AST 120 Activity 4
The Zodiac and the Precession of the Equinoxes

Name	Full	Partial	None

We have examined the apparent motions of the stars and the Sun. We've seen that the motion of the stars is easy: they act like they are fixed to the Celestial Sphere so that the RA and Dec of a star never seem to change. The Sun, on the other hand, drifts eastward relative to the stars along the Ecliptic. In this activity we will take a closer look at the constellations that lie along the Ecliptic, and we will use these constellations to define a new Zodiacal Coordinate System that we can use to track other unusual objects in the sky like the Moon, Mercury, Venus, Mars, Jupiter, and Saturn. We will also see that the fixed stars are not quite as fixed as we thought.

- Go to a computer and launch Stellarium. Make sure you are in Rome, GA.
- Set the time flow rate to zero (7) and set time to now (8).
- Turn off the atmosphere (a), fog (g), and ground (g).
- Turn on the ecliptic (,). Also turn on the boundaries (b), lines (c), and labels (v) for the constellations.
- Find the sun (you can use Search). Click on it and track (t) it.
- Hold down the = key to advance time by days. Follow the motion of the Sun and watch as it enters the vicinity of various constellations. The constellations along the Ecliptic (and thus the constellations through which the Sun passes) are known as the Zodiac. For each of the constellations of the zodiac, record the date that the Sun enters and exits that constellation in the table below.

Constellation	Symbol	Sun Enters	Sun Exits	Astrologic Start	Astrologic End
Libra	♎			Sep 23	Oct 23
Scorpius*	♏			Oct 23	Nov 22
Sagittarius	♐			Nov 22	Dec 22
Capricornus	♑			Dec 22	Jan 20
Aquarius	♒			Jan 20	Feb 19
Pisces	♓			Feb 19	Mar 21
Aries	♈			Mar 21	Apr 20
Taurus	♉			Apr 20	May 21
Gemini	♊			May 21	Jun 21
Cancer	♋			Jun 21	Jul 23
Leo	♌			Jul 23	Aug 23
Virgo	♍			Aug 23	Sep 23

* when you get to Scorpius, answer the next question below (on the next page)

1. Shortly after entering Scorpius the sun passes into a constellation that is not on our zodiac list. Record the name of this constellation below, but in the table above treat this constellation as though it is part of Scorpius.

2. Based on your results, would you say that your astrological sign is determined by where the Sun was in the sky when you were born?

3. Note that the different parts of the Ecliptic can be broken up into pieces occupied by these constellations. This gives rise to yet another coordinate system, called the *ecliptic system*. One way to give the coordinates of a planet (it is really only used for planets) in this system is to give the constellation the planet is in and the number of degrees East the planet is from the Westward edge of that constellation. The *ecliptic latitude*, the number of degrees above (North) or below (South) the Ecliptic, can also be given. Just to see how this works, find Jupiter's location right now. Set the date to January 1, 2001 (and pick any time) and find Jupiter. You may want to turn on the equatorial grid (e) to help you estimate angles. In the ecliptic system we would list Jupiter's location as (♉8°, -1°). This indicates that it is 8° from the western edge of Taurus (note that the zodiacal constellations all occupy roughly 30° segments of the Ecliptic) and a little bit below the Ecliptic. Now find the location of Venus on January 1, 2001. Give its location in the zodical system below. Use the correct symbol for the constellation in which Venus appears.

4. Find the location of Mars on January 1, 2001. Give its location in the zodiacal system below. Use the correct symbol for the constellation in which Mars appears.

5. Leave the date on January 1, 2001. Turn on the equator (.). Go back to the Sun, hold down the = key and follow the Sun around the Ecliptic until it reaches the vernal equinox ♈ (RA = 0^h). Note that the vernal equinox has the same symbol as the constellation Aries. Is the vernal equinox located in Aries? If not, in what constellation is it located?

6. Now set the Date (in the Date and Time window) to 200 BC (-200). Find the vernal equinox again (you may need to first find the Sun and then follow it along the Ecliptic). In what constellation was the vernal equinox located in 200 BC?

7. Set the time to now (8). Search for the star "Regulus". This will take you to a bright star in the constellation Leo that lies almost exactly on the Ecliptic. You should find that Regulus lies to the West of the autumnal equinox ♎(RA = 12^h). But we just saw that the vernal equinox moves around, so the autumnal equinox must move around as well. Use the Date/Time window to advance time forward until the autumnal equinox is located at Regulus. I suggest jumping ahead by 1000 years to start. When you get Regulus to the autumnal equinox, record the year below.

8. The equinoxes are defined to be the intersections between the Celestial Equator and the Ecliptic. Note that Regulus stayed on the Ecliptic the whole time. However, it started well off of the Celestial Equator but ended up right on it. So which line actually moves relative to the fixed stars, the Ecliptic or the Celestial Equator?

9. What direction, relative to the fixed stars, does the autumnal equinox move along the Ecliptic?

10. The movement of the autumnal and vernal equinoxes is known as the *precession of the equinoxes* and was known to the Ancients. Let's try to determine the period of this precession. Continue to move time forward in units of centuries until the line for RA = 14^h passes through Regulus. Record the year below.

11. Find the number of years between the time when the RA = 12^h line passed through Regulus and the time when the RA = 14^h line passed through Regulus. Record your answer below.

12. About what fraction of the way around the ecliptic has each equinox moved during this time?

13. How many years would it take for the equinoxes to travel all the way around the ecliptic and return to their starting points? In other words, what is the period of the precession of the equinoxes?

14. Now set the date to 2800 BC and set your view so that you are looking toward the North Celestial Pole. Increase the time flow rate (l) until you can see the stars move in their daily rotation. What moderately bright star played the role of the pole star (currently played by Polaris) in 2800 BC?

15. To take a closer look at the phenomenon of precession, quit Stellarium and run the CelestialGlobe program. Under Extra Options, select Display Additional Controls. Under Sky View Options (in the Sky View window) deselect Show Daylight. Now use the Year slider to go back to the distant past. Then move forward to the present, slowly so that you can see what is happening (in both windows). The stars seem to be circling around what point? This point is the pole associated with what circle?

16. Measure the period of precession using CelestialGlobe. In other words, find the time it takes the stars to complete a circle around the point you identified in the previous question. Record your answer below. How does this compare with your previous value for the period of precession?

17. Earlier we determined the time it takes for the sun to go all the way around the stars (the *sidereal year*). Now we see that the equinoxes (and solstices) move, very gradually, relative to the stars. This means that the time it takes for the sun to go from one vernal equinox to the next, a time known as a *tropical year*, is not quite the same as a sidereal year. Use what you know about the direction of the sun's annual motion along the ecliptic and the direction of the motion of the equinoxes (due to precession) in order to determine which year is shorter. If you can't figure this out, try using the CelestialGlobe program to measure which year is shorter. Explain how you determined your answer.