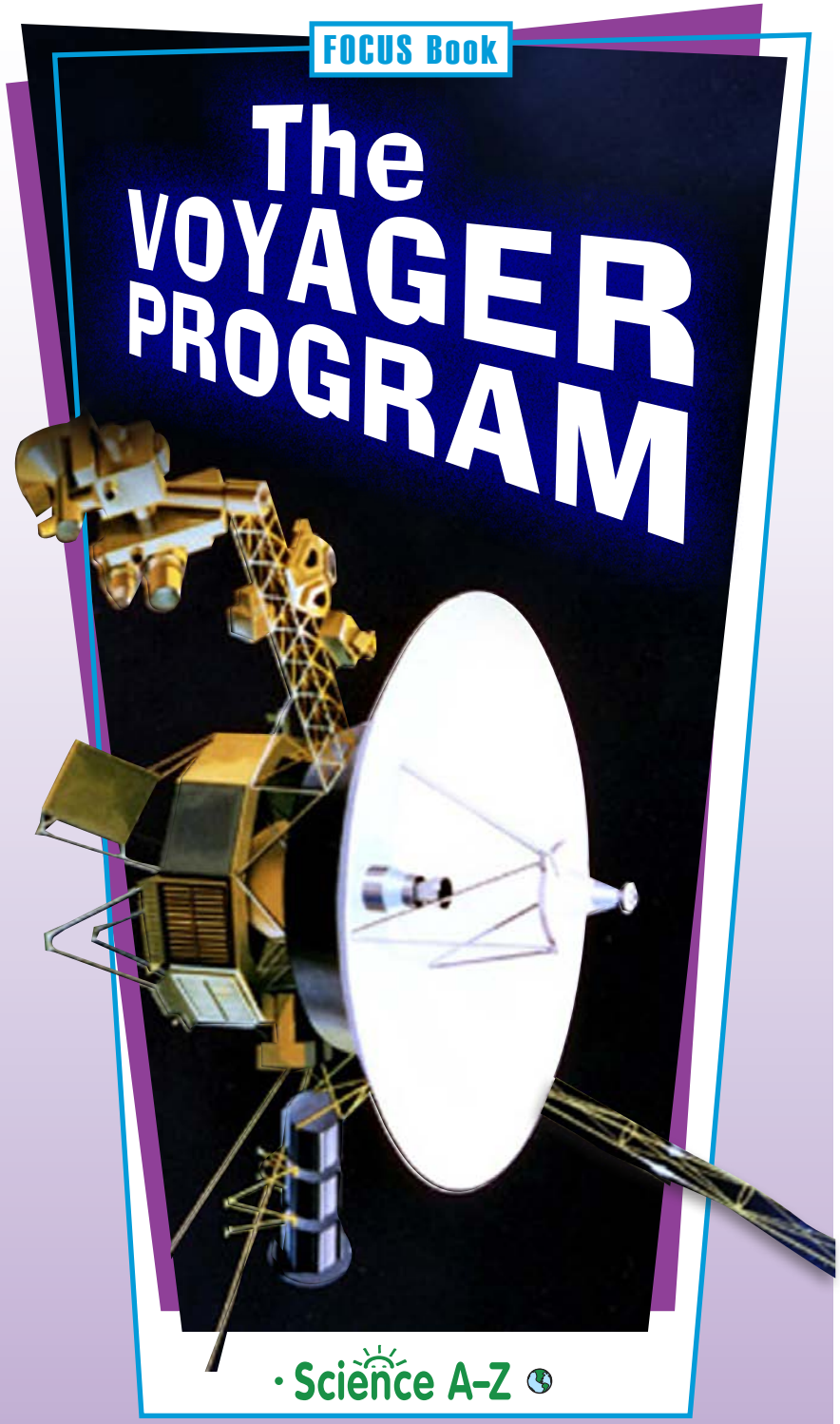
Be an Engineer!

Scientists and engineers use models to plan investigations and to describe results. Create a scale model that represents part or all of Voyager 1 or Voyager 2's journey so far. Your model can be on paper, it can be 3-D, or it can even be a role-play model that uses other students. Make sure your model includes some or all of the important places where the spacecraft has traveled during its voyage.

Be prepared to explain your model. What does it show? What doesn't it show? What is accurate about your model? What is not accurate?

Beyond the Book

Where are the Voyager spacecraft now? What have they discovered about what space is like at the edge of the solar system, or beyond? Search the Internet to find out about their latest locations and discoveries.



The VOYAGER PROGRAM

FOCUS Question

What can the Voyager spacecraft tell us about the outer solar system and beyond?

Scale, Proportion, and Quantity

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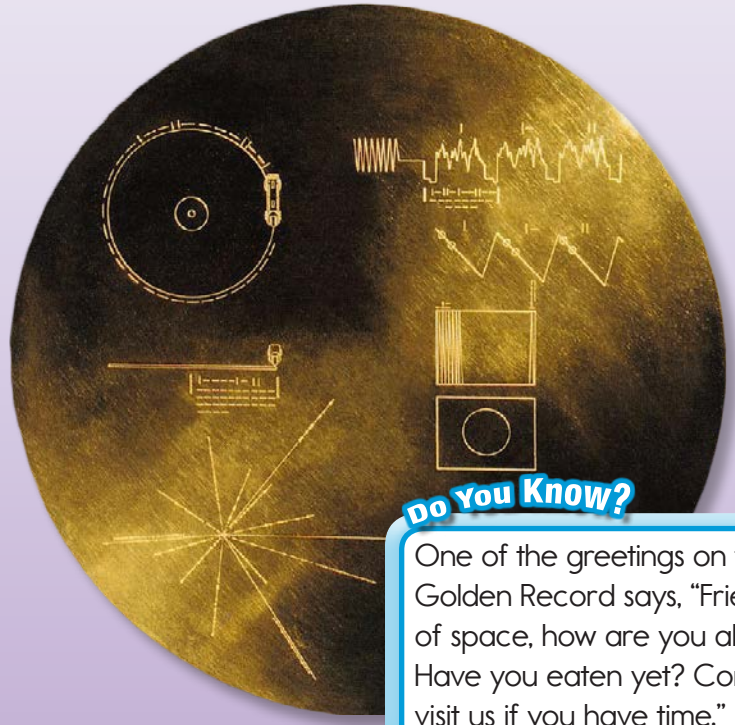
Messages from Earth

Deep in space, two little spacecraft are speeding out of the solar system. Voyager 1 and Voyager 2 travel thousands of kilometers farther from the Sun every hour. Each spacecraft carries a golden record album. On the records are pictures and sounds from Earth, including those of animals, plants, people, and technology. They also include music and greetings from people all over Earth. Scientists hope that someday, intelligent life from another solar system will receive these messages from Earth!



Do You Know?

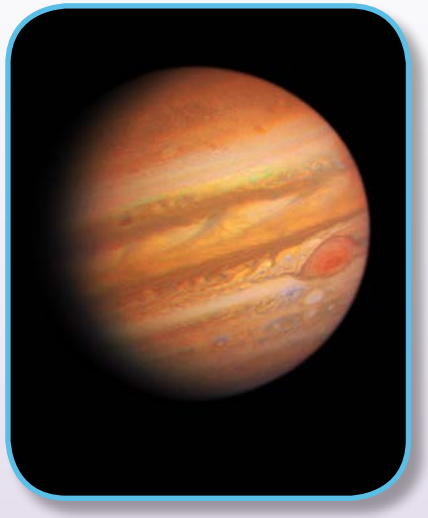
One of the greetings on the Golden Record says, "Friends of space, how are you all? Have you eaten yet? Come visit us if you have time."

The Voyager Mission

The two Voyager spacecraft were launched into space in the summer of 1977. They were designed to explore the outer planets of the solar system. Because its route to the outer planets was longer, Voyager 2 launched first, but it reached Jupiter second.

At first, the plan was just to visit Jupiter and Saturn. Later, NASA realized that the spacecraft could also be sent to Uranus and Neptune. These planets had never been visited before.

After passing the outer planets, the Voyagers set out on a new mission: to explore the space beyond the planets.



Voyager 1 sent back this image of Jupiter. It was the first time people had such a clear, close view of this distant planet.

Math Moment

One astronomical unit (AU) is the distance between Earth and the Sun. If the Voyagers have been flying at 3.5 AU per year, how far have they traveled to date?

The Grand Tour

Long before the Voyagers were launched, scientists dreamed of a "grand tour" of the solar system. Study the timeline to learn about some of the Voyager program's top moments.

August and September 1977

Voyager 2 and then Voyager 1 launch from Cape Canaveral, Florida

On Earth, 150 million km (1 AU) from the Sun

Voyager 2 launch

March 1979

Voyager 1's closest approach to Jupiter; studies Io (EYE-oh), one of Jupiter's moons; discovers active volcanoes

778 million km (5.2 AU) from the Sun

Jupiter's moon Io

July 1979

Voyager 2's closest approach to Jupiter; studies Europa, another one of Jupiter's moons; discovers evidence of water beneath its icy surface

778 million km (5.2 AU) from the Sun

Huge storms in Jupiter's atmosphere

November 1980

Voyager 1 flies by Saturn; records images of the planet and its moons

1.4 billion km (9.5 AU) from the Sun

Saturn and moons

August 1981

Voyager 2 flies by Saturn; studies its atmosphere, rings, temperature, and how it rotates

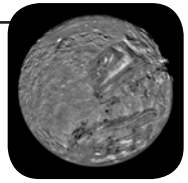
1.4 billion km (9.5 AU) from the Sun

Close-up of Saturn's rings (color added to show separate rings)

January 1986

Voyager 2 becomes the first and only spacecraft to visit Uranus; comes within 81,500 km of the planet; records thousands of images of planet's atmosphere, rings, and moons

2.9 billion km (19.1 AU) from the Sun



Uranus's moon Miranda

August 1989

Voyager 2 becomes the first and only spacecraft to visit Neptune; flies within 5,000 km of the gaseous surface of the planet; discovers several moons orbiting the planet

4.5 billion km (30.1 AU) from the Sun

Neptune

August 2012

Voyager 1 enters interstellar space

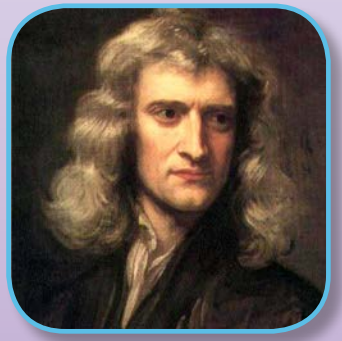
18.7 billion km (125 AU) from the Sun

Voyager 1 leaves the solar system

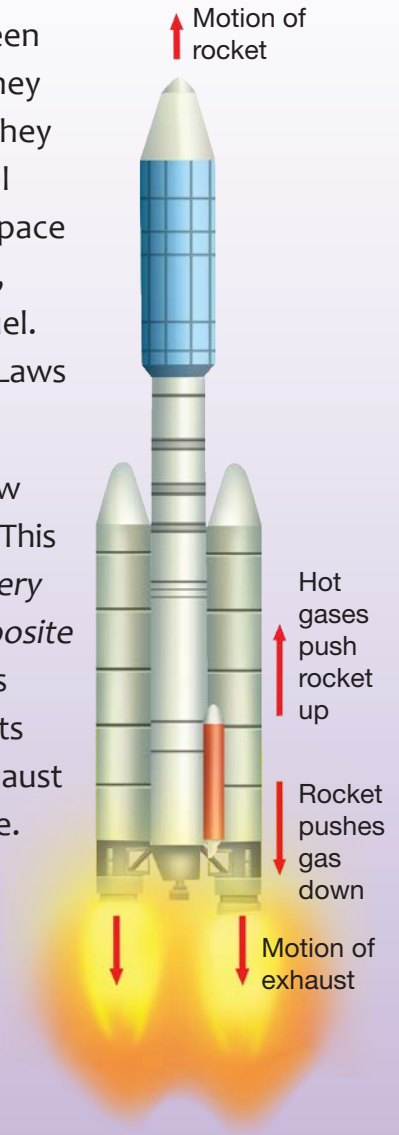
The Laws of Motion in Space

The Voyager spacecraft have been traveling through space since they were launched in 1977. Unless they collide with something, they will continue to move deeper into space for thousands of years. And yet, they left Earth with very little fuel. How is this possible? Newton's Laws of Motion can explain it.

Newton's Third Law explains how Voyager 1 and 2 were launched. This rule of science states that *for every action, there is an equal and opposite reaction*. In this case, the rockets burned rocket fuel. As the rockets pushed the exhaust out, the exhaust pushed the rockets up into space.



Isaac Newton

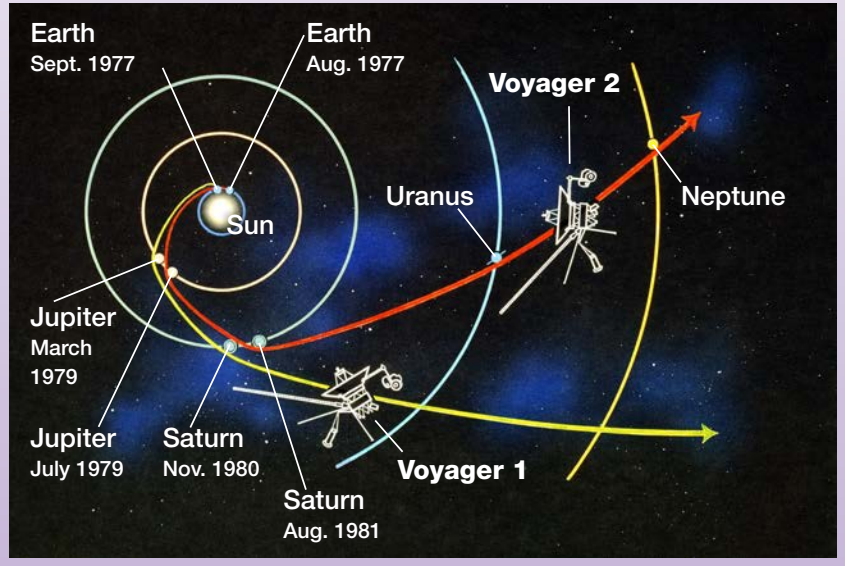


Titan IIIE Centaur rocket, used to launch the Voyagers

source: nasa.gov

Once in space, the two spacecraft need almost no fuel to keep going. This is because of Newton's First Law. It states that *an object in motion stays in motion.* Unless some force causes the Voyagers to slow down, they will keep going at the same speed and in the same direction—forever!

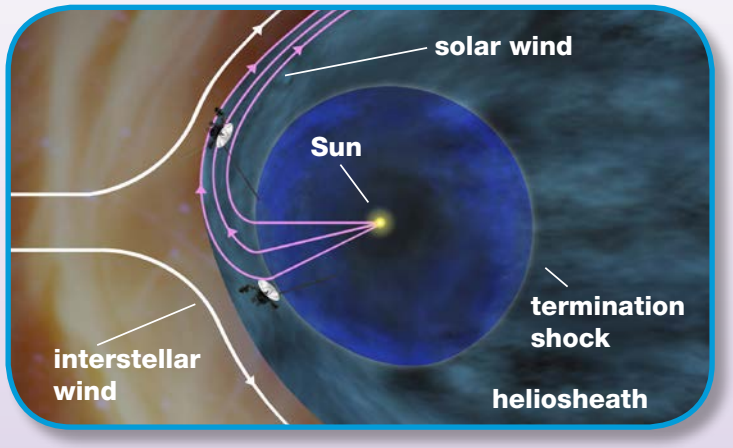
When one of the spacecraft needs to change speed or direction, Newton's Second Law is applied. This law states that applying a force to an object causes it to *accelerate*, or change speed or direction. Each Voyager spacecraft has sixteen thrusters. When the spacecraft needs to speed up, slow down, or turn, one or more thrusters give it a push. The spacecraft can also use gravity from nearby planets to get a push or pull.



The Voyager spacecraft did not move in a straight line. The spacecraft used the force of gravity from the planets to accelerate.

Leaving the Solar System

The Voyagers' new mission is to find out what space is like beyond the solar system. Scientists hope that they will continue to send data from outside the solar system as long as possible.

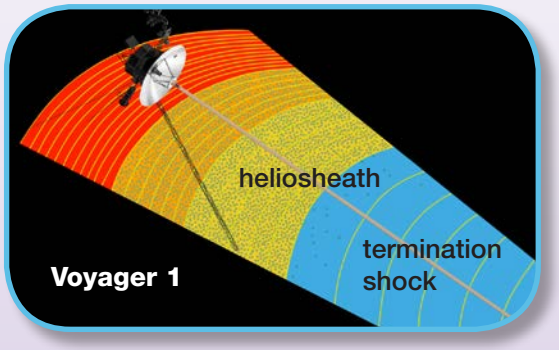


source: NASA/JPL-Caltech

How do we know when we have reached the edge of the solar system? The Sun gives off both light and *charged particles.* These are atoms that have an electrical charge. They are a part of something called the *solar wind.* The Sun also has a *magnetic field,* so it acts like a giant magnet.

Beyond the solar system, the *interstellar wind* blows. This wind is made of charged particles from stars other than our Sun. The edge of the solar system is the place where the interstellar wind keeps the solar wind from moving out any farther.

The solar system does not end suddenly. In 2004, Voyager 1 reached the *termination shock*. Voyager 2 got there in 2007. This is the place where the solar wind starts to slow down. Before the termination shock, particles in the solar wind move at more than 100,000 kilometers per hour. Then the craft travels through the *heliosheath*, where solar wind particles bump into particles moving *toward* the Sun. The solar wind gradually slows until particles are no longer moving away from the Sun. That is the outer edge of the solar system.



source: NASA/JPL-Caltech

In August 2012, Voyager 1 left the solar system! It was about 18 billion kilometers (11 billion mi.) from the Sun. This spacecraft was no longer among solar particles. It was instead surrounded by the denser, colder particles between stars. Voyager 2 lags about one year behind Voyager 1.

Scientists hope to keep getting data from both spacecraft until their electrical power runs out in 2025. After that, the ships will keep moving due to Newton's First Law, but they won't send data. The Voyagers have gone where no other spacecraft has gone before.

Read-Think-Write

Write your answers on separate paper. Use details from the text as evidence.

1. What were the Voyager spacecraft *originally* designed to do?
2. *Interstellar space* is all the open space between star systems. What do you think "inter" means? What do you think "stellar" means?
3. Why did it take more time for Voyager 2 to travel from Saturn to Neptune than it took to travel from Earth to Saturn?
4. Newton's Third Law states that—
   - Ⓐ there is no gravity in outer space.
   - Ⓑ spacecraft can travel through space forever.
   - Ⓒ if you push on something, it pushes back on you.
5. How did scientists know that Voyager 1 had left the solar system?

FOCUS Question

What can the Voyager spacecraft tell us about the outer solar system and beyond? Based on the text and the images, write three questions that you think scientists could try to answer using Voyager data.