Math Objectives

- Students will create realistic word problems when given the equation that models a situation.
- Students will use variables to represent quantities in a real-world or mathematical problem, and construct simple equations to solve problems by reasoning about the quantities.
- Students will use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities (CCSS).
  Students will make sense of problems and persevere in solving them (CCSS Mathematical Practice).

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Vocabulary

- model
- equation
- graph
- expression
- independent variable
- dependent variable
- function
- variable
- reverse engineering

About the Lesson

- This lesson involves reverse engineering of word problems.
- As a result, students will:
  - Write an equation from a traditional word problem.
  - Explore a given equation numerically and graphically.
  - Create a word problem that is modeled by the given equation.

TI-Nspire™ Navigator™ System

- Transfer files and collect student work.
- Use Screen Capture to examine student work and descriptions.
- Use Live Presenter to allow a student to demonstrate work and/or present a story.
- Use Teacher Edition computer software and Class Analysis to review student work.
- Use Quick Poll to rank student solutions.

TI-Nspire™ Technology Skills:
- Download a TI-Nspire document
- Open a document
- Move between pages
- Grab and drag a point

Tech Tips:
- Make sure the font size on your TI-Nspire handhelds is set to Medium.
- You can hide the function entry line by pressing [ctrl] [G].

Lesson Files:
Student Activity
What's_Your_Story_Student.pdf
What's_Your_Story_Student.doc

TI-Nspire document
What's_Your_Story.tns

Visit www.mathnspired.com for lesson updates and tech tip videos.

Discussion Points and Possible Answers

> **Tech Tip:** Students will need to know the name of the folder where .tns file is saved. TI-Nspire skills that students should possess are as follows: Moving between pages; selecting answers on a multiple guess question; giving open response answers; checking answers; and adding a Notes Page.

Move to page 1.2.

1. Write a word problem you remember from an earlier mathematics class or from this class. Do you recall the equation or expression that matched it? Write the problem in the space below or on your TI-Nspire handheld.
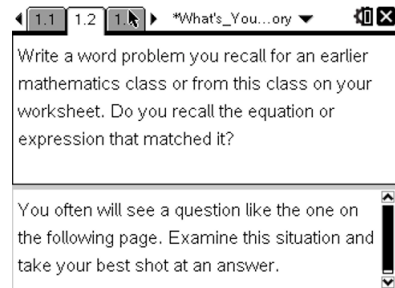
   Sample Answers: Sally wants some apples, and they cost $0.77 each. How many can she get with her $21?
   0.77 * Apples; 0.77 * Apples ≤ 21.00

       or

   Timmy has $0.23 in nickels and pennies. He has 7 coins altogether. How many coins of each kind does he have?
   0.23 = 0.05 * N + 0.01 * P
   N + P = 7

> **Teacher Tips:** Students will write a word problem they recall from an earlier mathematics class or from your class in previous interactions. They may do this in the Nspire, or on their worksheet. They might recall the equation that went with this, most likely not.
> Ask the students to share their story problems, looking for constants, and variables. As an extension, help the students come to see the ultimate goal of the equation, to extrapolate and interpolate for a given situation, that is, to determine values above or below the stated values for x and to give values for intermediate values of x within the stated values.
> Also point out that the equation can still serve as a good model even when the constants change. For example in the equation 7.50 * Hours_Worked + 150 = Weekly_Pay the 7.50 is a constant. If the individual gets a raise to 8.50 an hour, the equation will still work, when updating the constant.

> Students will be asked to examine the question on the next page. This should not be the first time that they have seen this kind of question.

Move to page 1.3.

2. On this page, you see the traditional set-up for a word problem. You select the equation that best models the cell phone story given. Notice the wording of the problem and how it matches up to the parts of the equations. You might be asked by the teacher to share your choice or reasoning.
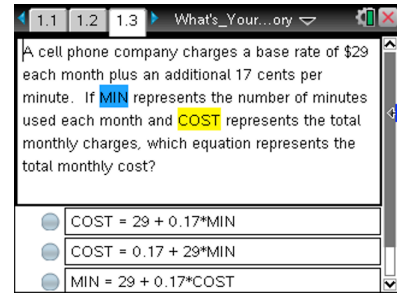
    Answer: COST = 29 + 0.17*MIN

> **Teacher Tip:** Students, as individuals, will examine this word problem and select the answer that makes the best case for the given situation.
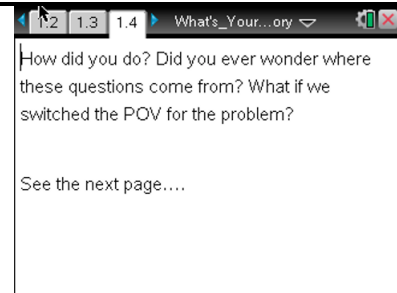

TI-Nspire Navigator Opportunity: *Quick Poll, Screen Capture, and Class Analysis*
See Note 1 at the end of this lesson.

Move to page 1.4.

3. Check your answer on Page 1.3 by pressing [ctrl] ▲ to see if you got it right. The check mark means you picked the correct answer. How did you do?

    Answer: Student answers will vary.

4. Explain where you think the questions on Page 1.4 come from.

    Answer: Student answers will vary.

> **Teacher Tip:** Discuss class answers. Tell the students that we now want to switch the problem where we will start with the equation and then write the word problem.

Move to page 1.5.

Now let's consider switching the point of view (POV) for the problem and look at outcomes first. On this page, you are given the equation 4F – 3.90 = G.

- Since the value of G comes directly from the value of the expression 4F – 3.90, we could just pick values for F, and plug them into the expression to get a value for G as shown in the example below where F = 11.

5. Fill in the Table below by selecting different values for F and recording the resulting values for G.
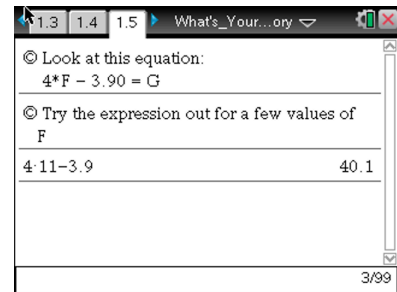
   Sample Answers:

F	G
11	40.10
0	-3.9
5	16.1
10	36.1
15	56.1
20	76.1
25	96.1
30	116.1

Teacher Tip: As students explore these values they could develop a sense of the relationships shown in the equation. Looking at the values used by students for F might lead to some insight. If they use whole numbers, integers, or decimals, this should impact the word problem they create. Try to bring the types of real numbers used in the stories to the attention of the class.

The question might arise regarding the number of ordered pairs needed. This could lead to some rich discussion, ie., Two points determine a line; three points are needed to show that this line is the one that we want, etc.

6. What would happen if F = 0? Could G ever be equal to zero?

   Answer: G would equal -3.90 when F = 0 which is a negative number indicating you would be in the red. Yes, when 4F = 3.90, and F = 0.975, G=0.

> **Teacher Tip:** Help students move from a quantitative answer to a
> contextual answer for #6. That is, in what world could F be zero or what
> situation might make G = 0.

7. What could the variables G and F represent in real life? Suggest some realistic possibilities.

    Answer: F could stand of the number of frogs you buy for supper and G could be the amount of
    green (cash) you pay for the frogs. The 3.90 is the incentive to buy the frogs and frogs sell for $4
    each, of course. For example, You get 3 frogs and the store pays you $3.90 as an incentive to
    encourage you to buy their frogs. This results in you paying only $8.10.
    or
    F could stand for the number of hours Mary worked at $4.00 per hour and G could be the
    amount she has earned after paying $3.90 for her lunch.

> **Teacher Tip:** The students should now be laying the foundation for the
> story that makes the word problem by answering #7.

TI-Nspire Navigator Opportunity: *Screen Capture*
See Note 2 at the end of this lesson.

> **Teacher Tip:** Students will now consider what the shape of the graph of
> this proposed model will look like on the next page. They need to note that
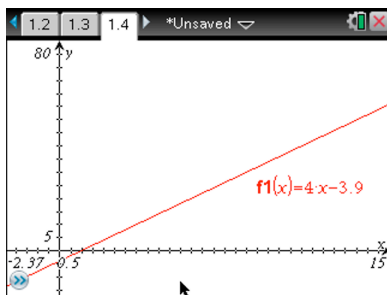> F and G will not be the variables used in this graphing tool.

Move to pages 1.6 and 1.7.

Next, let's look at a graph of the equation as a function to see how it illustrates the story problem in a different way.

8.　Enter the value of *f1*(x) as 4*x-3.90. You might want to adjust the Window [menu 4 1] or use Graph Trace [menu 5 1] to explore different values for F (now x) and G (now *f1(x)*).

Sample Answers:

> **Tech Tip:** Students will need to know that the TI-Nspire uses x as the independent variable and that all functions are represented by **f#(x),** where the # is 1, 2, 3, etc. So the 1st function would be *f1*(x). Expanding the Window or using Graph Trace help students develop a story for the word problem that is modeled by 4F – 3.90 = G.
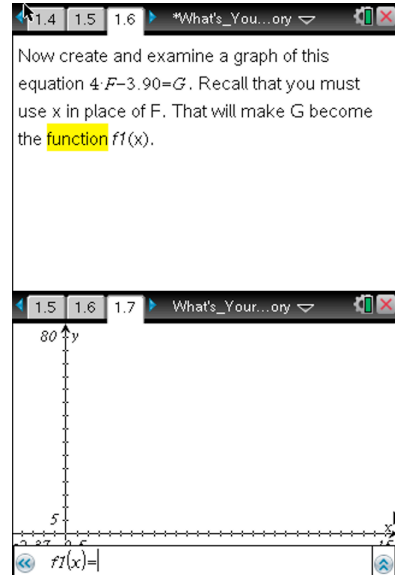
Move to page 1.8.

9.　Explain what appears to be going on with the graph in the context of a real-life situation.

　　Answer: As F (or *x*) gets larger, f(*x*) or *y* or G gets larger in a regular way (linear). So if F was the number of hours you parked your Ferrari, G might be the amount you owe the Garage for parking fees.
The values of G are less than zero until F gets to a certain value. This could be interpreted as the attendant at the garage likes your car so much that you are paid for parking the car for the first few hours.
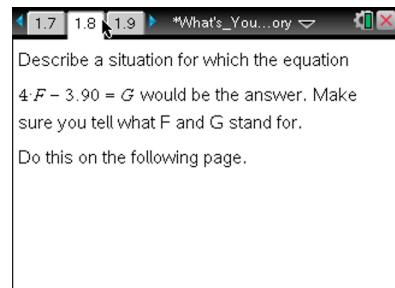
> **Teacher Tip:** Discussing what students see will help those that are struggling. Walk around the room, report some student answers to the class, and discuss.

Now you are ready to write your own word problem from a given equation. Before you write, consider how the words of the problem matched up to the parts of the equation, how you experimented with the set of outcome values for F and G, and how the graph of the relationship between F and G gave you another perspective.

Move to page 1.9.

10. Write your story in the space below the question on this page. Try to keep it simple but real. Identify what the variables G and F represent in your story. Be prepared to share your story and explain to the class how the equation models the story.
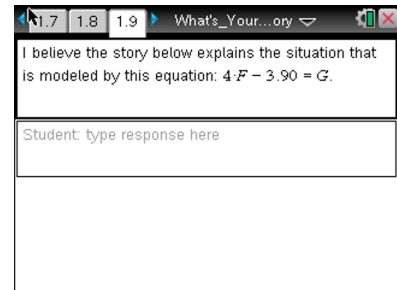
<u>Sample Answers:</u> Student answers will vary. For example: Frank gets 4 dollars per hour at his work. He also has to pay the boss $3.90 a day for parking at his work. G will be the amount of pay he earns in a day, and F will be the number of hours he works in a day. So if Frank works 7 hours on Tuesday he will earn: $4*7 - 3.90 = 28 - 3.90 = \$24.10$ for the day.

> **Teacher Tip:** Students will key in their story for a situation that could be modeled by the equation: $4F - 3.90 = G$. They will need to identify what the variables G and F represent in their story. This is should be done by each student individually.
> Students should plan to share and reflect on their solutions. They should reflect on the completeness of the solution and be concerned about how sensible and "real" their story is.

> **TI-Nspire Navigator Opportunity:** *Live Presenter, Screen Capture, Quick Poll, and Class Analysis*
> **See Note 3 at the end of this lesson.**

Move to page 2.1.

11. Team up, and use what you learned above to repeat the process of writing a word problem that can be modeled by the equation given on Page 2.1.

12. Choose one team member to write the equation and story on a Notes page on their TI-Nspire handheld. Your team might want to add other pages such as Graph, Geometry, Calculator, List & Spreadsheet to help in the documentation of your story. Before you finish, document the names of your team in the document. Plan on reporting your story to the class.
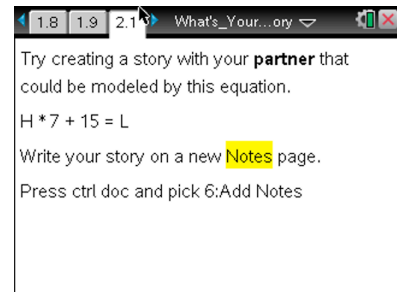
<u>Sample Answers:</u> Student answers will vary. For example:
For the equation H * 7 +15 = L, we have H as the number of horses on our farm that can have babies. Each horse will be required to have seven babies before we stop them. We have 15 other horses on the farm that are unable to facilitate the creation of baby horses. L stands for the total number of horses we can expect to have on the Lazy Horse ranch when the birthing is done.
or
The length (L) of the base of a triangle has to be 15 units more than 7 times its height (H). What is the length of the base of the triangle for any value of height coming from boards cut in integral unit lengths?

> **Teacher Tip:** Students will now take what they learned from the first problem and repeat the process of writing a word problem that can be modeled by the given equation. Students should be prepared to share the results they get as before, but in this case, Class Analysis will not be an option. In addition, this may be the first time the students work as teams while using the TI-Nspire handheld. They should assign jobs with one student keying in the word problem and documenting who is in the group. Others in the team might want to use the Scratchpad or other Applications to Graph, Evaluate, or otherwise analyze the proposed story. Teams larger than three students tend not to be productive.
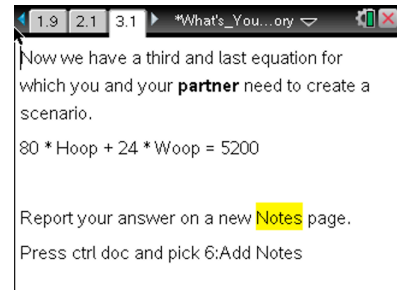
TI-Nspire Navigator Opportunity: *Live Presenter, Screen Capture, and Quick Poll*
See Note 4 at the end of this lesson.

Teacher Tip: Student teams can be the same or regrouped for 3.1.

Move to page 3.1.

13. Your teacher might re-group you for this last problem. Make sure you incorporate what you learned as you participate in the construction of the word problem for the given equation. Document as before, and plan to share with the class.

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1.9  2.1  3.1  ▶  *What's_You...ory ▽
Now we have a third and last equation for
which you and your partner need to create a
scenario.
80 * Hoop + 24 * Woop = 5200

Report your answer on a new Notes page.
Press ctrl doc and pick 6:Add Notes
```

<u>**Sample Answers:**</u> Student answers will vary. For example:

For the equation 80 * Hoop + 24 * Woop = 5200, we have a situation where we must have as the daily minimum requirement 5200 grams in our energy snack. Hoops, which are hydrators, have a mass of 80 grams and Woops, which are cleansers, have a mass of 24 grams. This equation will tell us how many Hoops are needed if we pick a certain number of Woops or visa versa. For example, we could put in 50 Woops and then we would need 50 Hoops to get the 5200 grams.
80*50 + 24 *50 = 4000 + 1200 = 5200

TI-Nspire Navigator Opportunity: *Live Presenter, Screen Capture, Quick Poll, and Class Analysis*
See Note 5 at the end of this lesson.

Wrap Up

Upon completion of the investigation, the teacher should ensure that students are able to understand:

• How word problems can be explained by an equation, and how that equation allows for the generalizing of many different solutions/situations.

• How to create a word problem that can be modeled by a given equation.

Extension

Students can be asked to extend the idea of creating word problems to the younger grades by visiting other classrooms and helping the students create word problems to less complex equations. They also could consider more sophisticated equations that are nonlinear, or that are limited in Domain and Range values by the situation. This could lay the foundation to understanding Domain and Range in later grades.

Assessment

Have each student or team create an equation and a word problem that is modeled by their equation. Collect all of these and then place them randomly on different pages in a .tns document. Send the .tns document to each student with the directions: match each equation with the word story that it models.

> **TI-Nspire Navigator Opportunity:** *Quick Poll and Screen Capture*
> **See Note 6 at the end of this lesson.**

TI-Nspire Navigator

Note 1 Question 2, Name of Feature: Quick Poll, Screen Capture, and Class Analysis Do a Quick Poll to have students self-report their success on the question from Page 1.3. One could also ask students to press ⌷ctrl⌷ ▲ and then take a Screen Capture of the real results. Class Analysis could report the results. This was a Self-Check document.

Note 2 Question 7, Name of Feature: Screen Capture Taking a Screen Capture of the values used for F might help the class develop their story for the word problem. If they use -5 for F, what could that represent? How about 3.75 for F? A whole group discussion might lead to some insights for the teacher and the situation that is to be modeled.

Note 3 Question 10, Name of Feature: Live Presenter, Screen Capture, Quick Poll, and Class Analysis Have a student take over as Presenter, and let her share her story. Take a Screen Capture of all of the stories. Use Quick Poll to rate the quality of the story as it relates to the given equation.

Note 4 Question 12, Name of Feature: Live Presenter, Screen Capture, Quick Poll, and Class Analysis Use the Screen Capture tool and the Nspire TE software to determine which word problem goes with which equation. Or try the reverse. Show the equation on the software and then ask the students to move to the word problem that the equation models. Take the Screen Captures, and see what you get. Use Class Analysis to post all the word problems using the display from Class Analysis or the results shown by the student presenter. Use Quick Poll for students to report the Page Number that goes with a given equation or story.

Note 5 Question 13, Name of Feature: Live Presenter, Screen Capture, Quick Poll, and Class Analysis Use Quick Poll so the class can express their opinions on the quality of the stories. Take Screen Captures of individual handhelds as the students try to evaluate the equations or to find solutions.

Note 6 Assessment, Name of Feature: Quick Poll and Screen Capture Use Quick Poll to get the number of the page that matches the story or the equation. When creating the new .tns file, create individual questions on separate pages so that the stories will automatically be numbered by page. Then students can report the page number as the response/answer.

Connect-to-Class If you don't have the TI-Nspire Navigator system, you can collect tns documents from the students and open them, or compile the solutions using the C2C.