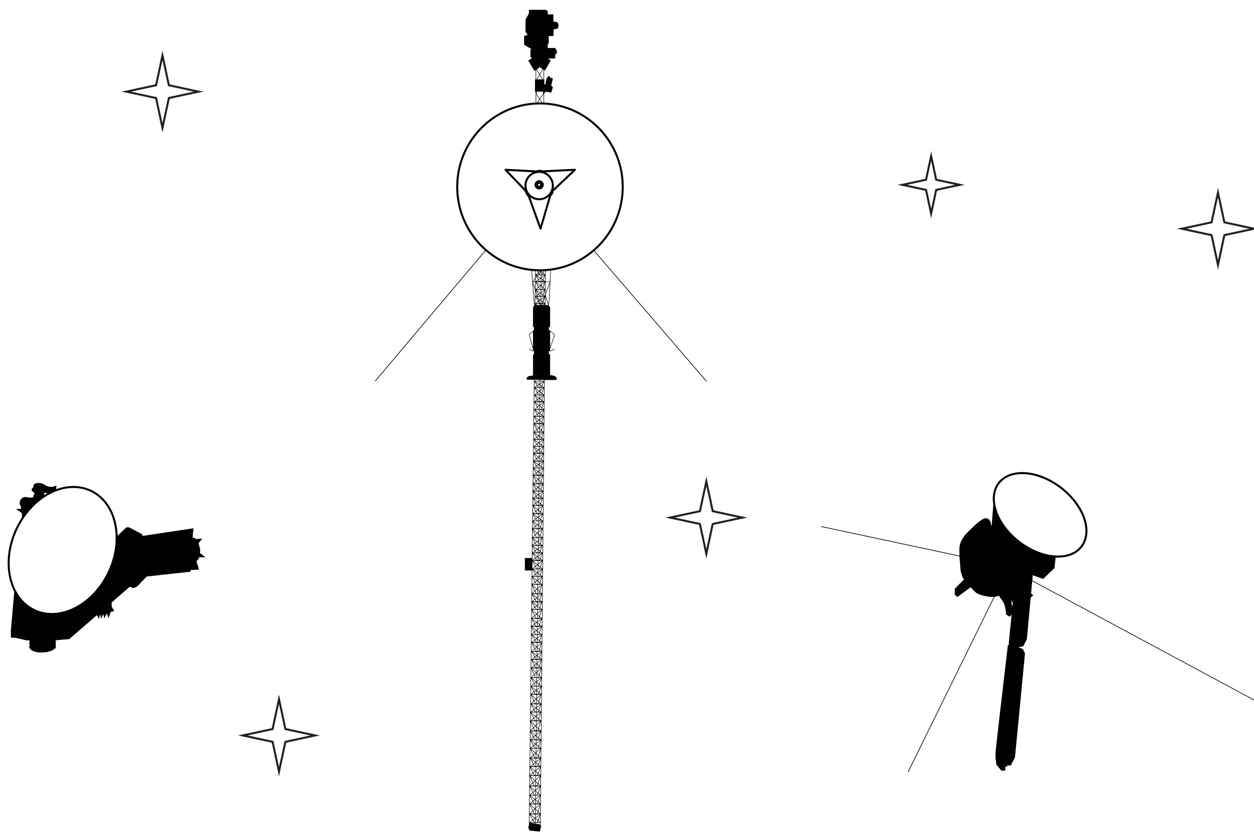
TOUCH THE STARS



Educator's Guide

Contents

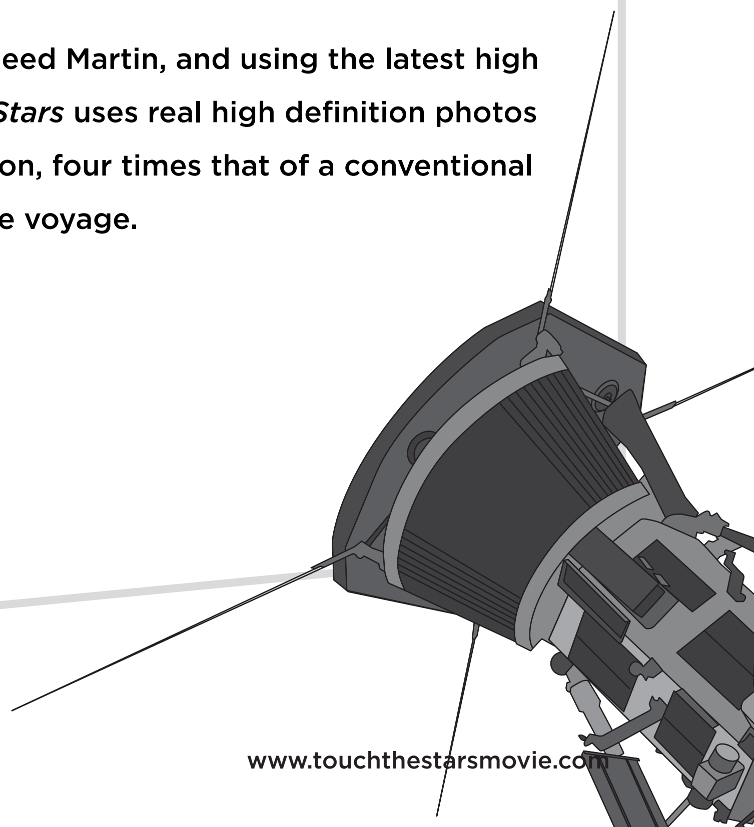
Film Synopsis

Only in the past 50 years have we visited our neighboring planets with robotic probes, orbiters, and landers, discovering them anew and unmasking their secrets.

Touch the Stars tells the dramatic history of these robotic explorers and their amazing discoveries. You'll visit the violent cyclones of Jupiter's North Pole, the 1000-km-wide ice sheet called the Heart of Pluto, the six-mile-high cliffs of Neptune's moon Miranda, the 250-mile-high lava blasts of Jupiter's moon Io, and many other exciting destinations. Along the way, you'll learn how these heroic spacecraft have changed the way we perceive our solar system.

In *Touch the Stars*, you'll join the Mariner, Viking, Voyager and other remarkable spacecraft on a majestic grand tour of the solar system, before heading into the future, as you'll learn how these robotic explorers set the groundwork for humanity's return to the Moon and on to Mars.

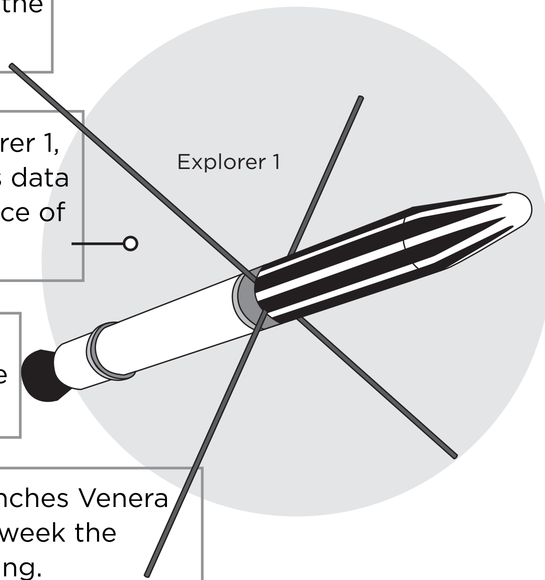
Created with the cooperation of NASA and Lockheed Martin, and using the latest high definition imagery and scientific data, *Touch the Stars* uses real high definition photos and 3 dimensional vistas processed at 8K resolution, four times that of a conventional movie theater, to take viewers on an unforgettable voyage.



Exploring our Solar System—A Timeline of Highlights

October 4, 1957: The Soviet Union launches Sputnik 1, the first artificial satellite of Earth. Sputnik broadcasts the first signal from space.

January 31, 1958: The United States launches Explorer 1, its first satellite. Explorer 1 returns data from orbit, confirming the existence of the Van Allen radiation belts.



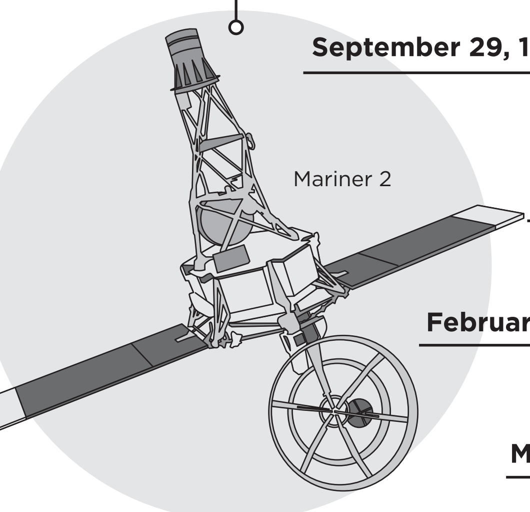
January 2, 1959: The Soviet Union launches Luna 1 and becomes the first artificial object to leave Earth orbit.

February 12, 1961: The Soviet Union launches Venera to Venus, but after a week the probe stops responding.

April 12, 1961: Cosmonaut Yuri Gagarin of the Soviet Union becomes the first man in space while orbiting the Earth a single time.

July 10, 1962: The United States launches Telstar 1, which enables the transatlantic transmission of television signals.

August 27, 1962: Mariner 2 launches and eventually performs the first successful interplanetary flyby when it passes by Venus.



September 29, 1962: NASA Thor-Agenda B rocket launches with Canada's Alouette 1 onboard. This becomes the first satellite from a country other than the United States or Soviet Union.

July 14, 1965: Mariner 4 executes the first successful Mars flyby.

February 3, 1966: Unmanned Soviet spacecraft Luna 9 makes the first soft landing on the Moon.

March 1, 1966: Venera 3 becomes the first spacecraft to land on Venus. Unfortunately, before it could return any data its communications system failed.

June 2, 1966: Surveyor 1, a lunar lander, performs the first successful U.S. soft landing on the moon.

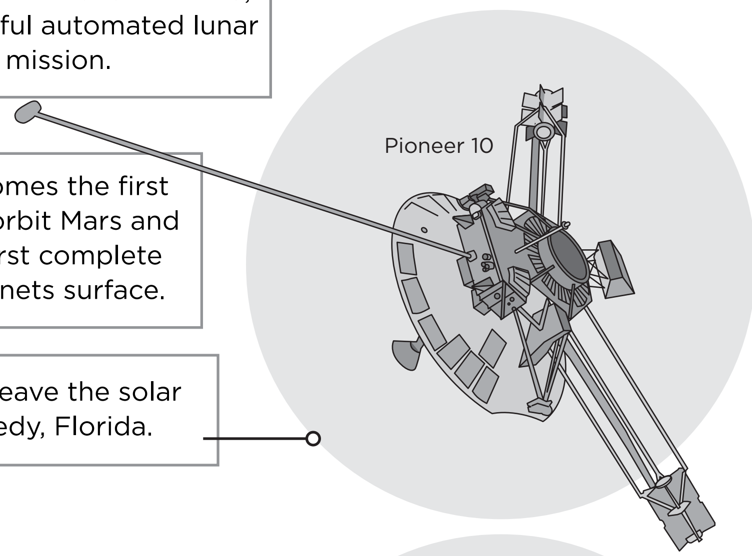
July 20, 1969: Neil Armstrong of Apollo 11 becomes the first man to walk on the the moon.

September 12, 1970: The Soviet Union launches Luna 16, the first successful automated lunar sample retrieval mission.

April 19, 1971: First space station launched unmanned into low Earth orbit.

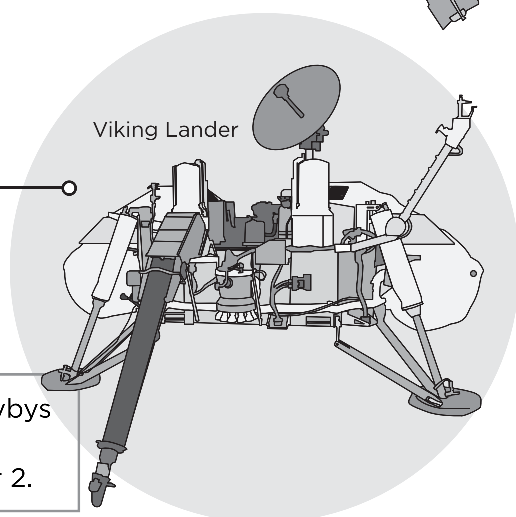
November 13, 1971: Mariner 9 becomes the first spacecraft to orbit Mars and provides the first complete map of the planets surface.

March 3, 1972: Pioneer 10, the first spacecraft to leave the solar system, launches from Cape Kennedy, Florida.



March 29, 1974: Mariner 10 becomes the first spacecraft to fly by Mercury.

July 20, 1976: Viking 1 becomes the first lander to successfully land on Mars.



August 20, 1976: Voyager 2 is launched on a course toward Uranus and Neptune.

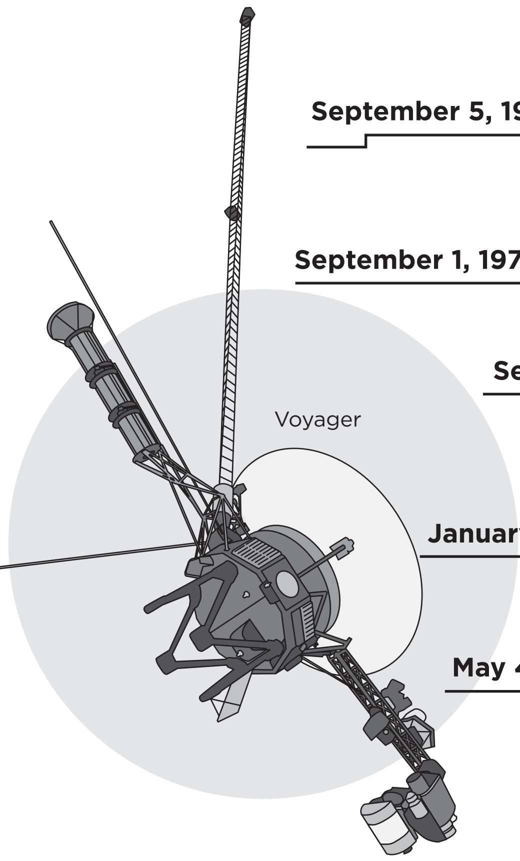
September 5, 1977: Voyager 1 is launched to perform flybys of Jupiter and Saturn. Only 16 days after the launch of its twin, Voyager 2.

September 1, 1979: Pioneer 11 becomes the first spacecraft to fly past Saturn.

September 11, 1985: The International Cometary Explorer, launched by NASA in 1978, performs the first comet flyby.

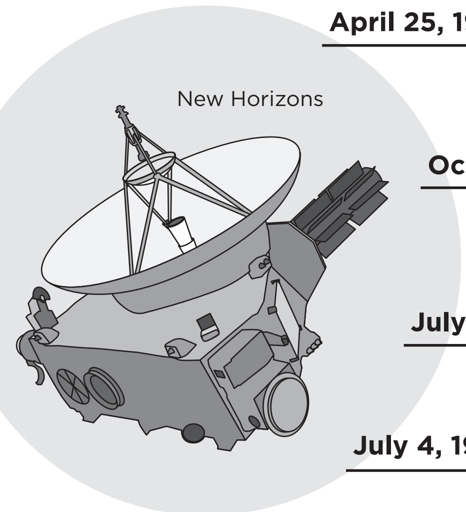
January 24, 1986: Voyager 2 makes its closest approach to Uranus, the only spacecraft to have visited the seventh planet.

May 4, 1989: The Space Shuttle Atlantis launches the Magellan space probe to use radar to map the surface of Venus.

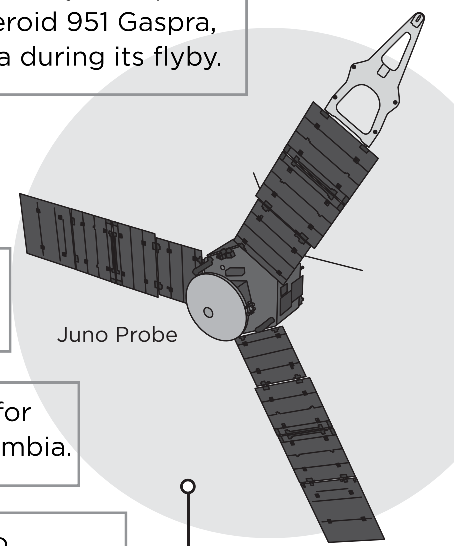


August 25, 1989: Voyager 2 makes its closest approach to Neptune, the only spacecraft to visit the eighth planet.

April 25, 1990: The Hubble Space Telescope is placed in orbit by Space Shuttle Discovery.



October 29, 1991: The U.S. Galileo spacecraft, on its way to Jupiter, successfully encounters the asteroid 951 Gaspra, obtaining images and other data during its flyby.



July 13, 1995: Galileo releases its space probe, which is bound for Jupiter and its moons.

July 4, 1997: Mars Pathfinder lands on Mars with Sojourner, the first successful planetary rover.

July 23, 1999: The Chandra X-ray observatory, NASA's flagship mission for X-ray astronomy, launches aboard the Space Shuttle Columbia.

September 27, 2007: Dawn, the first ion-powered probe to visit two celestial bodies in one go, launches on an eight-year mission to the asteroid Vesta and dwarf planet Ceres, the two largest space rocks in the solar system.

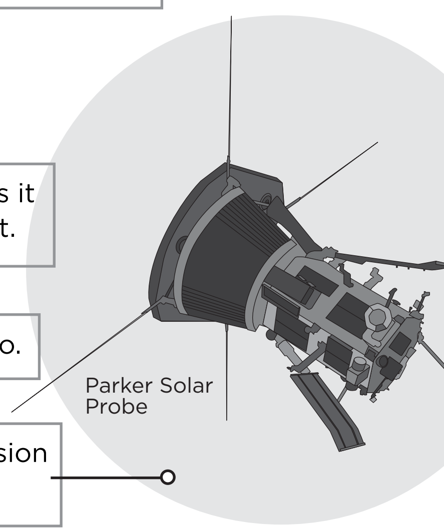
August 5, 2011: Spacecraft Juno is launched from Cape Canaveral on mission to Jupiter. Juno is the first outer planet probe powered by solar arrays.

August 25, 2012: Voyager 1, which launched on September 5, 1977, officially enters interstellar space, the first spacecraft to do so. At the time it was approximately 11.2 billion miles from the sun.

November 12, 2014: The European Space Agency’s robotic lander Philae makes the first soft landing on a comet.

March 6, 2015: The space probe Dawn is the first to visit a dwarf planet as it enters orbit of Ceres, the largest object in the asteroid belt.

July 14, 2015: New Horizons makes its closest approach to Pluto.



August 12, 2018: Parker Solar Probe launches, on its way to the sun. Its mission will take it closer to the sun than any other vessel to date.

Ultraviolet light

The Sun provides heat and energy to Earth everyday but that is not all it provides. It also sends a spectrum of visible and non-visible light that includes ultraviolet light rays. UV rays are invisible to our eyes but we can feel them on our skin. The ultraviolet region of the spectrum was first discovered by physicist Johann Wilhelm Ritter in 1801.

Sun Ultraviolet effects:

- Sunburn. Exposure to too many UV rays can cause skin cell damage causing pain and discoloration in the affected areas.
- Fades colors. Extended exposure to UV rays can cause colored items to become lighter in color. The UV rays break down the chemical dye and cause the color to become lighter. Fabrics, plastic lawn chairs and playground equipment are some items affected by this daily.

Controlled Ultraviolet uses:

- Forensics. Controlled UV light in the form of a black light can help find biologically contaminated evidence. Fluorescent molecules are found within many body fluids.
- Painting examination. Long wave UV lamps can be used to inspect a painting. With the use of UV light art restorers can determine what type of material was used, the approximate date the piece was created and show any places where alterations or fixes have been made.
- Disinfection. Short UV wavelengths are used to irradicate bacteria and viruses from water, food or air.

Where do ultraviolet rays come from?

Our Sun has multiple layers of atmosphere. The lowest level, called the photosphere, is about 300 miles thick. This layer emits solar flares: tongues of fire reaching heights of hundreds of thousands of miles above the sun's surface producing bursts of x-rays, ultraviolet radiation, electromagnetic radiation and radio waves. This layer emits the most light and the most visible light in the visible spectrum.

Ultraviolet rays come from the second layer called the chromosphere. The chromosphere passes the heat from the lowest level up to the outer corona level. As super-heated hydrogen burns within the chromosphere, it emits a reddish glow that is most visible during a solar eclipse. This layer reaches a temperature of 10,000 °F to 36,000 °F.

The corona layer is the final and the outermost layer burning at an average of 2.5 million °F. Scientists still don't know how the outer layer of atmosphere burns hotter than the lower layers of atmosphere. It's possible that the Parker Probe mission will provide additional information to answer this question and tell us even more about solar flares.

Activity:
Observing the effects of UV rays

Avoiding harmful rays and radiation from the sun is important to probes, explorers and anything that leaves Earth's atmosphere. But the atmosphere doesn't block all harmful rays. As humans we use chemicals and shade to help prevent long term damage from the sun.

In this activity, students will see how sunscreen can help protect them from harmful UV rays while also observing the damaging effects of UV light.

Materials needed:
- Construction paper (red and green work best)
- Sunscreen (SPF 30 or more and doesn't contain metal oxides)
- Rocks or other small, heavy objects
- A sunny spot outside or inside

1) Provide one page of construction paper to each student.

2) Provide all participants with about a pea sized amount of sunscreen.

3) Rub hands together to cover only the palms and fingers of your hands. Try not to rub the lotion in completely. There should be a light, barely visible, layer of sunscreen left.

4) Place sunscreen covered palms down on the construction paper. Press down firmly allowing the palm and all fingers to touch the paper completely. Remove hands and clean off excess lotion from hands.

5) Place construction paper outside in the sunny area with the sunscreen facing up. May also be able to place them near a sunny window in a classroom.

6) Place rocks on the corners to keep the paper in place. This will prevent the paper from blowing away in the wind.

7) Leave outdoors for 3 to 4 hours in the Sun.

8) Once the time has elapsed observe the change in the paper. The sunscreen will have protected the paper from UV rays keeping the bold color in the hand prints. Unprotected areas will be faded from the extended exposure to UV rays.

Spacecraft Exploration

SUN

Pioneer 6, 7, 8, & 9:
Launched 1965-1968

Helios-A & Helios-B:
Launched December 10, 1974 & January 15, 1976

Ulysses:
Launched October 6, 1990

Solar and Heliospheric Observatory (SOHO):
Launched December 2, 1995

Transition Region and Coronal Explorer (TRACE):
Launched April 2, 1998

Genesis:
Launched August 8, 2001

Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI):
Launched February 5, 2002

Hinode:
Launched September 22, 2006

STEREO (Solar Terrestrial Relations Observatory):
Launched October 26, 2006

Solar Dynamics Observatory (SDO):
Launched February 11, 2010

Interface Region Imaging Spectrograph (IRIS):
Launched June 28, 2013

Parker Solar Probe:
Launched August 12, 2018

MERCURY

Mariner 10:
Launched November 3, 1973

MESSENGER:
Launched August 3, 2004

VENUS

Mariner 2:
Launched August 27, 1962

Mariner 5:
Launched June 14, 1967

Mariner 10:
Launched November 3, 1973

Pioneer Venus Orbiter:
Launched May 20, 1978

Pioneer Venus Multiprobe:
Launched August 8, 1978

Magellan:
Launched May 4, 1989

Galileo:
Launched October 18, 1989

MESSENGER:
Launched October 15, 1997

MARS

Mariner 4,6,7 and 9:
Launched 1964-1971

Viking 1 & 2:
Launched August 20, 1975
& September 9, 1975

Mars Pathfinder:
Launched September 27, 1997

Mars Global Surveyor:
Launched November 7, 1996

2001 Mars Odyssey:
Launched October 24, 2001

Mars Exploration Rover (MER) Spirit & Opportunity:
Launched 2003

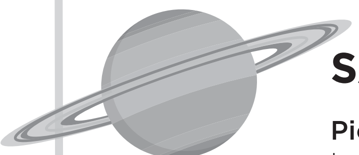
Mars Reconnaissance Orbiter:
Launched August 12, 2005

Mars Phoenix
Launched August 4, 2007

Mars Science Laboratory, Curiosity:
Launched November 26, 2011

Mars Atmospheric and Volatile Evolution:
Launched November 18, 2013

InSight
Launched May 5, 2018



SATURN

Pioneer 11:
Launched April 6, 1973

Voyager 1 & 2:
Launched August 20, 1977
& September 5, 1977

Cassini:
Launched August 3, 2004

JUPITER

Pioneer 10 & 11:
Launched March 2, 1972
& April 6, 1973

Voyager 1 & 2:
Launched August 20, 1977
& September 5, 1977

Galileo:
Launched October 18, 1989

Ulysses:
Launched October 6, 1990

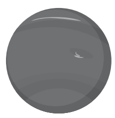
Cassini:
Launched August 3, 2004

Juno:
Launched August 5, 2011

New Horizons:
Launched January 19, 2006

URANUS

Voyager 2:
Launched September 5, 1977



NEPTUNE

Voyager 2:
Launched September 5, 1977

PLUTO

New Horizons:
Launched January 19, 2006

Activity:
Ions in Action

As technology advances we find new and innovative ways to do tasks. In particular we have developed an ion propulsion system for our space crafts to use in place of other engines. Ion engines reduce system cost, reduce system complexity, and enhance performance.

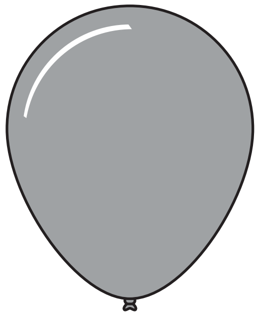
This activity demonstrates just how ions work and how it corresponds to how an ion engine works.

Materials needed:
- Balloon
- Paper
- Hole punch

What to do

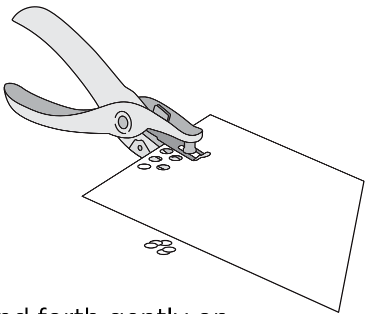
Preparation

1) Blow up the balloon large enough to hold in your hand but not to the point of possible popping.



2) Tie off balloon with a knot.

3) Use hole punch to create small paper circles from the sheet of paper.



Experiment

4) Rub the balloon back and forth gently on you hair about 10 times. For best results hair should be clean, dry and oil-free.
As you rub the balloon on your hair the balloon will pick up electrons. These electrons have a negative charge (-).

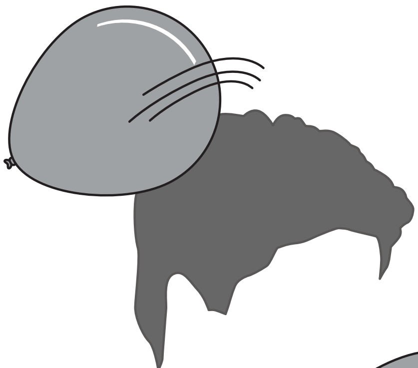
5) Hold the balloon close to, but not touching the small paper circles. Observe what happens.

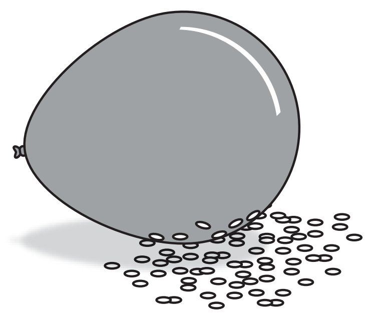
The paper has few electrons missing making their charge positive (+). As you hold the balloon close the paper will move toward the balloon and stick to it. This is the attraction between the negative (-) charged electrons and the positive (+) charged electrons pulling the two together.

Deep Space 1 Ion Engine

This ion engine contains a gas called xenon. The xenon is given a positive (+) charge. Inside the engine there is also a perforated sheet of metal that has been given a negative (-) charge. The metal will attract the xenon ions just like the balloon attracts the paper.

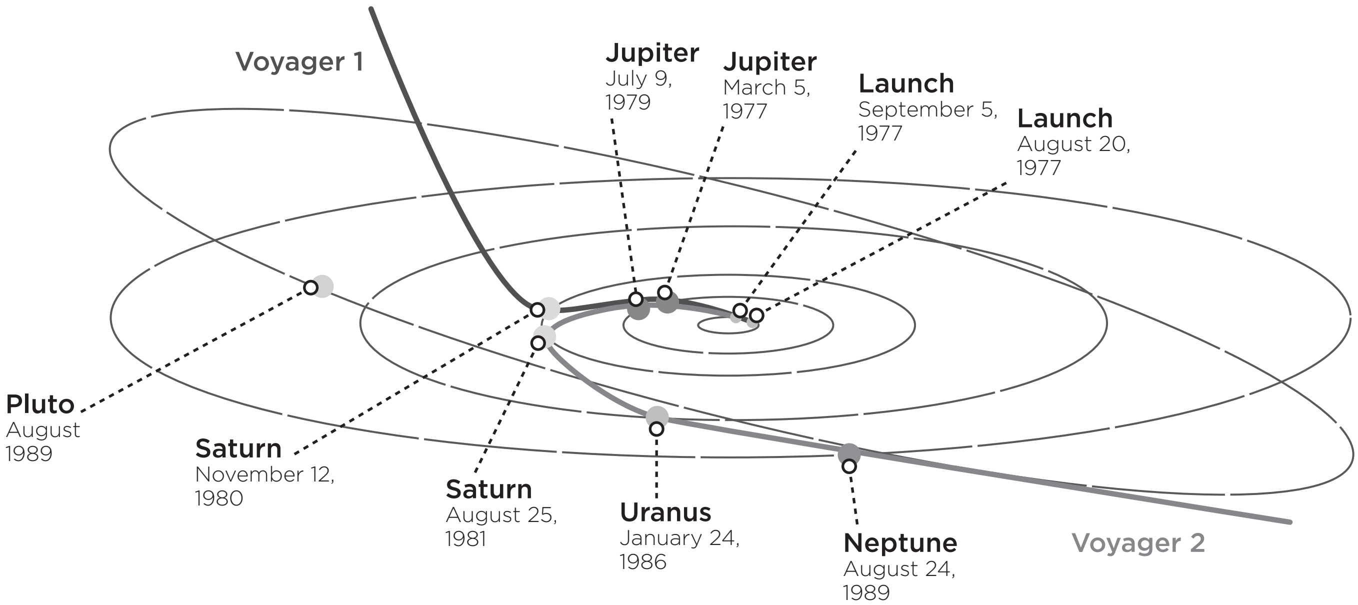
The charged metal will attract the ions in xenon making them move very fast. As they are attracted they will pass through the perforated metal very fast and shoot out the other side. As they shoot out they push back against the spacecraft moving it forward.



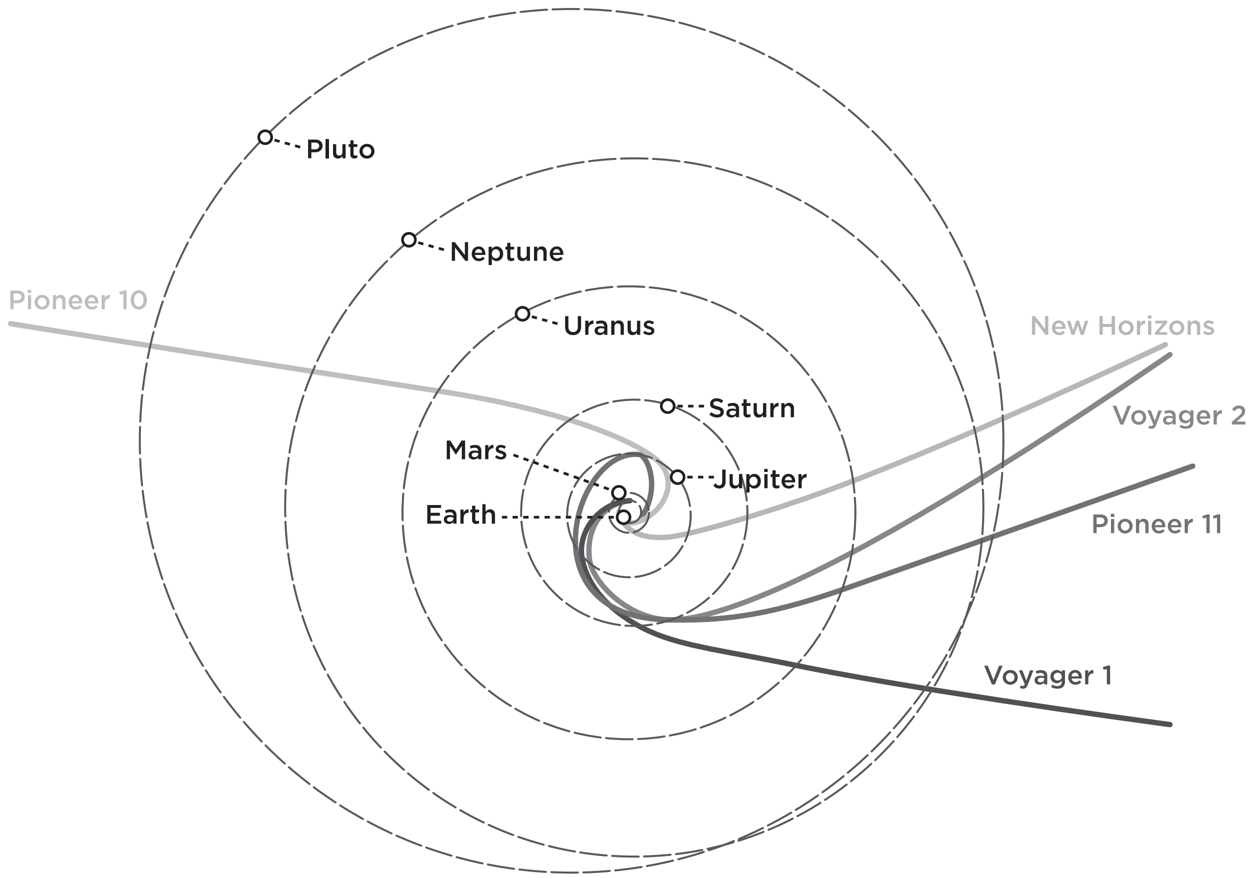


Spacecraft Flight Paths

Voyager 1 & 2 Flight Paths and Timeline



Voyager 1 & 2 Flight Paths and Timeline



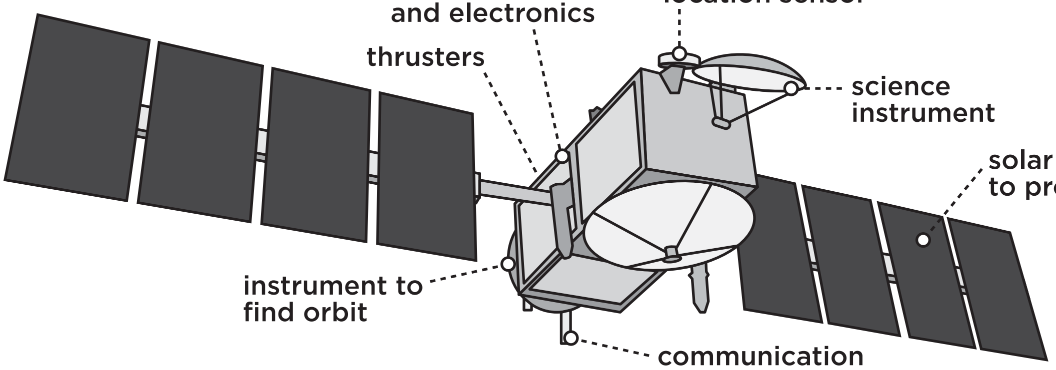
Activity:
Design and Build your own Spacecraft

All probes and satellites need to have the ability to communicate with Earth and make power for themselves. None of them share the same purpose so they all have different instruments. Some instruments are to monitor weather, map terrain, track, measure and more.

Materials needed:
Assorted elements for building. See box below for examples and ideas.

For younger students:
Let their creativity run wild! Set them up with juice boxes as the main base to their spacecraft. Allow them to decorate the box and add instruments with provided craft supplies.

For advanced students:
1) Assign a real satellite, probe or have them make up their own. Ask your students: What does your spacecraft do and what does it need to complete that task? Encourage them to research what instruments are needed.
2) Have them create a base for their spacecraft. Require the addition of a communication device and a power providing attachment.
3) When they have a basic satellite created have them add only instruments that pertain to their satellite's main purpose.
4) Once completed have the students present their satellites and talk about its instruments and their uses.



Material Ideas

- string, thread or yarn
- scissors, tape, glue
- cardboard box or tube, snack or juice box, shoe box
- egg cartons, styrofoam, paper cups, clay
- paper or plastic bowls and plates
- cotton swabs, screws, bolts, paper clips
- colored paper, plastic film, wax paper, foil, pieces of cardboard
- wooden craft sticks, chopsticks, stir sticks, wooden skewers

Activity:
Packing for a long trip to Mars

Pack your bags! You are going on a 2 and 1/2 year trip to Mars. This trip will start with a six month space trip as you make your way to the planet. Then a 19 month stay on Mars while you wait for Earth and Mars to be at their closest point again to optimize travel time and fuel. Lastly another six month trip back home.

In this activity you will pack what you would like to bring on this trip. Students will learn to work together to fill this imaginary box. They will need to brainstorm items, figure out the volume of each item and figure out if they will fit in the 1 m^3 space they are given.

Materials needed:

- Metric ruler or taper measure for each participant
- Graph paper
- Writing and coloring utensils

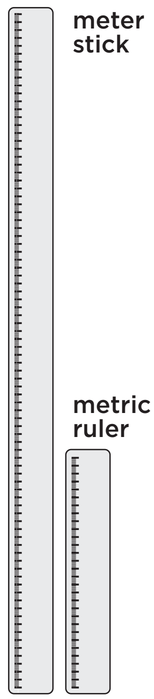
Separate into crews of 3 to 5 people.

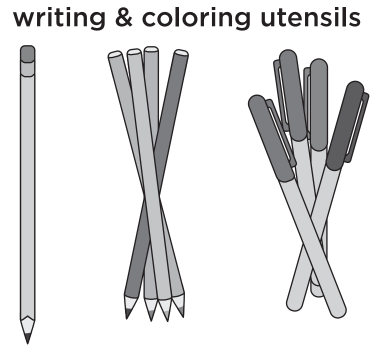
You and your fellow crew members will already have the basic needs of air, food, water, and warmth. The crew is allowed to bring along items of importance and entertainment but all of the crew's items combined must fit within a box that is 1 meter wide by 1 meter high by 1 meter deep.

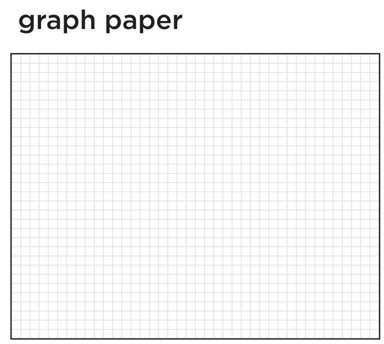
Start by thinking of all the items that would help you pass the time and make you happy.

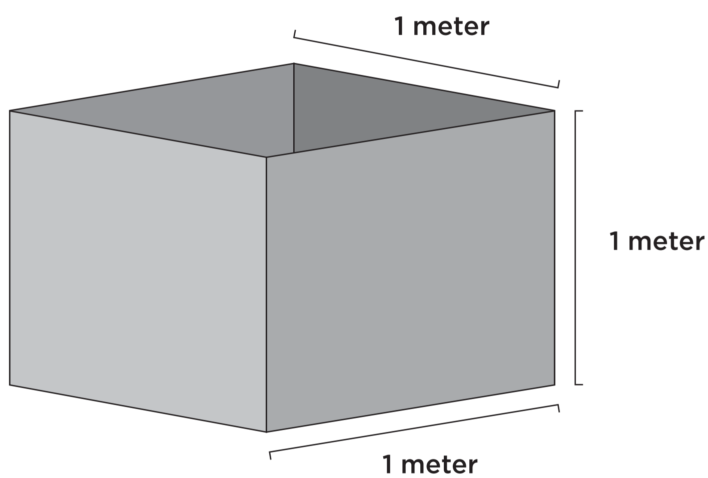
Keep in mind:

- No internet in space.
- Cell phones get no service in space.
- Cable and satellite TV are not available in space.
- For electronics that require batteries you must take along enough batteries to last 2.5 years.
- There are no electronic repair shops or computer experts in space.
- Consider items that disassemble or shrink to help save valuable space.
- During travel you will be in zero gravity. On Mars you will have 1/3 the amount of gravity Earth has.
- The weight of your items does not matter. We will assume that the Mars-bound spacecraft is assembled and launched in space.
- Consider items the crew can share or use together to optimize the amount of use per item.

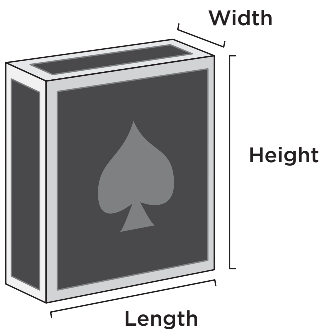




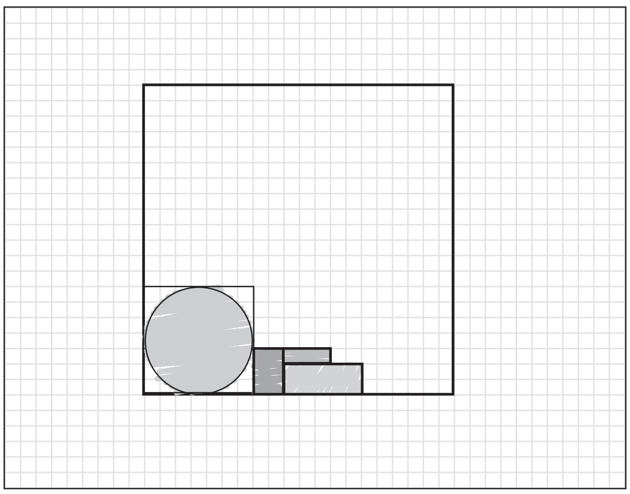




Activity Continued:
Packing for a long trip to Mars



Length x Width x Height = Volume



▼ **Conversion Factors**

Inches to millimeters	inches	x 25.4	= mm
Inches to centimeters	inches	x 2.54	= cm
Feet to centimeters	feet	x 30.48	= cm
Feet to meters	feet	x 0.3048	= m
Yards to meters	yard(s)	x 0.9144	= m
Miles to kilometers	mile(s)	x 1.6	= km

Once the list of items is created divide the items so everyone in the crew is responsible for finding the volume of some of the items.

How to find volume:

Measure the height, width, and depth of an item in centimeters or millimeters. Once acquired multiply them all together to get its volume. If the object is an unusual shape consider how large of a box it would take to hold it and only measure the areas where its dimensions are its largest.

If an object is not present for measuring try using the internet to find a site the item is for sale on. The dimensions will most likely be in inches so you will need to convert the measurements to centimeters or millimeters before calculating the volume.

After all the items have their volume calculated we will need to pack the box. Using graph paper and colored pencils map out the box. Starting with deciding a unit of measurement for the graph paper. For example 1 graph paper square could equal 5 centimeters.

As a group draw in the items you will be taking with you. Use multiple colors to help distinguish one object from another.

Once that side is completed use another piece of graph paper to draw the box from another side. Continue this until you have all 6 sides of the box drawn out.

Once completed have everyone present their packed boxes and explain:

- What was the process your team used to decide what to put into the box?
- What compromises were necessary in choosing the items?
- Why were the items picked?
- What items had to be left out?
- Do all the items represent the agreement of the team, or were some individuals given their chosen item?

Next Generation Science Standards

The historical and hypothetical space exploration portrayed in *Touch the stars,* along with the related science activities suggested in the *Touch the Stars Educator's Guide,* can be used to stimulate classroom discussion and projects that support Next Generation Science Standards. Examples of grade-appropriate class work, organized by Disciplinary Core Ideas relevant to subjects covered in *Touch the Stars,* are provided below.

Kindergarten—Motion and Stability: Forces and Interactions

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

Kindergarten through Second Grade—Engineering Design

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Third Grade—Motion and Stability: Forces and Interactions

3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.

Fifth Grade—Motion and Stability: Forces and Interactions

5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed downward.

Middle School—Earth's Place in the Universe

MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system.

High School—Motion and Stability: Forces and Interactions

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Recommended Reading

Ages 6 through 8

Astronauts
Hannah Wilson

Solar System for Kids for Fun and School: Stage 1
Jamie Maslen

Stars and Planets Handbook
Anne Rooney

Ages 9 through 11

Apollo 13
Kathleen Weidner Zoehfeld

Eye on the Universe: The Incredible Hubble Space Telescope
Michael D. Cole

Welcome to Mars: Making a Home on the Red Planet
Buzz Aldrin and Marianne Dyson

Ages 12 through 14

Curiosity's Mission on Mars: Exploring the Red Planet
Kathleen Weidner Zoehfeld

Flying to the Moon: An Astronaut's Story
Michael Collins

What's so Mysterious about Meteorites?
O. Richard Norton and Dorothy Sigler

Ages 15 and Up

Interstellar Age: Inside the Forty-Year Voyager Mission
Jim Bell

New Space Frontiers: Venturing into Earth Orbit and Beyond
Piers Bizony

You Are Here: Around the World in 92 Minutes: Photographs from the International Space Station
Chris Hadfield

Recommended Websites

Astronomy Picture of the Day
http://apod.nasa.gov/apod/astropix.html

Bradford Robotic Telescope
http://www.telescope.org/

Hubblesite (Hubble Space Telescope)
http://hubblesite.org/

International Space Station
https://www.nasa.gov/mission_pages/station/main/I

Kennedy Space Center Visitor Complex
https://www.kennedyspacecenter.com/

Mars Science Laboratory: Curiosity Rover
http://mars.nasa.gov/msl/

The Planetary Society
http://planetary.org/

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