Name ______________________________

Section ______________ Date ______________

exercise 21

the orbit of Mercury

1 materials

Protractor, millimeter rule, sharp pencil.

2 purpose

How do we know what the orbit of a planet is like? At first glance this appears to be a difficult question, but in many cases it is surprisingly easy to derive an orbit from basic observations. In this exercise you will use a set of simple observations, which you could have made yourself, to discover the size and shape of the orbit of Mercury. You will be repeating work that Johannes Kepler did to formulate his laws of planetary motion. Kepler made his first discoveries while studying the orbit of Mars. He then extended his analysis to the six planets then known. We will see how he studied Mercury.

3 observations

The ancient astronomers of Greece were familiar with planet Mercury, but they did not recognize it as the same object when it appeared in the evening sky and in the morning sky. It was known as Apollo when seen in the morning sky and as Mercury when seen in the evening sky. Sixteen hundred years later the motions of the planets were observed and recorded by the Danish astronomer Tycho Brahe. Brahe's records covered a period of 20 years, and on his death in 1601 these records were taken by one of his assistants, Johannes Kepler.

From Brahe's records Kepler was able to find the maximum angular distance from the Sun that Mercury reached during each of its passages. You could make the same observations, but to save time a list of these distances, called **maximum elongations**, is given in Table 21–1. These data were taken from observer's handbook for the years 1967-69. You could obtain similar data from the handbook for the current year. These data contain the dates on which

Mercury was at its maximum elongation, the angular distance, and the direction from the Sun.

Table 21–1 Maximum Elongations for Mercury

February	16,	1967	18°	east
March	31		28°	west
June	12		25°	east
July	30		20°	west
October	9		25°	east
November	18		19°	west
January	31,	1968	18°	east
March	13		27°	west
May	24		23°	east
July	11		21°	west
September	20		26°	east
October	31		18°	west
January	13,	1969	18°	east
February	23		26°	west
May	6		21°	east
June	23		23°	west
September	3		27°	east
October	15		18°	west
December	28		19°	east

4 drawing the orbit

Figure 21–1 shows the orbit of the Earth with the dates marked to represent the position of the Earth in its orbit throughout the year. The scale below the orbit is marked in astronomical units and will enable you to make measurements on the diagram in astronomical units. The Sun is of course located near the center of the Earth's orbit.

As you draw on the diagram use a sharp pencil; sharp so you can be accurate, and pencil so you can make corrections as necessary. (The width of a sharp pencil line on this diagram is about 100,000/km).

Now plot each of the elongation as follows: Locate the date of the maximum elongation on the orbit of the Earth. Draw a light pencil line from the position of the Earth to the Sun. Center a protractor at the position of the Earth and construct a line so that the angle from the Earth-Sun line to this constructed line is equal to the given maximum elongation. Extend this line across the diagram well past the Sun. It represents the direction toward Mercury. Remember, facing the Sun from the position of Earth, eastern elongations are to the left as in Figure 21–2. In each case the planet Mercury will lie somewhere along the line you have drawn. As you draw more lines, you will see the orbit taking form.

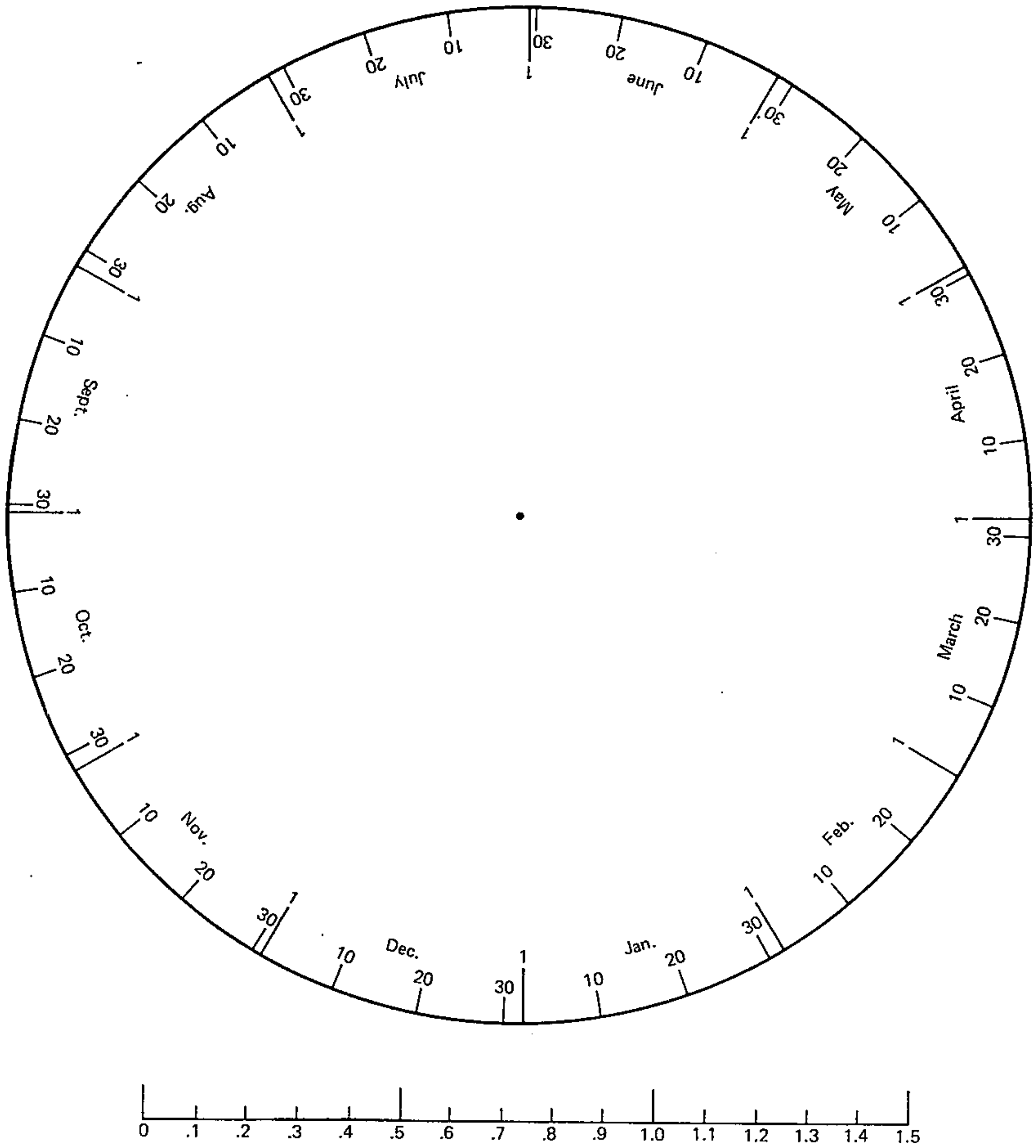

Figure 21-1. The orbit of Earth with the Sun near the center. The position of Earth in its orbit is indicated for various dates.

After you have plotted the data you may sketch in the orbit of Mercury. The orbit must be a smooth curve that just touches each of the elongation lines you have drawn. The orbit may not cross any of these lines.

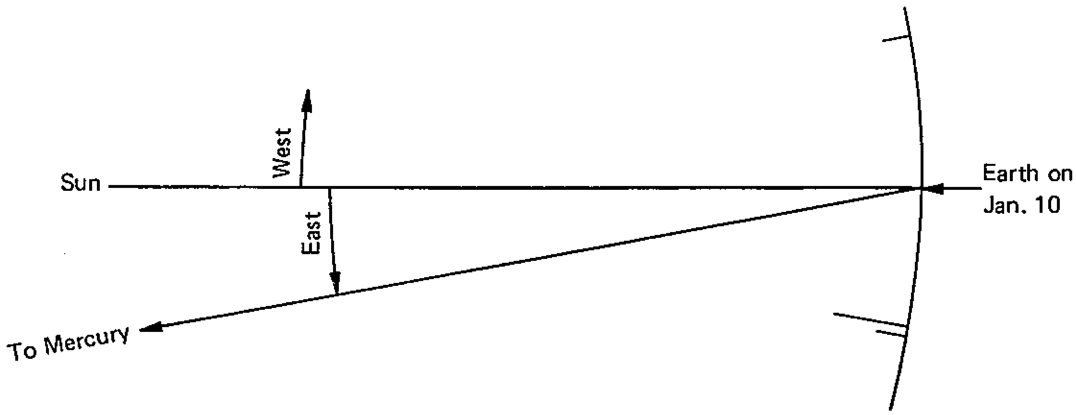

Figure 21-2. Example showing maximum eastern elongation on January 10.

5 the shape of the orbit

problems

1. Does it appear that the curve you have drawn is not a circle? How could you be sure?

Kepler had the same problem; his circles didn't fit either. At last he hit upon the idea of using ellipses for the orbits. They fit. Through the Sun draw the longest diameter possible in the orbit of Mercury. This is the major axis of the ellipse. Measure the length of the major axis, and bisect it to find the center of the ellipse. Draw the minor axis through the center perpendicular to the major axis.

2. What is the semimajor axis a of Mercury's orbit in astronomical units (A.U)? Does your result agree with that given in your book?

   (a) Measured semimajor axis: $a =$ ________________

   (b) Book value: $a =$ ________________

3. Use your measured value of a to calculate the sidereal period P of Mercury in years. To convert to days, multiply the sidereal period in years by 365.26.

   (a) Calculated pariod: $P =$ ____________ years = ____________ days.

   (b) Book value: $P =$ ________________

4. The Sun lies at one of the foci of the ellipse. Measure the distance from the