# ACTIVITIES

CHAPTER 13

## CROSS-CURRICULAR EXTENSIONS

1. **SCIENCE** With your teacher's help, contact a glass shop and ask them to save small pieces of mirror for a class project. Tape the edges of the mirrors to prevent cuts. Have each person in the class design and build an adjustable stand to hold the mirrors. Set all of the mirrors in the sun so that each one reflects sunlight toward a solar cell array. How does the voltage change when all the mirrors are adjusted properly?

2. **MATHEMATICS** Refer to Activity 1. Calculate which would be more cost-effective, a large number of solar cells or a few solar cells and many mirrors.

## EXPLORING CAREERS

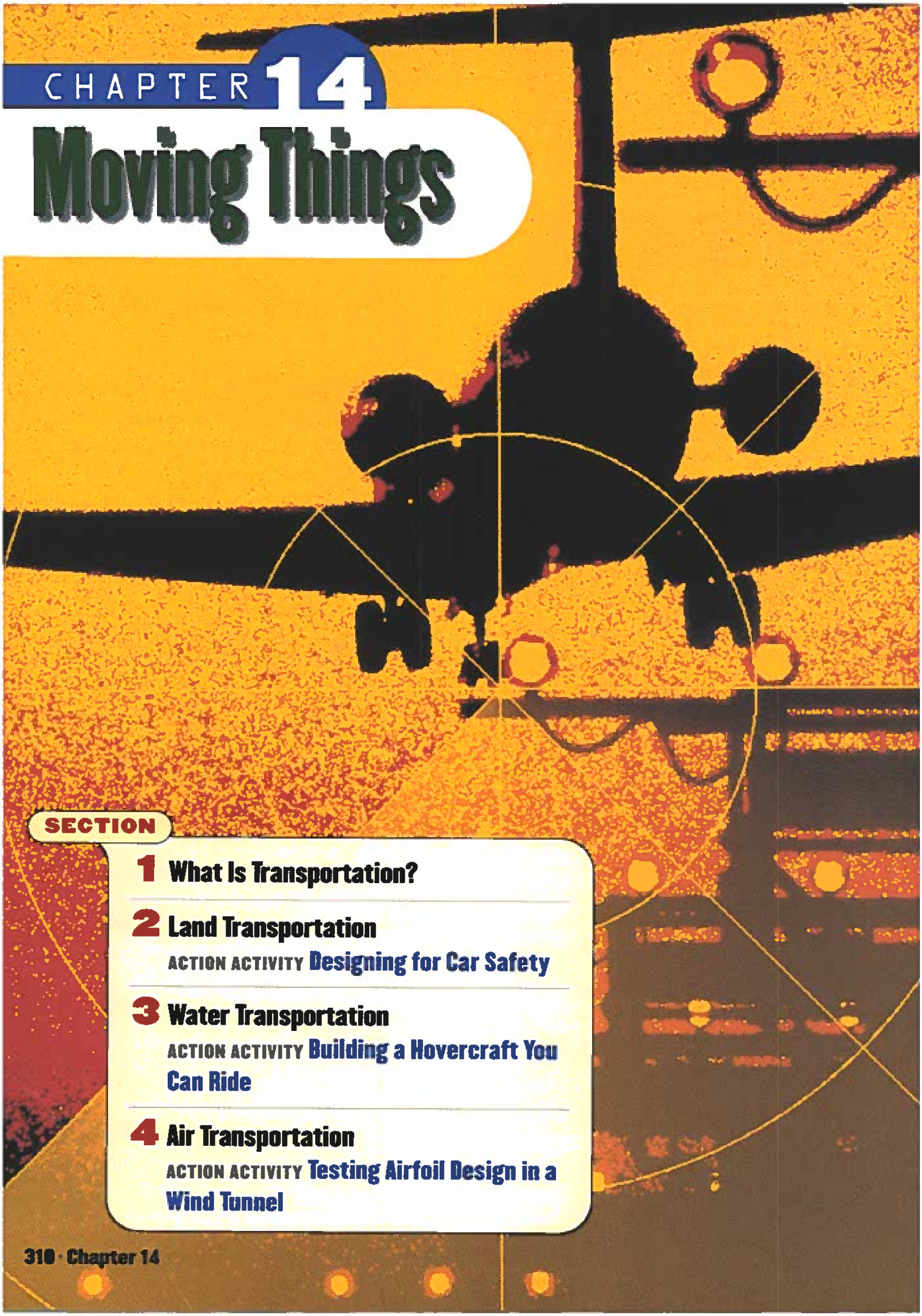
The ability to harness and use energy allows us to heat our homes, drive cars, and create powerful lasers. Expanding energy technology is also creating career opportunities like those listed below.

**Laser Technologist** Lasers can be used to cut through steel, reshape a cornea in the eye, and read the bar codes on packages. Lasers are being used in medicine, manufacturing, and retail businesses. Laser technologists transport, set up, demonstrate, and maintain various types of laser equipment. They must have mechanical abilities, be able to work well with customers, and be willing to keep up with the changes in laser technology.

**Nuclear Engineer** Nuclear energy is used to generate electricity. It powers ships and spacecraft and is used in medicine. Some nuclear engineers manage power plant facilities. They conduct and monitor tests or oversee daily operations. Nuclear engineers need strong management and problem-solving skills and a strong background in mathematics and science.

### ACTIVITY

Bring a product to class that has a bar code (Universal Product Code) on it. Find out what each of the numbers in the bar code represents.



# CHAPTER 14
# Moving Things

SECTION

# What Is Transportation?

SECTION 1

## THINGS TO EXPLORE

- Define transportation and tell how it affects you.
- Explain how transportation technology is changing rapidly.
- Describe the different modes of transporting materials.

**TechnoTerms**
composite
mode
transportation

Take a quick look around your classroom. Everything you see had to be transported to this room. **Transportation** is the movement of people or goods from one place to another. Transportation is a big industry that affects you in many ways.

Do you own a bicycle or a scooter? Does anyone in your house depend on a car or bus to get to work? How does your luggage get from the airplane into the main airport terminal? How did the food you ate for breakfast get to the grocery store? Transportation is very important to your way of life. You depend on transportation such as trains, ships, automobiles, airplanes, or buses to get you where you want to go. Almost everything you use, from the food you eat to the chair you are sitting in, is there for you because of transportation systems.

## Changes in Transportation Technology

Transportation technology is changing rapidly. Everything moves much faster today. At top speed, the first airplane built in 1903 could go only 30 miles per hour (mph). Now we have the *Concorde* jet, which can fly more than 1,200 miles per hour. Fig. 14-1 (page 312). In space, people travel faster than 17,000 miles per hour!

Most transportation systems today use a lot of computer technology. Computers also control lights, door locks, braking systems, and the amount of pollutants produced in many cars,

**TechnoFact**

**BREAKING THE SOUND BARRIER**
Have you heard the term "Mach I" before? Mach I is the speed of sound, or about 700 miles per hour. When an airplane approaches the speed of sound, the air it pushes ahead of it creates a shock wave. A loud noise is produced as the plane "breaks the sound barrier." Then the plane becomes very hard to handle. Chuck Yeager was the first person to fly at more than the speed of sound. The *Concorde* cruises at Mach 2, or twice the speed of sound. A hypersonic plane is being planned that will reach speeds of Mach 6 and up!

**OPPOSITE** Airplanes are our fastest form of everyday transportation.

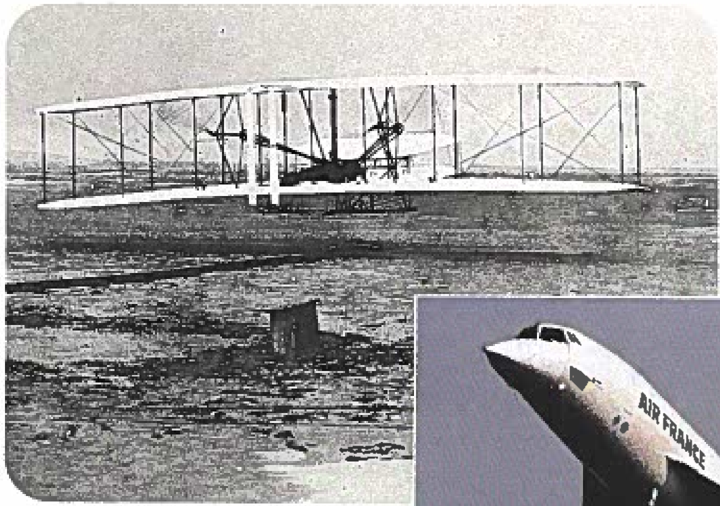



**Fig. 14-1.** The Wright Brothers made the first long, controlled, engine-powered flight. The Concorde is a bit faster. Do a little research on the Concorde. When was it first used, and how many passengers does it carry?

trains, and airplanes. Even farms use mechanized transportation technologies. Computers help schedule trains, and one day satellite communication systems will help air traffic controllers monitor (keep track of) planes on long-distance flights so they don't run into each other.

Design engineers are also looking for ways to reduce the weight of vehicles, using aluminum, plastics, or lightweight steel. Plastics and **composites** (fiber-reinforced plastics) are used to make smaller aircraft that are light and strong. Using more plastics in cars and trucks will soon make many exterior parts recyclable. These new designs are making vehicles more fuel-efficient.

In the future, transportation systems that use alternative energies will be explored further to see if they are practical and economical. Fig. 14-2. Wind energy is now being used to supplement electricity on large ships. Photovoltaic cells, which change sunlight into electricity, are being used to power motors in cars and airplanes.

Can you imagine how transportation systems will change in the next 100 years?

### TechnoFact

**SUPERHIGHWAYS IN THE SKY** In order not to run into other planes, pilots travel along numbered air routes, or *corridors*, in a three-dimensional traffic network. A corridor is about nine miles wide, and at lower altitudes each corridor is 1,000 feet above or below the next corridor. Keeping track of as many as 15 planes at one time is a challenge for air traffic controllers even with the use of computers and guidance systems!


**Fig. 14-2.** This Ford P2000 automobile uses both diesel and electric power. It is non-polluting, and its aluminum body is lightweight. **Why do you think weight makes a difference? What other lightweight materials might be used to make car bodies?**

## Modes of Transportation

We use different **modes** (ways) of transportation. The mode you use depends on whether you want to move people or products on land, water, air, or in space.

Industry and business depend on transportation systems to move goods. We want the fastest, most economical ways to transport products so we don't waste products, time, or money.

As you explore the different types of land, air, and water transportation in this chapter, think about those you use a lot.

**INFOLINK**

See Chapter 17 for more information about space travel.

### TechnoFact

**DIRTBOARDS** How about an all-terrain dirtboard that lets you ride on dirt hills, grass, and mud, just as if you were riding a regular skateboard on smooth concrete? What makes this dirtboard special are the wheels. They are air-filled tires 8 inches in diameter! Big wheels are safer. On the dirtboard, the wheels rise above the platform, so the board is still close to the ground.

### SECTION 1 TechCHECK

1. What is transportation?
2. How does transportation affect you in your daily life?
3. What are the different modes of transportation?
4. **Apply Your Knowledge.** Make a bulletin board display of different modes of transportation.

SECTION 2

# Land Transportation

**TechnoTerms**

**AMTRAK**
**automated transit system**
**fifth wheel**
**piggybacked**

**THINGS TO EXPLORE**

- Identify different kinds of land transportation.
- Explain what methods of land transportation are used for and give examples.
- Design and build a safe car to transport an egg.

When you think of land transportation, do you usually think of some kind of vehicle such as a car, a train, or a truck? Actually any transportation that moves on or beneath the Earth's surface is a form of land transportation. Pipelines, conveyors, moving sidewalks, escalators, and elevators all move products or people from one point to another.

## Automobiles

The automobile has become a necessity for many Americans. We depend on the car to get us where we want to go.

**Smart Cars** Almost all the cars made in the world today have on-board computers with special sensors to help the different mechanical systems work right. Fig. 14-3. Some computers let you know how far the car can travel before it runs out of gasoline or the time of your arrival at a certain place. Computerized navigation systems in cars show local maps and indicate the best *route* (path) to take.

**Car Safety** *Passive car safety systems* don't require the passengers to do anything. For example, *air bags* operate automatically in case of a collision. Even the car itself can be designed to absorb or cushion the impact of a crash. Special areas, called crumple zones, are built into the front of the passenger compartment.

**Fig. 14-3.** Computer chips are installed in cars at the factory. Write a paragraph describing the tasks you think a "smart" car should do for itself. Which should the driver be responsible for?

# Trucks

The trucking industry is big business in the United States. The big advantage to using truck transport is that goods can go directly from the producer or distributor of a product to where the product is going to be sold.

Most trucks are tractor-trailers. Fig. 14-4. They have a large tractor, which is the power plant, and one or more trailers, which hold the freight, or cargo. Tractor-trailers use powerful diesel engines that can go long distances before needing major repairs. Have you heard the term **fifth wheel**? The fifth wheel is really a large, disk-shaped hitch that hooks the trailer to the tractor.

**Fig. 14-4.** Truckers drive long distances to deliver their cargoes. Many trucks now have computers on board that log the miles traveled as well as the time in operation. These trucks are also called tractor-semitrailers. Look up the prefix semi. How do you think its meaning is applied here?

Trailers today are made to carry special products, from refrigerated goods to melted chocolate! Sometimes they are **piggybacked** (carried on railroad flatcars) to a location. Then a truck picks them up and takes them to their final destination.

# Buses

Many kinds of buses are used to move large numbers of people around. City buses, school buses, and motor coaches are the most common types. Fig. 14-5.


**Fig. 14-5.** People in London, England, ride double-decker buses.

**Fig. 14-6.** Heavily populated countries are looking for better systems of mass transit. This high-speed maglev train is being tested in Japan. Why do you think mass transit systems are popular in heavily populated areas?

**TechnoFact**

**FIRST IRON HORSE**
The first steam locomotive was the *Trevithick*, developed in England in the early 1800s. Its top speed was 13 mph when loaded.

## Trains

Trains have been used for many years to move people and products. In the United States, trains provided the fastest way to travel before the automobile was invented.

- **Modern passenger trains.** In Japan and France, passenger trains are still commonly used. Fig. 14-6. Trains in the United States have lost riders to buses, because buses are cheaper, and to airplanes, because they are faster. **AMTRAK** (*Am*erican *Tra*vel Tra*ck*) system provides all the long-distance rail service in the United States.
- **Mass transit rail systems.** Many types of mass transit rail systems can be located underground, above-ground, or at ground level. Subways, found in large cities, are underground rail systems. Subways often use tunnels, which are expensive to build. Monorails are transit systems that are sometimes elevated. They use a single rail.

Other mass transit rail systems are totally automated and do not have a driver. These **automated transit systems** (ATS) are often used at airports, remote parking areas, and shopping centers.

**INFOLINK**

See Chapter 20 for information about maglev trains.

**TechnoFact**

**THE SUPERLINER**
The AMTRAK Superliner is a passenger train made especially for long-distance travel. Designed to be a "rolling hotel," it has bedrooms, a snack bar, and a diner. Each room has individual controls for heat, air conditioning, and music.

- **Freight trains.** In the United States, railroads are used mainly to move freight. The big advantage of trains is that they can move large loads over long distances economically and efficiently. Most locomotives today are powered by diesel-electric power or gasoline turbine engines like those used in airplanes. For efficiency, computer systems keep track of every freight car in the rail network.

## Pipelines

Some transportation systems, such as pipelines, do not use vehicles to move things. Certain kinds of materials, such as natural gas or oil, can be moved by pipeline very economically. Most pipelines are buried under ground and the product moves through them in only one direction.

## Conveyors

Conveyor belts can move people or products. One of the most popular is the "people mover," or moving sidewalk, found in major airports. Have you ever walked on one of these? Fig. 14-7.

**Fig. 14-7.** **Moving sidewalks in airports help weary travelers cover long distances quickly.** **Where else do you think moving sidewalks would be helpful?**

### SECTION 2 TechCHECK

1. List six forms of land transportation.
2. What is the main advantage to using truck transportation?
3. For what purpose are railroads used most often in the United States?
4. **Apply Your Knowledge.** Make a photo-collage from magazine pictures of all the modes of land transportation you can find. Share it with your class.

# ACTION ACTIVITY

## Designing for Car Safety

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

### Real World Connection

Automotive engineers have been working for years to make cars safer. But current safety features can't prevent thousands of people from being injured each year in car crashes. There is a great need for improved cars designed with safety in mind. For this activity you will design and build a safe model car.

### Design Brief

Design and build a model of a car with safety in mind. Use a raw egg to represent the driver. The egg "driver" must be able to "see" out the front windshield. The egg can have a foam seat, seat belt, and shoulder harness but cannot be covered with foam. The balsa-wood frame can be designed with crumple zones and should be able to protect against both front and side impact. Design your car so that it is easy for the driver to get in and out. Then test your design on a crash test track.

### Materials/Equipment

- car test track
- balsa wood
- hot glue gun
- rubber bands
- plastic wrap
- spray paint
- masking tape
- plastic wheels
- dowel rod for axles
- bungee cord
- raw eggs
- plastic sandwich bags
- camcorder (optional)
- computer with simulation software (optional)
- Styrofoam plastic foam

**SAFETY FIRST**

- **Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.**
- **Ask your teacher for permission to use power tools. Use them with caution and only with teacher supervision.**
- **Wear safety glasses when using power tools and when testing your car. Place the raw egg in a plastic sandwich bag to prevent messy accidents.**

# Procedure

## Part 1 • Building Your Car

1. Ask your teacher if you should work in small groups or individually. Ask your teacher to help build the track.
2. Design a model car that would fit into a 12" long x 8" wide x 6" high box. Fig. A. Make a sketch of your ideas.
3. Build the frame of your car out of balsa-wood strips. Use a hot glue gun to assemble the frame.
4. Use Styrofoam plastic foam to make a seat for the driver. Foam can also be used to make bumpers.
5. Use rubber bands to make the seat belt and shoulder harness.
6. Think of new ways to protect your driver.
7. Cover your car by stretching plastic wrap around the frame. Wrap the plastic so that the seams are on the bottom of the car.
8. Use masking tape to protect the windshield, side, and rear windows from paint.
9. Follow teacher directions to spray paint your car. Be sure to use a spray booth.
10. Wait for the paint to dry. Peel off the masking tape to expose the "glass" areas.
11. Install the wheels and axles.
12. Cut a hole for the door so that your "driver" will fit in.

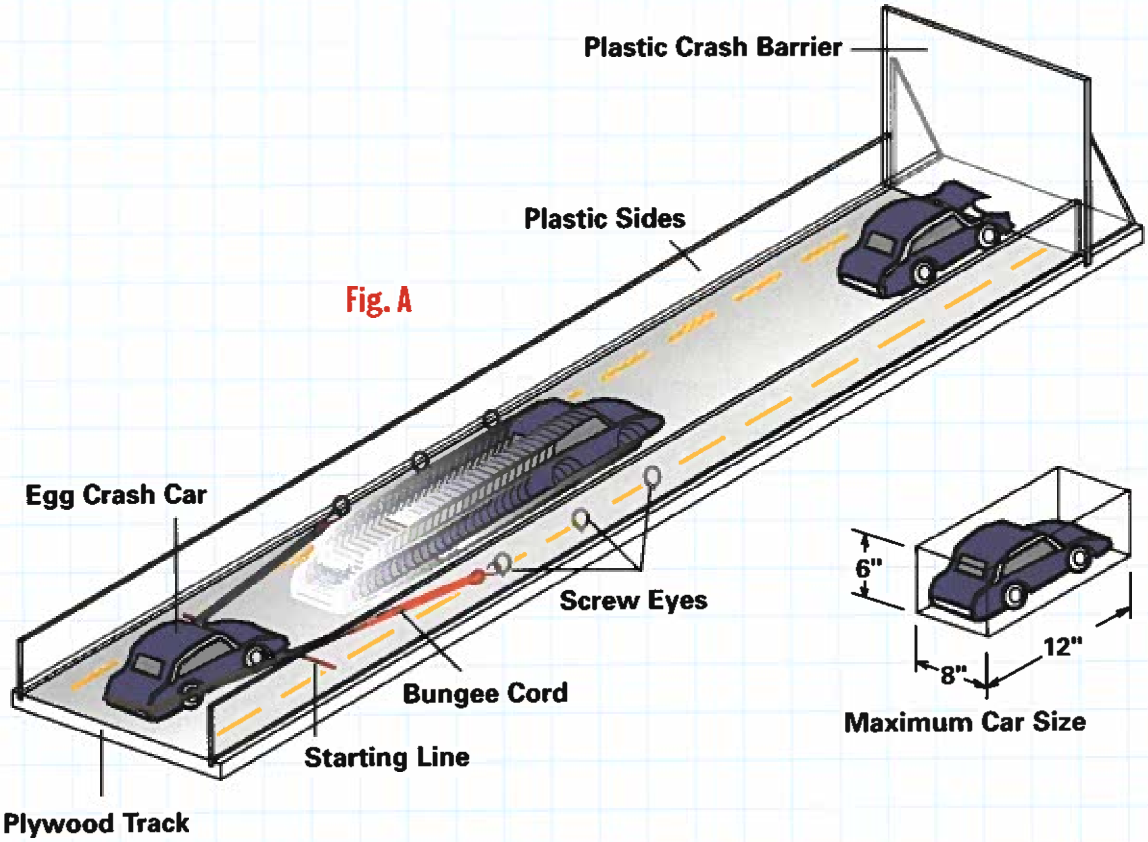


Fig. A

(Continued on next page)

## Part 2 · Testing Your Car

1. Start with the bungee cord hooked to the screw eyes set for the shortest distance (weakest pulling force). Wrap an egg in a plastic sandwich bag and place it in your car. Place your car on the test track.
2. Pull the cord and your car back to the starting line.
3. If possible, record the crash using a camcorder on the side and behind the crash barrier. Release the car and watch the crash.
4. Examine the egg for cracks. If your egg survived the first test, continue with the rest of the tests until it cracks.
5. Put the bungee cords on the second set of screw eyes. This will make the car hit the barrier harder.
6. Use a car that has already been eliminated to crash into the side of your car to test for side impact safety.
7. Put the bungee cords on the third set of screw eyes. This will make the car hit the barrier harder still.
8. Review the videotape to evaluate the safe design of your car.
9. From now on, remember to buckle up!

## Evaluation

1. List three different car safety devices.
2. What is a crumple zone?
3. What is a passive safety system?
4. **Going Beyond.** Carefully analyze the crash by playing your video a frame at a time or use a computer to digitize the video.
5. **Going Beyond.** Design and test a highway safety device, such as a crash barrier that helps to absorb impact forces. Use empty 35mm film canisters or other items to create the barrier. Re-test your car.
6. **Going Beyond.** Think of other test methods that would simulate real road conditions.
7. **Going Beyond.** Find out how auto manufacturers do crash testing. Fig. B. What kinds of information do the crash tests provide?

Fig. B

SECTION 3

# Water Transportation

### THINGS TO EXPLORE

- Describe historical changes in water transportation.
- Identify today's water transportation vessels and tell what each one does.
- Explain why computers are important to water transportation.
- Build a hovercraft you can ride.

**TechnoTerms**

air cushion vehicle (ACV)
barge
hovercraft
hydrofoil

Using water for transportation is nothing new. The first boats were powered by muscle only. For short trips close to shore, people moved boats with poles, paddles, and oars.

As people learned how to use wind power to move vessels (boats), they could travel longer distances. After the steam engine was invented, ships no longer had to depend on wind, currents, or muscle power. Steam-powered ships could sail any time, whether the wind was blowing or not. Also, the ships could be larger, and that meant larger cargoes could be carried.

## Modern Water Transportation

Today's modern ships have lighter-weight steel hulls and more efficient, powerful engines. Fig. 14-8. Some commercial ships have a double bottom, so the ship can safely carry liquid cargo or fuel for the ship's engines. Modern ships are built with prefabricated sections that are then welded together.

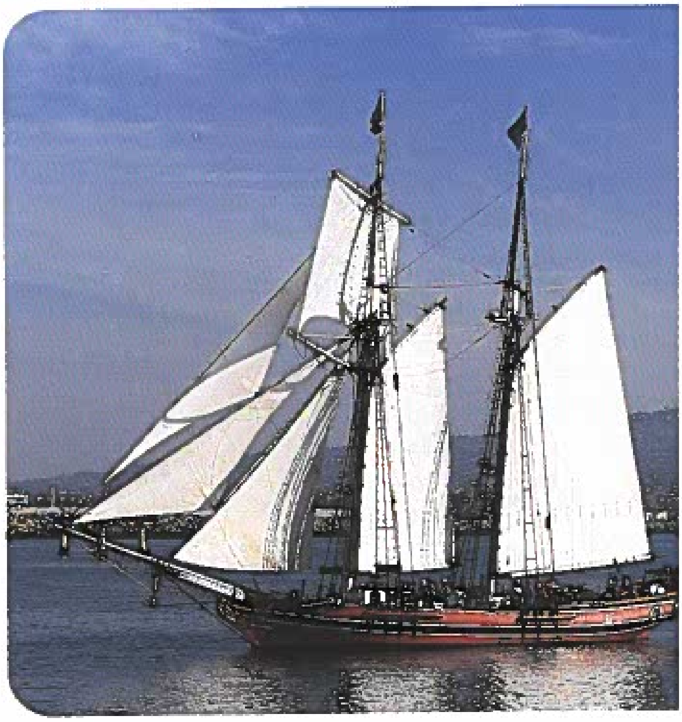


**Fig. 14-8.** At one time all ships used wind power. Now sailboats are only for recreation. What material was used to make early sailing ships?

Fig. 14-9. Hydrofoils skim over the water thanks to the lift created by the hydrofoil "leg." The shape of a hydrofoil is similar to that of an airplane wing.

Computers play a big role in water transportation today. They can determine a vessel's position and plot a course for the ship. The computer can store a complete set of charts that take up less space than paper charts and are easier to update.

In general, water transportation is slow, but it is also less expensive than air or land transportation.

- **Passenger ships.** The use of passenger ships for ordinary travel has declined. Small ocean liners or cruise ships are popular for vacations. Ferries are used to move people short distances over water.
- **Hydrofoils.** A **hydrofoil** is a passenger ship that moves above the surface of the water. Fig. 14-9. Hydrofoils can go very fast because there isn't much friction or resistance from contact with the water.
- **Hovercraft.** Also known as **air cushion vehicles** (ACVs), **hovercraft** ride on a cushion of air. High-speed fans driven by gas turbines push air under the boat. The air is trapped around the outside edges of the vehicle, so it is actually lifted above the surface of the water. You get a very fast, smooth ride. Hovercraft can travel over ice, snow, dry land, or marshes, too.
- **Submarines.** Submarines are ships that travel either on or beneath the surface

**TechnoFact**

**FULL STEAM AHEAD!** The *Clermont*, the first steam-powered ship to be used regularly, was built by Robert Fulton, an American, in 1807. After that, many other steamship designs were used to carry people and products.

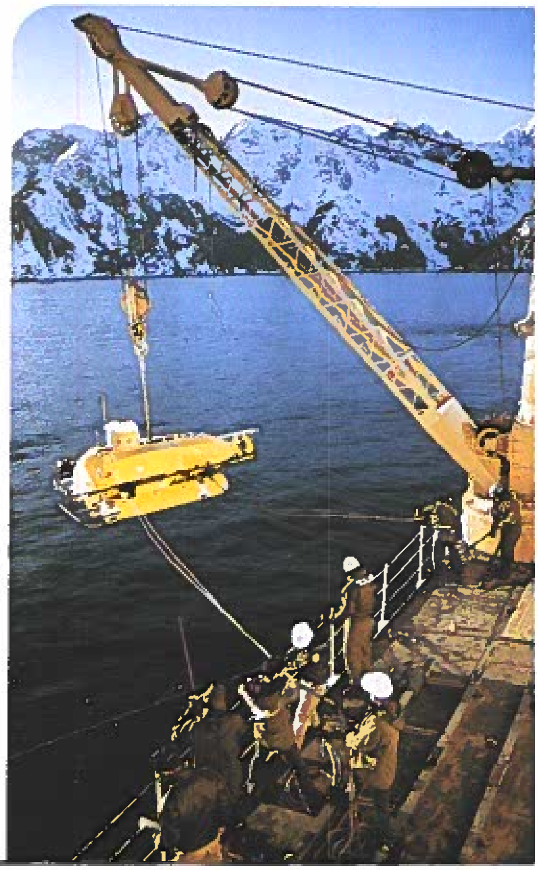


Fig. 14-10. Submersibles can study the deepest parts of the ocean. Some are robots; others carry scientists. What do you think can be gained by studying the ocean floor?

of the water. By changing the amount of air in their tanks, submarines can float at any level. The newest submarines are powered by nuclear energy. Smaller robotic submersibles are being used to explore deep-water areas. They are controlled by computers on ships at the surface. Fig. 14-10.

- **Cargo ships.** Most ocean-going ships in use today are cargo ships. Fig. 14-11. Specialized cargo ships carry products from one port to another. Cargo ships that carry liquids, such as oil, are called tankers.
- **Barges.** Barges have flat bottoms and blunt ends. They haul cargo on inland waterways such as canals, rivers, and lakes.
- **Tugboats.** Tugboats pull barges or ships into and out of harbors. They need powerful engines in order to move large ships such as ocean liners.

**Fig. 14-11.** A crane lowers cargo into the hold of a ship. Some method is usually used to hold the cargo in place. What do you think could happen if the cargo in a ship were to suddenly shift?

## SECTION 3 TechCHECK

1. What invention made it possible for ships to sail any time without waiting for the wind?
2. List seven types of water transportation vessels.
3. In what ways are computers used in today's ships?
4. **Apply Your Knowledge.** Research hydrofoils and find out how they can move so fast.

# ACTION ACTIVITY

## Building a Hovercraft You Can Ride

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

### Real World Connection

Hovercraft are vehicles supported on a cushion of air. They can move over land or water at high speeds. Hovercraft are used to transport people quickly across open water in some parts of the world. In this activity, you will make a hovercraft that you can actually ride. Fig. A.

### Design Brief

Design, build, and test a hovercraft that will support the weight of a person. It must meet the following requirements:

- Your design must be safe. Electrical extension cords must be the proper size for the vacuum motor. To prevent possible electrical shock, your hovercraft will not be tested over water or on a wet surface
- The area of the base of the hovercraft must be large enough to support the weight of a person.
- A switch must be provided so the rider can stop the vacuum motor and stop the hovercraft.
- The bottom of the hovercraft must be smooth and free of nails or screw points that could cut the plastic or scratch the floor.
- A chair or seat must be mounted to the hovercraft for people to sit on.

### Materials/Equipment

- 3/8" plywood
- polyethylene (Visqueen) plastic (6 mil)
- duct tape
- wood screws (flathead)
- abrasive paper (60 grit sandpaper)
- plastic coffee can lid
- saber saw
- stapler
- utility knife
- vacuum cleaner

**SAFETY FIRST**

**Do not use the hovercraft outside or near water.**

Fig. A

## Procedure

**1.** In this activity, your class will be divided into two groups. Your teacher will help each group with its hovercraft design. Fig. B.

**SAFETY FIRST**

- **Check with your teacher before beginning. Be sure to follow the general safety rules on pages 42-43 and the specific rules provided by your teacher for tools and machines.**
- **Wear eye protection while you build the hovercraft.**
- **Be careful with sharp tools.**
- **Keep extension cords out of the way.**

**2.** Make a list of the tasks needed to complete your hovercraft. Assign the tasks to individuals or small groups on your team. Some tasks might include

- Mark the plywood for cutting. Cut the plywood shape and sand the edges to remove sharp splinters.
- Drill a hole large enough for the vacuum motor exhaust port or hose.
- Measure and cut the polyethylene sheet to the desired size using a utility knife. Mark and cut the holes to release the air. Be careful not to scratch the workbench or floor while cutting.
- Staple the polyethylene sheet to the plywood. Screw or staple a plastic coffee can lid to the center of the plastic. This reduces the friction of the plastic against the floor.
- Design and build a mount for the vacuum motor.

**3.** Assemble the hovercraft using the parts built by each group. Place duct tape around the edges to help prevent rips in the plastic.

**4.** Attach the emergency stop switch with your teacher's help.

**5.** Attach the vacuum motor to the base with wood screws. Be sure the screws do not go through the plywood and cut the plastic. Seal around the motor and plywood with duct tape.

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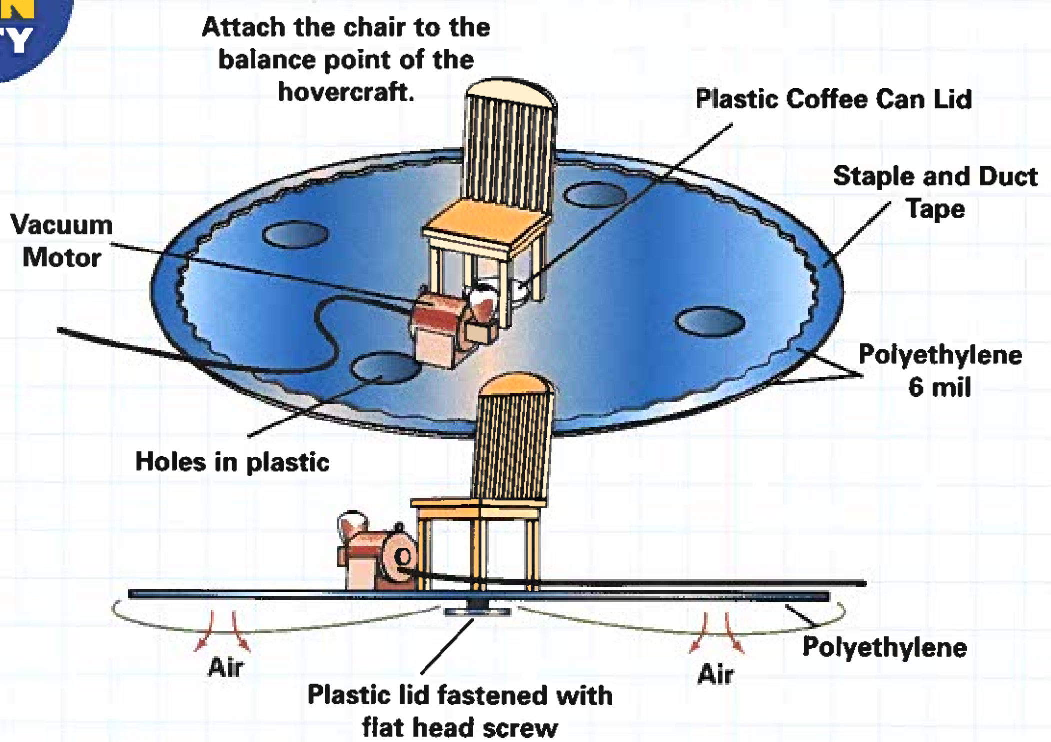



Fig. B

6. With your teacher's help, test your hovercraft without anyone riding it. Clear a path for the hovercraft test run. Be sure to keep the extension cord out of the way. Test the emergency stop switch so the driver will have brakes to stop the hovercraft. If everything is working, have the first test driver climb aboard.
7. No one should attempt to ride the hovercraft while standing. Only one person should ride at a time. Start the vacuum motor and give the rider a gentle push. The test driver should practice balancing on the hovercraft so the weight is distributed evenly. Take turns test driving your hovercraft, and suggest ways to make it better and safer.

## Evaluation

1. What are the advantages and disadvantages of hovercraft compared with cars?
2. Do you think you will have a choice of buying a car or a hovercraft in the future?
3. How could the hovercraft be made so it would not need to be plugged into an extension cord?
4. **Going Beyond.** Research other designs of hovercraft. See if you can find out which hovercraft is the fastest and which is capable of lifting and transporting the most weight.
5. **Going Beyond.** Design and test a safe method of propelling your hovercraft forward and backward.
6. **Going Beyond.** Design and test a way to steer your hovercraft.

# Air Transportation

SECTION 4

**THINGS TO EXPLORE**

- Describe how air transportation has changed since the early days of flight.
- Explain the difference between lighter-than-air vehicles and heavier-than-air vehicles.
- Test an airfoil design using a wind tunnel.

**TechnoTerms**

- aerodynamics
- airfoil
- blimp
- dirigible
- heavier-than-air vehicle
- lighter-than-air vehicle

Probably the most imaginative transportation ideas have come in the field of flight. Even great inventors like Leonardo da Vinci of Italy thought people should be able to fly by flapping some kind of wing device. What really started air transportation was dreams, not need.

## Lighter-than-Air Vehicles

You can divide aircraft into lighter-than-air vehicles and heavier-than-air vehicles. **Lighter-than-air vehicles** float in air. **Heavier-than-air vehicles** must supply power to fly.

The first successful aircraft of any kind was the hot air balloon designed by Frenchmen Joseph and Etienne Montgolfier in 1783. They did not know what really made their balloon go up. They thought maybe some unknown, mysterious gas was released from burning wood! Fig. 14-12.

This principle of lighter-than-air flight was used in many more designs as people experimented with hydrogen-filled and hot-air-filled balloons. The first human flight was also made in 1783, when two people remained at an altitude of 3,000 feet for 25 minutes.

**Fig. 14-12.** Many people like to take rides in hot-air balloons. What causes a hot-air balloon to rise? Explain.

In the early 1900s, lighter-than-air vehicles called **dirigibles** carried passengers and freight around the world. The *Hindenburg* was the largest at more than 800 feet in length. It could carry 100 passengers. But dirigibles were filled with hydrogen, which burns very quickly when it is ignited. The *Hindenburg*, like many other dirigibles, came to a tragic end when the hydrogen exploded and the dirigible burned.

Today's **blimps**, such as the Goodyear blimp, are filled with helium gas, which is safer than hydrogen. Most are used for advertising or photography and sometimes freight.

**TechnoFact**

**A SHORT HOP** Do you know who made the first takeoff in an engine-powered plane? It was a Frenchman named Clement Ader, in 1890. The wheels only came off the ground a few inches, and the flight was very short (only 160 feet), but it was a start!

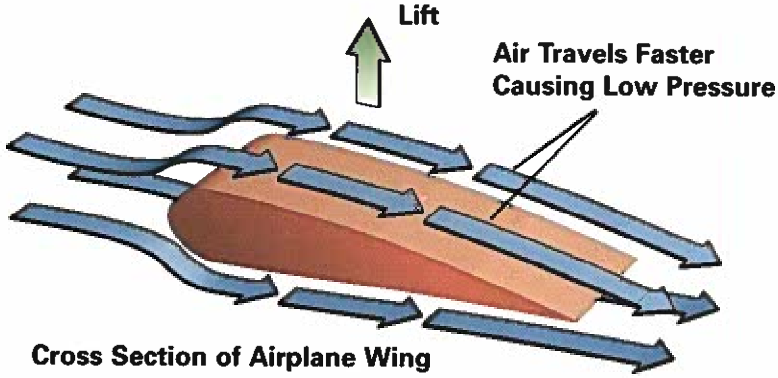
## Heavier-than-Air Vehicles

After people got one foot off the ground, there was no stopping them. The Wright Brothers' flight in 1903 was the first long, controlled, engine-powered flight. They had experimented with gliders and had even built a wind tunnel to test different *aerodynamic* (streamlined) shapes. They also experimented with how to control a plane in flight. This meant studying the forces that work on an airplane and how to adjust for them.

**Aerodynamics** is the branch of science having to do with forces created by air. Fig. 14-13. An airplane has to overcome both gravity and drag (air resistance). Wings that provide *lift* can

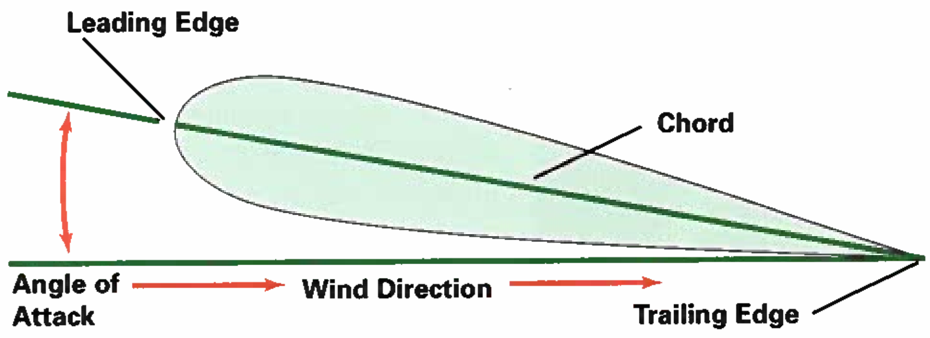
**SCIENCE CONNECTION**

### Bernoulli's Principle: What Keeps Airplanes Up?



Cross Section of Airplane Wing

Over 200 years ago, a Swiss mathematician named Daniel Bernoulli discovered a scientific principle that is one factor in how airplanes fly.




**Angle of attack:** The angle between the chord and the direction of the wind.
**Chord:** A straight line from the leading edge to the tail.
**Drag:** The resistance of an object to the flow of air, often determined by the object's shape.
**Leading edge:** The point on the wing that is farthest forward. The spot where wind hits the airfoil first.
**Lift:** The force created by the airfoil. It must be greater than the force of gravity so that an aircraft can fly.
**Trailing edge:** The back edge of the airfoil.

**Fig. 14-13.** Another name for an airplane wing is airfoil.

overcome gravity. But once in the air, the plane is held back by drag. Drag is overcome by the thrust of the engines and a streamlined shape. The less drag on an airplane, the less power is needed to propel it.

Bernoulli's Principle states that as the speed of a fluid increases, its pressure decreases. You're probably asking what that has to do with an airplane's flying. Well, a fluid can be a liquid or a gas. Air is a fluid.

As air flows over an **airfoil** (wing), the wing's shape and *angle of attack* cause the air to speed up above the wing's surface. As the air speeds up, its pressure goes down, creating a low-pressure area above the wing. This low-pressure area creates *lift*, drawing the aircraft upward. This allows the aircraft to overcome gravity and to fly.

Bernoulli would be amazed to learn how technology has put his discovery to use! His scientific principle has helped the Wright Brothers and every flier since.

## ACTIVITY

Place a ball above a leaf blower or hair dryer (on cool) that is blowing air. To demonstrate Bernoulli's Principle, see if you can balance the ball in the same position while slowly rotating the blower.

**Fig. 14-14.** This helicopter takes scientists for a view of an active volcano. Why do you think a helicopter would be ideal in this situation?

## Jet Aircraft

Many technological advances in airplane design and manufacture came during World War II. One of the most important was the jet engine.

Today, stronger, lightweight materials make new designs possible. There are many different kinds of planes, and each is built for a special job. Some airliners can take off and land on short runways. Jumbo jets carry hundreds of people over long distances but need a long runway.

## Helicopters

Helicopters are able to land people and supplies in places where other types of transportation can't go. Fig. 14-14. They can fly straight up while taking off or straight down while landing. Helicopters can also hover (fly in one place) in the air and change directions very quickly.

Helicopters are used for traffic control in large cities, where they monitor traffic jams or accidents. They are also used in the construction industry to move lumber or prefabricated sections.

### SECTION 4 TechCHECK

1. Name two lighter-than-air vehicles.
2. What do heavier-than-air vehicles need in order to fly?
3. Describe two early air vehicles.
4. **Apply Your Knowledge.** Make a lighter-than-air vehicle, such as a hot-air balloon, and see how many ways you can find to make it lift.

# ACTION ACTIVITY

## Testing Airfoil Design in a Wind Tunnel

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

### Real World Connection

When the Wright brothers were designing their airplane, they tested wings in a wind tunnel. Today, huge wind tunnels are used by NASA to test aircraft at supersonic (faster than the speed of sound) speeds. Models are often used, and many design problems can be solved by wind-tunnel testing before production starts.

For this activity you will design, build, and test an airfoil. Your test will show how airfoils create lift to make aircraft fly.

### Design Brief

Design, build and test an airfoil in a wind tunnel.

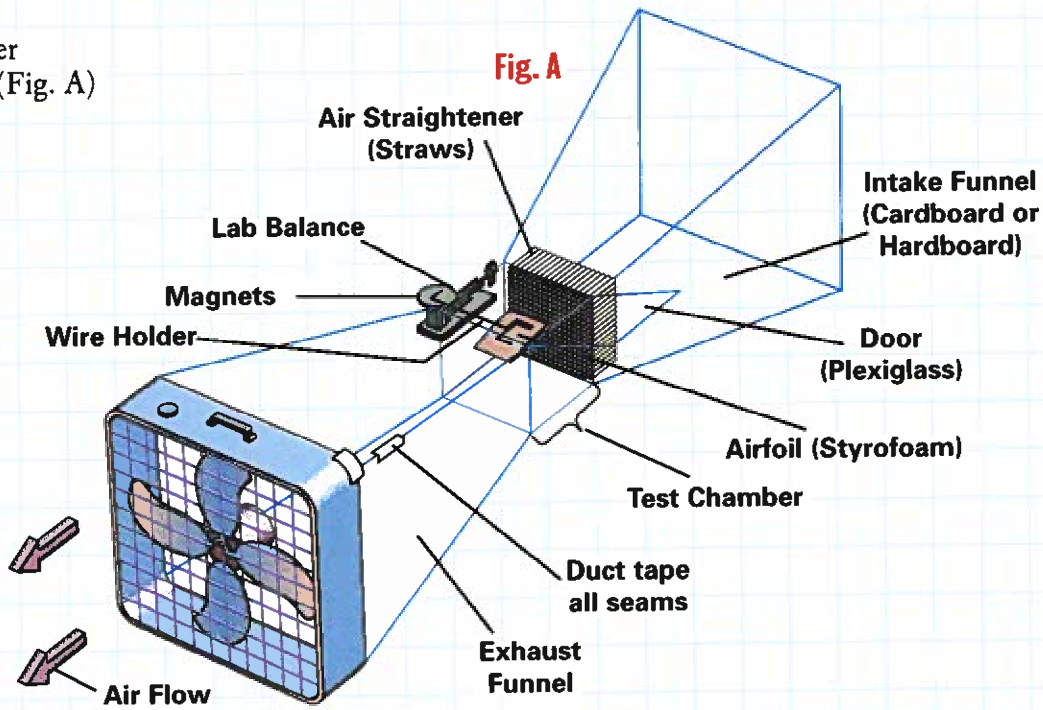
**SAFETY FIRST**

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

### Materials/Equipment

- Styrofoam plastic foam
- 1/16"-welding rod
- paper
- scissors
- pins
- hot wire cutter
- wind tunnel (Fig. A)

Fig. A

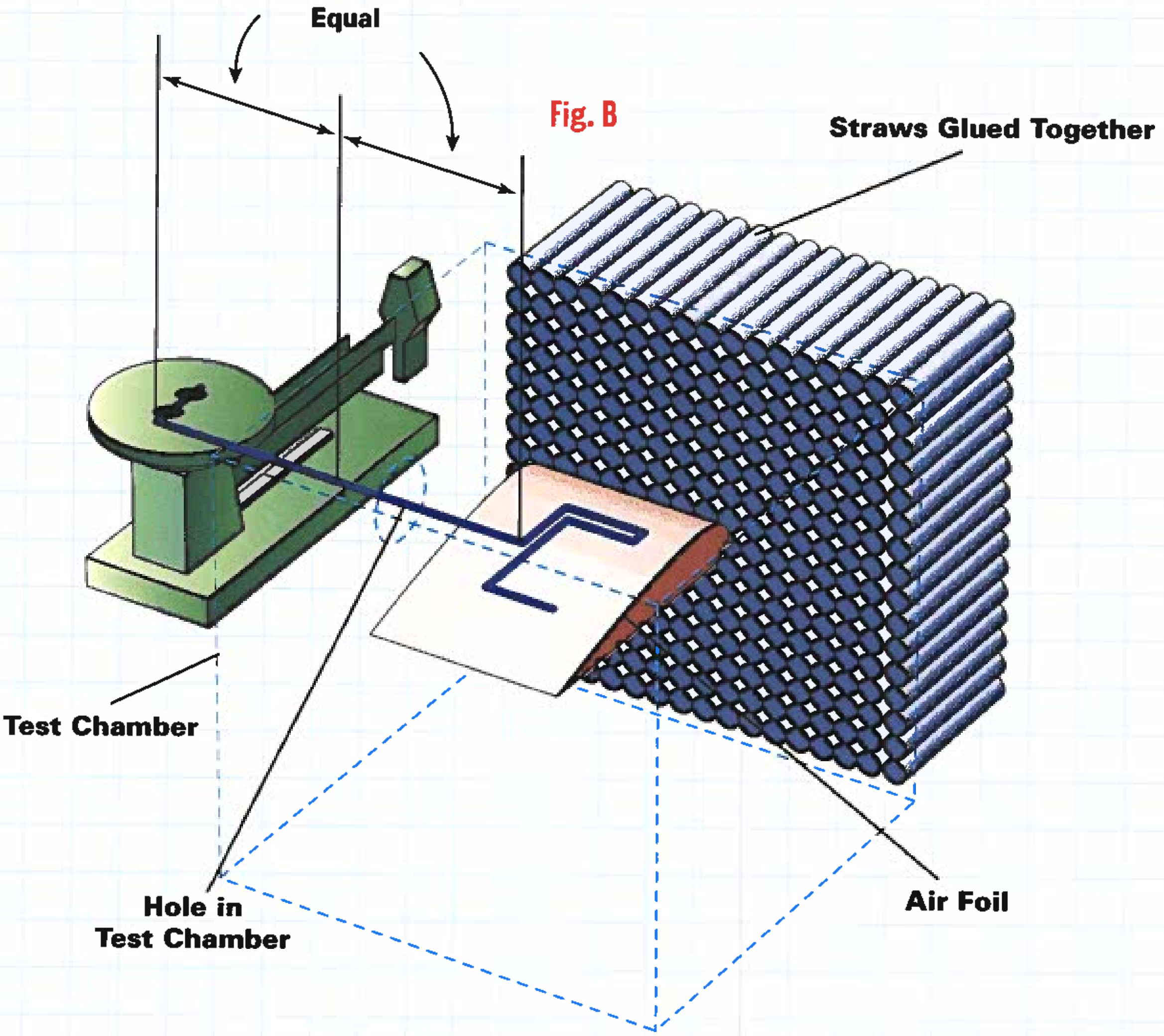



(Continued on next page)

## Procedure

1. Design an airfoil pattern on a piece of stiff paper. Cut out your design with scissors. Pin the pattern to a piece of Styrofoam plastic foam.
2. Use a hot wire cutter to cut out your airfoil. Follow the paper pattern carefully to make a smooth cut.
3. Locate the leading edge and trailing edge of your airfoil. (See Fig. 14-13.) Draw a straight line between the leading and trailing edges to show the chord.
4. Mount your airfoil on a wire holder made from a 1/16" welding rod. Place the wire holder through a hole in the test chamber of your wind tunnel. Attach the airfoil to the proper place. Fig. B. Adjust the airfoil so that the angle of attack is zero.
5. Make a data table to record all the measurements you are going to make. Your data table might look like the one in Fig. C.

Fig. B



6. You are now ready to test your wing for lift. Turn the wind tunnel fan on to a low speed. See if the wing goes up in the test chamber. Record the results.
7. Continue to test your airfoil at medium and high speeds. Record the results.

## Evaluation

1. Did your airfoil fly?
2. Did you see any relationship between the lift and the wind speed? Explain.
3. Is there a relationship between the angle of attack and the amount of lift? Explain.
4. **Going Beyond.** Make a graph that illustrates the effect of wind speed on the amount of lift. Make another graph that illustrates the effect of angle of attack on the amount of lift.
5. **Going Beyond.** Design and test a method to see any turbulence around the test shape. You might try a vaporizer or humidifier to make a safe "smoke" source.
6. **Going Beyond.** Design and test other wing shapes. Make a data table for each shape. Can you predict the performance of an airfoil by looking at its shape? Explain.

| Angle of Attack | 0° | | | 5° | | 10° | |
|---|---|---|---|---|---|---|---|
| **Wind Tunnel Test Data**<br>Fan Speed | A-Balance setting (fan off) | B-Balance setting (fan on) | C-Difference (B-A) | D-Balance setting (fan on) | E-Difference (D-A) | F-Balance setting (fan on) | G-Difference (F-A) |
| Low | | | | | | | |
| Medium | | | | | | | |
| High | | | | | | | |

Fig. C

CHAPTER 14

# REVIEW &

## CHAPTER SUMMARY

### SECTION 1

- Transportation is the movement of people or goods from one place to another.
- There are different ways, or modes, of transporting, or moving materials on land, water, air, and in space.
- Transportation systems that use alternative energies, such as wind energy or solar energy, are being explored.

### SECTION 2

- Land transportation includes cars, buses, trucks, railroads, pipelines, conveyors, moving sidewalks, escalators, and elevators.
- Many types of mass transit rail systems are used to move many people at one time.

### SECTION 3

- Before the steam engine was invented, ships had to depend on wind, currents, or muscle power to move them.
- Water transportation includes passenger ships, cargo ships, hydrofoils, hovercrafts, submarines, barges, and tugboats.

### SECTION 4

- Hot air balloons, dirigibles, and blimps are examples of lighter-than-air vehicles.
- Airplanes and helicopters are heavier-than-air vehicles that need power to fly.

## REVIEW QUESTIONS

1. Does where you live make a difference in the transportation systems you use most? Explain.
2. Figure out how far the Trans-Alaska pipeline moves crude oil starting at Prudoe Bay and ending at Valdez.
3. What kind of materials are carried in barges?
4. What is the meaning of leading edge, trailing edge, chord, and angle of attack?
5. Why do car designers try to make cars lighter?

## CRITICAL THINKING

1. How does Bernoulli's Principle affect car design?
2. Research the design of a jet engine. Make a chart or bulletin board display to show how it works.
3. Make a video showing how planes fly that elementary school students would enjoy.
4. With the help of your teacher, arrange a visit to an airport and investigate aircraft maintenance and air traffic control.
5. Write a major oil company and ask what that company is doing to prevent oil spills.