Math Objectives

- Students will explore a geometric sequence.
- Students will determine a rule for the sequence.
- Students will apply the rule recursively to extend the sequence.
- Students will graph the resulting data.
- Students will derive, evaluate, and graph an exponential function to model the data.
- Students will discuss the meaning of the constants *a* and *b* in the exponential function $\mathbf{f}(x) = a \cdot b^x$.
- Look for and express regularity in repeated reasoning. (CCSS Mathematical Practice)
- Model with mathematics. (CCSS Mathematical Practice)

Vocabulary

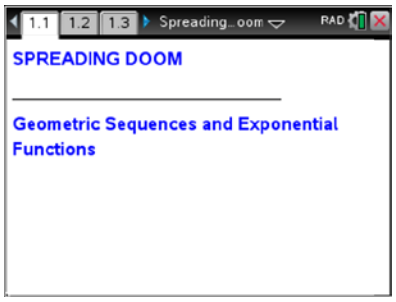
- geometric sequence
- common ratio
- recursive
- exponential function

About the Lesson

- Students explore a geometric sequence that models the spread of the 2004 mydoom virus. After finding a rule for the sequence, they apply it recursively to extend it and graph the resulting data as a scatter plot.

TI-Nspire™ Navigator™ System

- Use **Class Capture** to monitor student progress.



TI-Nspire™ Technology Skills:

- Using the *Lists & Spreadsheet* application
- Graphing scatter plots in *Data & Statistics*
- Graphing functions

Tech Tips:

- To enter a formula in a cell of a spreadsheet, begin by pressing [=].
- Change the general settings in the spreadsheet to **fix0**.

Lesson Files:
Student Activity
Spreading_Doom_Student.doc
Spreading_Doom_Teacher.doc

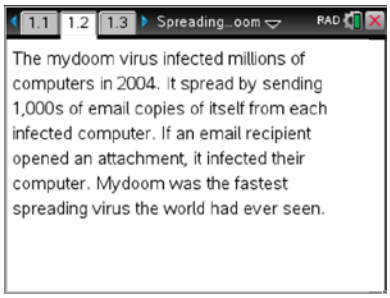
TI-Nspire™ document
Spreading_Doom.tns

Discussion Points and Possible Answers

Discuss how the students anticipate the value of the number of viruses to grow. Will the growth be fast or slow?

Tech Tip: Change the Document Settings for this activity to **Fix0**.

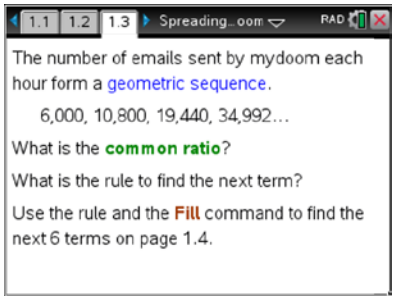
Move to page 1.2.



1. On page 1.2, read about the mydoom virus. In your own words, describe how the virus spread.

   Answer: This virus spread when the recipient of an e-mail opened an attachment. Once the attachment was opened, the computer was infected.

Move to page 1.3.



2. What is the common ratio for this sequence?

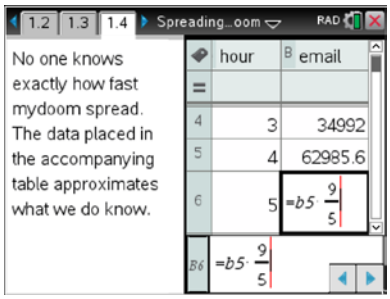
   Answer: $r = \frac{t_n + 1}{t_n} = \frac{10800}{6000} = \frac{9}{5}$

3. What is the rule for finding the next term?

   Answer: To find the next term, multiply the previous term by the common ratio: $t_{n+1} = \frac{9}{5} t_n$

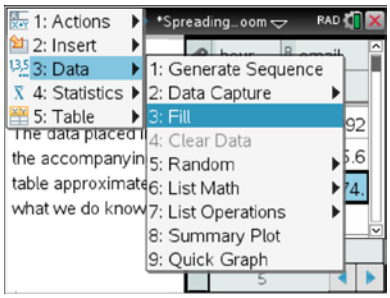
Tech Tip: To move from one application to another on a split page, move the cursor to the appropriate application and press ⬚, or press ctrl tab.

Move to page 1.4.

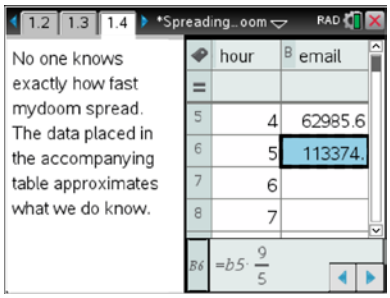


4. Move to cell B6, and enter the formula for finding the value of the next term in this sequence. Then, press enter.

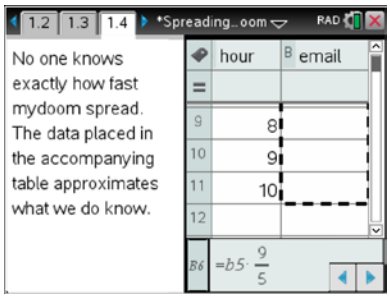
5. Move to cell B6, and press **Menu > Data > Fill**.



6. Notice the bold, dashed frame around the cell.

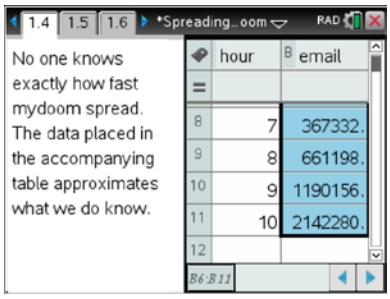


7. Press the down arrow until the next five terms have been selected; press enter.



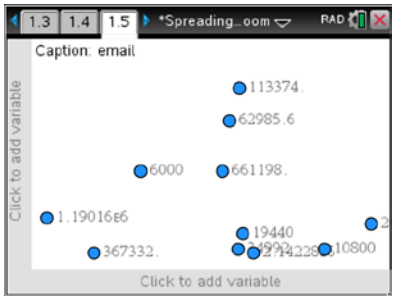
8. The highlighted cells will be populated with values based upon the formula entered.

> **Teacher Tip:** Use TI-Nspire™ Navigator™ to verify that students are successful at filling the spreadsheet.

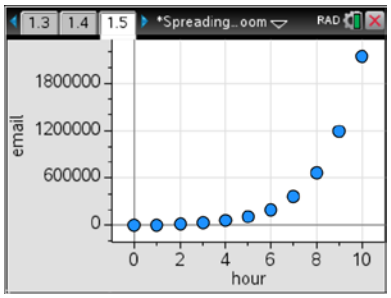


Move to page 1.5.

9. This is a *Data & Statistics* page displaying the events from the spreadsheet.



10. To graph a scatter plot of the data, click on the "Click to add variable" message in the center of the lower part of the screen, and select the variable **hour**. Then click on "Click to add variable" on the left side of the screen, and select the variable **email**. The scatter plot will be displayed.



11. Describe the shape of the scatter plot.

Answer: Answers may vary. The scatter plot has the shape of an exponential function.

12. Complete the table on your worksheet and on page 1.6 of the TI-Nspire™ document to help determine a function to model the spread of the mydoom virus.

Answer: See the table below.

x	**f(*x*)**	**Exponential Expression**
x = 0	**f**(0) = 6,000	**f**(0) = 6,000 x 1.8^**0**
x = 1	**f**(1) = **f**(0) x 1.8 = 6,000 x 1.8	**f**(1) = 6,000 x 1.8^**1**
x = 2	**f**(2) = **f**(1) x **1.8** = 6,000 x 1.8 x 1.8	**f**(2) = 6,000 x 1.8^**2**
x = 3	**f**(3) = **f**(2) x **1.8** = 6,000 x **1.8** x **1.8** x **1.8**	**f**(3) = 6,000 x 1.8^**3**
x = 4	**f**(4) = **f**(3) x **1.8** = 6,000 x **1.8** x **1.8** x **1.8** x **1.8**	**f**(4) = 6,000 x 1.8^**4**

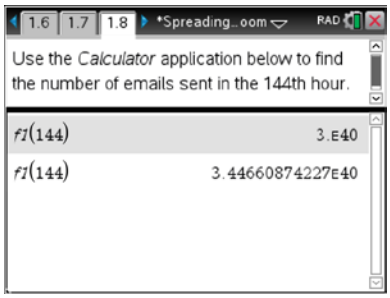
Move to page 1.7.

13. Write a function that gives the number of e-mails, f(*x*), sent by the virus in the x^{th} hour after its release.

Answer: **f**(*x*) = 6000 $(\frac{9}{5})^x$ or **f**(*x*) = 6000 $(1.8)^x$

Teacher Tip: To enter the function in the Math Box, click immediately to the right of the := symbol, and be sure the Math Box is open. (There will be a red frame around the Math Box.) Then enter the function, and press enter.

Move to page 1.8.

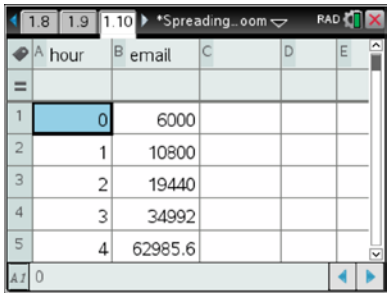


14. Select the *Calculator* application, enter **f1(144)**, and press enter.

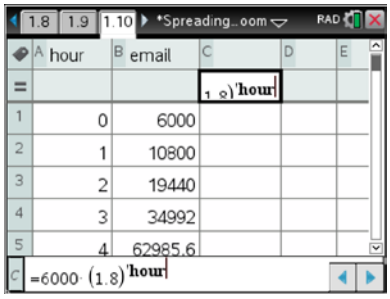
> **Teacher Tip:** If **f1** does not appear in bold when it is typed in the Calculator application, the function was not entered correctly on page 1.7. See the previous **Teacher Tip**.

> **Tech Tip:** Change the Document Settings to **float** to display more significant digits for this result.

Move to page 1.9.

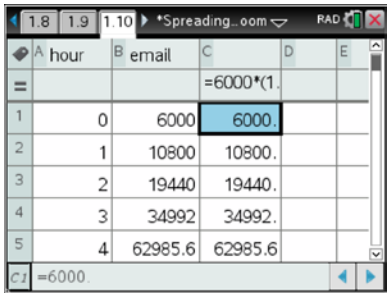


15. To copy the spreadsheet, move to page 1.4, and move to the *Lists & Spreadsheet* application. Press ctrl K to select this application (the frame should be flashing), and press ctrl C to copy it. Move to page 1.9, and press ctrl I to insert a new page. Press esc to close the menu, and finally press ctrl V to paste the spreadsheet.



16. Move to the formula row in column C. Enter your function, using **hour** for the independent variable, and then press enter.

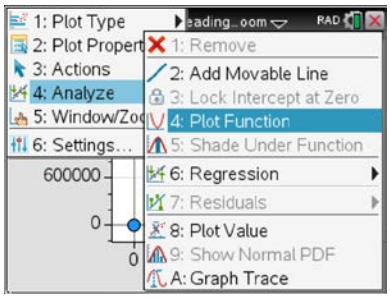
> **Teacher Tip:** Be sure that students understand why **hour**, rather than *x,* is used when entering the function in the spreadsheet.



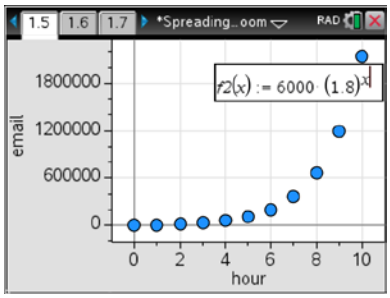
17. Compare the values in column B with those in column C.

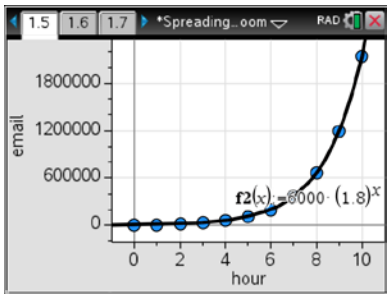
Move to page 1.5.

18. Press **Menu > Analyze > Plot Function**.



19. Enter your function in the dialogue box, and press enter.





20. This function is an exponential function of the form $\mathbf{f}(x) = a \cdot b^x$. In your own words, explain what the values of *a* and *b* represent.

Answer: In the exponential function *a* represents the initial value at time zero, and *b* represents the common ratio in the geometric sequence.