We now take it for granted that the Moon orbits the Earth and Earth-Moon system orbits the Sun. But this was not always the case. Trying to determine the paths of celestial bodies while on a spinning, tilted Earth that's orbiting the Sun is an extremely difficult task. Imagine trying to draw a map of your own hometown while riding the Tilt-a-Whirl at the amusement park!

Throughout the 17^{th} century, scholars advanced several different explanations for the motions of the Sun, planets, and stars. In the absence of unambiguous scientific data, theories were often justified on aesthetic, religious, or philosophical grounds. By 1632, the controversy surrounding the many explanations of celestial motions had become so intense that Galileo was summoned before the Roman Inquisition for publishing a book describing a *heliocentric* model. At the time, a geocentric theory was the accepted explanation for the motions of objects seen in the night sky and was the model taught by the [Roman Catholic] Church. But Galileo based his argument on careful observations that he made with a newly invented tool: the telescope.

Four centuries of increasingly sophisticated astronomical observations later, we now know that Galileo's heliocentric theory was correct. But it wasn't until Isaac Newton's 1687 theory of universal gravitation that the last piece of the puzzle fell into place.

Even before Newton, Johannes Kepler was able to show that all the planets orbit the Sun and the Moon orbits the Earth along elliptical paths. The data also showed that the farther a moon or planet is from the body it is orbiting, the longer it takes to complete one orbit. For example, the Moon is 3.8×10^5 km from the Earth and it completes one round trip every 27.3 days. The Earth is 1.5×10^8 km from the Sun and it makes a complete orbit in about 365.25 days. We now know this is because of gravitational interactions. But despite the apparent simplicity of this description, the Sun, Moon, and stars follow relatively complicated paths across the sky.

You may have previously observed the motion of a planet (or the Moon) over a very short time. In this exercise, you will see the motions of the Sun and Moon over an *extended* period of time. As you watch the Sun and Moon (and planets and stars) travel through the sky, try to keep in mind that their paths are the combined result of four relatively simple facts: (1) the positions of the stars relative to each other are nearly constant; (2) the planets orbit the Sun; (3) the Moon orbits the Earth; (4) the Earth spins.

MOTION OF THE MOON

Before you begin any observations, you should make sure you understand how to read and use the SC001 chart. There is a link on to a tutorial found in the same place where you retrieved this document.) If you need additional help ask a classmate or attend one or more help sessions.

The Moon is one of the most prominent objects in the sky and nearly everyone is aware of its phases. Yet few people think about it deeply enough to note how it moves among the stars, or to recognize how both position and time relate to its phases. Over the course of the next several weeks, observe the Moon with respect to the stars as often as possible, plotting its position on the SC001 chart. You may either visually estimate the position of the Moon or measure the angle and direction between it and a few bright stars. The star chart is labeled in both RA and DEC so you can determine angular positions relatively accurately. Remember to record the date, time, and phase of each observation.

In addition to noting the phase, you must also make a sketch showing how the Moon looked during that observation. This should be included with your observations table (see Table 1). Do not draw phases on your SC001 chart! Rather, draw a small circle, dot, etc. and number the position. Make sure the numbers correctly correspond to the appropriate observation in the table (see Table 1).

Note that as the Moon moves through its cycle, you may have to adjust the time at which you observe it (you should already know this!). This is the reason you should not let too many days pass without at least finding the Moon – you might otherwise lose it. **Continue to observe the Moon until it returns to and passes the phase that it had when you first began your observations. If it has not yet passed the location in the sky with respect to the stars that it had when you initially observed it, continue following it until it does.** You will get better results if you follow the Moon through more than one complete cycle. You must make **a minimum of 10 lunar observations**, with at least 12 hours between consecutive observations. Record your data in a table similar to that in Table 1.

Obs #	Weather & Notes	Date	Time (CST)	Phase	Sketch
1	mostly clear; some clouds; high humidity	2001 Feb 15	05:50	3Q	
2					
3					
…					
10					

Table 1. Sample data table for lunar observations.

You will find this exercise both easier and more rewarding if you start early and come to one or more help sessions to check your work after making one or two observations. For example, you'd hate to go the entire term, make ten observations, turn it in at the last opportunity, and then get very little or no credit because you did it incorrectly and made errors that could have been corrected if only you'd been asking for help and checking your work all along. Successful students start early, ask for help often, and check their work multiple times before turning it in.

ANSWER THE FOLLOWING QUESTIONS AS COMPLETELY AS POSSIBLE.

1. **In what direction does the Moon travel in its orbit (E-to-W or W-to-E)? What plane does the Moon orbit in?**
2. **Roughly how many degrees per day did the Moon move? Use the full dataset and make sure it is clear how you determined the answer.**
3. **Use the rate in question 2 to calculate how long it takes the Moon to make a full 360° circuit with respect to the stars. This is called the *sidereal* period of the Moon (Figure 1).**
4. **The *synodic* period of the Moon is the time it takes to go from one particular phase back around to that same phase (Figure 1). Based upon your data, how long is the synodic period of the Moon?**

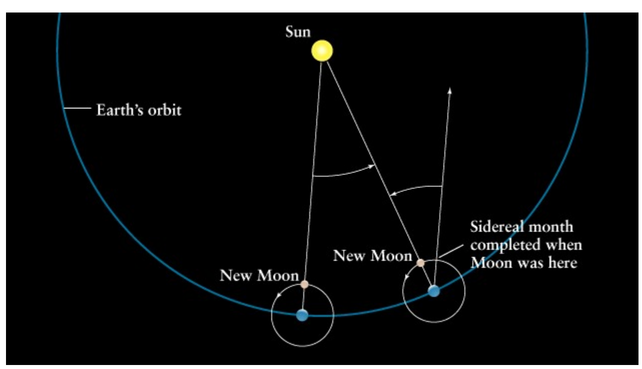

Figure 1. Sidereal and synodic lunar periods.

5. **Are the sidereal and synodic periods you calculated the same? Should they be? Why or why not? (Hint: look at Figure 1.)**
6. **Based on your data, when would you expect the next new moon, first quarter, full moon, and third quarter? *Be specific: you must include the date and approximate rise-set times; these must be estimated from the alignments. Do NOT quote actual rise and set times!***