Where is Mars?

Duration
Two 45-minute class periods

Lesson Overview
In this activity, students will research specific data concerning the Sun, Earth, and Mars in order to calculate ratios leading to the creation of a scale model of the orbits of the Earth and Mars.

The lessons can be conducted in multiple ways. Teachers may choose to follow the instructions and use the spreadsheet provided to assist students with the mathematical calculations needed to build the orbital model. This places emphasis on the research that is conducted by the students. An option to shorten the lesson using the calculations key puts the emphasis on building the orbital model. A third option is to present the problem of building a scale model of the orbits of Earth and Mars to the students and facilitate their learning as they brainstorm ideas of how this scale and motion can be modeled. In this case, the materials provided illustrate one way to develop the scale, but students can also be nurtured in their use of math as they conduct their own research and calculations. Utilizing any of these options for this activity, it will become evident that our Solar System is a very big, very empty place.

Lesson Objective
Students will:

- Work collaboratively within teams to make decisions based on research;
- Collaborate between teams by engaging in discussions, creating and sharing information in the form of charts, maps, and reports; and
- Take responsibility for the success of the project by working effectively together.

Next Generation Science Standards Addressed
Science and Engineering Practices

Asking Questions and Defining Problems
Analyzing and Interpreting Data
Developing and Using Models

Disciplinary Core Ideas

ESS1.A: The Universe and Its Stars
ESS1.B: Earth and the Solar System

Crosscutting Concepts

Patterns
Scale, Proportion, and Quantity
Systems and System

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Texas Essential Knowledge and Skills for Science

Scientific Processes

A.2G: Scientific processes. The student uses scientific methods during laboratory and field investigations. The student is expected to organize, analyze, evaluate, make inferences, and predict trends from data, including making new revised hypotheses when appropriate.
A.2H: Scientific processes. The student uses scientific methods during laboratory and field investigations. The student is expected to communicate valid conclusions in writing, oral presentations, and through collaborative projects.
A.2I: Scientific processes. The student uses scientific methods during laboratory and field investigations. The student is expected to use astronomical technology such as telescopes, binoculars, sextants, computers, and software.
A.3A: Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student.

Science Concepts

A.9A: Science concepts. The student knows that planets of different size, composition, and surface features orbit around the Sun. The student is expected to compare and contrast the factors essential to life on Earth such as temperature, water, mass, and gases to conditions on other planets.
A.9B: Science concepts. The student knows that planets of different size, composition, and surface features orbit around the Sun. The student is expected to compare the planets in terms of orbit, size, composition, rotation, atmosphere, natural satellites, and geological activity.
A.14A: Science concepts. The student recognizes the benefits and challenges of space exploration to the study of the universe. The student is expected to identify and explain the contributions of human space flight and future plans and challenges.
A.14B: Science concepts. The student recognizes the benefits and challenges of space exploration to the study of the universe. The student is expected to recognize the advancement of knowledge in astronomy through robotic space flight.

Materials

- *Giant Mars Map*
- *Where is Mars? Student Form*
- *Where is Mars? Calculations*
- *A ball/item to serve as a scale model of the Sun (we have found a thumb to be the perfect size for in-classroom models)*
- *Blue cord*
- *Red Cord*
- *White, yellow or black cord*

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Teacher Preparation Instructions

In this activity, students will be conducting research to prepare a scale model of the orbits of the Earth and Mars around the Sun. The big idea is to determine ratios that can be used with any ball/item that serves as the model of the Sun. Once students know the ratios, students can create a model of any size. The larger the item representing the sun, the more string you will need. *(Using a thumb to represent the sun usually works well for in-classroom models.)*

Please consider using blue cord for the distance to the Earth, red cord for Mars, and either white, yellow or black to measure light minutes. The spreadsheet can be used to do the calculations. The second page of the spreadsheet has the numbers filled in with the calculations.

Engagement

1. Conduct research to complete the Where is Mars Research Questions spreadsheet. This document will supply the data for the Calculations spreadsheet.

Exploration

1. Cut a blue cord at least four inches longer than the distance calculated as *Scale Earth Aphelion*.
2. Tie a small loop near the end of the blue cord.
3. Tie a knot in the blue cord at the distance calculated for Scale Earth Perihelion.
4. Tie a knot in the blue cord at the distance you calculated for Earth's Scale Earth Aphelion.
5. Cut a red cord at least four inches longer than the distance calculated as *Scale Mars Aphelion*.
6. Tie a small loop near the end of the red cord.
7. Tie a knot in the red cord at the distance calculated for Scale Mars Perihelion.
8. Tie a knot in the red cord at the distance calculated for Scale Mars Aphelion.
9. Prepare a white, yellow, or black cord with a knot tied at the scale distance for each light minute. Make sure the cord is at least 30 scale light minutes long.

Explanation

1. Consider the motion and scale distances of the Sun, Earth, and Mars.
    - Direct the student holding the scale Sun to stand at the 0 – 0 point on the Giant Mars Map (equator, prime meridian), facing South on the map.
    - Guide the student representing the Earth to stand straight south from the Sun at Aphelion as measured by the blue cord.
    - Guide the student representing Mars to stand straight south from the Sun at Perihelion as measured by the first knot in the red cord.

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When Earth is at its greatest distance (aphelion) from the Sun, Mars is at its closest distance (perihelion).

- Measure the distance between Earth and Mars using the light minute string.
  - The number of minutes is how long it will take for a radio signal to travel between the planets.
  - This is close to the location at which we launch probes headed to Mars.
  - It takes about six months to travel to Mars so we must aim where Mars will be in six months.
  - The Earth is traveling just short of 70,000 miles per hours around the Sun.
  - Mars is traveling in an elliptical orbit, so its speed is not consistent as it revolves around the sun.
- Advance the planets by six months. In this elapsed time, the Earth will go from straight south of the Sun to straight north of the Sun. Mars travels approximately one quarter of the way around the Sun so it can be located about straight east of the Sun.
  - The Earth is now at perihelion.
  - Mars is now halfway between its aphelion and perihelion.
- Measure the distance between Earth and Mars using the light minute string.
  - The number of minutes is how long it will take for a radio signal to travel between the planets.
  - This is close to the relative location of Earth and Mars when a probe lands on Mars.
  - Consider how long it takes from the time a probe lands until we know about it on Earth.
- Advance both planets another six months
  - Earth will now be straight south of the scale Sun.
  - The Earth is now at aphelion.
  - Mars will now be about straight north of the scale Sun.
  - Mars is now at aphelion.
- Measure the light minutes between the Earth and Mars and consider that when the Sun is exactly between them that communications is totally cut off for about two weeks by the position of the Sun.
- Continue to advance six months at a time. Each time the Earth moves 180 degrees around the circle and Mars moves about 90 degrees around the circle. This is not perfectly accurate, but it is a reasonable facsimile. We challenge you to consider the exact locations.
- Conclude that the planets line up relatively closely once every two years. This allows for a launch window to Mars every two years.
- Consider what it is like to conduct conversations between a person on Earth and a person on Mars.

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Extension

- Collect maps of the region surrounding the school.
- Use a tool such as Google Maps to locate an object (i.e. a water tower or tank) to be designated as the Sun. Get a picture of this object.
- Research the size and volume of this object.
- From these measurements determine the scale sizes of the planets and describe what a scale models would look like (i.e. what size objects would be needed.)
- Also, from these measurements, determine the scale distances for perihelion and aphelion for each of the planets you have selected to model.
- Draw the orbits of each planet you have selected on your local maps or GPS map.
- Research the current relative locations of each of the planets you have selected and "pin" a marker at the proper location on the map.
- Prepare a letter explaining the project and describe the locations of each planet researched and the relative size it would be, given that your landmark is a scale representation of the sun's size and location. Share the letter with interested groups who live near the location of the scale sun. (Examples might be other student groups, astronomy organizations, museums, and professors.)
- Consider connecting this activity with students and teachers from other schools.

Evaluation

- Student teams will be evaluated through formative assessment methods throughout the activity.
- Teacher interviews of groups and gathering data/products of team work such as their generated notes will provide evidence of learning.