SIZE MODELS: THE DIAMETERS OF THE PLANETS

Background:

Planetary scientists sometimes use the Earth as a reference point in making measurements. For example, the distance between the Earth and the Sun is called an Astronomical Unit or AU, and is used to describe distances in the Solar System. Another example is Earth's atmospheric pressure (14.7 lb per square inch); it is referred to as one atmosphere (1 atm), and the atmospheric pressure of the other planets is sometimes expressed in this unit. In the following tables, we use Earth's diameter and Earth's distance from the Sun as base units for constructing scale model diameters of the planets and scale model distances from the Sun to the planets and to objects beyond the Solar System. You can think of these as roadmaps of the Solar System and the Universe. Below are two models of the Solar System, the first representing the diameters (sizes) of the planets and the second representing the distances to the planets.

Materials for Size Model of the Solar System:

Beads and Styrofoam balls to match the sizes of the planets

Procedure:

You will need about 11 girls for this activity. Ask the girls what the closest star to us is. They should answer the Sun! Have one girl (about 5 feet tall) stand to the left of what will eventually be a line of 11 girls.

Next, ask the girls what is the closest planet to the Sun. They should answer Mercury. The one who answers first should become Mercury and stand next to the "Sun." We usually do left to right as you are facing them since that is the way one usually sees the planets in books. Hand that girl the bead (example below) that represents Mercury. Explain to them that you are creating a scale model of the sizes of the planets in the Solar System. Continue this with Venus, Earth (and the Moon), Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

Size Model:

The table on the following page (Table I) shows the names of the planets and their true diameters (in miles and kilometers). Column 4 is to be used for determining the sizes of the planets relative to Earth (Earth = 1.0). Column 5 is to be used for determining a scale model of the planetary sizes relative to a 1.28-cm (0.5-in) Earth. This is the scale model that we will use in class. This is a 1:1,000,000,000 scale where 1cm represents 10,000 km.

TABLE I
MAKING A MODEL OF THE DIAMETERS OF THE PLANETS AND THE SUN

Scale: One Earth Diameter = 1.28 Centimeters (0.5 in)
(1 cm = 10,000 km, 1:1,000,000,000)

Planet	Diameter Kilometers	Diameter Miles	Dia. Relative to Earth	Diameter to Scale	Object
Sun	1392000	865000	108.7	139.20 cm	5-ft person
Mercury	4878	3031	0.38	0.49 cm	5 mm bead
Venus	12104	7521	0.95	1.21 cm	_ inch bead
Earth	12756	7926	1.00	1.28 cm	_ inch bead
Moon	3476	2160	0.28	0.34 cm	3 mm bead
Mars	6794	4222	0.53	0.68 cm	7 mm bead
Jupiter	142984	88730	11.21	14.3 cm	6 in ball
Saturn	120536	74940	9.45	12.1 cm	5 in ball
Uranus	51118	31763	4.01	5.11 cm	2 in ball
Neptune	49528	30775	3.88	4.95 cm	2 in ball
Pluto	2302	1430	0.18	0.23 cm	2 mm bead

Closure:

Remind them that this is just a scale model of the sizes of the planets. Ask them what the beads and Styrofoam balls represent [the relative sizes of the planets]. Then ask them what is not represented by this model (what is not correct) [planets not lined up like this and their distances are greater than in the model].

Materials for Distance Model of the Solar System:

_ inch bead (the Sun)
_ inch dowels (2), 1 foot long (for Mercury Venus, Earth, and Mars)
_ inch dowel, 15 inches long (for Jupiter)
1 inch dowel, (3 15 inch and 1 18 inch) (for Saturn, Uranus, Neptune, and Pluto)
macramé (thin) for Mercury, Venus, Earth, and Mars
macramé (medium) for Jupiter
macramé (thick) for Saturn, Uranus, Neptune, and Pluto

Procedure:

You will need at least 10 girls for this activity. Other girls can become asteroids and comets. If you have just done the size model, ask the girl who is Mercury, ask them to get in front of the "Sun" and move to the "correct" distance (on this model) from the Sun. Have the others coach them to get the "correct" distance. After a few guesses, tell them that, on this scale, Mercury would be 200 feet away! Therefore, you are going to use a smaller scale model to represent the distance to the planets. If they ask, Pluto is over 4 miles away on this model!

This part is best done outside. The girl who was the Sun should be given the _ inch bead. Tell the girls that this bead now represents the size of the Sun.

Next, ask the girls what is the closest planet to the Sun. They should answer Mercury, as before. The one who answers first should become Mercury. Hand that girl the string that represents the distance to Mercury. Explain to them that you are creating a scale model of the distances to the planets in the Solar System. Continue this with Venus, Earth (and the Moon), Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. Have them go out in different directions and either ask them or tell them why they are doing this [planets never lined up]. Caution: "Pluto" will be about 200 feet away and it takes time for them to get there and even longer to rewind the macramé!

Distance Model:

As we saw with the size model, we cannot do a reasonable scale model of planetary distances on the same scale as we do planetary diameters. We use a scale that is 100 times smaller than in Problem 1 — 1:100,000,000,000. For example, the scale distance from the Sun to the Earth (1 AU = 149,600,000 km = 14,960,000,000,000 cm) is 150 cm (149.6 cm, rounded; 1 cm = 1,000,000 km).

Table II gives the true (mean) distances of the planets from the Sun: Columns 2 and 3, in millions of miles and kilometers; Column 4, their distances in Astronomical Units (1 AU = the mean distance of Earth from the Sun); and

Column 5, their distances in solar diameters (e.g., 107 Suns laid side-by-side would be needed to stretch from the Sun to Earth). Column 6, light time (minutes), gives the time it takes light to travel from the Sun to each planet (186,000 miles or 299,800 km in a second). For the Moon distances are from Earth, distance in Earth diameters, light time from Earth, and time it takes to orbit the Earth.

TABLE II: PLANETARY (SOLAR) DISTANCES

PLANET	DISTANCE			Solar Diameters	Light Time (Min.)	Distance to Scale (macramé length)
	Miles (Millions)	Km (Millions)	AU			
Mercury	36.0	57.9	0.387	42	3.2	58 cm
Venus	67.2	108.2	0.723	78	6.0	108 cm
Earth	93.0	149.6	1.000	107	8.3	150 cm 1.5 m
Moon	0.238	0.383	0.003	30[a]	1.3[b]	
Mars	141.7	228.0	1.524	164	12.7	2.3 m
Jupiter	483.7	778.4	5.203	559	43.3	7.8 m
Saturn	885.2	1425.0	9.523	1025	79.5	14.2 m
Uranus	1785.0	2873.0	19.210	2061	159.7	28.7 m
Neptune	2797.0	4501.0	30.090	3230	250.4	45.0 m
Pluto	3695.0	5946.0	39.750	4280	332.1	59.5 m

[a]Relative to diameter of Earth

[b]Number of seconds for light to travel from the Earth to the Moon

Closure:

Remind them that this is a scale model of the distances of the planets in the Solar System. Tell them that, as they stand at the ends of the macramé and look back at the "Sun," the bead is what the Sun would look like from that planet. Also, while they are not lined up, in the real Solar System, the individual planets are all moving around the Sun at different speeds. Finally, on this scale, the next nearest star is about 250 miles away.