How to use this handout—This handout contains a skeleton of the notes that we will study in class this week. I've typed out definitions and theorems so that you don't have to exasperatedly copy what I'm writing, and populated these pages with a number of examples. My expectation of you is that you will fill in all of the details, ideas, *etc*, that I've left out.

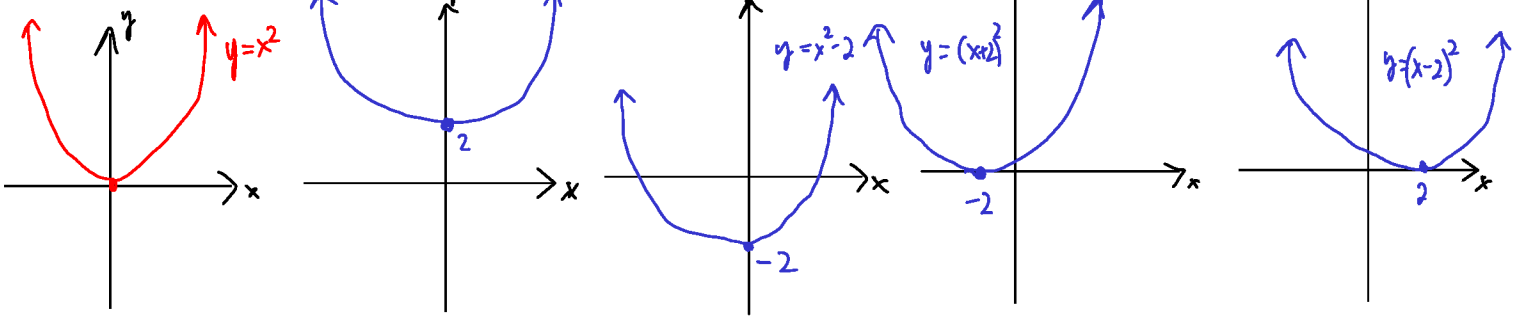
Section 2.2—Vertical and Horizontal Shifts of Graphs

Let $c > 0$ be a positive constant, and let $y = p(x)$ be a function with a known graph. (We call p a "parent function.") The following table describes how to obtain the graph of a function $y = f(x)$ by using the graph of the parent function.

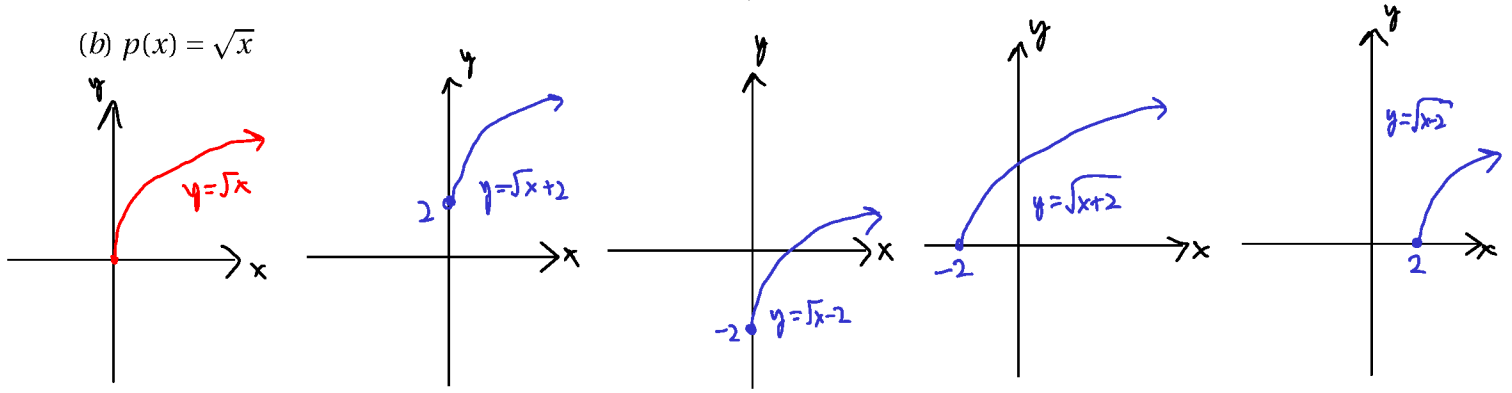
function	*shift of the parent graph*
$f(x) = p(x-c)$	**right** c units
$f(x) = p(x+c)$	**left** c units
$f(x) = p(x)+c$	**up** c units
$f(x) = p(x)-c$	**down** c units

Examples Let $c = 2$. Sketch the graphs of each possible shift in the table above.

(*a*) $p(x) = x^2$



(*b*) $p(x) = \sqrt{x}$



Examples Identify the parent function and list the shifts in the graph.

(*a*) $y = \sqrt{x-5}$

parent function : $p(x) = \sqrt{x}$

shifts: right 5 units

(*b*) $y = (x+6)^3 + 1$

parent function: $p(x) = x^3$

shifts: left 6 units
up 1 unit

(*c*) $y = |x| + 2$

parent function: $p(x) = |x|$

shifts: up 2 units

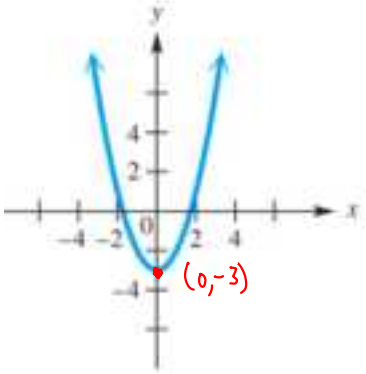
(*d*) $y = (x+4)^2 - 9$

parent function: $p(x) = x^2$

shifts: left 4 units
down 9 units

Examples Identify the parent function and list the shifts in the graph. Write the equation of the function defined by the graph.

(*a*)

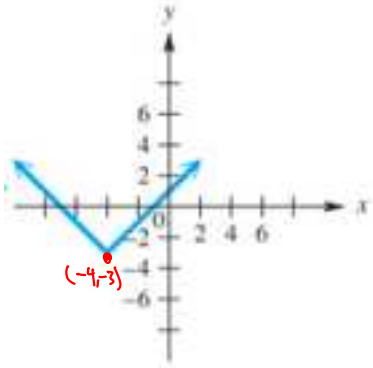


parent function: $p(x) = x^2$

shifts: down 3 units

equation: $f(x) = x^2 - 3$

(*b*)

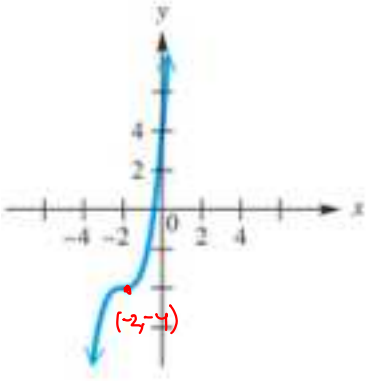


parent function: $p(x) = |x|$

shifts: left 4 units
down 3 units

equation: $f(x) = |x+4| - 3$

(*c*)



parent function: $p(x) = x^3$

shifts: left 2 units
down 4 units

equation: $f(x) = (x+2)^3 - 4$

Example Write the function $y = x^2 - 4x + 9$ in vertex form, and describe how to obtain the graph from that of the parent function.

$y = (x^2 - 4x + 4) + (9 - 4)$

$y = (x-2)^2 + 5$

$b = -4$

$\frac{b}{2} = -2$

$\left(\frac{b}{2}\right)^2 = 4$

by completing the square.

* The graph $y = x^2 - 4x + 9$ is obtained from the graph of $y = x^2$ by shifting right 2 units, and up 5 units.