Section 5.1

1. (a)

x	–1	0	1	2	3
$g(x) = f(x-1)$	$f(-1-1) = f(-2) = -3$	$f(0-1) = f(-1) = 0$	$f(1-1) = f(-0) = 2$	$f(2-1) = f(1) = 1$	$f(3-1) = f(2) = -1$

(b)

x	–3	–2	–1	0	1
$h(x) = f(x+1)$	$f(-3+1) = f(-2) = -3$	$f(-2+1) = f(-1) = 0$	$f(-1+1) = f(-0) = 2$	$f(0+1) = f(1) = 1$	$f(1+1) = f(2) = -1$

(c)

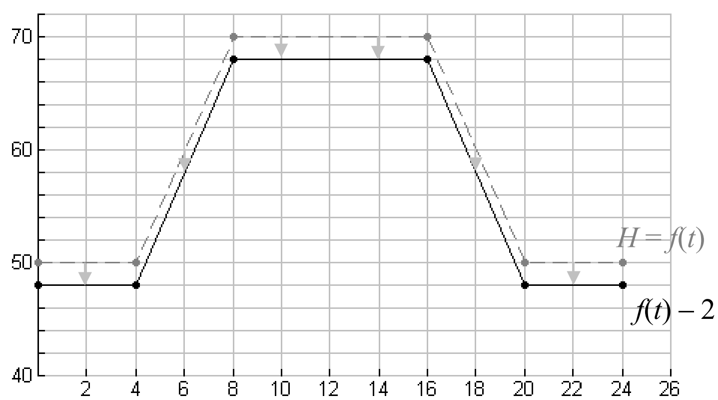
x	–2	–1	0	1	2
$k(x) = f(x)+3$	$f(-2) + 1 = f(-2) = -3$	$f(-1) + 1 = f(-1) = 0$	$f(0) + 1 = f(-0) = 2$	$f(1) + 1 = f(1) = 1$	$f(2) + 1 = f(2) = -1$

(d) Since $m(x) = f(x-1) + 3$, and $f(x-1) = g(x)$ from part (a), take the last row of the table in part (a) and add 3 to each.

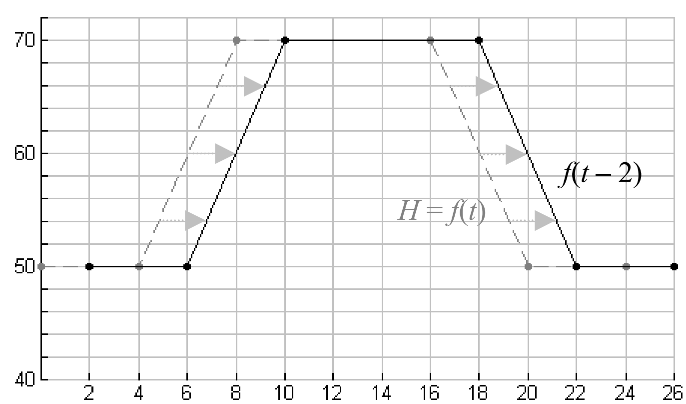
x	–1	0	1	2	3
$g(x) = f(x-1)$	–3	0	2	1	–1
$m(x) = f(x-1) + 3 = g(x) + 3$	$-3 + 3 = 0$	$0 + 3 = 3$	$2 + 3 = 5$	$1 + 3 = 4$	$-1 + 3 = 2$

2. (a) The function results in lowering the temperature 2°F.

$H = f(t) - 2$



(b) The function $H = f(t-2)$ results in changing the heating schedule to start 2 hours later than before.

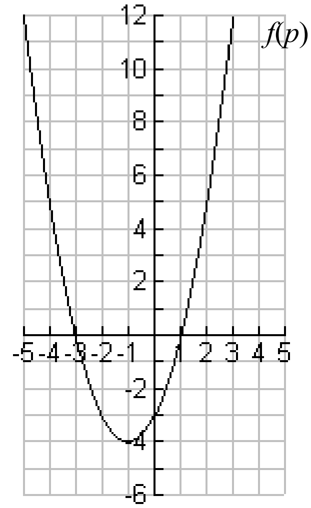


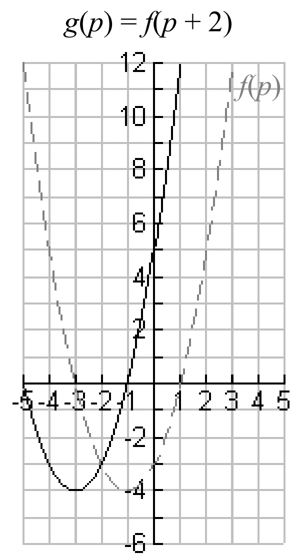
(c) The building is warmer under the $f(t)$ schedule, where it is 70°F.

(d) The function $f(t) - 2$ saves the company the most.

3.

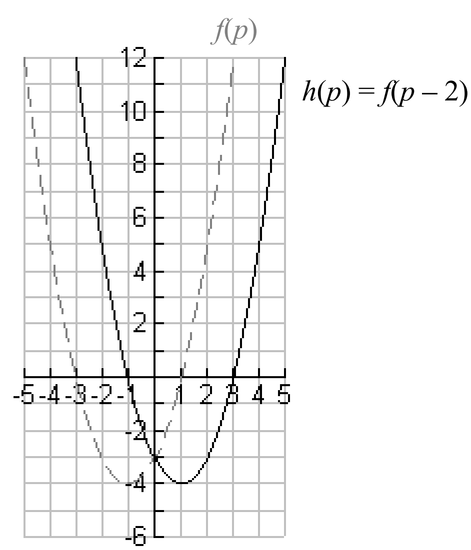
x	–3	–2	–1	0	1	2	3
$f(p)$	0	–3	–4	–3	0	5	12





x	–3	–2	–1	0	1	2	3
$g(p)$	–4	–3	0	5	12	21	32

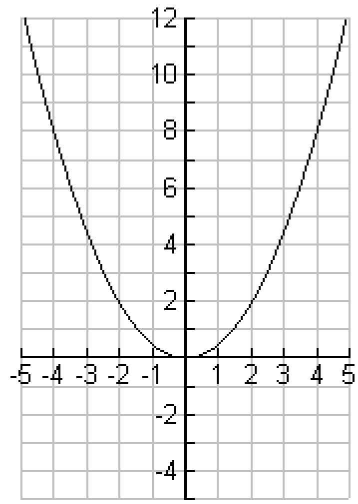
The graph of $g(p)$ is the graph of $f(p)$ shifted horizontally 2 units to the left.



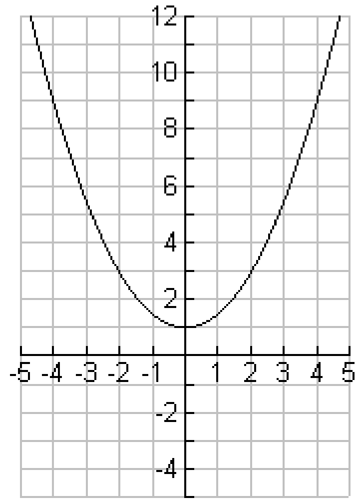
x	–3	–2	–1	0	1	2	3
$h(p)$	12	5	0	–3	–4	–3	0

The graph of $h(p)$ is the graph of $f(p)$ shifted horizontally 2 units to the right.

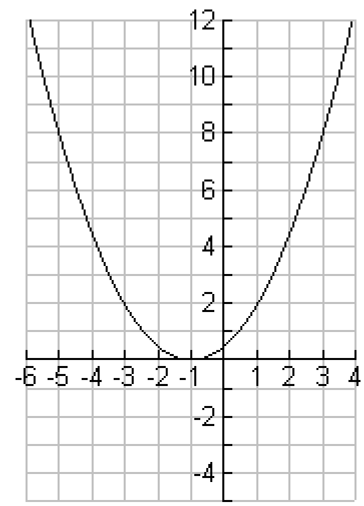
4. $m(n) = \frac{1}{2}n^2$



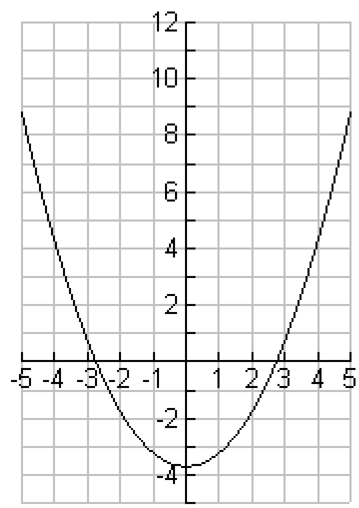
(a) $m(n) + 1 = \frac{1}{2}n^2 + 1$



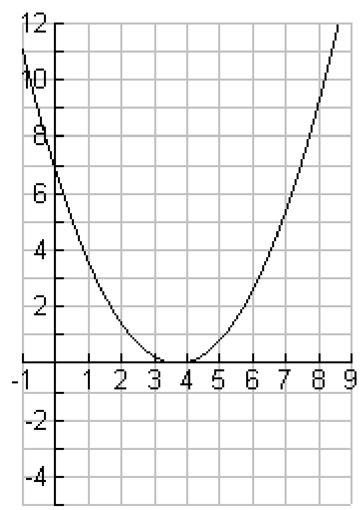
(b) $m(n + 1) = \frac{1}{2}(n + 1)^2$



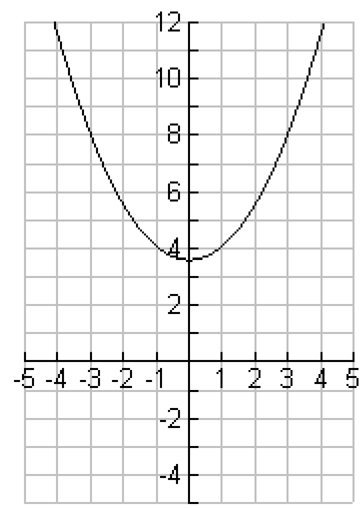
(c) $m(n) - 3.7 = \frac{1}{2} n^2 - 3.7$



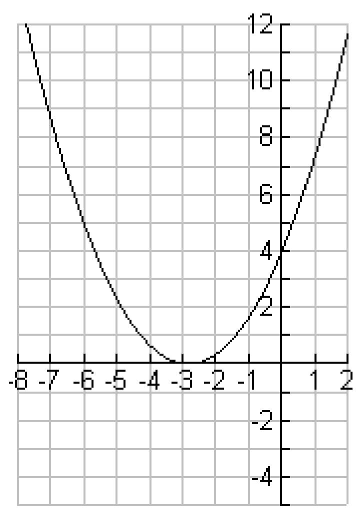
(d) $m(n - 3.7) = \frac{1}{2}(n - 3.7)^2$



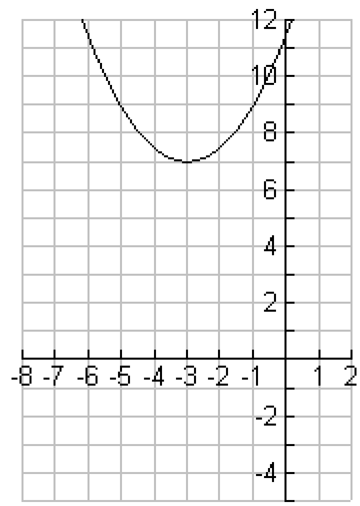
(e) $m(n) + \sqrt{13} = \frac{1}{2}n^2 + \sqrt{13}$



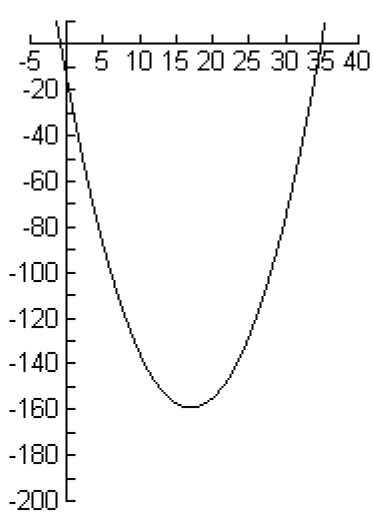
(f) $m(n + 2\sqrt{2}) = \frac{1}{2}(n+2\sqrt{2})^2$



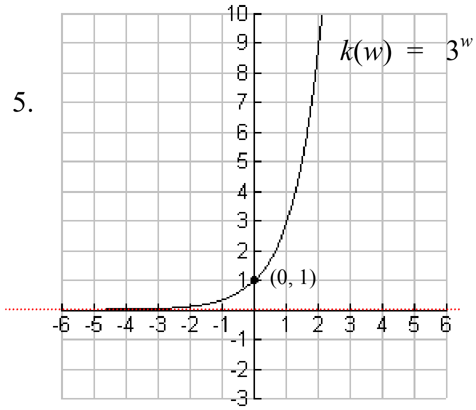
(g) $m(n + 3) + 7 = \frac{1}{2}(n + 3)^2 + 7$



(h) $m(n - 17) - 159$
$= \frac{1}{2}(n - 17)^2 - 159$

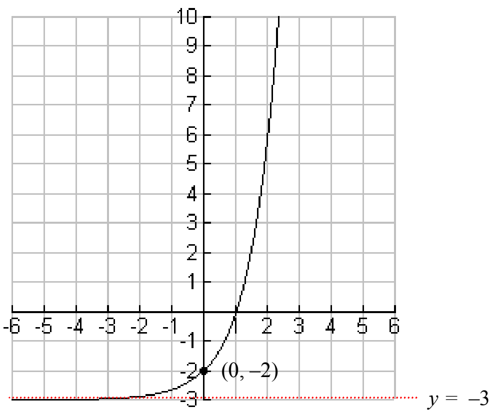


5.

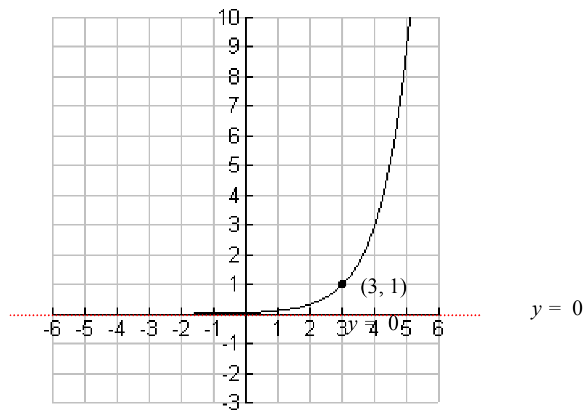


In each new graph, we draw the vertical asymptote as well as mark the point that corresponds to the point (0, 1) on the graph of $k(w) = 3^w$.

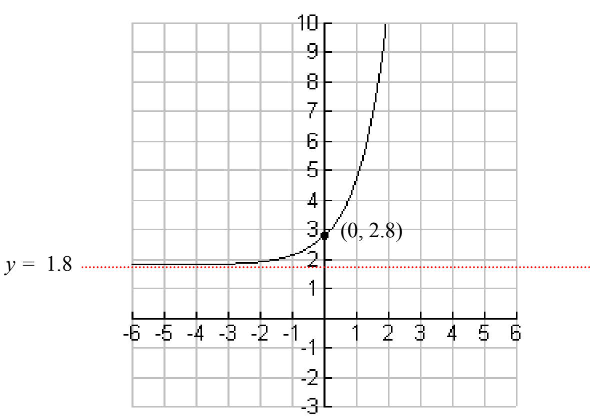
(a) $k(w) - 3 = 3^w - 3$



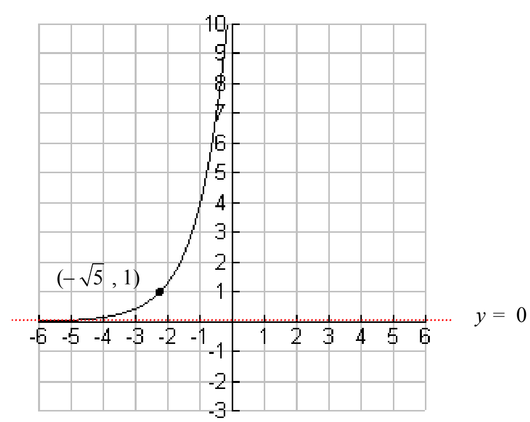
(b) $k(w - 3) = 3^{w-3}$



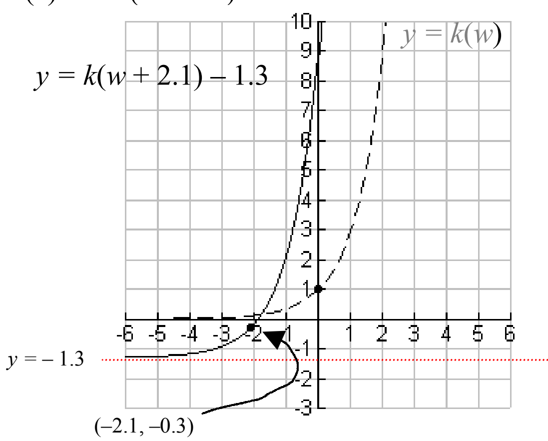
(c) $k(w) + 1.8 = 3^w + 1.8$



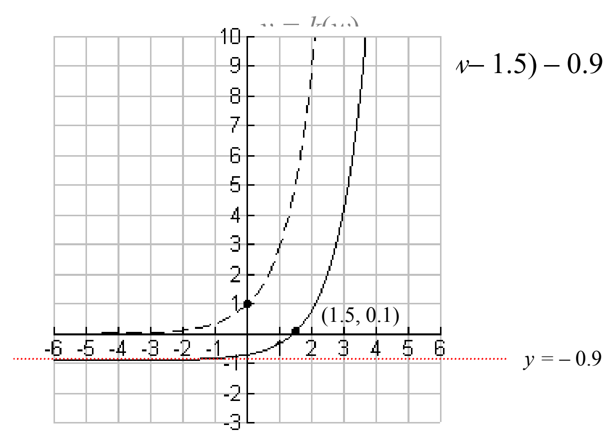
(d) $k(w + \sqrt{5}) = 3^{w+\sqrt{5}}$



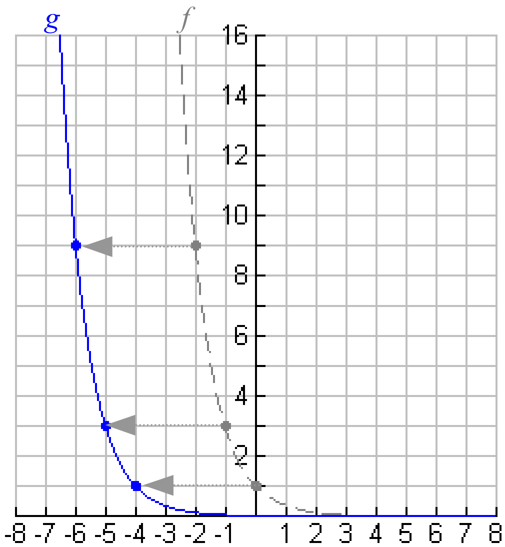
(e) $k(w + 2.1) - 1.3 = 3^{w+2.1} - 1.3$

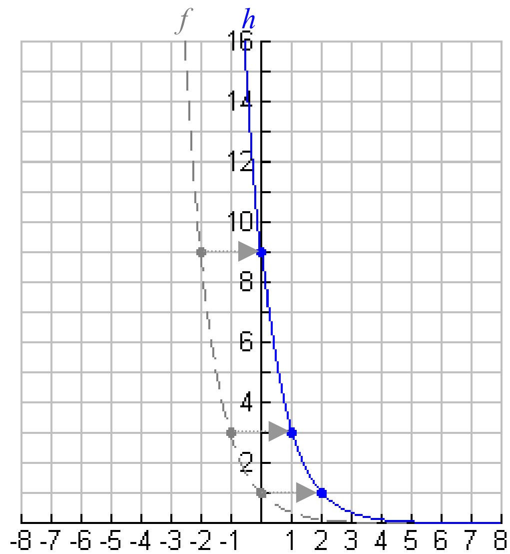


(f) $k(w - 1.5) - 0.9 = 3^{w-1.5} - 0.9$



6. In each figure, the graph of f is the dashed exponential function.

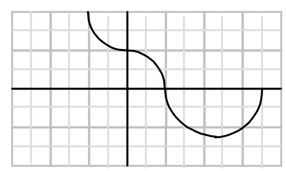




The graph of g is the graph of f shifted horizontally 4 units to the left. Note $g(x) = f(x + 4)$.
The graph of h is the graph of f shifted horizontally 2 units to the right. Note $h(x) = f(x - 2)$.

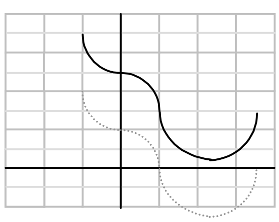
7. (a) (vi) (b) (iii) (c) (ii) (d) (v) (e) (i) (f) (iv)

8. Think of this graph as portions of two quarter-circles and a semicircle.

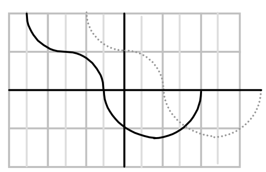


$s = c(t)$

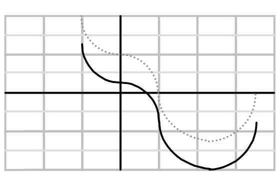
(a) $s = c(t) + 3$



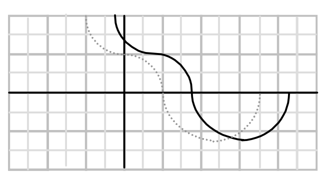
(b) $s = c(t + 3)$



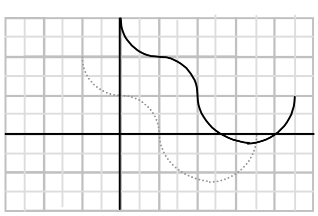
(c) $s = c(t) - 1.5$



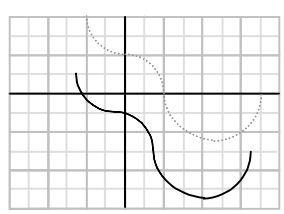
(d) $s = c(t - 1.5)$



(e) $s = c(t - 2) + 2$

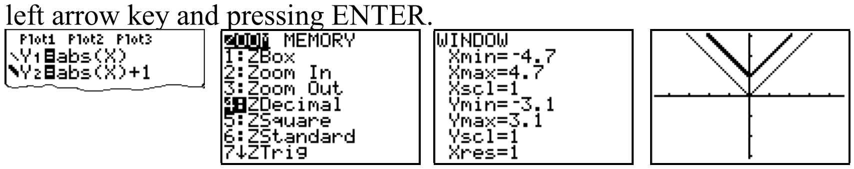


(f) $s = c(t + 0.5) - 3$

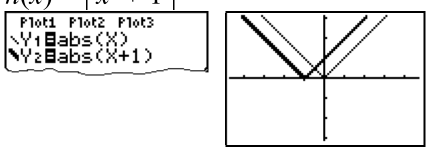


9. Sketch by hand. You can check with a graphing calculator.
On a TI-83 or TI-83 Plus, you can find the absolute value function by pressing [MATH] ▷ [1]
If you have another model, go to the Assistance with Graphing Calculators Web Page at http://www.ipfw.edu/math/graphcalc.html.

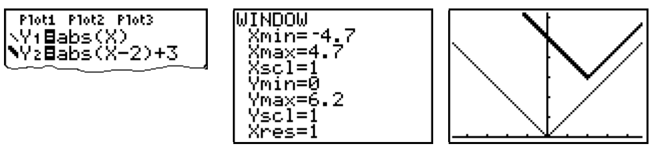
(a) $g(x) = |x| + 1$
If you have a TI-83 or TI-83 Plus, you can change the graph style of one of the functions using the left arrow key and pressing ENTER.



(b) $h(x) = |x + 1|$



(c) $f(x) = |x - 2| + 3$



11. (a) $T(d) = S(d) + 1$
(b) $P(d) = S(d - 1)$

12. (a) $n(r) = m(r) + 2$
(b) $p(r) = m(r - 1)$
(c) $k(r) = m(r + 1.5)$
(d) $w(r) = m(r - 0.5) - 2.5$

13. (a) $h(x) = f(x) - 2$
(b) $g(x) = f(x + 1)$
(c) $i(x) = f(x + 1) - 2$

14. (a) $a(t) = g(t) + 0.5$
(b) Check: If you substitute –1.5 in for t, your expression for $b(t)$ should make $b(-1.5) = g(0)$.
Answer: $b(t) = g(t + 1.5)$
(c) $c(t) = g(t + 1.5) - 0.3$
(d) Check: If you substitute 0.5 in for t, your expression for $d(t)$ should make $b(0.5) = g(0)$.
Answer: $d(t) = g(t - 0.5)$
(e) $e(t) = g(t - 0.5) + 1.2$

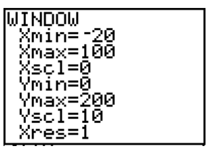
15. (a) A reasonable window is the standard viewing window: $-10 \le x \le 10$ by $-10 \le y \le 10$.
Other choices are reasonable as well.
(b) $-100 \le x \le 100$ by $0 \le y \le 200$.

17. Vertical shifts

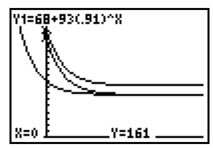
19. (a) $y = k \cdot 2^x$, where k is any arbitrary positive constant
(b) $y = 2^x + b$ where b is any arbitrary constant
(c) $y = k \cdot 2^x + b$ where k is any arbitrary positive constant and b is any arbitrary constant.

20. (a) $H(t) = 68 + 93(0.91)^t$,
$H(t + 15) = 68 + 93(0.91)^{t+15}$,
$H(t) + 15 = 68 + 93(0.91)^t + 15 = 83 + 93(0.91)^t$

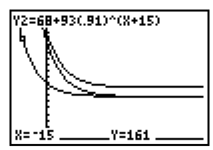
(b) See graphs below.
You might use the table feature to find appropriate values for a viewing window.
Recall from Section 4.3 that the graph of $H(t)$ is the same as the graph of $y = 93(0.91)^t$, only shifted up 68.
Since the graph of $y = 93(0.91)^t$ has a y-intercept of 93, then $H(t) = 68 + 93(0.91)^t$ has a y-intercept of 93 + 68 = 161.
Since for large values of t, the graph of $y = 93(0.91)^t$ will approach 0, then for large values of t, $H(t)$ will approach 68.
This kind of thinking helps find n appropriate viewing window. You might also try using a table feature of the calculator to get an idea of y-values.



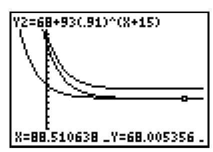
The y-intercept of $H(t)$ is 161
In other words, $H(0) = 161$.



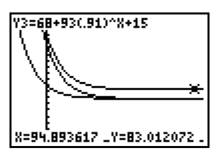
When $t = -15$, $H(t + 15)$ is the same as $H(0)$, which is 161.



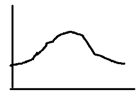
For large values of t, $H(t)$ and $H(t + 15)$ both approach 68.



For large values of t, $H(t) + 15$ approaches 83, (which is 15 more than 68).



(c) $H(t + 15)$ is the graph of $H(t)$ shifted 15 to the left. It describes the temperature of a cup of coffee that is identical to the one originally brought to class, only it was brought to class 15 minutes earlier.
$H(t) + 15$ is the graph of $H(t)$ shifted 15 degrees Fahrenheit up. It describes the temperature of a cup of coffee that was brought in at the same time as the original cup of coffee, only in a classroom that is 15 degrees warmer. (It still cools at the same rate.)
(d) As t gets very large, both $H(t)$ and $H(t + 15)$ both approach the same value, 68 degrees Fahrenheit. This is the temperature of the classroom. However $H(t) + 15$ approaches the value of 83 degrees Fahrenheit, which is 15 degrees warmer.

21. (a) A typical graph might be 

(b) The value of $T(6)$ is a temperature for a day in early January, $T(100)$ for a day in mid-April, and $T(215)$ for a day in early August. $T(371) = T(365+6)$ should be nearly the same as $T(6)$.

(c) $T(d) = T(d + 365)$ are average temperatures on days which are a year apart.

(d) $T(d + 365)$ is the average temperature on the same day of the year 1 year earlier. So the graph of $y = T(d + 365)$ should be similar to the graph of $y = T(d)$.

(e) $T(d) + 365$ is a temperature on a day that is 365 degrees hotter than the average temperature. Pretty unrealistic.

22. (a) $C(x) - 50 = 750 + 1.082x$, which means the fixed cost is \$50 cheaper.

(b) $D(x) + 250 = 1250 + 15x$, which means that the fixed cost (materials + tax) has been increased by \$250

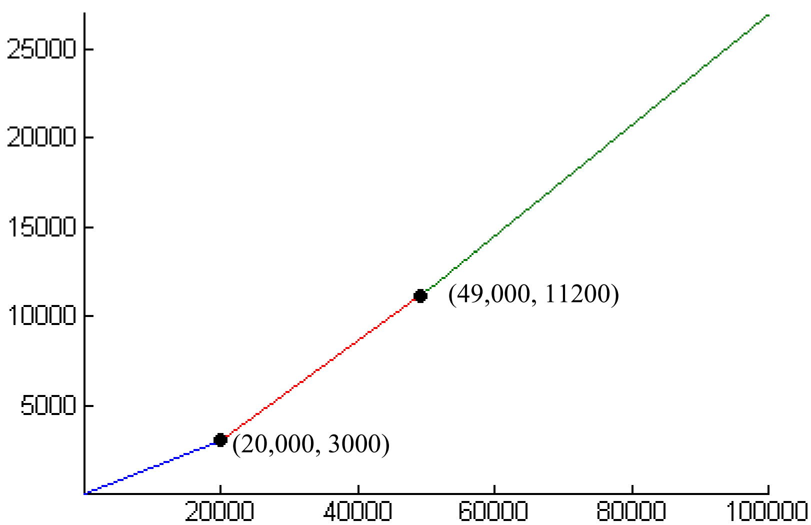
(c) $D(x - 8) = 880 + 15x$, which means it took the carpenter 8 hours less to do the job than it would normally. It could also mean that you have a coupon where the first 8 hours are at no charge. How nice!

23. (a) $t(x) = 5 + 3x$ for $x > 0$

(b) $n(x) = 1 + t(x)$ (vertical shift)

(c) $p(x) = t(x - 2) + 5$ for $x > 2$

25. (a)



(b) The graph of $I(d) + 200$ is the graph of $I(d)$ shifted up 200. You owe \$200 more in taxes than under the previous system.

(c) The graph of $I(d + 1000)$ is the graph of $I(d)$ shifted to the left 1000. Under this system, you first add \$1000 to your taxable income and then use the old system to compute your income tax. The system under $I(d + 1000)$ could be interpreted as "Exactly the same as the previous way, but eliminate \$1000 worth of deductions." Bummer.

(d) $I(d + 1000)$
Reason: We have $I(d + 1000) = \$2400$ and $I(d) + 200 = \$2450$

(e) Yes. $I(d) + 200$ since we have $I(d + 1000) = \$6080$ and $I(d) + 200 = \$6000$

(f) \$19,385