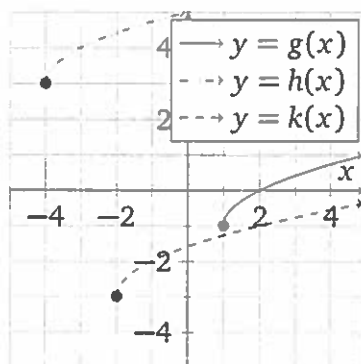
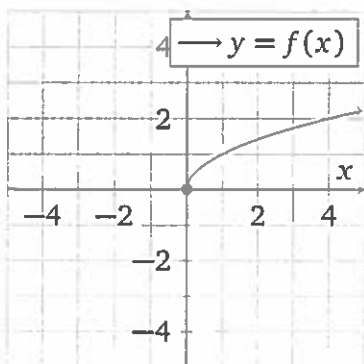


Shifting Functions and Graphs

In these exercises, we practice using the rules for shifting a function up, down, left, and right. We will use a verbal description of a shift of a function to create a representation of a new function in various ways. We will also compare two function graphs and identify how it has been shifted.

1. On the left we have the graph of f , where $f(x) = \sqrt{x}$. On the right, we have several transformations of f .



For each of the functions g , h , and k , do the following:

- Verbally, how has the graph been changed from f 's graph?
- Write a formula for the function.

g : shifted right 1 and down 1 from f

$$g(x) = f(x-1) - 1 = \sqrt{x-1} - 1$$

h : shifted left 4 and up 3 from f

$$h(x) = f(x+4) + 3 = \sqrt{x+4} + 3$$

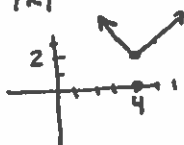
k : shifted left 2 and down 3 from f

$$k(x) = f(x+2) - 3 = \sqrt{x+2} - 3$$

2. For each of the functions below, do each of the following.

- What basic function from the catalog of graphs does this function's graph resemble?
- Verbally, what changes have been made to create this function's graph?
- Make a graph of this function on paper, using your understanding of the basic function that each function resembles and the transformations that have been made.

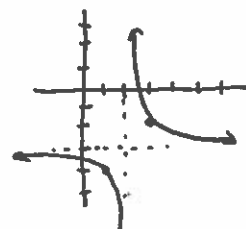
a) $p(x) = |x-4| + 2$
resembles $|x|$
has been shifted right 4, up 2



b) $q(x) = (x+5)^2 + 1$
resembles x^2
has been shifted left 5 and up 1



c) $r(x) = \frac{1}{x-2} - 3$
resembles $\frac{1}{x}$
has been shifted right 2 and down 3



3. The function f defined by $f(x) = 2x^5 + x^2$ has its graph shifted left 3 units and shifted up 7 units, making a new function we can call h . What is a formula for h ?

$$h(x) = f(x+3) + 7 = 2(x+3)^5 + (x+3)^2 + 7$$

4. The function g defined by $g(x) = \frac{2^x}{x}$ had its graph shifted down 3 units and shifted right 7 units, making a new function we can call s . What is a formula for s ?

$$s(x) = g(x-7) - 3 = \frac{2^{x-7}}{x-7} - 3$$

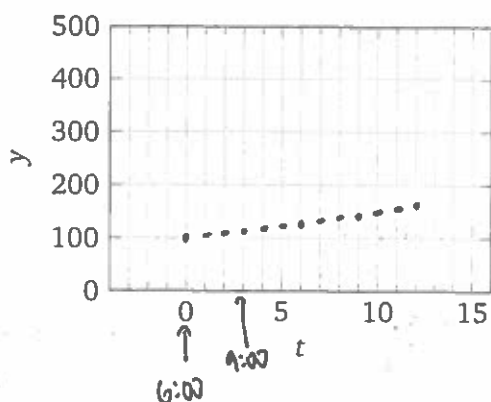
5. The curve $y = k(x)$ was shifted right 5 units and up 13 units. Write an equation for the new curve. (The equation for the new curve will still involve "k".)

$$y = k(x-5) + 13$$

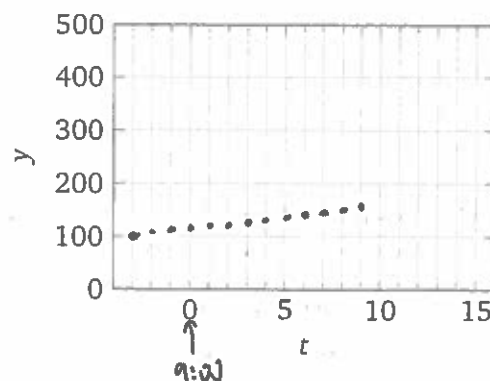
6. Let $t = 0$ correspond to 6:00 in the morning, with t measured in hours. The size of a bacteria colony (in millions) at time t is

$$P(t) = 100(1.22)^{0.20t}$$

- (a) Use your calculator to help you plot points for the population from 6:00 in the morning until 6:00 in the evening. Mark points at every hour.



- (b) Your boss tells you to recalibrate the graph so that $t = 0$ corresponds to 9:00 in the morning. What kind of shift would that be? Sketch the graph that would represent this new function.



- (c) Give a formula for this new function.
 $100(1.22)^{0.20(t+3)}$

7. A function f has domain $(-\infty, 3) \cup (3, \infty)$ and range $[4, \infty)$. If g is defined by $g(x) = f(x+10) + 4$, what are the domain and range of g ?

shifted left 10, up 4

So domain is $(-\infty, -7) \cup (-7, \infty)$

and range is $[8, \infty)$

8. The function f has the table below. If the function g is defined by $g(x) = f(x-3) + 1$, make a table for g . Hint: what kinds of transformations have been made to f 's graph to get g 's graph?

x	$f(x)$
4	2
5	2
9	6
13	12
14	16

$f(x-3) + 1$
 shift right 3, shift up 1

$(4, 2) \rightarrow (7, 3)$
 $(5, 2) \rightarrow (8, 3)$
 $(9, 6) \rightarrow (12, 7)$
 $(13, 12) \rightarrow (16, 13)$
 $(14, 16) \rightarrow (17, 17)$

x	$g(x)$
7	3
8	3
12	7
16	13
17	17