TOPIC 8 People in Space

Figure 5.57 Space shuttle Atlantis blasts off in 1997 on its way to dock with the Soviet space station Mir.

There are many reasons why all types of technology are developed. In Unit 5, you've seen that some technology is developed out of curiosity. Galileo built his telescope because he was curious about the stars and planets. You've also learned that some technologies are built to help countries fight an enemy in war. The German *V-2* rocket is one example of this. You may have learned in social studies class about the cold war between the United States and the former Soviet Union. There was no fighting with guns or bombs. However, these countries deeply mistrusted each other and became very competitive. They tried to outdo and intimidate each other. This competition thrust these countries into a space race, which was a race to be the first to put satellites and humans into space. Topic 8 looks at how the desire to go into space drove people to produce technologies that could make space travel a reality.

Breaking Free of Earth's Gravity

Figure 5.58 *Sputnik 1* was the world's first artificial satellite. It was only about the size of a basketball and weighed 83 kg. It took about 98 min to orbit Earth. This was a great achievement and marked the beginning of the space age for humankind.

Although space is only a hundred or so kilometres "up there," it takes a huge amount of energy to go up and stay up there. The problem is gravity. Imagine throwing a ball as high as you can. Now imagine how hard it would be to throw the ball twice as high or to throw a ball twice as heavy. Gravity always pulls the ball back to Earth.

Anything that escapes Earth's gravity completely must reach a speed of about 8 km/s (29 000 km/h)! The rocket power needed to put capsules into orbit with people inside is incredible. If the smallest thing goes wrong, the rocket may explode or crash land. Once in orbit, a broken windshield, a misfiring control rocket, or a malfunctioning heat shield spells disaster.

Sputnik 1 and *Vostok 1*

The Soviet Union was the first to successfully orbit a satellite with no astronauts inside. They launched *Sputnik 1* in 1957. The Soviets were also first to put a person in space. On April 12, 1961, Cosmonaut Yuri Gagarin, in his *Soyuz* class space capsule, *Vostok 1*, orbited Earth once at an altitude of 302 km for 108 min.

Figure 5.59 *Vostok 1* travelled at close to 29 000 km/h. The rocket that carried cosmonaut Yuri Gagarin to space was *Vostok* 8K72K. Gagarin was the first person actually to see that Earth is round! After re-entering the atmosphere, his capsule parachuted to the ground. (He ejected from his capsule before it landed and parachuted to the ground separately.)

DidYouKnow?

On June 16, 1963 Valentina Tereshkova, a 26-year-old Soviet cosmonaut, became the first woman to travel in space. She was launched into orbit aboard the Soviet spacecraft, *Vostok 6*. She orbited Earth 48 times and spent almost three days in space. She never made a second trip into space.

Alan Shepard and *Freedom 7*

The American response to the Soviet manned space program was Project Mercury. The ultimate goal of Project Mercury was to place an astronaut in orbit. On May 5, 1961, aboard the spacecraft *Freedom* 7, Alan B. Shepard, Jr., became the first American astronaut in space. Shepard flew a suborbital flight. A **suborbital** trajectory is one in which the spacecraft is boosted above the atmosphere and then falls back to Earth without going into orbit. In 1962, astronaut John Glenn was the first American to make a full orbital flight.

Figure 5.60 Alan Shepard was the first American in space.

The Apollo Program

United States scientists were determined to play an important role in space exploration. Now that they had safely put a person in orbit, they set their sights on the Moon. The Apollo Program was designed to send a three-person team to the Moon, land two of them, and bring everyone back safely. The *Apollo* spacecraft consisted of an orbiter (the command and service modules), and a lander (the lunar module).

Did You Know?

Project Gemini was a bridge from Project Mercury to the Apollo Program, the program that landed astronauts on the Moon. Project Gemini put teams of two astronauts in orbit. The Gemini astronauts practised docking manoeuvres, performed space walks, and spent longer periods of time in space to prepare for the lunar landing.

The Moon Landing

In the summer of 1969, *Apollo 11* carried the first humans to the surface of another world — the Moon! Neil Armstrong was the first to step onto the Moon's surface, followed by Edwin Aldrin. Michael Collins manned the command module in lunar orbit. As Neil Armstrong stepped onto the lunar surface, he said these famous words: "That's one small step for [a] man, one giant leap for mankind."

Pause & Reflect

Consider the words that Neil Armstrong spoke when he stepped onto the Moon's surface. In your Science Log, write down what you think he meant by them. What would you say if you were the first person to step onto the surface of Mars?

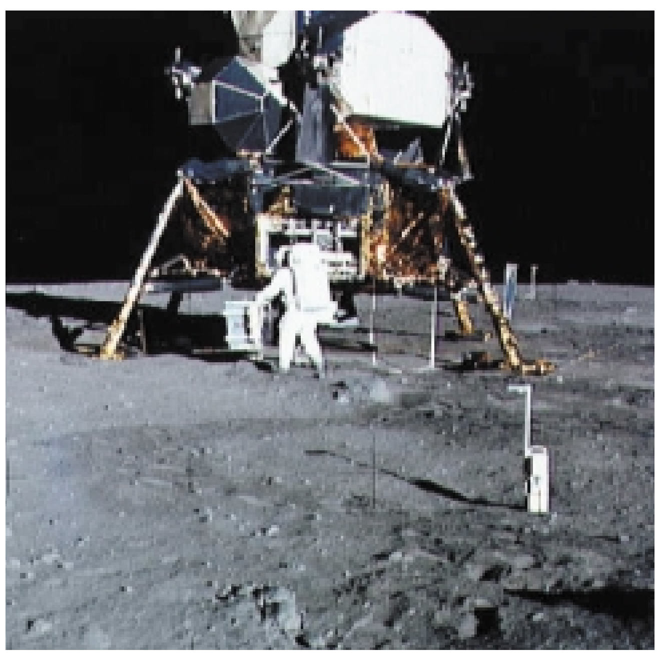


Figure 5.61 Edwin Aldrin works on some equipment near the lunar module. Neil Armstrong took the picture.

Off the Wall

Apollo astronauts left reflectors on the Moon so that astronomers could bounce laser pulses off them. By timing how long the light takes to return to Earth, they are able to measure the distance to the Moon to within a few centimetres.

PROBLEM-SOLVING

INVESTIGATION 5-J

SKILLCHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Design a Space Capsule

Space capsules have to withstand the tremendous acceleration of a rocket launch. They have to protect the occupant from the vacuum of space and the radiation from the Sun while in orbit. Finally, they have to withstand the heat of re-entry and land safely.

Challenge

Design and construct a "capsule" that can be launched and will land safely with its "astronaut," a raw egg, intact. It must also be able to withstand the "heat of re-entry" in a pot of boiling water.

Safety Precaution

- Any completely airtight container will build up pressure inside when heated. To avoid any danger of an explosion, your capsule must be able to "breathe."
- **Do not boil your capsule for longer than 3 min or it may explode.**

Apparatus

hotplate
pot
timer
gloves that serve as hot pads
tongs

Materials

eggs
any kind of padding or outside container is allowed as long as your teacher doesn't find it to be dangerous

Design Specifications

A. All the capsules will be launched by the same device provided by your teacher.

B. Your capsule must fit into the launching device.

C. You may use a parachute if you want to.

D. After a successful flight, your capsule will be placed into a pot of boiling water and cooked for 3 min. Your egg will then be opened to see if it is still raw. A successful flight means that your egg is unbroken or uncracked afterward.

Plan and Construct

1. With your group, discuss any egg drop-type events you have done or seen. What kind of padding can keep an egg safe?
2. Is it important to prevent your capsule from tumbling in flight?
3. Discuss whether or not a parachute is needed.
4. How will you keep your egg from cooking?

Evaluate

1. Which is harder on the eggs — launching or landing?

2. Were there any parachute designs that failed to open properly? Why did they fail?

3. What characteristics did the most successful "heat shields" share?

Extend Your Skills

4. The Americans parachuted their astronauts into the ocean while the Soviets landed on solid ground. How much of a difference does that make in designing to ensure a soft landing?

5. Can you think of any devices we use on Earth that use the same principles as the capsules?

Meeting in Space

Cold war tensions between the Soviets and Americans were easing in the 1970s. The Americans proposed a joint mission of the two countries. They would use existing hardware, *Apollo* and *Soyuz*, in a linking mission. The *Apollo/Soyuz* test project was flown in 1975. It was the first international space mission. *Apollo/Soyuz* was a test of the warmer relations between the United States and the Soviet Union and would hopefully be a preparation for a future international effort in building a permanent space station. A universal docking module was designed to enable the linking of the two spacecraft to take place. Each country built its half of the docking linkage. Joint tests were done to ensure workability and reliability of the linking parts.

Life-Support Compatibility

The *Soyuz* and *Apollo* spacecraft provided life support to their crews in different ways. This posed a problem for the linking structure. Many facets of the life-support systems had to be made compatible. The atmosphere on Earth is a mixture of 78 percent nitrogen and 21 percent oxygen, with small quantities of water vapour and carbon dioxide, plus traces of other gases. Since astronauts (like all people) continually breathe oxygen and generate carbon dioxide and water vapour, the spacecraft needed devices to replenish oxygen and to eliminate excess carbon dioxide. The Soviet and American engineers removed carbon dioxide and humidity by using the same chemical reactions. However, they approached the problem of oxygen supply differently.

Table 5.1 Soviet/American Oxygen Production in Space (as of 1975)

	Soviet system	American system
Cabin atmosphere	80% nitrogen, 20% oxygen at normal air pressure	100% oxygen at about one-third air pressure
Advantages	simplicity and minimal danger from fire	a switch from cabin to suit system oxygen would not subject the crew to decompression problems
Disadvantages	cosmonauts would be exposed to potential decompression should they have to switch to a spacesuit life-support system in an emergency	danger from fire, requirement for flameproofing all materials used in the cabin
Oxygen replenishment	chemical reactions with solid chemicals	oxygen stored in high-pressure containers

The module between the American and Soviet craft was designed to act like a life raft. The module's atmosphere could be set to be the same as existed in either the American or Soviet crafts. This made it easier for the astronauts and cosmonauts to move between the two vessels.

Many other detailed considerations (other than life support) were slowly worked out. Five years after the original proposal was offered, the mission flew successfully.

DidYouKnow?

From the beginning, scientists had cosmonauts and astronauts do strenuous exercises while they worked in space for extended periods of time. Even with this exercise program, their muscles were so weak upon return to Earth that they had to be lifted from their capsules and placed in wheelchairs. Why did this happen? On Earth, we are constantly working against gravity. Lifting your arm to take a drink involves lifting a weight — your arm — which is levered for speed and not force. In space, all body movements are done in microgravity, which means your muscles exert very little force. Therefore, the muscles atrophy or deteriorate.

Figure 5.62 When the shuttle lands in California, it is returned to Florida on the back of a Boeing 747. The shuttle is almost as big as the commuter jets that fly from Edmonton to Calgary.

The Space Shuttle

As the 1970s drew to a close, the United States decided to develop a reusable spacecraft — the Space Shuttle. Up to this time, all spacecraft could be used only once. A reusable spacecraft would lower the cost of working in the near-space environment of a space station. At 56 m long and with a mass of 100 t, the shuttle became NASA's primary launch vehicle. It is used as a lab to do experiments in space, to deploy satellites, to photograph Earth, and to carry repair crews for orbiting equipment.

Columbia's First Flight

DidYouKnow?

All shuttle missions are designated numbers that begin with "STS." This stands for space transport system.

The first shuttle, *Columbia*, flew its first mission to space in 1981. Some of the heat-shielding tiles were damaged during the launch, but the tiles on the underside were intact. These tiles protect the shuttle from burning up in the atmosphere upon re-entry. The shuttle is shaped like a plane because it glides to Earth with no power of its own.

Seven months later, *Columbia* flew again. The Canadian-built space arm (the Canadarm) was tested on this flight and has been part of all shuttles since. This second mission proved that a craft like the shuttle could be used over and over.

Canadian Astronauts Join In

DidYouKnow?

Space travel is always a dangerous endeavour. In 1986, the shuttle Challenger was to launch a mission that included a teacher who would teach a lesson in space. A leak in one of the solid fuel boosters ignited the main fuel tank, which exploded, destroying the shuttle and killing everyone aboard.

In 1983, the Canadian Space Agency hired Canada's first team of six astronauts: Roberta Bondar, Marc Garneau, Steve MacLean, Ken Money, Robert Thirsk, and Bjarni Tryggvason. In 1992, Chris Hadfield, Julie Payette, Mike MacKay, and David Williams joined the team of Canadian astronauts. Roberta Bondar and Ken Money left the CSA in the summer of 1992 and Capt. Mike McKay in 1995. Canadian astronauts spend most of their time training with the Americans at NASA.

Marc Garneau became the first Canadian in space aboard *Challenger* (STS-41G) in 1984. Roberta Bondar became the second Canadian, and the first Canadian woman, in space aboard *Discovery* (STS-42) in 1992. Both were mission specialists conducting research. Canadian astronauts will remain mission specialists and payload specialists for a long time because Americans use their own astronauts to pilot the shuttles.

Figure 5.63 Canadian astronaut Chris Hadfield "floats" through the docking mechanism, as crews from the *Atlantis* and *Mir-20* spacecraft got together during space orbit in 1995. On his second trip into space in 2001, Chris became the first Canadian to "walk" in space.

The *International Space Station*

In addition to launching and fixing satellites, the shuttles are being used to help build the *International Space Station* (ISS). This project is truly international as it involves contributions from 16 nations. It is the largest and most complex international scientific project ever undertaken. It will contain six state-of-the-art laboratories for international research. Along with the United States (NASA), major partners in the ISS are Canada (CSA), the European Space Agency (ESA), Japan (NASDA), and Russia (RSA).

Did You Know?

China has been working on a manned space program of its own for the last several years. The Chinese are somewhat secretive about this program, but news reports say that they are close to their first launch. Watch the newspapers in the coming months and years for new developments.

Figure 5.64A and B This is the state of the *International Space Station* in the year 2000 when its first crew went aboard. Three pieces had been connected at this time. The first crew to occupy the station is shown in the inset. From the left, they are Russian Cosmonaut Yuri Gidzenko, U.S. Astronaut Bill Shepherd, and Cosmonaut Sergei Krikalev.

Looking Ahead

Turn to the Unit 5 Project, An Arm of Your Own, on page 432 of your textbook. The project gives you a chance to design your own manipulating arm.

The Next Canada Arm

Canada developed a second generation of space robotics for the ISS that will be a key component for the station's assembly and maintenance. The device, called the Canadian space station remote manipulator system (SSRMS) or "Canadarm2," is a giant mechanical arm attached to the space station. In 2001, Canadian astronaut Chris Hadfield travelled into space to help attach the Canadarm2 to the ISS. Attached to the end of the arm is the special purpose dexterous manipulator (SPDM) or "Canada Hand."

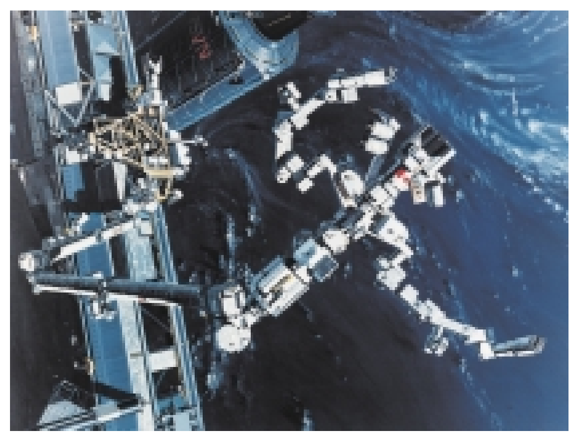


Figure 5.65 Canadian companies have produced a large version of the space arm that will attach to the space station. It has a "hand" unit on its end.

Benefits from the ISS

The *International Space Station* will provide an orbital laboratory for long-term research, where one of the fundamental forces of nature — gravity — is effectively reduced by the free-falling effect. In addition, research in biology, chemistry, physics, ecology, and medicine can be conducted. In short, the science will cover all the sciences we do on Earth, but in the microgravity environment. The term "**microgravity**" is used instead of "zero gravity" because there is almost as much gravity in orbit as there is on Earth.

DidYouKnow?

The European Space Agency has a core of astronauts too. The European astronauts' home base, the European Astronaut Centre, is located in Cologne, Germany. For the *International Space Station*, international crews will come to Cologne to be trained in operation of the ESA contribution to ISS: the Columbus Laboratory, the automated transfer vehicle, and a number of payload facilities for scientific experiments.

Figure 5.66 This is how the *International Space Station* will look when it is finished.

Weightlessness occurs because orbiting has the same effect as falling. In orbit you are constantly falling around the world!

The medical benefits of conducting science in space could lead to new drugs and a new understanding of the building blocks of life when we see how they behave in microgravity. Researchers also expect a thorough understanding of the effects of long-term exposure on humans in a microgravity environment.

Industrial benefits may lead to stronger, lighter metals and more powerful computer chips.

While some experiments will take place inside the space station, others will take place externally. These experiments will help reveal the effects of long-term exposure to the external space environment. Understanding phenomena, such as extreme temperatures and micro-meteorites, will help engineers improve spacecraft design. Observations of Earth will enable researchers to study changes to our environment whether they occur naturally or by human action. Other benefits may also lead to advanced weather forecasting systems and the most accurate atomic clocks.

Commercialization of space research will enable industries to explore new products and services. Finally, the result of such innovation will create new jobs here on Earth and in space.

INTERNET CONNECT

www.mcgrawhill.ca/links/sciencefocus9

There were many space stations before the *International Space Station*. In the early 1970s the Soviets began orbiting a series of space stations called *Salyut*. Later, in 1986, they launched *Mir*, which stayed in orbit until 2001. The Americans launched *Skylab* in 1973. Research one of these older space stations to find out some of their scientific accomplishments. Write a report of your findings. Go to the web site above, and click on Web Links to find out where to go next.

SKILLCHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

A Debate: Merits of Space Travel Using Astronauts

Think About it

Dreams of human exploration of the solar system have never died, however expensive it may be. By the end of the twentieth century, proposals by NASA and independent teams for a voyage to Mars had again caught people's interest. Still, the least expensive of the proposals had a price tag of over $30 billion Canadian.

Do you think we should send people to explore the Moon and planets in our solar system? What are the advantages of space travel using astronauts? What are the disadvantages? Are there better alternatives? In this investigation, you have the opportunity to debate them.

How Can Science Help?

Scientists must monitor astronauts' reactions to gravity and overall health in preflight tests and while they are in space. Research must be carried out into developing better technology for space flights and into the possibility of living and working in space permanently.

Resolution

"Be it resolved that a modern aerospace program, to be effective, must involve sending people to explore outer space."

Procedure

1. Read the "Points For" and "Points Against" on this page and think about other points that could be made in favour of and against this resolution.
2. Two teams made up of two students each will debate the topic. One team will speak in support of the resolution and the other one will speak against it.
3. Two other students will be assigned to work with each team to research background information needed to make a strong case for the point that the team is defending.
4. The rest of the class will act as the jury in hearing the debate. In preparation for the debate, they should do their own research in order to understand the science and technology behind the issues raised.
5. Your teacher will provide you with the proper debating procedures to follow.

Points For

- Space travel using astronauts puts humans "on site" to experience the mission first hand; unmanned space travel is limited by what information computers can relay to Earth.
- Space travel using astronauts is the only realistic way to study the effects of space travel on the human body and other living organisms.

Points Against

- Space travel using humans is much more costly than space travel using robots, and diverts money away from other, perhaps more beneficial, projects.
- Space travel using astronauts puts the lives of humans at risk; space travel using robots does not.

Analyze

1. (a) Based on overall presentation, which team won the debate?

(b) Was it the team's research or its delivery that made their case more convincing? Explain.

2. What was your position on the issue of astronaut versus robotic space travel before the debate? Did the arguments you heard from the two teams change your mind? If so, explain how. If not, did the team representing the view opposite yours still raise some good points you hadn't thought of before? What were they?

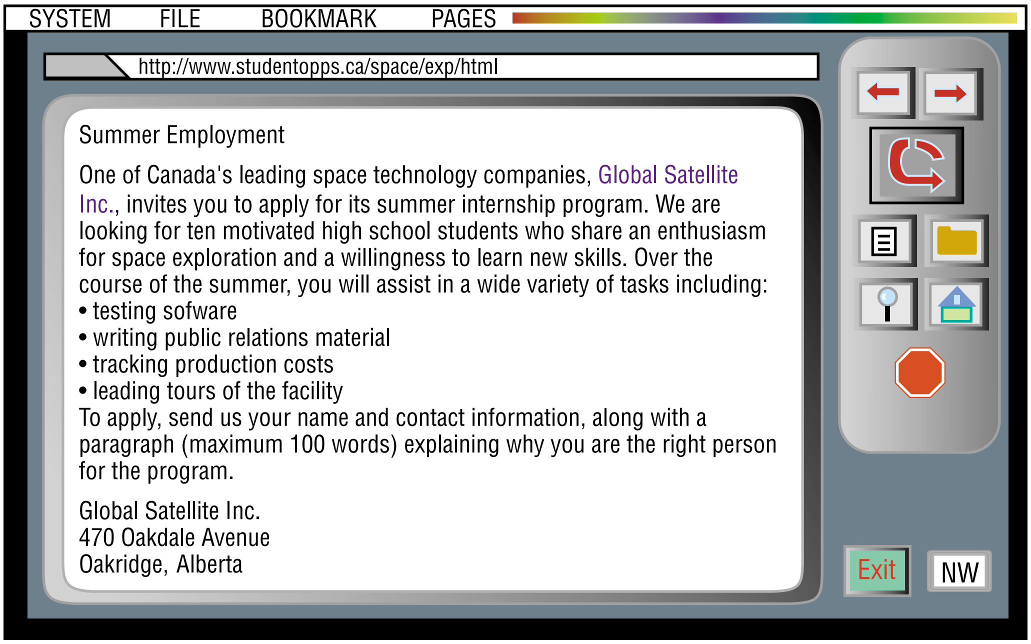
Skill FOCUS

For tips on decision-making, turn to Skill Focus 8.

Career CONNECT

SPAR Aerospace, the Canadian company that designed and built the *Canadarm*, is also the maker of its successor, the SSRMS (the Space Station Remote Manipulator System or "Canadarm 2") and the other components that make up the *International Space Station's* Mobile Servicing System. This newer arm is so advanced that, once astronauts on the delivery shuttle released its travel restraints, it walked out of the cargo bay on its own.

Suppose that a similar Canadian company posted the following internship notice on the Internet. Write your application. Then exchange it with that of a friend. Discuss the possible strengths and weaknesses of your applications.



TOPIC 8 Review

1. Name two things that engineers need to consider when designing a space capsule to protect the astronaut.

2. Why is the space shuttle different from all the other space vehicles that came before it?

3. What is the main role that Canadian astronauts have on the shuttle missions?

4. Explain the term "microgravity."

5. **Thinking Critically** Think of your everyday activities. What is one thing you do that would be difficult to do in a microgravity environment? Suggest a method for helping astronauts overcome this difficulty if you were designing a spacecraft.

6. **Apply** What experiment would you suggest be tried on the ISS? Describe why you think the space station is the right environment to perform your experiment.

7. **Thinking Critically** Describe two reasons why new technology is developed. Provide specific examples from Unit 5 with your answer.

Wrap-up TOPICS 6–8

If you need to check an item, Topic numbers are provided in brackets below.

Key Terms

rocket
payload
exhaust velocity
staged rocket
ballistic missile
cosmonaut
gravitational assist
charge coupled device (CCD)
artificial satellite
low Earth orbit
geosynchronous orbit
remote sensing
global positioning system
solar wind
inner planets
outer planets
suborbital
microgravity

Reviewing Key Terms

1. In your notebook, match the description in column A with the correct term in column B.

A	B
• planets with gaseous composition	• suborbital (8)
• an orbit a few hundred kilometres above the ground	• microgravity (8)
• has taken the place of photographic plates for telescopes	• inner planets (7)
• an orbit that takes 24 hr to circle Earth	• low Earth orbit (6)
• the nearly weightless conditions in orbit	• geosynchronous orbit (6)
• stream of charged particles coming from the Sun	• rocket (6)
• fleet of satellites used to locate things on Earth	• gravitational assist (6)
• a space flight that goes only part way around Earth	• CCD (6)
• planets with terrestrial composition	• global positioning system (6)
• a device that uses controlled burn of a fuel to propel itself directly upward	• outer planets (7)
• a method of acceleration that uses gravity	• solar wind (7)

Understanding Key Concepts

2. Where would you expect the solar wind to be the most intense and the least intense? Why? (7)

3. Venus is farther from the Sun than Mercury, yet it is hotter than Mercury. Why? (7)

4. What changes in payload have rockets had from World War II to the space age? (6)

5. Name three things that computers are used for by space engineers. (6)

6. Why are most of Canada's astronauts research scientists? (8)

7. Scientific research will be done on the *International Space Station*. Name two new things that might be developed on the space station. Pick one in biology and one in engineering. (8)

8. **Apply** Name two existing uses for the global positioning system. Think of one new application for this system. (6)

Ask an Expert

Ever since Robert Thirsk — who grew up in British Columbia, Alberta, and Manitoba — was in Grade 3, he knew he wanted to be an astronaut. He devoted the rest of his education to becoming an astronaut — he earned four university degrees, including a Bachelor of Science from the University of Calgary. After training since 1984, Robert finally got his wish. In 1996, he spent 17 days aboard a space shuttle.

Q Were you nervous on your first mission?

A I was, but not for the reasons you'd think. I was more nervous about possibly making a mistake. A typical shuttle flight costs about $400 million U.S., and often on orbit we have only one chance to perform a task correctly. I think I was more worried about messing up than about the small chance of injury or death.

Q What did you find most memorable about your space flight?

A I was in a state of exhilaration throughout my space flight. It didn't matter whether I was performing experiments or looking out the window at the beautiful Earth below or brushing my teeth. I was exhilarated the whole time I was in space.

Q What are you most proud of during the mission?

A I am most proud of the fact that I worked successfully as a team member, not only with my crew mates aboard the shuttle but also with the flight controllers and scientists on the ground, to accomplish 100 percent of what we had intended to do.

Q What is the greatest challenge to being weightless?

A Stabilizing my body in a weightless environment so I could perform an intricate task was challenging. On Earth, gravity helps to keep our feet firmly planted on the ground, and we can easily remain stable and oriented. In space, we may start an experiment in front of a laboratory rack, but within seconds we'll begin to drift off unless we are properly restrained.

Q I understand you helped design an antigravity suit. How does it work?

A An antigravity suit (or g-suit) is a device that allows an astronaut's cardiovascular system (i.e., heart and blood vessels) to readapt to gravitational forces during the return to Earth. A g-suit looks like a pair of trousers, but within the leggings and lower abdomen of the suit are rubber bladders that can be inflated. When inflated, the bladders collapse the blood vessels within the legs and abdomen, and shift that blood volume up to the chest and head where it's most needed during re-entry.

Q **Does everyone wear these suits?**

A All astronauts will wear antigravity suits during re-entry. It's up to us whether we inflate the bladders or not. For instance, if we feel light-headed or notice visual problems, then we'll inflate the suit. We'll keep the suit inflated after touchdown until a medical doctor has determined that it is safe to deflate it.

Q **I understand you conducted experiments on materials processing as well as medicine. Could you tell me about one of the experiments you conducted in space?**

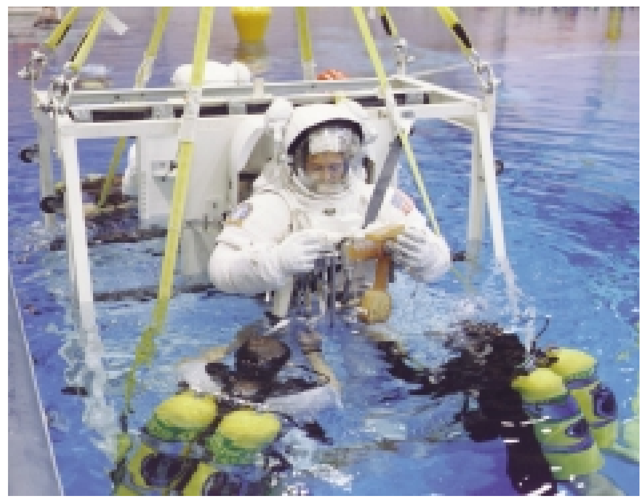
A Medical scientists are concerned that very long space flights — such as missions to Mars — will cause astronauts' bones to demineralize and muscles to atrophy. They are also concerned that we may be exposed to high levels of ionizing radiation. On my flight, we investigated these potential medical problems. In particular, we spent a lot of time investigating changes in our muscle strength and performance as well as the reasons for these changes.

Q **How did you test this?**

A The main device we used for these muscle experiments was the torque velocity dynamometer, or TVD. You can think of the TVD as an arm- or leg-wrestling machine. Every couple of days we'd strap ourselves into the TVD and have a series of wrestling matches with the machine. Sometimes the astronauts would win these matches, sometimes the machine would win. What was most important, however, was that the TVD measured subtle changes in our muscle strength and speed of contraction. Throughout the mission, we sent this scientific data down to the scientists on the ground. By studying the data, scientists could better understand the changes that were taking place during space flight at the level of our individual muscle fibres.

Q **Are you planning to go back to space?**

A Yes. At present, I am undergoing advanced astronaut training not only on space shuttle systems but also on the new *International Space Station*. Several nations, including Canada, are working together to build this marvellous new research platform. The space station is now being assembled and we expect that by 2004 it will be completed. It'll be about twice the size of a football field and the second brightest object in the nighttime sky. If I have an opportunity to fly another space mission, I hope it will be aboard this station.



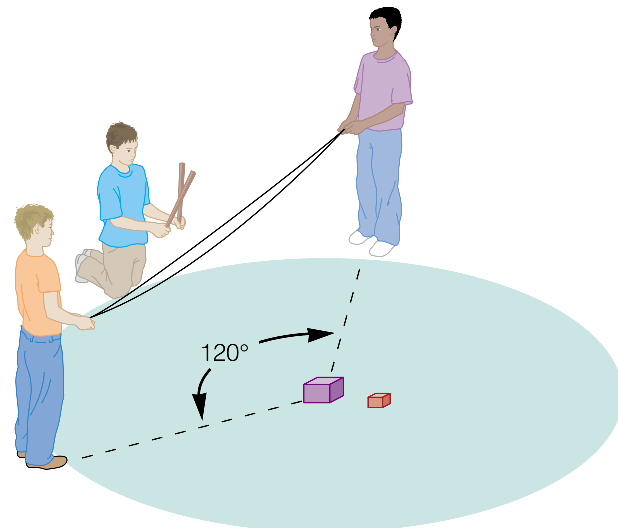
The Neutral Buoyancy Laboratory is a large pool at the Johnson Space Centre. Here, astronauts train for space walks.

EXPLORING Further

Not only do astronauts have to deal with the feeling of weightlessness, but they also have to be able to work under extra g-forces during launch. Try this activity. Crumple up a piece of paper and toss it into a basket five times. Then hang a 2 kg weight on your wrist and try again. Finally, remove the weight and toss the paper for a third set. Did the addition and the removal of the weight affect your accuracy? How is this exercise similar to what an astronaut might experience on a mission to space?

UNIT 5 PROJECT

An Arm of Your Own



Canada has designed the Canadarm for the shuttles, and a giant arm for the *International Space Station*. Gears move the "joints" of the Canadarm. The arms move as the gears turn. The Canadarm helps launch and recover satellites. As you learned at the beginning of Unit 5, the Canadarm helped repair the Hubble space telescope.

Remote manipulation technology is important on Earth too. Many materials are too dangerous to handle directly. For example, radioactive materials, toxic waste, and hot metals cannot be handled directly by humans.

Challenge

Design and construct a device that can remove two objects from the centre of a 6 m diameter circle without you going into the circle.

Safety Precautions

Be careful of sharp objects and tools while constructing your device.

Materials

You may use any materials that your teacher deems safe. Look around your house or garage for old pipes, wood, long-handled tools, and even curtain rods might come in handy.

Design Specifications

A. The two objects will be placed at the centre of the circle, either on the floor or on a table. (Your teacher will tell you which.)

B. You will know in advance what the two objects are. One will be heavier and larger than the other.

C. At your turn, you and your group may position yourselves anywhere outside one third of the circle to operate your device. At no time may anyone in the group step into the circle.

D. You may change the grasping end of your device after retrieving one of the objects.

E. A successful retrieval occurs if an object is removed from the circle without the device touching the floor, and is set down outside the circle undamaged.

F. You have 5 min to remove the objects from the time your teacher calls on your group.

Plan and Construct

1. This is a big project. You and your group will need to brainstorm ideas well in advance of the day of the event. A good rule of thumb is that you want to be able to lift the objects one week before the event. This gives you a week to fine-tune your arm.
2. There are many ways to do this. Brainstorm for lots of ideas. Sometimes a crazy idea will trigger an excellent one.
3. Your arm will need to reach the centre of the circle and grasp the objects. Keep both of these things in mind.

Skill FOCUS

For tips on problem-solving, turn to Skill Focus 7. For help with technological drawing, turn to Skill Focus 11.

Evaluate

1. Most designs start out complicated, and a simplifying idea comes from hard work. Was there a point in your design where a simplifying idea emerged? Explain the process you went through to come up with your final design.
2. How many completely different ways did your class solve this problem? How are your classmates' designs like the one your group designed? How are they different?
3. What would you change about your design if you were to begin again?
4. Think of three places on Earth where a design like yours would be useful to people in real-life situations.
5. What modifications would you have to make if you were asked to make a prototype for one of these applications?

MORE PROJECT IDEAS

Research one specific application of a remote manipulator on Earth (for handling toxic waste, for example). Design (or re-design your existing manipulator) to suit the specific needs of this application. For example, will you need to reduce the chances of the item being dropped? How can you re-design your manipulator to increase its hold reliability? Will you have to shield your device from its environment? What other considerations will you have to take into account? You do not need to build your new design, just create technical drawings of your new plans.

UNIT 5 Review

Unit at a Glance

- Ancient astronomers learned a lot about the heavens without much, if any, technology.
- Earth was the first frame of reference people used.
- Careful measurements of planetary motions led to two conflicting theories of the universe — geocentric and heliocentric.
- The invention of the telescope enabled astronomers to make more precise measurements of celestial objects, and the heliocentric theory won out.
- The invention of the spectroscope enabled astronomers to infer the composition of stars.
- Spectroscopy also enables astronomers to find out the direction of motion of celestial bodies because of the Doppler effect.
- The distances to the nearest stars are found with parallax.
- Radio signals come from the sky. Radio astronomers made many more discoveries about celestial bodies.
- Telescopes of all types have been made bigger over the years. They have been connected through the use of computers. Some telescopes have been placed in space.
- Rockets were designed for war and have been turned to peaceful applications. All of the things we put in space need rockets to get them there.
- Computers are important for space technology. They are used to calculate orbits, store and manipulate images, and to receive and act upon instructions from Earth.
- The Hubble space telescope is one of a series of space-based observatories planned or launched.
- Scientists are studying Earth from space with satellites. These satellites may be in low Earth orbits, or in geosynchronous orbits. This is called remote sensing.
- The global positioning system is a fleet of satellites used by people to locate their position on Earth.
- The Sun, Moon, and every planet (except Pluto) have been visited by at least one Earth spacecraft. We have some close-up data on these as a result.
- The main focus of a human presence in space at this time is to occupy a space station. Canada is a partner in this endeavour, supplying many technological devices and astronauts as mission specialists.

Understanding Key Concepts

1. How did the ancient astronomers know the planets were different than the stars?

2. How did the ancient astronomers account for day and night? How did Copernicus account for this?

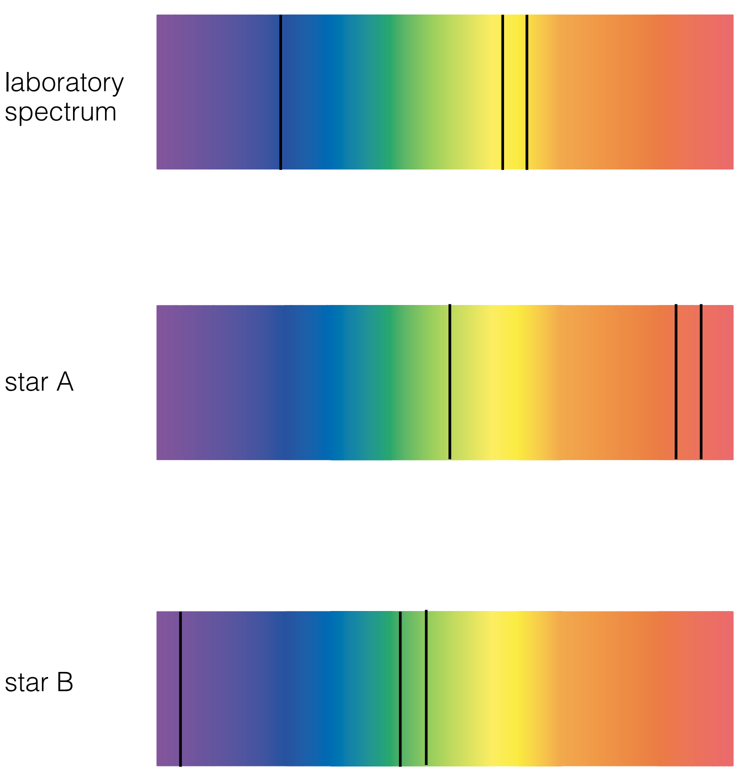
3. Why did the ancient astronomers think that Earth wasn't moving?

4. Galileo observed four small stars that were always near Jupiter. Why did he conclude that they were moons of this planet?

5. According to Newton, how does the Sun keep the planets going in orbit around it?

6. How can astronomers know that two stars are of the same type?

7. Look at the spectra of these stars. What can you say about the motions of the stars from these spectra?



8. Name one way astronomers have minimized, or eliminated, the twinkling of stars when viewing through telescopes.

9. What is a radio object?

10. Give one advantage and one disadvantage of radio waves over visible light waves for astronomical work.

11. What is the difference between a low Earth orbit and a geosynchronous one?

12. Give three uses for remote-sensing satellites.

13. How do computers help astronomers to get better images of celestial objects? Give two examples.

14. How were radio waves important in the study of Venus?

15. What is the main difference between the first four planets from the Sun, and the next four?

16. Who was: the first human in space? ___________

    the first man on the Moon? ___________

    the first Canadian in space? ___________

    the first Canadian woman in space? ___________

17. Canadian engineers built a lot of devices for space missions. What is the most famous one?

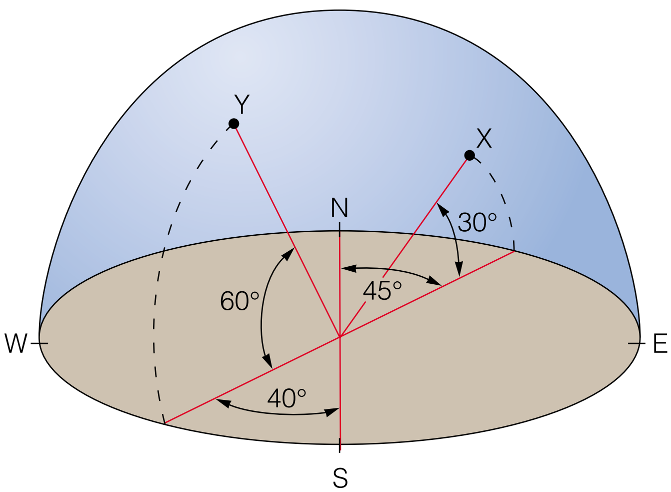
18. When you pass a beam of white light through a prism, what colours are found in the resulting spectrum?

19. What is a diffraction grating? Why are diffraction gratings more useful than prisms?

20. Describe how the Doppler effect is used to measure the speed and direction of stars?

Developing Skills

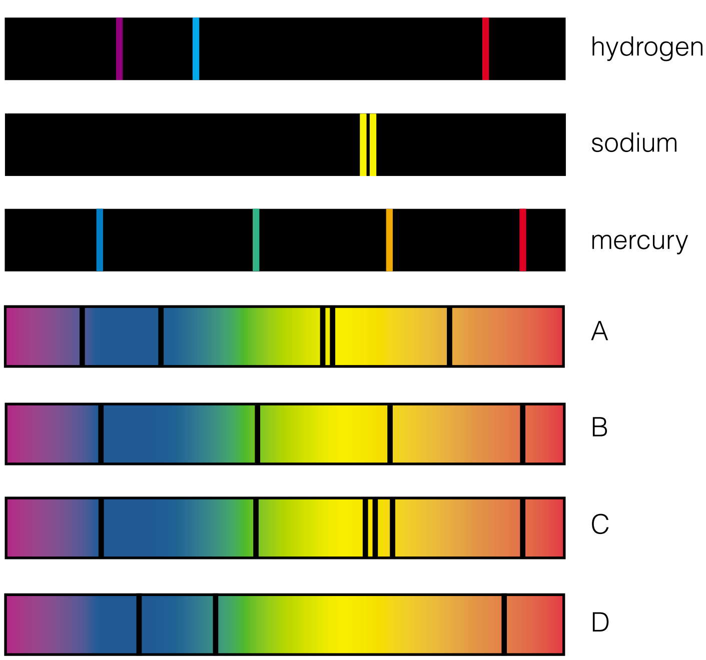
21. For each star shown, give its altitude and azimuth.



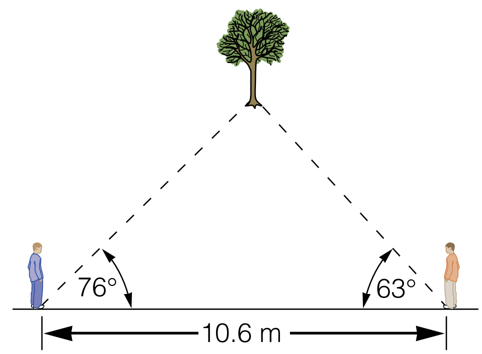
22. Answer questions (a) and (b) using the following spectra.

(a) What elements are present in each star?

(b) Which star(s) are approaching us? How do you know?



23. What value should the students in the diagram calculate for the distance to the tree?



24. A group of students want to set up an experiment to show other students in their class how to find the distance to a distant building using triangulation. They want the measured angles to be 88° at each end of the baseline. If the building is 1.50 km away, then how long a baseline should they use for their demonstration?

Critical Thinking

25. Suggest a reason why Canada was the first country to place a geosynchronous communications satellite into orbit.

26. Give an example of a technology designed for war being used for a peaceful space science purpose. Why do you think this happens?

27. Building and maintaining the *International Space Station* and a possible manned mission to Mars will be incredibly expensive. Suggest some arguments for and against doing these projects.

28. It is said that the engineering involved in sending a mission to Mars with people on board is easy, but it is the biology that is hard. What do you think this statement means?

29. Explain why using Earth as your frame of reference is the most "natural," or common sense way to view the stars.

Pause & Reflect

In your Science Log, compare the Hollywood image of human space travel with the reality. What is it about the Hollywood image that is so appealing? Does this say anything about why we have spent so much time, effort, and money on the quest to put humans in space?

Pause & Reflect

Go back to the beginning of the unit on page 354 and check your original answers to the Focussing questions. How has your thinking changed? How would you answer these questions now that you have investigated the topics in this unit?