Presented by

Shelton Ford, Shari Brockington, Tonja McGill, Trabille Cobb, and Gabrielle Alexander-Lee (2013, April). ***Let's Go Bungee Jumping.*** **Presented at the Annual Meeting of the NCTM, Denver, CO.**

Contact Information:

Shelton Ford
Fayetteville State University
Sford2@uncfsu.edu

<u>Outline for a Project Write-up</u>

There are 3 projects due in this course. Below is the basic outline that should be followed when writing a project.

I) Typed report with a cover page.
   1) Paragraph style using complete sentences as if you were turning in an English paper.
   2) Grammar, punctuation, spelling, organization, analysis, and adequate detail will be evaluated as well as the mathematics involved.
   3) Excel tables, graphs, and calculations should be incorporated into the paper not attached to the end.

II) First paragraph of the paper is the introduction.
   1) Group Projects – List who was in the group, describe the experiment, how your data was collected, and the tools used. Give as much detail as needed to describe your project for those who do not know what you were doing.
   2) Individual Projects – Include why you chose your topic, how your data was collected, and references.

III) The body of the paper is the analysis portion.
   1) It should be <u>**at least**</u> two paragraphs long.
   2) It should include an Excel generated list of your data, a description of the independent and dependent variables, a description of a reasonable domain and range, a discussion of the model you found including the correlation coefficient, a graph of the data created in Excel, a description of the concavity, and any other function related topics that are in the project description.
   3) It should include answers to any questions asked in the project description.
   4) All projects require you to make predictions based on your model. Show the calculations used to arrive at your predictions and discuss whether or not they are realistic. Be sure to discuss anything that may have affected your experiment or data collection.

IV) The last paragraph is the conclusion.
   1) It should summarize your project.
   2) Include any discoveries and comparisons requested in the project description.

PROJECT 1: Bungee Jumping

Introduction

In industrial, engineering, and business applications it is sometimes necessary to develop a mathematical model to predict how a system, economy, or invention will perform. The mathematical model is based on a set of sample data and the model that is developed is then used to predict behavior in new situations. In this activity we will need to develop a mathematical model (an equation) to describe the amount of stretch there is in a bungee cord of varying length. You will be provided with a participant (an egg) and harness, bungee cord (several rubber bands), and a meter stick. Your goal is to develop an equation that can be used to predict the number of rubber bands needed to provide an exciting and safe jump from a height to be determined later in the class. Of course part of the thrill of bungee jumping is to see how close the participant can come to the ground without actually contacting the ground.

Developing Your Model

Your group will need to make several jumps varying the number of rubber bands and measuring the total elongation of the cord for each jump. Be sure to record the number of rubber bands involved and the maximum length of the unit for each jump. After you have done several jumps enter your data into your calculator and plot the data. Use the calculator to find the equation that will best fit your data.

Exploring Your Model

Now that you have an equation, what does the slope of the line represent with regard to the bungee-jumping problem? Measure the length of the egg and the netting. Does this measurement seem to correspond to any part of the model you have? With what part of the model would you expect it to correspond? Why?

Testing Your Model

Toward the end of class we will put your model to the test. You will be given a height from which your jumper is to make the leap. Your group will need to decide how many rubber bands are required for a safe jump. Points will be awarded for a safe jump. Additional points will be awarded for the group that has a safe jump as well as the minimum ground clearance. Scoring will be as follows:

POINTS	SUCCESSFUL JUMPS
10	The jump is within 1 inch of the ground.
9	The jump is 1 to 3 inches from the ground.
8	The jump is 3 to 7 inches from the ground
7	The jump is 7 to 10 inches from the ground.
6	The jump is 10 to 13 inches from the ground.
5	The jump is more than 13 inches from the ground.
2 Bonus Points	The jump that is closest to the ground with out touching the ground.
7	A minor impact with the ground. Small crack or can hear it touch.
6	Impact with the ground that results in a fairly large crack, but the egg is

	still pretty much intact.
5	The impact results in the egg shattering.

Report

A group report is expected that follows the outline and includes the data used to obtain the model, the calculations used to determine the number of rubber bands required for the contest jump, the results of your jump, and the answers to the questions in the Exploring Your Model section above.

Project 1   Grading Rubric

	Percent of Grade	Points Earned
Cover Page		
Title, Name, Class, Date		
Subtotal	**5%**	
Introduction		
Group members		
How data collected		
Tools used		
Description of project		
Subtotal	**10%**	
Body		
List of data		
Description of dep. & indep. variables		
Linear Regression Model		
Correlation Coefficient		
Excel Scatter Plot Graph		
Reasonable Domain and Range		
Describe y-intercept		
y-intercept meaning		
Describe slope		
Slope meaning		
Prediction from model (test jump)		
Calculations to get prediction		
Realistic prediction? (Did your egg break?)		
Reasons for error		
Subtotal	**55%**	
Conclusion		
Summarize the report		
State discoveries made		
Conclusions		
Subtotal	**10%**	
Presentation		
Grammar/Spelling		
Organization		
Neatness and clarity		
Graphs and data tables incorporated in the document.		
Subtotal	**10%**	

Contest points	**10%**	
Grand Total	**100%**	

Bungee Jump Data

Group Members:

Number of Rubber Bands	**Distance in inches**

Height from which your jumper is to make the leap:

5 feet6 inches
6 feet2 inches
4 feet1 inches
5 feet10 inches
6 feet4 inches
4 feet5 inches
3 feet1 inches
3 feet6 inches

PROJECT 2: The First Taste of Exponentials*

This Project involves collecting, organizing and describing exponential data. Each pair of students will turn in a computer generated detailed report that incorporates Excel generated lists, graphs, and equations into a word document. Grammar, punctuation, spelling, organization, analysis, and adequate detail will be evaluated as well as the mathematics involved in the descriptions contained in the graphs and verbal communication.

You and your partner will be collecting data using M&M candies. Begin by collecting the data for parts A and B of the lab. Then go back and answer the questions.

Part A: Exponential Growth

1. Begin with four M&M candies in your shaking cup; put the number 4 in the first output box. Each roll consists of the following actions:

   Shake up the candies in your cup and turn them out onto the plate. For each candy that is showing an M, add a candy to the plate from your supply cup. In the table below, record the total number of candies (old and new) on the plate. Put all of the candies on the plate into your shaking cup.

   Example: Put the number 4 in the first box. Shake out 4 M&Ms. If 2 Ms are showing, then write the number 6 in the second box and put 6 M&Ms in your shaker cup to begin the second roll. Continue the rolls until you have done 10 rolls, or you have a total of 50 candies recorded, which ever comes first.

Roll	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total Number of Candies											
Ratio of number of candies (y_2/y_1)											

2. a. Enter the data (Roll and Total Number of Candies) into your calculator and make a scatter plot.

   b. Use regression on your calculator to find an **exponential equation** (rounded to 4 decimal places) to model your data.

3. a. Using your exponential model, how many candies would you have at the end of 25 rolls?

   b. How many rolls would your model require to accumulate 1,000,000 candies?

4. a. Looking at your model, what is the practical meaning of a?

b. Find the average for your ratio of number of candies. To which part of the model does this compare?

Part B: Exponential Decay

1. This time, start with 50 candies in your cup. Put 50 in the first output box. Each roll consists of the following actions:

   Shake up the candies in your cup and turn them out onto the plate. Remove each candy that shows an M. Count the remaining candies on your plate, and record that number in the table below. Put the candies on the plate into your shaking cup.

   Continue the rolls until there is **one** candy left. Or you reach 10 rolls, whichever comes first.

Roll	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Total Number of Candies										
Ratio of number of candies										

2. a. Enter the data into your calculator and make a scatter plot.

   b. Use regression on your calculator to find an **exponential equation** (rounded to 4 decimal places) to model your data.

3. a. Using your exponential model, how many candies should you have at the end of 4 rolls?

   b. How many rolls would your model require to have 20 candies?

4. a. Looking at your model, what is the practical meaning of a?

b. Find the average for your ratio of number of candies. To which part of the model does this compare?

* This activity modified from original version generated by Kathy Ivey, Western Carolina University.

Project Analysis – In addition to the required elements of a project write-up, this Project 2 requires the following elements:

- The exponential growth and decay regressions from the calculator and Excel. Include a discussion comparing both forms ($y = a * b^x$ and $y = a * e^{kx}$) of the exponential regressions.
- Detailed answers to **<u>ALL</u>** the questions asked in the growth and decay data sections. In particular provide evidence that you found the answers to question 3 on the calculator **<u>AND</u>** in Excel and compare. (Hint: In Excel you will need to use Goal Seek for 3.b.)
- The conclusion should include an analysis about how exponential growth compares to exponential decay. Include how exponential growth and decay are different and how they are the same. Be specific about how well your data fit an exponential equation and

the reasons why or why not the data fit the models.

PROJECT 2 Grading Rubric		
	Value	**Grade**
Cover Page	**3**	
Introductory Paragraph	**5**	
Body		
Excel generated table and graph of exponential growth and decay data, including exponential regressions and R^2 values.		
The exponential growth and decay regressions from the calculator.		
Discussion comparing both forms of the exponential regression.		
Answers to question 3 from the calculator AND from Excel.		
Practical meaning of “a” in growth model.		
Average for ratios. Which part of growth model?		
Practical meaning of “a” in decay model.		
Average for ratios. Which part of decay model?		
Description of the domain and range of growth model.		
Description of the domain and range of decay model.		
Description of the concavity of the exponential growth and decay data.		
Subtotal	**62**	
Conclusion		
How exponential growth and decay are different.		
How exponential growth and decay are the same.		
Be specific about how well your data fit an exponential equation and the reasons why or why not the data fit the models.		
Subtotal	**20**	
Presentation	**10**	
Total	**100**	

PROJECT 3 Data Collection

Project 3 involves collecting, organizing and describing data. Each student will turn in a computer generated detailed report that incorporates Excel generated lists and graphs into a word document. Grammar, spelling, organization, analysis and adequate detail will be evaluated as well as the mathematics involved in the descriptions contained in the graphs and verbal communication.

1. Choose a topic on which to collect data. You may use the Internet, data from work, or data from the newspaper.

2. Collect at least 10 data points that exhibit a trend. However, the more data collected the better.

3. After one week you must have your project and data approved by your instructor.

4. **Project 3 Analysis** – In addition to the required elements of a project write-up, Project 3 requires the following elements:

    - Complete analysis that explains why you chose your model. This could include computing rates of change, ratios of outputs, limiting values, residuals, or other techniques you have learned in this course. It **must** include a column calculating the predicted values for your data. Be thorough in analyzing the data and choosing a model.
    - Judge the accuracy of your model by comparing the predictions of your model with actual data.
        - An example of predicting output for an input (this would be an input NOT in your set of data). Use Excel to calculate this and include it in the table of data.
        - An example of predicting input for an output (this would be an output NOT in your set of data). Use Excel to calculate this and include it in the table of data.
    - Summarize why your model applies to your topic and identify any outliers (data points that are outside the general trend). Explain the reason for these in detail.
    - Hypothesize whether your model is appropriate beyond your current domain. That is, give a complete discussion of what your model predicts for the future and if it is realistic.

PROJECT 3 Grading Rubric		
	Points	**Points Earned**
Cover Page	**2**	
Introductory Paragraph	**8**	
Body	**60**	
Conclusion	**20**	
Presentation	**10**	
Grand Total	**100**	

Project 4: Path of a Space Shuttle Activity

Names of Group Members ____

____

____

____

You are in charge of planning the first orbit for the space shuttle. The shuttle is to be launched from the Kennedy Space Center in Florida. Your route may not cross over land immediately after launch.

Tools

Materials needed: globe, large rubber band, data collection sheet, world map.

Task

A. Working in groups of 3 to 4, use the rubber band to plan your orbit on the globe. The path should form a great circle around the globe. Send the shuttle off in a northeast or southeast direction.
B. Using the attached data collection sheet, record the data points that describe your shuttle's path.
C. From your data, determine the parameters needed to write the equation that models the path of the space shuttle, $f(t) = \text{A}\sin(\text{B}(t - \text{C})) + \text{D}$.

Questions to Answer

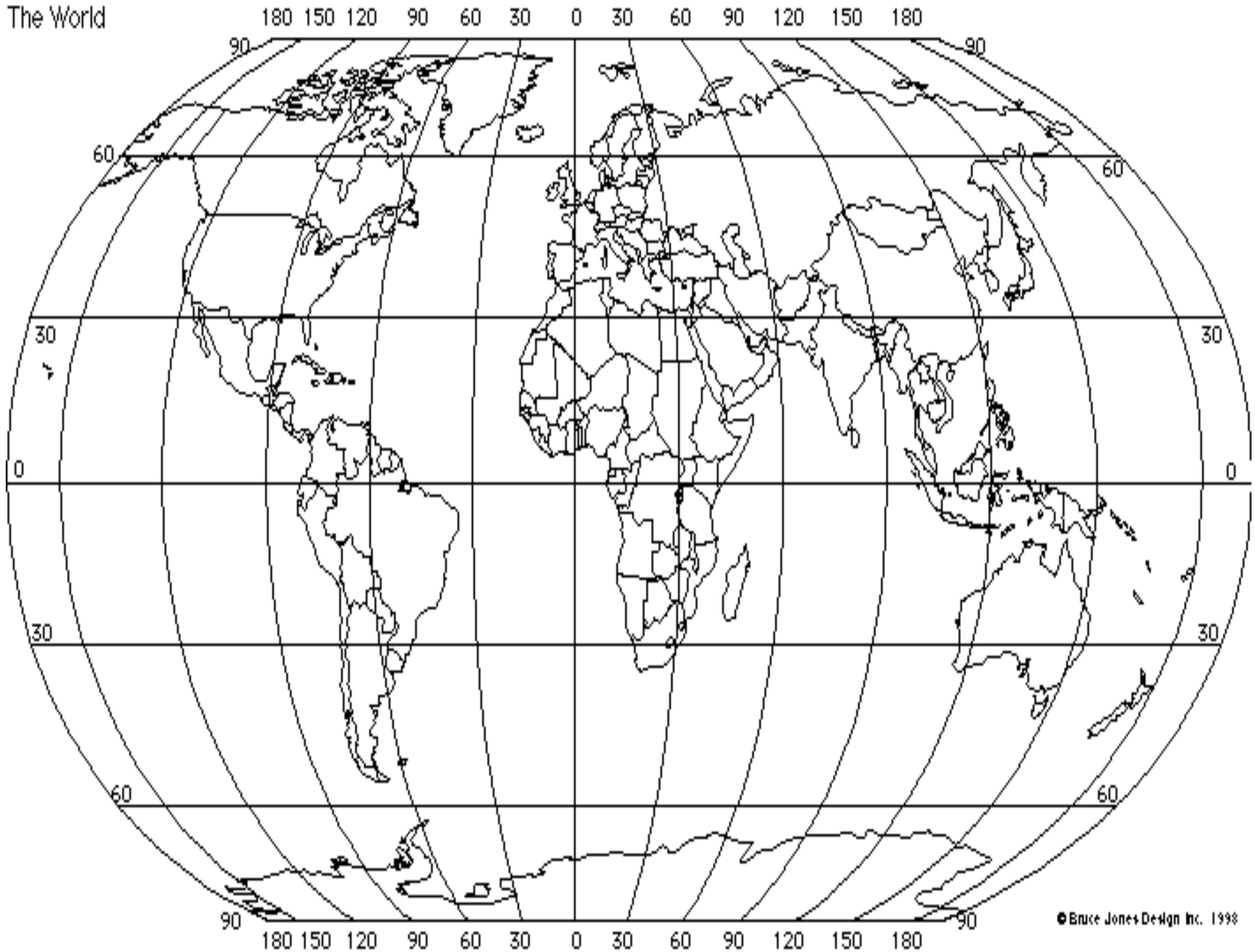
1. Submit a table of Longitude and Latitude measurements. (The table is on the next page.)
2. Provide a graph Latitude vs. Longitude on the world map. (The world map is provided on the page after the table.)
3. Determine the values of A, B, C, and D from your data and write the model for the path of the space shuttle, $f(t) = \text{A}\sin(\text{B}(t - \text{C})) + \text{D}$.

4. Predict the Latitude reading for a Longitude reading of 128°.

Table of Data

Longitude	Latitude

The World



COPY OF A PAPER PRESENTED BY A STUDENT GROUP
USE THIS TO GRADE/COMPARE AGAINST THE RUBRIC FOR THIS PROJECT.

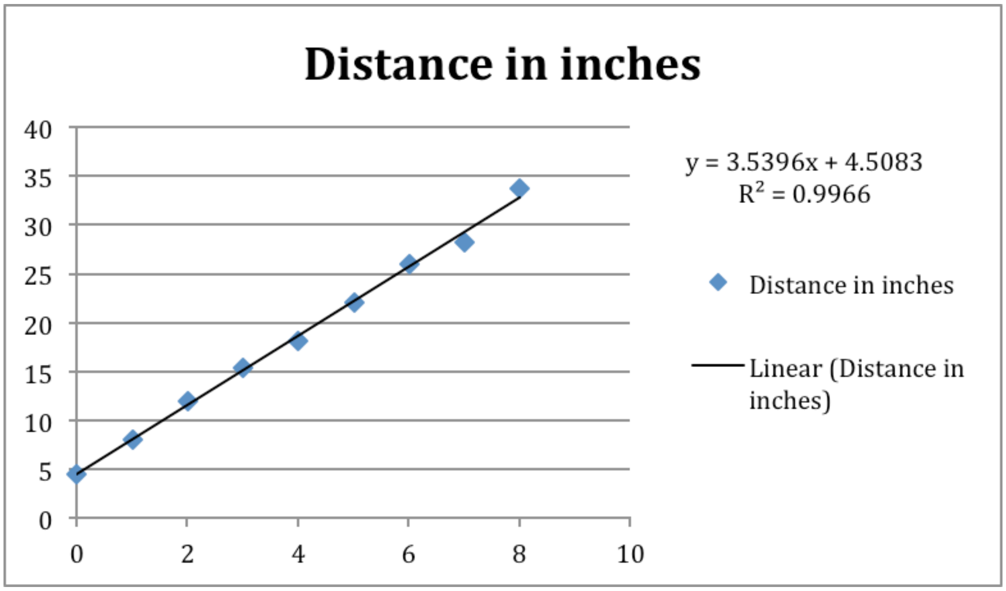
Bungee Jump

STUDENT NAMES
DATE
TEACHER

For the bungee jump project, the people in our group were STUDENT NAMES. The goal of the project was to develop an equation that could be used to predict the number of rubber bands needed to provide a safe "jump" from a height that was determined by selecting a height from an envelope. Another part of the project was to see how close the participant could get to the ground without actually contacting the ground. The tools used in the project were the bungee cord (rubber bands), a participant (an egg) with a harness, a metric ruler with paper clips to attach the participant to, and a meter stick to measure the height of the participant drop. For collecting the data we had to use the tools provided and explained previously. We set up a meter stick vertically against the wall and found our selected height (4 feet, 5 inches [53 inches]). STUDENT A held the metric ruler horizontally from the meter stick. STUDENT B attached rubber bands for each jump of the participant and pushed the participant off the ruler. Every time the participant was pushed off the ruler, a rubber band would be added to see how close the participant could get to the ground. STUDENT C accurately observed the distance the participant reached with the number of rubber bands used. We recorded the number of rubber bands used and the distance in inches for each rubber band.

The Excel generated list of the data, Excel scatter plot graph, and the linear regression model are attached below. The independent variable is the x-axis which is the number of rubber bands we used. The dependent variable is the y-axis which is the distance in inches that was used to measure the distance of the participant jump. The correlation coefficient is 0.9966. The domain of the data is 0, 1, 2, 3, 4, 5, 6, 7, and 8. The range of the data is 4.5, 8, 12, 15 3/8, 18 1/8, 22, 26, 28 2/8, and 33 6/8. The domain and range are reasonable because there are no negative numbers. Also, as the domain increases the range increases at an appropriate rate – meaning that the range does not have any dramatic increases. The y-intercept is 4.5. When there are no rubber bands the egg hangs are 4.5 inches. On the graph the y-intercept is when the y variable(s) intersect the x-axis at zero. The slope is the incline of the line on a graph at any point. The slope in the data is 3.5396 inches.

Number of rubber bands	0	1	2	3	4	5	6	7	8
Distance in inches	4.5	8	12	15 3/8	18 1/8	22	26	28 1/4	33 3/4



Based on looking at the graph's line and the meter stick, our group predicted we would need three or four extra rubber bands added onto the eight rubber bands we had already. Our group also did a test run on the egg drop and realized that we needed more rubber bands. To get the calculations for the prediction, we needed to put the data on an Excel spread sheet and create a graph. After the graph was created, we inserted a trend line and predicted that we would need four rubber bands for the egg to reach as close to the ground as possible. Our first prediction was that we would need three rubber bands – this, however, was short a rubber band. We ended up using four rubber bands. The second prediction – to add another rubber band – was the realistic prediction. Our egg did not break but because the drop was close to the wall, the egg did crack.

The purpose of the project is to develop an equation that could be used to predict the number of rubber bands needed to provide an exciting and safe jump from a height that was predetermined. A discovery we made was that the egg length is similar to the length of one rubber band. This can help us to use fewer rubber bands, but still be able to allow the egg to get close to the ground without touching it.