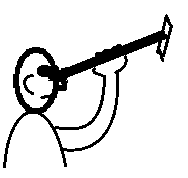
Union College Spring 2016

**Astronomy 50 Lab: Charting the Paths Two Outer Planets**

The word “planets” comes from the greek word for “wanderers.” The planets are the objects in the sky (other than the Sun and Moon) that are seen to move relative to the stars. Charting the motions of the planets is one of the most fundamental observations of the solar system. In this lab, you will track the positions of Jupiter and Mars. We start with Jupiter, since Mars doesn’t rise at a reasonable time just yet (we’ll pick up Mars in about 2 weeks).

**Your tool – the cross-staff**:

Figure 1 gives a cartoon idea of the device you will use to measure angles between objects on the sky.



**Figure 1**: depiction of a cross-staff being used.

Imagine that your eye is located at the center of a circle as you view the sky through a transparent ruler. We can then measure the separation between two objects as indicated on the ruler and relate that to an angle. More specifically, by attaching the ruler to the end of a stick with a length of 57.3 cm, and viewing the sky with the other end of the stick on your cheek, next to your eye, then the ruler measures the distance along the arc of a circle of radius 57.3 cm. The circumference of this circle is equal to 2R = 2(57.3 cm) = 360 cm. And, since there are 360o in a circle, each cm on the ruler corresponds to one degree.

So, to make your cross-staff, simply pin a see-through ruler with cm markings onto the end of a stick of length 57.3 cm (provided for you), and then when using this to view the sky, remember that one cm on the ruler equals one degree on the sky.

**Finding Jupiter**. In order to track Jupiter’s motion, you need to know where to find it. First, use your Star and Planet Locator (as instructed in lab) to find the rough location of Jupiter. Then, use Figure 2, which shows the expected location of Jupiter in April 2016, for a more precise idea.

**Measurements**: After dark, bring your cross-staff and star chart (and pen and paper) to a location where you can see the region of the sky that should contain Jupiter. Identify Jupiter (it will be the brightest object in that part of the sky). Identify three bright stars near Jupiter. Using your cross-staff, measure the angles between Jupiter and the three bright stars. On Table 1 (at back) record the date (and observing conditions), the three angles, and the names of the stars that each of these angles were measured from.

Continue with these measurements once per week, until May 22. Starting May 1, do the same with Mars. Figure 3 shows the expected location of Mars, relative to the bright star Antares, which you can find on your star chart (it is part of Scorpius). Locate Mars two times per week for the following three weeks.

**Analysis**: Bring your data table and star chart to lab. Following the in-lab instructions, use the provided compasses to triangulate the positions of Jupiter and Mars for each date.

**Questions to Consider for Discussion**:

1. Do the planets follow the ecliptic?

2. Which direction do the planets move? You’ve learned in class that all planets orbit in the counterclockwise direction, as viewed from the North Celestial pole. Is this consistent with your data? If not, why not. (Ask your instructor for guidance if the answer to this is unclear.) One of the more confusing aspects of planets’ motions was that they some times appeared to move backwards — which was called “retrograde motion” – compared to normal.

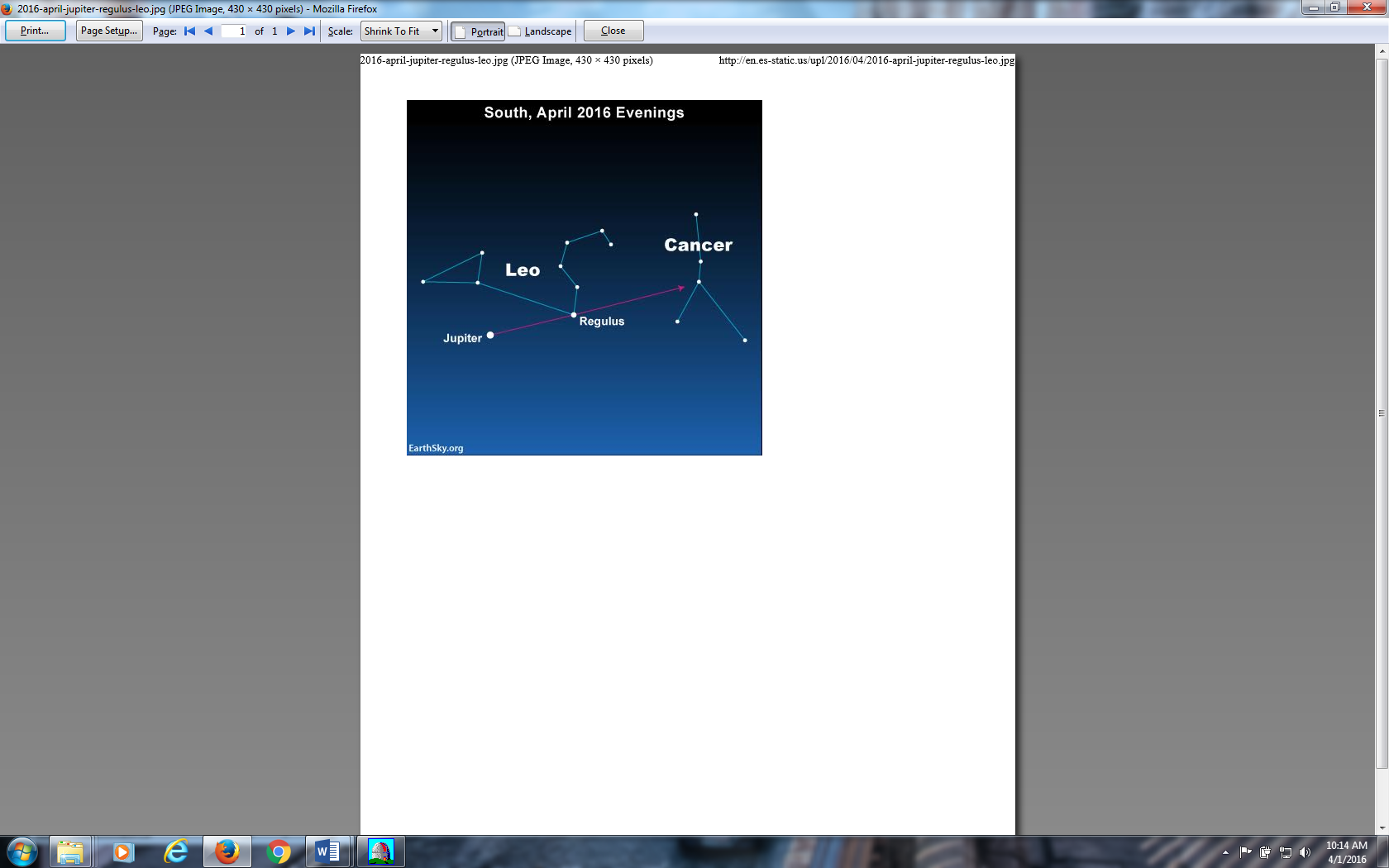
**Retrograde Motion**

3. Read the report of the “Period and Shape of Mars’ orbit” reported in Ast50 Lab Journal, Volume IV, and consider the chart in the report and imagine the locations of Earth and Mars when Mars is at opposition. Referring to this other report, explain retrograde motion. When Mars is orbiting the Sun while at opposition with respect to Earth”

a. How does the position of Mars changes along its orbit in time—which direction does Mars move?

b. How does the direction angles of Mars as seen from Earth change in time – which direction does Mars *appear* to move to observers on Earth at this time?

Explain why we see retrograde motion of the outer planets? Are they actually moving backwards? Imagine being in a car on the highway going 65 mph and passing a car going 50 mph. What direction does the other car appear to go relative to the background trees?



**Figure 2:** Rough location of Jupiter, relative to Leo and Cancer, in the month of April 2016



**Figure 3:** Rough location of Mars and Saturn, relative to Antares, in May 2016.