Goals

1. To become familiar with graphing functions on the computer
2. To explore the behavior of families of functions
3. To become familiar with graphical techniques for understanding functions of two variables.

In the lab

1. You will be working groups of two or three.
2. Work through the problems and record your data/observations in a *Mathematica* notebook.

The Lab Report

The lab report should be a thoughtful, well-written, and neatly organized document that summarizes both your experience in the lab and what you learned as a result of that experience. Keep in mind what you learned about good mathematical writing in Guide to Writing Mathematics, use the checklist from that document to evaluate your first draft, and revise your draft as needed before submitting your lab report. Each group of students will hand in a single report. Your report should contain the following parts:

1. Heading. At the top, list the title of the lab and the names of the people in your group.
2. Abstract. In one paragraph, summarize the purpose of this lab. State what it was that you were asked to explore.
3. Data. Summarize the data you collect in a succinct, easy-to-grasp form, such as a table or a picture or graph with labels. I am interested in your answers, thoughts, analysis, not simply the output from the computer.
4. Conclusions. Write your conclusions in a paragraph or two. They should be inferences you draw from your data and calculations. Here is your opportunity to show that you understood the purpose of the lab, saw patterns in the data, and gained significant insights. Be as swooping in your conclusions as you dare, but back them up by explicit references to your data and calculations.

Submitting the Lab Report

1. Use the typesetting feature of *Mathematica*.
2. Save your file frequently, using the naming convention Lab2_YourName.nb
3. Use the Classes folder on the M-drive to submit your file.
4. This lab will be due on Thursday, September 22.
5. You will have two lab periods to work on it.
6. If you are working with a group of people, please only turn in one report. Make sure you put all your names on the report.

1. **Basic transformations**: We will consider the transformations of the graphs of $y = \sin x$ and $y = x^3 - x$.

   (a) Graph $y = \sin x$ for $-2\pi \leq x \leq 2\pi$. Graph the following four functions on the same domain.

   $$p(x) = \sin(2x) \quad q(x) = 2\sin x \quad r(x) = \sin x + 2 \quad s(x) = \sin(x + 2)$$

   Note the period, the amplitude, the intercepts, and other relevant details.

   (b) In each case, explain the effect the number 2 had in modifying the graph of $y = \sin x$.

   (c) Let $g(x) = x^3 - x$.. Use *Mathematica*'s `Manipulate` function to compare the graphs of $y = g(ax)$ and $y = a\,g(x)$ with the graph of $g(x)$ for a ranging from 0.5 to 5. Let f be *any* function and let a be any positive constant. Make a general statement about the relation of the graphs of $y = f(ax)$ and $y = a\,f(x)$ to the graph of $y = f(x)$.

   (d) For $g(x) = x^3 - x$ again, use the `Manipulate` function to compare the graph of $y = g(x + a)$ and $y = g(x) + a$ with the graph of $y = g(x)$ for a ranging from -3 to 3.

   (e) Let f be any function and a be any constant. How are the graphs of $y = f(x + a)$? and $y = f(x) + a$? related to the graph of $y = f(x)$?

2. **Absolute value** We will study the effect of the absolute value function on the graph of the following function:

   $$f(x) = \frac{2x}{3x + 1}$$

   (a) Graph the function f and discuss the main features of the graph, such as intercepts, the horizontal and vertical asymptotes.

   (b) Graph $y = |f(x)|$. How does the absolute value function affect the graph of f?

   (c) Graph $y = f\big(|x|\big)$ and discuss the relation of this graph to the graph of f.

3. **Slices and contours**

   (a) Consider the function $f(x, y) = e^{-(x^2+y^2)}$.

      i. Plot graphs of $y = f(x, a)$ for several fixed values of a, including some positive and some negative. You may use the `Manipulate` function to do this in one command. Can you tell what the graph of the surface $z = f(x, y)$ in 3-dimensional space will look like?

      ii. Use the `ContourPlot` command to generate a contour diagram for $f(x, y)$. Can you tell what the graph of the surface $z = f(x, y)$ in 3-dimensional space will look like?

      iii. Use the `Plot3D` command to generate a 3D graph of $z = f(x, y)$. Explain how the information from the 2D plots and the contour plot fits with 3D graph.

   (b) Consider the function $f(x, y) = x^2\, e^{-y^2}$.

      i. Plot graphs of $y = f(x, a)$ for several fixed values of a, including some positive and some negative. You may use the `Manipulate` function to do this in one command. Then plot graphs of $y = f(b, y)$ for several fixed values of b, including some positive and some negative. Can you tell what the graph of the surface $z = f(x, y)$ in 3-dimensional space will look like?

      ii. Use the `ContourPlot` command to generate a contour diagram for $f(x, y)$. Can you tell what the graph of the surface $z = f(x, y)$ in 3-dimensional space will look like?

      iii. Use the `Plot3D` command to generate a 3D graph of $z = f(x, y)$. Explain how the information from the 2D plots and the contour plot fits with 3D graph.

4. **Basic transformations** As above, consider the function $f(x,y) = x^2\, e^{-y^2}$. Use whatever graphical commands you like to explore transformations of the graph of $z = f(x,y)$. Choose at least three of the following: $x \to x + a$, $y \to y + a$, $x \to ax$, $y \to ay$, $f(x,y) + a$, $a \cdot f(x,y)$ and describe what you observe.

5. **Product functions**

   (a) Consider the function $f(x,y) = \sin x \cdot e^{-y^2}$. Can you guess what the 3D graph will look like? Use whatever graphing commands you like to determine what the graph looks like.

   (b) Given two one-variable functions f and g, can you guess what the 3D graph of the two-variable function $h(x,y) = f(x) \cdot g(y)$ will look like? Make a conjecture and support your conjecture with examples from the previous exercises.

Title of the Lab: Calculus I Lab 2 Graphing Functions
Names of People in the Group: Ralph Rally, Sid Swift, Terri Terse

Abstract

In this lab, we investigated a variety of functions and the behavior of their graphs when certain parameters were changed... blah, blah, blah....We looked at some specific functions and we generalized our observations ...

1. Basic Transformations: Exploring the effects of basic transformations on the graphs of ...

We graphed the following four sinusoidal functions:

(*diplayed formulas*)

The next figure shows them all on the same set of axes.

(*Figure here.*)

We noticed that ...

We then looked at the function ... and the graphs of ... for a variety of values of a. We noticed that ...

Thus we can conclude that, in general ...

2. Absolute value: We considered the effect of the absolute value function on the following function ...

3. Slices and contours: ...

...