Title: Does It Fit?

Link to Outcomes:

- **Problem Solving** Students will demonstrate their ability to collect data, answer open-ended questions related to the collected data, and use technology to verify results.
- **Communication** Students will describe the process necessary for finding the line of best-fit. Also, students will use their results to make inferences about other possible scenarios.
- **Reasoning** Students will use collected data to make conjectures and build arguments.
- **Connections** Students will use knowledge of: economics when considering cost constraints; scientific method when collecting data; and human development when analyzing foot size and height.
- **Estimation** Students will estimate the line which best fits a given set of data and will evaluate the reasonableness of their solution.
- **Geometry** Students will plot related data on a two-dimensional graph.
- **Measurement** Students will select the appropriate units for measuring their foot size and height, and then will measure them accurately.
- **Statistics** Students will collect, organize, display, and interpret data for given situations.
- **Patterns & Relationships** Students will demonstrate their ability to generalize a relationship from collected data.
- **Algebra** Students will demonstrate their ability to express the equation of a line, given a set of points.

Brief Overview:

Students will use data to draw the line which best fits a scatter plot. The students will then express the equation of the line using the slope and y-intercept taken from the graphs they drew. Students will draw conclusions and make predictions based on the extrapolated lines. Initially, the teacher will provide the students with the data to be graphed, then the teacher and students will collect the data together. Finally, as an assessment, the students will conduct an experiment to collect the data which they will then graph.

Grade/Level:

Algebra I, any grade
Algebra II, with extensions to other types of graphs and equations
Pre-Algebra (simply plot points, find best-fit line, and answer questions)

Duration/Length:

At least 4 class periods are needed for the basic lesson. More time is needed if you are including any extensions.

Prerequisite Knowledge:

Students should have working knowledge of the following skills:

- collecting data
- setting up an appropriate interval and scale for the x and y axis
- plotting points in two-dimensional Cartesian planes
- estimating the coordinates of two points on a line
- finding the equation of a line given two points

Objectives:

The students will:

- make a scatter plot.
- finding the line which best-fits a set of points.
- making predictions based upon the graph and equation of the line.
- measure lengths accurately.
- conduct an experiment or do research to gather data.
- write a lab report.

Materials/Resources/Printed Materials:

- graph paper
- Pythagoras' Pizza worksheet (2 pages - 1 of prices and graph and 1 of questions)
- Subtraction Shoes worksheet (2 pages - 1 of graph and 1 of questions)
- Subtraction Shoes foot outline sheet
- Between The Lines worksheet (2 pages - 1 of ideas and 1 of graph and questions)
- uncooked spaghetti or linguine (not lasagna and definitely not tortellini; angel hair is fine but inappropriately named)
- yard sticks or tape measures
- calculators
- rulers
- graphic calculators (for extension)

Development/Procedures:

Activity 1:

- Distribute a pizza menu to each student. Search for a relationship between the number of toppings and the cost of the pizza. Determine if topping-price relationship is linear.

- Discuss the appropriate interval and scale for plotting this information on a Cartesian graph. Use the bottom of Worksheet 1 to plot the information on a Cartesian graph.

- Align uncooked spaghetti so it passes through the maximum number of points with a fairly equal distribution of points above and below the spaghetti line. (Spaghetti is useful here because it is small enough so all points can be seen and can be moved around until the correct fitting line is found.) Mark the endpoints of the spaghetti and then use a ruler to draw the line.

- Choose and name two points on the line. Determine the equation of the line.

- Complete Worksheet 2, Pythagoras' Pizza, analyzing the graphed data. Students may need to complete the worksheet as part of their home assignment.

Activity 2:

- Gather data comparing foot length to height. Use Worksheet 3, 'Subtraction Shoes,' provided as a guide for measuring foot length. It is recommended that the teacher create the page on an 11 x 14 inch sheet of paper to accommodate larger feet. Also, an inch measuring scale will need to be added to the foot outline sheet. Teachers may produce one foot outline for each student or produce a few to be shared by the whole class. NOTE: for uniformity, it is recommended that students remove their shoes prior to measuring.

- After recording own height and foot length, collect data from nine other classmates. (Be sure to instruct students to get nine <u>different</u> sets of data - some students will have the same height and foot length.)

- Repeat the steps of Activity 1; plot data on Worksheet 4, and find the line of best-fit.

- Complete the Worksheet 5, 'Subtraction Shoes,' analyzing the graphed data.

Activity 3:

- Give students Worksheet 6 containing a list of possible experiments and research ideas.

- Instruct students to follow the same procedures in collecting data, creating a graph, and analyzing the data by answering the worksheet questions. Use Worksheet 7, the second 'Between The Lines' worksheet, for this.

- Ask students to present their results to the rest of the class.

Evaluation:

Activity Three will serve as an evaluator tool in itself. Students are asked to demonstrate their understanding of the process of finding lines of best-fit by working independently. Students are expected to plot all points and draw the line of best-fit; however, since the actual line is very subjective and will vary among students, they should only be graded on their ability to draw the line and find its equation. The bulk of their grade will come from using the graph they drew to completely answer all questions.

Extension/Follow Up:

Following Activity Two, give the students the equations for determining shoe size given the foot length:

for women, $S = 3L - 22$
for men, $S = 3L - 26$

where S is shoe size and L is foot length in inches.
Then, ask the students to use the data from Worksheet 5 to find the shoe sizes of the NBA All-Stars.

At any point during these lessons, graphic calculators can be used to plot points and find the line of best fit. The graphic calculators will help to verify the actual results.

Following Activity Three, students can collect data which fit other models such as: quadratic, cubic, or exponential. This data should also be plotted and students can then find the best-fit curve. The graphic calculator can also be used to plot points and find best-fit curve. Examples of collection models are: finding volume of cubes compared to edge length (cubic); areas of equilateral triangles compared to side length (quadratic); measuring the temperature of ice water at regular intervals (exponential); and the change in minimum wage over time (exponential);.

A tie-in for statistics is finding lines of regression.

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Worksheet 1

PYTHAGORAS' PIZZA

Our Pizza π *is Infinitely Delicious*

PIZZA
Hot, fresh, and with maximum area everyday

Regular, tomato and cheese	$ 8.49
1 Topping	$ 9.58
2 Toppings	$10.67
3 Toppings	$11.76
4 Toppings	$12.85
5 Toppings	$13.50

Title your graph and label your axes.
Set up the interval and scale.
Your graph should include at least 15 toppings across the horizontal axis.
Plot the points.
Find the line of best fit using your spaghetti.
Answer questions on Worksheet 2.

PYTHAGORAS' PIZZA

We Always Think About What We Cook

Answer the following as completely as possible. Justify your answers where needed.

1. Write the equation of the line.

2. Describe the steps you took to find the equation of the line.

3. To what does the y-intercept correspond?

4. To what does the slope correspond?

5. According to your line/equation, how much should a pizza with 8 toppings cost?

6. If the manager offered you a 10 topping pizza for $18.50, would that be a bargain price? Why?

7. According to your line/ equation, which pizzas are good deals and which are ripoffs? Why?

8. A Super-Deluxe pizza has 14 toppings, how much would you charge for it? Why?

9. You manage the pizza parlor and someone offers you $120 for 8 pizzas with 7 toppings. Would you sell the pizzas for this amount? Why?

ANSWERS for:
PYTHAGORAS' PIZZA

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PIZZA
Hot, fresh, and with maximum area everyday

Regular, tomato and cheese	$ 8.49
1 Topping	$ 9.58
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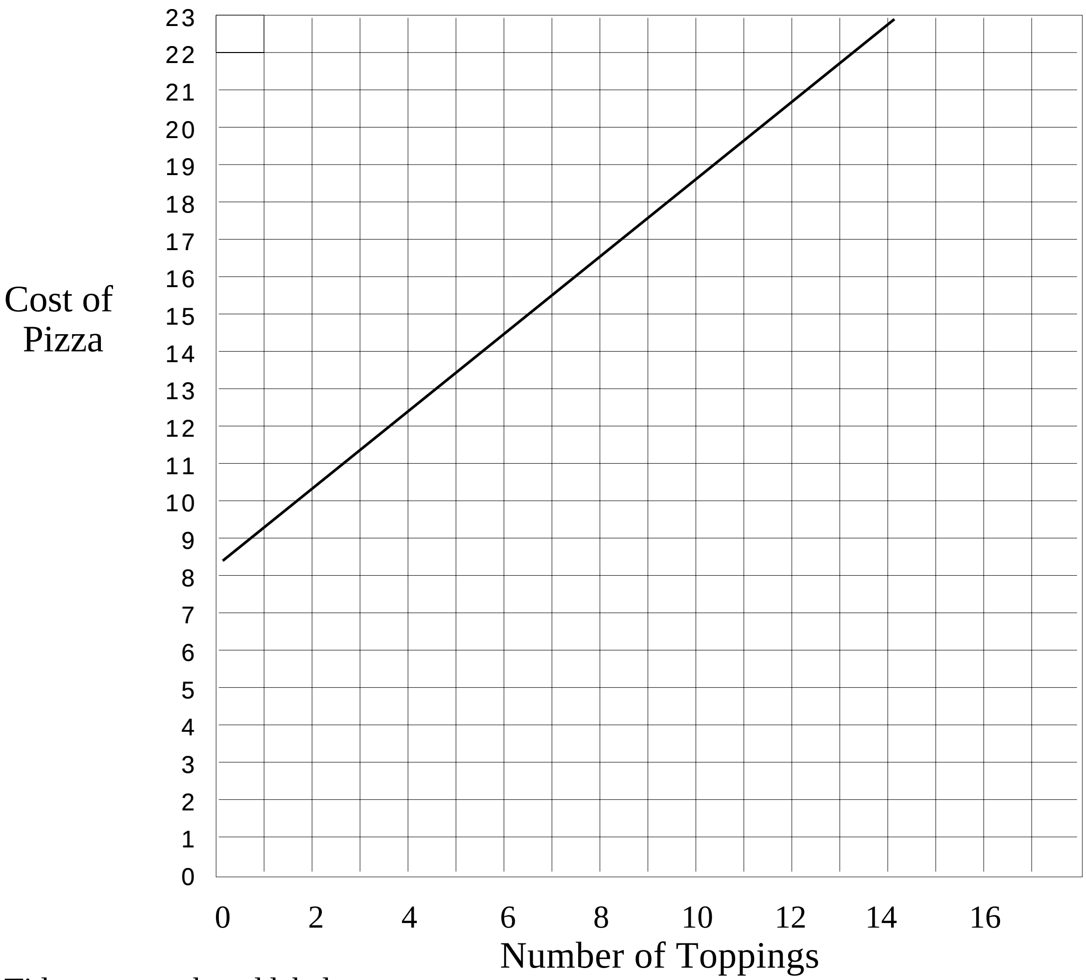
PIZZA PiES



Title your graph and label your axes.
Set up the interval and scale.
Your graph should include at least 15 toppings across the horizontal axis.
Plot the points.
Find the line of best fit using your spaghetti.
Answer questions on Worksheet 2.

ANSWERS for:
PYTHAGORAS' PIZZA

We Always Think About What We Cook

<u>Answers may vary according to the line of best-fit.</u>

1. Write the equation of the line.
   Approximately $y = 1.03x + 8.57$

2. Describe the steps you took to find the equation of the line.
   After plotting the points, the line of best-fit was drawn on the graph paper. Two points were chosen and the slope was calculated. This information was plugged into the slope-intercept format and then a point was used to find the y-intercept.

3. To what does the y-intercept correspond?
   This corresponds to the price of a pizza with no toppings.

4. To what does the slope correspond?
   The slope is the additional cost per topping.

5. According to your line/equation, how much should a pizza with 8 toppings cost?
   An 8-topping pizza should cost approximately $16. 79.

6. If the manager offered you a 10 topping pizza for $18.50, would that be a bargain price? Why?
   Yes, 10 toppings should cost approximately $18.85.

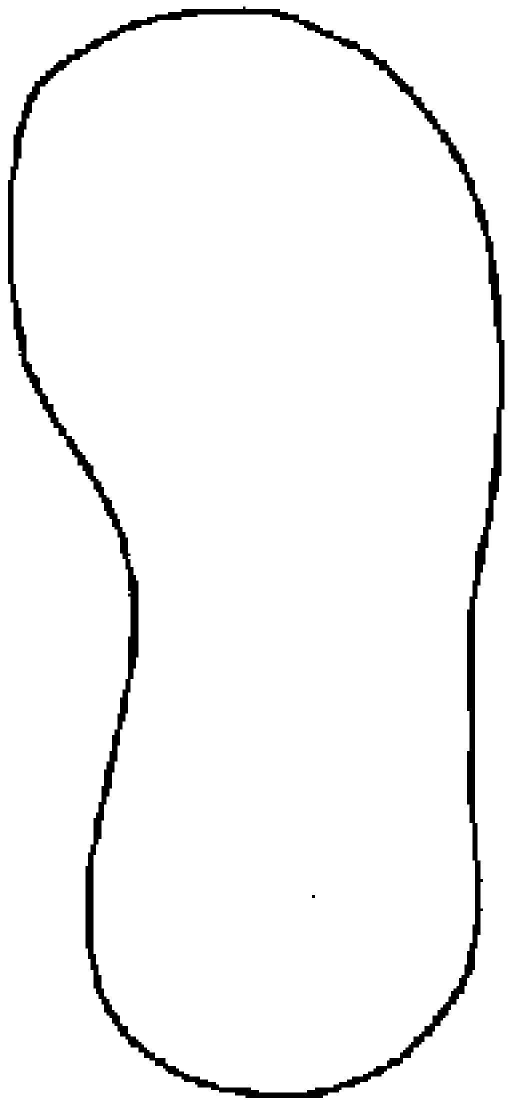
7. According to your line/ equation, which pizzas are good deals and which are ripoffs? Why?
   Good 0, 1, 5 toppings
   Ripoff 2, 3, 4 toppings
   Good pizzas are those whose cost falls below the line and are thus less expensive than the trend shows.
   Ripoffs are the pizzas whose price lies above the curve and are therefore more expensive than the trend allows.

8. A Super-Deluxe pizza has 14 toppings, how much would you charge for it? Why?
   $22.95. This is the price found by either using the equation and substituting 14 in for x or by reading the line across at the place where the number of toppings is 14.

9. You manage the pizza parlor and someone offers you $120 for 8 pizzas with 7 toppings. Would you sell the pizzas for this amount? Why?
   No, because 8 pizzas @ $15.76 would cost $126.08, you would not be making the same profit as you would by selling each pizza individually.

SUBTRACTION SHOES

We Measure Your Feet In Inches



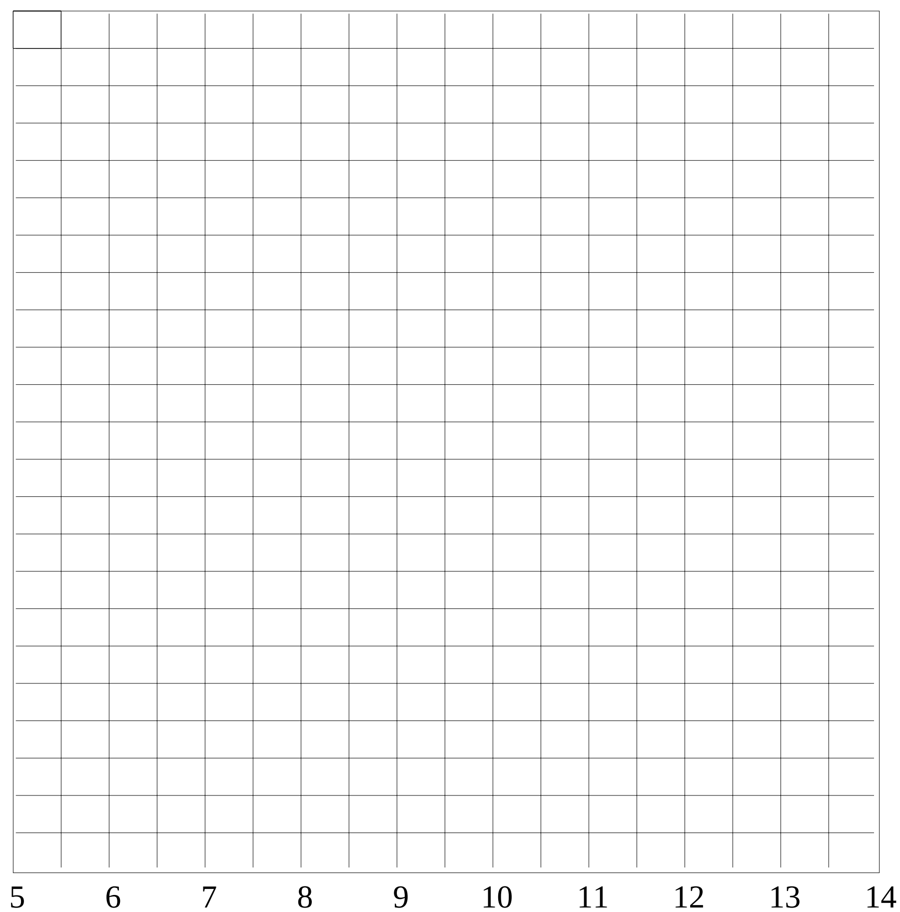
When using this chart, place your foot so your heel lies in the heel on the drawing. Then, measure the distance,to the nearest half inch, from your heel to your big toe.

SUBTRACTION SHOES

We Take Nothing Away From Your Feet

Collect data from 9 other classmates and enter the data on the chart below.

Foot length Height



Title your graph and label your axes.
Set up the interval and scale.
Plot the points.
Find the line of best fit using your spaghetti.
Answer questions on Worksheet 5.

Worksheet 4A

SUBTRACTION SHOES

We Take Nothing Away From Your Feet

Name _________________________ Partner(s) _________________________

Directions for gathering data:

SHOES NEED TO BE REMOVED FOR BOTH MEASUREMENTS. (CLEAN SOCKS ARE REQUIRED. P.U.)

Foot Measure:

1. Right heel should be on edge of shoe print.
2. Stand in place with normal weight on feet.
3. Have partner measure to nearest one-half inch from back of heel to tip of big toe. Repeat measurement to check for accuracy.

My right foot is _________________ inches.

Height Measure:

1. Stand with both heels to the baseboard of a wall.
2. Use a yard stick to measure height to the nearest one-half inch.

My height is _________________ inches.

SUBTRACTION SHOES

Home Of The Foot-Long Answer

Answer the following as completely as possible. Justify your answers where needed.

1. Explain what you did to collect the data.

2. Write the equation of the line.

3. Describe the steps you took to find the equation of the line.

4. Was your line a perfect fit for the data you collected? Why?

5 What factors affected your results?

6. How long is the foot of a new-born baby who is 18 inches tall?

7. Assuming that the general trend is that each generation is taller than the one before it. In 5 generations, the average male height will be 75 inches and the average female height will be 69 inches. What are corresponding foot lengths for males and females?

8. You own a store in Tallville where the shortest adult is 67 inches and the tallest adult is 81 inches. What range of foot lengths would you service?

9. You are a Nike representative who is responsible for providing shoes for some of the NBA All-Star team. Given the following information, complete the chart of player height and foot length.

PLAYER	HEIGHT	FOOT LENGTH
Charles Barkley	78 inches	
Patrick Ewing	84 inches	
Anfernee Hardaway	79 inches	
Grant Hill	80 inches	
Kevin Johnson	73 inches	
Shawn Kemp	82 inches	
Reggie Miller	79 inches	
Hakeem Olajuwon	84 inches	
Shaquille O'Neill	85 inches	
Scottie Pippen	79 inches	
David Robinson	85 inches	

ANSWERS FOR SUBTRACTION SHOES

Home Of The Foot-Long Answer

All student lines will differ depending on the data collected and how the line was fit, not all answers could be provided.

1. Explain what you did to collect the data.
   Measure the length of people's feet and their heights in inches.

2. Write the equation of the line.
   For example, Y = 3X + 33.

3. Describe the steps you took to find the equation of the line.
   After plotting the points, the line of best-fit was drawn on the graph paper. Two points were chosen and the slope was calculated. This information was plugged into the slope-intercept format and then a point was used to find the y-intercept.

4. Was your line a perfect fit for the data you collected? Why?
   There is no exact perfect fit to these points but the drawn line best represents the trend seen in the data.

5 What factors affected your results?
   Developmental differences, sock thickness, toe nail length, inaccurate measurement, and prohibitively smelly feet.

6. How long is the foot of a new-born baby who is 18 inches tall?

7. Assuming that the general trend is that each generation is taller than the one before it. In 5 generations, the average male height will be 75 inches and the average female height will be 69 inches. What are corresponding foot lengths for males and females?

8. You own a store in Tallville where the shortest adult is 67 inches and the tallest adult is 81 inches. What range of foot lengths would you service?

9. You are a Nike representative who is responsible for providing shoes for some of the NBA All-Star team. Given the following information, complete the chart of player height and foot length. Using the equation Y = 3X + 33, the foot lengths are:

PLAYER	HEIGHT	FOOT LENGTH
Charles Barkley	78 inches	15 inches
Patrick Ewing	84 inches	17 inches
Anfernee Hardaway	79 inches	15.33 inches
Grant Hill	80 inches	15.66 inches
Kevin Johnson	73 inches	13.33 inches
Shawn Kemp	82 inches	16.33 inches
Reggie Miller	79 inches	15.33 inches
Hakeem Olajuwon	84 inches	17 inches
Shaquille O'Neill	85 inches	17.33 inches
Scottie Pippen	79 inches	15.33 inches
David Robinson	85 inches	17.33 inches

BETWEEN THE LINES

We Will Set You Straight

Select one of the following and collect the appropriate data. You must get at least 6 data points.

1. THE WAVE. Conduct The Wave (people consecutively standing, raising their hands above their heads, and sitting down) and time how long it takes from the moment the first person stands to the moment the last person sits. Repeat this process using different numbers of people in your wave.

2. ARM SPAN/HEIGHT. Measure the arm spans (fingertip to fingertip) and heights of different people.

3. BOUNCING THE BALL. Drop a ball from different heights and measure the height of the first bounce.

4. TEMPERATURE AND TIME OF DAY. Measure the temperature at different times during the same day.

5. CIRCUMFERENCE/DIAMETER. Measure the circumference and diameter of different sized circular items.

6. POSTAGE STAMP COST. Find the cost of a first class postage stamp for a given time period.

7. RISING WATER. Fill a glass with water. Add five pennies at a time and measure the water level.

8. TEMPERATURE AT DIFFERENT LATITUDES. Find the average temperature for April in cities at different latitudes.

9. SPRINGS. Measure the length of a spring when different weights are suspended from it.

10. OVERHEAD PROJECTOR. Measure the size of an image when the overhead is different distances from the screen.

BETWEEN THE LINES

The Farthest Distance Between Points

Use the results of your research or experiment to graph the points, then draw and find the equation of the line of best fit. On another sheet of paper, completely answer the questions.

1. Explain what you did to collect your data.
2. Write the equation of the line of best-fit.
3. Describe the steps you took to find the equation.
4. What factors affected your results?
5. Was your line a perfect fit for your data? Why?
6. How could you use this information to predict future actions or events?