# PHYS 133 – Lab 4
# Retrograde Motion and Solar Altitude

**Goal:**

- Follow Mars on Stellarium across various months in order to observe retrograde motion.
- Observe the progression of the Sun's altitude at a certain time throughout the year on Stellarium, and understand how this connects to the season.

**What You Turn in:**

- Turn in either an annotated pdf file, or screenshots of the lab worksheet via Canvas.

## Background

### Retrograde Motion of Mars:

Since ancient times, astronomers have noticed that every once in a while, Mars undergoes retrograde motion, meaning the planet appears to move backwards when compared to the background stars for a while before going forward again. The reason for this is that Earth is in the inner orbit compared to Mars, so Earth moves faster than Mars. At certain times during the orbit, the Earth begins to approach and overtake Mars, which causes the line of sight between Earth and Mars to move backwards in comparison to the stars. See diagram 1 for a visualization. For this section of the lab, you will use Stellarium to observe Mars over many months as it moves across the sky.

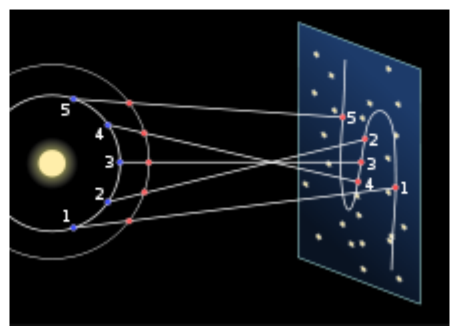


Figure 1: How the motion of two planets create an apparent backward motion. Source*: Wikipedia*

### The Seasons and the Apparent Position of the Sun:

The most telling changes that occur during a season is the temperature. It is cold during the winter and warm during the summer. Furthermore, the day becomes short in winter and long in summer. The reason for this is that Earth orbits the Sun at an axial tilt of 23 degrees. And so as the Earth moves around the Sun, different latitudes of the Earth will be exposed to varying amount of Sunlight. The way we see this when we are on Earth is that the altitude of the Sun will vary if we observe it at the same time every day throughout the year. For this section of the lab, you again use Stellarium, this time to observe the latitude of the Sun once a month at noon, and then sconnect this to the passing of the seasons.

Figure 2: This is the annalema. A photograph of the Sun was taken at the same time of the day during various days of the year. Source*: Wikipedia*

## Procedure

Part 1: Retrograde motion of Mars

1. Using a web browser, access Stellarium.
2. Search for Mars using the search bar, and lock on to it. Turn on the equatorial grid. Set the date to August 15, 2020, and the time so that Mars is visible high in the night sky. Then stop the time.
3. Observe the stars around Mars and draw a few reference stars so you are able to keep track of the position of Mars. I suggest you turn on the constellations and use a few of the brightest stars from the nearest constellation.
4. Draw a dot that represents Mars at the initial position in August 15. Label this dot 1.
5. Move the days forward. For every 10 days, record the position of Mars and label each subsequent dot with the next number. Do this until you reach the beginning of December.
6. Draw a line connecting these dots.

Part 2: The Seasons and the Apparent Position of the Sun

1. Using a web browser, access Stellarium.
2. Turn on the meridian line and the azimuthal grid. Turn off the atmosphere.
3. Set the date to June 21, and move the time such that the Sun is on the meridian line. Click on the Sun and record the date and altitude.
4. Repeat this with the other eleven months of the year. Just click on the month arrow.

After you are done, answer the questions below.

## Data Sheet

Draw the diagram for part 1 here:

Part 2 Data:

| Month | Altitude | Month | Altitude |
|---|---|---|---|
| ________ | ________ | ________ | ________ |
| ________ | ________ | ________ | ________ |
| ________ | ________ | ________ | ________ |
| ________ | ________ | ________ | ________ |
| ________ | ________ | ________ | ________ |
| ________ | ________ | ________ | ________ |

## Questions

1. Approximately how long did it take for the retrograde motion to complete? Using this, by how many degrees does the Earth orbit during the retrograde phase? Look up how long it takes for Mars to complete a period, and do the same calculation.

2. Using the formula $(\theta_e/\theta_m)^{2/3} = r_m$, find the distance of Mars from the Sun in AU. $\theta_e$ and $\theta_m$ are the angles Earth and Mars sweep that you found in the previous question. How does the calculated distance compare to the accepted value?

3. Using the fact that Earth is tilted 23 degrees, and Newark, De is approximately 40 degrees N latitude, what is the maximum altitude that the Sun reaches during the summer? What is the lowest altitude the Sun reaches during winter? How do these calculations compare to your results?

4. Consider the altitudes you measured for March and September. How does that compare to the altitude of Newark, DE?

5. What happens to the position of the Sun from June to December, and then from December to June? What seasons are encompassed during each of the interval of time?