Building Distance Relationships in Space Created By: Donna Grygiel

Time Needed: Seven 55-minutes class periods
Targeted Grade Level: Grade 8 – 9

Integration of NASA Resources & Statement of Purpose

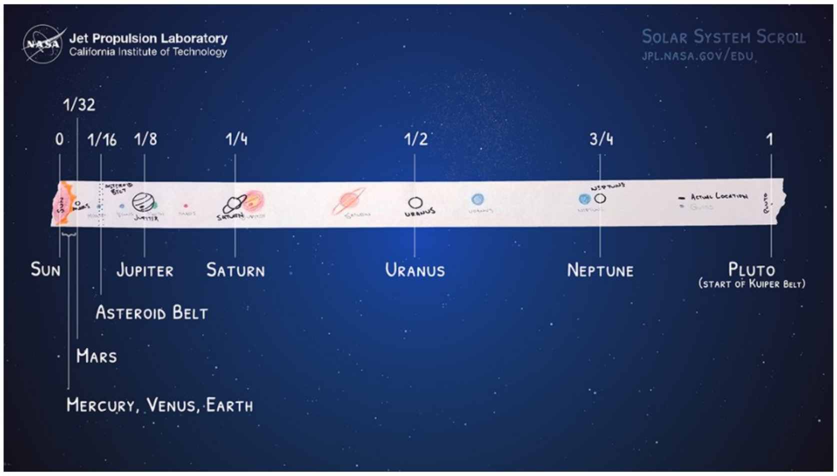
I used NASA Resources and other resources to integrate the subjects of Science, Math Engineering, Technology, and even ELA to create my unit. My focal point of my unit started with a lesson from NASA Jet Propulsion Laboratory (JPL), "How Far is Space?" Then, I built an entire unit for my Algebra 1 Resource Class using many activities and lessons to help review foundational math concepts while scaffolding lessons, and create a meaningful real world connection to science standards to create my unit, "Building Distance Relationships in Space". When students in an Algebra class have a chance to apply their knowledge to science topics, this helps the students to build a deeper understanding through application. I have included a list below of incorporated NASA Resources and NASA Activity Links, which will be in my References list at the end in APA citation format.

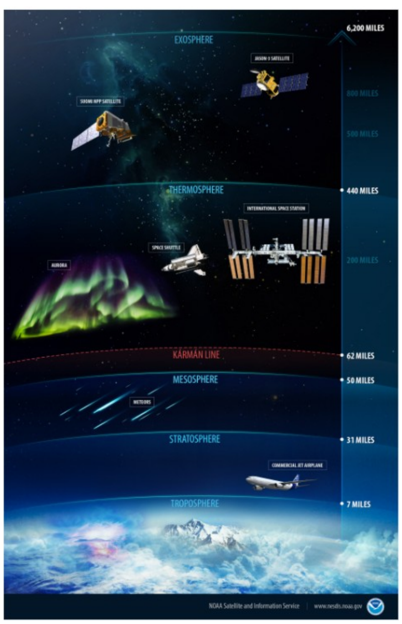
Math Skills Developed in the Lesson

Algebra students will be able to develop a deeper understanding of their mathematical content standards by applying them to science standards through a variety of activities and lessons. Students will be able to build their mathematical knowledge through incorporating the common core standards for mathematical practices. At times when integrating a whole unit, as a teacher I am looking more at the mathematical practices to guide my instructional approach. I want to see my students making sense of the problems and working at solving these problems. When working collaboratively, I am looking to see if my students can build and express their argument skills as well as their reasoning skills. Students will be able to model with mathematics and be able to produce viable solutions for problems presented to them. They will be able to apply proper formulas and tools for each situation presented before them. As a final result, my students have learned self-reflection through questions at the end of an activity or lesson in order to understand and express their learning through an activity or project. They will be able to express their successes and failures along the way in order to build themselves into the best math student by learning and growing from their mistakes as much as from their successes.

NASA Resources & Activity Links:
(These resources will be included in my References list at the end in APA citations)

https://www.jpl.nasa.gov/edu/learn/project/how-far-away-is-space/
https://www.nesdis.noaa.gov/content/peeling-back-layers-atmosphere
https://www.nasa.gov/image-feature/international-space-station-transits-the-full-moon
https://www.youtube.com/watch?v=DMZ5WFRbSTc&t=69s
https://www.jpl.nasa.gov/edu/teach/activity/solar-system-scroll/
https://www.jpl.nasa.gov/edu/teach/activity/create-a-solar-system-scale-model-with-spreadsheets/
https://www.nasa.gov/image-feature/international-space-station-transits-the-full-moon
https://eol.jsc.nasa.gov/ESRS/HDEV/





***Images credit: NASA/JPL**

NGSS Science Standards

HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.

HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

HS-ESS3-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ESS3-4 Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.

HS-ETS1-2 Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.

Crosscutting Concepts: Scale, Proportion, and Quantity

The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)

Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (HS-ESS1-4)

Common Core State Standards for Mathematics

CCSS.MATH.CONTENT.HSA.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

CCSS.MATH.CONTENT.HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.

CCSS.MATH.CONTENT.HSG.MG.A.1 Use geometric shapes, their measures, and their properties to describe objects

CCSS.MATH.CONTENT.HSG.GPE.B.6 Find the point on a directed line segment between two given points that partitions the segment in a given ratio.

CCSS.MATH.CONTENT.HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

CCSS.MATH.CONTENT.HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

CCSS.MATH.CONTENT.HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

CCSS.MATH.CONTENT.8.F.B.4 Constructs a function to model a linear relationship between two quantities.

CCSS-Math Practices:

CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them

CCSS.Math.Practice.MP2 Reason abstractly and quantitatively

CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others

CCSS.Math.Practice.MP4 Model with mathematics

CCSS.Math.Practice.MP5 Use appropriate tools strategically

CCSS.Math.Practice.MP6 Attend to precision

CCSS.Math.Practice.MP7 Look for and make use of structure

CCSS.Math.Practice.MP8 Look for and express regularity in repeated reasoning

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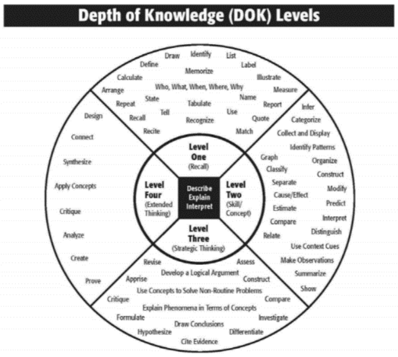
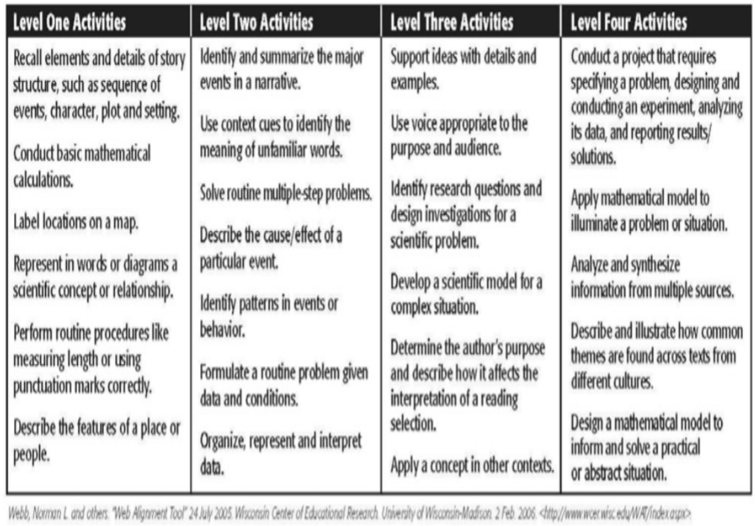
ISTE Standards for Students

Empowered Learner - Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences.

Knowledge Constructor – Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others

Creative Communicator - Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.

Global Collaborator Communicator - Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.

Webb's Depth of Knowledge 	

Level One Activities	Level Two Activities	Level Three Activities	Level Four Activities
Recall elements and details of story structure, such as sequence of events, character, plot and setting. Conduct basic mathematical calculations. Label locations on a map. Represent in words or diagrams a scientific concept or relationship. Perform routine procedures like measuring length or using punctuation marks correctly. Describe the features of a place or people.	Identify and summarize the major events in a narrative. Use context cues to identify the meaning of unfamiliar words. Solve routine multiple-step problems. Describe the cause/effect of a particular event. Identify patterns in events or behavior. Formulate a routine problem given data and conditions. Organize, represent and interpret data.	Support ideas with details and examples. Use voice appropriate to the purpose and audience. Identify research questions and design investigations for a scientific problem. Develop a scientific model for a complex situation. Determine the author's purpose and describe how it affects the interpretation of a reading selection. Apply a concept in other contexts.	Conduct a project that requires specifying a problem, designing and conducting an experiment, analyzing its data, and reporting results/ solutions. Apply mathematical model to illuminate a problem or situation. Analyze and synthesize information from multiple sources. Describe and illustrate how common themes are found across texts from different cultures. Design a mathematical model to inform and solve a practical or abstract situation.

Webb, Norman L. and others. "Web Alignment Tool" 24 July 2005. Wisconsin Center of Educational Research. University of Wisconsin-Madison. 2 Feb. 2006. <http://www.wcer.wisc.edu/WAT/index.aspx>

The 5E Lesson Plan Model includes 5 Levels for Activities: Engage, Explore, Explain, Elaborate and Evaluate. This type of model for my lesson plans allows the teacher to integrate a wide variety of lessons and activities in order to reach a wider range of learners. When students are engaged with multiple types of activities, they benefit with greater growth and development. Using this variety allows for different methods such as group discussions, group activities, reflection on activities successes or misconceptions. The methods covered include but not limited to Webb's Depth of Knowledge Levels which include recall, skill, strategic thinking, and extended thinking. Levels are seen as a transition from one onto the next.

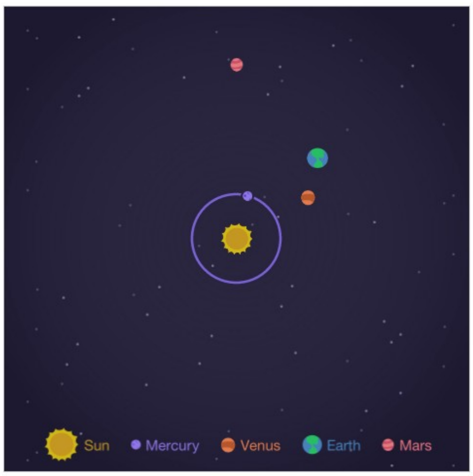
Engage: **Day 1-2: DOK 1-2** **The Solar System and Scientific Notation in Desmos** **https://teacher.desmos.com/activitybuilder/custom/60f423835e6967e29d9805bf** **Objectives:** Students will be able to identify numbers written in scientific notation. Students will be able to write large and small numbers in scientific notation to represent numbers in standard form. Students will be able to compare numbers in scientific notation. **Essential Question:** What is the pattern you see or need to remember to use when writing your numbers in scientific notation? Why do scientists use scientific notation when they are discussing distance in the Solar System?

Procedures:
Diagnostic Pre-Assessment Google Form Combining Questions from JPL Activities/Resources
How far is it to space from Earth's Surface?
How far away from Earth's surface is the International Space Station's orbit?

In this Desmos Activity, students will warm up by putting numbers in order from least to greatest. They will compare the two lists of numbers and discuss which list was easier to sort.

Picture of Slide 6: (created in Desmos)
Looking to self-check how the students write the distance of each planet written using scientific notation.

Put the Planets Into Orbit



Write the distance from the Sun for each planet using scientific notation.

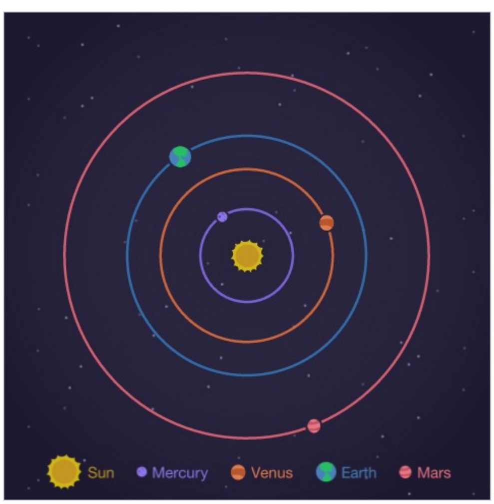
Then press "Check My Work."

Planet	Distance (miles)	Scientific Notation
Mercury	36 000 000	$3.6 \cdot 10^7$
Venus	$67 \cdot 10^6$	
Earth	92 960 000	
Mars	141 700 000	

Check My Work

Picture of Slide 6 Completed: DOK 2
When completed correctly, the students will see each planet rotating, but if the student is incorrect there will be an X where the circle meets the planet instead of starting it's rotation.

Put the Planets Into Orbit



Write the distance from the Sun for each planet using scientific notation.

Then press "Check My Work."

Planet	Distance (miles)	Scientific Notation
Mercury	36 000 000	$3.6 \cdot 10^7$
Venus	$67 \cdot 10^6$	$6.7 \cdot 10^7$
Earth	92 960 000	$9.296 \cdot 10^7$
Mars	141 700 000	$1.417 \cdot 10^8$

Students will be able to explore the use of scientific notation with smaller numbers using a negative exponent.
Students will then double check how to write scientific notation, then practice their own.

Reflection will be our essential question where students will explain how using scientific notation will help when scientists are talking about distance in the Solar System.

Assessments: During Desmos activity, real time student observation of responses to check understanding of scientific notations and comparison of sizes.

Formative Assessment includes slide 6 self-check with a rotating planet when correct.
Formative Assessment Slide 9 and Slide 10 understanding of scientific notation

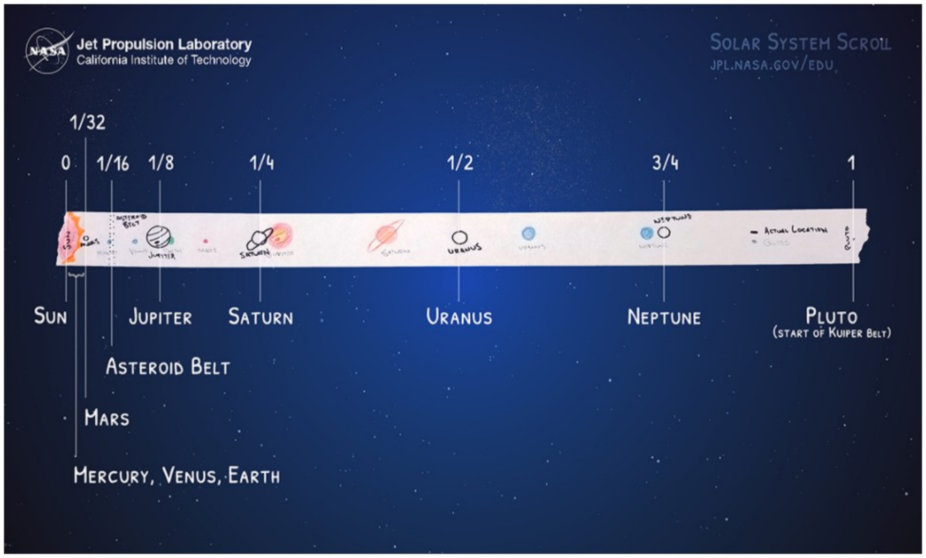
Summative Assessment – Reflecting with explanation of why scientists are using scientific notation when referring to planets and distance in our Desmos Activity.

Engage: Day 2 Solar System Size & Distance
Objectives:
Students will be able to discuss the proportions when discussing the solar system.
Students will be able to create a fractional representation of the solar system.
Students will be able to look at distance by using ratios.

Essential Questions:
How can you represent distance when discussing planets?
Are they evenly spaced? Or are some closer than others?
Explain your thoughts on the distance and spacing of planets using a linear relationship.
Ask students what surprised them about their guesses versus the actual scale of the solar system?
Discussion: Using Jamboard First to have students collaborate facts they may know about our Solar System. Then using another Jamboard have to leave “I wonder” statements with their names to help when we revisit.

Watch YouTube Video Solar System Size and Distance

JPL Activity: Solar System Scroll
https://www.jpl.nasa.gov/edu/teach/activity/solar-system-scroll/



Materials:
Roll of cash register tape or similar
Color Markers and black sharpie
Color Pencils

Procedures:
Prepare strips of arm length piece of rolled paper for each student. On their paper, have students draw and label the Sun on one end and Pluto on the other, using colored pencils or markers. (For our purposes, we include Pluto, but Pluto is not a planet. If you prefer, you can label this end "Kuiper Belt.")

Take a guess! Have students fill in the remaining objects of our solar system in the space between the Sun and Pluto, paying attention to the relative distances between the objects. Are they evenly spaced? Or are some closer than others?

Now with their guesses marked, students can find the actual distances between solar system objects. First, have them fold the strip in half. Using a bold color, label the midpoint (1/2 mark) Uranus. Now, take the side where you have the Sun labeled and fold it to the Uranus mark. The new crease (at the 1/4 mark) is where Saturn is located.

Repeat the last step but this time with the Pluto side. This crease (at the 3/4 mark) is Neptune. Starting with the Sun again, fold the strip of paper to the Saturn mark. This new crease is at the 1/8 mark and is where we would find Jupiter. Repeat again, taking the Sun to the new Jupiter mark. This represents 1/16 and is where the asteroid belt is found. Repeating once more, at the 1/32 mark, we find Mars.

That means that all of the remaining inner planets (Earth, Venus and Mercury) are between Mars and the Sun. So when you hear them called the "inner planets," there is a good reason

why! Have students add a key to their scroll to identify which marks are guesses and which are the actual planet locations.
Assessment: Diagnostic was as a group during Jamboard activities
Formative Assessment - observation during activity for active participants and comparing results from actual and predicted positions.

Summative Assessment Google Form including:
Multiple Choice on your solar system scroll, which planet is represented at ½ of your scroll.
Compare your actual scale that we created together of the solar system to the one you predicted in at least 2 ways.

Reflection Question:
Ask students what surprised them about their guesses versus the actual scale of the solar system?
Would you like to share anything else that you would like your teachers to know?

Explore: Day 3-4 DOK 2-3
Objectives:
Students will gain a better understanding of where space begins.
Students will use a map scale to determine the relative distance to space from the surface of a map.
Students will create a stack of coins representing the appropriate height to mark the edge of space.

Essential Questions:
How does seeing the distance to space from Earth using a 3D model from a 2D map help you create a relationship with this distance?

What type of differences do you have in our 3D model than the 2D model of space?

How does the width of the coins make a difference when stacking them to represent the height of space compared to Earth?

Looking for an equivalence of 62 miles to space. How many coins would be able to represent this above your map of New Jersey?

How far do you need to travel from West Windsor to be able to represent the distance between Earth and space? What would be your new location (city,state)?

How does the width of the coin impact this activity?

JPL Activity: How Far Away is Space?
https://www.jpl.nasa.gov/edu/teach/activity/how-far-away-is-space/

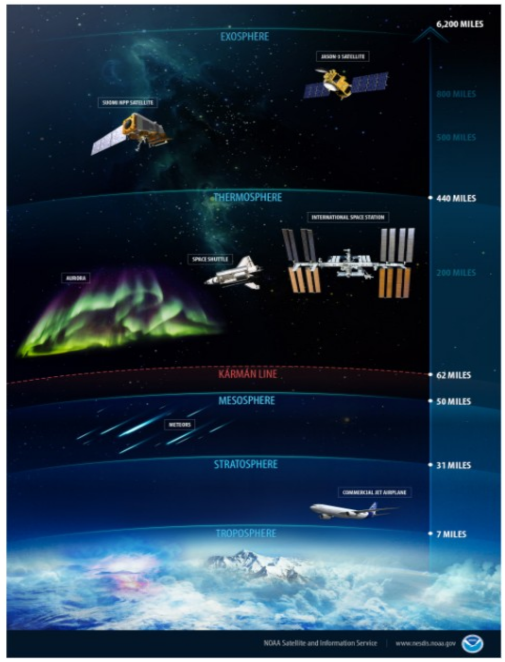
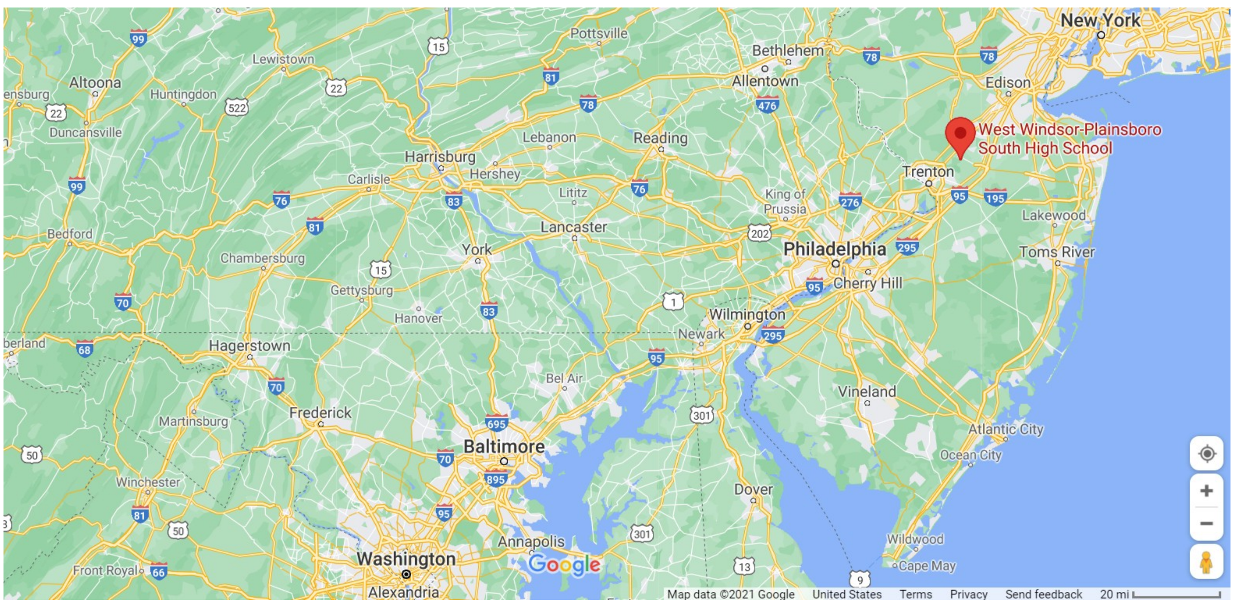


*Image credits: JPL

Materials:
State map with scale distance bar
Various coins
Ruler with millimeter markings

Procedures:
Students will discuss the layers of space with the above photo to create a hook.
Students will then receive a printed out map using Google Maps with a scale bar displayed and West Windsor-Plainsboro High School South as a reference point on this map.



Take a moment for students to work with a partner to find some places that are 62 miles away from High School South. Have the students mark with pencil these places on their maps to be used as a distance reference.

JPL provides this background information: We often think of space as being very far away. Planets are many millions or even billions of miles away, and stars are so far away that their distances are measured in light years. (A light year is the distance light travels in a year and is equal to six trillion miles.) Yet the edge of space – or the point where we consider spacecraft and astronauts to have entered space, known as the Von Karman Line – is only 62 miles (100 kilometers) above sea level.

Ask students how far they would have to travel from the surface of Earth to reach space. After several responses, tell students that the distance to the edge of space is 62 miles above sea level. Mention the altitude of the International Space Station and the Hubble Space Telescope. Share several landmarks, cities, or other notable features that are approximately 62 miles from your school or city. You can also reference locations students may know that are farther than 62 miles to make a point that those places are farther from them than the edge of space.

Hand out maps to each student or group. Have them find the distance scale bar and identify its scale length (20 miles). Ask students to measure the length of their map scale bar in millimeters. 20 miles = x millimeters, so x= __

Based on their measurements, students should now determine what 62 miles on the scale bar equals in millimeters. There are a variety of ways to find this answer, depending on the math concepts with which students are familiar. For simplicity, students could determine how far 60 miles on the scale bar is in millimeters.
Now, students will model the distance from the surface of Earth to space. Have students stack coins on their map until the height of the coins is equal to the millimeter figure they calculated in Step 3. *Each group will be using the same coin, but group A may have quarters and group B may have dimes.

Discussion from JPL:
Why do you think getting to space is so difficult when it's only 62 miles away?
Answer: Space is 62 vertical miles away. It takes a lot of energy to overcome gravity for that distance and gain the speed required to stay in orbit (approximately 17,500 miles per hour) once you've arrived.
How would the distance to space be different from Denver compared with Los Angeles?
Answer: The distance to space from Denver is approximately 61 miles while it's about 62 miles to space from Los Angeles. This is because Denver is 1 mile above sea level while Los Angeles is close to sea level.

Partners will choose centers with extension activities and rotate through together.
Center A: Different types of coins to stack to the same height and explain differences and reasons why with different widths.

Center B: Ask students to make a stack of coins reaching the altitudes of the following objects orbiting Earth: International Space Station: 250 miles (400 km) and Hubble Space Telescope: 340 miles (550 km)
Center C: Ask students to determine how high a stack of coins would need to be to represent the distance from Earth's surface to the Moon, which orbits 238,855 miles (384,400 kilometers) away.

Assessment:

Formative Assessment through discussion and observations from JPL Activity
Students should be able to correctly measure the scale distance bar on the map in millimeters.
Students should be able to correctly determine how far 62 (approximately 60) scale miles span in millimeters.
Students should be able to correctly stack coins to the scale height representing approximately 60 miles.

Summative Assessment will include a reflection question on how the width of each coin affects each group's stack and other activities through centers.

Summative Assessment will also be included on our Google Form to retake at the end of the unit.

Explain Day 5 DOK 3-4

Show Track ISS map and links to video of Earth from ISS.

Groups will share & show us how they represented the distance from the Earth to the ISS.

Reflection Google Form including formative assessment, group work, active member of group, and how this can be expanded. Activity solar system distance bands on map - related to the scale/proportions

Objectives: Students will be able to show a scaled and proportional relationship on their map to explain what they have learned.

Materials:
WWPHSS Map from last activity
Supplies around the classroom including compass, ruler, string, color pencils, and more.

Procedures:
Students will remain in their same partner groups.
Supplies are available around the classroom.

Assessment:
Formative Assessment will be observed during this lesson.

Ask them their summative question: Just as solar system models have rings to show rotations, how can you show what you know now on your WWPHSS map we used in our coin distance activity.

Elaborate; Day 6-7 DOK 3-4
Objective:
Students will be able to make a choice of an extension activity for distance in space.

Essential Questions:
Tell me more about relationships and distance compared to Earth.

Materials:
Varies with activities

Procedures:
The following can be used as choice activity for Evaluation individually or with a partner.
***These can be used as Extensions** if not chosen for Final choice activity.

(1) PhET Sims Showing Gravity and Orbits with the sun, earth, moon, and/or space station https://phet.colorado.edu/sims/html/gravity-and-orbits/latest/gravity-and-orbits_en.html Groups will be able to show us through a variety of modalities (at least 2) one of the following: how does an object x rotate around object y
- the distance from one object to another
- using data to show the movement of the ISS
- research which apps help us or guide us with any of the above learning objectives and make a video to teach us about your app

(2) Solar System Bead Activity https://www.jpl.nasa.gov/edu/teach/activity/solar-system-bead-activity/
Use this activity as a template for an idea, but your representation can be made in a multitude of ways. Students will need to include a paragraph reflection on this activity.

(3) Creating a Solar System using a Spreadsheet https://www.jpl.nasa.gov/edu/teach/activity/create-a-solar-system-scale-model-with-spreadsheets/
Use this activity as a template for an idea, but your representation can be made in multiple ways. Students will need to include a paragraph reflection on this activity.
Picture of Spreadsheet: **https://www.jpl.nasa.gov/edu/pdfs/scaless_reference.pdf**

Day 2: Have each person or group share 2 new things they learned and talk for less than 5 minutes about their extension activity.

Assessment:
Formative Assessment: through observation in class and during partner work.

Summative Assessment: Completion of their chosen activity correctly, completely, and with precision. Using a point system for their share and talk which will be given to students Day 1. Also Google Form at the end of the unit.

Evaluate: Day 7
Objectives:
Students will build a relationship with distance and objects in space.

Procedures:
Retake Google Form from beginning of unit to be used as a compare and contrast showing growth and understanding.

If time also, students will be able to explore more activities from unit, find other resources on their own to share on Jamboard #3, and during the last part of class we will revisit our Jamboard #2 “I wonder” posts.

Assessment:
Students may use their resources from this unit during their Post Assessment Google Form.

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