## Section Summary: 1.3

### a. Definitions

- **Transformations** of a function: suppose $c > 0$. To obtain the graph of
  - $y = f(x) + c$, shift the graph of $y = f(x)$ **up** a distance of $c$ units;
  - $y = f(x) - c$, shift the graph of $y = f(x)$ **down** a distance of $c$ units;
  - $y = f(x - c)$, shift the graph of $y = f(x)$ **right** a distance of $c$ units;
  - $y = f(x + c)$, shift the graph of $y = f(x)$ **left** a distance of $c$ units.
- Vertical and horizontal stretching, and reflection: suppose $c > 1$. To obtain the graph of
  - $y = cf(x)$, stretch the graph of $y = f(x)$ **vertically** by a factor of $c$;
  - $y = \frac{1}{c}f(x)$, shrink the graph of $y = f(x)$ **vertically** by a factor of $c$;
  - $y = f(cx)$, shrink the graph of $y = f(x)$ **horizontally** by a factor of $c$;
  - $y = f(\frac{x}{c})$, stretch the graph of $y = f(x)$ **horizontally** by a factor of $c$;
  - $y = -f(x)$, reflect the graph of $y = f(x)$ about the $x$-axis;
  - $y = f(-x)$, reflect the graph of $y = f(x)$ about the $y$-axis.
- Combinations of functions: given two functions $f$ and $g$; if both are defined for $x$, then the sum, difference, product, and quotient functions are also defined at $x$ (with one caveat):
$$(f + g)(x) = f(x) + g(x)$$
$$(f - g)(x) = f(x) - g(x)$$
$$(f * g)(x) = f(x) * g(x)$$
$$(f/g)(x) = \frac{f(x)}{g(x)} \qquad (g(x) \neq 0)$$
- **Composition** of functions: Given two functions $f$ and $g$, the **composite function** $f \circ g$ (also called the **composition** of $f$ and $g$) is defined by
$$(f \circ g)(x) = f(g(x))$$
  Notice that while $x$ must be in the domain of $g$, it is $g(x)$ which must be in the domain of $f$!
  Also notice that $f \circ g \neq g \circ f$ in general. Try a few examples, and you'll see!

### b. Summary

These transformations are really important: if you understand them, then you're way ahead. Check out how they are functioning in Figures 1 through 4, pp. 36-37.

Figures 3 and 4 are especially useful because they reinforce the sines and cosines.

I love Figure 9, p. 39 – did you know that daylight hours change like that, depending on where you live on the globe? What happens if you get above the Arctic circle?

Compositions of functions are tremendously important, and we don't spend enough time on them. When you get to the chain rule, you'll wish that you knew them well (if you don't!).