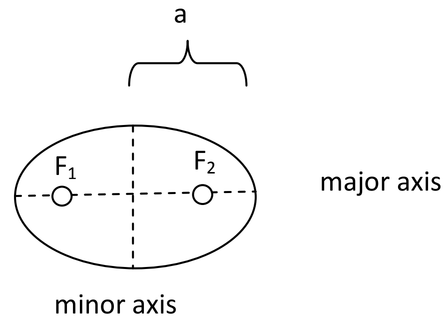
EXPLORER 35 AND KEPLER'S LAWS

Introduction. The satellite, Explorer 35, was put into an orbit around the moon in 1967. The position data for this satellite will be used to show that its orbit is described by Kepler's Laws.

Procedure

1. Using a pencil, draw the major and minor axes of the orbit on page the first graph of the orbit by symmetry. The goal is to divide the ellipse into four equal sections as show at right.



2. The center of the moon is one focus (F_1) of the ellipse. Find the other focus by symmetry and label it, F_2.

3. Calculate the eccentricity of the ellipse represented by the orbit.
eccentricity = distance between foci/(2a)

4. Determine the period of the orbit in hours. (Caution: some points are numbered twice.)

5. Kepler's First Law. When drawing an ellipse with two tacks and a loop of string, the length of string remains constant. If P is any point on the ellipse, then the sum $F_1P + PF_2$ will be constant.

a. Choose any 5 points on the ellipse. For each of these points in turn, draw lines from that point to each of the foci. Measure F_1P and PF_2 in centimeters. Fill in the table below with data for your points.

Point	F_1P (cm)	F_2P (cm)	$F_1P+ F_2P$ (cm)
1			
2			
3			
4			
5			

b.Compute the average value of the $F_1P + PF_2$ sums. In your conclusion to this part of the experiment, some indication of how close together your values are should be included. One method is to compute the range of the values and then to state your final value of the sum as: (average value) +/- 1/2(range) Where the range of a set of measurements = highest value - lowest value.

Note: we are not adding/subtracting ½(range) we are reporting it with the +/- symbol to indicate an estimate of the spread or uncertainty of the result.
For example, if I got 12cm, 13cm, 14cm, 15cm I would report the value as 13.5 +/- 1.5 cm since 1.5 is ½(15cm-12cm) which is the range of values.

Report your result here:

Q. 1. How closely do your measurements support the statement that this is an elliptical orbit?

6. Kepler's Second Law

a. On the second copy of the orbit graph, draw five different areas (pie slices with apex at the focus corresponding to the moon's location) which correspond to areas swept out over 30 minute time periods. Identify these with I, II, etc. Choose at least one area very close to the moon.

b. Determine the size of each of these areas. The simplest method is to count the number of squares contained in each area. You must estimate carefully fractions of squares along the edges. Record your results in the table.

Area number	Number of squares in that area
I	
II	
III	
IV	
V	

c. Compute the average size of these areas. State your final value as the average +/- 1/2 (range):

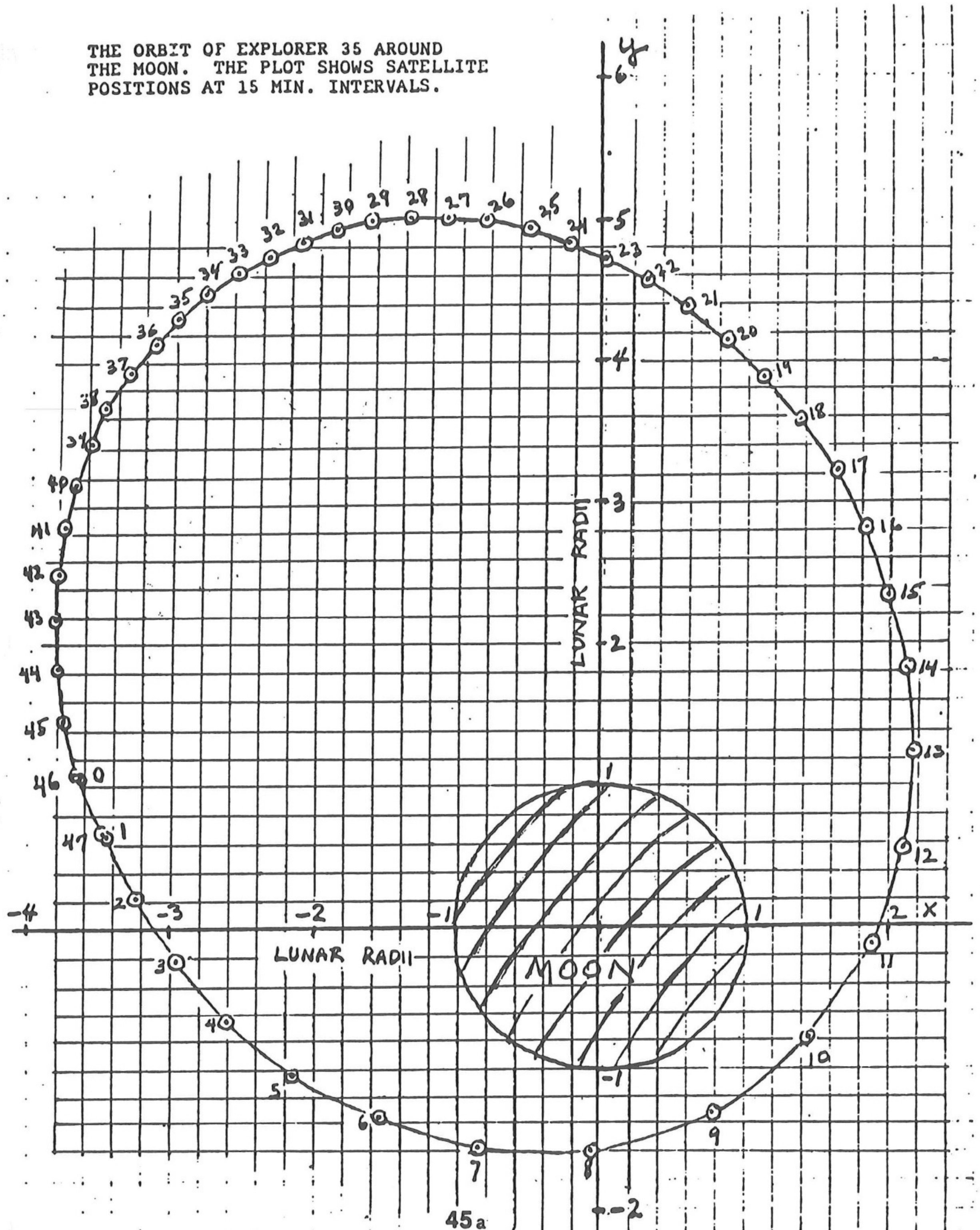
Q.2. How closely do your values support the statement that these areas are equal?

7. Kepler's Third Law. Using data from the appendix of your textbook, complete this table:

Planet	Period (yr)	Semi-major Axis,a (au)	$(\text{Period})^2/a^3$
Earth			
Mars			
Saturn			

Q.3. Does this data support Kepler's Third Law?

THE ORBIT OF EXPLORER 35 AROUND THE MOON. THE PLOT SHOWS SATELLITE POSITIONS AT 15 MIN. INTERVALS.



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