

Lunar Motion

Name _____

The purpose of this exercise is to determine the lunar sidereal and synodic months from observations.

The Moon has been observed by ancient astronomers. The Moon with its constantly changing face, or phases, has enthralled observers with its predictability. This spectacle influenced our ancestors to create a unit of time based upon the motion of the Moon, or months. The Moon can be studied in great detail without the use of instruments. Through naked eye observations, the motion of the Moon can be analyzed. For example, from a set of observations the length of a lunar month can be determined. However, the Moon will travel faster across the sky during different months, so a single month of observations is only an estimate. In order to get an accurate value for the length of a month, several months must have observations. The length of a lunar month would then be the average of these measurements.

There are two types of lunar months. First is the synodic month which is defined as how long does it take for the Moon to complete a cycle of phases. The second type of lunar month is the sidereal month. This is defined by how long it takes the Moon to return to the same position in the sky relative to the stars. These months have different lengths because they are relative to two different types of astronomical objects; sidereal month is relative to the stars where the synodic month is relative to the Sun.

A. Sidereal Month

1. Determine a scale factor (degrees/mm)

First you need a scale factor to relate your observations with the actual motion of the Moon. The simplest method for doing this is to measure the distance between two stars used as reference stars from your sketch. Both of these stars are most likely along the ecliptic, where the Moon is always found. Use two stars that have similar declinations. This will reduce the error and geometric effects of inclination.

Distance in mm between two stars: _____

Look up the Right Ascension (RA) of these two stars. This value will most likely be given to you in hours:minutes:seconds. You must transform these values into degrees (HINT: 360 degrees make a circle).

Calculate the scale factor: _____

2. Measure the angular rate of motion (degree/day)

First you must convert your dates and times into decimal days. This is done simply by the dividing how many units of time are in a day (e.g., 24 hour/day ; 60×24 minutes/day) then adding all of the fractions plus the date. For example, August 23 at 9 15 pm = 23.885 days.

Write this decimal date in column 1 of Table 1.

It will be easiest to measure the distance the Moon is from a single reference star. Using your ruler, measure in mm the distance to the Moon. Write down your measurements in column 2 of Table 1.

Using the scale factor, transform the distance measurements from column 2 into degrees and write in column 3 of Table 1.

Now that you know the decimal date and the distance the Moon traveled, calculate the angular rate of the Moon.

How fast does the Moon travel across the sky? _____

3. Calculate the Sidereal Month

You know the rate at which the Moon travels across the sky. Now, how many degrees must the Moon travel to return to the same location with respect to the star? _____

Using the angular rate and the distance the Moon must travel to return to a particular location in the sky, calculate the length of a lunar sidereal month.

B. Synodic Month

4. Size of Full Moon

You should have observed the Full Moon and have a direct measurement of its width. However, if you did not observe the Full Moon, you can estimate the width of the Full Moon. If you observed the Moon at 1st quarter, then you know exactly half of the full size of the Moon. If you observed 3rd quarter, then you measured 1/2 of the size of the Full Moon. If you do not have any of these measurements, then you can estimate the full size of the Moon from the curvature that you have sketched.

5. Rate of Change (percent/day)

In Table 2, you must fill in the decimal day and your observed measurements of the illuminated portion of the Moon in columns 1 and 2, respectively.

In column 3, you must write the fraction of the illuminated portion of the Moon. This fraction can be thought of as a percent and is calculated by dividing the observed measurement by the width of the Full Moon (or the size at 100%).

Take two days where both days are either before or after the Full Moon. Calculate the rate that the Moon changes phase by subtracting these two days and dividing by the time interval.

At what rate does the Moon change phase? _____

6. Synodic Month

To calculate the time it takes the Moon to go from 0% illuminated to 100% illuminated, the following equation must be solved:

$$\text{Rate} * \text{days} = 1,$$

where the Rate is how fast the Moon changes phases and 1 is when the Moon is completely illuminated.

However, this is only $\frac{1}{2}$ of the cycle. The Moon must return to New Moon, or 0% illumination, to be a complete cycle of phases. So, the equation now becomes

$$\text{Rate} * \text{days} = 2$$

Solving this equation for days will give you the length of the synodic month according to your observations.

Name _____

C. Answers to Sidereal Month

Rate _____

Sidereal Month _____

D. Answers to Synodic Month

Rate _____

Synodic Month _____