

Teacher Guide: Function Machines 1



Learning Objectives

Students will...

- Write a function rule based on an input-output table.
- Create an input-output table for a given function.
- Find input and output values based on a function and/or an input-output table.



Vocabulary

function, input, output



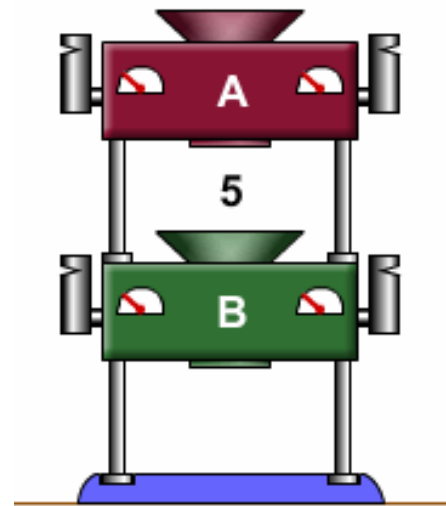
Lesson Overview

The *Function Machines 1* Gizmo™ introduces students to the concept of functions and function tables. (Note: There are two additional lessons that use this Gizmo. In *Function Machines 2*, students graph functions; in *Function Machines 3*, students use functions to model situations. See **Selected Web Resources** on page 3 of this document for the links.)

In *Function Machines 1*, students program machines with function rules and use the machines to create input-output tables.

The Student Exploration sheet contains three activities:

- Activity A – Students complete input-output tables for given functions.
- Activity B – Students determine functions based on input-output tables.
- Activity C – Students create functions to match given input-output tables.



Suggested Lesson Sequence

- 1. Pre-Gizmo activity** (🕒 10 – 15 minutes)
 Play a game with your class where a called-on student says a number and you respond with a number that is one higher. After 2-3 rounds ask, “What’s the rule that I’m following?” Do this a few times with very simple rules. Then have a student be the machine (“Who wants to be the -3 robot?”), using the rule on numbers that their classmates call out.
- 2. Prior to using the Gizmo** (🕒 10 – 15 minutes)
Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class. At this point, letting students share how they thought about the questions is more valuable than “going over” the correct answers. After the discussion, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations.

3. **Gizmo activity** (🕒 15 – 20 minutes per activity)
Assign students to computers. Students can work individually or in small groups. Have students work part of the Student Exploration sheet using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

It may be overwhelming for students to do all of the activities in the Student Exploration in one sitting. We recommend starting with the first page of the Student Exploration sheet (Prior Knowledge Questions and Gizmo Warm-up) plus one of the three activities. Extend the lesson if you want using the extensions below. Return to the Gizmo and the unused activities in future class periods to reinforce the concepts.

4. **Extending the Gizmo** (🕒 15 – 20 minutes)
Here are some suggestions for extending the activities in the Student Exploration sheet:

Activity A Extension – Have students fill in tables for more unusual functions, such as multiply by 0 or divide by 1. Completing tables for division functions reveals patterns that can reinforce fraction concepts. For example, for the function “Divide by 3”, have students write the output when the input is {1, 2, 3, 4, 5}. If they do the division by hand, they can see the connection between the remainder and the fractional part of the output.

Activity B Extension – By deselecting “Show function” in the FMP 500, students can hide the functions of the programmable machines. Assign students to work in pairs. Have students take turns programming function machines for their partner to guess. The goal of the guesser is to determine the function as quickly as possible.

Activity C Extension – Give students a function table with only one row of input-output values: Input = 2 and Output = 6. Then ask them to find a function that matches the table. Is there only one function that matches, or is there more than one? Once it’s been established that there is more than one possible function, challenge students to find as many functions as they can that match the input-output pair. If students use more than one machine to create their functions, there will be many possible answers. ($Output = Input + 4$, $Output = 3 \times Input$, $Output = 2 \times Input + 2$, etc.) Then repeat this extension for a table that has two rows of input-output values. Students will discover that if there are two input-output pairs, there is only one function that can match. (They might also make the corollary that it’s possible to determine the function from only two input-output pairs.)

Another way to extend students’ work with the Gizmo is class discussion. After students are done with their activity, discuss the following questions:

- In this Gizmo, if the output values are greater than the input values, what does that tell us about the function?
- In this Gizmo, if the output values are less than the input values, what does that tell us about the function?
- Could we ever have a “Multiply by” function where the output was less than the input? [*Yes. Although it’s not possible to make those functions with the Gizmo, multiplying by a number less than one will give an output less than the input.*]
- When trying to guess a function machine by creating a table, what kind of input values are most helpful? Does it help to go in some kind of order, or can the input numbers be completely random? Are there certain input values that are particularly useful (like 0 and 1)?

5. **Follow-up activity: Function Game** (🕒 at least 5 minutes)
 The function game is a good way to fill spare moments in the school day. Draw an empty input-output table on the chalkboard or overhead projector. Think of a function, but don't tell your students what it is. Write down a number in the input column. Students then raise their hands if they want to guess the corresponding output value. If a student guesses correctly, she goes to the front of the class and writes the output value in the table. Continue in this fashion. No student is allowed to say the function rule until you write "Input" as an input value. Then the called-on student can write the function rule as the output value for that row of the table.



Mathematical Background

A function is a relationship where each input value has only one possible output value. (However, several input values can have a common output value.)

function		function		not a function	
Input	Output	Input	Output	Input	Output
1	3	1	1	1	4
2	6	2	0	1	6
3	9	3	1	2	9
4	12	4	4	3	11

All of the functions that can be created by the *Function Machines* Gizmo are *linear functions*. A linear function forms a straight line when graphed on the coordinate plane. When playing the function game, you can also expose your students to *nonlinear functions* such as $Output = Input \times Input$ or $Output = 24 \div Input$.

In this Gizmo, students may encounter negative numbers when working with function machines that do subtraction. (A simple function of $Output = Input - 3$ will result in negative numbers for input values of 0, 1, and 2.) If your students haven't worked with negative numbers in the past, and if you don't want to discuss the topic in depth during the lesson, you could tell them that negative numbers are numbers that are less than zero (like the temperature when it drops below zero degrees).

In this lesson, finding the functions for machines can provide significant practice in "mental math." Students may also start to notice helpful patterns in the output values, particularly when they choose input values systematically instead of randomly. The *Function Machines 2* Gizmo explores these patterns and also has students graph input-output values on the coordinate plane. This makes it a great follow-up activity for *Function Machines 1*.



Selected Web Resources

Function Machines 2 Gizmo: <http://www.explorellearning.com/gizmo/id?1039>

Function Machines 3 Gizmo: <http://www.explorellearning.com/gizmo/id?1040>

PBS Lesson: <http://pbskids.org/cyberchase/parentsteachers/lessons/lessonplans/lesson12.html>