LESSON **18**

# Motion of a Fan Car



*The assembled fan car*

## INTRODUCTION

You will now begin the first of four lessons in which you will investigate the relationship of force, motion, and energy. In this lesson, you will study the motion of a fan car that you construct using K'NEX® parts and a battery-powered fan. You will observe the motion of the fan car with the fan turned off and with the fan turned on. In Lesson 19, you will study the motion of a vehicle powered by a mousetrap. Then, in Lessons 20 and 21, you will build a model roller coaster and study the motion of a car moving on the roller coaster. As in previous lessons, you will make predictions, record observations, gather data, and draw conclusions based on evidence from your observations and data.

### OBJECTIVES FOR THIS LESSON

**Describe the force exerted by a battery-powered fan.**

**Describe the motion of a fan car.**

**Determine the effect of a constant force on the speed of a fan car.**

**Calculate a fan car's average speed at different times as it moves along a path.**

## Getting Started

**1.** Read "Measuring Motion" on page 177. What does the term "average speed" mean? How do you calculate it? Discuss these questions with the class.

**2.** Solve the following two exercises to practice calculating average speed.

**A.** A car travels 100 meters (m) in 2 seconds. What is its speed?

**B.** A jogger runs 50 meters in 25 seconds. What is the jogger's speed?

**3.** Assemble the fan car as shown in Figures 18.1 and 18.2. (Your teacher will provide the batteries later in the inquiry.) Figure 18.1 is an exploded diagram, which shows you the parts needed to make the fan car. Figure 18.2 shows how the parts look in the completed car. Your teacher has a model that you can also examine.

**4.** When you are finished, your car should look like the one in the photo at the beginning of this lesson. Check to make sure that it does.

### MATERIALS FOR LESSON 18

**For you**

1 copy of Student Sheet 18.2: How Fast Is the Car Going?

**For your group**

1 fan car
1 battery-powered fan
2 AA batteries
1 rubber band
1 student timer
1 meterstick
1 2.0-m piece of adding machine tape
1 20-cm piece of masking tape

K'NEX® parts for the fan car (see Appendix A: Directory of K'NEX® Parts):

- 8 gray connectors (C1)
- 8 red connectors (C4)
- 8 white rods (R2)
- 4 blue rods (R3)
- 1 yellow rod (R4)
- 3 small wheels (W1)
- 3 small tires (T1) (optional)

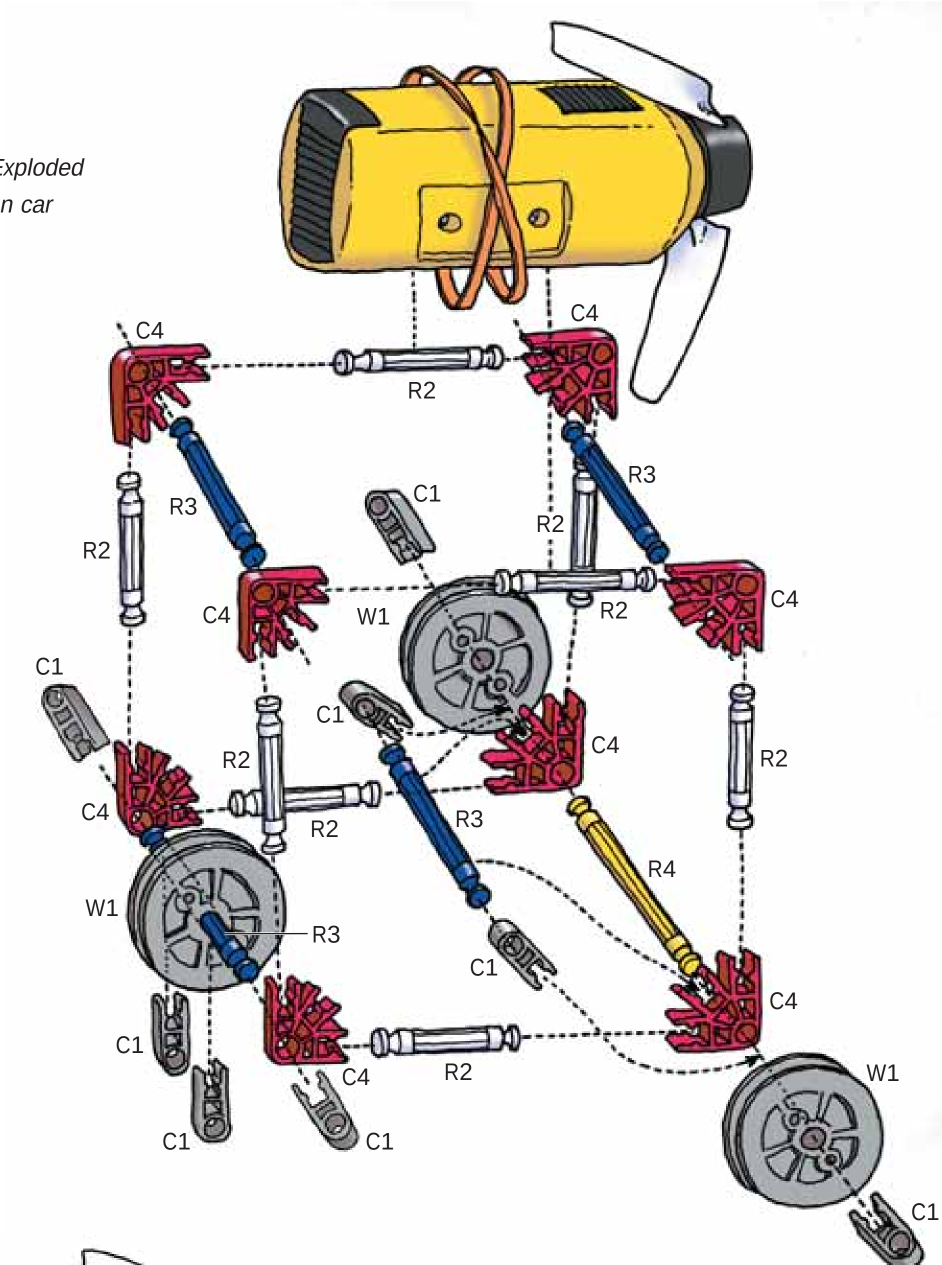



**Figure 18.1** *Exploded view of the fan car*

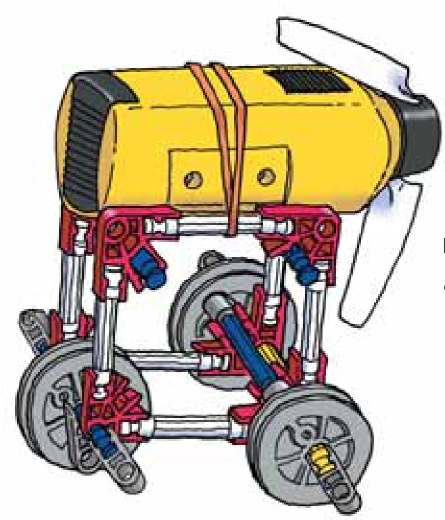


**Figure 18.2** *The assembled fan car*

## MEASURING MOTION

We see motion everywhere—think, for instance, of joggers, runners, swimmers, cars, and buses, to name just a few examples. Motion is easy to recognize. It can be described with words such as "fast" and "slow." But these words do not describe motion as precisely as scientists like to describe it. How fast is fast? How slow is slow? Fast to one person may seem slow to another. To help deal with these differences, scientists have developed a way to describe an object's motion. They measure or calculate the speed of objects that are moving. When they do that, they can easily compare the motion of fast and slow objects.

What is speed? When something is moving, it is changing its position. It takes time for this change to happen. Speed tells how fast the object changes its position. How do you measure or calculate the speed with which this happens? The speed of an object is calculated as the distance it traveled divided by the time of travel.

The speedometer on a car measures the speed of the car. It tells how far the car travels during a given time period. For example, if the speedometer registers 96 kilometers per hour (60 miles per hour), then the car is changing its position by 96 kilometers every hour. You will travel 96 kilometers each hour you ride in the car.

Is 96 kilometers per hour fast? That depends on how the speed compares with the speed of other things. For example, a jogger may have a speed of 5 kilometers per hour. Compared with the jogger, the car is moving fast. But how does the speed of the car compare with that of a plane moving 800 kilometers per hour? That comparison makes the car seem to be moving pretty slowly.

By using speed to measure the motion of things, we can compare motion in a meaningful way. If the speed of an object varies during a time interval the way the speed of a car does, the total distance traveled divided by the time to travel the distance is called the average speed.

How do you know the speed of objects if they don't have speedometers? You need two measurements. One measurement is how far an object has traveled. The other measurement is how much time it takes to travel that distance. The rate at which the object is changing its position—its average speed—can be calculated using the following equation:

$$\text{Speed} = \frac{\text{Distance traveled}}{\text{Time of travel}}$$

For example, if a car travels 200 kilometers in 4 hours, its speed is 200 kilometers divided by 4 hours, which equals 50 kilometers per hour.

In this lesson, you will use this definition of speed to calculate the speed of a moving fan car. To calculate accurate values for the speed, you will measure the distance traveled with a meterstick. You also need to measure the time it takes the car to travel each distance with a student timer.

# Inquiry 18.1
# Investigating the Motion of the Fan Car

## PROCEDURE

1. Now that you have constructed your fan car, you will make some predictions and observations about its motion with the fan *off*. In your science notebook, design a table to record your predictions and observations as you complete the activities below. Later, you will discuss your predictions and observations with the class.

2. Record your predictions for the motion of the fan car if you push it and release it without the fan running.

3. Now push the fan car. Use a steady push. Record your observations of its motion after you release it.

4. Repeat Step 3 using forces of different strengths.

5. What differences in motion do you see when you change the push on the car? Cite evidence from your observations to support your answer.

6. When you pushed on the car, your hand exerted a force on it. List in your science notebook any other forces that were acting on the car when you pushed it.

7. What force(s) acted on the car after you released it? Record your answer in your science notebook.

8. You will now investigate the motion of the car with the fan on. Put two AA batteries in the fan base. Place the fan car on the table or on another flat surface, hold it in place, and turn on the fan *without letting go of the car.* Both you and your partner should do this. Answer the following questions in your science notebook:

   *A. What do you feel when you simply hold the car with the fan running?*

   *B. In what direction does the fan move the air?*

   *C. In what direction does the fan car want to move?*

9. Before releasing the car, discuss with your partner how you think the fan car will move if you release it with the fan turned on.

10. Now release the car with the fan turned on. Observe and describe its motion in your science notebook.

11. Discuss with your partner how the motion of the fan car with the fan running compares with its motion after you released it with the fan turned off.

**SAFETY TIP**

Keep your fingers away from the moving fan blades.

# Inquiry 18.2
# Measuring the Fan Car's Speed

## PROCEDURE

1. With the class, review the behavior of the fan car turned off and turned on.

2. In this inquiry, you will measure the motion of the fan car. One way to do this is to measure the speed of the fan car as it moves across the table or floor. Review the information in the reader "Measuring Motion." Find the equation for calculating average speed and write it in your science notebook. You will use this equation in the activities that follow.

3. Place a long piece of adding-machine tape across the tabletop or floor. Use a piece of masking tape to mark a starting point at one end of the adding-machine tape.

4. Beginning at the starting point (0.0 m), mark distances in 0.4-m segments along the adding-machine tape, going all the way to 2.0 m (if possible), as shown in Table 1 on Student Sheet 18.2: How Fast Is the Car Going?

5. Label your tape distances along the tape as shown in Figure 18.3.

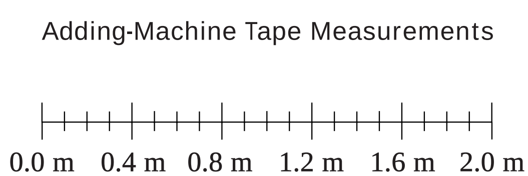



**Figure 18.3** *How to mark the tape for measuring average speed of the fan car*

6. Accurate timing is important for this inquiry. The times you measure will be very short. Before you begin collecting your data, practice your timing skills. Take turns operating the student timer and see who in your group is best at measuring short time intervals with it. Your teacher will provide an object for you to practice with. Drop the object and measure the time it takes the object to fall to the floor. The best timer is the person who can easily operate the student timer and get very close to the same timings for each drop. The best timer should operate the student timer for your group.

7. Using the student timer, determine the average time it takes the fan car to travel each 0.4-m interval along the tape. Work as a team. It is important to start and stop the student timer at the right instants. Try to keep the car traveling in a straight line along the tape.

8. Use your average time to pass through each 0.4-m interval to calculate the *average* speed of your fan car during the intervals indicated in Table 1 on your student sheet. Calculate and record the speeds in Table 1.

9. What patterns do you observe in your speed data? Answer this question in your science notebook.

10. Follow your teacher's instructions to disassemble your car and return the parts to storage.

## REFLECTING ON WHAT YOU'VE DONE

Answer the following questions in your science notebook. Be prepared to discuss your answers in class.

*A. What are the forces on the fan car when the car is moving with the fan turned off and when it is moving with the fan turned on? What evidence do you have to support your answer?*

*B. Is the force of the fan constant or changing as the car moves along? Give reasons for your answer.*

*C. What is the effect of the force of the fan on the speed of the car? Cite evidence for your answer.*

*D. What can you conclude about the effect of a constant fan force on the motion of the car?*

*E. What energy changes take place as the car moves along with the fan running?*

# PROPELLERS: VEHICLES IN MOTION

In this lesson, you observed the spinning blades of the fan producing a force that moved your fan car. That fan acted like a propeller. Like all propellers, it had a blade that rotated around a central hub. Fan cars aren't the only vehicles that use propellers. Vehicles for air, sea, and land all use propellers. ☐

## In Air

NASA

*Helicopters use their propellers to create a force that lifts them off the ground. By changing the angle of the main propeller, the pilot can make the helicopter move forward. The smaller propeller on the tail of the helicopter creates a force that keeps the body of the helicopter from spinning in circles. Its force can also be used to turn the helicopter.*

NASA

*Many airplanes have propellers. Like the propellers on a helicopter, these propellers are used to move the airplane forward. However, in most planes, the propellers don't directly cause the plane to lift off the ground. The angle of the wings and the air flowing around them lift the plane into the air. But a special kind of plane, called a tilt-rotor plane, has a propeller that can be used like a helicopter's propeller to lift the plane off the ground. When the helicopter is aloft, the propellers can be turned and used like propellers on a regular airplane.*

## On Water

CORBIS/DAN GURAVICH

*Boats, like aircraft, use propellers to move. Many boats use propellers below the surface of the water. These propellers—unlike those on an aircraft and on a fan car—push against water instead of air to move the vehicle forward. Some boat propellers are very big. Notice the size of the propeller compared with the size of the men in this photograph. This propeller was used on a boat that transported oil from Alaska to the East Coast of the United States.*

*Sometimes underwater propellers can cause problems. In swamps and places like the Everglades, where the water is shallow and where plants grow along the surface, a propeller can get tangled in plants or caught on the bottom. Airboats are designed to solve these problems. Airboats work much the same way as fan cars. A fanlike propeller on the back of the airboat pushes against the air to move the airboat across the surface of the water.*

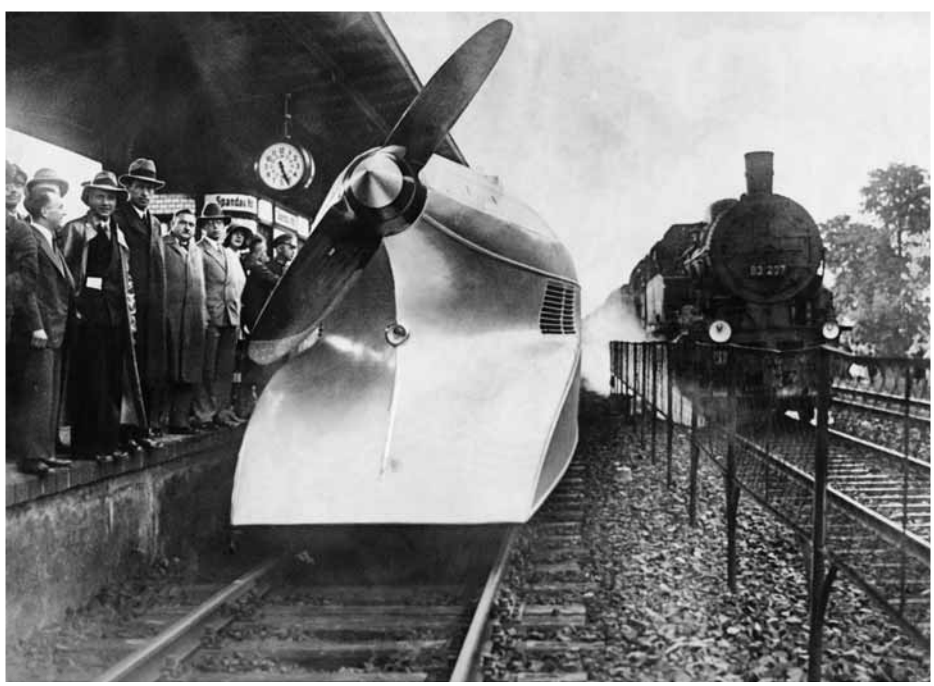
CORBIS/RAYMOND GEBMAN

## On Land

CORBIS

*Propellers are not used on land vehicles as commonly as they are on air and water vehicles. However, some creative people have designed propeller-powered land vehicles. This snow sled uses a propeller just like the one on your fan car. Because the sled is designed for the snow, it has skis instead of wheels.*

*In 1931, a propeller was used to move an unusual vehicle along a railroad track. The vehicle, named a railway zeppelin, traveled 269 kilometers (168 miles) at an average speed of more than 160 kilometers (100 miles) per hour. Its highest speed was 230 kilometers (144 miles) per hour.*



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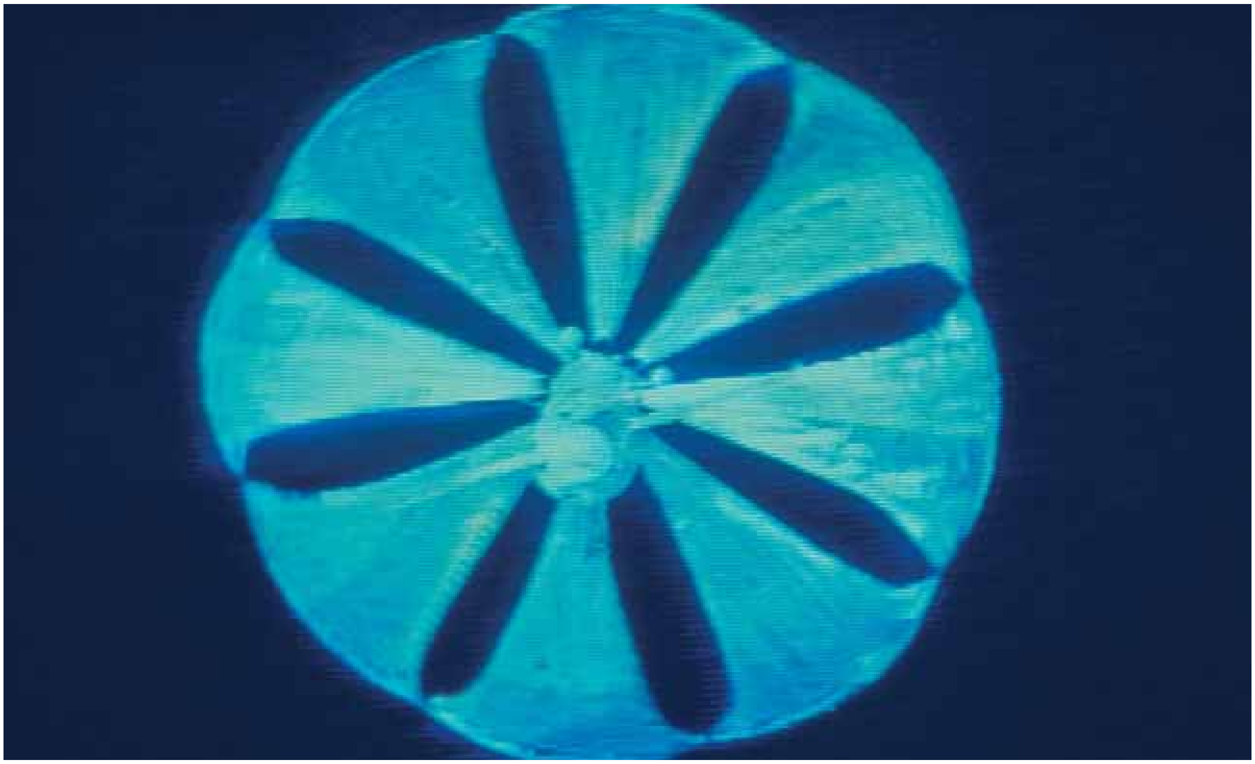
# Sailing Through the Solar System





*Solar sails may take many shapes and use different materials. Cosmonauts tested this circular, shiny blue Znamya solar sail to show that solar sailing may indeed one day be possible.*

Scientists and engineers are always looking for ways to improve things. They try to achieve two goals: making things work better and making them cost less. The more complex a project, the bigger the challenge.

From this perspective, one of the biggest challenges is space travel. A great deal of energy is required to send spacecraft into space. Powerful rockets are needed to launch spacecraft and to provide the velocity they need to travel through the solar system. These rockets are expensive. The fuel is expensive, too.

How could space travel be made less expensive? One idea that scientists are exploring is solar power. Some scientists believe that a spacecraft could actually *sail* through the solar system. Solar-sailing spacecraft could travel large distances through the solar system using very little fuel.

CORBIS / KELLY-MOONEY PHOTOGRAPHY

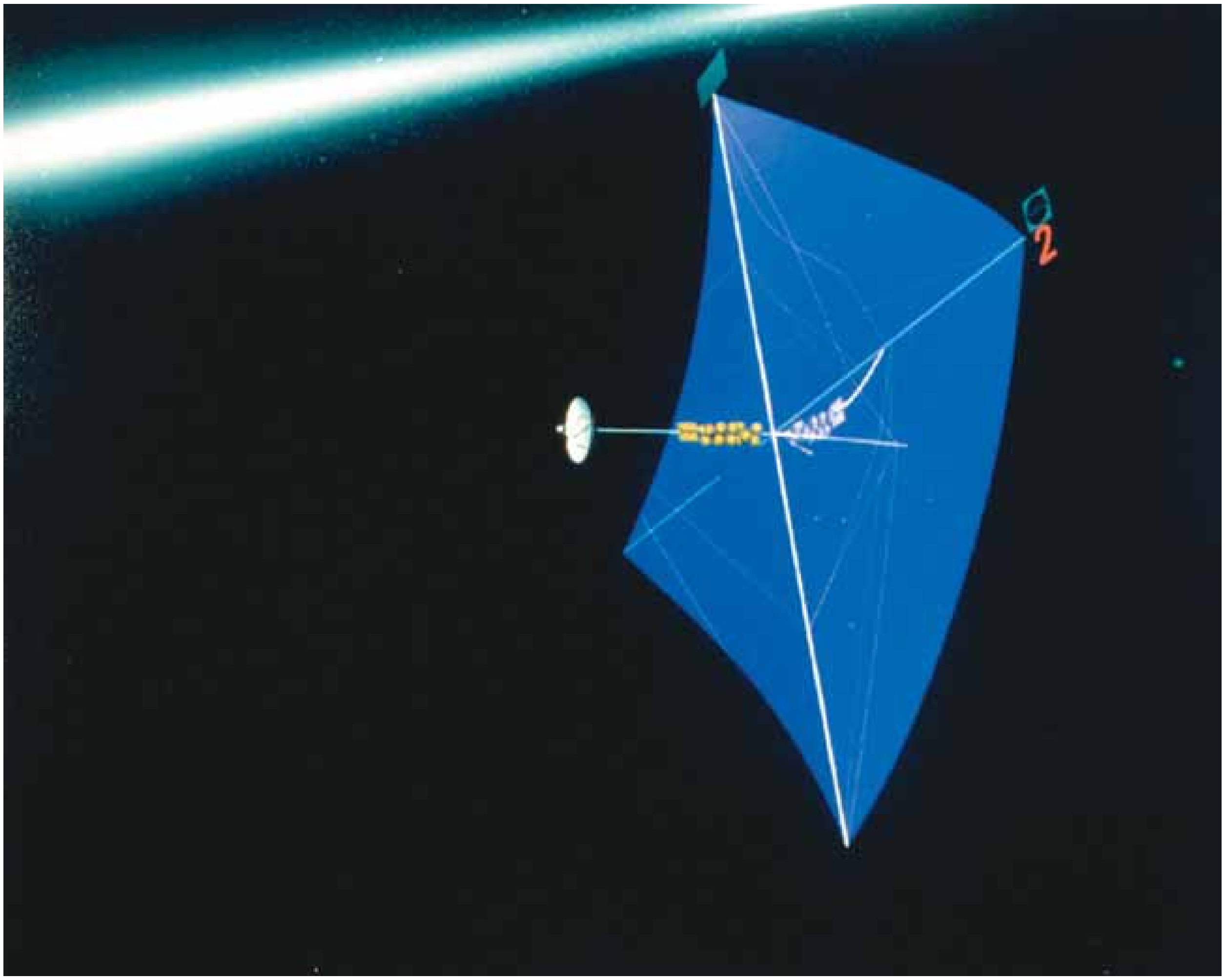

*On the earth, sailboats use the pressure of the wind.*

### Sailing Boats on Earth

On the earth, sailboats glide across lakes, oceans, and bays. Sailboats need no fuel. They are powered by the wind. When the force of the wind is greater than the drag (friction) of a sailboat in the water, the wind pushes the boat forward. The navigator speeds the boat up or slows it down by controlling the angle the sails make with the wind. The navigator can also use the force of the wind and the rudder to change the direction the boat is going.

But in space, there is neither air nor wind. So how could a spacecraft *sail?* The answer is this: Spacecraft may be able to sail using the pressure of sunlight.

NASA


Here is one design for a solar sail. Solar sails will be very large in size but not very massive. Large sails are needed to reflect enough sunlight to create pressure to push the craft through space.

## How Solar Sails Would Work

Sunlight is made of tiny energy packets called photons. If light traveling in straight lines out from the sun struck the sails of a spacecraft, the photons would bombard the sail like tiny Ping-Pong balls. When the photons struck the sail, they would push on it with a very small force. Because there is no air friction in space, the spacecraft would sail along with only the pressure of the photons of light and gravity acting on it.

So far, so good. But here's the drawback. A very large force is needed to power something as big as a spacecraft. Photons come in vast quantities, but their individual power is small. One way to increase the force would be to make the sails of the spacecraft larger; in this way, more photons would hit it. But scientists have estimated that to catch enough photons to make a spacecraft move, the sails would have to measure a kilometer on each side. A sail that big would cover about 175 football fields!

### More Solutions, Please!

Another way to maximize the force of the photons on the sails would be to make sure the light reflects off the surface of the sails as strongly as possible. This could be accomplished by manufacturing sails from a material that reflects light like a mirror.

Another solution might be to make the sails as lightweight as possible. Scientists and engineers will be challenged to develop and design sails made of ultra-lightweight materials so the spacecraft will have as little mass as possible.

Scientists and engineers are creative. They have many ideas about how to make space sailing work. But on one thing they do agree: Designing huge sails that have very little mass and that are highly reflective is a real technological challenge.

There are no solar-sailing spacecraft yet, but scientists do hope to have them one day. These spacecraft could be placed in positions that would allow them to constantly monitor the earth and the sun. The findings they would transmit could help us better understand weather patterns and climate changes on the earth, as well as storms on the sun. Solar-sailing spacecraft might be able to visit planets, moons, comets, and asteroids and send back exciting new data. Some scientists even hope to use such vehicles someday to send a spacecraft to the stars.

Solar sailing is a dream of the future, but scientists and engineers are working to make it happen. New materials and technologies will be needed. New challenges will be met, and new discoveries made. ☐