Back in Time?

TI-NSPIRE™ CX FAMILY

Math Objectives

- Students will explore the definition of a function and how it can be represented using a graph, a table, and an equation.
- Students will be asked to create their own functions given input/output values and discuss how they discovered these functions.
- Students will try to make a connection with how to understand these topics in IB Mathematics courses and on their final assessments.

Vocabulary

- Ordered Pairs
- Input/Output
- Vertical Line Test
- Model
- Domain
- Range

About the Lesson

- This lesson is aligning with the curriculum of IB Mathematics Applications and Interpretations SL/HL and IB Mathematics Approaches and Analysis SL/HL
- This falls under the IB Mathematics Content Topic 2 Functions:
    2.2: **(a)** Concept of a function, domain, range, and graph
    (b) Function notation eg) f(x), v(t), C(n)
    (c) Concept of a function as a mathematical model
    2.3: **(a)** The graph of a function; its equation y = f(x)

    As a result, students will:
   - Apply this information to real world situations.

TI-Nspire™ Navigator™

- Transfer a File.
- Use Class Capture to examine patterns that emerge.
- Use Live Presenter to demonstrate.
- Use Teacher Edition computer software to review student documents.
- Use Quick Poll to assess students' understanding

Activity Materials

Compatible TI Technologies: ⊞ TI-Nspire™ CX Handhelds, 📱 TI-Nspire™ Apps for iPad®, 💻 TI-Nspire™ Software
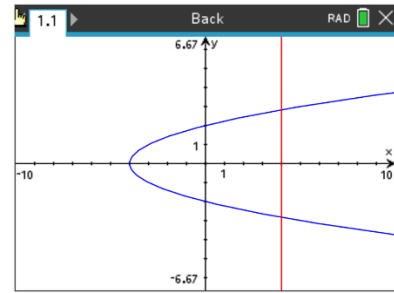
Tech Tips:
- This activity includes screen captures taken from the TI-Nspire CX II handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the 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
Nspire-BackInTime-Student.pdf
Nspire-BackInTime-Student.doc

This activity gives students an opportunity to explore the definition of a function graphically, with a set of ordered pairs, and by using equations to apply function models to real world situations. These models dynamically allow students to discover the function by experimenting with input values that produce the desired output. Function notation will also be reinforced.
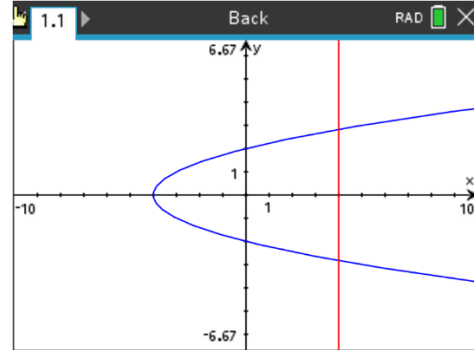
Definition

A function is a relation in which each input is paired with exactly <u>one</u> output.

For every value that goes into a function, the function outputs one unique result.

Teacher Tip: Throughout this activity, the students are asked to discuss with classmates and explain how they achieved their answers. This is a wonderful opportunity to create a student led classroom. As you float around the room, listen to what they are saying, add to their discussions, and give them leading questions to see how they respond.

Problem 1 – Graphical

At time t = 0, Marty is at position d = 2.

1. Discuss with a classmate if the graph to the right describe Marty's position as a function of time. Explain.

    Possible Discussion: The students are asked to consider a graph of position vs. time. They are asked if this is a function. Since there is not one unique output of *d* for each value of *t,* it is not a function.
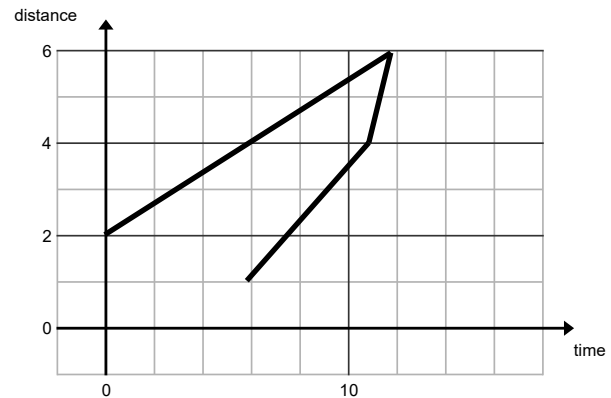
2. Describe what would have to happen for this graph to occur.
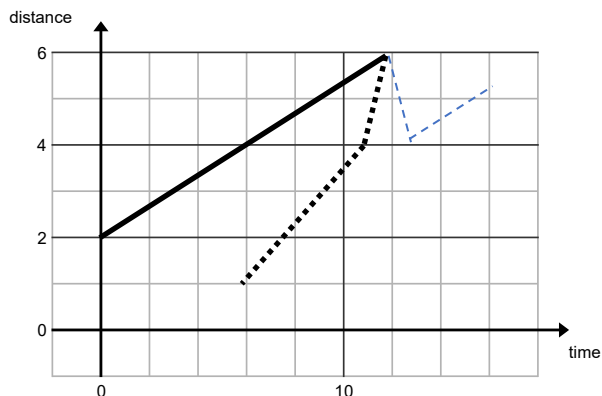
    Possible Discussion: Students then discuss with their neighbor why the answer is 'no' based on the definition, and under what circumstance could the graph occur. It could only occur if Marty went back in time.

3. Redraw the dashed lines to make the graph a function. Share your graph with a classmate and discuss any differences.

   Solution: Students then redraw the graph so that it is a function. An example of a solution is to the right.
   Use this opportunity to discuss the concept of the vertical line test.

Problem 2 – Set of ordered pairs

The first element of each ordered pair is the input value.

4. Discuss with a classmate which sets below describe a function. Explain why.

   A. {(0, 1), (1, 4), (2, 7), (3, 6)}

   B. {(−2,2), (−1, 1), (0, 0), (1, 3), (2, 4)}

   C. {(3, 2), (3, 4), (5, 6), (7, 8)}

   D. {(2, 3), (3, 2), (1, 4), (4, 1)}

   Possible Discussion: To review the notation of a set of ordered pairs this section begins with a multiple choice question with multiple solutions. Students should realize that as long as there is only one unique output for each input then it describes a function, otherwise it can only be referred to as a relation.

   Another question that can be asked is "What are some examples of relations that are not functions?" Answers include inequalities, like $y > 3x$, x as a function of y when $y = x^2$, and x as a function of y when $y = |x + 2|$.

   Functions are A, B and D because for every input value there is only one output value.

Marty flies to Mars, where the acceleration of gravity is 0.375 of what it is on Earth. So with a = 12 ft/s², use the distance formula $d = \dfrac{1}{2}at^2$ to compute the output when given the input for questions 5 through 8.

5. Use the formula to compute d. Give the set or ordered pairs (t, d) when the input t is the set {0, 1, 2, 6}.

   Solution: (0, 0), (1, 6), (2, 24), (6, 216)

Teacher Tip: Students will calculate the output values for given input values using the formula $d = \frac{1}{2} \cdot a \cdot t^2$ for when a = 12 ft/s². The formula can be simplified to $d = 6 \cdot t^2$. To compute d, students can substitute the t-values directly into the formula. To compute t, students need to either solve for t $\left(t = \pm \sqrt{\frac{d}{6}} \right)$ and then substitute the d-values into the formula or they can use the **Numerical Solve**. To use this, add a calculator page, press **menu**, **3 Algebra**, **6 Numerical Solve**, in the parenthesis enter the d-value = $6t^2$, t $(eg.\ 6 = 6t^2, t)$ and press **enter**.

6. Use the formula to compute t. Give the set of ordered pairs (d, t) if the input is d. The input set for d is $\left\{ 0, \frac{2}{3}, 6 \right\}$.

   Solution: $(0, 0)$, $\left(\frac{2}{3}, \frac{1}{3}\right)$, $\left(\frac{2}{3}, -\frac{1}{3}\right)$, $(6, 1)$, $(6, -1)$

7. Discuss with a classmate which of the two solutions sets from Questions 5 and 6 is a function. Explain why.

   Possible Discussion: The first set is a function because it has only one output for every input.

8. From solutions sets above, discuss with a classmate and explain which is true.

   A. d is a function of t B. t is a function of d

   C. both   D. neither

   Solution: A. d is a function of t

**Problem 3 – Function notation**

If f is a function of x this can be written as $f(x)$. For example, $f(x) = x^2$. So $f(3) = 9$.

To use the function ability of your graphing calculator, add a **Graphs** page and enter $x^2 - 2x + 3$ into **f1(x)** and press **enter**.

Add a **Calculator** page.

To enter different values for x and observe what $f(x)$ equals, type **f1**(value you are inputting) and press **enter**.

Press **up arrow** twice and then **enter** to recall the last entry.
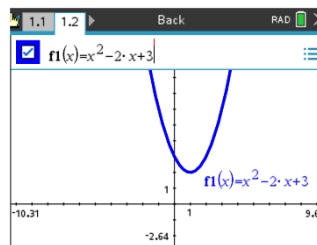
9. For $f(x) = x^2 - 2x + 3$, find $f(4)$ using the graphing calculator, then by substitution showing your work below.

   **Solution:** $f(4) = 4^2 - 2(4) + 3 = 11$

10. For $f(x) = 3x^2 + 5x + 3$, find $f(2)$ using the graphing calculator, then by substitution showing your work below.

    Solution: $f(2) = 3(2)^2 + 5(2) + 3 = 25$

Problem 4 – Find the Function

11. Given the input 17 for the function $f(x)$ that gives an output of 8.5, find two possible functions for $f(x)$. Discuss with a classmate how you found them and share with the class.

    (For example, $f(x) = x^2 - 16.5x$ will give an output of 8.5 for an input of 17. Be as simple or complex as you like with your functions!)
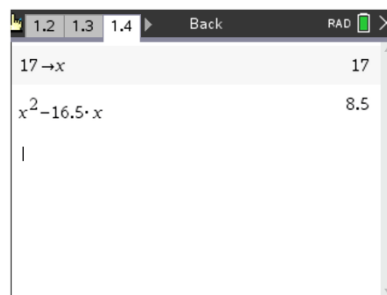
    Possible Solutions: $f(x) = 0.5x$ or

    $$f(x) = x - 8.5$$

12. Given the input -4 for the function $f(x)$ that gives an output of 6, find two possible functions for $f(x)$. Discuss with a classmate how you found them and share with the class.

    Possible Solutions: $f(x) = x + 10$ or

    $$f(x) = -\frac{3}{2}x$$

13. Given the input 20 for the function $f(x)$ that gives an output of 83, find two possible functions for $f(x)$. Discuss with a classmate how you found them and share with the class.

    Possible Solutions: $f(x) = 4x + 3$ or

    $$f(x) = 5x - 17$$

Further IB Application

In a longest throw competition, the height of a football thrown down field by a quarterback to a target down field is modelled by the function:

$$h(t) = -4.8t^2 + 15t + 1.8$$

Where *h(t)* is the height of the ball in meters above the ground at the instant it is thrown by the quarterback.

(a) Write down the height of the ball above the ground the instant it leaves the quarterback's hand.

> **Solution:** Substitute zero in for t and simpliy.
> $$h(0) = -4.8(0)^2 + 15(0) + 1.8 = 1.8 \; meter$$

(b) Find the value of *t* when the ball hits the ground.

> **Solution:** Set the function equal to zero and solve (eg. use the graph on the handheld, use the quadratic formula, etc.)
> $$0 = -4.8t^2 + 15t + 1.8$$
> $$t = 3.24 \; s$$

(c) State an appropriate domain for *t* in this model.

> **Solution:** This represents the start of the throw until it reaches the target.
> $$0 \leq t \leq 3.24 \;\; or \;\; [0, 3.24]$$

Teacher Tip: Basic understanding of the TI-Nspire CX II is needed to navigate through pages and menus. It may be a good idea to review these before the activity.

> **TI-Nspire Navigator Opportunity:** *Quick Poll (Open Response)*
> **Any part to any Problem in the activity would be a great way to quickly assess your student's understanding of finding and discussing both forms of Scientific Notation and Expanded Form.**

**Note: This activity has been developed independently by Texas Instruments and aligned with the IB Mathematics curriculum, but is not endorsed by IB™. IB is a registered trademark owned by the International Baccalaureate Organization.