Phys 270L Experiment 4

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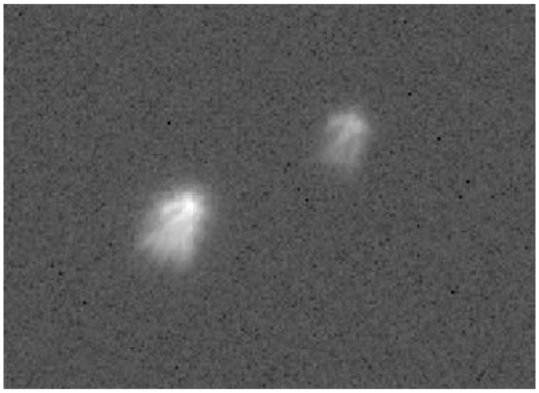
Part A

The data that I took was the lau_0704_2236.fit

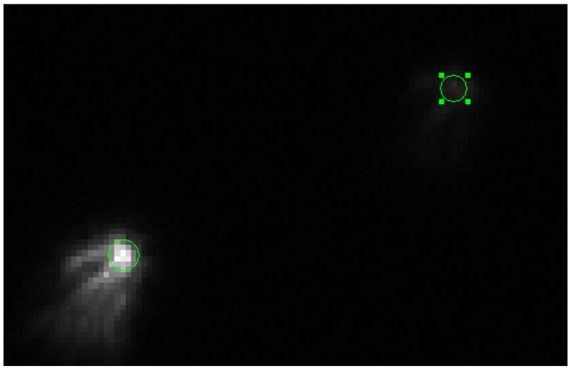
Part C

1)

First part is using the Calibration of Masoud0703_2337_Albireo_bin1x1.fit obtained from learn. The image below is of the binary star system Albireo. As you can see below the uncertainty of measuring the star's center will be quite high since both stars seem to be dragged by 45^o, this may be due to weather effects such as air or atmospheric turbulence. It's possible that the image is rotated about 90^o since the brighter orange star is supposed to be in the top left corner while the dimmer blue in the bottom right.



Using DS9 circle function I make circle around what I believe contains the stars and that result in this image:



From this I recorded the pixel value of the center of each circle:

	X	Uncer	Y	Uncer
Bottom Left	2234.273	3	1095.472	3
Top Right	2295.05	3	1126.172	3

From this data I calculated the distance between the centers of each circle.

X Dif	Uncer	Y Dif	Uncer	Distance	Uncer
-60.777	4.2	-30.7001	4.2	68.09067	6

Where X Dif and Y Dif are the differences of the pixel value of both circles and the Distance is how far each of the centers of the circles are from each other. Since both stars are 35 arcsec away from each that gives us a pixel scale of 68.1 /35 arcsec = 1.95 pixel / arcsec.

Since only one calibration was given on learn I will assume that the pixel scale will be the same throughout all the observation.

2)

The follow graph is the data that I have taken: lau_0704_2236.fit

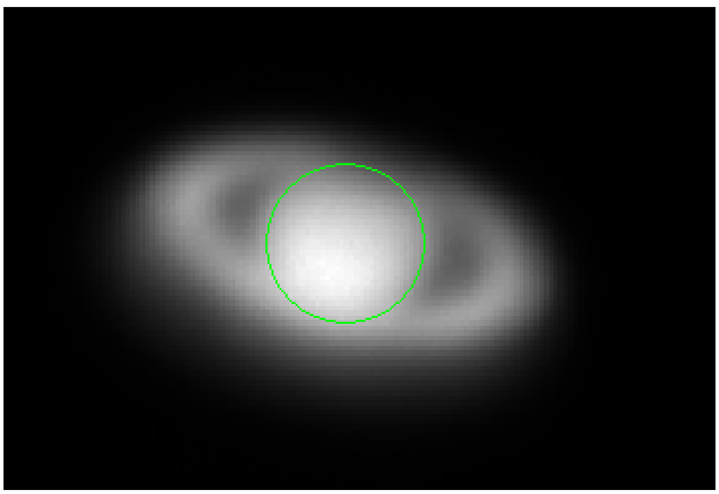


Figure 1.

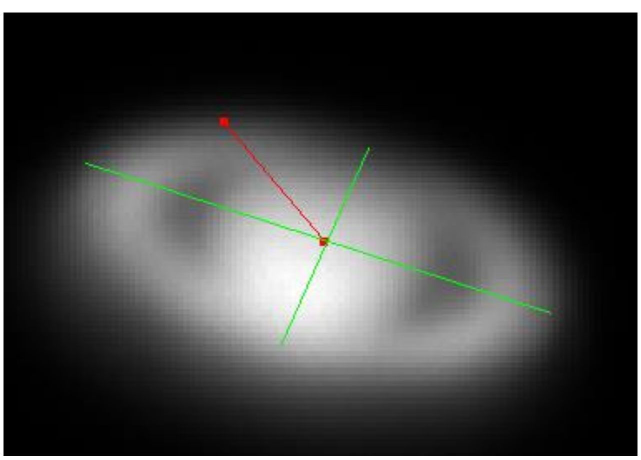


Figure 2.

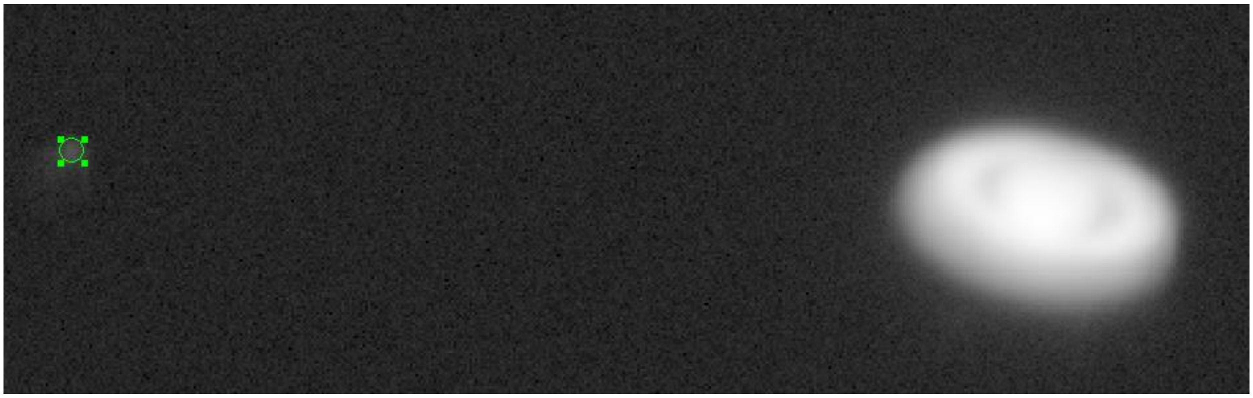


Figure 3.

	X	Uncer	Y	Uncer
Saturn's Center	1879.215	8	1410.374	8
Edge of Ring	1863.299	3	1432.769	3
Moon's Position	1522.519	2	1429.093	2

First in off to calculate the uncertainty I used the radius of the circle I've drawn on the planet or moon as a good reference to what uncertainty measurement since the more resolve the object is the more precisely I can circle around the object so the uncertainty of the object is related to how precise I can draw the circle around the planet. For example in figure 1, Saturn was a little harder to judge where the planets actual edge that means it'll have a larger uncertainty. Next, since the ring looks more like an ellipse I measured the longest and shortest lengths of the ring and then measured a third line that extends approx. in between both the longest and shortest and called that the edge. The uncertainty used to was taking the average of the longest and shortest line's radius then compare it to the red line I used to measure the distance. In this image the average between the two green lines were 29 and the length of the red line is 26, from this I assumed that the red line will be on average off by 3 pixels.

$X'_R = -15.916$ +/- 8.5	$Y'_R = 22.3952$ +/- 8.5
$X'_M = -356.697$ +/- 8.2	$Y'_M = 18.7189$ +/- 8.2

$D_R^2 = 684.2$ +/- 12.08

Using the equation $D_R\, D_M \cos\theta = X'_R\, X'_M + Y'_R\, Y'_M$

$D_M \cos\theta = 8.91$ +/- 3.5 $\longrightarrow$ Convert into arcsec with pixel scale = 4.56 +/- 1.8

The following Data is done in the exact same procedure as before so in the interest of saving time I will just put all the numbers in a chart:

Masoud0703_2232:

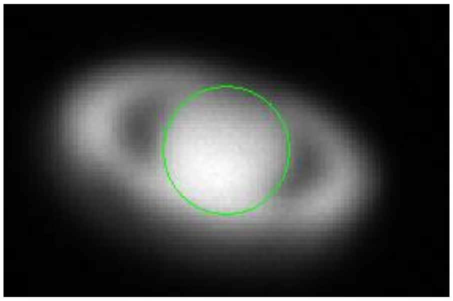


Figure 1

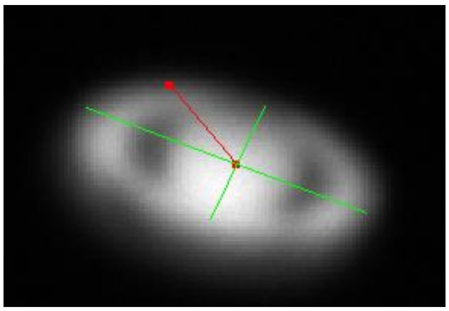


Figure 2

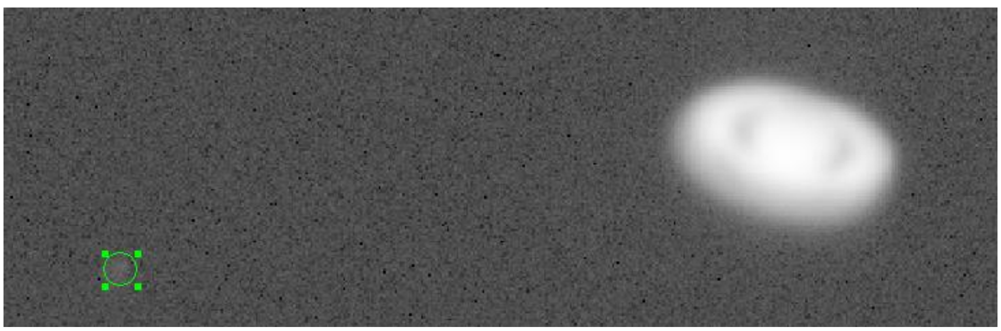


Figure 3

	X	Uncer	Y	Uncer
Saturn's Center	2107.778	8	1366.556	8
Edge of Ring	2089.812	2	1388.188	2
Moon's Position	1821.63	2	1312.852	2

X'_R = -17.9656 +/- 8.2	Y'_R = 21.6327 +/- 8.2
X'_M = -286.148 +/- 8.2	Y'_M = -53.70737 +/- 8.2

D_R^2 = 790.736 +/- 12.08

$D_M \cos\theta$ = 5.034 +/- 3.5 ⟶ Convert into arcsec with pixel scale = 2.58 +/- 0.92

cameron0627_2255.fit

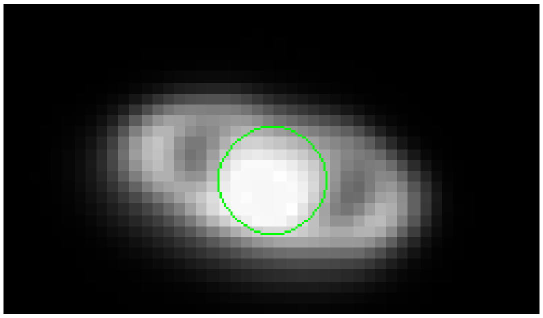


Figure 1

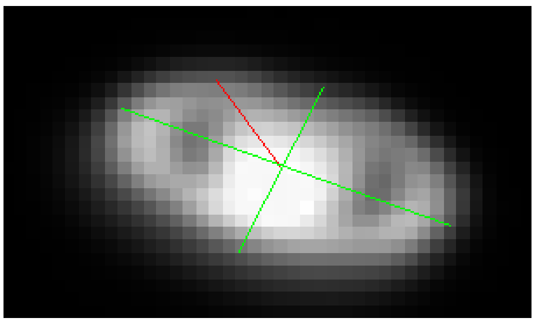


Figure 2

Figure 3

	X	Uncer	Y	Uncer
Saturn's Center	609.5336	4	414.571	4
Edge of Ring	604.2184	3	421.7294	3
Moon's Position	728.4922	2	388.3849	2

$X'_R = -5.31522 \pm 5$	$Y'_R = 7.15839 \pm 5$
$X'_M = 118.9586 \pm 4.5$	$Y'_M = -26.1861 \pm 4.5$

$D_R^2 = 79.3 \pm 1.2$

$D_M \cos\theta = -10.34 \pm 6 \longrightarrow$ Convert into arcsec with pixel scale $= -5.3 \pm 3.1$

Gunasekara_0626_2327.fit

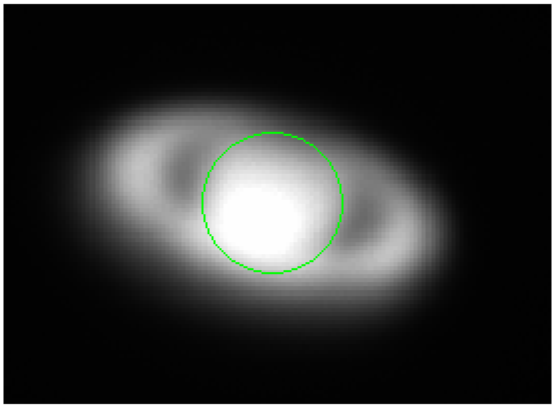


Figure 1

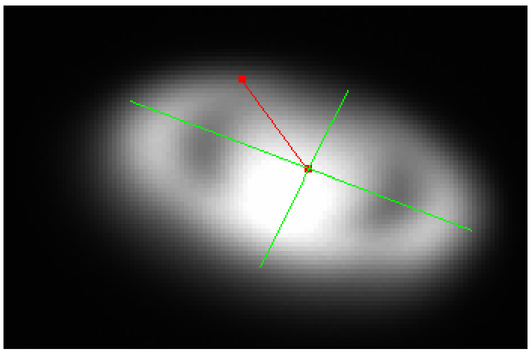


Figure 2

Figure 3

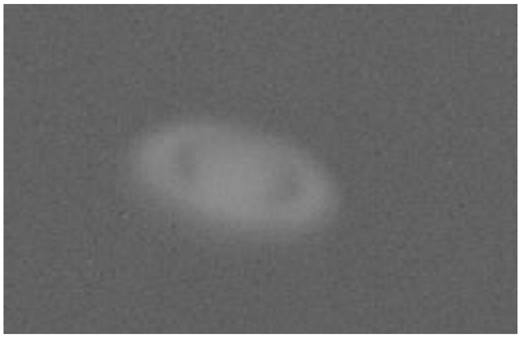
	X	Uncer	Y	Uncer
Saturn's Center	2118.636	8	1218.211	8
Edge of Ring	2105.446	3	1240.806	3
Moon's Position	2452.588	2	1212.447	2

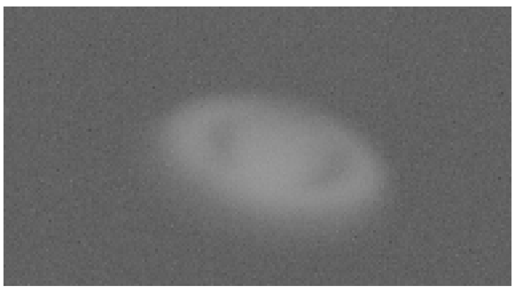
X'_R = -5.31522 +/- 5	Y'_R = 7.15839 +/- 5
X'_M = 118.9586 +/- 4.5	Y'_M = -26.1861 +/- 4.5

D_R^2 = 684.5 +/- 12.08

D_M Cosθ = -6.625 +/- 4.0 ⟶ Convert into arcsec with pixel scale = -3.39 +/- 0.9

Unfortunately I tried to do the data for June 24 however all the files done on that date weren't clear enough for me to analyze. Perhaps it was due to the weather but majority of them had images such as these:





As a result the only observation I can analyze are the four above with dates 0704, 0703, 0627, and 0626

3)

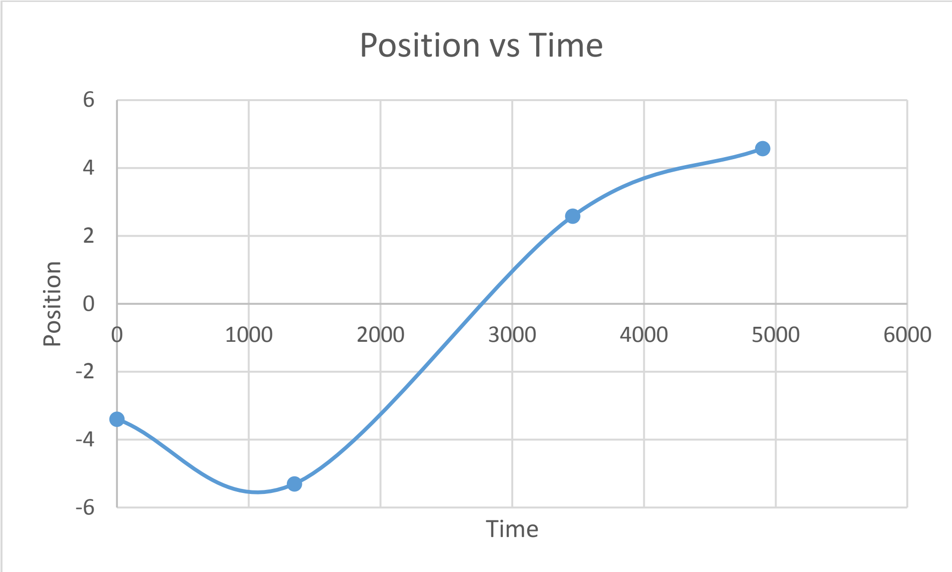
If I set my date 0704 as t_0 and if we based on the distance it seems that the moon we've been calculating is either Rhea or Titan the two furthest moon from Saturn, most likely looking at the data and the period of the Saturn's moon it is Rhea. So I will use Rhea period to calculate the time modulus the period. Rhea's period is 4.518 days = 6505.92 min

Date : Time	Time from t_0
0704 : 2236	0
0703 : 2232	24h 2min = -1442 min
0627 : 2255	6d 23h 41min = -355.08
0626 : 2327	7d 22h 9 min = -4902.08

4)

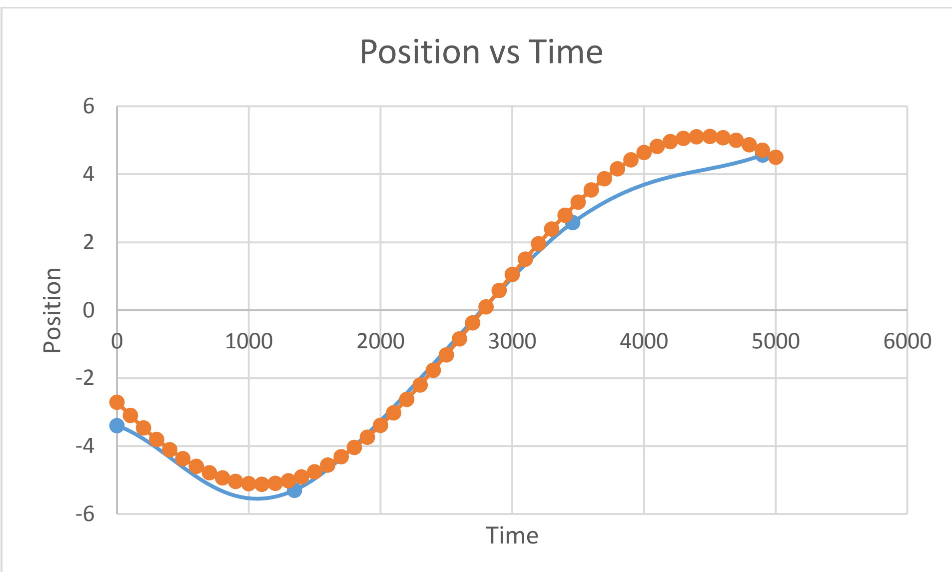
Date : Time	Time from t_0	Projected Orbital Position
0704 : 2236	0	4.56 +/- 1.8
0703 : 2232	24h 2min = -1442 min	2.58 +/- 0.92
0627 : 2255	6d 23h 41min = -10061	-5.3 +/- 3.1
0626 : 2327	7d 22h 9 min = -11409	-3.39 +/- 0.9

When you graph the position vs time data you get something that looks like this:



Note: Initially I had my data point on 0704 to be at t_0 however due to visual aspect I just shifted everything to the right so that the point 0626 will be at t_0 just so everything won't be at the negative x-axis.

After fitting a Sine wave to it you get:



The equation of the Sine function is f(t) = 5.12sin(2π / period – (1/1075)*(t+600)) where t is the time ranging from 0 to the period.

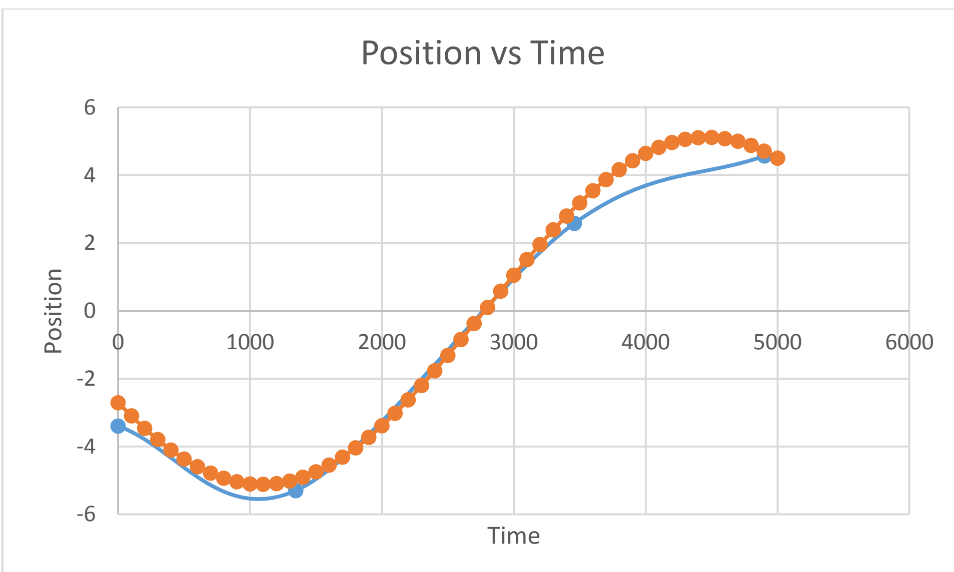
A = 5.12 and $\phi = -$ (1/1075)*(t+600)

6)

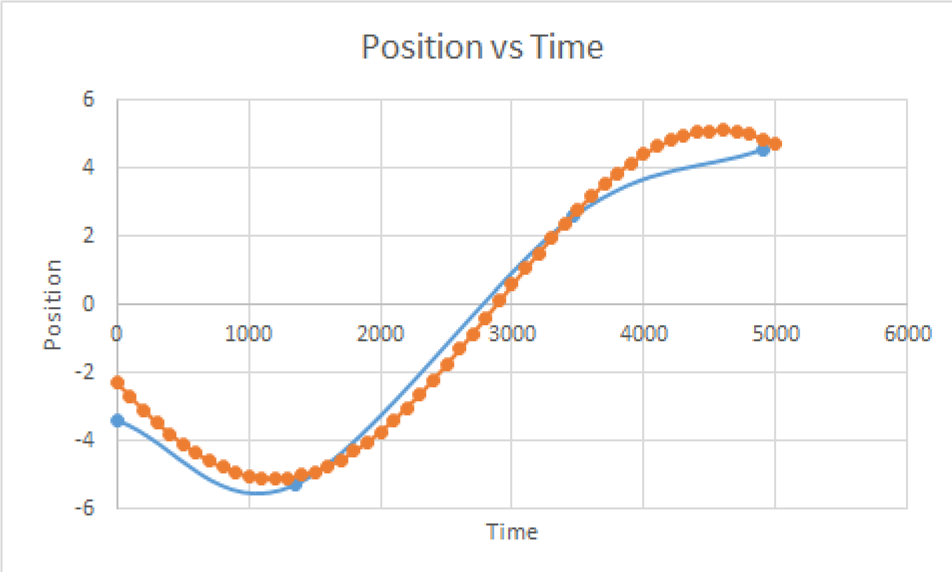
The uncertainty of A will mainly come from the Projected Orbital Position since they determine how high the sine function will reach. The Uncertainty for the data points are 1.8, 0.92, 0.9, 3.1. So it's safe to assume that the uncertainty of the amplitude will be somewhere along the range of those numbers. If we take the root mean squared and divide by the number of uncertainty you get 0.95, if I were to estimate the uncertainty of the amplitude it will be about +/- 0.95.

As for the uncertainty of ϕ it is a little more difficult to estimate since what determines the uncertainty is the period of the moon. However at the beginning of question 3) I made the assumption that the moon I've been measuring is Rhea and not titan. If I were wrong in the case and it was truly Titan I've been looking at then this will definitely effect ϕ. Another contributor to possible uncertainty is the period table giving to us on learn. All the period has uncertainty even though it does not specifically say but the uncertainty of period will also play a role to ϕ. Lastly just analyzing $\phi = -$ (1/1075)*(t+600) we see that for dimensional reasons the "600" must be in units of minutes and "(1/1075)" must be dimensionless. With that in mind if I change up the "600" by adding or subtracting 100 min the shape of the curve still looks relatively fit. Here is an example of the 600 vs 500 vs 700.

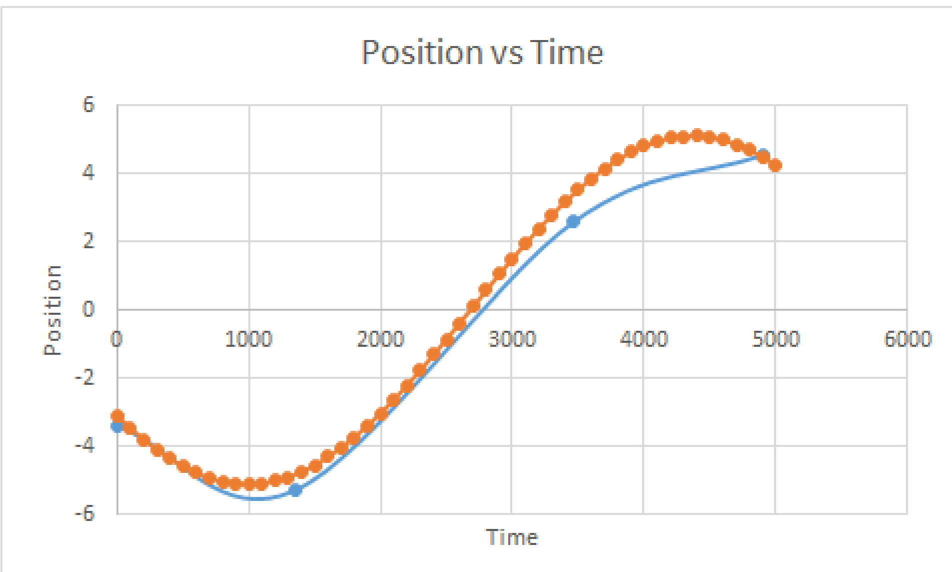
600:



500:



700:



As you can see they are still decent fits to the data. As a result if I were to estimate the uncertainty of ϕ it would be +/- (1/1075) * 100 = +/- 0.093

Conclusion

To conclude the plate scale of the telescope is 1.95 pixel/arcsec. From 4 observation dates gathered on 0704, 0703, 0627, and 0626 Saturn's moon Rhea was observed throughout the four days. From this the position function with respect to time of Rhea is f(t) = 5.12sin(2π / period – (1/1075)*(t+600)).