Title: Fitting a Line to Data

Grade Ranges:
___K-4
___5-8
_X_9-12

Subject Tag:
Math: Algebra
Math: Problem Solving

Synopsis:
Students, in groups of three or four, will create, collect, and graph data related to water that marbles displace. Each group will then determine the linear equation of the best-fitting line to the data. Individually or in groups, the students will use their equation to answer questions related to their data.

Keywords:
scatterplot, independent variable, dependent variable, best-fitting line, slope, intercept, linear equation, positive correlation, negative correlation

Body:
1. Students, in groups of three or four, should be given a glass half-filled with water, a ruler, and 20-30 marbles.

2. Students will place marbles two, three, or four at a time into the glass half-filled with water. (Beforehand, determine how many marbles to use at a time depending on the size of the marbles and the size of the glass. You want 10-15 data points.) Using a ruler, the students will measure the height of the water after each addition. It is also important that the students measure the initial height of the water. Students should not add more marbles if the marbles go above the height of the water.

3. Students will record these values in a table. Discuss the difference between dependent and independent variables. Students should determine the dependent and independent variables in this case and plot the points on an appropriate graph.

4. Students will use uncooked spaghetti to determine where the line of best fit lies on their graph. This allows students to try different lines without continually erasing their previous guesses. This step can be skipped if a calculator or computer is being used to determine the equation of the line.

5. Students will determine the equation of the line that best fits the data in their graph. Depending on the ability of the students and the materials available, this step can be done by hand, with a graphing calculator, or using graphing software, such as Excel, on a computer.

6. Students should then be given questions relating to their data and approximation equation. (See accompanying handout.)

Note: Searches on the web under the subject "line of best fit" and "data collection" provides other extensions to similar activities.

Related Links:
Fitting a Line to data
http://www.columbia.edu/~umk1/linefit1.html
Includes a lesson using the question "how does ___ affect___?" where the students get to choose the variables.

Finding the line of best fit: median-median line
http://www.ucs.mun.ca/~mathed/Stats/fit35.htm
Tells how to find the median-median line by hand and using a TI graphing calculator.

Line of Best Fit and Correlation Coefficient using the TI83
http://www.ferrum.edu/sgalinaitis/math208/TI83.doc
Gives step by step instructions of how to find a linear line of best fit on the TI83

Features:
___Contains special education tips
___Quick Activity (less than 30 minutes; story starter)
___Requires Internet access for students to complete

Objectives:
Students will be able to determine the linear equation that best represents the relationship and analyze the equation through exploration questions.

Standards:
NY: MST Standard 1.3: Critical thinking skills are used in the solutions of mathematical problems. **MST Standard 3.4:** Students use mathematical modeling/multiple representation to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships. **MST Standard 3.5:** Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data. **MST Standard 3.7:** Students use patterns and functions to develop mathematical power, appreciate the true beauty of mathematics, and construct generalizations that describe patterns simply and efficiently.

NYC: A5a: Participate in the establishment and operation of self-directed work teams. **M2m:** Understands the structure of standard measurement systems, both SI and customary, including unit conversions and dimensional analysis. **M3a:** Models given situations with formulas and functions, and interprets given formulas and functions in terms of situations. **M3k:** Makes predictions by interpolating or extrapolating from given data or a given graph. **M4b:** Organizes, analyzes, and displays two-variable data using scatter plots, estimated regression lines, and computer generated regression lines and correlation coefficients. **M4e:** Formulates hypotheses to answer a question and uses data to test hypotheses.

CT: Math Standard 3: Students will make estimates and approximations, and judge the reasonableness of results. **Math Standard 4:** Students will make and use measurements in both customary and metric units to approximate, measure and compute length, area, volume, mass, temperature, angle and time. **Math Standard 7:** Students will use basic concepts of probability and statistics to collect, organize, display and analyze data, simulate events and test hypotheses. **Math Standard 9:** Students will use algebraic skills and concepts, including functions, to describe real-world phenomena symbolically and graphically, and to model quantitative change.

NJ: 4.1. All students will develop the ability to pose and solve mathematical problems in mathematics, other disciplines, and everyday experiences. **4.9.** All students will develop an understanding of and will use measurement to describe and analyze phenomena. **4.11.** All students will develop an understanding of patterns, relationships, and functions and will use them to represent and explain real-world phenomena. **4.12.** All students will develop an understanding of statistics and probability and will use them to describe sets of data, model situations, and support appropriate inferences and arguments. **4.13.** All students will develop an understanding of algebraic concepts and processes and will use them to represent and analyze relationships among variable quantities and to solve problems.

Prerequisite Skills:
1. Students need to know how to plot points on a coordinate plane.
2. Students need to know how to determine the equation of a line using two points.

Time Required:
Two 45-minute lessons

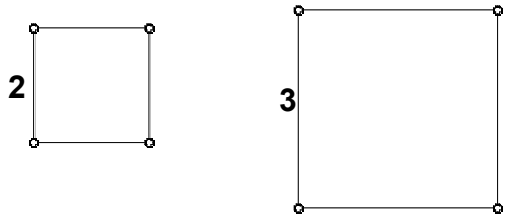
Technology and Materials Needed:
1. 12 16-ounce transparent glasses or cups (Canning jars work best because their sides are vertical and not angled so the data is more linear, and they tend to be fairly unbreakable. Large plastic cups also work well, but they need to be transparent enough so that the students can see the water line.)
2. Small marbles or small pebbles
3. Water
4. Rulers (metric or customary)
5. Paper and pencils
6. Spaghetti or vermicelli
7. Calculators (optional)

Assessment Criteria:
1. Check students' equations for accuracy.
2. Check for student understanding of the extended questions.

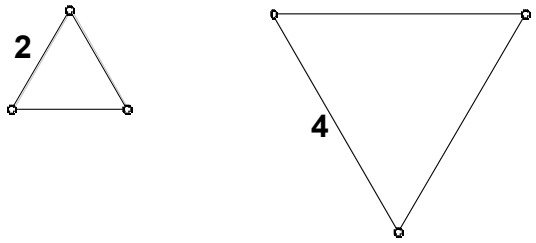
Areas of Similar Figures

Find the *areas* of all of the figures below.

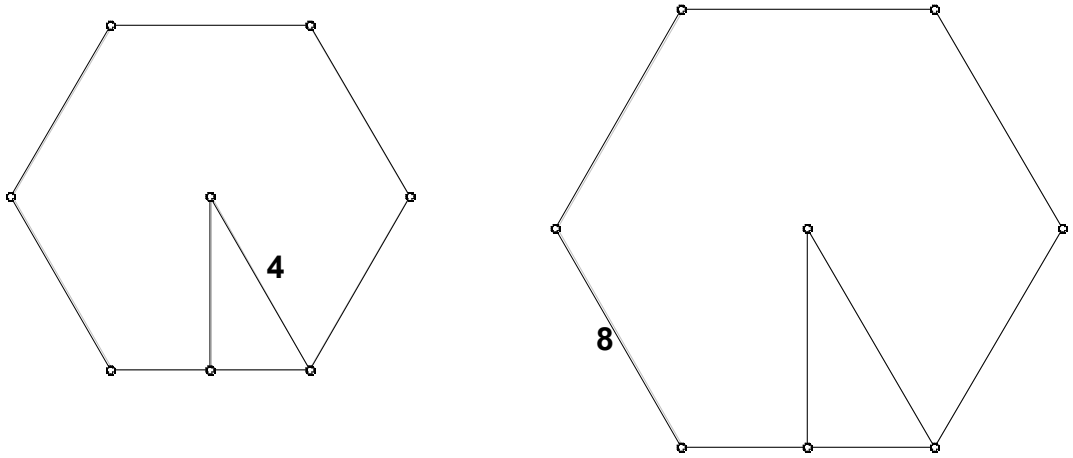
1. **Squares**:



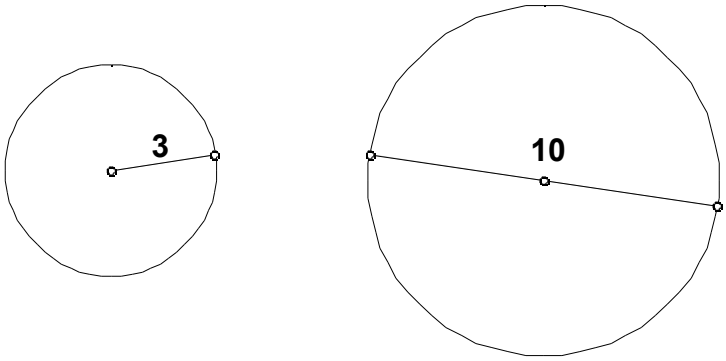
2. **Equilateral triangles**:



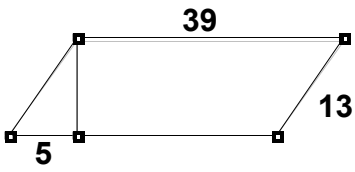
3. **Regular hexagons**:

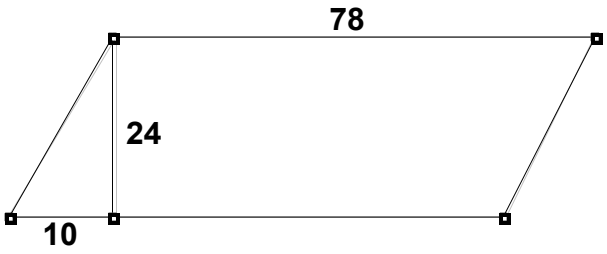


4. **Circles**:



5. **Parallelograms**:





6. Fill in the information in the chart below:

	Side Length of #1	Side Length of #2	Ratio of Side Lengths (scale factor)	Area of #1	Area of #2	Ratio of Areas
Squares	2	3	2:3			
Equilateral triangles	2	4	2:4 = 1:2			
Regular hexagons	?	8				
Circles	(radius) 3	(radius) ?				
Parallelograms	13, 39	?, 78				

7. Summarize what you've learned:

Name:

Date:

Fitting a Line to Data

Use the approximation equation to answer the following questions.

1. How high would the water be if 17 marbles were submerged?

2. How many marbles are needed to make the water exactly 6.5 cm high?

Is this possible?
Why or why not?

3. How many marbles are needed to make the water rise 1.5 inches?

4. How much does the water rise for every 10 marbles you add?

5. Explain how the line and equation would change if you were to use larger marbles.

6. Explain how the line and equation would change if the glass had a smaller diameter.