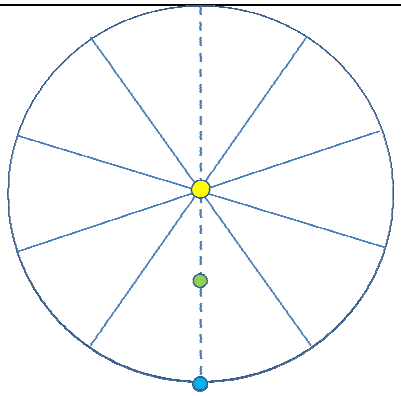
Transit of Venus Activity: Transit Frequency

On June 5-6, 2012, Venus will pass in front of the Sun and we will be able to see this from Earth (don't ever look right at the Sun!). This is a very rare event, and this activity explores why this is a twice in a lifetime event (the last time this happened was in 2004 and was not visible in Montana).

The Race

Imagine that daughter Venus and her mother Earth are going to race around their house. The young daughter, faster of the two, will run close to the house, while Mom will encircle the whole yard further out. As seen from above, they run anti-clockwise (i.e., "planetwise").

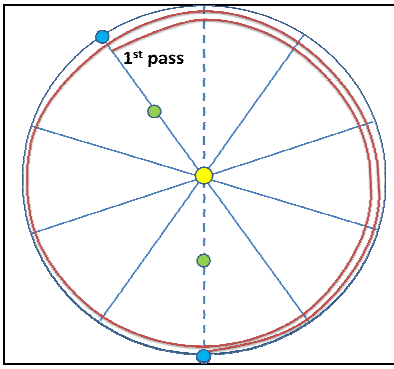


Directions:

1. Draw a dot in the middle of your paper plate for the Sun.
2. Draw a dotted line across the plate and through the Sun.
3. Separate your paper plate into 10 equal segments, as shown in the circle picture. There are about 7 divots in the paper plate per segment.
4. Draw two dots - one at the edge of the paper plate to represent Earth, and one closer to your Sun to represent Venus.

Earth and Venus line up at the dotted line to start the race. "On your mark...get set...GO!" Because daughter Venus is closer to the Sun, she runs around it faster than Mother Earth. Daughter Venus runs one lap in about 8/13ths of Mom's time. (Planet Venus orbits the sun in 225 days; planet Earth orbits the sun in 365 days. Dividing 225 by 365 equals 8/13.)

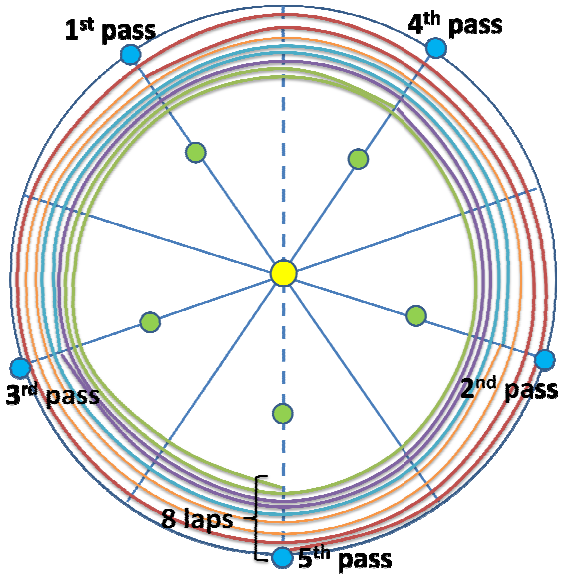
After running only 1.6 laps, mother Earth sees daughter Venus overtake her. At that moment, Mom has completed 1.6 laps while daughter has completed 2.6 laps. Mom notes her and daughter Venus' positions.



Directions:

1. Note that each segment of your grid represents 0.1 laps.
2. Use your grid to trace out 1.6 counterclockwise laps for Earth. Don't bother tracing Venus's path, or your paper plate will start to look messy!
3. At the 1.6 lap mark, draw dots to show that this is where Venus and Earth line up with the Sun.

The race continues. Each time mother Earth completes another 1.6 laps, daughter Venus catches up to and overtakes her on the inside track. Finally, after mother Earth has completed eight laps around the Sun, daughter Venus catches up to Mom for the fifth time. Conveniently, the finish line coincides with the original starting line.



Directions:

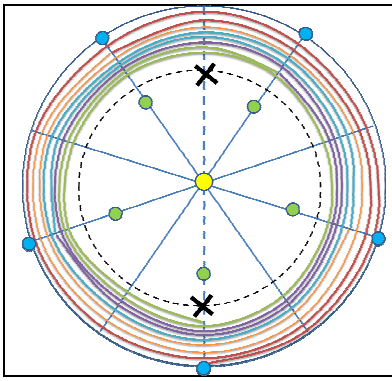
1. From the first pass, use a different color to again trace out 1.6 laps. Again, mark dots to show that this is where Venus and Earth line up with the Sun. **Try to keep your lines separate!**
2. Do this three more times and then you will be back to the starting line, and the pattern starts over again.
3. Count how many times Venus and Earth passed each other – was it 5 times?
4. Count how many total laps you drew around your paper plate – was it 8 total laps?

Mother Earth ran 8 total laps around the Sun in the time it took Daughter Venus to run 13 total laps (which weren't drawn). In that time, Earth and Venus lined up five times.

It would seem daughter Venus passes between mother Earth and the Sun five times in eight years. So why don't we see transits every 1.6 years? Two major factors interfere…

Factor One: The Inclined Orbit

First, daughter and mother are not running on a level surface.

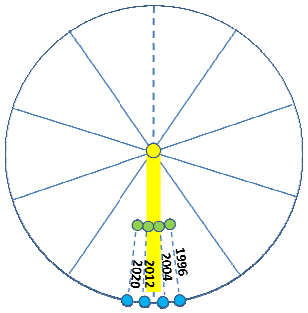


Directions:

1. Leaving the paper plate connected at the straight dotted line (at the X marks), cut two slits just outside the Venus markings but inside the Earth's orbits along the circular dotted line.
2. These hinges (X marks) represent the two nodes, where the planes of the orbits of Venus and Earth coincide.

Push the right half of the paper plate down, below the Earth's orbital plane, and the left half up, above the Earth's orbital plane. Only when the Sun, Venus and Earth are in a straight line can we see Venus pass in front of the Sun. The rest of the time, when Venus passes us it is either above or below the Sun from Earth.

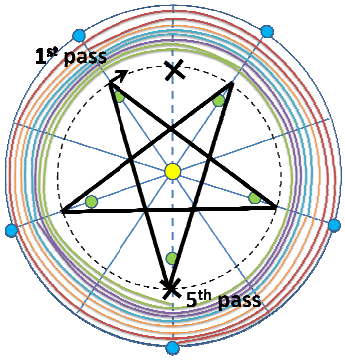
Now we see why there are not transits every 1.6 years, but why don't we see transits every 8 years?

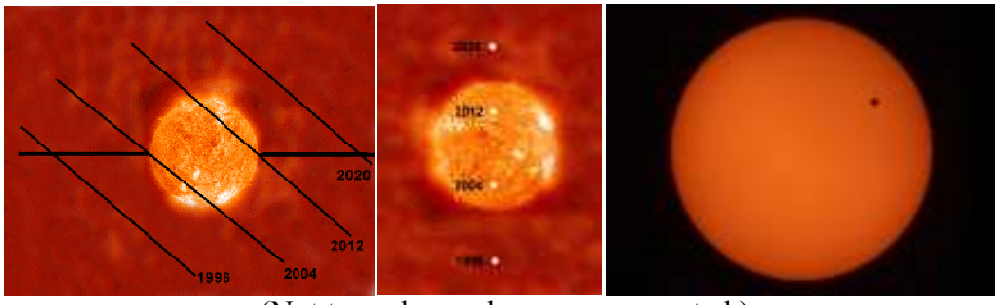


Factor Two: The Orbital Speed

*Venus actually makes it to the finish line **just before** mother Earth finishes her 8 laps.*

So each fifth alignment is a little short of the dotted line. The whole five-point star of passes is rotating clockwise a little bit every year. In 2004 the 5th pass alignment was just ahead of the dotted line, and Venus passed across one edge of the Sun, so we saw a transit. In 2012 Venus will pass across the other edge of the Sun for a transit. But after the next 8 year cycle, in 2020, Venus will be too far from the Sun for a transit. We will have to wait until the alignment from the 1st pass shifts all the way to the next node to see a transit again. This will happen in 2117 and 2125, and because the alignment is on the opposite side of the Sun, the transits will be in December rather than June. **That's why transits happen so rarely!!!**



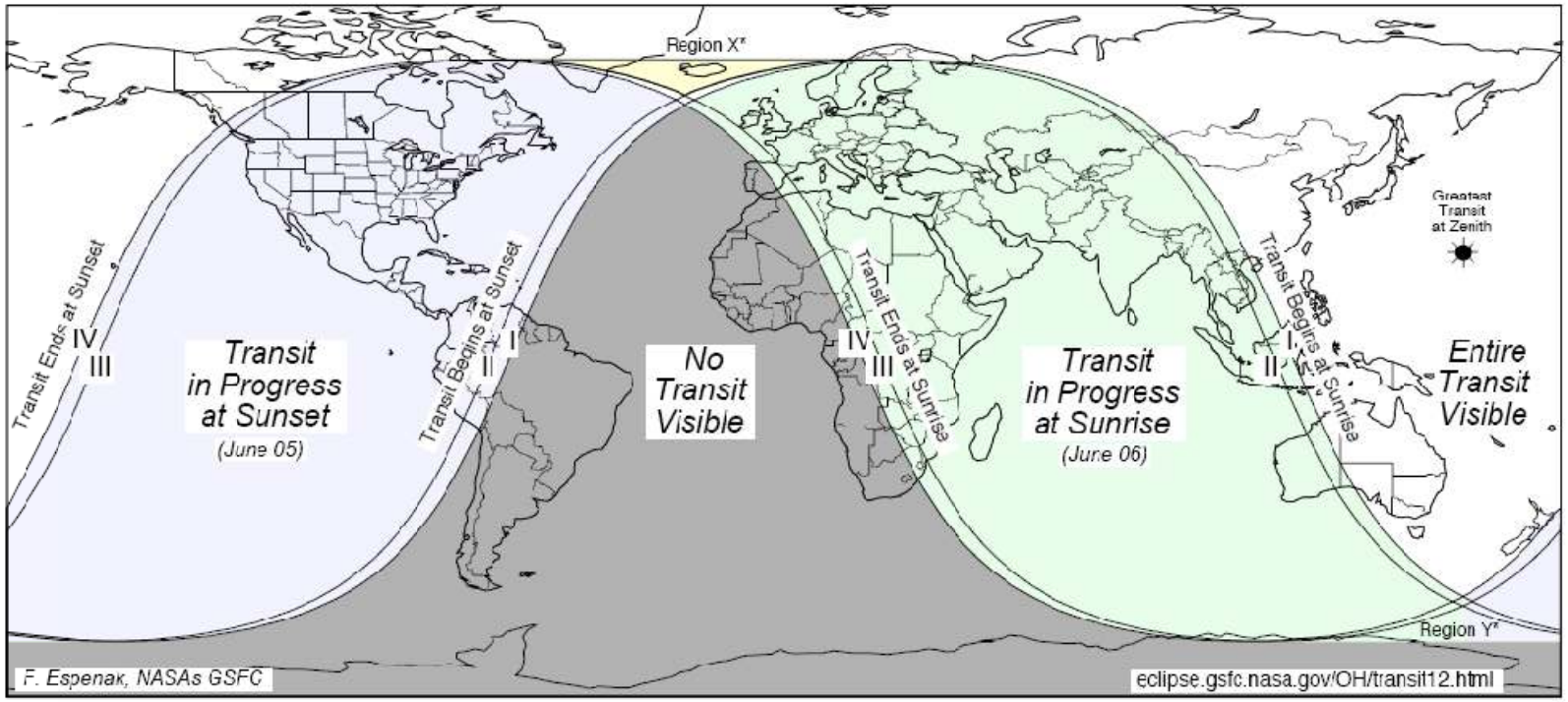


(Not to scale; angles are exaggerated.)

[Note: This activity ignores several important factors, including the eccentricity of orbits, the planet's varying orbital velocity along an ellipse, and precession.]

Adapted from material by Peter Langford and contributed by Chuck Bueter. Diagrams by Kathryn Williamson. Map courtesy of Fred Espenak (NASA GSFC).

Global Visibility of the Transit of Venus of 2012 June 05/06



* Region X - Beginning and end of Transit are visible, but the Sun sets for a short period around maximum transit.

* Region Y - Beginning and end of Transit are NOT visible, but the Sun rises for a short period around maximum transit.