| Earth's Place in the Universe | |
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| **Grade: 5** | **Recommended Timeframe:** Four – five 45 minute class periods. |
| **Unit Overview** Students will become familiar with the size and scale of the solar system. The will explore how light intensity is impacted by distance. Students will complete an engineering design lesson focused on rockets and how rockets have been used to help us learn more about our solar system and the Universe. | |
| **Essential Questions:** What tools and information can we use to understand Earth's place in the Universe? | **Major Concept**s<br>Science- size and scale of the solar system. Impact of distance on light intensity.<br>Technology- Use of light probes to collect data. Use of tablets to gather information.<br>Engineering- Rockets and influence of mass on the height and accuracy achieved by model rockets.<br>Math- Represent and interpret data, graph points, place value, multi-digit whole numbers and decimals to hundredths. |
| **Suggested Lesson Sequence**<br><br>Lesson 1 – Establishing Context "Solar Systems Scale" (45-90 minutes)<br>Lesson Overview: Students build a scale model of the solar system for both distance between planets and diameter of each planet.<br><br>Lesson 2 – Light Intensity "Distance from the Sun" (45 minutes)<br>Lesson Overview: Students determine the intensity of light at different distances using Vernier probes.<br><br>Lesson 3 – Engineering Design of Rockets (45 - 90 minutes)<br>Lesson Overview: Students investigate the relationship between the mass of a rocket and how high the rocket will travel. | |
| **Materials, Tools, & Technology**<br>*300 foot tape measures*<br>*Tablets and Internet connection (Lesson 1)*<br>*Vernier LabQuest & light probes (Lesson 2)*<br>*Film canisters, seltzer tablets and a variety of types of paper and card stock (Lesson 3)* | **Vocabulary**<br>Click here to enter text. |
| **STEM Professional Involvement Ideas**<br><br>● NASA Flight Systems Engineer – available online at nasa.gov | |

**Earth's Place in the Universe**

# Standards

- **5-ESS1-1.** Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.
- **3-5.ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

- 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.

- **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- **3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled

- **5.NBT** Understand the place value system. • Perform operations with multi-digit whole numbers and with decimals to hundredths.
- **5.MD** Measurement and Data - Make a line plot to display a data set of measurements in fractions of a unit.
- **5.G** Graph points on the coordinate plane to solve real-world and mathematical problems
- **6.RP.A** Understand ratio concepts and use ratio reasoning to solve problems.

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| **Notes** |
| **Appendices**<br><br>Appendix A: Teacher Resources<br>Appendix B: Student Resources<br>• Rockets – Exploring the Universe |
| |

| Solar System Scale | | |
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| **Grade Level:** 5 | **Time Needed:** 50 Minutes | **Subjects:** Science, Math, Technology |

**Objective:** Students will build a scale model of the Solar System

**Standards:**

Science

NGSS.5-ESS1-1

Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distance from Earth.

ESS1.A: The Universe and its Stars

The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)

Math

CCSS.MATH.CONTENT.6.RP.A.3.D

Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities. (Grade 6 Standard)

ELA

CCSS.ELA.LITERACY.W.5.2:

Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

**Background Information:**

Most of the mass in the solar system is in the Sun, with much of the remaining mass in Jupiter. The rest is divided through the inner rocky planets (composed of materials that don't easily evaporate at higher temperatures closer to the sun), gas planets (mostly hydrogen and helium), and the ice giants of Uranus and Neptune (ammonia and methane).

Our universe and Solar System are expansive, with lots of empty space. A 3-inch diameter "orange" sized Sun, to proper scale, would be three football fields away from Pluto. Pluto would be the size of a silt particle. On the same scale, the nearest star to us (other than the Sun) would be 1400 miles away.

Many representations of the Solar System and our Earth-Moon system are created to fit nicely on a page of a book or a neat handout. The actual locations with respect to the other bodies of the Solar System and Milky Way Galaxy are much different.

"Solar" comes from Latin "Sol" meaning Sun. There is only one "Solar System" and it's our own star-planet system.

**Materials:**

- Rulers/Measuring Tape/Yardsticks
- Notecards
- 300 foot measuring tape

**Vocabulary:**

**Scale:** The ratio of the length in a drawing (or model) to the length of the real thing

**Model:** Something that is made by people to describe or demonstrate details about an object or a scientific phenomenon

**Ratio:** A relationship between two numbers that shows the relative sizes or numbers of two or more things

**Star:** A huge sphere of very hot, glowing gas that

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| | produces its own light and energy<br>**Planet:** A planet is an object orbiting a star that is large enough to be rounded by its own gravity |

**Resources:**

- Student Resources and Reproducibles
    -
- Teacher resources including more detailed content information
    - Scale model calculator: http://www.exploratorium.edu/ronh/solar_system/
    - Another scale model calculator: http://thinkzone.wlonk.com/SS/SolarSystemModel.php
    - YouTube video of scale model in seven mile stretch of desert: https://www.youtube.com/watch?v=zR3Igc3Rhfg
    - Powers of Ten: https://www.youtube.com/watch?time_continue=3&v=Ww4gYNrOkkg
    - If the moon were one pixel: http://joshworth.com/dev/pixelspace/pixelspace_solarsystem.html

**Procedures:**

- What is a model? How do we use scale and ratio? Have a picture of a model aircraft box showing the scale. In the example below, 1:48 scale shown on the lower right corner means one inch on the model is 48 inches in real life, or the model is 1/48th the size of the actual aircraft.


- What is the sun?
- If the sun was the size of an orange, where would the Earth be?
    - Have students guess and record answers, or alternatively have students stand in a location where the sand grain sized Earth would be.
- Break into groups of three and have students investigate specific planets in small groups using online resources. They will create a notecard with: Name of planet, interesting fact, and distance from the sun. Remember to also do the Sun and Pluto. Additional data can be collected on the cards if needed.
    - Draw “example” card on whiteboard and specify required data
    - Students research online and create cards
- Have student lay about 180 ft of measuring tape down the hallway or outside. The larger the distance the better. Students may create their own scale model or the class can create one together. You’ll want about 150 feet for a ½ inch diameter sun...and Pluto will sit out even further. (Data for this below)
    - Students working on this should mark off distance with masking tape in 10 foot increments

- Teams will use their tape measures to get smaller increments if needed.

- If the class creates one scale model, have each group place all their planets on the string
- Once created, walk with students and assign one student or group to read all the facts about that specific planet. Continue asking questions of students, get wonderings, etc.
- At Neptune or Pluto, or at the end of the string, say, “Okay everyone. Now look at the Sun. What do you think the sun looks like from here?”
- Clean-up model
- Show students another scale model that was built in the desert: https://www.youtube.com/watch?v=zR3Igc3Rhfg
- If there’s time, show students or have students investigate this website that shows everything to scale if the moon is only a pixel: http://joshworth.com/dev/pixelspace/pixelspace_solarsystem.html

**Differentiation:**

Supports
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Extensions
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**Assessment Opportunities:**
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**Citations:**
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# Scale Model: Solar System

*Based on a ½ inch diameter Sun

| Body | Distance (feet) | Size (inches) |
|---|---|---|
| Sun | 0 | 0.50 |
| Mercury | 1 | 0.0017 |
| Venus | 3 | 0.0043 |
| Earth | 4 | 0.0045 |
| Mars | 6 | 0.0024 |
| Jupiter | 23 | 0.0513 |
| Saturn | 42 | 0.0418 |
| Uranus | 85 | 0.0168 |
| Neptune | 134 | 0.0163 |
| Pluto | 177 | 0 |

Earth's Place in The Universe -- Distance from the Sun

| **Grade Level:** 5 | **Time Needed:** 40 Minutes | **Subjects:** Science, Math, Technology |
|---|---|---|

**Objective:** Students will explain how distance affects the brightness of stars.

**Standards:**

Science

NGSS.5-ESS1-1

Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distance from Earth.

ESS1.A: The Universe and its Stars

The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)

Math

CCSS.MATH.CONTENT.5.G.A.2

Graph points on the coordinate plane to solve real-world and mathematical problems

ELA

CCSS.ELA.LITERACY.W.5.2

Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

**Background Information:**

The lumen is a unit of measurement for the brightness of visible light to the eye, just as the gram is a basic unit for measuring mass. If a light bulb is blindingly bright, it produces a lot of *lumens*. A typical light bulb in your home might produce about 1000 lumens. *Lumen* is related to the word *luminous* which means "bright" or "radiant."

One thousand lumens, concentrated into an area of one square meter, lights up that square meter with an illuminance of 1000 lux. The same 1000 Lumens, spread out over ten square meters, produces an illuminance of only 100 Lux

**Materials:**

- Flashlights or single light bulb in center of room
- Ruler
- LabQuest
- Light Sensor
- Data table
- Graph paper (Not required but helpful)

**Vocabulary:**

**Lumen:** a unit of measurement for the brightness of visible light to the eye

**Lux:** the SI unit of illuminance, equal to one lumen per square meter

**Apparent magnitude:** Brightness of the star/object as viewed from a distance

**Absolute magnitude:** Actual brightness of the star/object

**Resources:**

- Student Resources and Reproducibles
    - https://drive.google.com/drive/folders/0B4hSePEu3I88Tk1BYVdrTzhSLVU
- Teacher resources including more detailed content information
    - https://www.vernier.com/experiments/ewv/32/distance_from_the_sun/
    - https://betterlesson.com/lesson/635919/investigating-star-brightness-distance

**Procedures:**

- Have students look at a picture of different stars, some near and some far away. Ask and collect thoughts from students for each question:
  - What are some things that you notice?
  - Why do some stars appear very bright, and others very dim?
  - How could we test _________________?
- Discuss vocabulary terms
- Hand out data collection tables
- Introduce LabQuest and light sensor probe. Verify that students know what part of the probe is light sensitive...it's like a little silicon solar cell that creates voltage in light.
  - The light probe has three settings. Use the first setting, of 0 - 6000. (The 0 - 150,000 is used for direct sunlight)
- Assign student groups. Explain the process of taking 10 data points at varying distances from the light source and recording on the table. There are additional slots for more data!
- Have one student from each group collect LabQuest, measuring device, flashlight...or set up stations beforehand.
- Students expand to different areas to collect data for 10 minutes
- Pass out graphing paper. Have students graph their data. It may be good to have students represent their data in a way that makes sense to them, before
  - Grouping may stay with students in current groups or back at their desks.
  - Reinforce independent and dependent variable position on X/Y Axis. Distance from light source on X-axis (Independent Variable) and Lux on Y-axis (Dependent Variable)
- Group questions:
  - What do you see from your data? Curve? Line?
  - If we measured the sun closer or further away, what would your lux measurements look like?
- Students write a short paragraph about their data and something they are wondering about related to the topic.

**Differentiation:**

| Supports | Extensions |
|---|---|
| Click here to enter text. | Click here to enter text. |

**Assessment Opportunities:**

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**Citations:**

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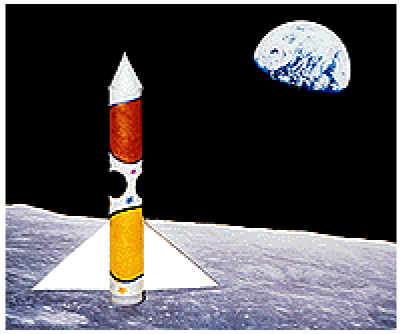
**Rockets**

**Exploring Earth's Place in the Universe**



| **Grade Level:** 5 | **Time Needed:** One or two 45 minute class periods | **Subjects:** STEM |
|---|---|---|

**Objective:**

1. Students will investigate the relationship between the mass of a rocket and how high the rocket will travel.
2. Students will conduct an inquiry investigation to determine the optimal proportions of water and seltzer tablet to allow a rocket to reach maximum height.
3. Students will design a rocket capable of carrying a payload of 15 grams and reaching a height of 3 meters with accuracy.

**Standards:**

**Engineering**

**3-5.ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

**Science Practices -**

- Asking questions and defining problems
- Plan and carry out investigations
- Analyzing and interpreting data
- Using math and computational thinking
- Engaging in argument from evidence

**Math**

**5.MD** Represent and Interpret data

**5.MD.B.2** Make a line plot to display a data set of measurements in fractions of a unit.

**5.G.A** Geometry

**5.G.A.1** Graph points on the coordinate plane to solve real-world and mathematical problems.

**Background Information:**

**Newton's First Law of Motion** states that an object at rest will remain at rest unless acted on by an unbalanced force. An object in motion continues in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

- How does it relate to rocket science? A rocket will stay on the launch pad until a force blasts it off. Once in space, where there is no gravity, a rocket will continue to move unless retrorockets are fired to slow the rocket down.
- Model rockets are acted on by gravity.

**Newton's Second Law of Motion** states that acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated), the greater the amount of force needed (to accelerate the object).

- How does it relate to rocket science? The main forces acting on a model rocket in flight are the weight of the rocket and drag as the rocket moves through the air.

**Newton's Third Law of Motion:** For every action, there is an equal and opposite reaction. The rocket's

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| | initial velocity comes from the pressure of the carbon dioxide that builds up in the film can during the chemical reaction of the seltzer tablet and water. The "push" that the escaping carbon dioxide gives the rocket determines the speed and height of the rocket.<br>• How does it relate to rocket science? A rocket can lift off from a launch pad only when it expels gas from its engine. The rocket pushes against the gas, and the gas in turn pushes against the rocket. Thrust is the force that causes the rocket to lift.<br><br>The terms **mass and weight** are often used interchangeably but they are different things. The mass of a body is the measure of how much matter it contains. Mass is made up of matter. Weight is the measure of gravity pulling on the mass of an object or pulling on the matter making up the object.<br><br>Chemical reaction - When you mix effervescing tablets with water, a chemical reaction takes place between the citric acid and sodium bicarbonate contained in the tablet and the water. This chemical reaction creates many, many bubbles of carbon dioxide gas. Citric acid is a weak acid and is in the juice of most citrus fruits like lemons or limes. Sodium bicarbonate is basically baking soda. (Baking soda and vinegar [acetic acid] produce the same reaction when mixed together. Lot of bubbles of carbon dioxide gas!) |
| | **Vocabulary:**<br>Mass<br>Apex<br>Chemical reaction |

**Resources:**

**Videos**

- Mass vs weight video - http://education.ssc.nasa.gov/mvw_stretching_mass_video.asp
- Flight Systems Engineer - http://www.jason.org/tracy-drain-systems-engineer
- Apollo 8 - https://www.youtube.com/watch?v=FzCsDVfPQqk
- Pale blue dot - https://www.nasa.gov/jpl/voyager/pale-blue-dot-images-turn-25
- NASA Education - https://www.nasa.gov/audience/foreducators/5-8/index.htmlJupiter Flyby - https://www.missionjuno.swri.edu/news/juno-completes-jupiter-flyby
- Myths about the solar system - https://www.youtube.com/watch?v=Iz6aR-WATYY
- Elementary design process - http://www.eie.org/overview/engineering-design-process
- Rocket directions for students - file:///C:/Users/drainbot/Downloads/pop-rocket.pdf

**Guiding Question**

How do rocket scientists design a rocket to launch for a specific mission?

**Engineering Challenge:**

Design a rocket that will consistently reach a height of 15 feet.

Must have a nosecone, fins and paper body

Must use ½ of a seltzer tablet

Make the lightest rocket possible then determine the amount of payload the rocket can carry and still reach 3 meters.

**Procedures:**

1. Students will conduct trials launching Seltzer Rockets and comparing the mass of the rocket with the height it obtains. The Seltzer Rocket is powered using the action-reaction principles of Newton's Third Law of Motion: For every action there is an equal and opposite reaction.
2. Students will begin with a "blast off" trial run to gain experience with launching their rockets. Have students then fill the canister about 1/3 full with water and then insert half a seltzer tablet. Push the top in firmly. **Invert** the rocket, place it on its top and then into a plastic basin or dish pan. Wait for lift off.
3. Once all students have successfully launched a film canister they need to create a data table to record:

   Mass of the Rocket

   Height of launch

   Time for rocket to return to earth.
4. Next students need to design two rockets with different masses. Students will decide on the materials to use and will then build their rockets.
5. Wrap and tape a tube of paper around the film canisters to make a rocket body. Slide an empty, film canister into the tube so that the canister opens at one end of the tube. Securely tape the paper tube to the canister. You do not want the paper and canister body to separate.
6. Cut two or three fins/rocket and tape them to the paper rocket bodies.
7. Make nose cones by cutting circles out of paper. Tape the nose cones onto the paper rocket bodies.
8. Turn the rockets upside down and fill the canister 1/3 full with water. Mark the water line on the canister so you fill it with the same amount of water for each launch.
9. Measure the mass of each of the rockets and record the information in the data table.
10. Prepare to launch one rocket at a time.
11. A minimum of two observers are required for the launch. One to record the flight time (amount of time it takes from launch till the rocket returns to earth). The other observer(s) to determine the height of the rocket at its apex and the accuracy of the rocket.
12. Drop in a 1/2 tablet of Seltzer tablet into one rocket and snap the lid on tight.
13. Quickly stand the rocket on its lid and stand back.
14. Time how long the rocket is in flight, the accuracy and the height of the launch. Record the data in the data table.
15. Repeat step 8-14 two more times for each rocket for a total of six flights.
16. Calculate the average height and time in flight for each rocket.
17. Graph the data on a bar graph.

| Rocket 1 – Mass | Height | Accuracy (Y/N) | Total Time in air |
|---|---|---|---|
| Launch 1 | | | |
| Launch 2 | | | |
| Launch 3 | | | |
| Average | | | |

| Rocket 2 – Mass | Height | Accuracy (Y/N) | Total Time in air |
|---|---|---|---|
| Launch 1 | | | |
| Launch 2 | | | |
| Launch 3 | | | |
| Average | | | |

**Differentiation:**

Supports

- Student Engineering Design Lab with data tables
- More advanced students can design their own data tables.

Extensions

Inquiry Questions to Explore:

- Use more or less fuel (effervescing tablets and water)
- Use hot or cold water
- Crush the seltzer tablet
- Use baking soda and vinegar
- Change the design of the rocket

**Assessment Opportunities:**

1. Explain how the mass of the rocket affects the height it travels when the amount of water and Seltzer tablet are kept constant.
2. Why did the rockets launch to different heights?
3. Describe other properties/factors that could be changed to make the rocket launch higher or lower.
4. Why would NASA need to launch rockets to different heights?

**Citations:**

https://media.nationalgeographic.org/assets/file/Seltzer_Rocket_Lab_Activity.pdf