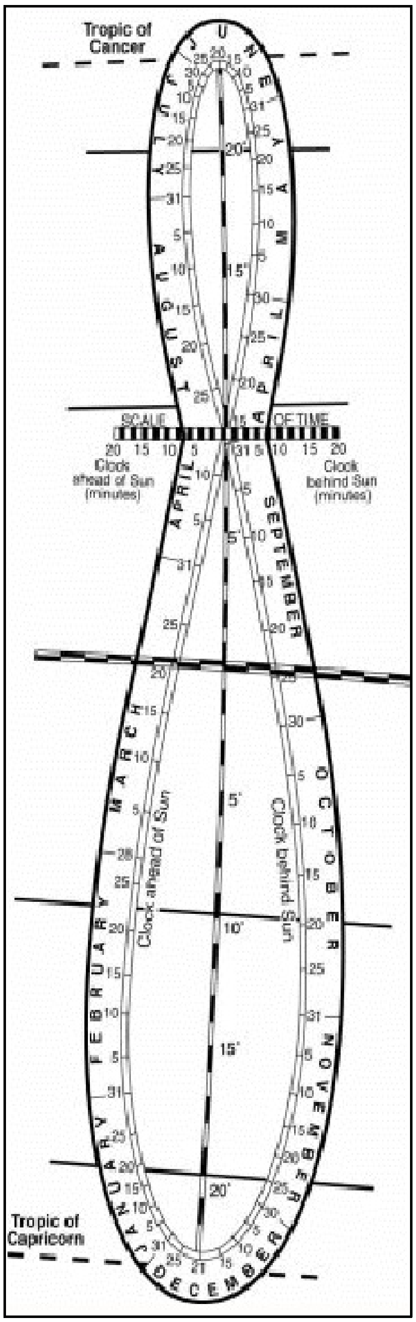
March Skies over the Pinnacles

March 2023

March's Four Principal Phases of the Moon

March 7	Full Moon	
March 15	Last Quarter	
March 21	New Moon	
March 29	First Quarter	

Cycles of Light



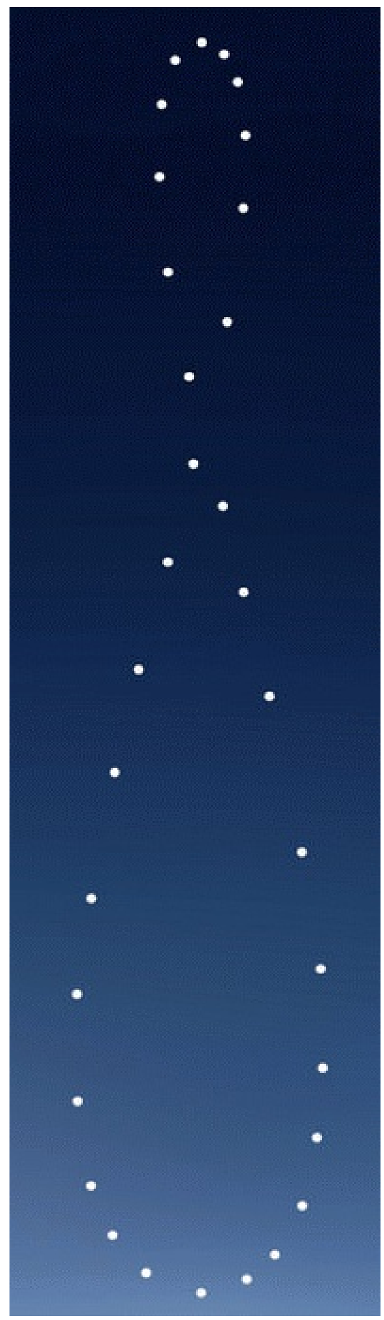
What is this? A figure '8'? The infinity symbol? Have you ever looked at an old globe of the Earth and asked your teacher, "What's that big '8' doing down there on the south Pacific? I did, but I don't remember the answer. There's no giant continent shaped like a figure '8' in the south Pacific. Since there aren't many islands down there, the globe maker thought that this area might make a good place for this mysterious figure. It's been embarrassing teachers who didn't know the right answer for a long time.

The answer is that figure is called the **analemma**. It is the pattern in the sky marked out by the Sun over one year. On the left is a diagram that you might find on the globe. The image on the right is what you would get if you took a picture of the sun, at noon and without moving your camera, on every 10 or 11 sunny days for a whole year.

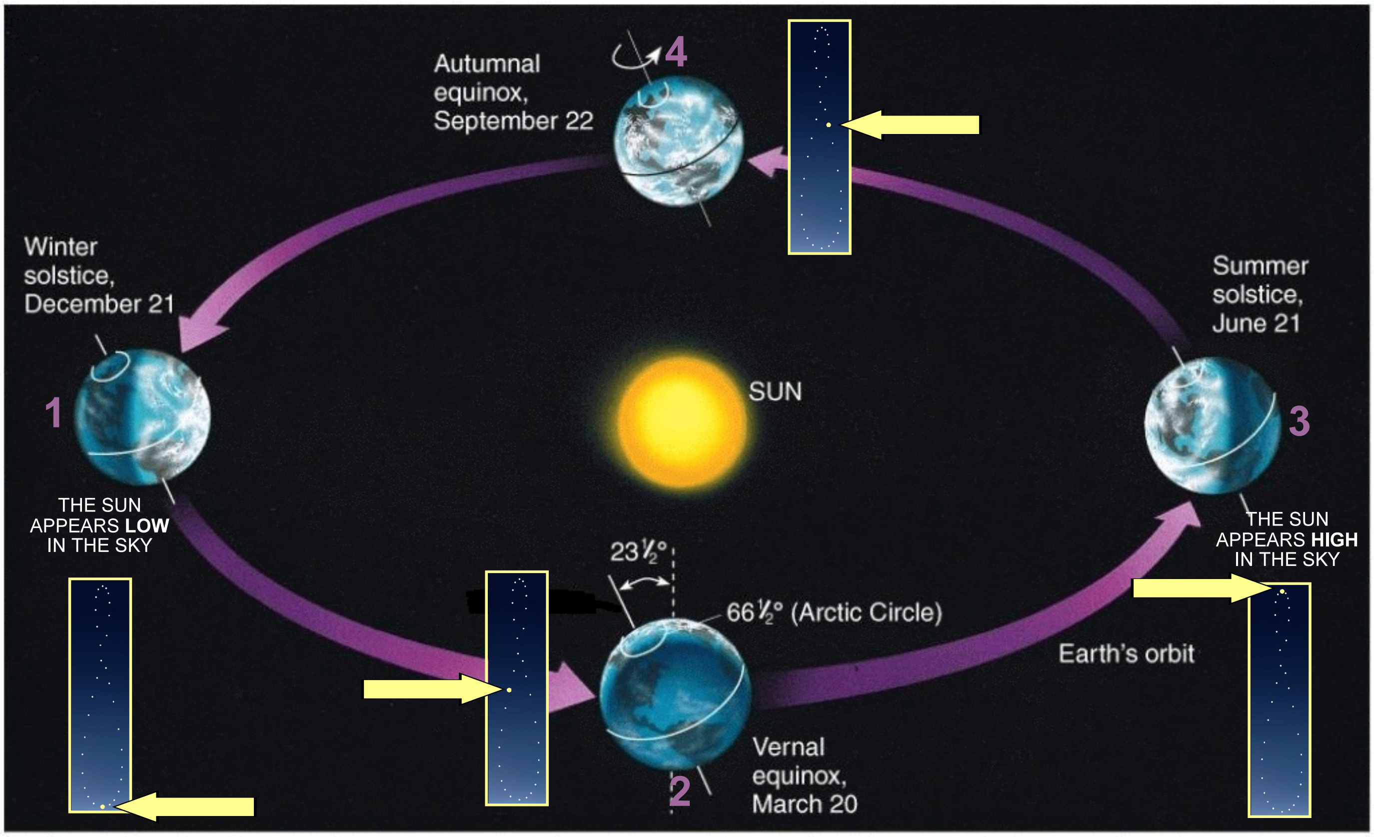
Before clocks and calendars, the position of the sun in the sky gave us the only reliable way to tell time or even what day it was!

Want to know *why the wacky shape*?

Read on.



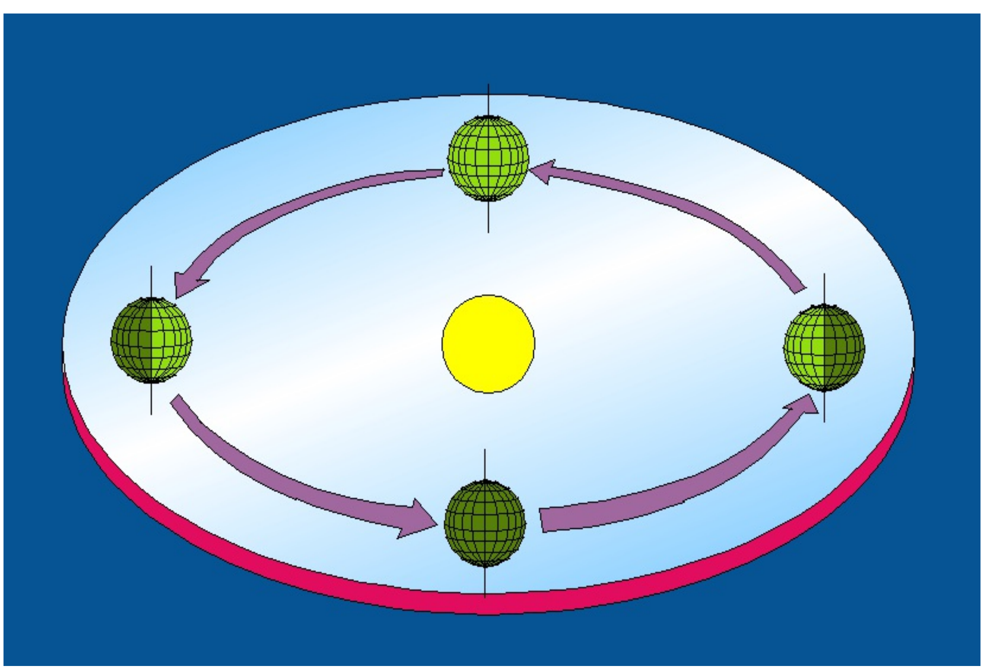
Let's do what Albert Einstein called a **thought experiment**. That's an experiment that you can't actually do because it's too expensive or it uses things that are too hard to move around, like stars and planets.



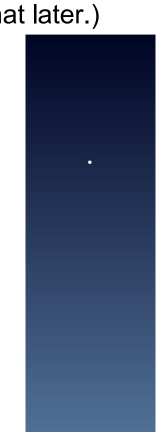
Look carefully at this illustration. It shows how the tilt (axis of the Earth's rotation) always points north, no matter the time of year. From the perspective of the Sun, the Earth appears to change its tilt, with the north pole tipped toward the Sun in summer and the south pole tipped toward the sun in winter. Now look at each of the four little **analemmas** next to the Earth at (1) winter solstice, (2) vernal equinox, (3) summer solstice and (4) autumnal equinox. The yellow arrow by each box shows where the Sun would appear in the sky on those dates. Compared to the plane of Earth's orbit, the Earth's axis is tipped at an angle of 23.5 degrees.

There are 2 main reasons for the shape of the **analemma**.

Number One: The Earth's tilt. The tilt of the axis of the Earth is 23.5 degrees, when compared to the plane of its orbit. *Here's the "thought experiment" part.*
Imagine the Earth's axis is straight up-and-down. At noon the sun would always be at the same spot.



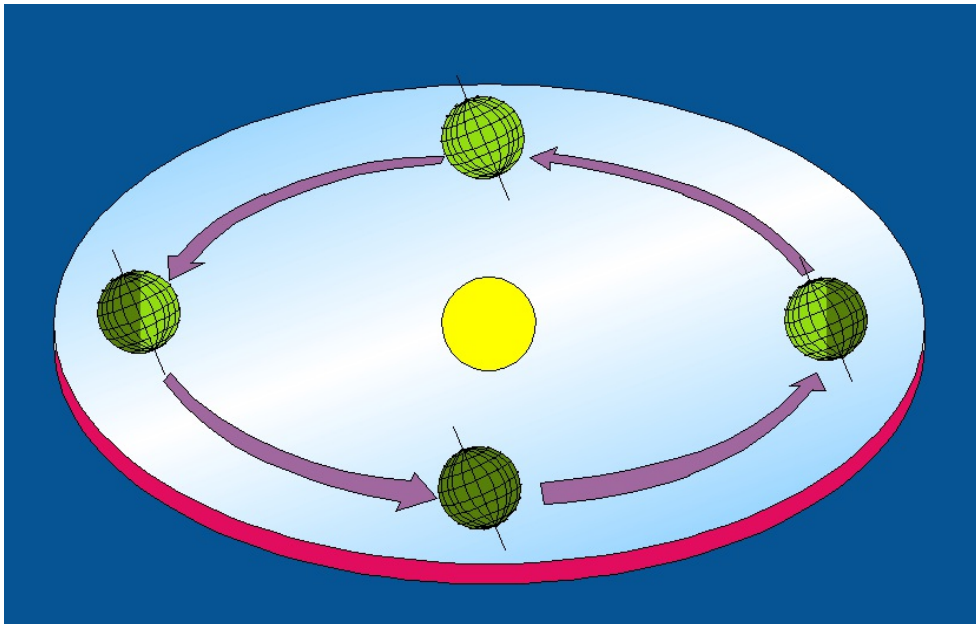
Suppose the Earth axis wasn't tipped over at 23.5 degrees but was at right angles to the flat plane of it's orbit around the sun. Also suppose that the orbit of the Earth around the Sun was exactly circular. (More about that later.)



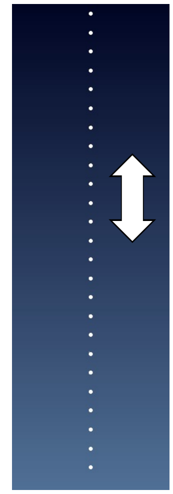
Earth with 0 degree tilt with a circular orbit

The Sun would always rise at the same spot along the eastern horizon and set at the same spot on the western horizon. It would always arrive at the same spot on the sky at noon, shown above-right every day, all year. The only way to change this would be to travel to the north or south. The further north you traveled, the further south the Sun would appear in the sky and the further south you traveled, the further north the sun would appear. If you were on the equator, the Sun would always rise due east, be directly overhead at noon and set due west. (No seasons, very boring!)

<u>Now tilt the Earth's axis at 23.5 degrees.</u> At noon, the Sun would always appear along a north-south line.



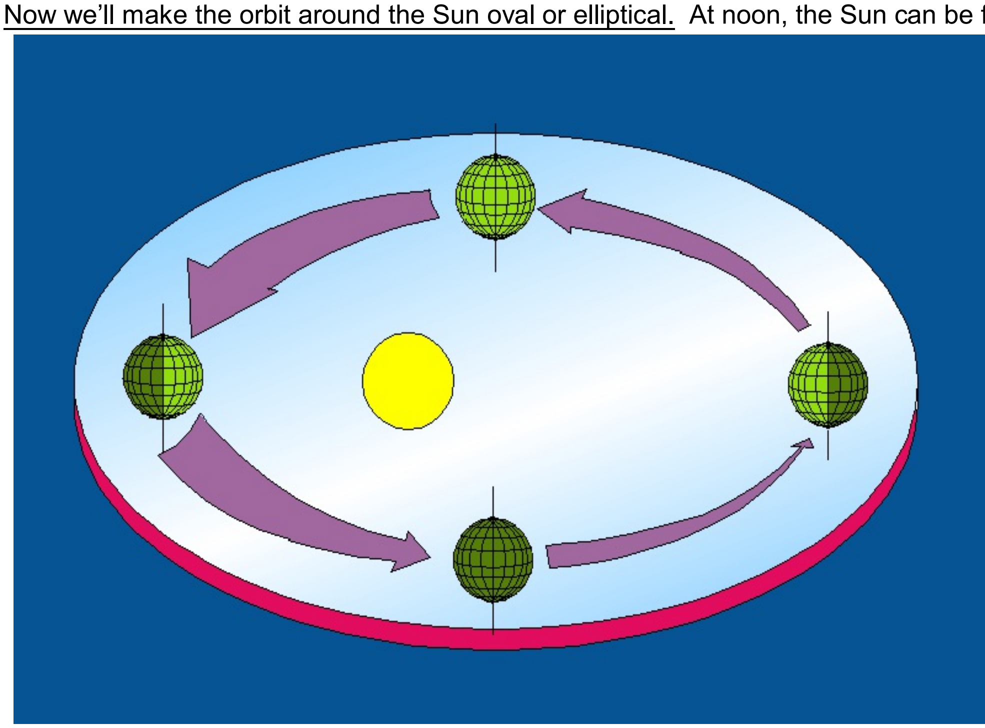
Now suppose we tilt the Earth over on it's axis, say 23.5 degrees, as shown at left.



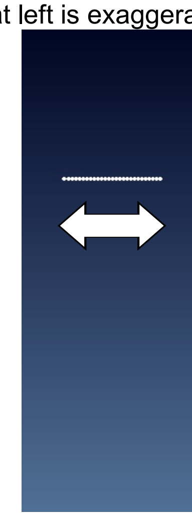
Earth with 0 degree tilt

The illustration on the above-right represents the analemma that we'd have with the 23.5 degree axis tilt but it doesn't look much like the figure '8' **analemma** that is actually traced out by the sun during the year. Above, we're keeping the orbit perfectly circular.

<u>Now we'll make the orbit around the Sun oval or elliptical.</u> At noon, the Sun can be found along an east/west line.

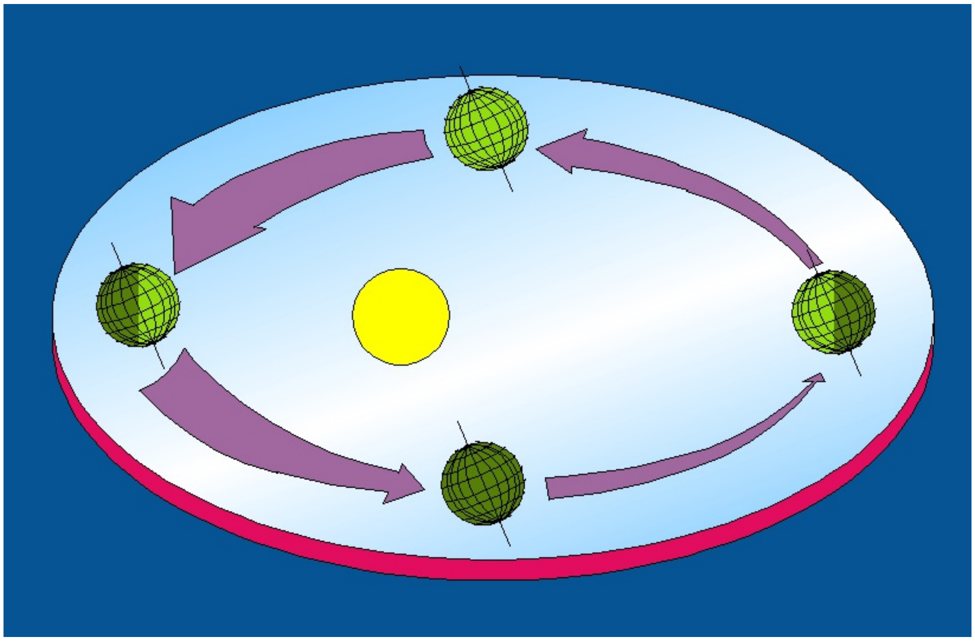


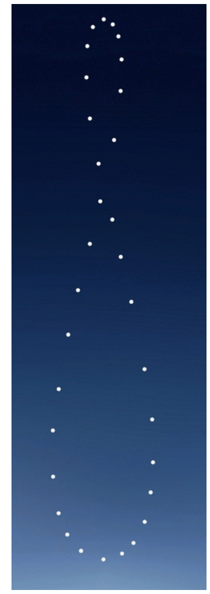
Let's now set the Earth's tilt back to 0 (zero) and make the orbit around the sun an ellipse, with the Sun off-center. That's where it actually is! The sun offset at left is exaggerated.



Earth with 0 degree tilt
with an elliptical orbit

Now the sun wanders left and right (east and west) throughout the year instead of appearing at the same place in the sky each hour of the day. Why the wander? That's because Earth travels faster on its orbit when it is nearer the sun and slower when it is farther from the sun. So, even though the Earth's rotation about its axis is always at the same speed (once in 24 hours) the varying speed of the Earth's journey on its orbit as appears to make the sun "ahead of schedule" in the summer when we are moving slowly on our orbit and "behind schedule" in the winter when we are moving much faster on our orbit.





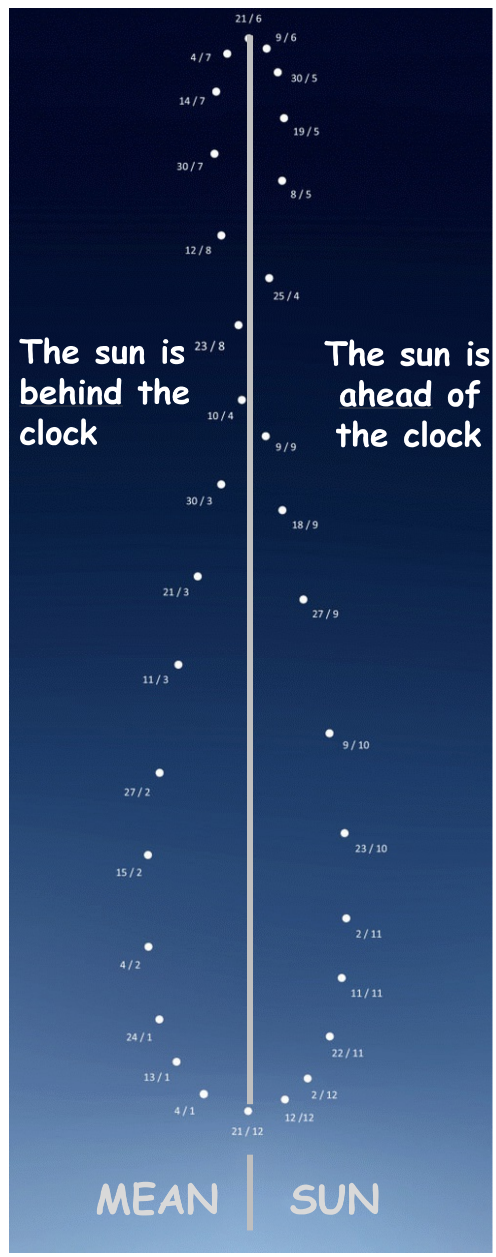
Earth with 23.5 degree tilt
and elliptical orbit

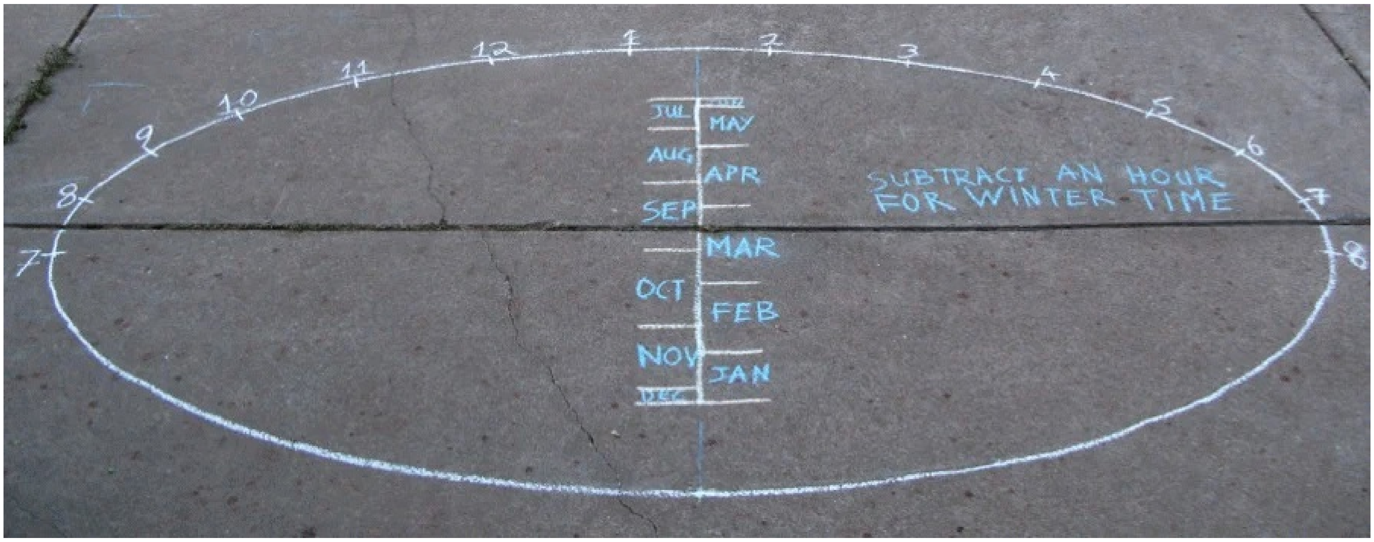
So, the <u>tilt</u> of Earth's 23.5 degree axis and its changing speed along the elliptical orbit around the sun combine to give us our beautiful **analemma**. There are other factors in play that change the shape of our **analemma** a little bit.

Solar timekeepers like to use the term "**mean Sun**" to describe a line that shows where the sun would be in the sky if the Earth revolved around the Sun on an circular orbit. This grey line is a lot like the second example in our mind experiment. The dates of each image of the Sun are listed on the illustration. For example "19/5" (May 19) shown at the upper right of analemma illustration indicates that is where the sun was on May 19.

Take a look at this garden sundial. An angled straight edge serves as a **gnomon** to cast a shadow in sunlight. A **gnomon** is usually a stick that is used to cast the shadow from the Sun. On a garden sundial, the **gnomon** points north. Here, it looks like the time is about 5:30. Or is it? The **gnomon** is set to align with the **mean Sun**. Judging by the flowers in bloom, it might be May when this picture was taken. If so, the sun would be ahead of clock time, so maybe it's only 5PM?

Garden sundials are only fairly accurate at the summer solstice, winter solstice and near the equinoxes when the actual Sun isn't far from the **mean Sun**. One way to make sundials agree more with clock time is to move the **gnomon** according to the date. A great way to have some fun and get an accurate sundial is illustrated below.





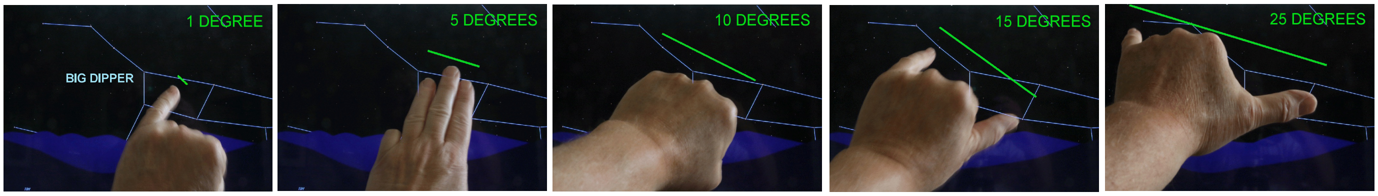
Here is a homemade sundial that is way more accurate than a typical garden sundial. In this 'sidewalk' sundial you stand on the marking for the date to tell the time. But where's the **gnomon**? You are! Your shadow will point to the correct time of day, marked on the upper curve. We plan to make such a sundial at the Forestry Outreach Center at Indian Fort parking lot on March 20. Come join us!

If you would like to try this yourself, go to https://www.youtube.com/watch?v=QYudi0YxmoU to see how. In order to get the correct sizes and dimensions for your location, go to https://analemmatic.sourceforge.net/cgi-bin/sundial.pl .

Above is an example of an **analemmatic sundial** that's located at the Cincinnati Observatory. Its construction is dedicated to the late Paul Nohr, astronomer at the observatory. In this image, Rev. Carla Gilbert, of Union Church, volunteers to be the **gnomon.** The date was late March and she is standing on the mark for late March on the bronze replica of the analemma. The arc in front has the hours of the day, also in bronze. We determined that the accuracy of this sundial to be about 10 seconds. It was exactly 3 PM.

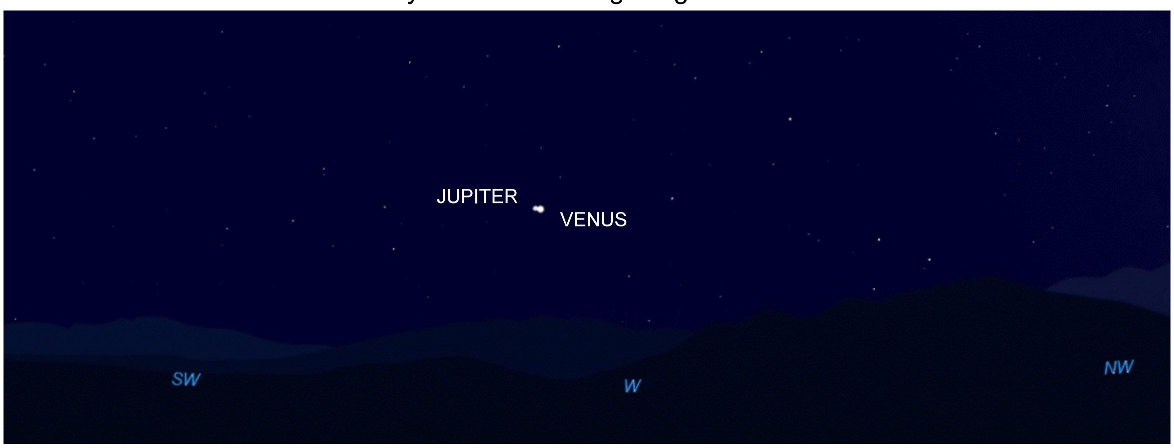
Attractions in March

Astronomers use a measuring scale of **angular distance** to show the apparent distance that separates two objects in the sky. A trip all the way around the sky would take 360 degrees. Here's a handy guide to estimate **angular distance** that you can use when you're out under the stars.

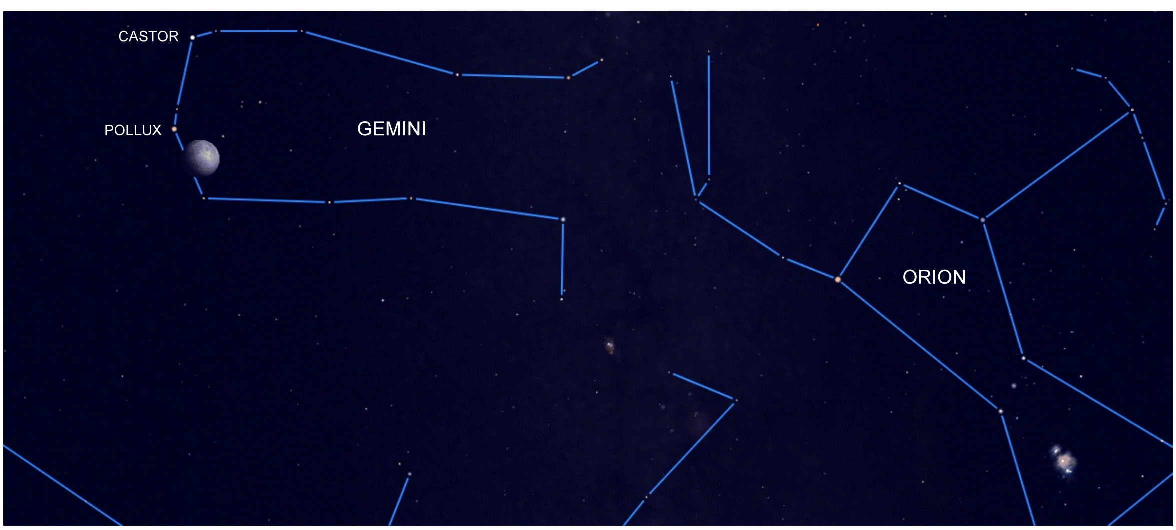


For instance, when you hold your hand all the way out and hold three fingers out, like the scout's salute in panel 2, your fingers create an **angular distance** of 5 degrees**,** about the width of the bowl of the Big Dipper. When I talk about the distance between, say, the Moon and a star or planet, I'll say that they are separated by a certain number of degrees. Sky and Telescope magazine is my source of most of the following information.

March 1 Binocular alert! This event is so cool that I also mentioned it the February article. From our perspective on Earth, the motions of Jupiter and Venus along their own orbits are going make them appear to be almost touching, less than ½ degree apart. That's less than the visible width of the Moon! Look low in the western sky as soon as it is getting dark.



March 2 This evening, look for the gibbous moon snuggling up next to the star Pollux, just 1-1/2 degree away.

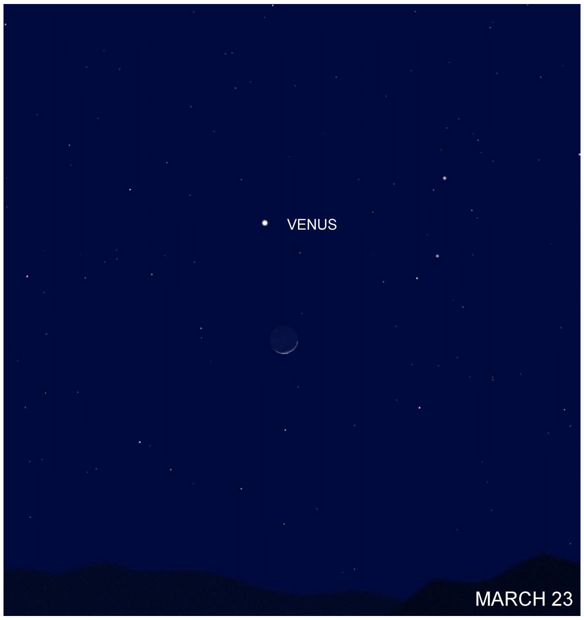


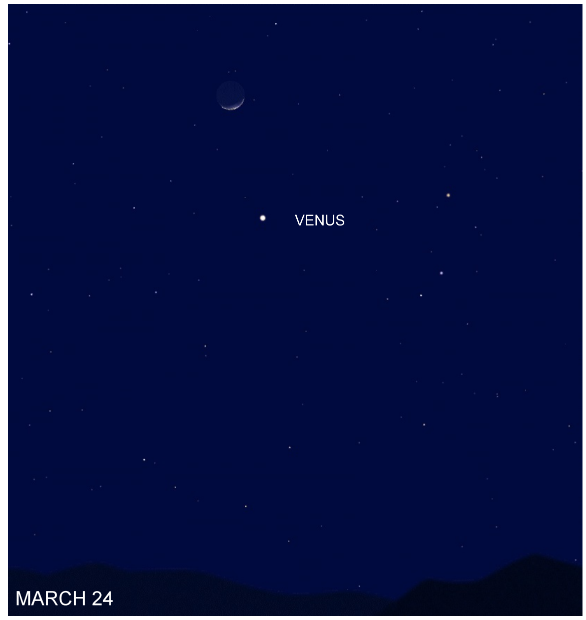
March 9 After it get's dark tonight, turn your attention to the southeastern horizon and watch the fatter moon rising together with the bright blue star, Spica, in Virgo.

March 12 This is the annual day of sorrow for star-gazers. We are again robbed of an hour of evening skywatching by the resumption of **Government Nuisance Time**, better known as Daylight Savings Time.

March 20 Today is the Vernal Equinox. On this day we receive equals amounts of daylight and starlight. (See no. 2 in the first illustration of the Earth-orbit illustration above.) Yes, the sun is a star!

March 23/24 Here's a nice demonstration on how far the Moon moves in a day. After dusk, check out the Moon and Venus as they do-see-do. On the 23d, the Moon is below Venus and on the 24th its above Venus. You might even catch Jupiter before it dips under the western horizon.





March 27 We've got another planet parade this evening. The last time this happened was a summer event in the predawn hours. This parade is joined by the star cluster known as the Pleiades, in Taurus.