Classroom Activity

Linear Relationship Activities

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Introduction

The National Council of Teachers of Mathematics (NCTM, 2000) suggests that students in grades 6 - 8 should be able to:

- Explore relationships between symbolic expressions and graphs of lines, paying particular attention to the meaning of intercept and slope;
- Use graphs to analyze the nature of changes in quantities in linear relationships.
- Model and solve contextualized problems using various representations, such as graphs, tables, and equations.

The following activities will help students develop both an understanding of linear relationships and an opportunity to apply their knowledge of linear relationships.

'Diving Board' Deflection

The linear relationship between the load and the deflection of the end of a cantilevered beam is well understood. While a diving board may represent a cantilevered beam more familiar to most students, a common meter or yard stick is an adequate and more convenient substitute for a classroom demonstration. (A meter or yard stick with approximate cross-sectional dimensions of 4 mm x 30 mm would be preferred – thinner sticks evidence greater deflection.)

Getting Started. Using a 10 cm (4 inch) C-clamp, secure the end of a meter stick to a rigid table or counter top. (the broad side of the meter stick should be parallel to the floor.) All but about 3 cm of the meter stick should extend unsupported from the table. Tie the prepared plastic bag (as described below in Rubber Band Tensile Test) to the meter stick through the hole at the unsupported end of the meter stick.

Collecting Data. The activity is conducted as follows:

- Measure and record the initial height of the unsupported end of the meter stick to the nearest millimeter.
- Insert a quarter into the bag. Similar uniform weights other than quarters may be used, as well.
- Measure and record the new height of the unsupported end of the meter stick.
- Repeat the procedure of inserting a quarter into the bag and measuring and recording the height of the unsupported end of the meter stick nine more times (until 10 quarters are in the bag).

Analyzing Data. The deflection of the meter stick will vary depending on the type of wood: an inexpensive pine meter stick deflects about 6mm per quarter. Plotting the deflection against the load (in one quarter increments) should yield a linear or very nearly linear relationship.

The following steps are suggested:

- Tabulate the recorded measurements in a chart. The Quarters column will have data from 0 to 10. The Deflection column will have corresponding measurement data in millimeters.
- Have the students create a scatter plot of this data.
- Now challenge students to determine an equation that models the observed data in $y = mx + b$ form. The use of a graphing calculator is recommended.

A completed table might resemble the following:

Table 1 Deflection data

Quarters	Deflection (mm)
0	130
1	136
2	141.5
3	148
4	154.5
5	160.5
6	167
7	173
8	179
9	185.5
10	191.5

Rubber Band Tensile Test

The next activity, which would be ideal for groups of three or four students, simulates a rubber band tensile test. Begin by assembling the rubber band stress/strain apparatus as shown in Figure 1.

Materials

- Rubber band (with a free length, after cutting, of 30 cm and a width of 3-4 mm, avoid rubber bands with a thin wide cross-section – approximately square cross sections)
- Plastic bag – (snack bag, 9 cm × 16 cm)
- 5-10 cm (2-4 inch) C-Clamp
- Measuring stick (30 cm or 1 m) with graduations in mm
- One nickel
- thirteen quarters (or similar uniform weights)
- Heavy duty staples and stapler
- Duct tape (one piece 5 cm × 8 cm)

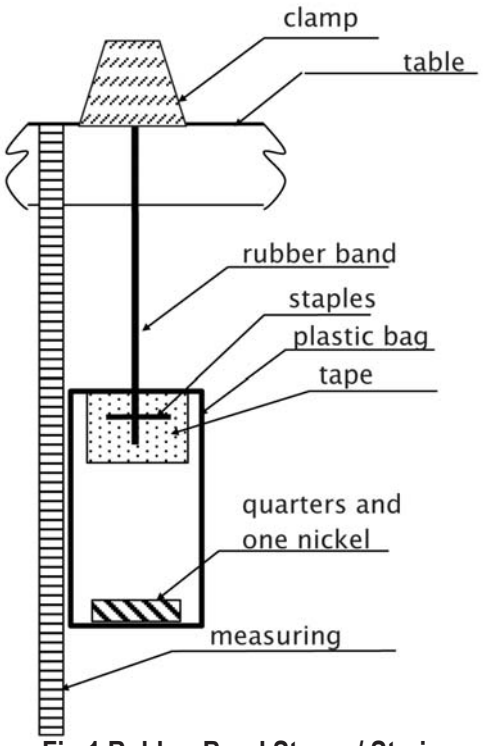

Fig 1 Rubber Band Stress / Strain Apparatus

Assembly

1. Cut rubber band – so that it is no longer a loop, but a rubber strip.
2. Attach duct tape to plastic bag - so that half of its length (about 4 cm) is affixed to one end of the bag. Then fold the remainder over the opposite side of the plastic bag (the tape reinforces the bag so that the staples do not tear the bag).
3. Attach the rubber band to the reinforced area of the plastic bag with heavy duty staples (ensure attachment is secure but do not use staples excessively – 3 should be plenty).

Conducting the Activity

- Clamp the rubber band to a rigid table or desk top, suspending about 22 cm from the edge of the table or desk.
- Insert one nickel into the plastic bag. (Eliminates initial slack in the assembly.)
- Measure and record the length, *L*, of the rubber band, as shown in Figure 2. (Ensure that the bag is not twisted and that the suspended rubber band hangs as straight as possible.)
- Insert one quarter into the plastic bag.
- Measure and record the length, *L*, of the rubber band, as shown in Figure 2.
- Continue adding quarters; one at a time, into the bag and recording the length, *L,* of the stretched rubber band until ten quarters have been added to the bag. When you have finished, create a two column data table showing the number of quarters in the bag and the corresponding length of the stretched rubber band. Students should also construct a scatterplot of this data and make a conjecture about the relationship between the variables.
- Challenge students to determine an equation that models the observed data in $y = mx + b$ form. The use of a graphing calculator is recommended.

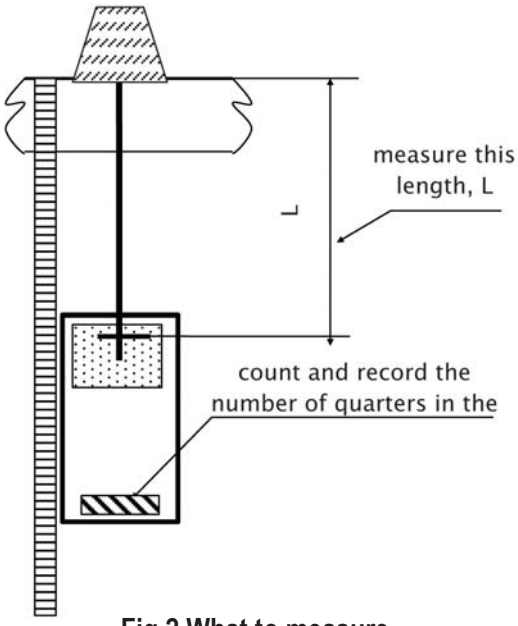

Fig 2 What to measure

Now ask students to predict the length of the rubber band after 3 more quarters have been added to the bag, (for a total of 13 quarters.) Allow each group to write its predictions on the board. Give each group three more quarters. Challenge groups to compare their results with their predictions. A completed table might resemble that shown in Figure 2.

Review/Reinforcement

YouTube features an assortment of laboratory tensile and compression test videos, that may, as they are conducted until failure, amuse if not inspire, the students. Challenge students to find one more tensile or compression test video on YouTube. Students should submit the URL from their browser and the video title to indicate which video they watched. They should also be asked to submit a brief written summary of the video.

Table 2 Strain data

Quarters	Deflection (mm)
0	223
1	225
2	229
3	230
4	231
5	234
6	236
7	237
8	239
9	240
10	242
11	246
12	247
13	250

In Conclusion

These activities have been well received by students in the middle school classroom. Their inclusion in a linear relationship unit affords students the opportunity to apply, and therefore enhance, their knowledge in a practical setting.

References

National Council of Teachers of Mathematics. *Principles and Standards for School Mathematics.* Reston, VA: The Council, 2000.

About the Author

The author of this activity, Mike Laub, passed away in 2010. He was a Masters of Arts in Teaching student at Towson University, majoring in secondary mathematics education. Dr. Krach was Mr. Laub's academic advisor at Towson University, and did final revisions of the activity. If you have any questions or suggestions, please contact Dr. R. Michael Krach at: rkrach@towson.edu.

Think About It!

It seems "learning" may not be that complicated

"Learning is the process by which memories are made ..."

McDermott, T. (2010). *101 Theory Drive: A neurologist's quest for memory, 17*. Pantheon Books. NY.