# Problem Solving # 1

**Instructions:** Working in a group of 3-4 people, explore stretches and shifts of functions. When you think your group has a clear understanding of this concept, write a paper (it should be as long as it needs to be) explaining it to someone who knows what a function is, but has not seen this concept before. Each group should submit one paper. Consider the following questions to be suggestions. If you find anything interesting outside of these suggestions, please write about it, too! Write-ups will probably include about 1-2 pages of text, and much more figures. Write-ups should include complete sentences and paragraphs, like an English paper about math (although we won't be quite as strict about grammar). Write-ups should not assume that this sheet will be accessible to the reader (in other words, they should stand alone). Any figures must be notated and referenced from the text. Figures may be hand-drawn, but text should be typed (equations may be written in by hand). Write-ups are due in class on **Friday, October 7**. If you will not be in class that day, please arrange to turn in your write-up before class (such as the day before), or send it with a friend. Note that office hours on Thursday, October 6 are cancelled. This means, if you want to talk to your instructor, do it on or before Wednesday, October 5. Good luck!

**The Problem:** Consider a function $f\colon \mathbb{R} \to \mathbb{R}$. Let $a, c$ be real numbers.

- What is the difference between the graphs of $f$ and $af$?
- What is the difference between the graphs of $f$ and $f + c$?
- Let $g(x) = x + c$. Are the functions $g \circ f$ and $f \circ g$ the same? If they are different, how are the graphs different?
- Let $h(x) = ax$. Are the functions $h \circ f$ and $f \circ h$ the same? If they are different, how are the graphs different?
- What happens if you compose all three of these functions?

You might want to start with an example function $f$ and explore what happens to it before trying to tackle the full generality of the above questions. Some good functions to try would be lines, polynomials, and trig functions. If there are interesting things that happen with specific functions, be sure to include it! Feel free to include any paths you explored that came to a dead-end.