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Spring Action Lab

A bouncy and engaging lab for your students

S.T.E.M. ON A SHOE STRING

- Graphing
- Measurement
- Forming hypotheses
- Forces
- Functions
- Variables
- Making predictions

By Brad Fulton
Educator of the Year, 2005
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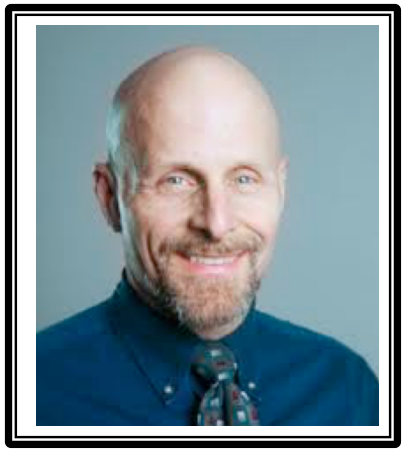
Brad Fulton

Educator of the Year



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- ♦ Consultant
- ♦ Educator
- ♦ Author
- ♦ Keynote presenter
- ♦ Teacher trainer
- ♦ Conference speaker

Known throughout the country for motivating and engaging teachers and students, Brad has co-authored over a dozen books that provide easy-to-teach yet mathematically rich activities for busy teachers while teaching full time for over 30 years. In addition, he has co-authored over 40 teacher training manuals full of activities and ideas that help teachers who believe mathematics must be both meaningful and powerful.

Seminar leader and trainer of mathematics teachers

1. 2005 California League of Middle Schools Educator of the Year
2. California Math Council and NCTM national featured presenter
3. Lead trainer for summer teacher training institutes
4. Trainer/consultant for district, county, regional, and national workshops

Author and co-author of mathematics curriculum

5. Simply Great Math Activities series: six books covering all major strands
6. Angle On Geometry Program: over 400 pages of research-based geometry instruction
7. Math Discoveries series: bringing math alive for students in middle schools
8. Teacher training seminar materials handbooks for elementary, middle, and secondary school

Available for workshops, keynote addresses, and conferences

All workshops provide participants with complete, ready-to-use activities that require minimal preparation and give clear and specific directions. Participants also receive journal prompts, homework suggestions, and ideas for extensions and assessment.

Brad's math activities are the best I've seen in 38 years of teaching!
Wayne Dequer, 7th grade math teacher, Arcadia, CA

"I can't begin to tell you how much you have inspired me!"
Sue Bonesteel, Math Dept. Chair, Phoenix, AZ

"Your entire audience was fully involved in math!! When they chatted, they chatted math. Real thinking!"
Brenda McGaffigan, principal, Santa Ana, CA

"Absolutely engaging. I can teach algebra to second graders!"
Lisa Fellers, teacher

References available upon request

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Like me even more? Then please don't make copies for your colleagues. I know it's tempting when they say, "Wow! Groovy activity! Can I have a copy?" But this is how I make my money, and why are they still saying "groovy" anyway?

If we make copies for our friends, can we honestly tell our students not to copy or take things that don't belong to them? (Ouch!)

Half priced site licensed copies are available on the TPT website. Please encourage them to take advantage of this affordable option. Okay?

Thanks and happy teaching,

Brad

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- ☐ c) Ongoing staff development
- ☒ d) *ALL OF THE ABOVE!*

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9. **Effective because** they are classroom-tested and classroom-proven. These popular DVDs of Brad's trainings have been utilized by teachers throughout the country for years.
10. **Affordable because** they are site-licensed. Buy only one copy for your whole school, print as many copies of the handouts as you need.
11. **Ongoing because** when you hire new staff, simply hit "play" and the training begins. There's no need to bring back the consultant.

Spring Action

A bouncy physics and math lab for elementary and middle grades

Overview:

Students will enjoy putting their learning to work in this engaging lab. Using springs or rubber bands, students measure and record data as they try to get a bucket to touch the floor by adding weights. Then they use their data and its graph to make predictions and write equations that will help them predict the outcomes. This simple and inexpensive lab will help your students learn graphing, t-tables, measurement, linear functions, and the physics of tension forces. This can be used as a stand-alone STEM activity or integrated into a unit on physics and functions.

Required Materials:

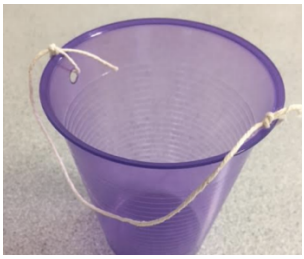
- ☒ Rubber bands (or tension springs 4' to 6' long)
- ☒ Plastic cups
- ☒ String
- ☒ Marbles, pennies or other weights
- ☒ Worksheet

Optional Materials:

- ☐ Calculators
- ☐ Water
- ☐ Graduated cylinders

Procedure:

1. Attach a string bail onto a plastic cup as shown. (A hole punch can be used to attach the string.)



2. You will need to suspend a spring or a daisy chain of rubber bands from the ceiling or from a table or desk. The cup should reach about halfway to the floor as shown.
3. Students should measure the distance from the bottom of the cup to the floor. This will be recorded on their table and graph. Their task is to find out how many marbles must be placed in the cup in order to make it just touch the floor.
4. As students add marbles to the cup, they need to measure the distance to the floor and record the data. They will soon realize that there is very little tension created when only one marble is added in the cup. They will likely begin to add marbles in greater increments.

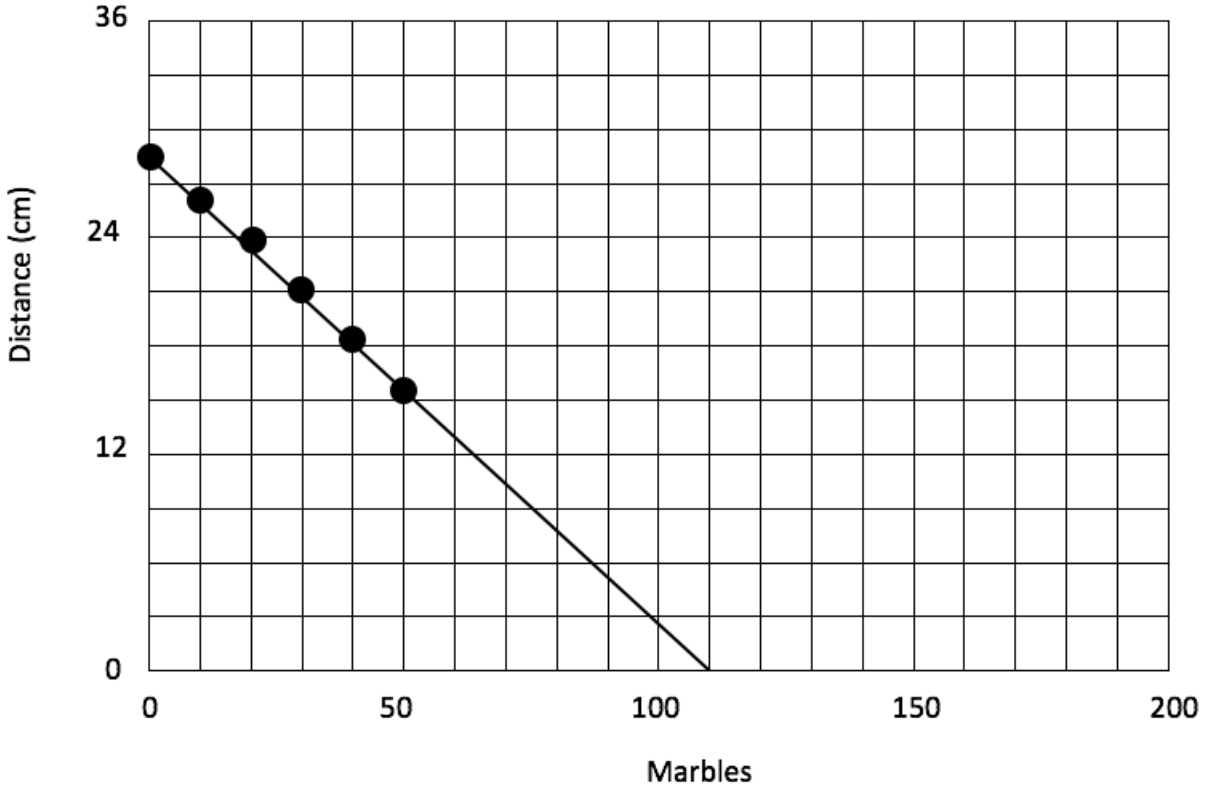
This is acceptable and will help older students gain a better understanding of slope as the relationship between rise and run.

5. With students in upper grades, it is suggested that you do not provide enough marbles to allow the cup to reach the floor. This will require students to analyze their table and graph and perhaps even write the formula for the function to make a prediction.

marbles	distance (cm)
0	28.6
10	26
20	23.6
30	21
40	18.4
50	16

6. Here is a sample table. This data is in centimeters. You could of course use inches. Think about what your students need to practice. Inches will require them to use fractions, and centimeters will involve decimals. You will notice that the data is not absolutely perfect in its decline. This is due to measurement error. Any time we measure, we have an acceptable margin of error. In this case, we were measuring to the nearest tenth of a centimeter (1 millimeter). This deviation from a perfectly linear relationship is not a problem. Once graphed the data appears to be a fairly straight line sloping downward. This means the data has a *strong negative correlation.*

7. Here is the graph of the data.



8. Notice that the data is remarkably straight showing that the tension force on a spring or elastic band is a linear function. Drawing the *line of best fit* allows us to predict that the cup will touch the floor if approximately 110 marbles are in it.

9. You may wish to have students find the formula for the function by finding the *slope* and the *y-intercept*. The y-intercept is the y-value of the function when x = 0. In this case, the cup was 28.6 cm from the floor when there were zero marbles inside.

10. Students can find the slope by analyzing the table or graph. In this case, the cup descends approximately 2.5 cm for every ten marbles. This is written as $^{-2.5}/_{10}$. Notice that the numerator is negative since the distance decreases.

    As a unit rate, it would descend –.25 cm for each marble. The slope can also be calculated by looking at a much bigger increment. For example, the cup descended 12.6 cm with 50 marbles. This is written as $^{-12.6}/_{50}$ or $^{-25.2}/_{100}$ or –.252. You can see that the values are amazingly close, off by only .002 cm!

marbles	distance (cm)
0	28.6
10	26
20	23.6
30	21
40	18.4
50	16

+50

-12.6 c

11. This yields the following formula:

$$y = -.25x + 28.6$$

12. In this formula, x represents the number of marbles and y is the distance to the floor. Since we want to know when the cup will touch the floor, we let y = 0.

$$0 = -.25x + 28.6$$

$$-28.6 = -.25x$$

$$^{-28.6}/_{-.25} = x$$

$$114.4 = x$$

It will take 114 marbles to reach the floor. This answer agrees with our former estimate of 110.

Great Options:

Here are ways to extend this activity and to customize it for students of varying grade levels.

- Using marbles requires students to count by units. Using pennies will require students to use decimals to the hundredths place. You could also use nickels so students skip count decimals.
- Using water measured in a graduated cylinder would require students to measure liquid volume in milliliters.
- Varying the starting height by suspending the cup from the ceiling will create a function with a new y-intercept with the same slope.
- Varying the type of rubber bands used will also yield different results. Now the slope will change, but the y-intercept will be held constant.
- Instead of measuring the distance from the floor, students can measure the distance from the table. As marbles are added the cup, this distance will increase instead of decrease, resulting in a function with a positive slope.

Spring Action

Name_____

Date_____ Class_____

Measure the distance from the bottom of the cup to the floor and record your data on the table and the graph. Add marbles to the cup and measure and record your data each time.

marbles	distance (cm)
0	

How many marbles will it take to make the cup touch the floor?

_____

Can you find the formula for the function?

_____

Common Core Connections:

Grade 5:

CCSS.MATH.CONTENT.5.OA.B.3
Generate two numerical patterns using two given rules. Identify apparent relationships between corresponding terms. Form ordered pairs consisting of corresponding terms from the two patterns, and graph the ordered pairs on a coordinate plane.
CCSS.MATH.CONTENT.5.G.A.1
Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., *x*-axis and *x*-coordinate, *y*-axis and *y*-coordinate).
CCSS.MATH.CONTENT.5.G.A.2
Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

Grade 6

CCSS.MATH.CONTENT.6.EE.C.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.

Grade 7

CCSS.MATH.CONTENT.7.EE.B.4
Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
CCSS.MATH.CONTENT.7.EE.B.4.A
Solve word problems leading to equations of the form $px + q = r$ and $p(x + q) = r$, where p, q, and r are specific rational numbers. Solve equations of these forms fluently. Compare an algebraic solution to an arithmetic solution, identifying the sequence of the operations used in each approach. *For example, the perimeter of a rectangle is 54 cm. Its length is 6 cm. What is its width?*

Grade 8

Define, evaluate, and compare functions.

CCSS.MATH.CONTENT.8.F.A.1

Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.[1]

CCSS.MATH.CONTENT.8.F.A.2

Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a linear function represented by a table of values and a linear function represented by an algebraic expression, determine which function has the greater rate of change*.

CCSS.MATH.CONTENT.8.F.A.3

Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. *For example, the function* $A = s^2$ *giving the area of a square as a function of its side length is not linear because its graph contains the points (1,1), (2,4) and (3,9), which are not on a straight line*.

Use functions to model relationships between quantities.

CCSS.MATH.CONTENT.8.F.B.4

Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.

CCSS.MATH.CONTENT.8.F.B.5

Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

High School

CCSS.MATH.CONTENT.HSF.LE.A.1

Distinguish between situations that can be modeled with linear functions and with exponential functions.

CCSS.MATH.CONTENT.HSF.LE.A.1.A

Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.

CCSS.MATH.CONTENT.HSF.LE.A.1.B

Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.

Next Gen Science Standards Connections:

Physical Science Progression:

Grades 3-5
The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact, some forces act even when the objects are not in contact. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

Grades 6-8
The role of the mass of an object must be qualitatively accounted for in any change of motion due to the application of a force.
Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object.

Science and Engineering Practices:

Grades 3-5
• Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.
• Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
• Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.
• Analyze data to refine a problem statement or the design of a proposed object, tool, or process.
• Use data to evaluate and refine design solutions.

Grades 6–8
• Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.
• Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.
• Distinguish between causal and correlational relationships in data.
• Analyze and interpret data to provide evidence for phenomena.
• Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).
• Analyze and interpret data to determine similarities and differences in findings.

Cross-cutting concepts: Cause and effect

Grades 3-5
Students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship.

Grades 6-8
Students classify relationships as causal or correlational, and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

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You can also find many free and inexpensive resources on my personal website, www.tttpress.com. Be sure to subscribe to receive monthly newsletters, blogs, and activities.

Similar activities include:

- *Ramp Races: Two physics labs on motion, force, distance and speed for both young and advanced students*
- *Vibrobots: An inexpensive and engaging robotics lab that fosters engineering skills while measuring speed and slope*
- *Invisible Ink Lab: Your students will love writing secret messages and using chemistry to reveal their writing.*
- *Electronic Quiz Cards: Great fun studying electronics and creating usable study cards for any class. So inexpensive!*

Feel free to contact me if you have questions or comments or would like to discuss a staff development training or keynote address at your site.

Happy teaching,

Brad