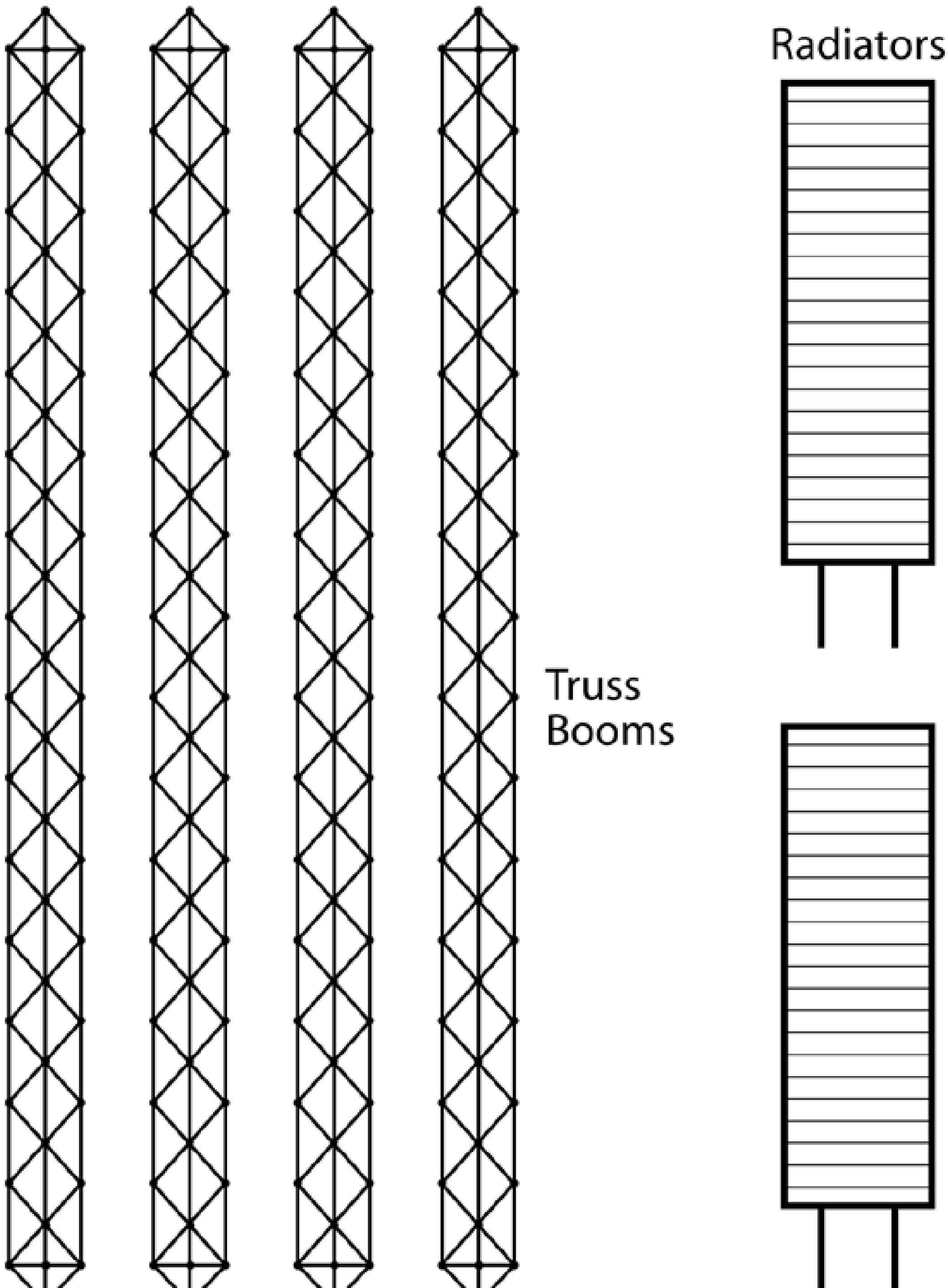
Alternative Activity: Space Station Parts




Solar Panels
Canadarm2


Radiators
Truss Booms

Activity #7: Mission Patch Design

Mission Patches and Their Descriptions[1]

Mission STS-41G

NASA Crew Patch: The 41-G mission insignia focuses on its seven-crew members (first to exceed six), the U.S. Flag and the Unity symbol known as the astronaut pin. The pin design in the centre shows a trio of trajectories merging in infinite space, capped by a bright shining star and encircled by an elliptical wreath denoting orbital flight.

Mission STS-42

NASA Crew Patch: STS-42 Mission Insignia depicts the orbiter with the Spacelab module aboard. The international composition of the crew is depicted by symbols representing Canada and the European Space Agency. The number 42 is represented by six white stars --- four on one side of the orbiter and two on the other. The single gold star above Earth's horizon honors the memory of astronaut Manley L. (Sonny) Carter, who was killed earlier in the year (1991) in a commuter plane crash.

Mission STS-52

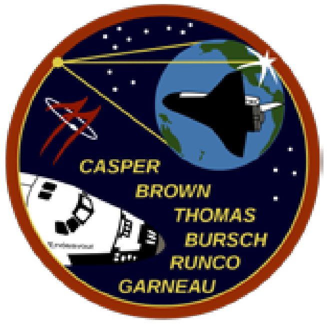
NASA Crew Patch: The official insignia of the NASA STS-52 mission, features a large gold star to symbolize the crew's mission on the frontiers of space. A gold star is often used to symbolize the frontier period of the American West. The red star in the shape of the Greek letter lambda represents both the laser measurements to be taken from the Laser Geodynamic Satellite (LAGEOS II) and the Lambda Point Experiment, which is part of the United States Microgravity Payload (USMP-1). TThe remote manipulator system (RMS) arm and maple leaf are emblematic of the Canadian specialist Steven MacLean.

Mission STS-74

NASA Crew Patch: STS-74 Mission Insignia depicts the orbiter Atlantis docked to the Russian Space Station Mir. The rainbow across the horizon represents Earth's atmosphere, the thin membrane protecting all nations, while the three flags across the bottom show those nations participating in STS-74: Russia, Canada and the United States. The sunrise is symbolic of the dawn of a new era in NASA space flight, that of International Space Station construction.

[1] NASA mission patch images and descriptions can be found at: http://www.nasa.gov/

Mission STS-77



NASA Crew Patch: The STS-77 crew patch, designed by the crewmembers, displays the Space Shuttle Endeavour at the lower left and its reflection within the tripod and concave parabolic mirror of the Shuttle Pointed Autonomous Research Tool. The reflection of Earth is oriented to show the individual countries of the crew as well as the ocean that Captain Cook explored in the original Endeavour. The mission number “77” is featured as twin stylized chevrons and an orbiting satellite as adapted from NASA’s logo. The constellation at the right shows the four stars of the Southern Cross for the fourth flight of Spacelab.

Mission STS-85

NASA Crew Patch: The mission patch for STS-85 is designed to reflect the broad range of science and engineering payloads on the flight. The primary objectives of the mission were to measure chemical constituents in Earth’s atmosphere with a free-flying satellite and to flight-test a new Japanese robotic arm designed for use on the International Space Station (ISS). Jupiter and three stars are shown to represent sources of ultraviolet energy in the universe. Comet Hale-Bopp, which was visible from Earth during the mission, is depicted at upper right. The left side of the patch symbolizes daytime operations over the Northern Hemisphere of Earth and the solar science objectives of several of the payloads.

Mission STS-78

NASA Crew Patch: The STS-78 patch tells the story of its mission and science through a design inspired by North America’s Northwest Coast Indigenous art. Central to the design is the Space Shuttle; its bold lines and curves evoke the image for the eagle, a Native American symbol of power and prestige as well as the national symbol of the United States. The wings of the Shuttle suggest the wings of the eagle whose feathers, indicative of peace and friendship in Native tradition, are captured by the U forms, a characteristic feature of Northwest Coast Indigenous art. The basic black and red atoms orbiting the mission number recall the original NASA emblem while beneath, the major mission scientific experiment package LMS (Life and Materials Sciences) is depicted in a manner reminiscent of totem-pole art.

Mission STS-90

NASA Crew Patch: The STS-90 crew patch reflects the dedication of the mission to neuroscience. Earth is revealed through a neuron-shaped window, which symbolizes new perspectives in the understanding of nervous system development, structure and function. The Space Shuttle Columbia is depicted with its open payload bay doors revealing the Spacelab within. An integral component of the mission, the laboratory/science module provided by the European Space Agency (ESA), signifies the strong international involvement in the mission. The seven crew members and two alternate payload specialists, are represented by the nine major stars of the constellation Cetus (the whale) in recognition of the International Year of the Ocean.

Mission STS-96

NASA Crew Patch: The crew patch for STS-96 space flight highlights the major themes of the Station Program: Earth-directed research, the advancement of human space exploration and international cooperation. The Space Shuttle Discovery is depicted shortly after reaching orbit as the crew prepares to carry out the first docking with the new Station. The triangular shape of the patch represents building on the knowledge and experience of earlier missions, while the three vertical bars of the astronaut emblem point toward future human endeavours in space. The blend of red, white and blue is a tribute to the nationalities of the crew members who are from the United States, Canada and Russia.

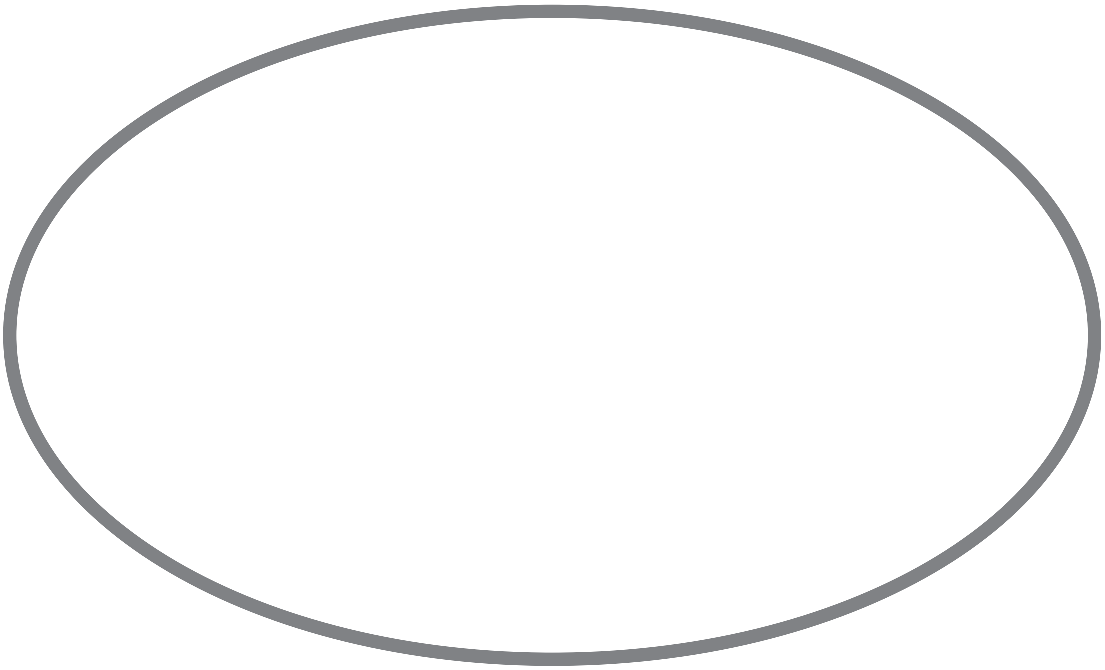
Mission STS-97

NASA Crew Patch: This is the crew insignia for STS-97, which will deliver, assemble and activate the U.S. electrical power system on board the International Space Station (ISS). The electrical power system, which is built into a 14-metre integrated truss structure known as P6, consists of solar arrays, radiators, batteries and electronics. P6 will be attached to the Station using the Shuttle's robotic arm in coordination with spacewalking crewmembers who will make the final connections. The 37-metre solar arrays will provide the power necessary for the first ISS crews to live and work in the U.S. segment.

Mission STS-100

NASA Crew Patch: The STS-100 emblem reflects the complex interaction of robotics and extravehicular activity (EVA) on this mission. During the mission, spacewalks will be conducted to deploy the Internal Space Station Remote Manipulator System (Canada Arm). The EVA helmet frames the patch, with the Canadian-built Arm shown below the visor. Reflected in the visor is the Space Shuttle Endeavour, with the International Space Station rising above the horizon at orbital sunrise. American, Russian, Canadian and Italian astronauts compose the crew, and their flags are stylized in the lower portion of the emblem. Ten stars adorn the sky, representing the children of the STS-100 crew and the future of space exploration.

Activity Document: Mission Patch Templates



Materials List for the Kit

Activity	What is in the kit	What you need to provide
Activity #1: Piloted and unpiloted space exploration	• Mini-telescopes • 1 Ball (30 cm diameter) per team • Velcro • Rocks • Cotton balls • Marbles • 1 small plastic animal per team • 1 small square of fabric per team • 1 set of walkie-talkies per team	• Pencils • Notebook for recording observations
Activity#2: Rockets and spacecraft	• Bottle rocket adapter kits • Bicycle pumps • Film canisters	• 2 L plastic soft drink bottles • Effervescent antacid tablets (or vinegar and baking soda) • Water pitcher • Large portable water container
Activity #3: Astronaut training	• Siphon pump and tube • 2 plastic containers • Towel or sock with toes cut out • Clear glass bottle • Kitchen vacuum pump • Small balloons • Work gloves or hockey gloves • LEGO blocks • Needle and thread • Chopsticks • Sponge • 2 kitchen containers • Marbles • Mirrors • Job cards	• Ice water • Paper and pencil • Copies of ***Disorientation Maze template*** (found in the manual) • Pencils • Prisms (optional)

Activity #4: Making a robotic Hand	• Hole punch	• Ribbons (at least 2 metres for each Cub) • Plastic straws with vertical lines (10 for each Cub) • Plastic or paper cups (2 for each Cub and an additional 20 or more for each team of 3-4) • Adhesive tape or glue • Paint sticks, wood dowels, cardboard tubes for the arm (1 for each Cub) • Scissors
Activity #5: Inflatable Space Station	• *Space Station Function Challenge cards* • Measuring tape	• 30 meters of plastic sheet (10 mil or 12 mil) in a roll about 3 meters wide • About 60 meters of duct tape (having multiple roles allows cubs to work on different parts of the project simultaneously)
Activity #6: Designer Space Station	• Space dollars • Materials price list • Design a space station budget sheet	• Paper Folders • Copies of the space station parts from the manual • Bowls, cups, rollers, scissors • Clothes pins, elastic bands, masking tape, paper clips • Paper plates, Styrofoam trays • Pipe cleaners • Popsicle sticks • String, tinfoil, toothpicks, straws • Egg cartons, Toilet paper
Activity #7: Mission Patch Design	• Mission patches samples	• Large paper • Felt-tip markers • Scissors • Copies of Mission Patch templates (found in the manual)

Visual Guide to Assembling the Kit

The kit

The bottom

1st level

2nd level

3rd level

The top