Kepler's Harmonic Planetary Law

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adapted from: Haley's Comet and Kepler's Laws of Planetary Motion by Sharon Orf.

Activity overview

Johannes Kepler noticed in the early 1600's that the further away a plant was from the sun, the longer it took to orbit the sun. Kepler's Third Law is an equation showing the relationship between the distance from the sun and planet revolution. In this equation, the square of a planet's orbital period is proportional to the cube of the mean distance from the sun. $P^2 = D^3$

P is the planet's orbital period in Earth years and D is the average distance from the sun in astronomical units (AU).

Concepts

Included in overview.

Teacher preparation

This activity should follow the teaching of Kepler's First and Second Laws of Planetary Motion.

Classroom management tips

Prepare copies of the activity. No other equipment necessary.

TI-Nspire Applications

In this activity, students will use the Lists & Spreadsheet application on the TI-Nspire™.

Step-by-step directions

1. Complete the chart below.

Planet	Period (yrs)	Period squared	Distance from the Sun (A.U.)	Distance cubed
Mercury	0.24		0.387	
Venus	0.62		0.723	
Earth	1.00		1.00	
Mars	1.88		1.524	
Jupiter	11.86		5.203	
Saturn	29.46		19.180	
Uranus	84.01		19.180	
Neptune	164.80		30.060	
Pluto	247.70		39.440	
Halley's Comet	76.00		17.900	

2. Open a new document and insert the *Lists & Spreadsheet* application.
3. Enter the distance cubed data for the 9 planets only in column A.
4. Arrow to the top of column A and name it distance.
5. Enter the period squared data for the 9 planets only in column B.

6. Arrow to the top of column B and it period.
7. Press **ACTIONS > Resize > Resize Column** Width and use the NavPad to make each of the first two columns wider.
8. To perform a regression, highlight Columns A and B by moving the cursor to the top of Column A, press ` on the NavPad to select Column A, hold down the g key, and press ¢ to extend the selection to include Column B.
9. Press **MENU > Statistics > Stat Calculations and choose Linear Regression (mx+b**).
10. For X list, choose distance and for Y list choose period.
11. Use the NavPad to arrow back to Column A. Repeat step 8 to select both columns.
12. Press **MENU > Data > Quick Graph.**
13. Press **MENU > Actions . Regression > Show Linear (mx + b)**

Assessment and evaluation

1. *What relationship exists between P^2 and D^3?*
2. *Use the regression equation to find the period of an imaginary planet that is located 7.5 AU from the Sun.*
3. *Examine your data from Haley's Comet. Do you think all comets traveling in an elliptical orbit follow Kepler's Law? What about satellites?*
4. *Explain what is meant by the data which states that Jupiter's period is 11.86 years.*
5. *Why are the values for the distance data and the period data for Earth both 1.000?*
6. *How could an astronomer use Kepler's Third Law to determine the distance of a planet if the period is known?*

Activity extensions

Research how astronomers use Kepler's Third Law to determine launch distances for satellites.

Research how astronomers use Kepler's Third Law to plot the orbit of comets.