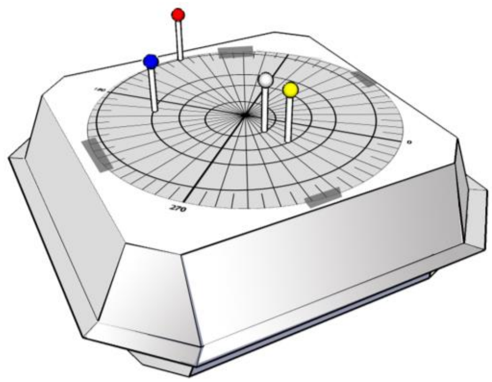
Race Around the Sun

Investigate the Secrets of the Inner Planets!



RAFT IDEAS

Topics: Planets, Orbits, Patterns

Materials List

- ✓ Hinged container, foam
- ✓ Pushpins, blue, red, and yellow plastic plus an aluminum, or equal
- ✓ Heliocentric blackline master or ruler, protractor & compass
- ✓ Ruler
- ✓ Tape or glue
- ✓ Chart of planet positions (heliocentric longitudes), see Website Resources

This activity can be used to teach:

Common Core Mathematics:

- Measurement and units (Measurement and Data, Grade 4, 1; Grade 5, 1)
- Ratios & Proportions (Ratios/Prop. Rel., Grade 6, 1-3; Grade 7, 2)
- Problem Solving/ Reasoning (Math Practices Grades 3-12)

Next Generation Science:

- Seasonal night sky (Grade 5, Earth and Space Science 1-2)
- Solar system: Scale of objects & orbits (Earth & Space Science, Middle School, 1-3; High School, 1-4)
- Gravity & solar system (Middle School, Physical Science 2-4; Earth & Space Science 1-2)

raft resource area for teaching
www.raft.net

Which inner planet has the shortest year? Learn the answer and more by building a model to show how Mars, Earth, Venus, and Mercury move around the Sun.

Assembly

1. Compare the size of the top of the hinged foam container with the size of the provided blackline master. If the two are not the same, decide how much to enlarge or reduce the master so that copies will fit the top.
2. Provide copies of the blackline master of the orbits or have students draw approximations of the orbits on copies of the "blank" master using a ruler and a circle compass. See the next page for details.
3. Label the 4 planetary orbits and the degree marks at 10 degree intervals.
4. Cut and then tape, or glue, the orbit/degree sheet to the top of the container.
5. Select and, if desired, label 4 pins to represent the planets. Red could be used for Mars, blue for Earth, yellow for Venus, and a silver/aluminum pin for Mercury.

To Do and Notice

1. Each planet's angular orbital location (heliocentric) for specific dates will be needed and can be found at the website listed on the next page.
2. Find the heliocentric angle for the date one year ago and insert each planet's pin into the appropriate place in the planet's orbit. Planets orbit counter-clockwise around the sun (as seen looking down on the North Pole).
3. Find the positions for the 1st of each of the following months and move each planet's pin to the next monthly position, in turn, until one planet passes the starting point found in step 2. Which planet came in 1st, 2nd, 3rd, and 4th?
4. What observations about the orbits of the planets can be gained from the model?
5. Using the same scale where would the outer planets be located?

The Science Behind the Activity

The speed of a planet traveling around the Sun (orbital velocity) is greater the closer the planet is to the Sun. Mercury travels around the Sun the fastest; Venus is the next fastest, etc. In traveling around the Sun each planet will also travel faster when nearer the Sun than when farther away. Most orbits of the planets are only slightly elliptical. Mercury's orbit is the most elliptical while the orbit of Venus is the closest to a circle. The Earth's orbit is nearly a circle, only 3% off. Heliocentric coordinates ("Solar Polar" so to speak) have the Sun at the center and the zero point for the 360º at the vernal equinox (also referred to as the 1st point of Aries).

Created and written by Michael Pollock (RAFT) and Tom Gates (RAFT)

Taking it Further

- Research additional details about the planets' orbits. The model implies all the inner planets are orbiting in the same plane. Which planet is the farthest off the plane and by how much? This is the "inclination of orbit". What about the outer planets? Most of the planets rotate in the same direction as they orbit (counter-clockwise as seen looking down on the North Pole). Which inner planet rotates clockwise?
- Model the "reason for the seasons" by using a straight pin, such as ball head pin, inserted at a 22º angle at four points around the Sun.
- Model the view of the Moon, as seen from the Earth, by using a 12 cm (4-3/4") diameter orbit for the Moon, a 2 mm (1/16") blue circle to represent the Earth, and a white ball head pin half colored black for the Moon. At that scale the diameter of the moon would be slightly smaller than the diameter of the shaft of the pin (.54 mm or less than 1/32"). The head of the pin would really represent a 4x magnified view of the Moon.

Details on charting the orbits of the inner planets

The blackline master of the orbits of the inner planets uses a scale of 5 cm = 1 AU (Astronomical Unit = the mean distance of the Earth from the Sun). At this scale a circle is an extremely good approximation for the shape of the very slightly elliptical orbits of the inner planets, even for the most elliptical, Mercury.
To have the students draw the orbits themselves use copies of the "blank" heliocentric master and then choose one of the following 3 methods, whichever is most appropriate given the needs and skills of the students.

1. The simplest method uses a circle drawn centered on the Sun with a radius based on the planet's mean distance from the Sun in AU. The mean distance is multiplied by 5 (for a scale of 5 cm = 1 AU) to give a radius in centimeters. Students can either use the values provided below or calculate the mean distance by adding the planet's perihelion (closest distance to the Sun) (p) to the aphelion (farthest distance from the Sun) (a) and then dividing by 2. (See the bottom table for the necessary data.)

Planet	Mercury	Venus	Earth	Mars
Mean distance (AU)	0.338	0.72	1	1.52
Scaled radius	1.9 cm	3.6 cm	5 cm	7.6 cm

2. To more accurately portray the more elliptical orbits of Mercury and Mars, the circle's center is offset from the Sun using the distance and direction shown. The circle's radius (r) is still the scaled mean distance.

Planet	Offset distance	Direction	Radius of orbit (scaled)
Mercury	4 mm	257º	1.9 cm
Mars	7 mm	156º	7.6 cm

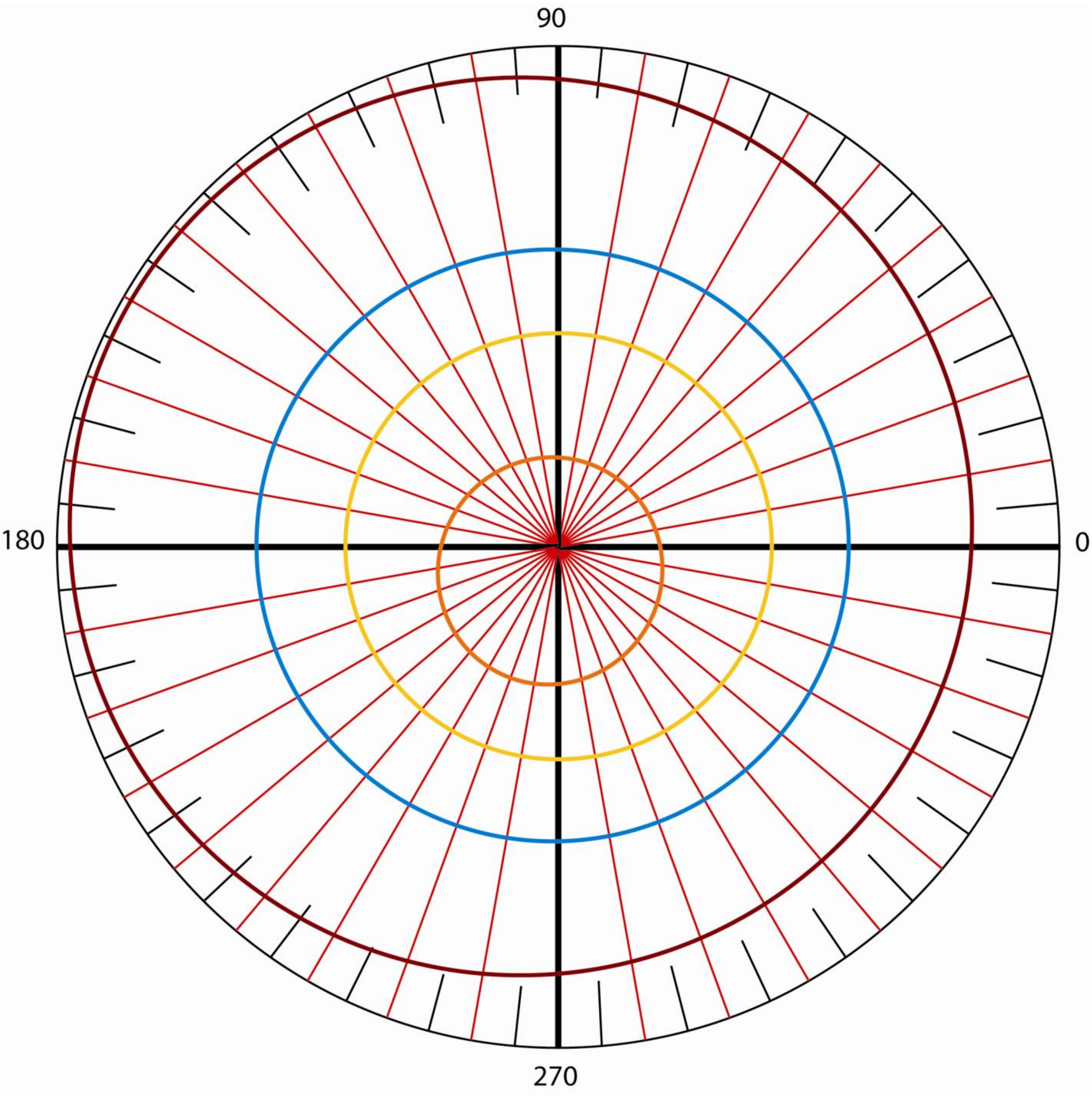
3. For a greater challenge, and more calculation practice, the offset distance and direction can be computed. The position of the orbit's center can be calculated from the eccentricity (e), radius (r), and the longitude of perihelion (l). The distance of the center (c) from the Sun can be calculated from $c = e * r$. The direction of the center from the Sun will be equal to the longitude of perihelion plus 180º. The longitude of perihelion is the heliocentric angle where the planet is closest to the Sun. Offsetting the circle in the other direction (found by adding 180º) will more closely approximate the planet's elliptical orbit around the Sun.

Planet	Perihelion (Closest to Sun) in AU	Aphelion (Farthest from Sun) in AU	Eccentricity of the orbit (0 = circle)	Longitude of Perihelion	Longitude of Perihelion + 180º
Mercury	0.304	0.467	0.206	77º	257º
Venus	0.718	0.728	0.007	132º	312º
Earth	0.983	1.017	0.017	103º	183º
Mars	1.381	1.666	0.093	336º	156º

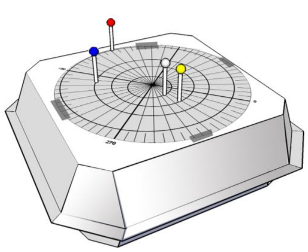
Web Resources (Visit www.raft.net/raft-idea?isid=566 for more resources!)

- Chart of planet locations for the first of each month -http://planetarium.wvu.edu/heliocentric

Race Around the Sun

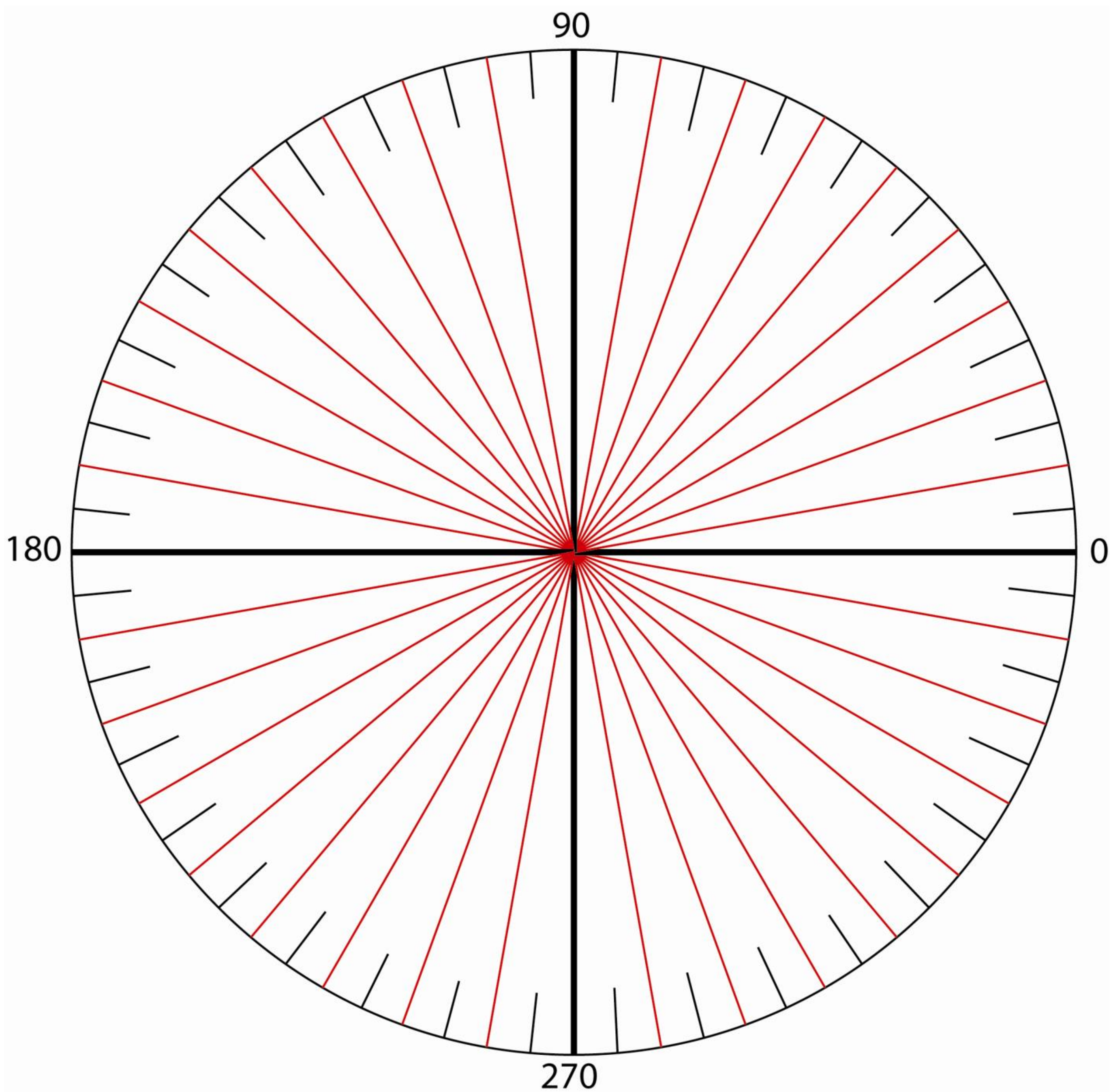


Orbits of the Inner Planets - Scale: 1 AU = 5 cm

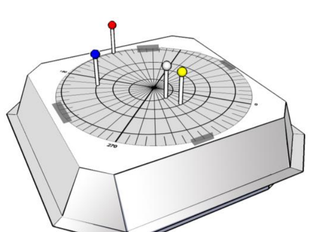


raft
resource area for teaching
1355 Ridder Park Drive San Jose, CA 95131
www.raft.net

Race Around the Sun



Blank heliocentric master for planetary orbits



raft resource area for teaching
1355 Ridder Park Drive San Jose, CA 95131
www.raft.net