RAFT IDEAS

Planet Orbit Locations to Scale

How near are our nearest neighbors and how far are the farthest?

Topics: Planets, Solar System, Measurement

Materials List

- ✓ Strip of adding machine tape or equal, 1 meter (40") long
- ✓ Metric ruler
- ✓ Calculator might be needed

This activity can be used to teach:

- Scale of objects in the Solar system (Next Generation Science Standards: Middle School, Earth and Space Science 1-3)

Common Core Math Standards:

- Measurement and units (Measurement and Data, Grade 4, 1; Grade 5, 1)
- Ratios & Proportions (Ratios and Proportional Relationships, Grade 6, 1-3; Grade 7, 2)
- Reason quantitatively and use units to solve problems (High School, Number and Quantity, Quantities 1, 2)

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Create a pocket sized foldable strip with a scaled down solar system that shows the relative distances between the planets' orbits and the Sun.

Assembly

1. Cut a 1 meter length of adding machine tape for each student.

Planet	Distance from Sun (semi major axis) in km	Scaled so Neptune's orbit = 1 m, in cm	Scaled and rounded to nearest 0.1 cm
Mercury	57,909,175	1.2874	1.3
Venus	108,208,930	2.4056	2.4
Earth	149,597,890	3.3257	3.3
Mars	227,936,640	5.0672	5.1
Jupiter	778,412,020	17.3048	17.3
Saturn	1,426,725,400	31.7173	31.7
Uranus	2,870,972,200	63.8242	63.8
Neptune	4,498,252,900	100.0000	100.0
Asteroid belt	300 to 600 million	6.6693 to 13.3385	6.7 to 13.3

To Do and Notice

This activity involves using measurement and scaling and can be adapted to require additional and more advanced math skills. See the **Taking It Further** section for additional suggestions.

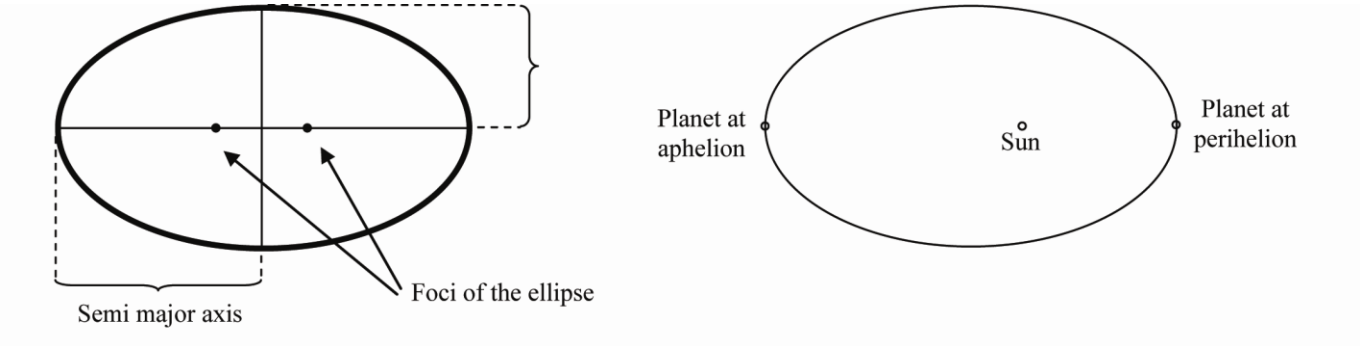
1. Place marks on the meter paper strip at 10 cm intervals.
2. Use the intervals and/or a ruler to place a mark at the scaled location for each planet assuming the Sun is at the left edge of the strip and Neptune is at the right edge. Choose one of the following methods based on students skills:
   - The simplest method is to use the scaled and rounded values from the fourth column of the table above.
   - To add a rounding activity, have the students round the numbers from the third column in the table above to the nearest tenth of a centimeter (fourth column).
   - To utilize more advanced math skills have the students calculate the scaled distances of the planets' orbits from the Sun so that the distance for Neptune's orbit equals 1 meter. The calculations can be based on the semi major axis distances listed in the table above (second column). See **Web Resources** for a link to the NASA webpage to check if the distances have been updated.
3. Label each corresponding mark with the name of the planet. Although technically not "in the picture" the Sun at this scale would have a diameter of about 1 mm. The planets would be much smaller. Jupiter would be only 0.1 mm in diameter.

Created and written by Michael Pollock (RAFT)

4. Optional - the asteroid belt could be added to the strip, see the last row in the table on the previous page.
5. Fold the paper strip, accordion style, to make the strip pocket sized.
6. Note that some planets are grouped closer to the Sun, the inner planets (Mercury, Venus, Mars, and the Earth), while the rest are considered the outer planets.

The Science Behind the Activity

The planets travel around the Sun in elliptical orbits. For a circular orbit the distance from the Sun would be equal to the radius of the circle and would be unchanging as the planet moved around the Sun. Elliptical orbits present a more complex problem as a planet's distance from the Sun varies from the closest point (the perihelion) to the farthest point (the aphelion). The elliptical orbits have 2 foci with the Sun being at one of them (a focus). The semi major axis of an ellipse is a half of the length of a line that runs through both foci and goes from one edge of the ellipse to the other, see below.



Most of the orbits of the planets are nearly circular ellipses with the Sun at one focus of the ellipse. The chart below shows that Mercury's distance from the Sun varies by over 50% during one rotation. The table below also shows that the average of the aphelion and the perihelion is equal to the semi major axis distance as listed on the previous page.

The planets all orbit in the same direction (counter-clockwise looking down from above the Sun's north pole) and in the same direction as the Sun rotates. Planets that are closer to the Sun will travel around the Sun faster, taking less time to complete an orbit, than planets farther away. Many comets, asteroids, and Kuiper belt objects (icy bodies in a region past the orbit of Neptune) follow highly-elliptical orbits.

Planets	Aphelion in km	Perihelion in km	Average distance in km	% farther	Aphelion in cm	Perihelion in cm
Mercury	69,815,301	46,003,049	57,809,175	52%	1.6	1.0
Venus	108,944,751	107,473,109	108,208,930	1%	2.4	2.4
Earth	152,096,175	147,099,605	149,597,890	3%	3.4	3.3
Mars	249,225,922	206,647,358	227,936,640	21%	5.5	4.6
Jupiter	816,087,162	740,736,878	778,412,020	10%	18.1	16.5
Saturn	1,504,053,917	1,349,396,883	1,426,725,400	11%	33.4	30.0
Uranus	3,006,482,088	2,735,462,312	2,870,972,200	10%	66.8	60.8
Neptune	4,536,937,875	4,459,567,925	4,498,252,900	2%	100.9	99.1

Taking it Further

- Have students calculate the time for sunlight to travel to each planet or for a "jet" to travel from the Sun to each planet. How long would it take a rocket? (See table below)
- What do the terms "inferior and superior" planets mean?
- Create a scaled solar system that will fit on the school's playground or playing field.
- Have students calculate the semi minor axis for each planet. Would the scale measurements be different if the semi minor axis was used instead?
- Calculate the aphelion and perihelion for each planet and mark the scaled range for each planet on the strip.
- Research why there are 8 planets and how the number was changed as new astronomical data was obtained.

Planet	Sunbeam's travel time in minutes	"Jet travel" from the Sun at 1,000 km/hr in years	Rocket travel from Sun at 40,000 km/hr in months/years
Mercury	3	7	2 mo
Venus	6	12	3.8 mo
Earth	8	17	5.2 mo
Mars	13	26	7.9mo
Jupiter	43	89	2.2 yr
Saturn	79	163	4.1 yr
Uranus	159	328	8.2 yr
Neptune	250	513	12.8 yr

Web Resources (Visit www.raft.net/raft-idea?isid=597 for more resources!)

- NASA's Solar System Exploration - http://solarsystem.nasa.gov/planets/charchart.cfm
- Ellipse information and interactive image - http://www.mathopenref.com/ellipsefoci.html
- Perihelion/aphelion with moving image - http://www.windows.ucar.edu/tour/link=/physical_science/physics/mechanics/orbit/perihelion_aphelion.html