Grade level: 9-12
Subject: mathematics
Statistics
Time required: 45 to 90 minutes

Exploring Planetary Motion

by – Diana Lossner

Activity overview

Students will find the best model for the orbits of planets about the sun. Students will practice using the laws of exponents.

Concepts

- *Laws of exponents*
- *Linear regression*
- *Exponential regression*
- *Power regression*

Teacher preparation

Download and read worksheet and Nspire documents before giving to students. Students should have knowledge of the laws of exponents.

Classroom management tips

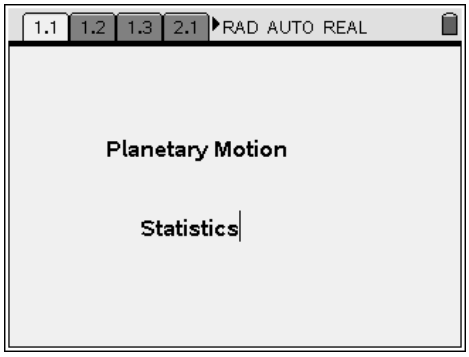
Let students do as much as possible on their own, but be available to answer individual questions that students might have.

TI-Nspire Applications

PlantMotion.tns

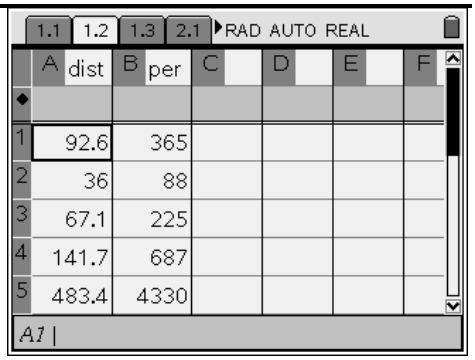
Step-by-step directions

Open PlanetMotion document on Nspire handheld.

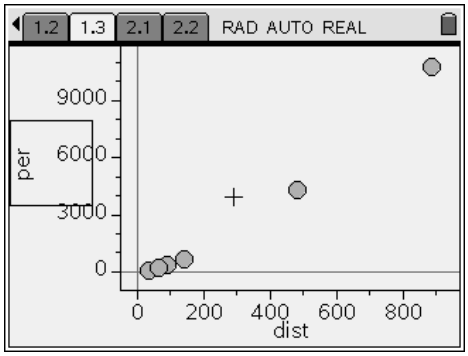


Planets revolve around the sun in elliptical orbits. We want to discover how the distance from the sun affects the planet's period in days compared to the earth's period of 365 days.

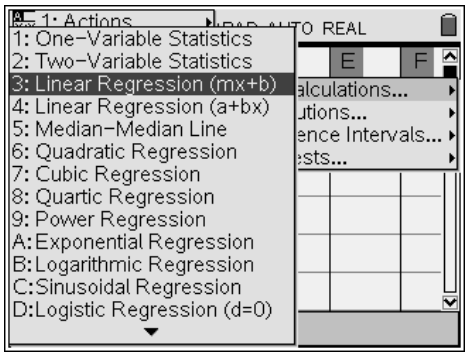
ctrl ▸ to get to page 2 of your document. You see the lists of distance from the sun in "dist" column and period in the "per" column.



ctrl ▸ to get to the next page. Click on x-axis and put your independent variable there. Click on the y-axis and put your dependent variable there. Sketch your graph. What type of graph do you think it might be? Let's find out for sure. (Dots on graph will change once you put in x- and y- values.



Go back to the previous page and do regressions to see which is best. menu ❹ (Statistics) ❶ (Stat Calculations) ❹ (Linear Regression (a + bx)). Use pull down menus to x List (dist), y List (per); (tab between entries), tab to OK and press enter. Your data will appear in the next columns of your list page. After linear, do exponential and power regression and fill in table below.



Type	Resulting Equation	Correlation Coefficient (r)
Linear	y = - 811.86 + 12.49x	.9924
Exponential	y = 183.59 (1.005^{x})	.9398
Power	y = 0.4098 x$^{1.499}$	..9999^{+}

By comparing correlation coefficients, which regression Power is best. Best "r" value and fits

equation fits best?

Look at the regressions on the graph, does one fit better than the others? Is it the same one with the best correlation coefficient?

the data better.

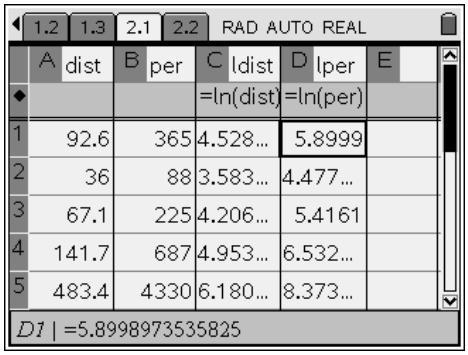
Copy your equation into the template. $y= 0.4098\ x^{1.499}$

Using algebra and the laws of exponents transform this function into a linear function.

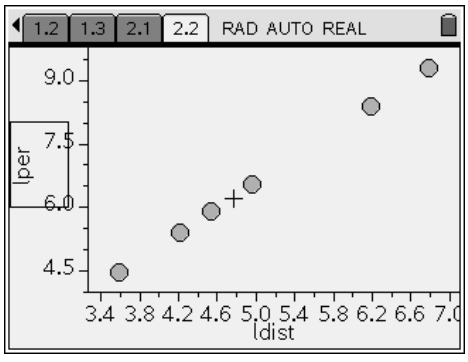
1. Take the ln of both sides. $\ln y = \ln (0.4098\ x^{1.499})$
2. Rewrite the right side using a property of logs. $\ln y = \ln$ _0.4098_ $+ \ln$ _ $x^{1.499}$ _
3. Rewrite the right side using another property of logs. $\ln y = \ln$ _0.4098_ $+$ _1.499_ $\ln$ _x_
4. Find the ln of the number on the right side. $\ln y =$ _-0.892_ $+$ 1.499 $\ln$ _x_

Notice that we have written ln y as a linear function of ln x.

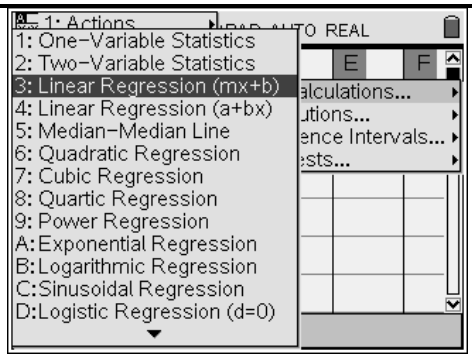
If the power function is the best fit for the data, we should see a linear relationship from the data if we graph the scatter plot (ln x, ln y). ctrl ▸ to get to the next problem. On this spread sheet go to the space next to C and type in "ldist", arrow down, press enter, type in ln(dist) and press enter. Arrow over to D, type in "lper", arrow down, press enter, type in ln(per) and press enter.



ctrl ▸ to get to the next page. Click on x-axis and put your new independent variable there. Click on the y-axis and put your new dependent variable there. Sketch your graph. Does it appear linear? Let's find the linear regression.



Go back to the previous page and do regressions to see which is best. (menu) ❹ (Statistics) ❶ (Stat Calculations) ❹ (Linear Regression (a + bx)). Use pull down menus to x List (ldist), y List (lper); (tab between entries), tab to OK and press enter. Your data will appear in the next columns of your list page.



Write your linear regression equation. Have you seen these numbers before? What does that tell you?

Slope of line = _1.499___

y-intercept = _- 0.892__

equation of line: y = - 0.892 + 1.499 x

Conclusion: If a, x, and y are positive, then the ordered pairs (x, y) are related by th power function if and only if the ordered pairs (ln x, ln y) are related by a linear function. To prove this, let's use algebra:

Using algebra and the laws of exponents transform this function into a linear function. $y = ax^b$

1. Take the ln of both sides. ln y = ln _ax^b_____
2. Rewrite the right side using a property of logs. ln y = ln __a____ + ln __x^b__
3. Rewrite the right side using another property of logs. ln y = ln _a__ + _b_ ln _x___

Assessment and evaluation *(NOTE: this section can be separate or included in the step-by-step directions.)*

- Have students look of the distance and periods of all the planets and see if their equation works for all of them. Find out for which planets we had data.
- Give students other data and have them evaluate the data and find the power function.

Activity extensions

- Give students other sets of data to evaluate.

Student TI-Nspire Document

PlanetMotion.tns