

# FUNCTION HOMEWORK – HORIZONTAL AND VERTICAL PERMUTATIONS\*

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## Abstract

This module provides sample problems designed to develop some concepts related to horizontal and vertical permutations of functions by graphing.

### Exercise 1

Standing at the edge of the Bottomless Pit of Despair, you kick a rock off the ledge and it falls into the pit. The height of the rock is given by the function  $h(t) = -16t^2$ , where  $t$  is the time since you dropped the rock, and  $h(t) = -16t^2$  is the height of the rock.

- a. Fill in the following table.

|                       |          |                                 |          |                                  |          |                                  |          |                                  |
|-----------------------|----------|---------------------------------|----------|----------------------------------|----------|----------------------------------|----------|----------------------------------|
| <b>time (seconds)</b> | <b>0</b> | <b><math>\frac{1}{2}</math></b> | <b>1</b> | <b><math>1\frac{1}{2}</math></b> | <b>2</b> | <b><math>2\frac{1}{2}</math></b> | <b>3</b> | <b><math>3\frac{1}{2}</math></b> |
| <b>height (feet)</b>  |          |                                 |          |                                  |          |                                  |          |                                  |

Table 1

- b.  $h(0) = 0$ . What does that tell us about the rock?  
 c. All the other heights are negative: what does that tell us about the rock?  
 d. Graph the function  $h(t)$ . Be sure to carefully label your axes!

### Exercise 2

Another rock was dropped at the exact same time as the first rock; but instead of being kicked from the ground, it was dropped from your hand, 3 feet up. So, as they fall, the second rock is always three feet higher than the first rock.

- a. Fill in the following table for the second rock.

|                       |          |                                 |          |                                  |          |                                  |          |                                  |
|-----------------------|----------|---------------------------------|----------|----------------------------------|----------|----------------------------------|----------|----------------------------------|
| <b>time (seconds)</b> | <b>0</b> | <b><math>\frac{1}{2}</math></b> | <b>1</b> | <b><math>1\frac{1}{2}</math></b> | <b>2</b> | <b><math>2\frac{1}{2}</math></b> | <b>3</b> | <b><math>3\frac{1}{2}</math></b> |
| <b>height (feet)</b>  |          |                                 |          |                                  |          |                                  |          |                                  |

\*Version 1.1: Dec 31, 2008 8:49 am -0600

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**Table 2**

- b. Graph the function  $h(t)$  for the new rock. Be sure to carefully label your axes!
- c. How does this new function  $h(t)$  compare to the old one? That is, if you put them side by side, what change would you see?
- d. The original function was  $h(t) = -16t^2$ . What is the new function?
- .  $h(t) =$
  - . (\*make sure the function you write actually generates the points in your table!)
- e. Does this represent a **horizontal permutation** or a **vertical permutation**?
- f. Write a generalization based on this example, of the form: when you **do such-and-such** to a function, the graph changes in **such-and-such** a way.

**Exercise 3**

A third rock was dropped from the exact same place as the first rock (kicked off the ledge), but it was dropped  **$1\frac{1}{2}$  seconds later**, and began its fall (at  $h = 0$ ) at that time.

- a. Fill in the following table for the **third** rock.

|                       |   |               |   |                |   |                |   |                |   |                |   |
|-----------------------|---|---------------|---|----------------|---|----------------|---|----------------|---|----------------|---|
| <b>time (seconds)</b> | 0 | $\frac{1}{2}$ | 1 | $1\frac{1}{2}$ | 2 | $2\frac{1}{2}$ | 3 | $3\frac{1}{2}$ | 4 | $4\frac{1}{2}$ | 5 |
| <b>height (feet)</b>  | 0 | 0             | 0 | 0              |   |                |   |                |   |                |   |

**Table 3**

- b. Graph the function  $h(t)$  for the new rock. Be sure to carefully label your axes!
- c. How does this new function  $h(t)$  compare to the **original** one? That is, if you put them side by side, what change would you see?
- d. The original function was  $h(t) = -16t^2$ . What is the new function?
- .  $h(t) =$
  - . (\*make sure the function you write actually generates the points in your table!)
- e. Does this represent a **horizontal permutation** or a **vertical permutation**?
- f. Write a generalization based on this example, of the form: when you **do such-and-such** to a function, the graph changes in **such-and-such** a way.