**WAMC Lab Template**

Math Concept(s): Collect and evaluate data to construct a linear function that is predictive of strength of a bridge.

Source / Text: Alamance-Burlington School System

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**Attach the following documents:**

- Lab Instructions
- Student Handout(s)
- Rubric and/or Assessment Tool

**Short Description (Be sure to include where in your instruction this lab takes place):**

The students will work in small groups of 2 and use uncooked spaghetti as a bridge to test and develop a linear function that models the strength of the spaghetti.

**Lab Plan**

Lab Title: Spaghetti Bridges

Prerequisite skills: Students will have to know how to collect data using a table and write a linear function from a table.

Lab objective: Students will be able to construct and use a linear function that models the strength of the spaghetti.

**Standards:** *(Note SPECIFIC relationship to Science, Technology, and/or Engineering)*

Mathematics K–12 Learning Standards:

- F-IF.2 “Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.”
- F-IF.6 Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.”
- F-BF.1 “Write a function that describes a relationship between two quantities.”’
- S-ID.7 “Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.”
- S-ID.8. “Compute (using technology) and interpret the correlation coefficient of a linear fit.”

Standards for Mathematical Practice:

- SMP 1. Make sense of problems and persevere in solving them.
- SMP 4. Model with mathematics.
- SMP 5. Use appropriate tools strategically.
- SMP 6. Attend to precision.

K-12 Learning Standards-ELA (Reading, Writing, Speaking & Listening):

- SL.9-10.1 “Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively”
- SL.9-10.1d “Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.”

K-12 Science Standards

- HS-ETS1-2 “Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.”
- HS-ETS1-4 Engineering Design “Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.”

Technology

- 1.c. Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.

Engineering

- HS-ETS1-2 “Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.”
- HS-ETS1-4 Engineering Design “Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.”

Leadership/21st Century Skills:

21st Century Interdisciplinary themes (Check those that apply to the above activity.)
☐ Global Awareness ☒ Financial/Economic/Business/Entrepreneurial Literacy ☐ Civic Literacy
☐ Health/Safety Literacy ☐ Environmental Literacy

21st Century Skills (Check those that students will demonstrate in the above activity.)

**LEARNING AND INNOVATION**
Creativity and Innovation
☐ Think Creatively
☒ Work Creatively with Others
☐ Implement Innovations
Critical Thinking and Problem Solving
☒ Reason Effectively
☐ Use Systems Thinking
☐ Make Judgments and Decisions
☒ Solve Problems
Communication and Collaboration
☒ Communicate Clearly
☒ Collaborate with Others

**INFORMATION, MEDIA & TECHNOLOGY SKILLS**
Information Literacy
☒ Access and Evaluate Information
☒ Use and manage Information
Media Literacy
☐ Analyze Media
☐ Create Media Products
Information, Communications and Technology (ICT Literacy)
☒ Apply Technology Effectively

**LIFE & CAREER SKILLS**
Flexibility and Adaptability
☐ Adapt to Change
☐ Be Flexible
Initiative and Self-Direction
☒ Manage Goals and Time
☐ Work Independently
☐ Be Self-Directed Learners
Social and Cross-Cultural
☒ Interact Effectively with Others
☒ Work Effectively in Diverse Teams

**Productivity and Accountability**
☒ Manage Projects
☒ Produce Results
Leadership and Responsibility
☒ Guide and Lead Others
☒ Be Responsible to Others

**Teacher Preparation: (What materials and set-up are required for this lab?)**

Materials

- Uncooked Spaghetti
- Paper/Plastic/Styrofoam Cups
- Washers (suggest 1/8 in x 1 in)
- Desmos Online Graphing Calculator
- Access to Computer or Chromebook

Set-Up Required:

- Each group will need at least 15 pieces of uncooked Spaghetti, a cup with two holes through the top of the cup, access to desmos online graphing calculator, and washers.

**Lab Organization Strategies:**

Leadership (Connect to 21st Century Skills selected):

- Students will work in cooperative groups of 2 to collect and evaluate data to create an equation. Students will also present their findings and stuck points during the lab. For groups of two, students will take the role of data analysts and facilitator. The data analysts will drop the washers in the cup, document the data in a table, input values and equations into desmos. The facilitator will get material, hold the cup, keep the group on task, will write answers on handout, and will lead the presentation at the end of the lab. Both students will be responsible for engaging in critical thinking, keeping works space clean, and producing results.

Cooperative Learning:

- Students will be required to work in cooperative groups to produce results and develop a presentation.

Expectations:

- Students will create an equation for the line of best fit for the data they collected from their spaghetti bridge. Students will also present their data, graph, equation, stuck points, and results.

Timeline:

- At least 110 minutes.

**Post Lab Follow-Up/Conclusions:**

Discuss real world application of learning from lab

- What careers need this type of information? Is it important for engineers and contractors to be able to have this knowledge of the line of best fit? What would be the result if no one did any of these tests with other material like concrete, wood, stone, or iron?

Career Applications

- Engineering
- Contractor
- Construction
- Material Science
- Architecture

Optional or Extension Activities

- Using the materials given, determine a better method of supporting the washers in the cup.

**Lab Instructions**

- Pass out an uncooked spaghetti to each group and a washer. Show the students the cup with the spaghetti through the holes and ask them to predict how many washers would it take to break the spaghetti bridge. Give the groups about a minute to analyze the materials before collecting predictions.
- Collect the predictions and then have a student come up and hold place their fingers one inch away from the cup. Place one washer in at a time until the spaghetti breaks.
- Then explain the roles of facilitator and data analysts along with the learning goal and expectations of the lab.
- Have the facilitator get supplies and the students begin working on the project.
- Monitor student progress and facilitate learning.

# Spaghetti Bridges

**Names:**_____

## Tools

- 1 paper cup with 2 holes punched on opposite sides
- 1 bag of washers
- Uncooked spaghetti (at least 15 pieces)

## Procedure

1. Thread a piece of spaghetti through the holes in the cup.
2. One person will suspend the cup by placing each index finger approximately one inch in from the ends of the spaghetti.
3. Another student will carefully add washers to the cup, one at a time, until the spaghetti breaks.
4. Record results below.
5. Repeat the above procedure with 2, 3, 4, and 5 pieces of spaghetti until one or more pieces of spaghetti breaks.

| (x)<br># of spaghetti | (y)<br># of washers |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |

6. **GRAPH THE RESULTS**
Go to desmos.com/calculator and plot the points on the table.

7. **READ THE RESULTS:** Use th**e graph** to answer the following:
Predict how many washers are needed to break "bridges" of
6 pieces: _____washers, 7 pieces: _____washers, 8 pieces: _____washers

8. **Draw a line of best fit.** Extend the line so that it crosses the y-axis. Identify the y-intercept: (0, ___ ). It sounds crazy, but the graph may suggest that a bridge of no spaghetti would crumple with a weight of _____washers.

9. Write the equation of the line in slope-intercept form. Show all your thinking.

10. Use your equation to predict how many washers would be needed to break a bridge of 20 pieces of spaghetti. Show all your thinking.

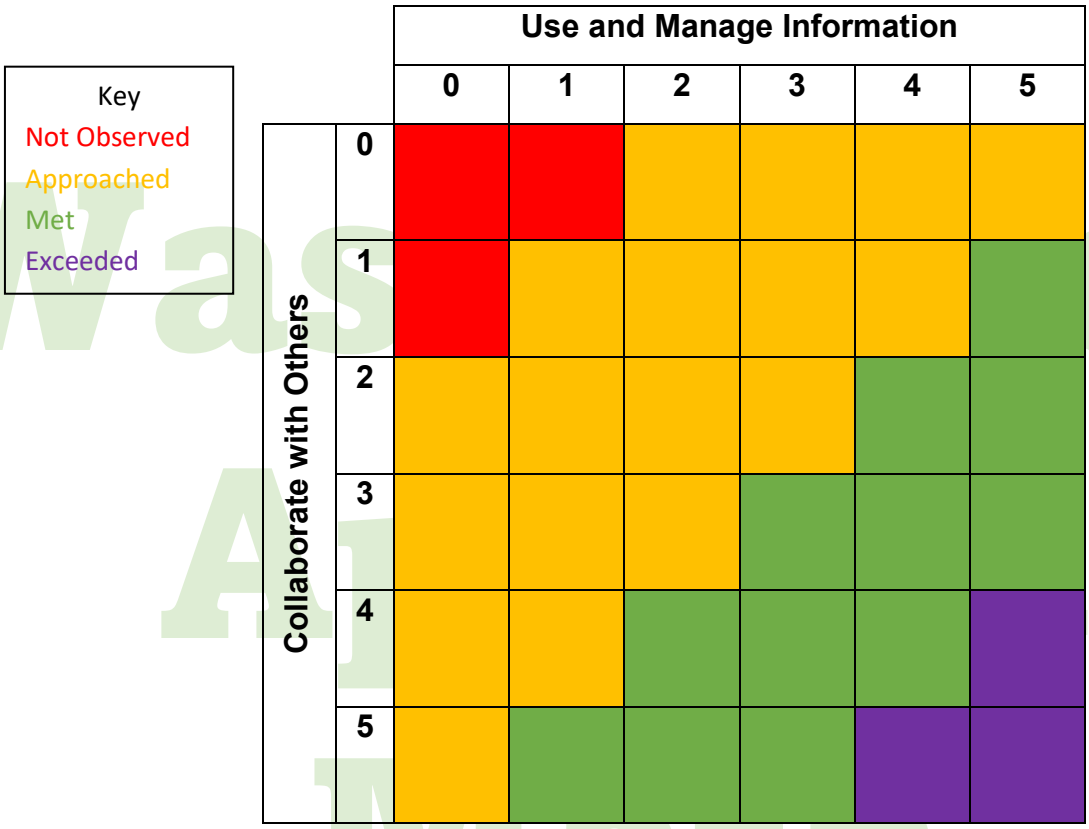
11. Use your equation to predict how many pieces of spaghetti 932 washers would break. Show all your thinking.

12. Explain the benefits of having the equation of a line of best fit and how this might be applied when constructing buildings, bridges, or any structure.

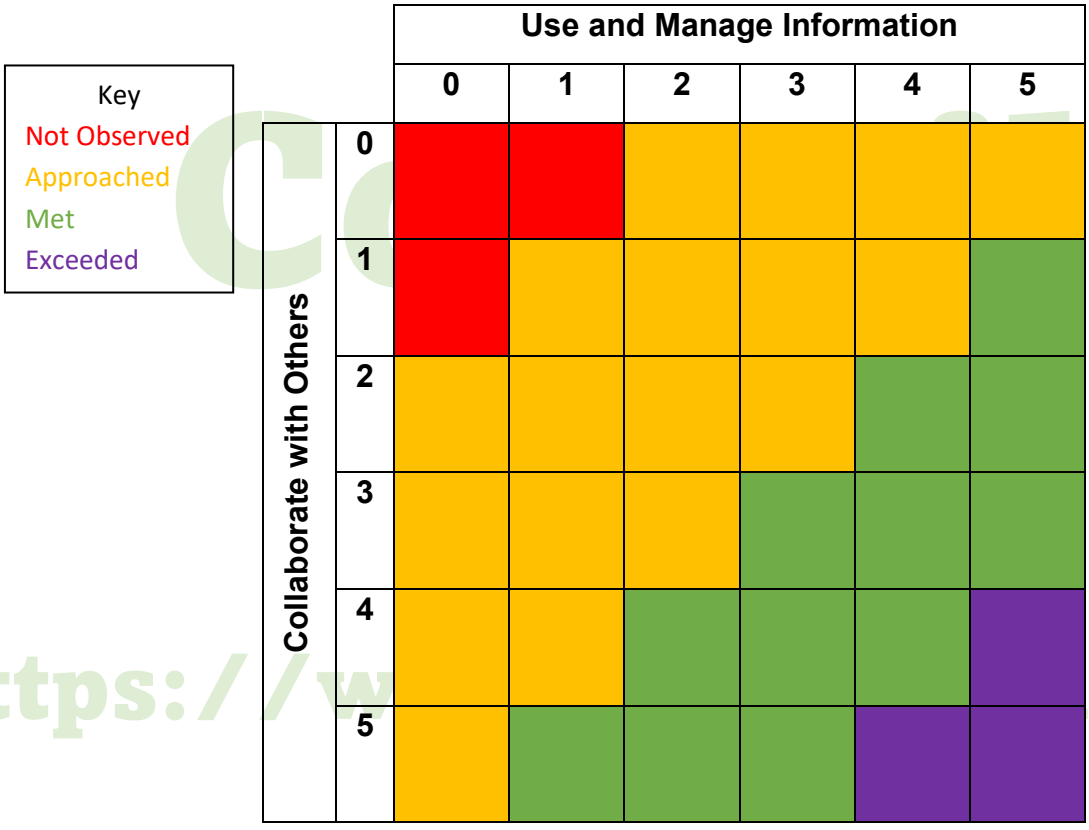
13. Prepare a 3 minute presentation where you will share the following information:

- data
- graph
- equation
- stuck points
- results of questions 10 and 11

## Partner Evaluation




## Self-Evaluation



## Evaluation Rubric for Lab

| Evidence can come from the presentation, observations, and student handout. | Great job! Fully developed reasoning (3 Points) | Almost there: Partially developed reasoning (2 points) | Getting there: Incomplete thinking (1 point) | Missing: No reasoning (0 points) |
|---|---|---|---|---|
| Clearly labeled and has values for all tests | | | | |
| Each data point is graphed | | | | |
| The line of best fit is graphed and is reasonable for the data | | | | |
| Equation has an accurate and reasonable slope | | | | |
| Equation has an accurate and reasonable y-intercept | | | | |
| Students communicate authentic stuck points and how they overcame them | | | | |
| Students communicate their answers and reasoning for questions 10 and 11 | | | | |
| Precision and Accuracy | | | | |
| Communicates clearly and uses appropriate mathematical vocabulary | | | | |
| Uses appropriate tools, including technology, strategically | | | | |
| Total out of 30 points | | | | |