Lab A-4: Orbit of Mars

Purpose:
1. To plot the orbit of Mars with respect to the earth.
2. To calculate some orbital data for Mars.

Discussion:

Now that you have carefully plotted the orbit of the earth about the sun, you can plot the orbit of Mars. Again you will use triangulation. This time, however, your observations of the planet Mars consists of eight pairs of sightings. Each of these pairs was made exactly 687 days apart. Mars is in the same place, but because the earth has moved, Mars appears to be in a different position. Since you now know exactly where the earth is in its orbit on any given day (the year doesn't matter), you can triangulate the position of Mars for each of the eight pairings of data. You will then be able to calculate a number of the parameters of Mars' orbit, and with great skill, your orbit should show agreement with Kepler's Laws of Planetary Motion.

Procedure:

1. Use a sharp pencil for this lab! Clarity and neatness count.
2. From the previous lab, you know how to figure out where the earth is on a particular day. The orbit of the earth is drawn for you on the back of this sheet. The location of the earth on 12 different days is shown (breaking up the orbit into 30° sections.) Even though the orbit was drawn ignoring the eccentricity, the positions take into account that the earth is not moving at a constant speed around the sun.
3. The data given is the position of Mars, as seen from the earth, for eight different pairs of dates. In each pair of dates, the second date is exactly 687 days after the first. (The time between different pairs of dates doesn't matter and could be anything.)
4. For each pair of positions, triangulate the location of Mars by the following:
   a. Locate the earth on its orbit for the date shown. Find the date on the orbit that is closest to the observation date and figure out how many days before or after the observation date is. For example, the first observation date is Feb 5, and the closest location on the earth orbit that you were given is Feb 19, so the observation date is 14 days before the other "known" location. Since the earth moves about 1° per day, that means the earth will be about 14° before Feb 19. Use the protractor to find the spot on the orbit that is 14° before the Feb 19 location.
   b. Draw the triangulation line. The data shows the location of Mars on that date, so use your protractor to draw a ray in the direction of that angle. Keep in mind that 0° always means exactly to the right, 90° straight up, etc. Don't spin the protractor around; try and keep it parallel to the horizontal dashed lines.
   c. Do this for the second date in the pair. The two rays that you drew should cross – that is where Mars is. Mark and label it with the pairing #. Repeat this step for the other seven pairs of observations.
5. Once you have all eight positions plotted, use a compass to draw in the best circle that fits your positions. The center of the circle will not be on the sun. Mark the center of the circle with an X.
6. **On your orbit, use a ruler to draw in the major axis. Label the following on the plot: major axis, perihelion, aphelion, center, and each mars position.**

Calculations:

Do the following calculations and questions on your orbit. Make sure your work is clear. Distances should be in astronomical units.

1. What is the semi-major axis of Mars' orbit?
2. What is the perihelion distance?
3. What is the aphelion distance?
4. What is the eccentricity of the orbit?
5. What is the closest that earth and Mars could ever be to each other?
6. What is the farthest that the earth and Mars could ever be?
7. Locate Mars on February 5 and on April 20. (You plotted these.) Draw lines from these positions to the sun. On your orbit, calculate the area (in AU^2) of the pie-shaped wedge of orbit that Mars would have swept out. Divide this area by the number of days from 2/5 to 4/20. (Label that as dA/dt.) Do the same for the positions of Mars from August 4 to November 22. How do your results compare to Kepler's Second Law?
8. Based on Kepler's Third Law, what should be the semi-major axis of the orbit of Mars? (Use T = 687 days for the period of Mars orbit.) How does this compare to the value you measured from the orbit?