Teacher Guide: Comparing Earth and Venus

Learning Objectives

Students will …

- Understand the astronomical meaning of a *day* and a *year*.
- Compare the length of a year on Venus and Earth.
- Measure how long it takes for the Moon to orbit Earth.
- Compare the length of a sidereal day and a solar day on Venus and Earth.
- Use algebra to determine how long it takes for one planet to "lap" another. (Extension)

Vocabulary

angular velocity, orbit, period, revolve, rotation, sidereal day, solar day, year

Lesson Overview

Venus and Earth have a lot in common. Venus is the closest planet to Earth, has a similar size, and possesses a thick atmosphere. But while Earth has a moderate temperature that allows life to flourish, the surface of Venus is hot enough to melt lead.

Venus's orbit has several interesting characteristics as well. For example, a sidereal day on Venus takes longer than one year! In the *Comparing Earth and Venus* Gizmo™, students can observe and analyze the movements of Venus, Earth, and the Moon.

Venus and Earth orbit the Sun.

The Student Exploration sheet contains two activities and an extension:

- Activity A – Students measure and compare the orbital periods of Earth, Venus, and the Moon.
- Activity B – Students measure and compare the rotational periods of Earth and Venus.
- Extension – Students determine how long it takes one planet to "lap" another planet in its orbit. [Note: This activity is recommended for students with strong algebra skills.]

Suggested Lesson Sequence

1. **Pre-Gizmo activity: Observe Venus** (one evening)
   After the Moon, Venus is the brightest object in the night sky. Venus is known as the "Evening Star" and the "Morning Star" because it sets early in the evening or rises shortly before sunrise.

   In 1610, Galileo observed Venus through his telescope. After taking observations for several months, he discovered that Venus shows a complete set of phases. This demonstrated that Venus orbited the Sun and gave credence to the heliocentric solar system model proposed in 1543 by Copernicus.

If you would like to organize a Venusian star party, first pick a date on which Venus will be clearly visible after sunset. (See the **Selected Web Resources** on the last page of this document.) Go to a location that allows a broad view of the sky and is away from city lights if possible. Through an ordinary telescope you should be able to observe the phase of Venus. In addition, look for other interesting celestial objects including Earth's moon, Jupiter and its moons, Mars, Saturn, the Orion Nebula, the Pleiades star cluster, Polaris (the North Star), and the Andromeda Galaxy.

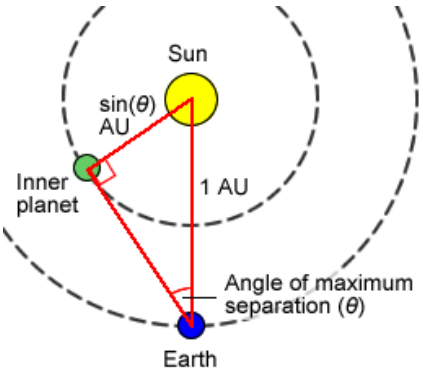
2. **Prior to using the Gizmo** (10 – 15 minutes)
Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations.

3. **Gizmo activities** (15 – 20 minutes per activity)
Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
As students are working or just after they are done, discuss the following questions:
   - Give two reasons a year on Venus is shorter than a year on Earth. [Venus revolves more quickly than Earth and doesn't have as far to go around the Sun.]
   - If you could see through the clouds, what would sunrise look like on Venus?
   - Why is the period of the Moon shorter than the period of Venus?
   - What might life on Earth be like if our day lasted as long as a day on Venus?

5. **Follow-up activity: Planetary distances** (20 – 40 minutes)
Calculating the relative distances of the planets is an excellent real-world application of geometry and algebra. If the Earth-Sun distance is defined as 1 astronomical unit (AU), the distances to all the other planets can be determined in AU. (Finding the absolute length of an astronomical unit is a greater challenge.)

The distances from the Sun to the inner planets Mercury and Venus can be determined by measuring the angle (θ) between each planet and the Sun. This angle is maximized when the line joining the planet to Earth is perpendicular to the line joining the planet to the Sun. The result is a right triangle with a hypotenuse of 1 AU, as shown at right. The distance from the planet to the Sun is simply the sine of the angle of maximum separation, or $r = \sin(\theta)$. The maximum angle of separation for Mercury is 22.77° and for Venus is 46.33°.



Determining the distances of the other planets from the Sun uses similar geometry but is a more complex calculation. (See the **Selected Web Resources**.) Measuring the Earth-Sun distance was a major challenge that also involved Venus (see the next page).

Scientific Background

Venus is known as Earth's "sister planet" because Venus is our neighbor, is nearly the same size as Earth, and possesses a thick atmosphere like Earth. Venus is the second-brightest object in the night sky and often appears in the sky at dusk or dawn. When observed through a telescope, Venus appears to be a smooth marble, covered by a thick layer of clouds. For many years, scientists and fantasists imagined what lay below the clouds. In the early 20th century, science fiction writers often described Venus as a warm, swampy paradise covered with jungles and populated by dinosaurs and other fantastic beasts.

Venus

In 1962, the *Mariner 2* probe passed by Venus and measured a surface temperature of over 400 °C, precluding the existence of liquid water or life on the surface of Venus. Subsequent missions have revealed a hot, dry planet with a thick atmosphere composed mainly of heat-trapping carbon dioxide. The clouds are composed mainly of corrosive sulfur dioxide. Atmospheric pressure on Venus is 92 times greater than the pressure on Earth's surface.

Venus takes 224.7 Earth days to orbit the Sun. Unlike most other planets, Venus rotates in a clockwise direction when viewed from above its north pole. The period of rotation is 243 Earth days, so a *sidereal* day lasts longer than a year on Venus. Because Venus has a clockwise rotation, a solar day is much shorter than a sidereal day—about 117 Earth days.

Historical Connection: Transit of Venus

In the 18th century, a major challenge for astronomers was to calculate the distance between the Earth and the Sun. Venus provided the key to solving this problem.

Venus's orbit is inclined 3.4° relative to Earth's orbit. When Venus passes between Earth and the Sun, it usually appears above or below the disk of the Sun to an observer on Earth. Every 120 years or so, Venus appears to cross in front of the disk of the Sun, an event called the *transit of Venus*. When observed from different latitudes on Earth, Venus appears to cross in front of different latitudes of the Sun. If the distance between the observation latitudes is known, the Earth-Sun distance can be determined through triangulation.

Using data from the 1761 and 1769 transits of Venus, the French astronomer Jerome Lalande calculated an Earth-Sun distance of 150 million km, close to the actual value of 153 million km.

Selected Web Resources

Venus: http://nineplanets.org/venus.html, http://www.nasa.gov/worldbook/venus_worldbook.html
Phases of Venus: http://www.pacifier.com/~tpope/Venus_Page.htm
Planet finder: http://www.wwu.edu/depts/skywise/planets.html
Planetary distances: http://www.davidcolarusso.com/astro/, https://eee.uci.edu/clients/bjbecker/ExploringtheCosmos/assign2a.html
Transit of Venus: http://www.transitofvenus.org/, http://www.exploratorium.edu/venus/

Related Gizmos:
Solar System: http://www.explorelearning.com/gizmo/id?636
Solar System Explorer: http://www.explorelearning.com/gizmo/id?441
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