Graphing and Interpreting Linear and Nonlinear Relationships

Math Enrichment Activity 1

Fall Quarter 2020 – Grades 4-8

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Mountain Math Initiative

Supplies (Provided):
150cm Measuring Tape (2)
Ruler (1)
Flashlight with Batteries (1)
Graph Paper (4 sheets)
Address Labels (4)
Sourpatch Kids (candy) (1 box)
Starburst (candy) (1 pack)
Activity Instructions and Blank Data Tables (1)

Supplies (Required at home):
Pencil and eraser (1)
Calculator
Computer with Internet Access (7th and 8th Grade)

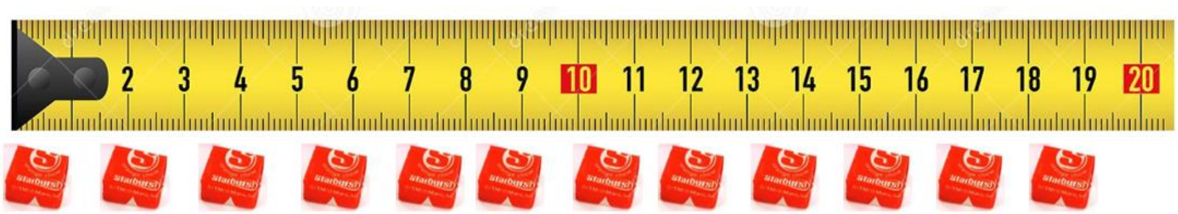
PART 1: LINEAR RELATIONSHIPS (Day 1)

In this activity, we are going to collect and analyze data on an activity that can be modeled with a linear graph and equation. It starts… with Starbursts! Don't eat them yet – you need all 12.

Preparation: Find a long, flat area where you can move easily and place starbursts at set intervals. This can be a long table or counter (if you move slowly) or on the floor or the ground. Open the Starburst package (not the individual candies), and hold the 12 wrapped candies in your hand.

Have a helper run a timer for you, or use the metronome timer provided on the activity website. The timer (or person with a stopwatch) will let you know every 2 seconds that have gone by.

Step 1: Activity. While walking **slowly** and **steadily** along the table or the ground, place a starburst on the surface every two seconds in a straight line. (Aim for approximately between 30 and 100cm between each one). Continue until all 12 of the candies are placed on the surface at approximately even intervals. *(Expect that some will be closer and some will be further apart – they should be approximately the same distance, but not exactly).*



Step 2: Measuring. We will be working in the metric system for this activity. Look at the measuring tape and find which side is in centimeters (cm) and which is in inches (in) (centimeters are smaller and are broken into 10ths – millimeters (mm)). Using the centimeter scale, measure the distance between each of the starbursts you laid down, to the nearest 1/10th of a cm (or the nearest mm). *Use a consistent method, such as measuring from leading edge to leading edge, or from center to center, etc.* Record your data in the table provided in column C – distance between candies.

Check in question: Looking at your data in column C, does your distances between candies all seem to be about the same? Do your candies look to be spaced about the same?

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Step 3: Complete Table. Fill in the total time that has elapsed for each candy placement (column B). Complete column D – total distance covered. Find this by adding the distance between candies (column B) to the previous total distance (column D).

A	B	C	D	E
CANDY (#)	**TOTAL TIME (SECONDS)**	**DISTANCE BETWEEN (CM)**	**TOTAL DISTANCE (CM)**	**RATE (CM/SEC)** *(6th - 8th grade)*
1	0		0	
2	2			
3	4			
4				
5				
6				
7				
8				
9				
10				
11				
12				

Step 4: Graphing. We are first going to graph the data by hand – this type of graph is called a scatterplot. Use a pencil in case of errors! Use the graph paper provided to follow the below instructions:

a) **Select a scale for your horizontal axis** (we will orient your paper in landscape – long side on the bottom). Select a scale so that you can get 30 seconds total to fit on the bottom edge. Label the axis every two seconds, and give the axis a title that includes units. (Time in seconds)
b) **Select a scale for your vertical axis.** Select a scale so that your furthest distance is about half way up the side, to allow for predictive graphing later. Make sure that your scale is easy to count by (nice round numbers – multiples of 5? 10? 20? 50cm?). Give the axis a title that includes units. (Distance in cm).
c) **Plot your data points.** We will be plotting the time (column B) versus the total distance (column D). Your first point should be (0,0) or zero seconds and zero distance. That is candy #1. Ask for help or watch the video if you are not sure how to plot these points on the graph.
d) **Connect your points.** Use the provided ruler to connect one point to the next.
e) **Give the graph a title.** Connect your two variables. (Maybe "Candy Distance over Time").
f) **Draw a line of best fit.** Use a colored pencil and a ruler to draw a single straight line that best represents all of your points. A good line of best fit will have approximately the same number of points above and below the line. You may also be able to get pretty close by just connecting the last point to the origin. Extend this line all the way past your 12 data points to the end of the paper.
g) Have your math coach or a parent check your graph. Is it good to go? Then enjoy your Starbursts!

************************************ **END OF DAY 1** ***************************************

DAY 2: INTERPRETING AND ANALYZING THE DATA

Work with your coach or a partner to answer the following questions:

1. If you were to cover more distance in the same amount of time (2 seconds), would the line on the graph be steeper? Or less steep? Why? ____

   ____

2. Between what points on your graph does it seem as though you were going fastest? How do you know?

   ____

   ____

3. Between what points on your graph does it seem as though you were going slowest? How do you know?

   ____

   ____

4. What factors could have affected the slight changes in speed over the course of this experiment?

   ____

   ____

   ____

5. Average speed is found by dividing distance by time. (Think miles per hour on a speed limit sign). Calculate your **average speed** by using the total time and distance for candy #12. What will the units be?

6. Let's make a prediction. Your line of best fit extends beyond your data points, and your graph has space out to 30 seconds. Assuming you had more starbursts, and continued to place them in a straight line at the same rate, how far would the candy be at
   26 seconds?

   30 seconds?

********************** **The next component is recommended for grades 6 – 8** **********************

The slope – or steepness - of a line is another way of describing rate of change. In this case, we are measuring the rate at which the candies travel. Speed is a type of rate. The slope of a line is calculated by finding the change on the vertical axis (distance) divided by the change on the horizontal axis (time). We are going to calculate the rate in cm/s between each candy you dropped.

Find Rate of Change: Divide the change in distance between two candies (column C) by the change in time between the two candies (2 seconds). Place your answer in column E. This is your actual speed, in cm/s, for that leg of the journey.

What was your fastest rate? ______________________

What was your slowest rate? ______________________

What was your average rate? (we found this yesterday) _____________________

Find percent change. We can find how much your rate changed from the average as a percent change. For example, you may find that your fastest rate was 12.5% faster than the average rate.

The formula for finding percent of change is:

Instead of "Old Value", let's use "average value."

Percent Change

$$\text{Percent Change} = \frac{\text{New Value} - \text{Old Value}}{\text{Old Value}} \times 100\%$$

If the result is positive, it is an increase.
If the result is negative, it is a decrease.

Find the percent change for your slowest rate:

And your fastest rate:

*********************** **The next component is recommended for grades 7 – 8** *********************

Please work with your Mountain Math Initiative Coach or use the video walkthrough on the website to learn how to enter data, use formulas in a spreadsheet to make your life easier, graph and interpret data, come up with an equation that models the data, and perform a basic linear regression on the data points.

PART 2: NON-LINEAR RELATIONSHIPS (Day 3)

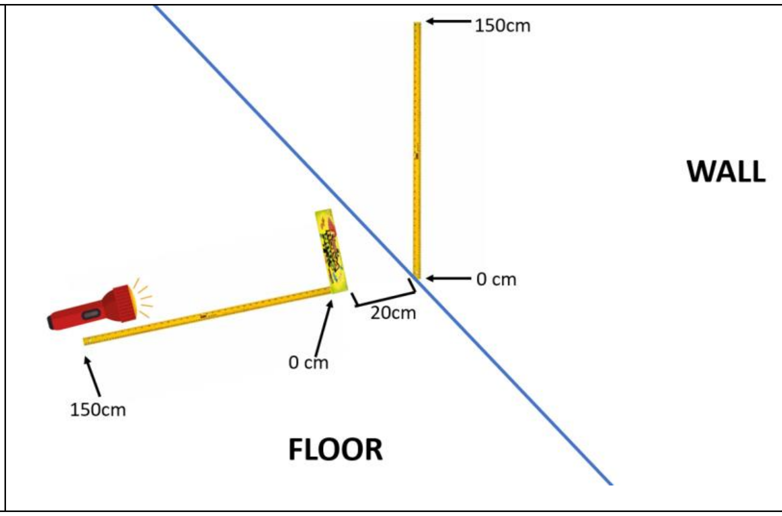
In this activity, we are going to collect and analyze data on a relationship that cannot be modeled with a straight line. We will conduct a simple experiment to find the relationship between the length of a shadow and the distance between the light source and the object. We will use a scatterplot and several methods of analysis to find the curve of best fit and evaluate its accuracy.

Preparation: You will need a fairly dark room to conduct this experiment.

1. Use the provided stickers to tape a measuring tape against the wall vertically so that the zero cm end rests against the floor. We will be using the centimeter (metric) side.

2. Place the box of Sour Patch Kids so that it stands vertically 20 cm in front of the wall-mounted measuring tape.

3. Use the provided stickers to fix your second measuring tape to the floor horizontally and perpendicular to the wall mounted measuring tape. The zero end should start at the box of candy.



Procedure: Record the height of the fixed object. Dim the lights in the room. Place the flashlight horizontally on the table next to or on the tape measure and shine it on your object from 150cm away. Observe the height of the shadow cast on the wall and record this data as point A. Repeat this process, with the flashlight moving 10cm closer to the box of candy for each data point. The last two points will be at distances of 5 and 1 cm.

1. **Complete the data table.**

2. **Complete a scatterplot (graph) of your data.** Select a scale that will best maximize the graph paper and uses easy round numbers. Give it a title and label your axis. Connect your points with the smoothest curve you can.

   Describe the relationship between the distance from the light source and the height of the shadow – is it linear?
   ____
   ____

3. Have your Math Initiative coach or a parent check your graph. Good to go? Enjoy your snack while we continue!

   Does the rate of change (steepness of your graph) seem to be the greatest when the flashlight is further away from the box? Or the closest?

Make Predictions:

What do you expect to happen to the slope of the curve as the light gets close to 0cm from the object?

Assuming a powerful enough light source and a tall enough wall, how high do you think the shadow would reach as the distance approached zero?

What do you expect to happen to the slope of the curve as the light gets much further from the object?

Assuming a powerful enough light source and plenty of room to back up, how high would you expect the shadow to be at a distance of 100m? Justify your answer.

Data:

Height (cm) of fixed object casting shadow:_____________________

Data Point	Distance Between Object and Light (cm)	Height of Shadow (cm)
A	150	
B	140	
C	130	
D	120	
E	110	
F	100	
G	90	
H	80	
I	70	
J	60	
K	50	
L	40	
M	30	
N	20	
O	10	
P	5	
Q	1	

****************************** The next component is recommended for grades 6 – 8 ***************************

Find the slope (rate of change) between points A and B.
Find the slope (rate of change) between points E and F.
Find the slope (rate of change) between points M and N.

************************** The next component is recommended for grades 7 – 8 ************************

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