Patterning Math Lab 1a

In Math Lab 1a, you will follow up and reinforce background material covered in the Week 1 Tuesday Lecture. You will explore expressions, graphs, tables; then variables and parameters in expressions; and finally evaluation and reverse evaluation of expressions. You'll use the online tool Desmos at desmos.com.

Part 1: Introduction to Desmos

1. Bring up desmos.com in a new tab on your browser.
2. On the main desmos.com page you can get the quick-start guide (a quick and handy pdf). Do this before you launch the desmos calculator. It is the third from the left at the bottom.
3. Launch Desmos and take a quick scan of the layout. Match up the parts of the screen with the quick-start guide.
4. Click on the question mark (?) in the upper right of the Desmos calculator. You can get three kinds of guides for Desmos: *Tours* (there are 4 of them that you can click on), a *Desmos User Guide* under Resources, and *Knowledge Base* under Resources. You'll use each of these later in the lab. Open up the User Guide so you have it available for the rest of the lab. It should open as a separate window or tab.
5. Now open up the Knowledge base. Search for *video tutorials* in the knowledge base. Among the videos you should see a **How To: Sliders** video tutorial and a **How to**: **Moveable Points** video tutorial. You'll use these later.
6. You can easily create a Desmos account that allows you to save work and share work. You don't need to do this, but it is available to you if later you want to save your work. To create an account, look for the create account button. As far as we have noticed, creating a Desmos account does not appear to be very intrusive.

Part 2: Expressions, Graphs, and Tables

The steps in the remaining parts of the lab are a rough guide for explorations intended to help you learn a handy mathematical tool for exploring patterns and solving problems, and help you become successful in completing the written Problem Sets and the corresponding on-line Problem Sets. Throughout this lab you are asked to *explain what happens*. This is an opportunity to practice communicating your understanding in words, either in your lab notebook, or orally to a classmate or faculty, or both. The phrase *explain what happens* means you have to be able to ***say*** *or* ***show*** meaning. It is not enough to simply think you understand; you have to actually explain. *Use your lab notebook as a record to show your understanding so you can say or show it to someone else*.

1. **Algebraic Expressions and Graphs**
   A. In Desmos, type in the expression 2*3+5 in the first item line and explain what happens. The * is a symbol that means multiplication. Notice what Desmos does to the *. What does Desmos do to expressions that are constructed entirely from numbers and mathematical operations?
   B. Now type in the expression x. What does Desmos produce? Based on your past mathematical experience, what do we call the x?
   C. Now type in the expression 2*x on the next Desmos item line. Explain what happens to the Desmos display. Explain the relationship between the Desmos display of x and the Desmos display of 2*x.
   D. Now type in the expression 2*x+3 on the next Desmos item line. Explain what happens to the Desmos display. Explain the relationship between the Desmos display of 2*x and the Desmos display of 2*x+3.

E. Change the expression 2*x+3 to the **equation** f(x) = 2*x+3. Notice that we have given the expression a name f and we have identified the variable of the expression as x. Did anything actually change in the Desmos display?
F. In the next Desmos item line type f(3). Explain what happens. Using the notation f(x) = 2*x+3 allows us to define a named f**ormula** for calculating a value. When we say f(3), we mean plug 3 into the place for the variable x and calculate the resulting value using the expression. Note that we're using the term formula to refer to an expression for calculating a value.
G. In the next Desmos item line type (3,f(3)). Explain what happens. If your answer is "nothing", then click the minus (-) on the Desmos display and zoom out. Now explain again.

Summary: At this point we hope you see the relationship between algebraic expressions in Desmos and the graphs that Desmos displays. We also hope that you see how to name and calculate the value of formulas. If you are not familiar with reading graphs and relating them to expressions, naming formulas, calculating values, or anything else so far, then be sure to ask your nearby classmates, the faculty, or the teaching assistants.

2. **Tables**.

A. Take the Tables tour (which you can find by clicking the question mark). The first entry in the first column should be 1. For the entry in the second column of the first row, type in 1. Hit enter. Now follow the instructions and enter 2 in the first column of the second row and a 4 in the second column of the first row. Again, hit enter; this time, you should see an entry automatically filled in the first column of the third row. Enter 9 in the second column of the third row. You should get a message "last trick". Ignore the "connect the dots message" and hit the escape key. Explain what you see in the Desmos display and how it relates to the table you just entered.
B. Hover over and/or click on one of the points on the graph. What happens? Click on the point again. If you haven't already, see if you can figure out how to connect the points on the graph. You'll need to click the gear in the upper right of the list and then click the circle next to the y to change the attributes of the graph. Click Done after you've made the changes. If you succeed in connecting the dots, then explain what happens if you try to click on line segment that connects the points. If you have trouble connecting the dots, then ask your neighbor or consult a teaching assistant or faculty.
C. Change one of the values in the first column to be greater than 10. Change one of the values in the second column to be greater than 6. What do you notice? Zoom in and out of the graph using the + and – buttons in the upper right corner of the graph. What does the house button do? Practice connecting the dots of the graph and disconnecting the dots of the graphs. Play with hovering over graphs of expressions and graphs of tables (with and without connected dots).
D. What is an essential difference between a table representation of a function and a formula representation of a function? Your answer will depend on your understanding of what happens when you hover over graphs of expressions and graphs of tables.

Summary: At this second checkpoint we hope you see the connection between tables in Desmos and the graphs that Desmos displays. We also hope you realize the significant difference between the graphs of tables and the graphs of expressions. If you do not realize the important distinction, then this is an extremely important question for you to pursue with your classmates, teaching assistants, or faculty.

Part 3: Variables and Parameters

1. **Sliders**

A. Find and watch the How to: Sliders video tutorial. (Remember, go to the knowledge base and search for "how to sliders".)

B. Take the Sliders interactive tour.
C. Type in the following expression slowly, watching what happens as you type in each symbol: $y = mx + b$. When do you see the error notifications? What does Desmos want you to do? Turn on all the sliders.
D. What is the difference between a variable and a parameter? How do you know what is a variable and what is a parameter? How does Desmos know? Do the sliders work with variables or parameters?
E. Play with the sliders for each of the m and b parameters until you can articulate exactly what each parameter does to the graph.

2. **Slope and intercept**. Watch the Sliders video tutorial again (well, you know, it's fun and easy). This time focus on the meaning of the specific parameters m and b.

A. Play with the m and b sliders to make sure you understand what role they play in the graphical display of the function.
B. How can you calculate the value on the slider for the parameter m using the graph?
C. How can you determine the value for the parameter b by just looking at the graph?

Part 4: Evaluation and Reverse Evaluation

1. **Function evaluation**. Functions can be thought of as input-output machines that produce specific answers when given specific inputs. The simplest specifications of functions are formulas that allow you to plug in an input variable, do some arithmetic calculations, and get an output answer. Read this web site about evaluating functions: http://www.freemathhelp.com/functions.html. Recall, you evaluated one of your functions above (f(x) = 2x+3) with the x input = 3. The result was a point (x,y) = (3,(f(3)) that Desmos plotted for you.

2. **Reverse function evaluation**. You may encounter this concept as *solving functions*. The essential idea is that some functions work in both directions - the output is a function of the input and, in addition, the input is also a function of the output. This can be very handy. Consider, for example, our function f(x) = 2x-3. We can ask the reverse calculation question: for what value of x does f(x) = 1? We establish the equation f(x) = 1 = 2x-3 and then *solve* for the appropriate value of x. Specifically, what is the value of x that is the solution of the equation 1 = 2x -3? Will solving a function always give a single value?