OUT OF THIS WORLD

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The Nature of Mathematics
- Mathematical ideas can be represented concretely, graphically, and symbolically.
- Numbers and shapes—and operations on them—help to describe and predict things about the world around us.

The Physical Setting
- The earth is one of several planets that orbit the sun, and the moon orbits around the earth.
- Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light.
- Things on or near the earth are pulled toward it by the earth's gravity.
- Like all planets and stars, the earth is approximately spherical in shape. The rotation of the earth on its axis every 24 hours produces the night-and-day cycle. To people on earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the earth once a day.
- Nine planets of very different size, composition, and surface features move around the sun in nearly circular orbits. Some planets have a great variety of moons and even flat rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geological activity. The earth is orbited by one moon, many artificial satellites, and debris.
- We live on a relatively small planet, the third from the sun in the only system of planets definitely known to exist (although other, similar systems may be discovered in the universe).
- The moon's orbit around the earth once in about 28 days changes what part of the moon is lighted by the sun and how much of that part can be seen from the earth—the phases of the moon.
- The moon looks a little different every day, but looks the same again about every four weeks.
- The sun can be seen only in the daytime, but the moon can be seen sometimes at night and sometimes during the day. The sun, moon, and stars all appear to move slowly across the sky.

The Designed World
- Communication technologies make it possible to send and receive information more and more reliably, quickly, and cheaply over long distances.

The Mathematical World
- Tables and graphs can show how values of one quantity are related to values of another.
- Graphical display of numbers may make it possible to spot patterns that are not otherwise obvious, such as comparative size and trends.
- The graphic display of numbers may help to show patterns such as trends, varying rates of change, gaps, or clusters.

Common Themes
- In something that consists of many parts, the parts usually influence one another.
- A system can include processes as well as things.
- Geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, and stories can be used to represent objects, events, and processes in the real world, although such representations can never be exact in every detail.
- Things change in steady, repetitive, or irregular ways—or sometimes in more than one way at the same time. Often the best way to tell which kinds of change are happening is to make a table or graph of measurements.
- Different models can be used to represent the same thing. What kind of a model to use and how complex it should be depends on its purpose. The usefulness of a model may be limited if it is too simple or if it is needlessly complicated. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering.
- Seeing how a model works after changes are made to it may suggest how the real thing would work if the same were done to it.
- Things that change in cycles, such as the seasons or body temperature, can be described by their cycle length or frequency, what the highest and lowest values are, and when they occur. Different cycles range from many thousands of years down to less than a billionth of a second.

Habits of Mind
- Add, subtract, multiply, and divide whole numbers mentally, on paper, and with a calculator.
- Make sketches to aid in explaining procedures or ideas.
- Use calculators to compare amounts proportionally.
- Organize information in simple tables and graphs and identify relationships they reveal.
- Use numerical data in describing and comparing objects and events.
Abilities Necessary to do Scientific Inquiry
- Develop descriptions, explanations, predictions, and models using evidence.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Use mathematics in all aspects of scientific inquiry.

Understandings About Scientific Inquiry
- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Mathematics is important in describing and comparing objects and events.

Position and Motion of Objects
- The position of an object can be described by locating it relative to another object or the background.

Objects in the Sky
- The sun, moon, stars, clouds, birds, and airplanes all have properties, locations, and movements that can be observed and described.

Earth in the Solar System
- The earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The sun, an average star, is the central and largest body in the solar system.
- Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.
- Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the earth’s surface and explains the phenomena of the tides.

National Science Education Standards
National Research Council
National Academy Press

Common Core State Standards for Math

Mathematical Practices
- Reason abstractly and quantitatively. (MP2)
- Model with mathematics. (MP4)
- Use appropriate tools strategically. (MP5)

Measurement and Data
- Represent and interpret data. (4.MD, 5.MD, 6.MD)
- Geometric measurement: understand concepts of angle and measure angles. (4.MD)
- Convert like measurement units within a given measurement system. (5.MD)

Geometry
- Graph points on the coordinate plane to solve real-world and mathematical problems. (5.G)

Ratios and Proportional Relationships
- Understand ratio concepts and use ratio reasoning to solve problems. (6.RP)

Statistics and Probability
- Develop understanding of statistical variability. (6.SP)
- Summarize and describe distributions. (6.SP)

Common Core State Standards for Math
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Topic
Planets

Key Question
How can we classify the eight planets?

Learning Goals
Students will:
• read tables and charts to learn about various aspects of the planets and their relationships with one another, and
• use Venn diagrams and graphs to organize information about the planets.

Guiding Documents
Project 2061 Benchmarks
• The earth is one of several planets that orbit the sun, and the moon orbits around the earth.
• Like all planets and stars, the earth is approximately spherical in shape. The rotation of the earth on its axis every 24 hours produces the night-and-day cycle. To people on earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the earth once a day.
• Tables and graphs can show how values of one quantity are related to values of another.
• Graphical display of numbers may make it possible to spot patterns that are not otherwise obvious, such as comparative size and trends.
• Use numerical data in describing and comparing objects and events.

NRC Standards
• Mathematics is important in all aspects of scientific inquiry.
• The earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The sun, an average star, is the central and largest body in the solar system.
• Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.

Common Core Standards for Math*
• Represent and interpret data. (4.MD, 5.MD, 6.MD)

Math
Using Venn diagrams
Graphing
Equalities and inequalities
Whole number operations

Science
Earth science
• astronomy
• planets

Integrated Processes
Observing
Comparing and contrasting
Classifying
Recording data
Interpreting data
Drawing conclusions

Materials
Student pages
Crayons or colored pencils
Scissors

Background Information
Much has been discovered about our planets as a result of information gathered by Voyagers 1 and 2. Students should be encouraged to look for articles that continue to report on new information about our solar system. An excellent web site for current information is http://nineplanets.org.

Management
1. Divide the class into pairs or collaborative learning groups for this activity. Alternate between small group activity and whole group discussions.
2. Each group of students needs one set of planet symbols to manipulate on the Venn diagrams. There are seven sets of symbols on the page.
3. The two pages with pictures of the planets and the sun can be copied and glue together as a visual representation of the relative sizes of the planets.

Procedure
1. Discuss with students what they already know about the planets. (total number [eight], appearance, distance from the Earth, etc.). Have them tell their sources of information whenever possible.
2. Discuss the **Key Question:** How can we classify the eight planets? [size, appearance, having moons, etc.]
3. Distribute the first two student pages. Have students use the *Planetary Facts* information to compare the size of the planets, whether they have rings, and whether they have moons.
4. Guide the students to choose three more attributes with which to classify the planets. Have groups compare their results and discuss any differences.
5. Distribute the planet symbols and the Venn diagram pages. Have the students cut apart one set of symbols and use them to complete the Venn diagrams. Once they have correctly arranged the symbols, have them record the names of the planets in the correct spaces.
6. As a whole class, discuss similarities and differences of the planets from information recorded on the Venn diagrams.
7. Hand out the two graph pages and instruct students to use the information in the *Planetary Facts* table to complete the graphs.
8. Distribute the final page of questions and allow time for students to complete the page.
9. With the whole class, make a list of what has been learned.

### Connecting Learning

1. Which planets have rings? [Jupiter, Saturn, Uranus, Neptune] What fraction of the planets is that? [1/2]
3. Which planets are larger than the Earth? [Jupiter, Saturn, Uranus, Neptune] What fraction of the planets is that? [1/2]
5. Would you like to live on a planet with a longer day? How do you think your life would change?
6. How many planets were there in the intersection of the three-circle Venn diagram? [four] Which planets were they? [Jupiter, Saturn, Uranus, Neptune]
7. Do more planets have rings or days longer than 24 hours? [more planets have rings] How do you know?
8. Which planet has the most known moons? [Jupiter] Where did you find this information?
9. What is the total number of known moons in our solar system? [166]
10. Which two planets are the closest in size? [Venus and Earth]
11. Which two planets have the closest length of day? [Earth and Mars] How many minutes difference is there between them? [41 minutes]
12. Which data display did you find to be the most helpful? Why?
13. What are you wondering now?

### Extensions

1. Enlarge the Venn diagrams so that they will accommodate the cutouts of the planets. Arrange the planets by a variety of attributes such as
   - smallest to largest
   - longest day to shortest day
   - no moons to most moons
   Be sure students label each continuum clearly: which is smallest, etc.
2. Research information on newly-discovered planet-like objects such as Sedna and Quaoar.

### Curriculum Correlation

**Language Arts**
Have students do research reports on individual planets. The *National Geographic* is an excellent source.

**Art**
Let each group choose a planet to make in papier-mâché by covering a balloon. Have students research the visual characteristics of their planet to represent it as accurately as possible without regard to its size in relation to other planets. Challenge students to create unique ways to show features such as the rings!

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Key Question

How can we classify the eight planets?

Learning Goals

Students will:

• read tables and charts to learn about various aspects of the planets and their relationships with one another, and

• use Venn diagrams and graphs to organize information about the planets.
<table>
<thead>
<tr>
<th>PLANET</th>
<th>Approximate Diameter</th>
<th>Approximate Period of Rotation</th>
<th>Moons</th>
<th>Rings?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>4,900 km</td>
<td>59 days (176 days) *</td>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>Venus</td>
<td>12,100 km</td>
<td>243 days (117 days) *</td>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>Earth</td>
<td>12,800 km</td>
<td>23 hours, 56 minutes</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>Mars</td>
<td>6,800 km</td>
<td>24 hours, 37 minutes</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>Jupiter</td>
<td>143,000 km</td>
<td>9 hours, 55 minutes</td>
<td>63</td>
<td>Yes</td>
</tr>
<tr>
<td>Saturn</td>
<td>120,600 km</td>
<td>10 hours, 39 minutes</td>
<td>62**</td>
<td>Yes</td>
</tr>
<tr>
<td>Uranus</td>
<td>51,100 km</td>
<td>17 hours, 14 minutes</td>
<td>27</td>
<td>Yes</td>
</tr>
<tr>
<td>Neptune</td>
<td>49,500 km</td>
<td>16 hours, 7 minutes</td>
<td>13</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* length of day sunrise to sunrise

** new moons are constantly being discovered
Sort out the planets. Next to each planet’s name, color in those spaces that are true.

<table>
<thead>
<tr>
<th></th>
<th>Larger than Earth</th>
<th>Has Ring(s)</th>
<th>Has Moon(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mars</td>
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<td></td>
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<tr>
<td>Jupiter</td>
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<tr>
<td>Saturn</td>
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<tr>
<td>Uranus</td>
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<td></td>
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<tr>
<td>Neptune</td>
<td></td>
<td></td>
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</tbody>
</table>

Select three different characteristics and compare the planets according to those.
Cut out these symbols to use on the Venn Diagrams.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Symbol</th>
<th>Symbol</th>
<th>Symbol</th>
<th>Symbol</th>
<th>Symbol</th>
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<th>Symbol</th>
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<tbody>
<tr>
<td>Mercury</td>
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<tr>
<td>Venus</td>
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<td>Venus</td>
<td>Venus</td>
<td>Venus</td>
<td>Venus</td>
<td>Venus</td>
<td>Venus</td>
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<tr>
<td>Earth</td>
<td>Earth</td>
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<td>Mars</td>
<td>Mars</td>
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<td>Mars</td>
<td>Mars</td>
<td>Mars</td>
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<tr>
<td>Jupiter</td>
<td>Jupiter</td>
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<td>Jupiter</td>
<td>Jupiter</td>
<td>Jupiter</td>
<td>Jupiter</td>
<td>Jupiter</td>
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<tr>
<td>Saturn</td>
<td>Saturn</td>
<td>Saturn</td>
<td>Saturn</td>
<td>Saturn</td>
<td>Saturn</td>
<td>Saturn</td>
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<tr>
<td>Uranus</td>
<td>Uranus</td>
<td>Uranus</td>
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<td>Uranus</td>
<td>Uranus</td>
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<tr>
<td>Neptune</td>
<td>Neptune</td>
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<td>Neptune</td>
<td>Neptune</td>
<td>Neptune</td>
<td>Neptune</td>
<td>Neptune</td>
</tr>
</tbody>
</table>
Use the information from the chart to place the planets in the correct circle or intersection of circles.
Use the information from the chart to place the planets in the correct circle or intersection of circles.
Graph the number of moons each planet has.

<table>
<thead>
<tr>
<th>Number of Moons</th>
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<tbody>
<tr>
<td>36</td>
</tr>
<tr>
<td>39</td>
</tr>
<tr>
<td>42</td>
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<td>45</td>
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<td>57</td>
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<tr>
<td>60</td>
</tr>
<tr>
<td>63</td>
</tr>
<tr>
<td>66</td>
</tr>
<tr>
<td>69</td>
</tr>
</tbody>
</table>

Mercury | Venus | Earth | Mars | Jupiter | Saturn | Uranus | Neptune |
Graph the diameters of the planets.
Use the Venn Diagrams or charts to answer the following questions.

1. Which planets are larger than Earth?

2. Which two planets are closest in size?

3. What percent of the planets are smaller than Earth?

4. Which planet have moons?

5. Which planet has the most moons?

6. What is the total number of known moons in our solar system?

7. What is the average number of moons per planet?

8. Which planets have days that are longer than 24 hours?

Think of two more questions you can ask your classmates. Write them below.
THE SOLAR SYSTEM

MERCURY
VENUS
EARTH
MARS

JUPITER
Connecting Learning

1. Which planets have rings? What fraction of the planets is that?

2. Which planets have moons? What fraction of the planets is that?

3. Which planets are larger than the Earth? What fraction of the planets is that?

4. Which planets have days longer than 24 hours? What fraction of the planets is that?

5. Would you like to live on a planet with a longer day? How do you think your life would change?
Connecting Learning

6. How many planets were there in the intersection of the three-circle Venn diagram? Which planets were they?

7. Do more planets have rings or days longer than 24 hours? How do you know?

8. Which planet has the most known moons? Where did you find this information?

9. What is the total number of known moons in our solar system?
10. Which two planets are the closest in size?

11. Which two planets have the closest length of day? How many minutes difference is there between them?

12. Which data display did you find to be the most helpful? Why?

13. What are you wondering now?