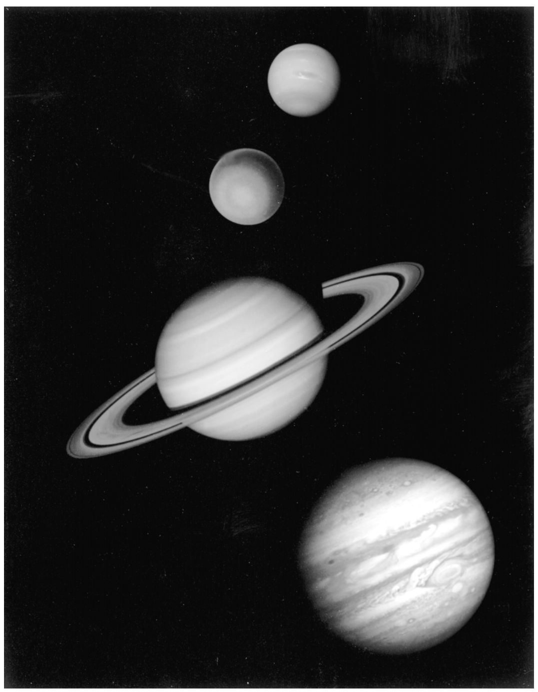
VOYAGER MISSION PROFILE

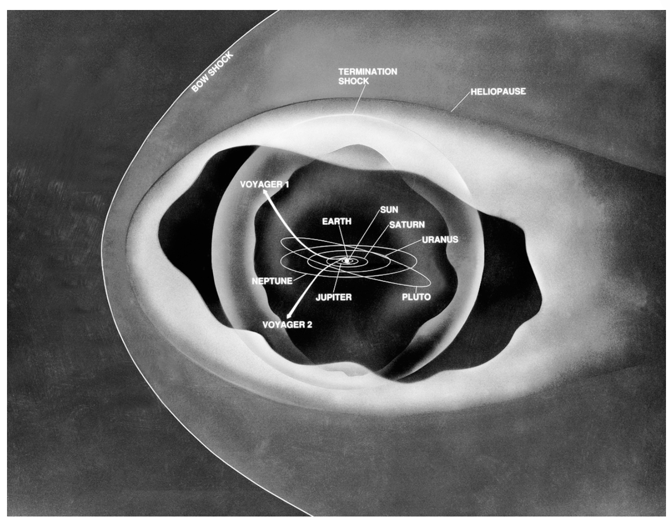
EW-2002-02-012-JPL

The twin Voyager spacecraft were launched in August and September 1977 on a mission to explore Jupiter and Saturn. After having completed those objectives, Voyager 1 continued on a path toward interstellar space while Voyager 2 continued on to be the first spacecraft to explore Uranus and Neptune. After its August 1989 encounter with Neptune, Voyager 2 headed out of the solar system but in a different direction than Voyager 1. In the course of their flybys of the giant outer planets, the Voyagers discovered volcanoes on Jupiter's moon Io, identified 25 new moons, characterized the atmospheres and chemical and geological compositions of the four planets, and characterized the properties of the interplanetary solar wind. The findings were monumental and drastically changed our understanding of the gaseous planets and the solar wind out to the orbits of Neptune and Pluto.

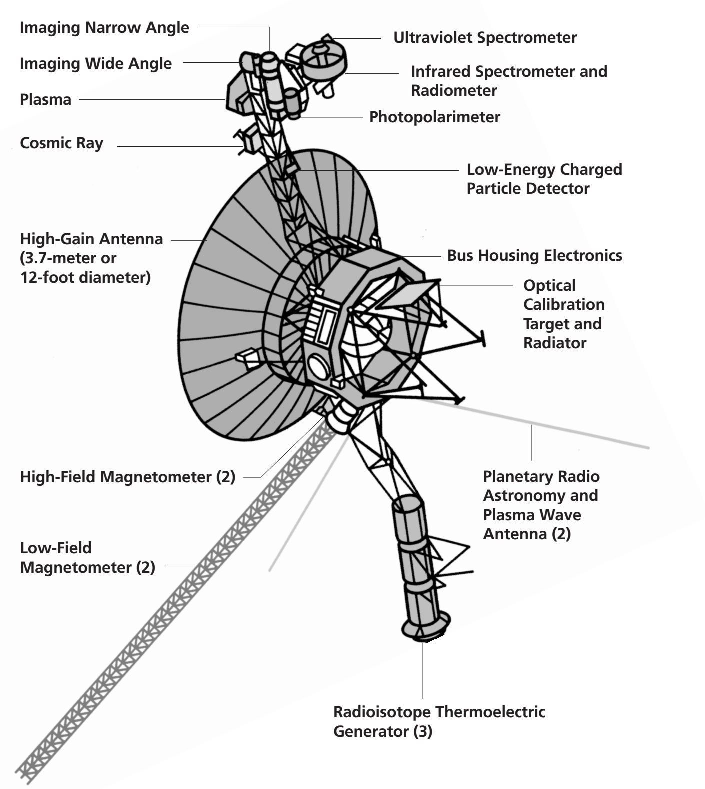


Since 1990, the Voyagers have been involved in an interstellar mission to characterize the far outer heliosphere, the distant solar wind, and the interaction between the two. This phase of the mission will allow us to explore the most distant reaches of our heliosphere and allow us to take the first tentative steps in the transition regions between space dominated by the Sun and interstellar space. On February 17, 1998, Voyager 1 became the most distant human-made object in the universe, passing beyond 10.4 billion kilometers (6.5 billion miles) from the Sun. (The previous record was held by NASA's Pioneer 10 spacecraft.) To put this distance into perspective, imagine that in the time it takes you to count from 1 to 3, you could have traveled 52 kilometers (32 miles) if you had been moving at Voyager 1's current rate of 17.3 kilometers per second (about 39,000 miles per hour), relative to the Sun. And consider this: Voyager 1 has been traveling at close to that speed for more than 24 years.

The Voyager spacecraft are now on a unique exploratory mission. The two spacecraft are exploring regions of space never before encountered, building on the legacy of one of NASA's most successful and productive solar system missions. The Voyager Interstellar Mission (VIM) is critical for meeting several science objectives of NASA's Sun–Earth Connection Enterprise. One of these objectives is to "understand our changing Sun and the effects throughout the solar system." Voyager is the only mission exploring the outer heliosphere and is thus in a prime position to contribute to the understanding on a global scale of the space carved out of the interstellar medium by the Sun. Because of their unique positions, the Voyagers are poised to contribute to another science objective: "Use the exotic space environments within our solar system as natural science laboratories and cross the outer boundary of the solar system to explore the nearby environments of our galaxy."



The Voyager Spacecraft



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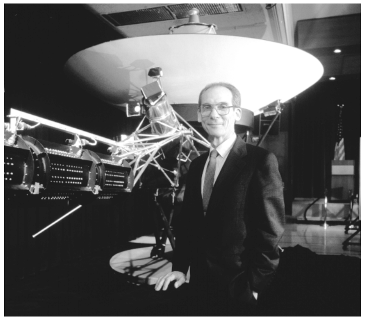


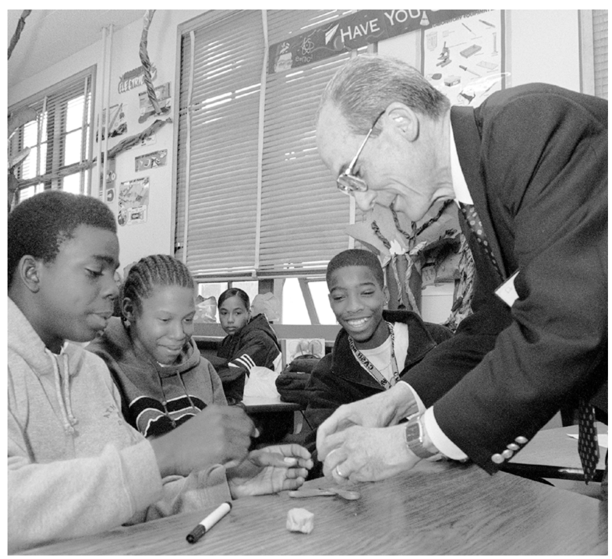
Edward C. Stone

Since 1961, Dr. Edward C. Stone has been a principal investigator on nine NASA spacecraft and a co-investigator on five other NASA missions. He has served as the project scientist for the Voyager mission since 1972, coordinating the studies of Jupiter, Saturn, Uranus, and Neptune, and the continuing search for the edge of interstellar space. When asked what scientific discovery surprised him most about the Voyagers or other JPL missions, Dr. Stone replied, “Finding a moon [Io, one of Jupiter’s moons] that’s 100 times more active volcanically than the entire Earth.”

From 1991 to 2001, Ed Stone was director of the Jet Propulsion Laboratory while continuing his role as Voyager Project Scientist. Dr. Stone has returned to Caltech as a professor, scientist, and researcher still reaping the riches of the Voyager data. Dr. Stone’s schedule is still extremely busy since he retired as director of JPL, yet he manages to carve out time to participate in education and public outreach activities at local schools, encouraging students towards careers in space and science. Dr. Stone received his Master of Science and Ph.D. degrees in physics from the University of Chicago.

Mr. Ed B. Massey is the manager of the Voyager Interstellar Mission and the NASA portion of the joint NASA/European Space Agency (ESA) Ulysses mission to study the Sun. Since joining the Jet Propulsion Laboratory in 1987, he has served as Ulysses Project Controller, Science Instruments Manager, and Operations and Engineering Manager. In 1998, when management of the Voyager and Ulysses projects was combined, Mr. Massey became manager of both projects.

While serving in the U.S. Air Force, Mr. Massey had extensive professional work experience in military space operations and acquisition prior to coming to JPL. He has a B.S. degree in electrical engineering from Tuskegee University and an M.S. degree in systems management from the University of Southern California.



Ed B. Massey

In addition to managing two JPL projects, Ed Massey participates in both project education and public outreach programs. By personally answering e-mails from the public, he knows first hand what they are interested in. Ed volunteers at the annual JPL Open House answering questions, assisting with educational activities, and doing one-on-one interviews with high school students. He was chair of the JPL Director’s Advisory Committee on Minority Affairs for five years.

Ed is married and has two adult daughters. He enjoys playing racquetball and regularly accepts a challenging game from fellow JPLers. In his spare time, he is editor of his high school alumni newsletter and website. Ed is a mentor and friend to many who have had contact with him.

A MESSAGE TO THE UNIVERSE

EW-2002-02-012-JPL

Flying aboard Voyagers 1 and 2 are identical "golden" phonograph records, carrying the story of Earth far into deep space. The 12-inch gold-plated copper discs contain greetings in 54 different languages, samples of music from different cultures and eras, natural and human-made sounds from Earth, and 117 pictures explaining ourselves and the planet Earth. The discs also contain electronic information that an advanced technological civilization could convert into diagrams and photographs. The cover of each gold-plated aluminum jacket, designed to protect the record from micrometeorite bombardment, also serves a double purpose in providing the finder with a "key" to play the record. This explanatory diagram appears on both the outer and inner surfaces of the cover, as the outer diagram will be eroded over time. Some of the scenes and sounds from the Voyager Golden Record can be viewed and heard at the Voyager Project website at **http://www.vraptor.jpl.nasa.gov/**. Voyager 1 flew past Jupiter in March 1979 and Saturn in November 1980 before heading out of our solar system. Voyager 2 surveyed Jupiter in July 1979, Saturn in August 1981, Uranus in January 1986, and Neptune in August 1989. Both spacecraft are moving so fast that they will never return to our solar system.

Standards Addressed by Voyager Activities

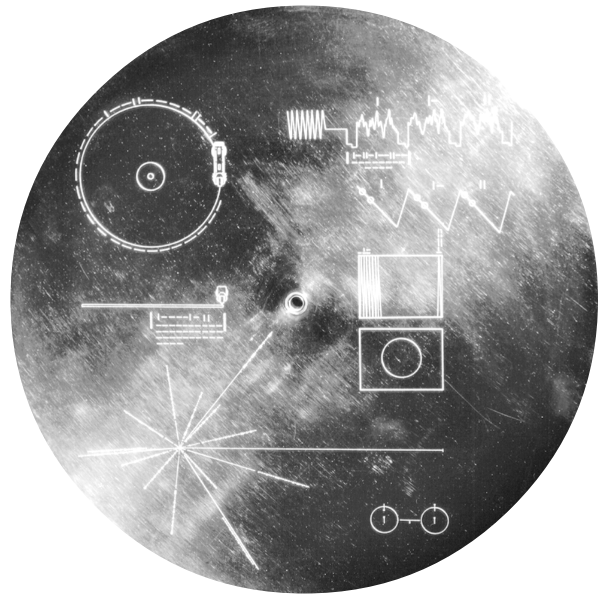
Mathematical Standards

Source: Principles and Standards for School Mathematics, National Council of Teachers of Mathematics, Reston, VA (2000)

Activity — Voyager 1 and 2: Where Are You?

Grades 6–8

Measurement — Understand measurable attributes of objects and the units, systems, and processes of measurement.



Number Operations — Understand meanings of operations and how they relate to one another.

Communication — Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.

Geometry — Specify locations and describe spatial relationships using coordinate geometry and other representational methods.

Activity — Where is Voyager Going?

Grades 6-8

Representation — Use representations to model and interpret physical and mathematical phenomena.

Connections — Recognize and apply mathematics in contexts outside of mathematics.

Geometry — Use visualization, spatial reasoning, and geometric modeling to solve problems.

Number Operations — Compute fluently and make reasonable estimates.

Science Standards

Source: National Science Education Standards, National Research Council, Washington, D.C. (1999)

Activity — Voyager 1 and 2: Where Are You?

Grades 6–8

Earth and Space Science

- The Earth is the third planet from the Sun in a system that includes the moon, Sun, and eight other planets and their moons.
- Most objects in the solar system are in regular and predictable motion.
- Gravity is the force that keeps planets in orbit around the Sun and governs the rest of the motion in the solar system.

Activity — Where Is Voyager Going?

Grades 6–8

Science and Technology

- Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as distance.
- Technology provides tools for investigations, inquiry, and analysis.

Educators —
Please take a moment to evaluate this product at http://ehb2.gsfc.nasa.gov/edcats/educational_wallsheet
Your evaluation and suggestions are vital to continually improving NASA educational materials. Thank you.

EW-2002-02-012-JPL

Learning Objectives: Students will appreciate the great distances between the planets and their comparable sizes, view the solar system in three dimensions in a useful scale, and visualize the paths of the Voyager spacecraft and their present distances and positions.

You Will Need: An open area with 120 meters of space (like a football or soccer field), meter sticks or measuring tape, 5 × 7 index cards, markers, calculators, balls of string (300 meters or 1000 feet), a plastic sandwich baggie per team, cardboard cut to fit in sandwich baggie, Popsicle sticks, glue, and a 360-degree protractor. (You will provide a Sun model).

For the first part, 11 teams of three students each are suggested. Students will choose roles to play for their team. Each team should be assigned one of the planets and each of the Voyager spacecraft.

Part A: The Hypothesis

Out in the Field: This activity will work best if the students are first able to make some predictions. Tell the students: "We are going to make a scale model of the solar system, including the Sun and the two Voyager spacecraft. We are going to locate the Sun in the corner of the field." Take them to the site — point out where the Sun will be (but don't use your scale model yet). Ask each team to discuss where they think their object would be on the field in this scaled system. Then, have a member of each team stand where the group has placed the object they were assigned. If possible, you might have the students leave some sort of marker where they think their object would be. One team member should take a 5 × 7 index card and draw dots to show where each of the objects is thought to be.

Back in the Classroom: If there's time, each group could make a brief presentation on why they think their object is where it is.

Part B: Inside Activity: Making a Scale Model of Objects in the Solar System

Give the students a copy of the *Planetary Data Table* giving distance and diameter information. Tell them the solar system needs to be fitted to the field you chose to construct the model and that they need to make a model of their planet the same scale. They will use a scaling factor for this. This number is 1 meter = 125,000,000 kilometers. They will need to divide each of the distances and the diameter for their planet by this number. The answers will come out in meters. If the calculators you use won't allow you to use numbers this large, leave off the last 3 zeros on all the numbers you use. The ratio will be the same as if the actual number was used. The calculations should be written on the *Student Data Table.*

Each group should be given a 5 × 7 card, which they will use as a placard for their object. They should write the actual distance from the Sun and the scaled distance from the Sun on one side of the card. They should attempt to draw the scaled planet on the other side in the approximate center of the card. They should use a ruler to accurately measure the diameter (in the case of all the terrestrial planets, this diameter will be only a tiny portion of a millimeter (impossible to draw that small). They can use the smallest "dot" from a pencil to approximate the size. Using markers, they should write the name of their object across the top portion of the card in large letters. They must take a piece of string and measure it, getting its length to the correct scaled distance, then carefully coil the string around a piece of cardboard and place in the baggie. You will make the Sun, which has a scaled diameter of 11 millimeters. Make a card for the Sun, label it "Sun," color it yellow, and glue it to a Popsicle stick. You will need the 360-degree protractor around the Sun (see "Part C: Back to the Field" below). You will need to photocopy the 360-degree protractor on panel 5.

Part C: Back to the Field

In placing the cards on the field, the planets drawn on the cards need to be placed the same distance off the ground (at the start). Cards will be glued to a Popsicle stick. Mercury can be placed about a centimeter above the others (because it is 7 degrees above the plane of the other planets). Pluto can be placed about 1 meter above the plane of the other planets (because it is 17 degrees above the plane of the other planets).

The planets need to be positioned close (in scale) to where they really are (in space). To do this, place the Sun in the following manner (see the "bird's-eye view" on panel 5). On a football field, place it on the right hand side of one goal line. On a standard-size soccer field, place it about 12 meters up on the right hand side from the goal line. On any other type field, you need about 12 meters of space behind you and the most space in front and off to the left. Place the 360-degree protractor around the Sun with 0 degrees (360 degrees) towards the far end of the field (football field/soccer field: align 0 degrees with the sideline). Tell each student team their angle. Student teams should use the protractor around the Sun. They should take the string out of the baggie. Then, one team member will stand at the protractor holding on to the end of the string. The second team member will find the angle of degrees on the protractor. The third team member, holding the other end of the string, will walk the length of the string in the direction that the protractor was pointing. The second team member will try to keep the string going on a "true path." The inner planets will be clustered very close to the Sun. Jupiter will

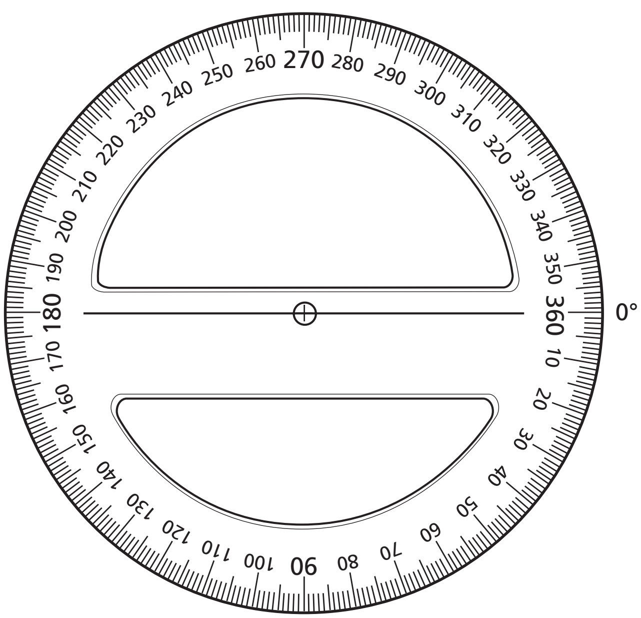
continued on panel 5

be slightly behind and off the field. Saturn will be directly behind on the sideline. The outer planets and the Voyagers will be a ways out on the field.

When the string is laid out, the Popsicle stick/index card should be held at the far end of the string. After all objects have been placed in the "correct" spots on the field, one team member should return to the Sun with the index card from Part A, turn the card over, and draw the positions as they now appear.

Extensions

How fast are the planets moving? Is it possible to scale the speed of the planets and compare their movement? Students can research other interesting data about each planet/object and prepare a report to the class.



Planetary Data Table

Planet or Object	Average Distance from the Sun, kilometers	Student Class Data, meters	Diameter, kilometers	Teacher: Scaled Distance on Playing Field, meters	Teacher: Angle Around the Sun, degrees
Sun	—	—	1,390,000	—	—
Mercury	57,910,000		4,880	0.45	Choose
Venus	108,200,000		12,103.6	0.9	Choose
Earth	149,600,000		12,756.3	1.2	Choose
Mars	227,940,000		6,794	1.8	Choose
Jupiter	778,330,000		142,984	6.2	155
Saturn	1,429,400,000		120,536	11.5	180
Uranus	2,990,504,000		51,118	24	295
Neptune	4,502,960,000		49,532	36	310
Pluto	4,558,312,000		2,274	36.5	0
Voyager 2	9,873,749,600		—	79	325
Voyager 1	12,484,718,400		—	99.9	358

Table Notes

- These are the present distances from the Sun. Because of Pluto's erratic orbit, it has recently moved from its position of being closer to the Sun than Neptune, and is now slightly farther from the Sun than Neptune; therefore, at the present time, it's comparatively close to the same distance.
- Mercury, Venus, Earth, and Mars: These are average distances from the Sun. They can be placed anywhere in their orbits (but at their correct distances from the Sun) because their positions change so greatly month to month. The outer planetary positions relative to the Sun were accurate as of August 2002 (Voyager's 25th anniversary). If you wish to place any planets in more exact positions, check at http://www.heavens-above.com/ for the daily planetary positions.

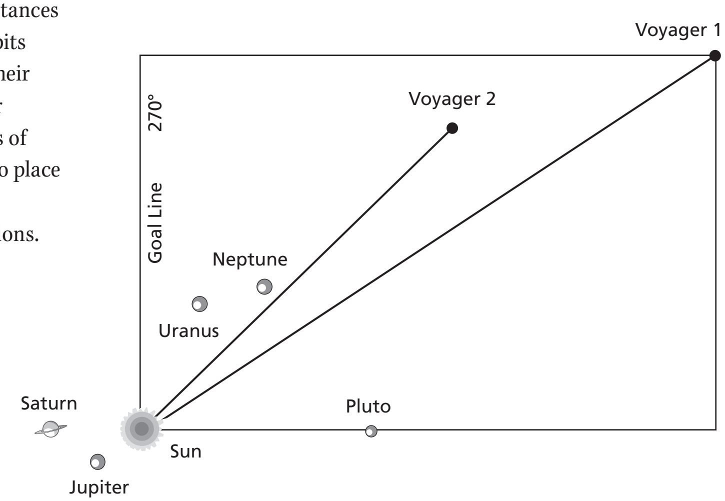
Sources

http://seds.lpl.arizona.edu/nineplanets/nineplanets/

http://seds.lpl.arizona.edu/nineplanets/nineplanets/data2.html

http://seds.lpl.arizona.edu/nineplanets/nineplanets/data.html

http://vraptor.jpl.nasa.gov/flteam/weekly-rpts/current.html#RTLT



EW-2002-02-012-JPL

This activity will build on the ideas developed in the "Voyager 1 and 2: Where Are You?" activity to demonstrate that the distances between stars are great and that the two Voyager spacecraft will travel very far.

Part A: Scale Models

For this part of the activity, a photocopier that can "photo-reduce" is helpful. In "Voyager 1 and 2: Where Are You?" the scale of the solar system was reduced so that it (and Voyagers' present positions) would fit on a standard football/soccer field. Students made a visual scale model of the Voyager–solar system set up on a 5 × 7 card. One of these cards should be borrowed from one student and photo-reduced enough times to make the Voyager–solar system the size of a period, 3 millimeters in diameter. This could be done with the students watching; however, if not, save all the "in-between" reductions to show the students. If a copier is not available, simply make a dot on a paper and describe how this now represents the Voyager–solar system (which is actually one light-day in diameter). So 3 mm/light-day is the scale of this activity, with a light-day [the diameter of our Voyager–solar system] becoming the basis of our measure. Voyager 1 is heading toward the constellation Ophiuchus [OFF-ih-YOU-kus]. It contains many stars — some are listed in the *Star Data Table*. Distances are in light-years (LY).

Part B. Back Outside

Place the card with the dot representing the Voyager–solar system in one corner of the soccer/football field. Place the 360-degree protractor (from the last activity) around the card with 0 degrees pointed towards the far opposite corner of the field. Tell each student team their angle. Student teams should use the protractor around the Voyager–solar system dot. They should take the string out of the baggie. Then, one team member will stand at the protractor holding on end of the string. The second team member will find

Star Data Table

Star Name	*Distance, LY*	*Degrees*	*Star Name*	*Distance, LY*	*Degrees*
72 Ophiuchi	82	345	70 Ophiuchi	16.6	346
Gamma Ophiuchi	94.8	347	Cebalrai	82	352
Rasalhague	46	354	44 Ophiuchi	83.7	356
Xi Ophiuchi	56.7	357	36 Ophiuchi	19.5	359
Kappa Ophiuchi	86	3	Eta Ophiuchi	84	0
Epsilon Ophiuchi	108	13			

Table Notes

- How stars are named is an interesting topic. Sometimes stars are given Greek letter first names with the constellation name second (e.g., Gamma Ophiuchi). A number followed by the constellation name may also be used (e.g., 72 Ophiuchi).
- The "degrees" were assigned to place the stars on the field. They were calculated using 1 degree = 4 minutes of right ascension (a unit of astronomical measure). Eta Ophiuchi was assigned 0 degrees because it is approximately in the middle of the constellation. The other stars are "placed" right or left of Eta Ophiuchi using the degree calculation from their right ascension.

Each group should now be assigned a star. Give the students the *Star Data Table* of distance and location information. Tell them their star needs to be fitted to the field you chose to construct the model. They will use a new scaling factor for this. This number is 1 meter (or 1,000 millimeters) = 1 light-year [3 mm/light-day × 365 days/yr = 1000 mm/light-year=1 meter/light-year]. With this scale, the number of light-years of distance will be equal to the number of meters from the Voyager spacecraft and our solar system.

Each group should be given a 5 × 7 card, which they will use as a placard for their star. They should write the actual distance from our solar system in light-years. Using markers, they should write the name of their star across the top portion of the card in large letters. They should also make a dot on the card to represent their star (note: on this scale, even the largest stars would be microscopic dots). They must take a piece of string and measure it, getting its length to the correct scaled distance, then carefully coil the string around a piece of cardboard, and place in the baggie.

the angle of degrees on the protractor. The third team member, holding the other end of the string, will walk the length of the string in the direction that the protractor was pointing. The second team member will try to keep the string going on a "true path."

When the string is laid out, the index card with the star information should be held at the far end of each string. After all the stars have been placed in the "correct" spots on the field, one team member should return to the Sun with a new index card and draw the positions as they now appear. (Note: for the purposes of this activity, the stars have been placed according to their angles <from side-to-side> and scaled distances from our Sun. They have not been placed in their proper angles up and down. This was done because of the impracticality of the height placement. The stars form a "fan" in the model. In real life, they would be above and below the plane they are in. This should be pointed out to the students). An illustration of the constellation Ophiuchus can be found at: http://www.heavens-above.com/

Extensions

This model is a spatial representation of the area in space where the Voyager I spacecraft is headed. Students might be interested in calculating the length of time for Voyager to come near each of the stars in Ophiuchus. They can use the following calculation: Voyager 1 has traveled about 12.5 billion kilometers in 25 years. This represents approximately 0.001 light-years. Students can figure out the ratio to calculate the total time (25 years × 1000 = years to travel 1 light-year).

How large is the solar system? What do the distances between each planet look like? How could the solar system be measured so that the distances between each planet can be visualized? Where are Voyagers 1 and 2 in relation to our solar system? In what direction are they headed? Your class, working as a team will be able to map these answers using a playing field and a little bit of math!

Materials Needed per Team

- Part A: 5 × 7 index card, pencil, activity sheet.
- Part B: 5 × 7 index card, paper, calculator, pencil, metric ruler with millimeter markings, black marker, copy of *Planetary Data Table,* 100 meters of string, scissors, reclosable baggie, cardboard, activity sheet.
- Part C: index card from Part A, index card from Part B, meter stick or measuring tape and a metric ruler with millimeter markings, Popsicle stick, class protractor (on field), baggie with string, activity sheet.

Team Members

(fill in student's name on the line next to their job)

- **Materials Engineer (ME):** ______________________

Tasks: Reads list of materials, finds materials and brings them to the team, cleans up, and returns all materials after each part of the activity is done, helps with tasks if asked by the Experimental Specialist.

- **Experimental Specialist (ES):** ______________________

Tasks: Reads the procedures for Parts A, B, and C; performs the experiment and directs others to help if necessary; completes the Student Data Table *with information from the Data Processing Statistician.*

- **Data Processing Statistician (DPS):** ______________________

Tasks: Computes numerical information, helps with tasks, and gives information to the Experimental Specialist.

Procedure

Part A: Hypothesis

1. Your team will be assigned an object in the solar system. Our object is

   ____

2. Your team will be going outside to the playing field. Bring a 5 × 7 index card and a pencil.
3. Once outside, you will be making a class hypothesis as to how the solar system and the two Voyagers are arranged within the playing field area. Your teacher will take you to the spot where the Sun will be stationed. Some back ground information/directions will be given.
4. Look out over the field and decide where you think your object should be located. The team should walk to that location.
5. After each team has decided where its object should be placed within the area, one member of your team should take the index card, go stand where the Sun is located, and plot (draw a dot) approximately where each object is located using your pencil. Make sure all groups have been plotted on your card. This is your team's hypothesis of how the solar system is arranged using the scale of the playing field.

Part B: Inside Activity — Making a scaled model of the objects in the solar system

1. ME: Gather materials listed for Part B.
2. Using the table, find your object from Part A. These numbers need to be adjusted to fit within the playing field. The DPS will calculate the new numbers for your object.
3. The scaling factor you will be using is 1 meter = 124,060,000 km (124,060,000 km/m).
4. DPS: Using a calculator, divide the distance your object is from the Sun by the number 124,060,000. ES: Record this number on the back of a 5 × 7 index card. Label the answer "Distance from the Sun in Meters." Also include the actual distance in kilometers as recorded on the table.
   (HINT: If your calculator won't allow you to use numbers so large, leave off the last 3 zeros on all the numbers you use. The ratio will be the same as if the actual number was used). The calculations should also be written in the Student Data Table.
5. Do the same calculations for the diameter of your object (if it is a planet). Record the number on the back of the index card and label the diameter in meters. Make sure to include the actual diameter in kilometers as recorded on the table. Also record these numbers in the *Student Data Table.*
6. On the other side of the index card, make a scaled drawing of your object. Use the metric ruler. Round to the nearest millimeter (3 spots to the right of the decimal point). HINT: If your diameter is less than 1 millimeter, make your drawing the smallest "dot" using a pencil.
7. With a thick black marker, print the name of your object across the top portion of your card in very large letters. Carefully go over your drawing with a thin black marker. Be careful not to change the size of the picture.
8. Measure out a piece of string that is equal to the distance of your object from the Sun in meters. Cut the string, wrap it around the piece of cardboard, and put it carefully in the baggie. Label the baggie with the name of your object using masking tape and pencil.

continued on panel 8

Part C: Back to the Field

1. Gather the materials needed for Part C.
2. Glue your card to the Popsicle stick with the stick on the "calculation side" of the card. Try to keep from covering the information on that side of the card.
3. DPS: Go to your teacher and write down the angle of degrees for your planet's place in its orbit on the handle of the Popsicle stick.
4. Find the protractor/Sun on the field. Take the string out of the baggie. One team member will hold the protractor. The third team member, holding the other end of the string, will walk the length of the string in the direction that the protractor was pointing. The second team member will try to keep the string going on a "true path."
5. When the string is laid out, the Popsicle stick/index card should be held at the far end of the string.
6. After all objects have been placed in the "correct" spots on the field, one team member should return to the Sun with the index card from Part A, turn the card over, and draw the positions as they now appear.

Conclusions

- Look at the two index card drawings.

  Were they the same? ____________ (yes/no)

- How many drawings could be seen from the Sun's position? ______________________________

- Which ones:

  ____

  ____

- Which objects were the farthest out?

  ____

  ____

- Do you know how long it took for these objects to get there? ______________________________

- Voyager 2 was launched on August 20, 1977. How long has it taken to travel to its current position?

  ____

  ____

- Voyager 1 was launched on September 5, 1977. How long has it taken to get to its current location?

  ____

Student Data Table

Name of Object

____

Average Distance from Sun in kilometers

____

Scaled distance from the Sun
(124,060,000 m/km)

____

Scaled diameter of object
(124,060,000 m/km)

____

Is Voyager 1 lost now that it has left the solar system? Towards what is it heading? Using several common items, some math, and a playing field, your class will discover where Voyager 1 is going and the distance that must be covered to get there.

Materials Needed per Team

Part A: 5 × 7 index card, pencil, black marker, string, meter stick with centimeter markings, table of information on stars, piece of cardboard, re-closable baggie, glue, Popsicle stick.

Part B: 5 × 7 index card with the name of your star on it (on the Popsicle stick), a blank 5 × 7 index card, a pencil, the baggie with the cardboard and string inside. Your teacher will supply a protractor.

Procedure

Part A

1. Your teacher will show you a series of photocopies taken from one index card made during the “Voyager: Where Are You?” activity. This is the new scale for this next activity. It will be called Voyager–solar system. It will take 1,000 Voyager–solar systems to equal 1 meter. This meter also equals 1 light-year. What is the unit of measure that makes up the Voyager–solar system?

   ____

2. Voyager 1 is heading toward the constellation Ophiuchus [OFF-ih-YOU-kus]. Your teacher will give you one of the stars to work with that make up this constellation.

   Our group’s star is ______________________________

3. Gather the materials needed for Part A.
4. Using the table, find your star. The “Distance in Light-Years” number needs to be adjusted to fit within the playing field used in the next part of the activity.
5. The scaling factor you will be using is 1 meter = 1 light-year.
6. Write the name of the star in large letters using a marker across the top of the index card. Write the actual distance from our solar system in light-years underneath the star’s name. Glue this card to a Popsicle stick.
7. Using a meter stick, measure a piece of string that will represent the correct scaled distance. Cut the string.
8. Carefully coil the string around the piece of cardboard, and place it in the baggie. Label the cardboard with the name of the star.

Part B

1. Gather the materials listed for Part B.
2. Meet on the playing field where directed to meet.
3. The teacher will place the Voyager–solar system card at that spot.
4. A 360-degree protractor will be placed in the same area.
5. Your teacher will tell you the angle of your star from the Voyager–solar system dot.

   Our angle is ______________ degrees.

6. One team member will take the string and cardboard out of the baggie while standing at the protractor.
7. The second team member will find the angle of degrees on the protractor and stand there. This member will also try to keep the string going straight as the string is unrolled. This member should also hold onto the blank index card and the pencil.
8. The third team member, taking the cardboard with the string wrapped around it and the index card with the star’s name on it, will walk the length of the string, unwrapping as you go.
9. When the string is completely laid out, the index card with the name of the star on it should be held at the end of the string.
10. Once all the stars have been laid out, the second team member should draw the positions of all the stars on the playing field using the blank index card to represent the playing field.
11. Listen to your teacher for final instructions before going back to the classroom.

Conclusions

- Look at your index card that represents the constellation Ophiuchus. Does it look like the drawing on your activity sheet? ________ (yes/no)

  Why do you think this is so?

  ____
  ____
  ____
  ____
  ____
  ____

- The “dot” by the protractor represents where the Voyager spacecraft is now. It has taken 25 years to cover that distance. Look at your index card with all the stars drawn on it. Estimate how long it might take to reach the closest star in the constellation. (How many “dots” would it take to get there?) ______________________________