Bungee Barbie

Subject Area(s): Engineering design, science, mathematics, art, English/language arts, social studies, technology

Grade Level: 6

Activity Dependency:

Students should be able to use a yardstick to make measurements, record data in a table, plot points in a coordinate plane, identify y-intercept, compute slope, generate a linear function rule, use a function rule to find an input value given an output value (students will receive some assistance with the last four ideas during the lesson)

Time Required: 45 minutes to 1 hour

Group Size: 2-3

Expendable Cost per Group: US$0

Summary: Students use rubber bands, a meter stick and a Barbie to take data and then design the cord for a bungee jump ride. Students construct and test their design.

Keywords: Measurement, slope, design, linear function, data interpretation, Bungee Barbie, South America, economics, writing

Educational Standards

Engineering Connection Standard

EG 6-8 D 5 Design and conduct an experiment to gather data required for an engineering design

Clarifying Objective: EG 6-8 D 5.1 Interpret collected data

Common Core Math Standards

6.EE Apply and extend previous understandings of arithmetic to algebraic expressions.

Clarifying Objectives: 6.EE 2a Write expressions that record operations with numbers and with letters standing for numbers. *For example, express the calculation "Subtract y from 5" as 5 – y.*

6.EE 2c Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving wholenumber exponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations). *For example, use the formulas V = s3 and A = 6 s2 to find the volume and surface area of a cube with sides of length s = 1/2.*

6.EE 6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

6.EE 9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation d = 65t to represent the relationship between distance and time.*

Common Core ELA Standards

W.6.1 Write arguments to support claims with clear reasons and relevant evidence.

W.6.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

W.6.6 Use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of three pages in a single sitting.

SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

SL.6.5 Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.

WHST.6.1 Write arguments focused on *discipline-specific* *content*.

North Carolina Essential Standards for Arts Education

6.CX.2 Understand the interdisciplinary connections and life applications of the visual arts.

> **Clarifying Objectives: 6.CX.2.1** Exemplify how skills and concepts developed in art are part of, and can be applied to, daily life.
>
> **6.CX.2.4** Understand the role of art in creating digital images, technological products, and design.

North Carolina Essential Standards for Science

6.P.3 Understand characteristics of energy transfer and interactions of matter and energy.

> **Clarifying Objective: 6.P.3.3** Explain the suitability of materials for use in technological design based on a response to heat (to include conduction, expansion, and contraction) and electrical energy (conductors and insulators).

North Carolina Essential Standards for Social Studies

6.E.1 Understand how the physical environment and human interaction affected the economic activities of various civilizations, societies and regions.
Clarifying Objective: 6.E.1.2 Explain how quality of life is impacted by economic choices of civilizations, societies and regions.

ITEEA Educational Standard(s)

STL 3 Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Clarifying Objective: STL 3.F Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.

STL 8 Students will develop an understanding of design

Clarifying Objectives: STL 8 E Design is a creative planning process that leads to useful products and systems.

STL 8 F There is no perfect design.

STL 8 G Requirements for a design are made up of criteria and constraints.

STL 10 Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Clarifying Objective: STL 10 H Some technological problems are best solved through experimentation.

Materials List

Each group needs:

- 1 meter stick or yard stick,
- about 30 rubber bands that are about the same size,
- 1 Barbie doll,
- 1 pencil,
- 1 ruler,
- 1 piece of graph paper,
- copies of the handouts

Introduction / Motivation

You have been hired by the tourist association of Antigua to design a bungee jump venture that is thrilling but safe for installation in the rainforest of the island of Antigua as a part of a group challenge course. *You might ask students if they have ever heard of a bungee jump (or if they have ever done it) and what it involves. Also locate Antigua on the map.* A link to such a challenge course can be found at: http://www.antiguarainforest.com/.

What decisions do we need to make about the bungee jump to make sure it is both thrilling and safe? (E. g., weight of the jumper, height of the jumper, distance from the platform to the ground, material for the bungee cord, length of the cord, etc).

Rather than use a real person in our experiments, we will do our testing using Barbie. We will assume that the material that is used for the cord is similar to a rubber band. The challenge is to see who can determine the best length for the cord (i.e., the ideal number of rubber bands) so that when Barbie is dropped from the top of the stairwell (or other high place), "The Big Jump," she comes close to the floor without hitting it. The team that comes closest will win the contract to design all of the ventures for the Tourist Association of Antigua. Before we send Barbie on the Big Jump, it might be a good idea to collect some data when Barbie takes shorter jumps. We can use that data to determine how many rubber bands we should use for the Big Jump.

Procedure

With the Students

1. Ask students to brainstorm a procedure for taking measurements in their group. Lead a group discussion of possible ideas and come to consensus on a single

procedure that everyone in the class will use OR choose to let each group use their own procedure. It does not matter which procedure you use if students stay consistent in their group, but if you want to compare data across groups, there should be a single procedure. Have each student record the procedure to be used in their STEM notebook.

2. Have groups implement the agreed on procedure.

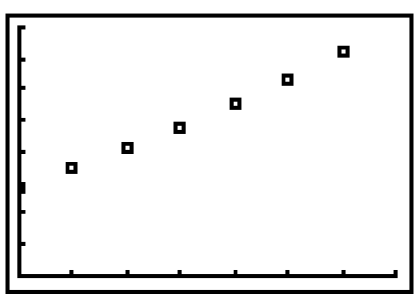
Possible roles for students:
One student can read the directions
One student can hold the meter stick
One student can drop Barbie
One student can measure the distance Barbie falls using the meter stick
One student can record the results
Two people from each group can pick up and return materials

3. Students might predict that distance Barbie falls will increase as the number of rubber bands used increases. They might also predict that she will bounce more as the number of rubber bands increases.

4. Students may need assistance in measuring the distance Barbie falls. Be sure they are recording the distance using centimeters. Data will vary. Sample data is shown below.

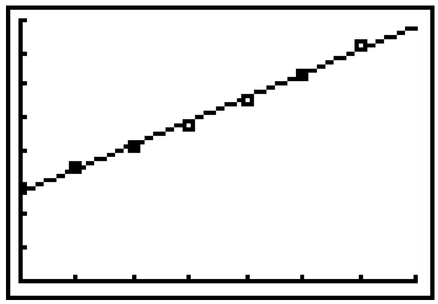
Number of rubber bands	Number of **centimeters** Barbie falls
0	28
1	35
2	41
3	48
4	56
5	63
6	72

5. Have students graph their group's data on the graph paper provided. Graphs will vary. Students may not be sure whether to assign the number of rubber bands to the x or y axis. You may wish to discuss the difference between independent and dependent variables. A sample (unlabeled) graph is below.



6. Have students draw in a line of best fit using the ruler provided. The line of best fit should be one that best models the data. This line may not pass through the data

points. Example is shown below. (Methods for finding the line of best (least squares) can be discussed depending on the level of student. A useful website for exploring the least squares method can be found at http://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=144)



7. Students should be able to read the y-intercept off of the graph. Ask the students to hypothesis about what physical quantity the y-intercept represents. When they suggest an answer, have them prove it. I. e., since the y-intercept represents Barbie's height, they can measure the height to see if it agrees with the quantity read off of their graph. The y-intercept for the line of best fit may be different from the y-intercept found in the table of values. Discuss why these may be different. In the example above, the y-intercept was 27.5.

8. Have students use two points from the line to compute the slope using the slope formula

m= (y2-y1)/(x2-x1). In the example the slope is 7.25. Ask students to hypothesize about what physical quantity is represented by the slope. (This number tells us how many centimeters Barbie falls for each rubber band that is contained in the cord.)

9. Have students write an equation that will tell them how many rubber bands to use for a particular fall distance. Equations will vary. Students may find slope-intercept form, y = mx+b, to be easiest to generate. In the example the equation is y = 7.25x+27.5.

10. Tell students the distance from the platform to the floor for The Big Drop. Given this information they should use their equation to solve for x. Have them create a chain of the proper number of rubber bands and fix it to Barbie. Ask them if they considered putting extra rubber bands for a safety factor. Discuss engineering safety factors if time allows.

11. Each team should have one member drop Barbie and the other members can observe to see how close Barbie comes to the floor. It might be best to have one Barbie drop at a time. If the competition is serious, a judge can measure how close she comes to the floor.

Discussion. Students can share the equations that they generated from their data. Why do we think the equations are different? The teacher should ask students why they think some of the Barbies came closer to the floor than others. When they solved the equation what did the answer represent (this tells you how many rubber bands were needed to hit the floor)? Which factors may influence the calculation (the stretchiness and length of each rubber band – the equation assumes all rubber bands are exactly the same; the temperature in the room versus outside—stretchiness is heat dependent)? Discuss other issues related to the predictions students made. If time allows, let students try again to see if they can create a better jump for Barbie for The Big Drop.

Extension/Summary. Discuss how the y-intercept was determined and what it represents. Discuss why the y-intercept for the line of best fit may have been different then the y-intercept in the table of values. Discuss why, in terms of the situation, the graph was linear. Discuss the different slope values students generated. Have them explain what the slope represents in terms of the situation. Explain how the line of best fit was determined and how this is just a best estimate. If time allows, use a graphing calculator to show how it can be used to create the line of best fit. Discuss the least squares method for finding the line of best fit, if appropriate.

If desired, conduct the activity with heat as a variable. Because the rubber bands are made from rubber, the amount that they stretch will be dependent on their temperature. Different groups could use rubber bands that have been chilled or heated (mildly) and compare their results.

As a next step, have each group produce a drawing of how their bungee jump would be integrated into a challenge course or zip line tour at the Rainforest Canopy Tour of Antigua (http://www.antiguanice.com/v2/client.php?id=570). They should use web resources, including the official web site given above, to see what the existing course might look like, and draw representations of how their design will fit in.

Have each group present their findings, their equation and the results of their experiments (using available technology to create a presentation, if time permits) and their sketches and drawings. Ask them to discuss whether their prediction was accurate and suggest reasons why it may not have been as they expected.

Safety Issues

Ensure that students are not in danger of falling over the balcony from which Barbie is dropped. Ensure that students do not stand below in a position to be hit by jumping Barbies.

Assessment

Homework or in-class problems, similar to the one below, can be assigned.

A biology student noticed that crickets seemed to chirp faster in the summer than in the spring or fall. Her grandmother had always told her that she could determine the temperature by listening to the crickets. Over the next season she counted the chirps per minute of a cricket and recorded the temperature. Her data is provided in the table below.

Number of Chirps (per minute)	Temperature (Fahrenheit)
55	50
67	54
75	55
83	58
91	60
99	63
119	67
134	69
140	70
149	74
164	77
178	79

a. Find a mathematical model that the student can use to estimate the temperature by listening to the crickets.
b. Interpret the slope and y-intercept in terms of the phenomenon.
c. Explain how this model could be used to estimate the temperature quickly by counting chirps for only 15 seconds.
d. If you wanted to describe mathematically the relationship between temperature and cricket chirps, which variable is more appropriate to consider as the dependent variable? Is this the same variable that you treated as the dependent variable in part a? If not, find a new model. Interpret the slope and y-intercept.

Additional Multimedia Support

References

On curve fitting and original experiment:

http://www.themathlab.com;
http://disney.go.com/disneylearning/teachercenter/gallery/bungee_barbie.html

http://www.science-house.org/teacher/empower/Bun_Bar.html

On the Antigua rain forest challenge course:

http://www.antiguarainforest.com/

http://www.antiguanice.com/v2/client.php?id=570

On temperature dependent behavior of rubber bands:

http://www.usc.edu/CSSF/History/2005/Projects/J0204.pdf

http://tpt.aapt.org/resource/1/phteah/v48/i7/p444_s1

Contributors

Modified by Laura Bottomley from original modification by Karen Hollebrand on August 2, 2004 from: http://www.themathlab.com/Algebra/linear%20functions%20regressions%20slope/regression%20lessons/barbie%20bungee/barbbungee.htm