Math Objectives

- Students will understand function notation and the distinction between an input value *x*, a function *f*, and a function output **f**(x)
- Students will determine the rule for a function machine after using several inputs and observing the outputs.
- Students will use function notation in problems.
- Students will look for and make use of structure (CCSS Mathematical Practices).

Vocabulary

- function
- input
- output

About the Lesson

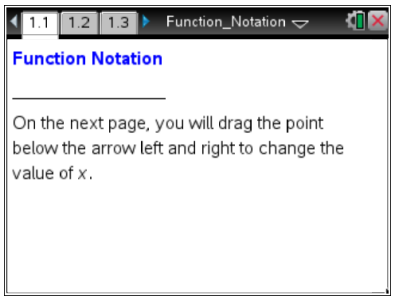
- This lesson allows students to freely vary the input to a process (represented by a "machine" diagram) and observe the resulting output.
- As a result, students will investigate and understand the symbolic language in the notation of functions used in mathematics.

TI-Nspire™ Navigator™ System

- Use Class Capture to assess students' use of the TI-Nspire document.
- Use Live Presenter to demonstrate the correct procedure with the TI-Nspire document.
- Use Quick Polls to assess students' understanding of function notation.
- Use Teacher Edition software to review student documents.

Activity Materials

Compatible TI Technologies : TI-Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software



Tech Tips:

- This activity includes screen captures from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire Apps. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Function_Notation_Student.pdf
- Function_Notation_Student.doc

TI-Nspire document

- Function_Notation.tns

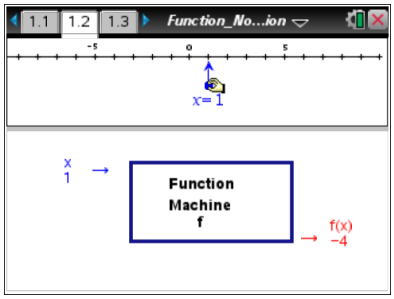
Discussion Points and Possible Answers

Tech Tip: If students experience difficulty dragging a point, check to make sure that they have moved the arrow until it becomes a hand (☜) getting ready to grab the point. Also, be sure that the word *point* appears. Then press ctrl ☜ to grab the point and close the hand (☜). When finished moving the point, press esc to release the point.

TI-Nspire Navigator Opportunity

Use *Class Capture* to determine is students are experiencing difficulty using the TI-Nspire document. Use Live Presenter to demonstrate the correct procedure for using the document.

Move to page 1.2.



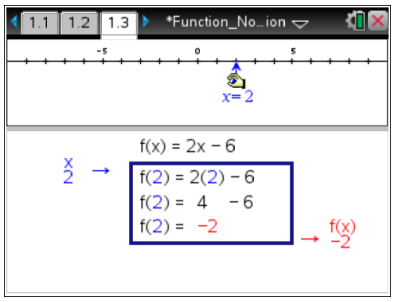
1. What do *x* and *f*(*x*) represent in the function machine?

   Answer: They both represent numbers. The variable *x* represents the input value; *f*(*x*) represents the output value.

Teacher Tip: Emphasize to students that function notation can be compared to what they have done previously with evaluating expressions, where *x* is the input number that gets substituted into the expression, and *f*(*x*) is the final output value after simplifying the expression. Students sometimes wonder why we even have function notation at all. Function notation is used for relationships between two quantities that are functions. The variables *x* and *y* can be related together as a function or a non-function, but when the relationship between them is a function, the notation *x* and *f*(*x*) is used. This allows one to see both the *x*- and the *y*-value at the same time.

Move to page 1.3.

2. Move the point to change the value of *x*. Use the function machine to complete the table.



Answer:

Input (*x*)	Output f(*x*)
0	**–6**
2	**–2**
4	**2**
7	8
–3	**–12**
–4	–14
3	0

3. a. Given the input variable *x*, explain the steps the function machine takes to find the output for the rule $f(x) = 2x - 6$.

Answer: It multiplies the input value, *x,* by 2 and subtracts 6**.**

b. Use one of the input values from question 2 to show how substitution gives you the same output.

Sample answer: Using $f(4) = 2$: Evaluate $y = 2x - 6$ for $x = 4$.

$y = 2(4) - 6$

$y = 8 - 6$

$y = 2$

Teacher Tip: Emphasize the connection to the notation students have previously used with substitution and evaluating expressions.

c. Describe why the function machine could be called a *substitution* machine.

Answer: Function notation is an alternate way to use substitution. Saying "If $y = 2x - 6$, solve for *y* when $x = 5$," is the same as saying "If $f(x) = 2x - 6$, find $f(5)$." You do exactly the same thing in either case: You substitute 5 for *x*, multiply by 2, and then subtract 6 to get a value of 4.

Teacher Tip: Again, students sometimes wonder why we use function notation if it's so much like substitution. Why not just use substitution? Reemphasize that in general, *x* and *y* can be related by a function or a non-function, but you use *x* and *f*(*x*) when the relationship between two quantities is a function. When using substitution, you end with the value of *y* but may forget the value of *x*.

Function notation allows you to see both the *x* and the *y*. These questions are intended to help students become more comfortable with the notation by comparing it to what they have done in the past. Giving them the context of when and why it is used will help students see the reason behind the notation.

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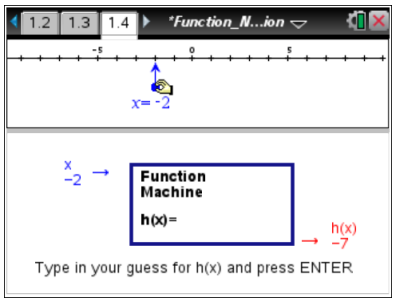

4. A mystery function is shown.

   a. Find *h*(9).

      Answer: *h*(9) = 4

   b. Find *h*(3).

      Answer: *h*(3) = –2

   c. Find a rule for *h*(*x*).

      Answer: *h*(*x*) = *x* – 5

   d. Use your rule to find *h*(7).

      Answer: *h*(7) = 2

   e. Check your result for *h*(7) using the function machine.

      Answer: The function machine also gives *h*(7) = 2.

   f. What is *h*(*a*)?

      Answer: *h*(*a*) = *a* – 5

Teacher Tip: Students can type in their guess for h(x) on the bottom part of the split page on 1.4 and press ENTER to determine whether their guess is correct.

5. David says that $f(2)$ means the same thing as $f(x) = 2$. Do you agree? Why or why not?

Answer: I disagree. They are not the same: $f(2)$ means that the input is 2. Or, $f(2)$ is the output number when the input value is 2. $f(x) = 2$ means the output value is 2.

Teacher Tip: Students need to understand the difference in both the notation and the meaning. Compare the different roles of the number 2 in the notation. Emphasize that in $f(2)$, 2 is the input number, but in $f(x) = 2$, 2 is the output number.

6. Given $f(x) = x + 3, g(x) = -2x + 7,$ and $h(x) = 4x - 5,$ find the following:

a. $f(4)$

Answer: $f(4) = 7$

b. $g(4)$

Answer: $g(4) = -1$

c. $h(4)$

Answer: $h(4) = 11$

d. $f(t)$

Answer: $f(t) = t + 3$

e. $g(1) + h(1)$

Answer: $g(1) + h(1) = 5 + (-1) = 4$

f. x when $f(x) = 12$

Answer: $x = 9$

TI-Nspire Navigator Opportunity

Use *Quick Polls* to assess students' understanding of function notation. Sample questions are shown below.

1. In the function $f(x) = 3x - 1$, identify the input and the output.

   Answer: x is the input and the output is $3x - 1$.

2. Given $f(x) = 3x - 1$, find $f(2)$.
   a. $f(2) = 2$
   b. $f(2) = 4$
   c. $f(2) = 5$
   d. $f(2) = 7$

3. Given $f(x) = 3x - 1$, what input results in $f(x) = -1$?
   a. Input of –1
   b. Input of 0
   c. Input of 1
   d. Input of 3

Wrap Up

Upon completion of the discussion, the teacher should ensure that students understand:

- Function notation.
- The distinction between an input value x, a function f, and a function output $f(x)$.