# Physics 10293 Lab #8:
# <u>The Outer Planets</u>

**<u>Introduction</u>**

Today we will explore the motions in the sky of the outer planets that are easily visible to the naked eye: Mars, Jupiter and Saturn.

**<u>Step 1</u>**

Start by opening the Skyguide tab on the sidebar, then select the "Unit C: The Planets". Then choose "Exercise C1: The Inner Planets of the Solar System" and from here, exercise "Part 1: Orbits of the inner planets."

When one of the outer planets is directly on the opposite side of the Earth from the Sun, we call this <u>opposition</u>. During this time, the planet and the Earth are at their smallest distance from one another, and the planet is therefore at its brightest in our nighttime sky, high overhead at midnight.

The simulation "<u>Part 1: Orbits of the inner planets</u>" begins in 2009. Let's instead set the starting time to "Now" and the time step to 1 day. Starting from now and going forward, find the approximate dates of the next five oppositions of Mars. Remember, during opposition, you should be able to draw a straight line from the Sun, through the Earth, to Mars.

Opposition #1 date: ______________________________

Opposition #2 date: ______________________________

Opposition #3 date: ______________________________

Opposition #4 date: ______________________________

Opposition #5 date: ______________________________

What is the approximate average interval, in years and months, between successive Martian oppositions? This is the Martian synodic (solar) period.

_________ years __________ months

**Step 2**

You may have noticed that during Opposition #1, the Earth and Mars were much closer together than during later oppositions. Since Mars has an elliptical orbit, such close approaches will occur when Mars is near perihelion (the little notch marked in its orbit), its closest approach to the Sun.

In fact, the closest approach recently occurred on August 27, 2003. Set the date to this day to see where Mars was with respect to the Earth on that day. You may need to zoom in a bit to make sure Mars appears.

Every time Mars has an opposition (especially back in August 2003), we are typically bombarded with messages about Mars being "huge" or "the size of the full moon" as if this is some sort of amazing record or incredible and unprecedented visual phenomenon, but actually, Mars doesn't look all that different at various oppositions. Its brightness and apparent size depend on the distance from Earth to Mars at the time of opposition.

Use the "Home" button to return to Fort Worth and set the date for the first opposition date recorded above. Set the time to 11pm, then use the "Find" sidebar to find Mars. Once you see Mars on your screen, hover your cursor over it to determine the distance from Earth (observer) to Mars.

Repeat this for each of the opposition dates we studied in Step 1 and record the information below (round off to three digits). Note that "au" for distance means "astronomical unit" which is the Earth-Sun distance, approximately 93 million miles.

Earth-Mars distance for Opp. #1: ________________ au

Earth-Mars distance for Opp. #2: ________________ au

Earth-Mars distance for Opp. #3: ________________ au

Earth-Mars distance for Opp. #4: ________________ au

Earth-Mars distance for Opp. #5: ________________ au

Earth-Mars distance for Aug 27, 2003: ________________ au

% difference between Aug 27 and other close opposition: ________

The 1st opposition represents a “typical” minimum opposition. The Earth-Mars opposition occurs near the Martian perigee about every 9th or 10th opposition. The August 27, 2003 opposition was heralded by many as something incredibly special, but in reality, it wasn’t much different from an ordinary opposition near perigee.

On your worksheet, calculate the percentage difference in distance 100 * (difference) / closest distance, which shows in percentage terms, this opposition wasn’t much different than most other oppositions of this kind.

In order for Mars to truly appear to be “the size of the full moon” in the sky, its distance from Earth would have to be about 0.004 au, not 0.372 au!

**Step 3**

For this part of the lab, we will go to another Skyguide exercise. Open the Skyguide, then open “Unit C: The Planets” and “C3: Direct and Retrograde Motion” and “1: Direct Motion”.

Step time forward one sidereal day at a time (if you let it run, it goes too fast) so that you can watch the motion of the planets. You will notice the planets moving right to left (West to East) along the Ecliptic. Most of the time, planets tend to travel at a roughly uniform speed along the ecliptic toward the East. That means if we map the planets against the background stars, they will seem to move a tiny bit further east each day.

Right-click on Saturn and select “Local Path” from this menu. On the very top, select the Options menu, then select “Orbit/ Path options…”. In this dialog box, click “infinite path length”, then slide the circular markers slider all the way to the left, then uncheck “show date/time”.

Run time forward until you see Saturn complete a few retrograde loops, a short time interval where it seems to reverse course and go opposite of its normal easterly motion along the ecliptic.

In what three constellations are these loops located?

____________________, ___________________, ____________________

**Step 4**

In the Skyguide sidebar, return to “Unit B: Solar System”, then select “B1: Geocentric to the Heliocentric Model” and finally “2: The Geocentric Model”. Run time forward to see how the geocentric model explains the retrograde loops of the outer planets (in this case, Mars).

Notice that in this model, when Mars is undergoing a retrograde loop, it is closest to Earth and therefore brightest, which matches the observations they were able to make at that time.

For the last part of the lab, we will explore the geocentric vs heliocentric debate a little further by reading a Scientific American article with a more detailed history of the issue. Read the article “Astronomy in the Age of Columbus” at the link:

http://personal.tcu.edu/dingram/Astronomy_Columbus.pdf

Answer the questions below, which are asked in the same order as they are covered in the article.

**Q1**. The author asserts that most scientists of Columbus’ era (late 15th century) agreed that the Earth is round. Why did many people abandon this belief in the United States after the American Revolution? Explain.

**<u>Q2</u>**. Columbus himself agreed that the world is round. Explain how he justified his voyage to the king and queen of Spain, to make them believe it was possible.

**<u>Q3</u>**. Although Columbus wasn't much of an astronomer, he did make use of "Ephemerides," a reference book for timing astronomical phenomena such as lunar phases and eclipses. Explain how.

**Q4**. Explain why Ptolemy's original geocentric model of the solar system was doubted by scholars of Columbus' era.

**Q5**. Explain why Copernicus' original heliocentric model of the solar system was no more accurate that Ptolemy's geocentric model.

**Q6**. Name and explain three different arguments or lines of evidence that helped prompt the revolutionary change in consensus from Ptolemy's geocentric model to a Copernican heliocentric model.

There is no essay with this week's lab.