

Investigating the Height of a Stack of Cookies

Is there a relationship between the height of a stack of sandwich cookies, such as regular Oreo™ cookies, and the number of cookies?

Using sandwich cookies and a centimeter ruler, measure, to the nearest 0.1 centimeter, the height of a variety of stacks, such as 0, 2, 3, 5, 7, and 10 cookies. Record your data.

number of cookies	height of stack
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

The collected data can be entered into the accompanying "Just Add Data" Excel spreadsheet (http://academic.pgcc.edu/~ssinex/cookies_stack.xls), which will determine the line of best-fit by a linear regression performed on the data. This is your mathematical model! A measure of the goodness of fit for the regression is given by r^2 . A perfect fit of the model to the data would yield an $r^2 = 1$. Record your equation in terms of the variables studied (not x and y) and the value of r^2 .

What does the slope represent in terms of the variables investigated?

What are the units of the slope?

What should the y-intercept be for this mathematical model?

What are the regression results for the y-intercept? What is the cause of the non-zero value?

What are the heights of 20 and 150 cookies?

How could you verify your predictions?

What can you conclude about the uniformity of the thickness of the cookies?

How would the graph change if Double-Stuf Oreo™ cookies were used? Could you draw this graph with only one measurement? The spreadsheet has a spinner to allow you to investigate changing the average thickness.

Suppose that there was random variation in the thickness of the cookies, how would this influence the data on the graph? (You could investigate this by randomly mixing regular and Double-Stuf Oreo™ cookies together in a stack!)

Go to the Variation in Thickness tab and see how the random variation in cookie thickness influences the graph. Describe what happens.

Notes to the instructor:

This activity is designed to be an introduction to the mathematical modeling of experimental data. Using the stacking of sandwich cookies, such as Oreos™, allows easy measurement of stack height with a centimeter ruler. Measurements can easily be made to the nearest 0.1 cm (or 1 mm).

Oreo™ cookies tend to have a relatively consistent thickness; hence, a good fit of the data occurs on performing a linear regression. The accompanying interactive Excel spreadsheet allows for "Just Add Data" to produce the best-fit line. A discussion of linear regression and goodness of fit can be delayed until later as they are not needed to do this activity.

Once the linear equation is determined, you have the mathematical model. The slope of the model is the average thickness of the sandwich cookies in units of cm/cookie. The y-intercept should actually be zero; however, it usually is a very small value near zero (errors in measurement and actual cookie thickness variation cause this small value). Have students write the equation in terms of the variables and define them as:

$$H = tn$$

where H = height of the stack, n = number of cookies, and t = average thickness of the cookies. You can use the model to make predictions too. Consider if the model has any limitations.

Once you have data in the interactive Excel spreadsheet, you have the option of using the simulation aspects of the model. The average cookie thickness can be changed to see the effect on the slope of the model. Also random variation in cookie thickness can be added to show how it causes scatter in the data and decreases the value of r^2 .

For further materials on mathematical modeling and developing interactive Excel spreadsheets, see the Developer's Guide to Excelets at <http://academic.pgcc.edu/~ssinex/excelets>.