

10th planet – fact or fiction?

Checkpoints



Activity 1: Viewing the data - theory vs practice



Part A – Drawing the scatter plot.

Enter the data then press GRPH [F1] and check the settings by pressing SET [F6]



Press [EXIT] then GRPH [F1] to obtain the scatter plot of radius R against period P.



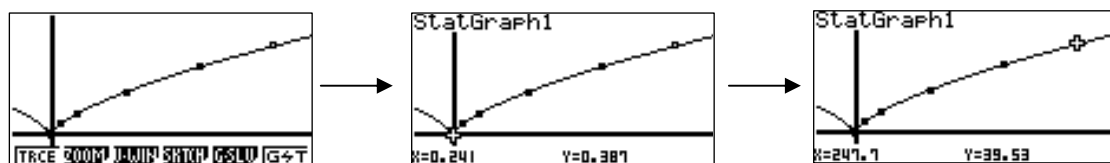
Part B – Graphing the theoretical model.

By pressing DefG [F2] you can enter Kepler's third law and press DRAW [F6].

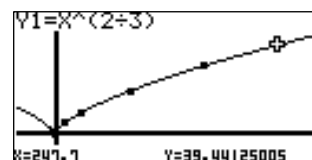


Activity 2: Looking closer –how well does the theory fit the practice?

By using TRCE ([SHIFT] then [F1]) you can see data values by using [◀] and [▶].



And by using [▲] and [▼] you can swap from the data to Kepler's law - comparing real and theoretical values.



Answers

- Kepler's third law fits Pluto worst.
- The discrepancy between observed and model value is 0.09 AU. This seems very small in absolute terms. In relative terms, expressed as a percentage of the observed value of 39.53 it equates to an error of 0.22% (less than a quarter of a percent error). This discrepancy is not trivial as, because an AU is roughly 150 million kilometres, it equates to around 13.5 million kilometers.

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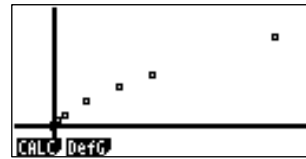
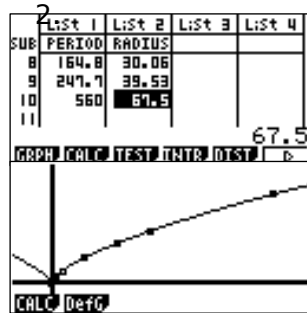
Checkpoints



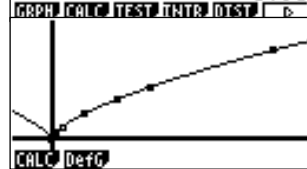
Activity 3: What about 2003UB₃₁₃ ?

Answers

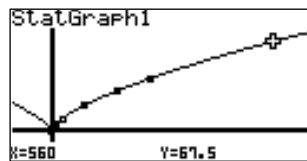
1.



3.



4.



compare these



5. An analysis of the errors in the way a model fits given data can be completed in mode, using the ideas that

Error = measured value - model value

$$\text{Percentage Relative Error} = \frac{|\text{error}|}{\text{measured value}} \times 100\%$$

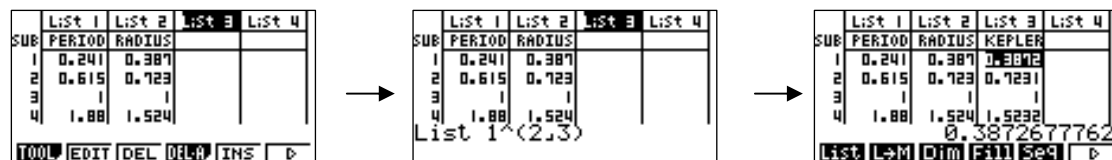
These values can be calculated in following way:

- Move the input bar into the heading row of the desired list.
- Enter the formula required and press **EXE**.
- Name the list if desired.

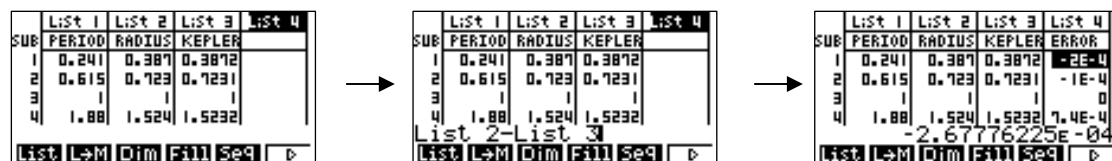
The following keys are required

- List is obtained by pressing **OPTN** then LIST **F1** then List **F1**.
- Abs is obtained by pressing **OPTN** then **>** **F6** NUM **F1** then Abs **F1**.

The algebraic model's values for the planet's orbital radii are calculated thus



The error in these values are found by



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This allows us to determine the percentage relative error for Kepler's model

Sub	List 2	List 3	List 4	List 5
1	0.387	0.3872	-2E-4	
2	0.723	0.7231	-1E-4	
3	1	1	0	
4	1.524	1.5232	7.4E-4	

Sub	List 2	List 3	List 4	List 5
1	0.387	0.3872	-2E-4	
2	0.723	0.7231	-1E-4	
3	1	1	0	
4	1.524	1.5232	7.4E-4	
Abs List 4 = List 2 * 100				

Sub	List 2	List 3	List 4	List 5
1	0.387	0.3872	-2E-4	0.06919282
2	0.723	0.7231	-1E-4	0.02574158
3	1	1	0	0
4	1.524	1.5232	7.4E-4	0.04904857
0.069192823				

This information can be seen more clearly in a table like the one below

Planet	Period	Radius (AU)	Radius (Kepler)	Error	Relative Error %
Mercury	0.241	0.387	0.38726778	0.00026778	0.06919282
Venus	0.615	0.723	0.72318611	0.00018611	0.02574158
Earth	1	1	1	0	0
Mars	1.88	1.524	1.5232525	0.0007475	0.04904857
Jupiter	11.86	5.203	5.20063602	0.00236398	0.045435
Saturn	29.46	9.539	9.53868473	0.00031527	0.00330503
Uranus	84	19.18	19.1801879	0.0001879	0.00097965
Neptune	164.8	30.06	30.0587884	0.00121157	0.00403052
Pluto	247.7	39.53	39.4412501	0.08874995	0.22451289
2003UB ₃₁₃	560	67.5	67.9399701	0.43997009	0.65180754

Based on this table, Kepler's law does not fit 2003UB₃₁₃ as well as it does for the other planets. The law's relative error for 2003UB₃₁₃ is three times bigger than its relative error for Pluto, which in turn is three times bigger than the relative error for any of the other 8 planets.

It does, however, still have a greater than 99% accuracy for 2003UB₃₁₃. Further, given that the orbital data for 2003UB₃₁₃ is first of many measurements that will be taken of this new planet, it may turn out that error is with the initial measurements and not with Kepler's law!