ACTIVITIES

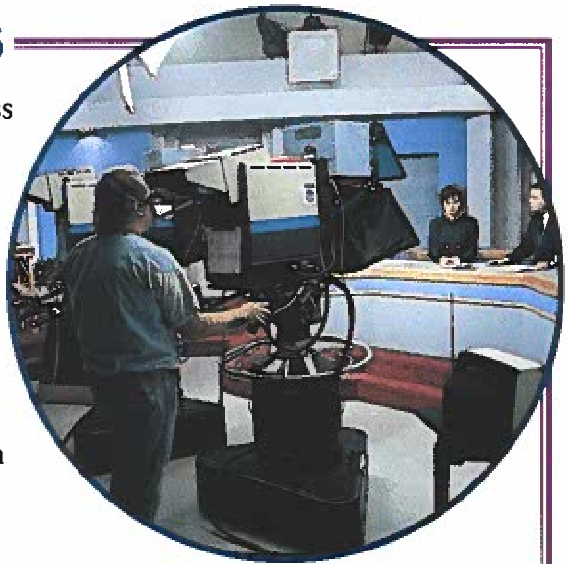
CROSS-CURRICULAR EXTENSIONS

1. **COMMUNICATION** Produce a promotional video about your school that could be shown to new students. Ask the foreign language teachers to help make the video in other languages. Team up with a language arts and drama class to write and produce your production.

2. **SCIENCE** Research high-definition television. How is it different from the TV you usually watch? What do you think television will be like 50 years from now?

3. **MATHEMATICS** Create a display of the electromagnetic spectrum. Include the wave lengths of the different radiation waves in exponential powers of 10.

EXPLORING CAREERS



Cable, fiber optics, and satellites allow people access to TV broadcasts all over the world, not just in their local areas. TV is also becoming more interactive. With larger international audiences and expanded services, the career opportunities in this field will grow as well.

Digital Film Editor Film editing has been changed by technology. Editors today sit behind a computer holding a mouse in one hand and a script in the other. Editors combine their artistic abilities with technology to produce quality films. They must have patience and diligence to work on a film and see it through from start to finish.

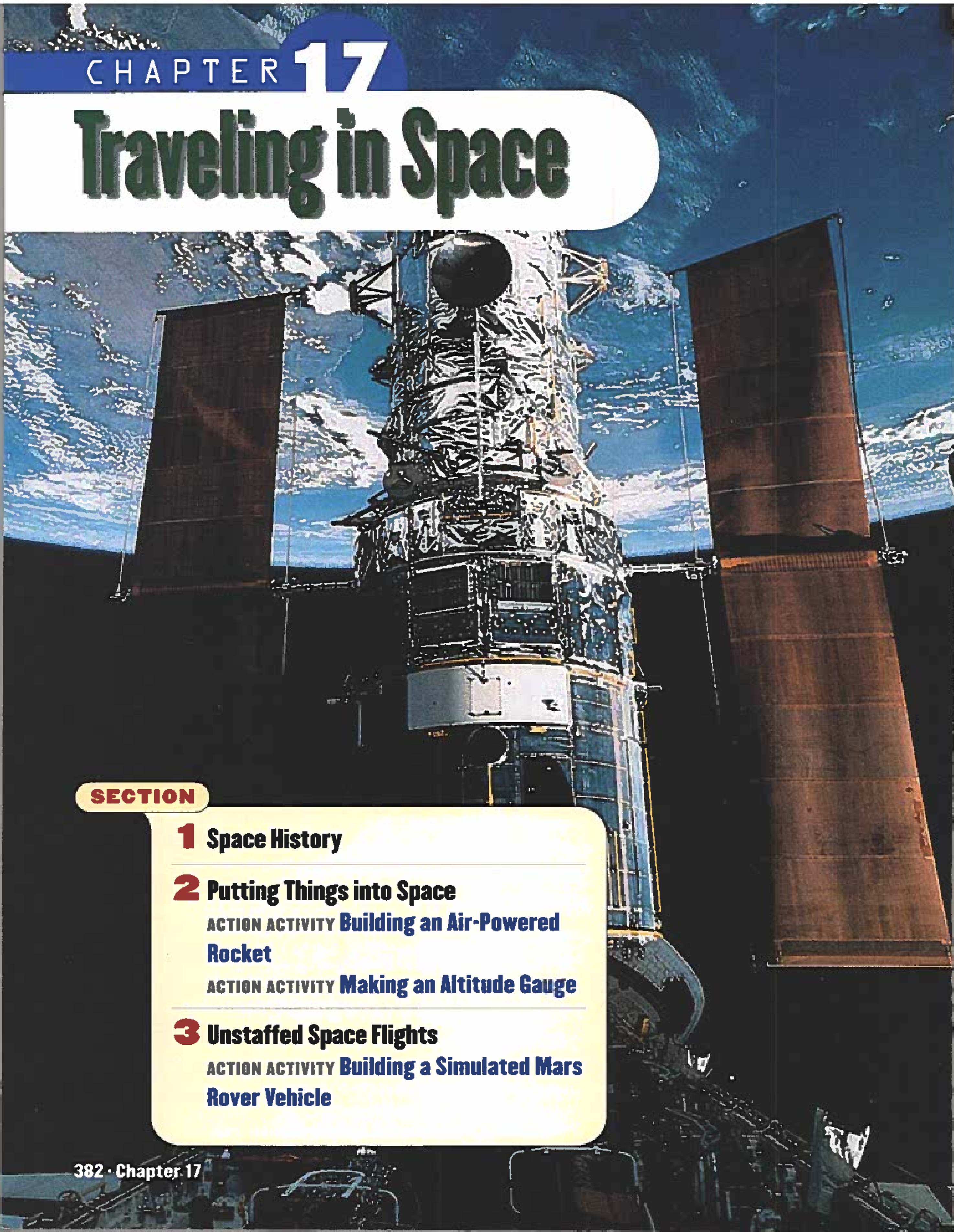
Broadcast Technician Broadcast technicians work behind the scenes. They set up, operate, and maintain the electrical and electronic equipment used in television and radio broadcasts. They may work in the studio or on location to ensure smooth broadcasts. A background in computers and electronics and the ability to work well with others are necessary.

ACTIVITY

As part of a team, develop the format for a new radio or television program for an audience you think is currently not being reached. Share your program ideas with the class.

CHAPTER 17

Traveling in Space



SECTION

Space History

SECTION 1

THINGS TO EXPLORE

- Identify major milestones in space history.
- Explain how the development of the Space Shuttle changed the space program.

TechnoTerms
- NASA
- *Skylab*
- *Sputnik*

Do you ever look up at the sky at night and watch the stars and planets? Fig. 17-1. Do you wonder what it's really like out there? For a long time, space travel was just a dream. Now it's the real thing. We've already explored much of the Earth, so it seems natural to go beyond Earth. For this reason, space is sometimes called the "final frontier." Fig. 17-2 (pages 384-385). The challenges are great. How do we send scientific instruments, machines, and people into space and bring them back safely?

Pioneers of Rocketry

Stories of rocket-like devices come from as far back as 400 B.C. The Chinese in the thirteenth century used a form of gunpowder to launch a simple form of a solid-propellant rocket they called "fire-arrows."

OPPOSITE In this NASA photo, the Space Shuttle has docked at the *Hubble Space Telescope* to make repairs.

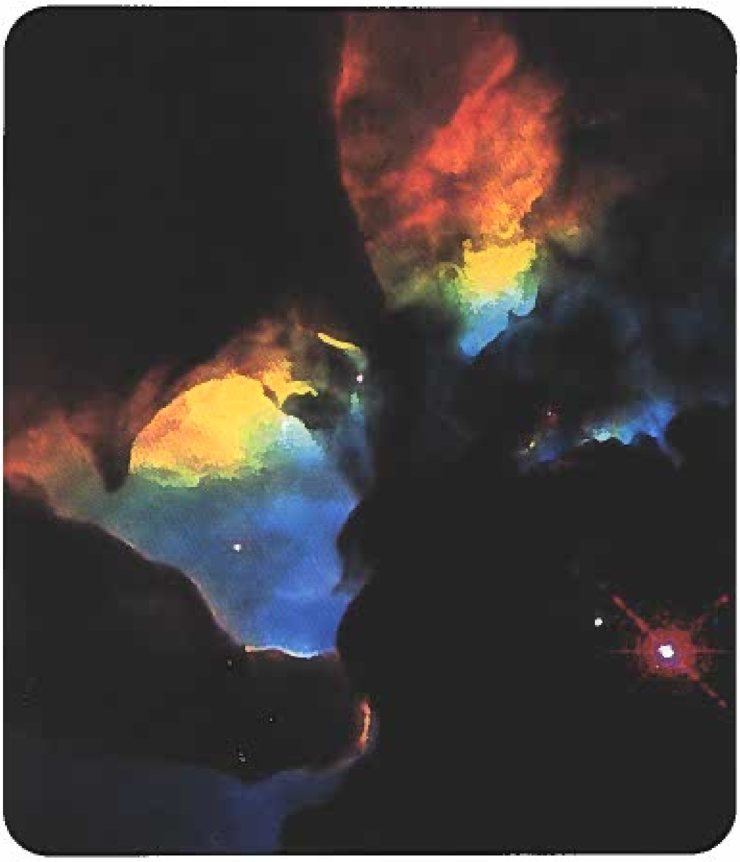
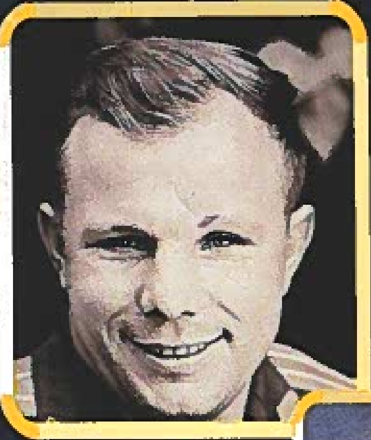
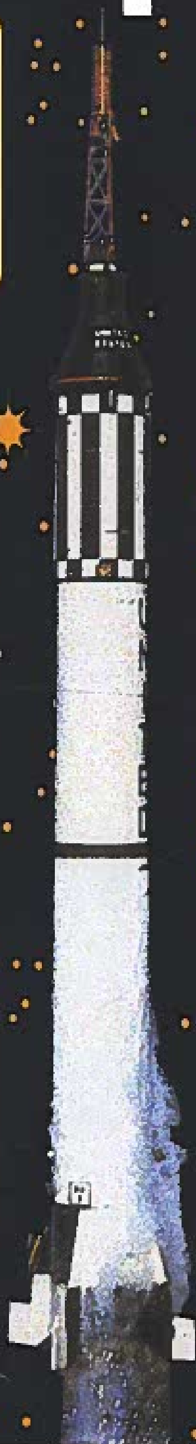


Fig. 17-1. The Lagoon Nebula is a bright, misty region found in the southern constellation of Sagittarius. This photo was taken by the *Hubble Space Telescope*. Find a photo of this nebula taken by an earth-bound telescope and compare the two. Was the *Hubble* worth the investment?

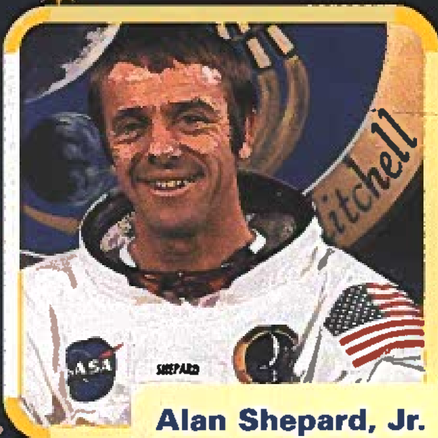
Fig. 17-2

Adventures in Space





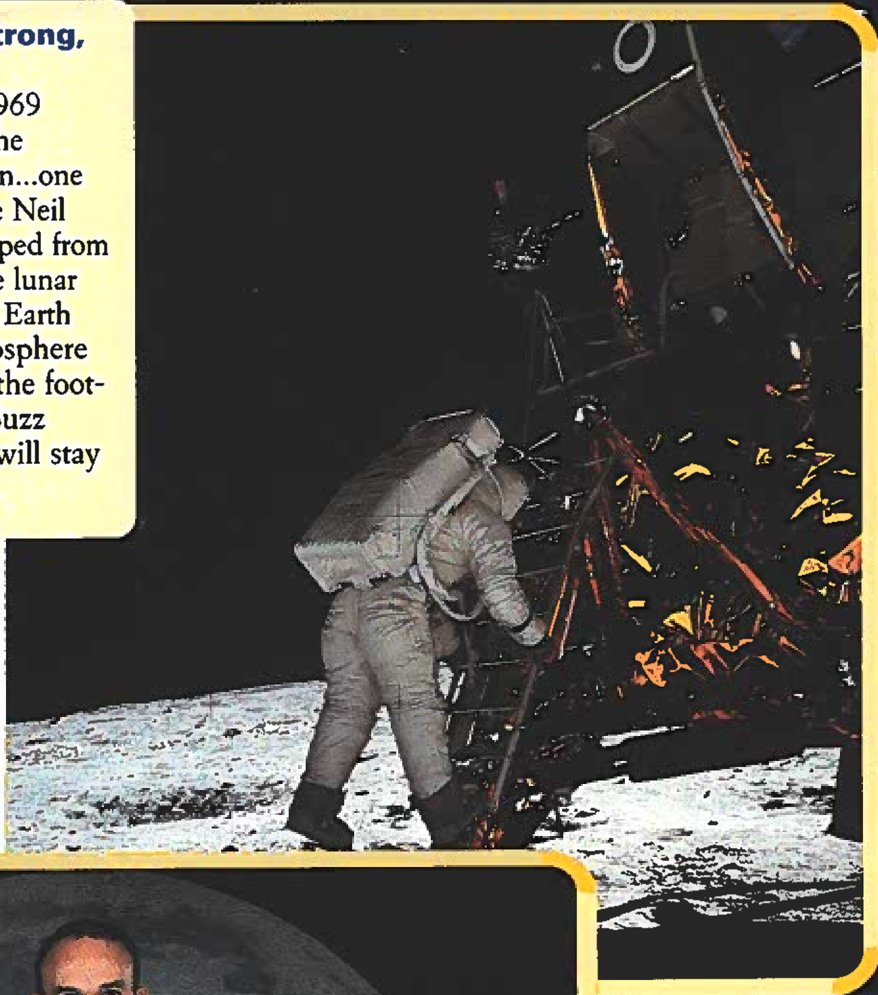
Yuri Gagarin, a Russian cosmonaut, became the first human to attempt space flight. His ship, the *Vostok 1,* entered orbit on April 12, 1961.

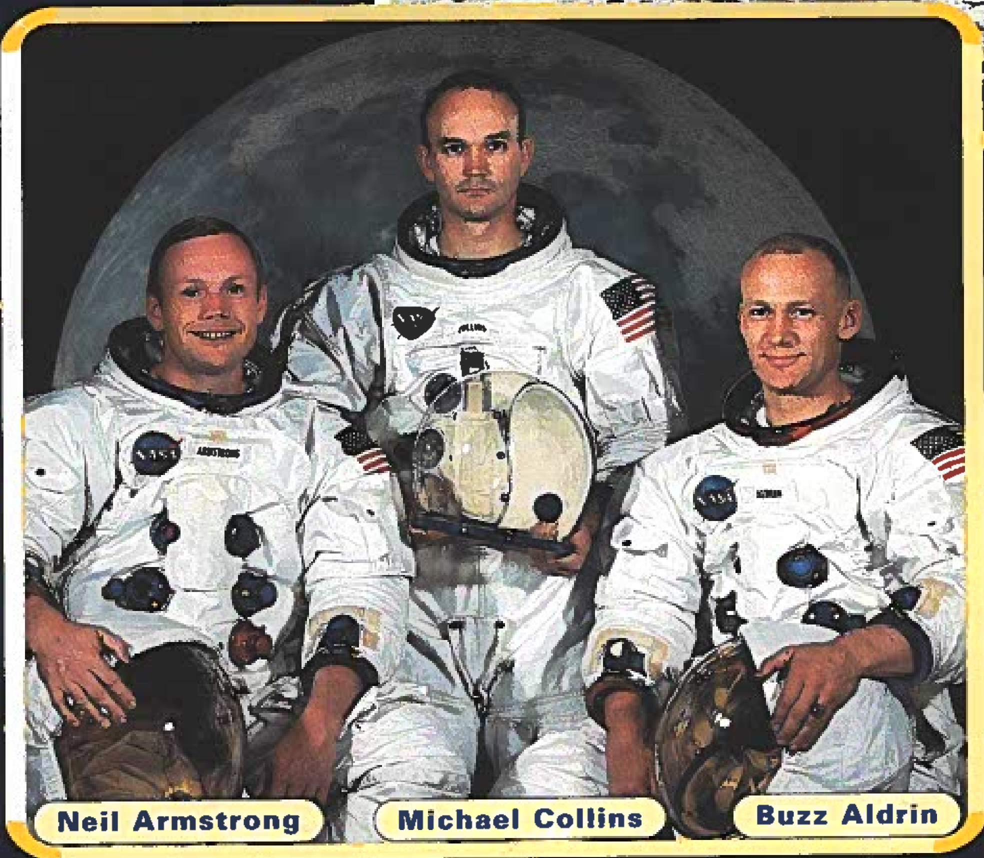


Alan Shepard, Jr. became the first American in space on May 5, 1961. His flight in the *Freedom 7* lasted 15 minutes, 28 seconds, and he traveled at a speed of 5,134 mph.

Virgil "Gus" Grissom became the second American to escape the Earth on July 21, 1961. Although the flight was successful, the capsule of the *Liberty Bell 7* sank in 15,000 feet of water right after splashdown. But Grissom escaped safely, and the capsule itself was recovered from the ocean in 1999.

Buzz Aldrin, Neil Armstrong, and Michael Collins
began a mission on July 16, 1969 which would put people on the moon."One small step for man...one giant leap for mankind," were Neil Armstrong's words as he stepped from the *Apollo 11* module onto the lunar surface. The ship returned to Earth on July 24. Without an atmosphere or weather to disturb them, the footprints left on the moon by Buzz Aldrin and Neil Armstrong will stay there for thousands of years.





Neil Armstrong   Michael Collins   Buzz Aldrin

Fig. 17-3. **Tourists in Russia view a Sputnik satellite in a museum. Sputnik 1 weighed 184 pounds and was only 23 inches in diameter.** **Find out the size of modern communication satellites. How do they compare to Sputnik?**

Modern rocketry really began with the following three people. They are called the first true pioneers of space travel. They took the ideas and dreams of people like Jules Verne, the science fiction writer, and tried to make them work.

- In 1898, Konstantin Tsiolkovsky, a Russian schoolmaster, suggested using liquid fuels for rockets. Even though he never launched a rocket, he explained the principles by which rockets could fly in space.
- An American, Robert H. Goddard, launched the first liquid-propellant rocket in 1926. The flight, rising only 41 feet, lasted 2.5 seconds, but it was a start.
- Hermann J. Oberth, a German, also worked with long-range rockets between 1917 and 1955. His writings got scientists and engineers excited about building rockets.

TechnoFact

SPUTNIK ***Sputnik*** **proved that a human-made object really could stay up in space and orbit the Earth. This was a giant step!** ***Sputnik*** **remained in a low orbit, where it circled the Earth once every 90 minutes. Then** ***Sputnik 2*** **carried the first dog, Laika, into space. This experiment proved that living things could survive there. The next step was to put people into space.**

Early Space Travel

New developments in technology helped people move from dreaming about space travel to making it happen. The launch of ***Sputnik*** by the Soviet Union in 1957 was an exciting moment for the entire world. Fig. 17-3. With *Sputnik*, we had entered the Space Age.

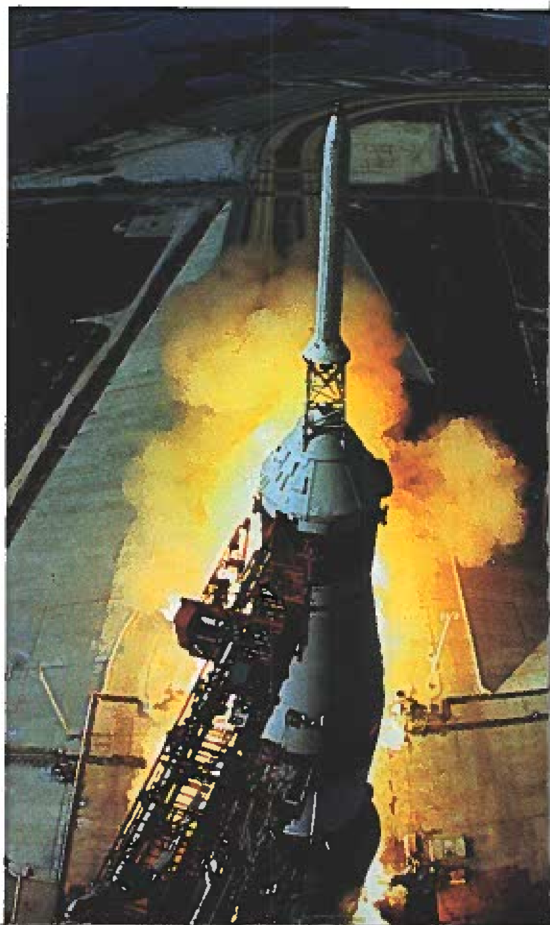


Fig. 17-4. **The rocket launcher used for this Apollo mission could be used only once. This made missions more costly.** **Watch a video of the film Apollo 13. Report what you learned about space missions to the class.**

Skylab and the Space Shuttles

Fig. 17-5. This photo shows *Challenger* before the accident. A teacher was on board and died along with the astronauts. Do you think civilians should continue to go on shuttle missions?

Outer space has become an important area for research and development for the United States. In 1973, ***Skylab***, the United States' first space station, was launched. Three different crews worked and lived in *Skylab* as it orbited 270 miles above Earth.

Until 1981, **NASA** (National Aeronautics and Space Administration) used rocket launchers, such as those for *Mercury*, *Gemini*, *Apollo*, and *Skylab*, only once. Fig. 17-4. Then space shuttle technology was developed. A shuttle takes off like a rocket but lands like a glider on a runway. The *Columbia* became the first reusable space vehicle. Even the solid rocket boosters were rebuilt after every mission. Russia's *Buran* worked the same way.

Then, in 1986, the shuttle *Challenger*, carrying a crew of seven, exploded shortly after it was launched. Fig. 17-5. That disaster reminded us that there are still many problems to solve in making space travel safe.

There are many *milestones* (important events) in space history. Robot spacecraft have traveled to the planets. Satellites launched by rockets and the shuttles have enabled us to investigate our planet, forecast weather, and communicate instantly with other people around the world. Which events that have taken place during your lifetime have affected space travel most?

SECTION 1 TechCHECK

1. What is a milestone?
2. Name the three pioneers of modern rocketry.
3. What makes the Space Shuttle different from other spacecraft?
4. **Apply Your Knowledge.** Do you think life exists beyond the Earth? Write a paragraph explaining your answer.

SECTION 2

Putting Things into Space

TechnoTerms

- escape velocity
- gravity
- Newton's Laws of Motion
- thrust

THINGS TO EXPLORE

- Using the correct terms, explain how rockets work.
- Apply Newton's Laws of Motion to model rocketry.
- Safely use pneumatic force to launch model rockets.

What does it take to get objects into space? Putting objects like satellites and space shuttles into orbit takes lots of energy to overcome the Earth's gravity. Fig. 17-6.

Escaping Earth's Gravity

In general, **gravity** is the force of attraction between objects. Space transportation systems are used to provide power and speed to overcome Earth's gravity. In order to get into Earth orbit, you must travel more than 17,500 miles per hour.

Some people think the Space Shuttle can go to the moon. That's not true. The moon is about 240,000 miles away. But the shuttle's powerful engines can put it only in low Earth orbit, or about 300 miles out. The farther out an object is going, the more energy is needed to get it there. If a space vehicle is to move farther away from the Earth, it needs an extra push, or **thrust**, from its engines. It must reach **escape velocity** (25,000 miles per hour).

Fig. 17-6. Gravity pulls the shuttle downward as a 50,000 pound weight. The fuel required for a shuttle launch is burned by the two booster rockets on either side. Would there be any advantage to many small launches versus one big launch in delivering payloads to space? Explain.

How Rockets Work

Rockets work differently than jet planes. Rocket engines are designed to work outside Earth's atmosphere. They actually work better in space, where there's a near vacuum, than they do in air.

A rocket engine must carry all of its own fuel and oxygen. The fuel may be either a solid or liquids carried as two separate chemicals. When the chemicals mix, they burn. The hot gases produced then push out of the rocket to produce thrust. Fig. 17-7. **Newton's Laws of Motion** explain how things move on Earth. They also apply when we're trying to get off the Earth and into space. (See pages 398-399.)

Designing, building, and testing model rockets will give you a chance to explore how Newton's laws work. Some model rockets have solid-fuel engines. In the first activity for this section, you will use pneumatic force (compressed air) to launch your rocket. You will be able to find how high your rocket goes by using an altitude gauge and mathematics.

TechnoFact

NO "OFF" SWITCH
Did you know that once a solid-fuel rocket is started, it can't be turned off? A liquid-fuel rocket works differently. It can be turned on and off.

Fig. 17-7. This photo shows a close-up view of the booster rockets used to launch *Endeavor.* Look up the meaning of the word *endeavor.* Why do you think it was chosen as the name for a shuttle?

SECTION 2 TechCHECK

1. What is thrust?
2. What is gravity?
3. What causes the thrust that pushes a rocket away from Earth?
4. **Apply Your Knowledge.** Using the NASA Internet site, research the rockets used to put satellites into space. Print pictures of various launch vehicles and make a poster describing them.

SECTION 2

ACTIVITY 1

ACTION ACTIVITY

Building an Air-Powered Rocket

Be sure to fill out your TechNotes and place them in your portfolio.

SAFETY FIRST

- **Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.**
- **Use only paper to make nose cones.**
- **Follow your teacher's instructions while using a propane torch for soldering. Wear safety glasses. Keep flammable materials away from the torch and open flame. Follow the directions for using solder flux.**
- **Wear a clear face shield and keep at least ten feet away from the pad during launch. Warn those watching not to try to catch the rocket as it comes down.**

Real World Connection

You probably have seen old movies of early attempts to fly. People learned about rocket and airplane flight mostly by trial and error. They tried their idea and if it didn't work, they learned a valuable lesson. They knew what not to try again.

Many design concepts apply to small rockets as well as large ones. The design concepts that are most important for a rocket to fly correctly are center of gravity and center of pressure. In this activity, you will work as an aerospace engineer to design a launch system and a rocket. Your rocket will be made of paper and use compressed air to fly.

Design Brief

Design, build, and test a model rocket and launch system that can safely launch a paper model rocket. You will use plumbing fittings, valves, and copper tubing to make a safe launch pad. Compressed air will provide the thrust. To determine the height your rocket reaches, you will use an altitude gauge. (See Activity 2 on page 394.)

Materials/Equipment

- 3/4" copper tubing (1 piece 3' long; 1 piece 2' long)
- 3/4" copper tubing-to-pipe adapter
- 1/4" acrylic sheets (4 pieces, 5 3/4" x 14")
- portable drill; 3/16", 5/16", and 7/8" drill bits
- 3/4" ball valve
- 1/4" air hose
- 1" U-bolts (2)
- 2" x 6" pine, 5 1/2" long
- abrasive paper, 180 grit
- Teflon pipe-sealing tape
- 3/4" to 1/4" pipe-reducing bushing
- 3/4" copper elbow
- 3/4" plywood (36" x 6")
- 1/2" dowel rod (36" long)
- wood screws, string
- solder flux, solder, propane torch
- paper, white glue, brush, file folders
- tubing cutter

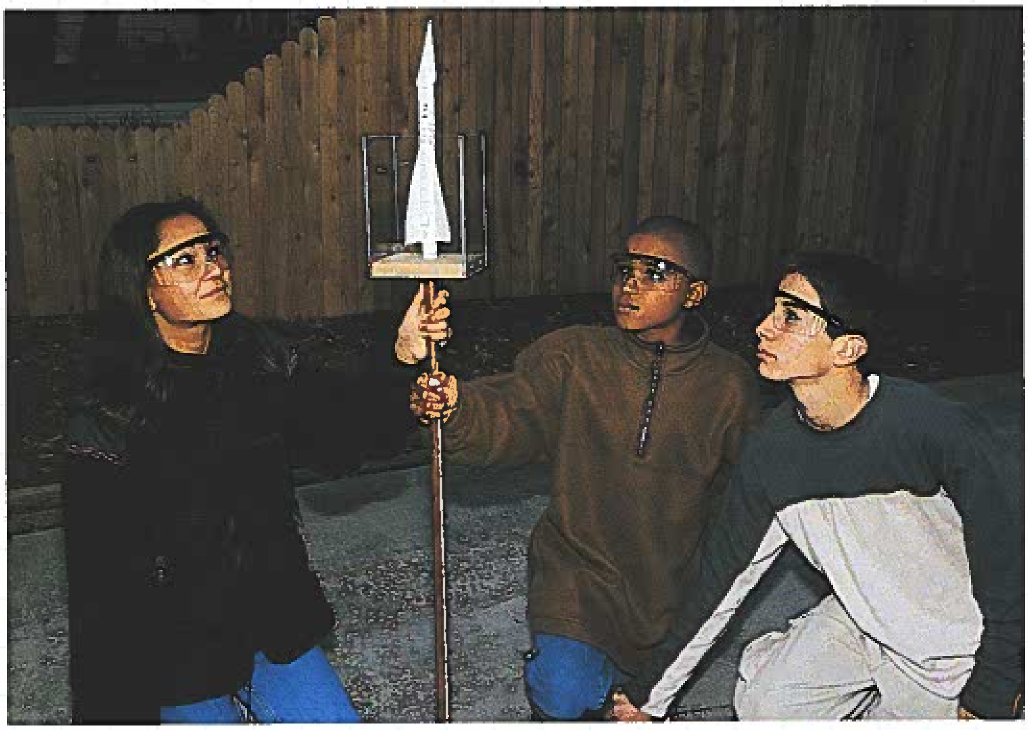


Fig. A

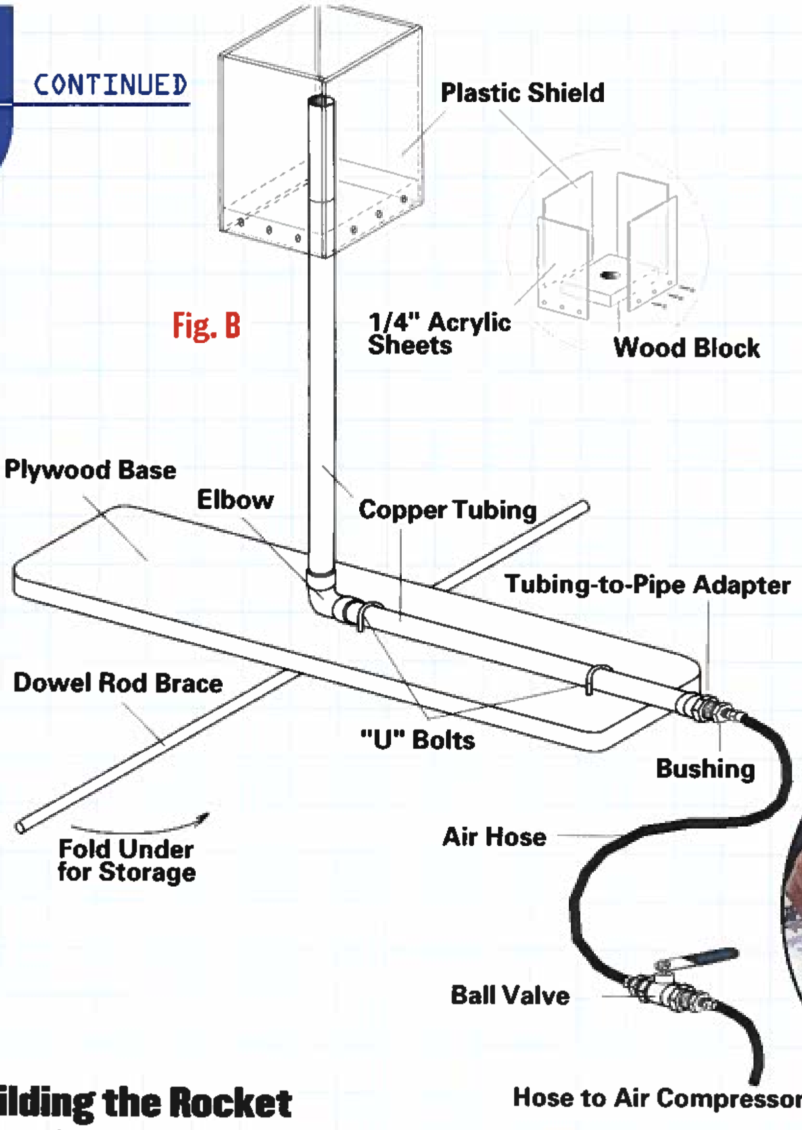
Procedure

Part 1 • Building the Launch Pad

Work in small groups of 2 to 4 students. One group can make the copper tubing assembly (Fig. A), another the launch pad, and so on.

1. *Copper tubing assembly.* With your teacher's help, cut the copper tubing to the lengths listed on page 390.
2. Clean the ends of the tubing with the abrasive paper and apply solder flux.
3. Solder the two tubes to the elbow. Solder the tube-to-pipe adapter to the end of the shorter tube. Ask your teacher for help.
4. Smooth any rough edges on the long end of the tube with abrasive paper.
5. *Launch pad base.* Cut the plywood base to the size listed. Sand the edges.
6. Measure and mark the center of the 36" dowel rod.
7. Drill a 3/16" screw hole in the center of the dowel. Use a wood screw to attach the dowel to the center of the base as shown in Fig. B. The dowel rod will steady your launch pad.
8. Drill 4 5/16" holes for the U-bolts to hold the short tube as shown.
9. *Safety shield.* Cut 4 pieces of acrylic plastic for the safety shield.
10. Cut the 2" x 6" pine to length and drill a 7/8" hole in its center to fit over the long copper tube.
11. Drill 3/16" screw holes in the plastic and assemble with wood screws as shown in Fig. B.
12. *Air hose and valve.* Assemble the bushing, air hose, and valve as shown in Fig. B.
13. Use Teflon pipe-sealing tape on all threaded connections to prevent leaks.
14. Connect the valve to a long air hose so that the launch can take place outside.

(Continued on next page)



Part 2 • Building the Rocket

1. Roll a piece of paper around a piece of copper tubing to form the rocket body. Tape the paper and remove the tube. Cover with a coat of glue. See Fig. C.
2. Cut another piece of paper as shown to form the nose cone. Cover the paper with white glue and roll it into a cone shape that will fit your rocket body.
3. After the glue dries, attach the nose cone to the body and coat the rocket with white glue. Let the glue dry.
4. Cut 3 or 4 fins out of file folders as shown. Glue the fins to the rocket body. Let the glue dry and brush another coat over the entire rocket.
5. Test your rocket for stability. Fig. D.

SAFETY FIRST

When you launch the rocket, stay at least 10 feet away from the launch area.

Part 3 • Launching Your Rocket

1. Wear a clear face shield and warn others to stay clear of the launch area.
2. Launch the rocket.
3. Have a student use the altitude gauge to determine the maximum height, or *apogee*, of the rocket's flight. Follow the instructions for calculating the altitude. Show your work on your TechNotes.

Evaluation

1. What is the apogee of a rocket?
2. What do real rockets have in common with model rockets?
3. Use a video camera to tape a launch. Play the tape for the class.
4. **Going Beyond.** Design, build, and launch a rocket that has a parachute recovery system to slow its descent.
5. **Going Beyond.** Try to make longer rockets using two or three sheets of paper instead of one.

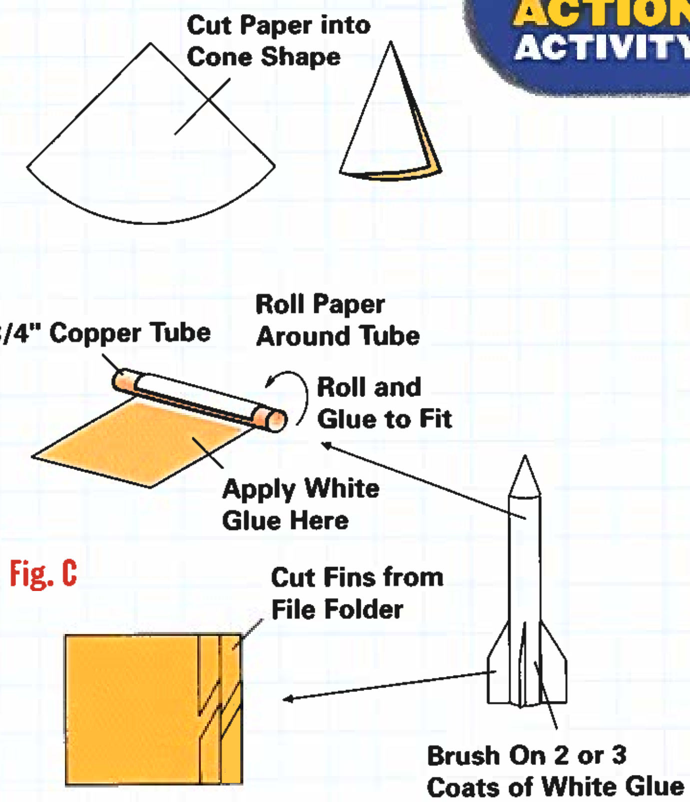


Fig. C

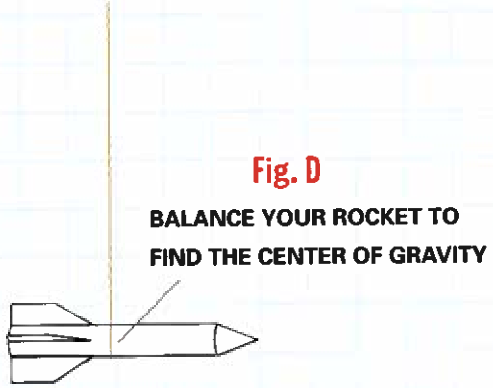
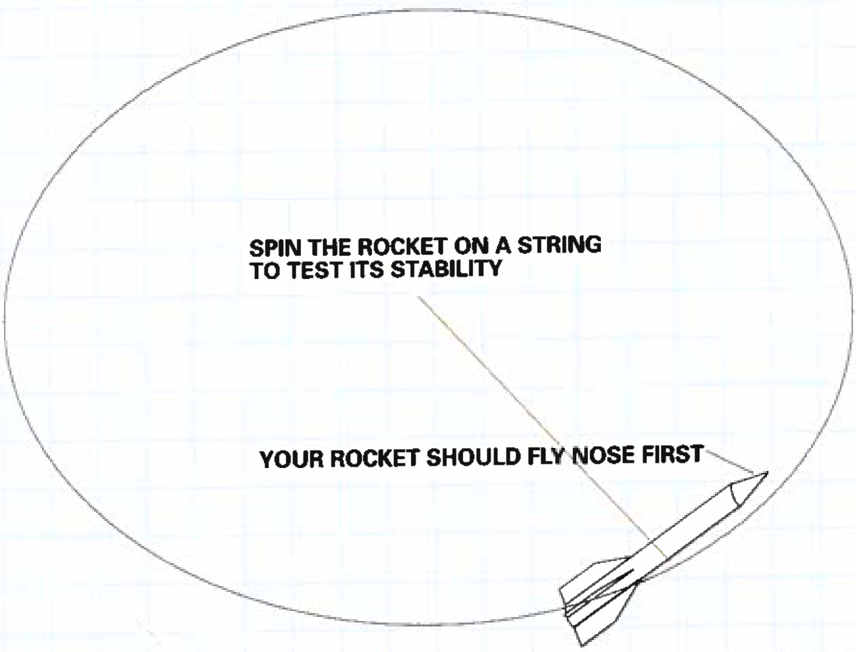


Fig. D



ACTION ACTIVITY

Making an Altitude Gauge

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

Mathematics is used to solve many engineering problems. Trigonometry is used to solve many of those dealing with measurement.

Design Brief

Design, build, and use an altitude gauge to determine the maximum height your rocket reaches. The gauge will be used to measure an angle so you can use trigonometry to calculate the altitude.

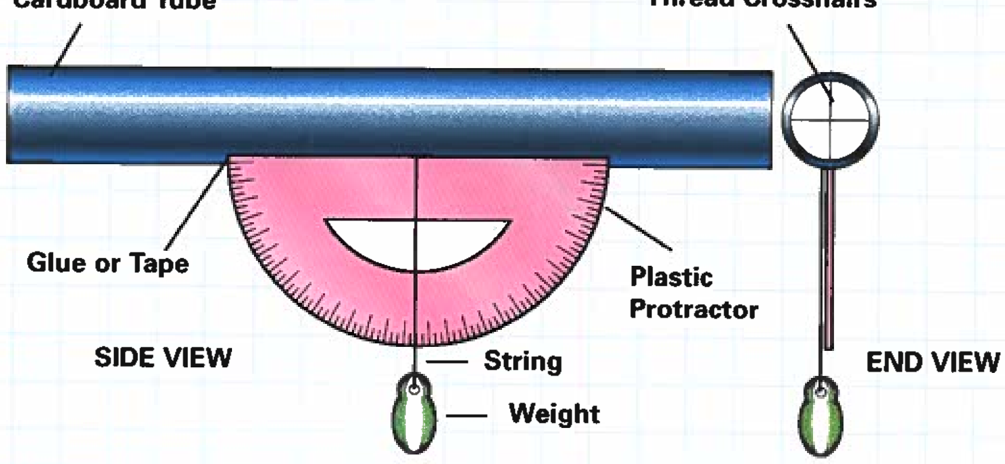
Materials/Equipment

- calculator
- trigonometry table (see Appendix)
- protractor
- string
- cardboard tube
- weight
- thread

SAFETY FIRST

Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.

Fig. A



Procedure

1. Roll a piece of paper into a tube, or use a cardboard tube from foil or plastic wrap. Tape two pieces of thread to one end to make cross hairs for accurate sighting. Use tape or glue to attach a protractor to the side of the tube. Attach a string and weight as shown in Fig. A.
2. Measure a distance of 100 feet from the launch pad. Someone in your group should stand with the altitude gauge at this location and be ready to sight the rocket's highest point.
3. As the rocket is launched, hold the altitude gauge to sight the maximum altitude. Measure the angle created using the protractor on the altitude gauge.

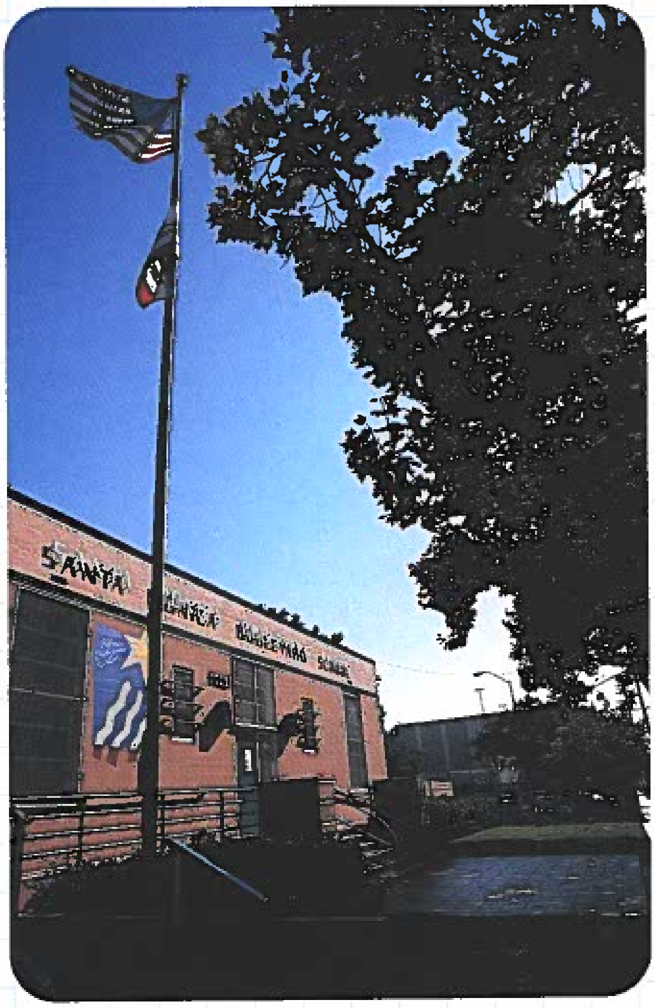


Fig. B

4. The height of your rocket's flight will be measured using trigonometry ratios for right triangles. This sounds hard, but most of the hard work has actually been done for you. First, subtract the angle you measured on your altitude gauge from 90°. This will give you the angle from the ground to the highest point your rocket reached.

   angle from ground = 90° − angle on altitude gauge
5. To calculate the height, you will use a trigonometry function called *tangent* (TAN). The formula is easy:

   TAN angle __° = opposite side (altitude) ÷ adjacent side (100 feet)
6. The tangent of the angle you measured can be found in the trigonometry table in the Appendix. To make it even easier, this formula can be changed to look like this:

   TAN angle __ x 100 feet = __ altitude (feet)
7. Record your angle and the maximum height of your rocket's flight.

Evaluation

1. Why do you need to subtract the angle you measured on the altitude gauge from 90°?
2. How could the design of your rocket have been changed to make it go higher?
3. **Going Beyond.** Use your altitude gauge and the trigonometric formula to measure the height of other objects, such as flagpoles, trees, or your school. Fig. B.

SECTION 3

Unstaffed Space Flights

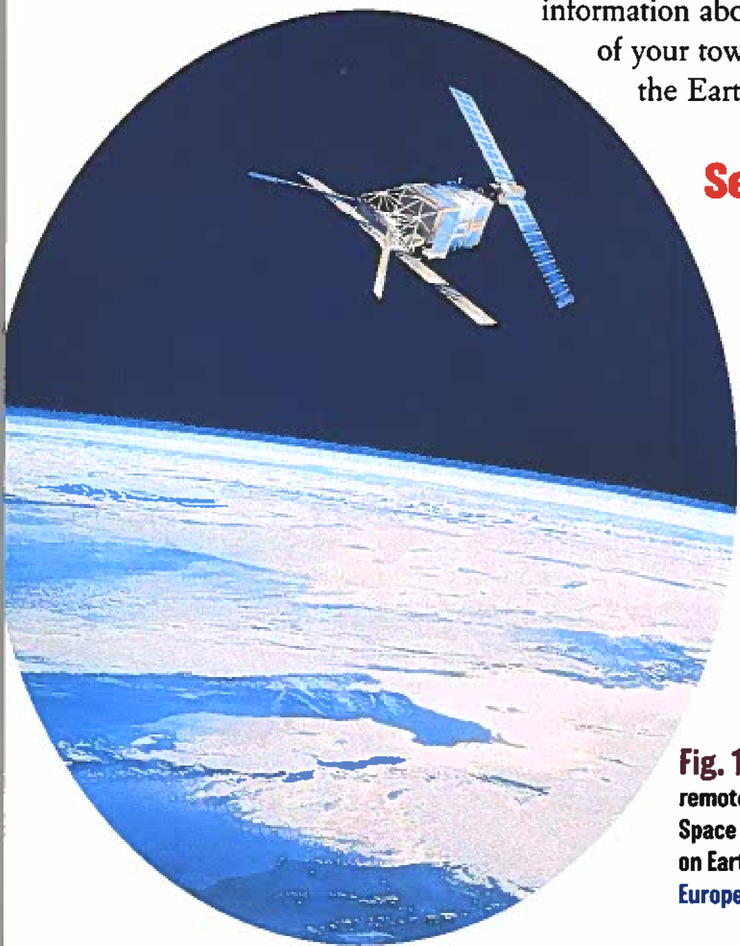
THINGS TO EXPLORE

- Explain why unstaffed space flights are important.
- Describe sensor probes used to find information in space.
- Design, build, and test a Mars rover vehicle.

TechnoTerms
Hubble Space Telescope
Mars Pathfinder
sensor probe
Voyager

Unstaffed space missions are those having no people on board. Thanks to new technology, exploration doesn't always require people to travel in space. Fig. 17-8. This means the missions can be smaller, faster, and cheaper—NASA's way of exploring space on a budget.

There are many spacecraft out there sending us important information about space. They can even take close-up pictures of your town and school from thousands of miles above the Earth!



Sensor Probes

Information about the moon, planets, and even comets can be gathered by sensor probes. A **sensor probe** is a device that can measure such things as temperature and radiation. A probe also can analyze the chemicals or elements, such as hydrogen and helium, found in space. The data are sent back to Earth where scientists can evaluate what they mean.

Fig. 17-8. This composite illustration shows a remote-sensing satellite put into orbit by the European Space Agency. Its purpose is to study climate change on Earth. Find out which countries contribute to the European Space Agency.

Satellites and Other Spacecraft

Satellites are objects that orbit a body in space. For example, the moon is a satellite of Earth. Artificial satellites and other spacecraft can be sent to explore and map the surface of planets. They are equipped with sensor probes and other instruments, such as spectrographs and cameras, that can detect light and other forms of radiation. Fig. 17-9. These spacecraft have sent back fantastic images of moons, atmospheres, and planet surfaces.

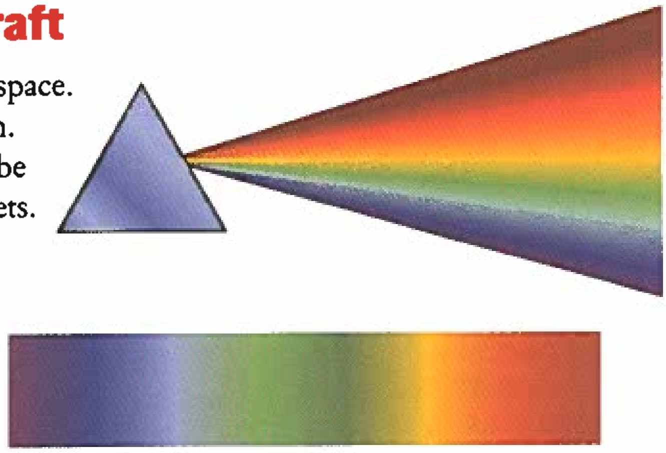


Fig. 17-9. When white light passes through a prism, it is separated into different colors and wavelengths. The occurrence of different wavelengths gives scientists information about the source of the light. For example, sensor readings tell scientists that there is water ice on the north pole of Mars. **Look at light that has passed through a prism. What colors do you see?**

The two unstaffed ***Voyager*** spacecraft, launched in 1977, visited Jupiter, Saturn, Uranus, and Neptune. Fig. 17-10. Now nearing the edge of our solar system, they will continue to operate until about 2020. *Voyager 1* is the most distant human-made object in space. Science information from *Voyager* is returned to Earth through the Deep Space Network (DSN) antennas located in California, Australia, and Spain.

Fig. 17-10. Spacecraft carry many sensors. **What do you think is the purpose of the dish on the *Voyager* spacecraft?**

Fig. 17-11. This photo of the planet Pluto and its moon Charon was taken by the *Hubble* in 1994 when those worlds were 2.6 billion miles away from Earth—equivalent to seeing a baseball at a distance of 40 miles! Find out who Pluto and Charon were in Greek mythology.

TechnoFact

SNAPSHOTS OF THE UNIVERSE While the *Hubble* is sending us pictures from deep space, we can continue to look at the sky through large telescopes on Earth's surface. The largest is the Keck telescope, located on top of Hawaii's Mauna Kea volcano. Through it you can see two-thirds of the way to what may be the most distant objects in the universe.

The *Hubble Space Telescope* and the Chandra X-Ray Observatory are satellites in orbit around Earth. They allow us to see objects in deep space much better than we can from Earth, where the atmosphere distorts the view. The satellites are able to send back detailed pictures. Fig. 17-11.

Robots

Sometimes, robots can be used for exploration. The *Mars Pathfinder* mission used the *Sojourner* rover, a remote-controlled robot vehicle developed by NASA, to explore Mars' surface. Fig. 17-12. *Pathfinder* landed with the help of parachutes and inflated cushions. The *Sojourner* vehicle was only about the size of a microwave oven.

SCIENCE CONNECTION

Newton's Laws of Motion

Sir Isaac Newton (1642-1727) described physical motion with three scientific laws. The laws describe the motion of all objects, whether on Earth or in space. These are his laws stated in their simplest form:

- **First Law of Motion:** *Objects at rest will stay at rest, and objects in motion will keep moving in a straight line unless acted on by an unbalanced force.* A rocket on the launch pad is balanced and at rest. The surface of the pad pushes the rocket up, while gravity tries to pull it down. As the engine starts, the rocket thrust causes things to become unbalanced. The rocket travels upward. In space, a spacecraft will travel in a straight line if all the forces stay balanced. If it gets close to a larger body such as a planet, the planet's gravity will pull on the spacecraft and cause its path to curve.

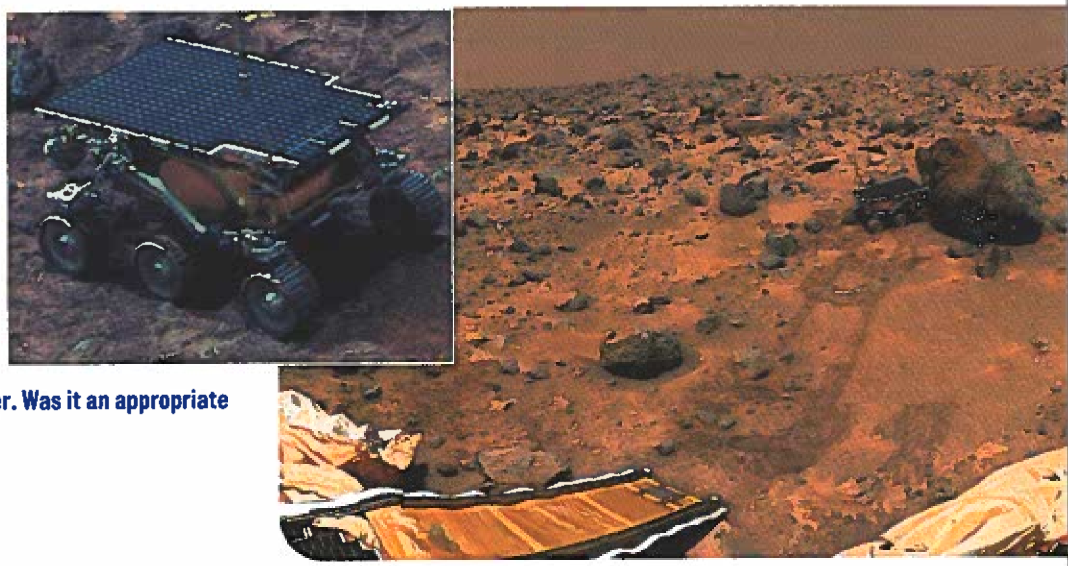


Fig. 17-12. ***Sojourner*** **roamed over the surface of Mars and sent data back to scientists on Earth. This photo was taken by a camera mounted in the *Pathfinder* module. Look up the definition of sojourner. Was it an appropriate name for the vehicle?**

SECTION 3 TechCheck

1. Why do we have unstaffed space missions?
2. What is a sensor probe used for?
3. Where are the *Voyager* spacecraft?
4. **Apply Your Knowledge.** Research photos of the Martian surface provided by the *Pathfinder* mission.

- **Second Law of Motion:** *Force is equal to mass times acceleration (F = ma).* To make something as large as a rocket move quickly, you need a lot of force. The amount of force or thrust produced by a rocket engine is determined by how much (mass) rocket fuel is burned and how quickly the gas escapes from the rocket.

- **Third Law of Motion:** *For every action, there is an equal and opposite reaction.* A rocket can lift off the launch pad only when gas is pushed out of its engine. The rocket pushes on the gas, and the gas pushes on the rocket. The action is the gas coming out of the engine. The reaction is the movement of the rocket in the opposite direction.

In space, even tiny thrusts will cause the rocket to change direction because there is so little gravity or other forces.

ACTIVITY

What happens when two football or hockey players collide? Explain which of Newton's Laws are working.

ACTION ACTIVITY

Building a Simulated Mars Rover Vehicle

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

NASA's *Pathfinder* mission used a robot rover that moved around on the surface of Mars. Refer to Fig. 17-12. Robotic exploration of space can add to our knowledge without putting people in danger. In this activity, you will build and control a simulated Mars rover that will send a video signal for you to analyze.

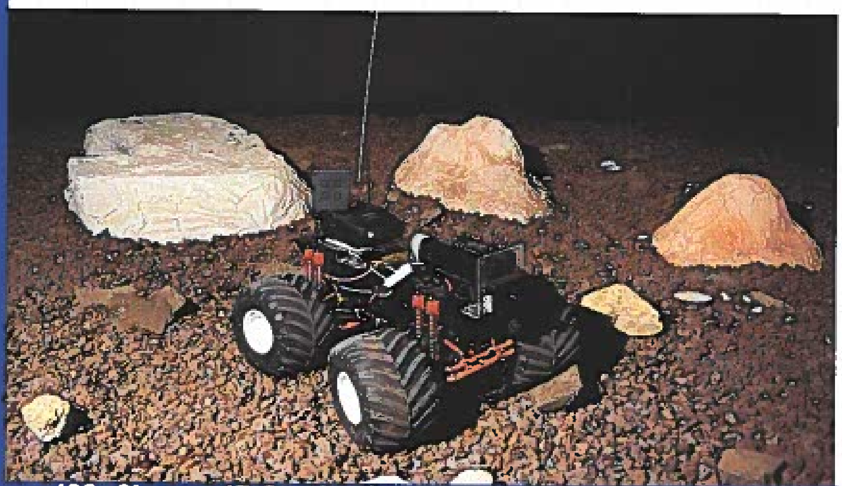
Design Brief

Design, build, and use a simulated Mars rover to explore a model of a Martian landscape. The rover will consist of a remote-controlled model truck with a wireless video camera transmitter and receiver. Fig. A. The rover will send a video signal to your tech classroom. You will analyze the video to determine the surface characteristics of your model planet.

Materials/Equipment

- remote-controlled (R/C) 4-wheel-drive model truck with radio controller
- 12-volt DC video camera
- 12-volt DC video transmitter
- 12-volt DC rechargeable power-tool battery and plastic cap
- video receiver and TV monitor
- rocks, sand, plaster, foam model-making materials
- velcro fastener tape
- plastic cable ties
- variety of screws and nuts

Fig. A



SAFETY FIRST

Follow the general safety rules on pages 42-43 and the specific rules provided by your teacher for tools and machines. Double-check all electrical connections to prevent short circuits when a wire goes directly from negative to positive. Use caution while soldering electrical connections.

Procedure

Divide into groups for the following tasks.

Part 1 • Building the Mars Rover

1. Remove the plastic body from the R/C model truck.
2. Design a system to hold the video camera securely to the front of the vehicle. Use velcro fastener tape or cable ties.
3. Connect the video transmitter to the vehicle with Velcro fastener tape.
4. Attach the power-tool battery using plastic cable ties.
5. Fasten the wires and connectors as shown or follow the wiring diagram that came with your video camera. Be careful not to get positive and negative wires mixed up.
6. Punch a hole in both sides of the plastic battery cap. Tighten two screws to be used as electrical contacts as shown in Fig. B.
7. Assemble the wires and test the system using a receiver to show the video signal on a TV monitor.

Part 2 • Creating the Mars Landscape

1. Ask your teacher where to build your Mars landscape. If weather permits, work outside.
2. Try to make your landscape look like Mars. Study Fig. A or research photographs in your school's library or on the Internet. Use rocks, sand, plaster-covered foam, or other model-making materials to make it look real.
3. Design backdrops to look like the Martian horizon.

Part 3 • Exploring Mars

1. Take turns controlling your Mars rover with a radio transmitter from a different room or a different area of the tech lab.
2. Set up your mission control area to view the wireless video signal coming from your rover.
3. Study and analyze the images received.

Evaluation

1. What was the name given to NASA's Mars rover?
2. Why is it safer to send robots to explore planets?
3. **Going Beyond.** Connect the video signal from your Mars rover to a computer. Send the images from your rover to another school using the Internet.

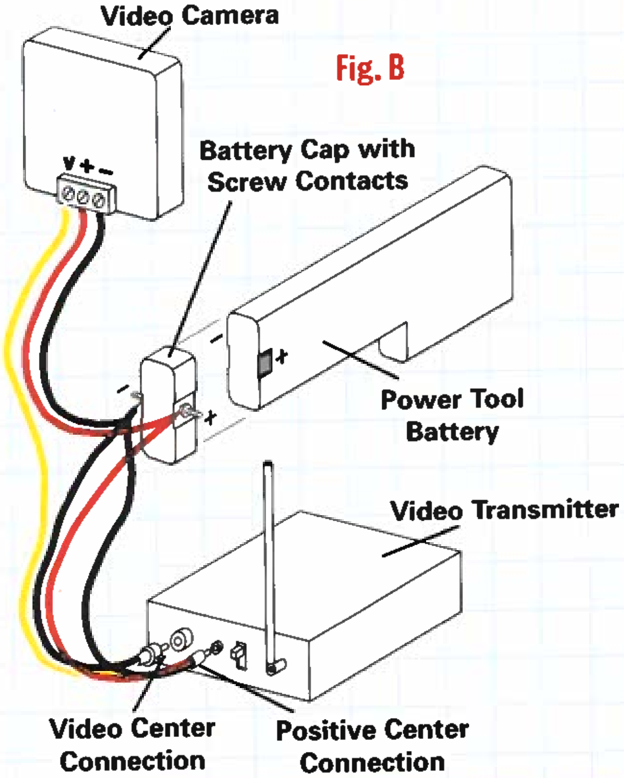


Fig. B

CHAPTER 17

REVIEW &

CHAPTER SUMMARY

SECTION 1

- Milestones in space history include the launch of *Sputnik*, humans walking on the moon for the first time, and the Space Shuttle missions.
- Early space pioneers such as Konstantin Tsiolkovsky, Robert Goddard, and Hermann Oberth developed modern rocketry.
- The development of the Space Shuttle made reusable launchers possible.

SECTION 2

- Escape velocity is the speed needed to get spacecraft away from the Earth.
- Newton's Laws of Motion explain how rockets work on Earth and why they also work in space.
- Launchers give the spacecraft extra power, or thrust.

SECTION 3

- Unstaffed space missions are used to find information about planets and other space objects.
- Satellites and other spacecraft use sensor probes to test for such things as temperature and radiation.
- Robots, such as the Mars *Sojourner* vehicle, can be remotely controlled from Earth.

REVIEW QUESTIONS

1. What does escape velocity have to do with gravity?
2. Who was the first person in space?
3. What must rocket engines carry with them in addition to fuel?
4. What kinds of instruments do satellites carry?
5. State Newton's Laws of Motion.

CRITICAL THINKING

1. Design and conduct three experiments that demonstrate Newton's Laws of Motion.
2. Explain the main difference between rockets and jet engines.
3. Discuss the advantages and disadvantages of unstaffed space flight.
4. Make a sketch of a Mars rover that could scoop a sample of Mars soil.