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Learn More About: Planets & Their Orbits

SCIENCE MADE SIMPLE
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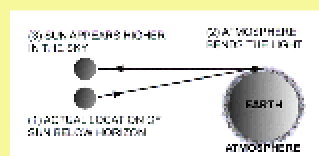
Day and Night Are Not Equal on the Equinox

The sun is not a point of light, but appears as a circle in the sky. Sunrise is defined as the time when the top edge of the sun appears above the horizon. Sunset is when the last edge of the sun disappears below the horizon.

In addition, these times are affected by the refraction of light in the atmosphere. As the light enters the air it bends. The sun appears higher in the sky than it otherwise would. Sunrise occurs a little earlier, because we can see the sun before it actually moves above the horizon. And sunset is delayed, because we can still see the sun after it drops below the horizon.

(See picture, "Location of Sun at the Equinox.")



Location of Sun at the Equinox

(Credit: SCIENCE MADE SIMPLE)

At the equinox, the sun is directly above the equator. Everywhere on Earth, the center of the sun is actually above the horizon for 12 hours. But the time between sunrise and sunset is longer than that.

Close to the equator, the day is about 7 minutes longer than the night. Moving away from the equator towards the poles, the day can be more than 10 minutes longer than the night.

The dates on which both day and night are exactly 12 hours long depend on location. Near the equator, they occur around February 25 and October 15. Through the middle of the U.S. (latitude about 40°N) they are around March 17 and September 26.

The Size and Shape of the Earth

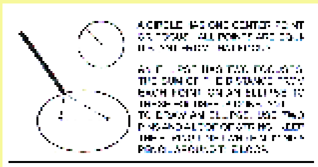
The Earth is not quite a perfect sphere. It is a shape called an oblate ellipsoid. It bulges slightly at the equator and North Pole, and is flattened at the South Pole.

At sea level, the circumference of the Earth at the equator is about 40,075 km (24,900 miles). The circumference around the poles is about 67 km (42 miles) less. The diameter at the equator is 12,756 km (7926 miles) while the distance between the North and South Poles is 12,713 km (7900 miles). These differences may seem small, but for comparison, Mount Everest rises less than 9 km (6 miles) above sea level.

How do we know the Earth is not a perfect sphere? As artificial satellites circle the planet, there are small variations in their orbits. These are caused by changes in the gravitational pull of the Earth. Scientists use these changes to accurately calculate the Earth's shape.

Elliptical Orbits

The orbits of the planets around the Sun are not perfect circles. Instead, they are ellipses. The Sun is not at the center of the ellipse, but slightly off to one side, at a point called a focus.



Elliptical Orbits of Planets

(Credit: SCIENCE MADE SIMPLE)

(See picture, "Elliptical Orbits of Planets.")

As the planets orbit, their distance from the Sun varies. The average distance between the Earth and Sun is 149,600,000 km. Its closest approach, called the perihelion, is about 2% closer than average. This occurs around January 3, during the winter in the Northern Hemisphere. Its greatest distance from the sun, called the aphelion, is about 2% farther than average. This occurs around July 4.

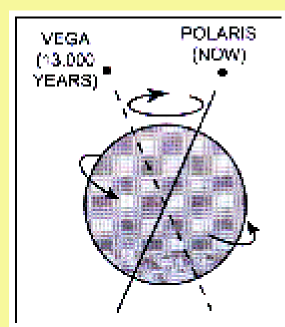
A planet's speed changes throughout its orbit, depending on its distance from the sun. It moves faster when it is closer to the Sun and slower when it is farther away. Planets that are nearer to the sun have shorter years. Planets that are farther from the Sun take longer to complete an orbit because they travel more slowly and have a greater distance to go.

Precession of the Axis

As the Earth travels around the sun each year, the North and South Poles continue to point towards the same place in space. The Earth's axis stays at a 23.5 degree angle to the ecliptic (the plane of the Earth's orbit around the sun).

Currently, the North Pole points to Polaris, which we call the North Star. But Polaris was not always the North Star. The Earth's axis wobbles, like a spinning top. Although it stays at a 23.5 degree angle, the axis slowly moves. Over time, it traces out a circle, pointing to different places in space. In about 13,000 years, Vega will be the "North Star."

(See picture, "Earth's Axis.")



Earth's Axis

(Credit: SCIENCE MADE SIMPLE)

This wobbling is called precession of the axis. It is caused by the gravitational pull of the Sun and Moon. One whole cycle is completed every 26,000 years.

Longer Days

The speed at which the Earth rotates also changes through the year. It rotates fastest in late July and early August, and slowest in April. This makes a difference of about 0.0012 seconds in the length of each day.

In addition, our days are slowly getting longer. Tides cause friction between the oceans and the planet's surface. This slows down the Earth's rotation. Every century, the days become 1.5-thousands to 2-thousands of a second longer. 400 million years ago, each day was 22 hours long and there were over 400 days each year.

How do we know this? First, through ancient records of eclipses kept by the Babylonians, Greeks, Arabs and Chinese. These records are compared to the times expected using the Earth's current rotation rate. The differences are used to calculate how much the Earth's rotation has slowed. Other data come from studies of coral fossils. Certain kinds of coral grow small new ridges each day. The growth changes with the time of year, so the corals have growth rings, like those in trees. The rings can tell us the number of days in a year.

Leap Years and Leap Seconds

One calendar year is normally 365 days long. However, it actually takes longer than that (precisely 365.24219 days) for the Earth to travel completely around the sun. Since it would be difficult to add one-quarter of a day every year, we ignore the extra time for three years. Then all four quarters, or one day, is added to the calendar at once. This is called a leap year. We add the extra day as February 29. But it is not quite that simple. Years that end in 00 (like 1900) are not leap years, unless they are evenly divisible by 400. So the year 2000 will be a leap year, but 2100 will not. These corrections keep the calendar in step with the seasons.

In addition, sometimes leap seconds are added. These are used to keep our clocks, now based on "atomic time," matched to the spinning of the Earth. There have been 22 leap seconds added since 1972, the most recent on June 30, 1997, and December 31, 1998. Another is scheduled for December 31, 2005. You may not notice an extra second once in a while. But keeping exact time is very important in areas like communications, navigation, power transmission and many scientific studies.

Fun Facts: The Earth's Seasons

2005

Perihelion: Jan 2
Aphelion: July 5
Equinoxes: Mar 20, Sept 22
Solstices: June 21, Dec 21

2006

Perihelion: Jan 4
Aphelion: July 3
Equinoxes: Mar 20, Sept 23
Solstices: June 21, Dec 22

2007

Perihelion: Jan 3
Aphelion: July 7
Equinoxes: Mar 21, Sept 23
Solstices: June 21, Dec 22

2008

Perihelion: Jan 3
Aphelion: July 4
Equinoxes: Mar 20, Sept 22
Solstices: June 20, Dec 21

2009

Perihelion: Jan 4
Aphelion: July 4
Equinoxes: Mar 20, Sept 22
Solstices: June 21, Dec 21

Planet Facts

Planet: Mercury
average distance from sun (millions km): 57.9
length of year[(1)]: 88 days
length of day[(2)]: 59 days
orbital tilt[(3)] (degrees): 7
axial tilt[(4)] (degrees): 0
average orbital speed (km/sec): 48

Planet: Venus
average distance from sun (millions km): 108.2
length of year[(1)]: 224.7 days
length of day[(2)]: 243 days (retro)
orbital tilt[(3)] (degrees): 3.4
axial tilt[(4)] (degrees): 3
average orbital speed (km/sec): 35

Planet: Earth
average distance from sun (millions km): 149.6
length of year[(1)]: 365.24 days
length of day[(2)]: 23 hours 56 min
orbital tilt[(3)] (degrees): 0
axial tilt[(4)] (degrees): 23.45
average orbital speed (km/sec): 30

Planet: Mars
average distance from sun (millions km): 227.9
length of year[(1)]: 687 days
length of day[(2)]: 24 h 37 m
orbital tilt[(3)] (degrees): 1.9
axial tilt[(4)] (degrees): 25.2
average orbital speed (km/sec): 24

Planet: Jupiter
average distance from sun (millions km): 778.3
length of year[(1)]: 11.86 years
length of day[(2)]: 9h 55 m
orbital tilt[(3)] (degrees): 1.3
axial tilt[(4)] (degrees): 3.1
average orbital speed (km/sec): 13

Planet: Saturn
average distance from sun (millions km): 1430
length of year[(1)]: 29.46 years
length of day[(2)]: 10 h 39 m
orbital tilt[(3)] (degrees): 2.5
axial tilt[(4)] (degrees): 26.7
average orbital speed (km/sec): 9.6

Planet: Uranus
average distance from sun (millions km): 2870
length of year[(1)]: 84 years
length of day[(2)]: 17 h 14 m (retro)
orbital tilt[(3)] (degrees): 0.8
axial tilt[(4)] (degrees): 98
average orbital speed (km/sec): 6.8

Planet: Neptune
average distance from sun (millions km): 4500
length of year[(1)]: 165 years
length of day[(2)]: 16 h
orbital tilt[(3)] (degrees): 1.8
axial tilt[(4)] (degrees): 28.8
average orbital speed (km/sec): 5.4

Planet: Pluto
average distance from sun (millions km): 5900
length of year[(1)]: 248 years
length of day[(2)]: 6 days (retro)
orbital tilt[(3)] (degrees): 17.2
axial tilt[(4)] (degrees): 68
average orbital speed (km/sec): 4.7

• **Notes: To convert to miles, multiply kilometers by 0.621**

(1) & (2) All times in Earth Units

(2) Three planets have retrograde (retro) rotations; they spin clockwise when viewed from above Earth's North Pole.

(3) Tilt of the orbital plan compared to Earth's orbit.

(4) Tilt of the planet's axis compared to its plane of orbit.