National Aeronautics and Space Administration

How Big Is It?

A Lesson in Scale Comparison

NP-2015-07-061-MSFC

How **Big** Is It?

National Council of Teachers of Mathematics
Principles and Standards for School Mathematics

Algebra: Grades 3 – 5

Represent and analyze mathematical situations and structures using algebraic symbols.

- represent the idea of a variable as an unknown quantity using a letter or a symbol
- express mathematical relationships using equations

Use mathematical models to represent and understand quantitative relationships.

- model problem situations with objects and use representations such as graphs, tables, and equations to draw conclusions

Geometry: Grades 3 – 5

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

- identify and build a three-dimensional object from two-dimensional representations of that object

Measurement: Grades 3 – 5

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

- understand such attributes as length, area, weight, volume, and size of angle and select the appropriate type of unit for measuring each attribute
- understand the need for measuring with standard units and become familiar with standard units in the customary and metric systems
- carry out simple unit conversions, such as from centimeters to meters, within a system of measurement

Number and Operations

Understand numbers, ways of representing numbers, relationships among numbers, and number systems.

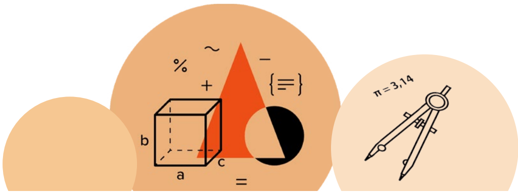
- understand the place-value structure of the base-ten number system and be able to represent and compare whole numbers and decimals

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

- understand various meanings of multiplication and division
- understand the effects of multiplying and dividing whole numbers
- identify and use relationships between operations, such as division as the inverse of multiplication, to solve problems

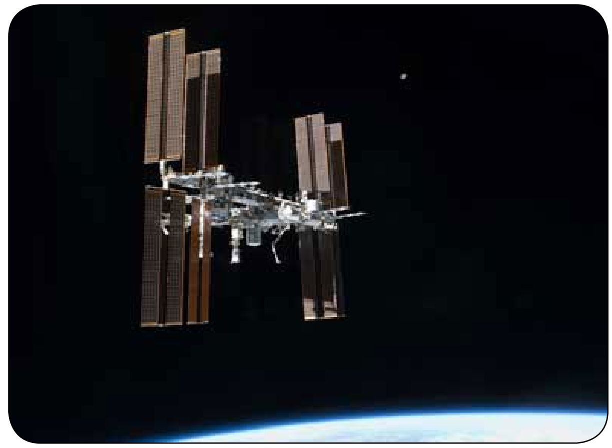
Compute fluently and make reasonable estimates

- develop fluency in adding, subtracting, multiplying, and dividing whole numbers
- develop and use strategies to estimate the results of whole-number computations and to judge the reasonableness of such results
- select appropriate methods and tools for computing with whole numbers from among mental computation, estimation, calculators, and paper and pencil according to the context and nature of the computation and use the selected method or tools



NASA's Journey to Mars

Teacher Notes



NASA is developing the capabilities needed to send humans to Mars in the 2030s. Mars is a rich destination for scientific discovery. Its formation and evolution are comparable to Earth, helping us learn more about our own planet's history and future.

While robotic explorers have studied Mars for more than 40 years, NASA's path for the human exploration of Mars begins in **low-Earth orbit** aboard the **International Space Station** (ISS). Astronauts on ISS are helping NASA prove many of the technologies and communications systems needed for human missions to **deep space**, including Mars. The ISS also advances our understanding of how the body changes in space and how to protect astronaut health.

The next step is deep space, where NASA will send a robotic mission to capture and redirect an asteroid to orbit the moon. Astronauts will explore the asteroid in the 2020s, returning to Earth with samples. This experience in human spaceflight beyond low-Earth orbit will help NASA test new systems and capabilities. Beginning in late 2018, NASA's powerful Space Launch System rocket will enable these "proving ground" missions to test new capabilities.

The Space Launch System

NASA's Space Launch System (SLS) is an advanced launch vehicle for a new era of exploration beyond Earth's orbit into deep space. SLS will launch astronauts in the Orion spacecraft on missions to an asteroid and eventually to Mars, while opening new possibilities for other payloads including robotic scientific missions to places like Mars, Saturn and Jupiter.

Offering the highest-ever payload mass and volume capability and energy to speed missions through space, SLS will be the most powerful rocket in history and is designed to be **flexible** and **evolvable**, to meet a variety of crew and cargo mission needs. The SLS will be NASA's first **exploration-class vehicle** since the Saturn V took American astronauts to the moon more than 40 years ago and will expand our reach in the solar system.

This next wave of human exploration will take explorers farther into the solar system — developing new technologies, inspiring future generations and expanding our knowledge about our place in the universe.

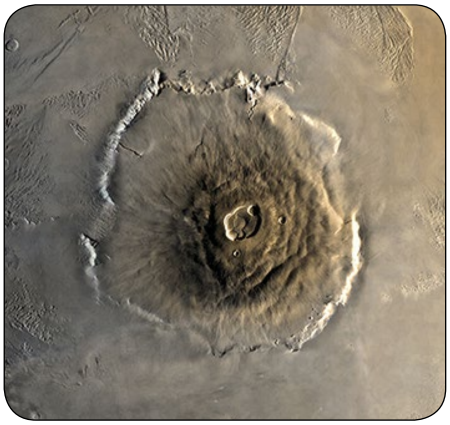
How **Big** Is It?

NASA's Journey to Mars

Teacher Notes

Volcanoes

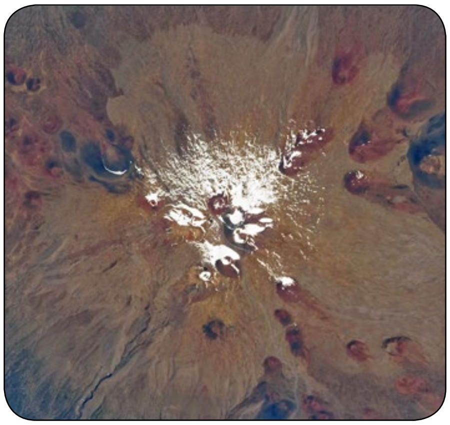
Volcanoes are prominent features on all large rocky planetary bodies. **Volcanism**, is one of the major geologic processes in the solar system. Mars has a long history of volcanic activity from the ancient volcanic areas of the southern highlands to the more recent major volcanoes of the Tharsis bulge. Some of the volcanoes on Mars are basaltic shield volcanoes like Earth's Hawaiian Islands. In addition to shield volcanoes, there are dark, flat layers of basaltic lava flows that cover most of the large basins of Mars.



Olympus Mons

Olympus Mons

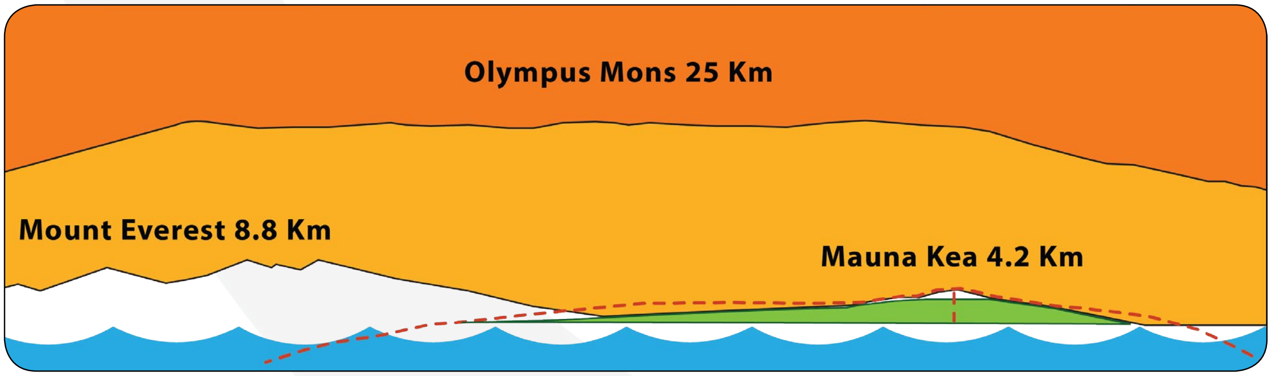
The largest of the volcanoes in the **Tharsis Montes** region of Mars, as well as all known volcanoes in the solar system, is Olympus Mons. Olympus Mons, Latin for Mount Olympus, is 25 km (16 mi) high. A **caldera** 80 km (50 mi) wide is located at the **summit** of Olympus Mons. The entire chain of Hawaiian Islands would fit inside Olympus Mons!

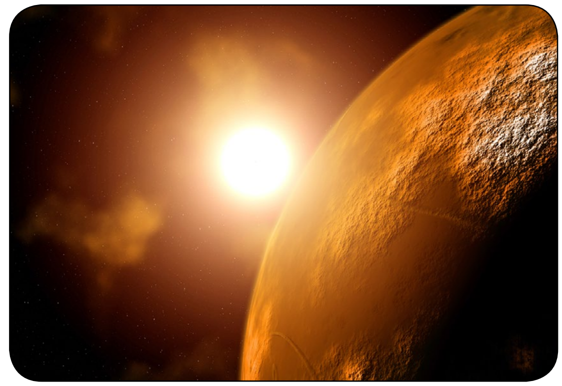


Mauna Kea

Mauna Kea

Mauna Kea, Hawaiian for White Mountain, is 10 km (33,481 ft.) high, although it is only 4.2 km (13,796 ft.) above sea level. This makes Mauna Kea taller than any other volcano on Earth. Mauna Kea does not have a summit caldera, but there are numerous **cinder cones**.





Vocabulary

Basalt – dark, fine-grained igneous rock; makes up most of the ocean floor and is the most common type of lava

Caldera – large basin-shaped crater at the top of a volcano that was formed by the eruption or collapse of the center of the volcano

Cinder cone – a conical hill formed by the accumulation of volcanic debris

Deep space – space beyond the Earth's atmosphere, especially that part lying beyond the Earth-Moon system

Evolvable – a design that allows for initial elements, like engines and core stage, to be used with new elements in later designs to create more powerful versions of the rocket

Exploration-class vehicle – a rocket that has both the mass and volume capability to support significant human exploration beyond Earth

Flexible – capable of modification or adaptation

International Space Station (ISS) – a large, orbiting laboratory where astronauts live and work

Low-Earth orbit (LEO) – the first 100 – 200 miles of space; LEO is the easiest orbit to get to and stay in; this is where the ISS is located

Summit – the highest point of a volcano

Tharsis Montes – the largest volcanic region on Mars; it is approximately 4,000 km (2,485 mi) across, 10 km (6.2 mi) high and contains 12 large volcanoes

Volcanism – the eruption of molten rock (magma) onto the surface of a planet; a volcano is the vent through which magma and gases are discharged; magma that reaches the surface is called lava

How **Big** Is It?

The Challenge

Construct a scale representation comparing the height of Olympus Mons to the height of Mauna Kea.

1. Be prepared

- Read the Teacher Notes and Student Work Sheet.
- Gather materials for the activity listed on page 7.
- Place materials at each work station (or other suitable location) for ease of access by students.

2. Background information

Clickable links below to interesting and useful web sites:

- [NASA Facts – Space Launch System]()
- [Space Launch System webpage]()
- [NASA's Journey to Mars]()

3. Introduce the challenge

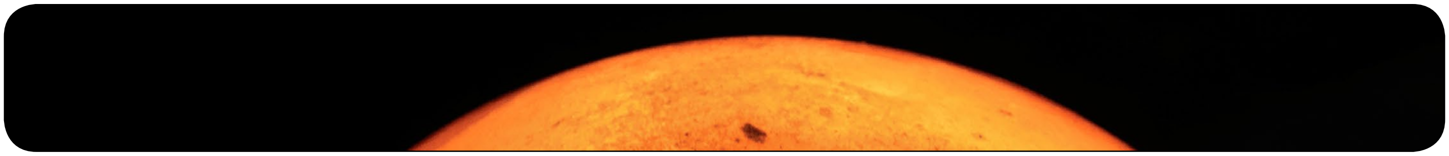
- Students should develop an understanding of volcanoes and some of their characteristics.

A volcano is an opening on the surface of a planet or moon that allows material warmer than its surroundings to escape from its interior. When this material escapes, it causes an eruption. An eruption can be explosive, sending material high into the sky. Or it can be calmer, with gentle flows of material. These volcanic areas usually form mountains built from the many layers of rock, ash or other material that collect around them. Volcanoes can be active, dormant or extinct. Active volcanoes are volcanoes that have had recent eruptions or are expected to have eruptions in the near future. Dormant volcanoes no longer produce eruptions, but might again sometime in the future. Extinct volcanoes will likely never erupt again.

- Introduce the activity to the students.

Tell your students they will be constructing scale representations comparing the height of Olympus Mons and the height of Mauna Kea. They will be using edible products but must first complete the challenge before they can eat their volcanoes. Put students in groups of 2 (1 per volcano) or 4 (2 students per volcano).

The students will need pencil & paper, or a calculator if you allow, to make the calculations for the scale comparison. [The comparisons in this lesson use the height of Mauna Kea above sea level since that is the part of the volcano seen from the surface of the Earth.] Talk with the students about the steps and mathematical operations needed for each comparison – Metric and U.S. Customary. Ask them why the comparison using Metric units does not yield the same answer as when using U.S. Customary units. Discuss rounding, and if appropriate, the use of significant figures.



4. The Math – Metric units

Mauna Kea	Olympus Mons
• 10 km from the ocean floor • 4.2 km above sea level	• 25 km from the surface of Mars

$$\frac{25\text{ km}}{4.2\text{ km}} = 5.952$$

Olympus Mons is about 6 times taller than Mauna Kea!

5. The Math – U.S. Customary units

Mauna Kea	Olympus Mons
• 33,481 feet from the ocean floor • 13,796 feet above sea level	• 16 miles from the surface of Mars

16 miles = ______?______ feet

1 mile = 5,280 feet

16 miles X ________ $\frac{\text{feet}}{\text{mile}}$ = ____________ feet

• 33,481 feet from the ocean floor • 13,796 feet above sea level	• 84,480 feet from the surface of Mars

$$\frac{84{,}840\text{ feet}}{13{,}796\text{ feet}} = 6.124$$

Olympus Mons is about 6 times taller than Mauna Kea!

Materials (per group):

- Cookies (2 – 1 each of two types [for example – sugar and chocolate chip])
- Icing (spreadable or squeezable; two flavors/colors)
- Plastic knife (2)
- Plastic spoon (2)
- Wax paper (2 pieces – 1 for each cookie)
- Ruler
- Paper towels
- OPTIONAL: Various materials (raisons; chocolate sprinkles; chocolate or butterscotch chips; etc.) for use as volcano features (cinder cones; lava flows; etc.)

6. Construct

- Distribute or have students collect their materials.
- Explain that each group will build one representation of Olympus Mons and one representation of Mauna Kea using the materials provided. The representations will be constructed on wax paper. The icing will represent the volcano. The OPTIONAL items are to be used if you want students to add volcanic features to their representations.
- Talk with students about picking a unit, such as ½ inch or 2 inches, to represent the height of one of the volcanoes. Using the ruler, they can place this amount of icing on the cookie representing the volcano they selected. It makes the most sense to select a measurement for Mauna Kea since it is the shorter of the volcanoes, thus, making it easier to “scale up” to then construct Olympus Mons. Scaling up is an easier operation than scaling down for most students. [For example, if Mauna Kea’s height is selected to be ½ inch of icing, then the height of Olympus Mons would be 6 times as high, or 3 inches.]

7. Activity Enhancements

- Have student groups research Olympus Mons & Mauna Kea prior to the activity and give a presentation about what they learned.
- Have students research other geological features common to both Earth and Mars.

How **Big** Is It?

Work Sheet

Name: ______________________________ **Date:** ______________________________

The Challenge

Construct a scale representation comparing the height of Olympus Mons to the height of Mauna Kea.

Think it Over

The volcano representations must be to scale.
Discuss with your group:

- What does it mean for something to be to scale?
- What mathematical operations will you need to use to calculate the height comparison?

The Math – Metric Units

Using the height of each volcano in Metric units, calculate the height comparison below. Show all steps.

The Math – U. S. Customary Units

Using the height of each volcano in U.S. Customary units, calculate the height comparison below.
Show all steps.

Construct

Using the materials provided, construct a representation of the scaled heights for each volcano.

Draw

In the space below, draw each representation. Label each representation with the icing height on each cookie.
[If you found the comparison to be one volcano is 3 times the height of the other, you may represent one volcano with 1 inch of icing and the other volcano with 3 inches of icing (1 inch x 3 = 3 inches).]

Olympus Mons

Mauna Kea

How **Big** Is It?

SLS Block 1

Liftoff weight: 5.75 million pounds

- Comparable to 8 fully-loaded 747 jets

Height: 322 feet

- Taller than the Statue of Liberty

Cargo Volume:

- 9,000 - 22,000 ft^3

SLS Block 2

Liftoff weight: 7 - 7.5 million pounds

- Comparable to 10 fully-loaded 747 jets

Height: 365 feet

- As tall as a 30-story building

Cargo Volume:

- 58,000 ft^3

Payload

Block 1 (154,000 pounds) to orbit
- ~77 1-ton pickup trucks' worth of cargo
- Equivalent of 12 fully grown elephants

Block 2 (286,000 pounds) to orbit
- ~143 1-ton pickup trucks' worth of cargo
- Equivalent of 22 fully grown elephants

Thrust/Power

At liftoff, the Block 1 configuration has 8.4 million pounds of thrust, more than 31 times the total thrust of a 747 jet.
Produces horsepower equivalent to:
- 160,000 Corvette engines
- 13,400 locomotive engines

10 percent more thrust than the Saturn V at liftoff

At liftoff, the Block 2 configuration has 9.2 million pounds of thrust, more than 34 times the total thrust of a 747 jet.
Produces horsepower equivalent to:
- 208,000 Corvette engines
- 17,400 locomotive engines

20 percent more thrust than the Saturn V at liftoff

Propulsion

Solid Rocket Boosters (SRBs)
- If their heat energy could be converted to electric power, the two SRBs firing for 2 minutes would produce 2.3 million kilowatt hours of power, enough to supply power to over 92,000 homes for a full day.
- Each burns 5 tons of propellant per second.

RS-25 Core Stage Engines
- The power generated by 4 RS-25 engines is equivalent to the output of 16 Hoover Dams.
- If 4 RS-25 engines pumped water, rather than fuel, they would drain a family-sized swimming pool in 20 seconds.
- 4 RS-25 engines generate power equivalent to 3,386,364 miles of residential street lights. That's a street long enough to go to the moon and back 7 times, then circle the earth $1\frac{1}{2}$ times.


JOIN US ON THE JOURNEY
National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, AL 35812
www.nasa.gov/marshall
www.nasa.gov
For more info:
www.nasa.gov/sls
NP-2015-07-061-MSFC