SNC1D/1P The Study of the Universe/Space Exploration

Student Activity: Comparing the Sizes of Planets and Their Distances from the Sun

Topics	**Timing**
sizes of planets	preparation: 10 min
relative differences in planetary orbits	activity: 20 min

Specific Expectations

SNC1D

A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions

D2.5 compare and contrast properties of celestial objects visible in the night sky, drawing on information gathered through research and using an appropriate format (e.g., compare the size of planets; represent the distance of stars from Earth using scientific notation; compare star temperatures and colour) [PR, AI, C]

D3.3 describe the major components of the solar system and the universe (e.g., planets, stars, galaxies), using appropriate scientific terminology and units (e.g., astronomical units, scientific notation, light years)

SNC1P

A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions

D2.3 use a research process to compile and analyse information on the characteristics of various objects in the universe (e.g., planets, stars, constellations, galaxies) [PR, AI]

D3.2 compare the characteristics and properties of celestial objects that constitute the solar system, including their motion and their distance from other celestial objects in the solar system (e.g., composition, size, rotation, presence and composition of atmosphere, gravitational pull, magnetic field)

Introduction

There are eight planets in the solar system in two distinct groupings. The four inner terrestrial planets (Mercury, Venus, Earth, and Mars) are very small and relatively close together. The outer planets or gas giants (Jupiter, Saturn, Uranus, and Neptune) are very large and far apart from each other. This activity presents a scale model that illustrates the vast differences in the sizes of the planets and their distances from the Sun.

Materials

- 150 m long field measuring tape
- 15 flag markers
- 2 small balloons
- 2 medium-sized balloons
- 2 large balloons
- 2 extra large balloons or beach balls
- marker

Safety Considerations

- If students have latex allergies, advise them not to touch the balloons.

Procedure

Part A: Size of Planets

1. Before class, prepare balloons to represent the planets by inflating them to the dimensions shown in Table 1.

Table 1 Dimensions of balloons representing planets

Size of uninflated balloon	Planet(s) represented	Equatorial diameter (km)	Scaled planet size (cm) (1 cm ≡ 1000 km)	Diameter of inflated balloon (cm)
small	Mercury	4879	4.9	5
small	Mars	6794	6.8	7
medium	Venus	12104	12.1	12
medium	Earth	12756	12.8	13
large	Neptune	49530	49.5	49
large	Uranus	51120	51.1	51
extra large	Saturn	120540	120.5	120
extra large	Jupiter	142980	143	143

When class starts:

2. Display the balloons in no particular order. Ask the students "What do the objects at the front represent?"
3. Discuss the relative sizes of the planets and have students determine which planet is represented by which balloon. Follow up by asking:
    a. "How do you know?"
    b. "What information do you already know about the planets that allows you to determine which balloon represents each planet?';
    c. "Do you notice any similarities in groupings of size? For example, are there groups of "two's" that are similar to each other in size?" [Answer: Mercury is like Mars, Earth is like Venus, Jupiter is like Saturn, and Uranus is like Neptune.]
4. Label each balloon with its planet name.

Part B: Planetary Distances

5. **Predict**
   Discuss with students the scale used for planetary, diameter 1 cm ≡ 1000 km. Ask whether this same scale would work for interplanetary distances. Why or why not? Discuss what would be a practical scale to fit the solar system on the football field. A suitable scale might be 1 m ≡ 30 000 000 km or 1 m ≡ 3 × 10^7 km.
6. Organize students into 8 groups and assign a planet to each group. Optional: Ask each group to calculate the distance that their planet should be from the Sun, using the agreed scale. Check their calculations. If you use the scale 1 cm ≡ 300 000 km, the values are given in **Table 2**.

Table 2 Scaled planetary orbits

Planet	**Average distance from Sun (km)**	**Scaled distance from Sun (m)** (1 m ≡ 3 × 10^7 km)
Mercury	5.79×10^7	1.93
Venus	1.08×10^8	3.61
Earth	1.50×10^8	4.00
Mars	2.28×10^8	7.60
Jupiter	7.78×10^8	25.9
Saturn	1.43×10^9	47.6
Uranus	2.88×10^9	95.8
Neptune	4.50×10^9	150

7. Take the class out to the open field. Mark the beginning of the field with a flag to indicate the location of the Sun. From the edge of the Sun, measure the distance to the scaled location of the furthest planet, Neptune, at 4.50×10^9 km. Place a flag marker every 10 m from the Sun. Invite each planetary group to predict where their planet is located relative to the Sun and to the nearest planets.
8. **Observe**
   Provide each student group with a copy of Table 2 and allow students time to determine where their planet should be, and to hold it in its correct location.
9. Discuss with students the accuracy of their placements and, if necessary, direct them to the correct distance from the Sun.
10. Prompt students to notice the relative distances between the planets and in particular the closeness of the inner planets compared to the outer planets.
11. **Explain**
    Return to the classroom and discuss and compare the relative distances between planets.

Disposal

Balloons may be popped and disposed of in the garbage. Beach balls should be deflated and stored for future use.

What happens?

When students accurately measure the distances of the eight planets from the Sun, using an appropriate scale, they observe that the four inner terrestrial planets (Mercury, Venus, Earth, and Mars) are very small and relatively close together. The outer planets or gas giants (Jupiter, Saturn, Uranus, and Neptune) however, are very large and far apart from each other. Students should also be aware that this is a linear representation of the average distances of these planets' orbits from the Sun and not the actual positions of the planets.

How does it work?

There are two scales used here because the planetary orbits are so large compared to the diameters of the planets. For example if the scale for distances were also used for the diameter of planets, the largest planet would be 0.5 cm in diameter, and 6 of the other planets would be less than 2 mm in diameter. Therefore, to help students visualize the differences in size between the planets a smaller scale is used.

Teaching Suggestions/Hints

1. Students should know the order of the planets before starting this activity. If necessary, teach them a mnemonic, such as My Velvet Elephant Munches...
2. In this activity the Sun is placed at one end of the field and the planets are arranged linearly. Discuss with students that this is not an accurate representation of reality. Students are identifying the orbital radii, not the actual positions of the planets.
2. Instead of using balloons, use balls (e.g., ping-pong balls, beach balls) with the approximate dimensions required for each planet.
3. This activity could be modified for indoors by having students working together on designing and building scale models.
4. To evaluate the accuracy of the model, ask: "Do the planets really line up like that?"
5. Extension/alternative: Invite students to draw a diagram of the planetary orbits, using appropriate scales. You could provide data for the diameter of each planet and its distance from the Sun, and have students perform the necessary calculations.
6. Extension: Ask students to calculate the diameters of the planets if the same scale (1 m ≡ 3×10^7 km) were used for the sizes of planets as was used for the distances of the planets from the Sun. Discuss why a different scale was actually used in the activity.

Next Steps

- As a follow-up to this activity, students could research and compare other properties of the planets including: mass, number of satellites, revolution period, rotation, internal composition, gravity, rings, and the axial tilt.
- Now that students have considered some of the properties of the eight planets, begin further discussion on the other celestial objects in the solar system, including the asteroid belt, comets, meteors, dwarf planets, and the Kuiper belt.
- An understanding of the scale and the distances between planets will help students understand one of the challenges of space travel. For example, ask students how long it would take a space craft cruising at 30 000 km/h to reach each of the outer planets.
- Enrichment: Invite students to compare and construct scale models for some of the most well-known stars in our galaxy (e.g., Polaris, Sirius, Betelgeuse, Proxima Centauri).

Additional Resources

1. Planetary Size Comparison simulator: provides a visual and quantitative comparison of the sizes of any two planets.
   http://sciencenetlinks.com/interactives/messenger/psc/PlanetSize.html
2. National Geographic: detailed outline of an activity to compare the sizes and relative distances of each planet from the Sun.
   http://education.nationalgeographic.com/education/activity/planetary-size-and-distance-comparison/?ar_a=1
3. Solar System Model Calculator: instructions on how to make a scale model of the Solar System.
   http://www.exploratorium.edu/ronh/solar_system/