AFM Group Activity
Stacking Cup Group Project

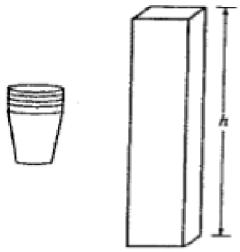
Your Name:_____
Date Given: _____ Block:_____
Group Members: _____, _____

Disclaimer: Groups are created to collect data together and may ask each other for help. Please note that all student work and words should be individual. Please follow PFHS honor code guidelines. Please show ALL work to receive credit!

Problem:

You are the package design director for a paper products company that has decided to introduce different sized paper cups in the general shape shown below as a new product line. Your design team has been given the assignment of designing a cardboard carton that could be used to package the cups for sale. Your supervisor has given you the following requirements:

1. All faces of the carton are to be rectangular.
2. The square base should be just large enough to accommodate a single stack of cups.
3. The height of your carton should be given as a function of the maximum number of cups it will hold, since the marketing director has not yet determined the number of cups that would be best to include for optimum sales.
4. All measurements should be given in ***metric units, preferably centimeters***, since the company is an international one.
5. The expense of constructing the container should not be a factor in your proposal.



Since this is a new product for the team, you decide to study actual stacks of cups to help you discover which features of the cup affect the height of a stack of cups. To do this, the team uses two types of plastic cups that were found around your office. Complete your study, then ***summarize your findings in a report*** that you will submit to your supervisor.

Part I: Initial Exploration

1. Using the sample cups you found around the office, complete the following charts with appropriate measurements (cm). **Measure carefully**! Use the data you collect to look for a pattern that might help you determine the relationship between the height of the stack and the number of cups in that stack.

CUP #1	
# of Cups	Height of Stack

CUP #2	
# of Cups	Height of Stack

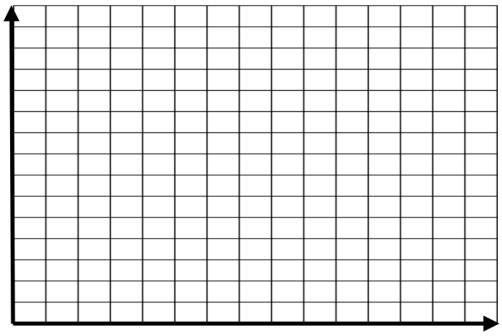
PART II: Developing the Model

Throughout this part, your team should restrict its attention to only one of the two styles of cups you found. Which cup number are you using?_____ Return the other set of cups.

2. Making use of the data that you collected above, graph the data below:

Make sure to label the axes correctly!

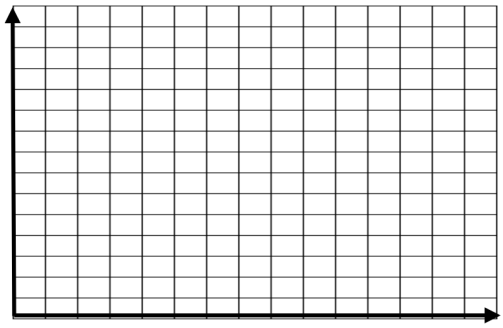
(Name each axis and provide scale)



3. Predict, ***without measuring***, the height of a stack of: 16 cups: _____ 100 cups: _____

4. Define a function, *f*, such that *f(n)* gives the height of a stack, *h*, in terms of the number of cups in that stack, *n*. When your team has this result, call your teacher (who is working part-time as a quality control inspector) over to verify your results.

5. Sketch the graph of *f* on the axes below. Be sure that your team chooses an appropriate domain for this situation. Label your axes!



6. As you are planning your report for your supervisor, your team realizes that it has not dealt with the dimensions of the <u>*square*</u> base of the carton. What would be the dimensions of the base of the carton if your company were to use the cup style you used to create function *f*?_____

Suppose your boss has not given you the dimensions of the cup. If the cup selected has the largest base of a circle of radius, R, what would be the general dimensions of the base of the carton?_____

7. SUMMARIZE your findings below: (report to your supervisor with your measurements and functions)

Part III: Analyzing the Model

Several days after submitting your report to your supervisor, she sends word back that it proved to be extremely helpful. She also reports that the style and size of cup have been decided. The cup will be of the same basic style as the cups you described in your report, but the lower base will be a circle of diameter 7 cm, the upper base will be a circle of diameter 10 cm, and the height of the cup will be 13 cm. Because you wrote such a clear report, she has been able to determine that the height function for the new cups should be $\boldsymbol{S(n) = 0.5n + 12.5}$

Your team should **use this relationship**, in which *S(n)* represents the height of a stack of n cups, to explore linear functions in more depth in the sections that remain. (You are NOT using your equation f(n) found from your data).

8. If you decide to increase an existing stack by 2 cups, the height of the stack increases by a constant. What is the constant for 2 additional cups?_____ If you were to increase an existing stack by 20 cups, by what amount would the height of the stack increase; i.e., what is the constant for 20 additional cups?_____

Suppose the number of cups you add is **unknown**. In general, if the number of cups you add to an existing stack is *k*, then the increase in the height of the stack is:_____

9. Suppose that another student said, "If you double the number of cups in the stack, then you also double the height of the stack." Clearly explain why this statement is incorrect. Be sure to include a numeric example or two (numeric).

10. If, at some future time, your marketing director decides to increase the height of the cartons by 5 cm, what will be the increase in the maximum number of cups that can be packaged in one box?_____ If the height of the cartons is increased by 6.4 cm, what will be the increase in the maximum number of cups that can be packaged in one box?_____

Suppose the increase in height is **unknown**. In general, if the marketing director decided to increase the height of the cartons by *d* cm, how many additional cups could each new box hold?:_____

11. Suppose that the heights of 2 different cartons are 36 cm, and 50 cm, respectively. How many cups will each of these cartons hold? 36 cm:_____ 50 cm:_____

12. The function *S(n)* from above expresses the height of a stack of cups in terms of the number of cups, *n*, in the stack. Now, write a function *g(h)* that expresses the number of cups in a stack in terms of the height, *h*, of the stack. (you are using the *S(n)* equation from above and solving for *n*). Don't forget to call this new function *g(h)*.

_____

Note: Slope can be interpreted as a rate of change. Rates should be familiar to you from expressions such as "20 miles per gallon," "$15 per 1GB", or "10 cents per call." Rates can also be written in ratio form. For example, 20 miles per gallon is equivalent to $\frac{20\ miles}{1\ gallon}$. Notice that rates of change are ratios of the change that has occurred in two variables that are somehow related. That is, to say that a car gets 20 miles per gallon is another way of saying that for every additional gallon of fuel, the car will go an additional 20 miles.

13. Using the *S(n)* from, what number represents the slope of your function *S*?_____

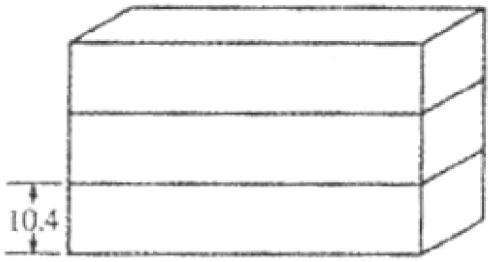
What rate of change does this slope represent (*remember this is written as "miles **per** gallon"*)? _____

What number represents the slope of your *g(h)* function from above?_____

What rate of change does this slope represent? (*remember this is written as "miles **per** gallon"*)? _____

14. Suppose that you are stacking the cartons of cups for packing and that the cartons are 10.4 cm high. Define a function *c* such that *c(n)* gives the height of a stack of *n* such cartons.

function:_____



15. Graph the function *c(n)*. Be sure that your team chooses an appropriate domain for this situation. Label your axes!