National Aeronautics and Space Administration

NASA Explorer Schools Pre-Algebra Unit
Educator Guide

Solar System Math

Where Should Humans Next Explore?

http://quest.nasa.gov/vft/#wtd

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Solar System Math – Unit Overview

What is Solar System Math?

Solar System Math is a series of four pre-algebra lessons in which students use the *What's the Difference* software application plus hands-on classroom activities to investigate our solar system scientifically and mathematically. The ultimate goal is for students to select a planet or moon that is well suited for human exploration based on key attributes such as size, distance from the Earth, composition, and minimum mission duration.

Solar System Math Modules:

- Lesson 1: Comparing Size and Distance
- Lesson 2: Comparing Mass, Gravity, Composition, and Density
- Lesson 3: Comparing Planetary Travel Distance
- Lesson 4: Analyzing Payload Size and Cost

Lesson Module	Instructional Objectives	Major Focus Skills
1. Size and Distance	• Gather information about the planets and moons in our solar system. • Create a scale model of our solar system in terms of diameter of the planets. • Walk a scale model of our solar system representing distances from the Sun. • Use ratio and proportion to compare the size of the scale model to the actual size of our solar system. • Describe the parts of the solar system in terms of size, distance, & location. • Match appropriate units with given situations and convert units within a system of measurement. • Graph the distances from the planets to our Sun.	• Measurement— metric and standard units • Unit conversion • Ratio and proportion • Calculating scale • Problem solving • Data analysis and representation through graphing

Lesson Module	Instructional Objectives	Major Focus Skills
2. Mass, Gravity, Composition, and Density	• Create a mass/volume/ density scale model of our solar system. • Compare planet and moon masses to Earth's mass using fractions, decimals, and percents. • Identify the interval of values for mass that will allow a planet to have a surface that humans can visit. • Graph the bodies in the solar system whose interval of values for mass are/are not suitable for human visitation.	• Data representation through graphing • Comparing and ordering fractions, percents, and decimals • Solving problems involving scale, ratio, and proportion • Converting ratios, fractions, decimals, and percents • Measuring circumference • Estimating & rounding • Finding patterns and relationships • Calculating density using mass and volume
3. Planetary Travel Distance	• Use the geometry of circles to calculate the distances a crew vehicle would travel from Earth to other planets and moons. • Use the speed of a crew vehicle to calculate the time a journey to each destination would take. • Calculate the length of a mission from Earth to other bodies in our solar system. • Use ratio and proportion, fractions, decimals, and percentages to compare mission lengths to average human lifetimes/careers. • Choose data points to graph. • Consider the different mission lengths and determine which destinations are too far.	• Converting units • Calculating speed using distance and time • Solving speed problems for distance or time • Data representation through graphing • Ratio and proportion • Converting metric units, customary units, and time units

Lesson Module	Instructional Objectives	Major Focus Skills
4. Mission Payload Size & Cost	• Calculate the mass of the resources needed to sustain a three-person crew on a mission to a given planet or moon. • Calculate the proportion (as a fraction, decimal, or percent) of a crew vehicle that is available for scientific instruments for a particular destination and plot the proportion on a number line to compare it with other destinations. • Calculate the cost of a launch to each destination and create graphs to compare these costs and the amount of room that is needed for scientific instruments for each mission.	• Ratio and proportion • Comparing and ordering fractions, decimals, and percents • Units of metric and other standard measurements • Data collection and representation

Lesson Structure

Each of the four lessons in the Solar System Math Unit is divided into six sections and follows the 5-E lesson model:

- **Pre-Lesson Activity** — Determines students' pre-knowledge
- **Engage** — Sets the stage for the lesson's purpose, concepts, and skills
- **Explore** — Hands-on application of key concepts and skills
- **Explain** — Synthesis of key concepts and skills
- **Evaluate** — Assessment of student learning
- **Extend and Apply** — Optional challenge activities allowing for special projects or reinforcement of key lesson skills and concepts

Solar System Math – Teacher Resource

Helping Students Communicate Math

Teacher's Resource

Problem solving is one of the most challenging areas to teach in mathematics. In addition to solving a problem correctly, students must be guided in communicating how they calculated a solution. Frequently math students find the right answer, but they have no idea how they achieved it. The result is like finding a lost city without a map—great, you got there, but once you leave can you get there again?

In order to provide students with a rich and complete mathematical education, it is important to stress communication in math. Students need to be able to express how they solved a problem and why they used the strategies they did. The better they can explain to others, the better they understand it for themselves.

Allowing students to communicate their mathematical reasoning often illustrates that more than one strategy is correct. Some problems have more than one correct solution. Some problems can be solved in a variety of ways. Allowing students to see the variety of solutions and strategies further enriches their mathematical understanding.

Following is a series of questions that can be asked when students share their solutions or graphs with the class. The questions can be asked of individuals or of an entire group, but it is important to ensure that all members of a group understand their results and the decisions they made.

Solving Challenging Math Problems

After groups or individuals have found a solution, have them share their result with the class. The following questions are examples of the types of questions that will help strengthen students' math communication skills:

- How did you find your solution? Explain.
- How do you know it is right? Why did you do a (particular) calculation that way?
- Do other students have questions about how your group solved a problem? Does anyone disagree with your group's solution?
- Does your answer make sense?
- Do you think your strategy would apply to other situations? How? (You can provide "what if" scenarios to help students generalize to other situations.)

- How do different students' strategies for solving the problem compare? Which strategy do you like best? Why?

Graphing Data

After groups or individuals have graphed their data, have them share their result with the class. You can ask the same questions for graphing data as you asked for solving math problems to strengthen students' math communication skills:

- How did you decide to use your particular data set and graph? Explain.
- How do you know your graph is accurate?
- Do other students have questions about how your group graphed their data? Does anyone disagree with your group's graph?
- Does your graph make sense?
- How do different students' strategies for graphing the data compare? Which strategy do you like best? Why?