

# The, "You Can Learn a Lot from a Graph" Unit

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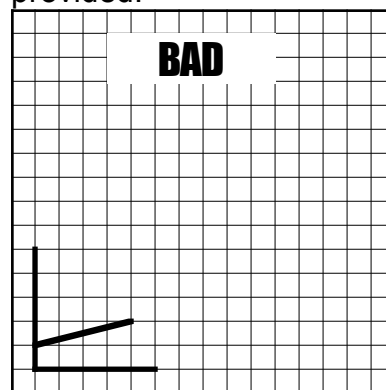
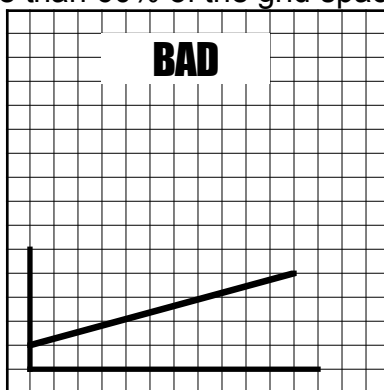
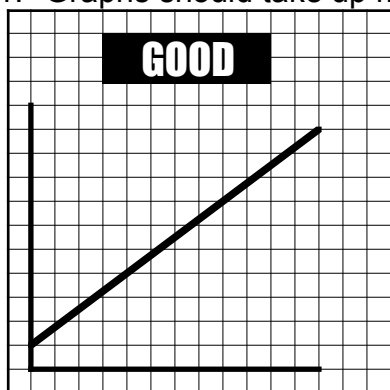
## Objectives:

Students will be able to:

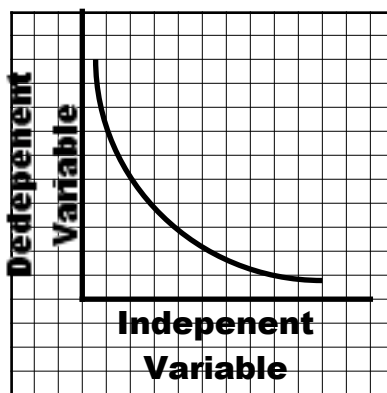
- Draw a graph with correct labels, units, number spacing, and best-fit line.
- Calculate slope of a given line.
- Write the equation for a line drawn from data in slope-intercept form.
- Draw a data points with correct error bars.
- Determine non-linear relationships from linear "curves"
- Identify independent and dependant variables
- Write the dependent and independent variables on a graph's correct axis's

A graph gives us a visual representation of an algebraic expression. To correctly interpret information from a graph, the graph itself must be drawn correctly. Here is a quick review of the basics you should know already.

1. Graphs should take up more than 60% of the grid space provided.



2. Graphs show the relationship between two variables or measured quantities.
3. Independent Variable: Decided upon by the experimenter.
4. Dependent Variable: Read or calculated from the lab.
5. The independent variable goes on the horizontal axis. The dependent variable goes on the vertical axis.



The independent variable is set by the person designing the experiment. It is the value recorded at predetermined intervals. The dependent variable is the variable read from a measurement device as part of the experiment.

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## **STUDENT EXERCISE #1**

For each situation described below identify a variable as either dependent or independent.

### **EXAMPLE**

5A. Every day the humidity is measured at 1:00 PM on the roof of the school.

INDEPENDENT VARIABLE: Time: Experimenter sets the time

DEPENDENT VARIABLE: Humidity: Result measurement

5B. The speed of a car is recorded every mile the car travels from home.

INDEPENDENT VARIABLE: Distance: Experimenter sets every mile

DEPENDENT VARIABLE: Speed: Result that is measured

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5C. A lady bug is placed on the edge of a cd. Every  $\frac{1}{10}$  of a second the bugs facial expression is examined.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

5D. Every day after lunch time the amount of trash on the breezeway is collected and weighed.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

5E. A car is driven into a unmovable cement wall, front first, at 7 mph. After each collision the, distance the front is smashed in is measured.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

5F. The height a super ball bounces is measured after each bounce.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

5G. In a cold study the researchers measure the amount of nasal discharge every 6 hours.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

5H. The time it takes to for a snail to travel every foot is recorded.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

5I. The number of students in each teacher's class is counted every period.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

5J. A car speeds up on a highway from rest. Every time the car's speed increases by 10 mph the time is recorded.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

5K. Every year the number of commercials during the superbowl is recorded.

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INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

- 5L. A model rocket is launched 10 times. Each time it is launched its maximum height is measured and recorded.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

- 5M. During the movie the Wizard of Oz, the number of times each person says the word "Oz" is recorded.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

- 5N. While walking between classes the number of times each student steps on a crack is recorded.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

- 5O. While watching the Power Rangers the seconds in between each time you hear "Go, go power Rangers," is said is recorded.

INDEPENDENT VARIABLE: \_\_\_\_\_

DEPENDENT VARIABLE: \_\_\_\_\_

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6. EACH axis should have a label. A label is concisely describes what is being measured (e.g., distance, velocity, time, acceleration, force, track position, angle of swinging arm, incident angle of light, velocity of car, etc.)

7. EACH axis should have a unit.

- a. Everything graphed to show a relationship will be in standard S.I. units.

Measured quantity → units it is measured in

- i. length → meters
- ii. time → seconds
- iii. mass → kilograms
- iv. force → Newtons
- v. energy → Joules,
- vi. power → Watt, etc.

- b. You may use abbreviations, such as those below, when describing the units.

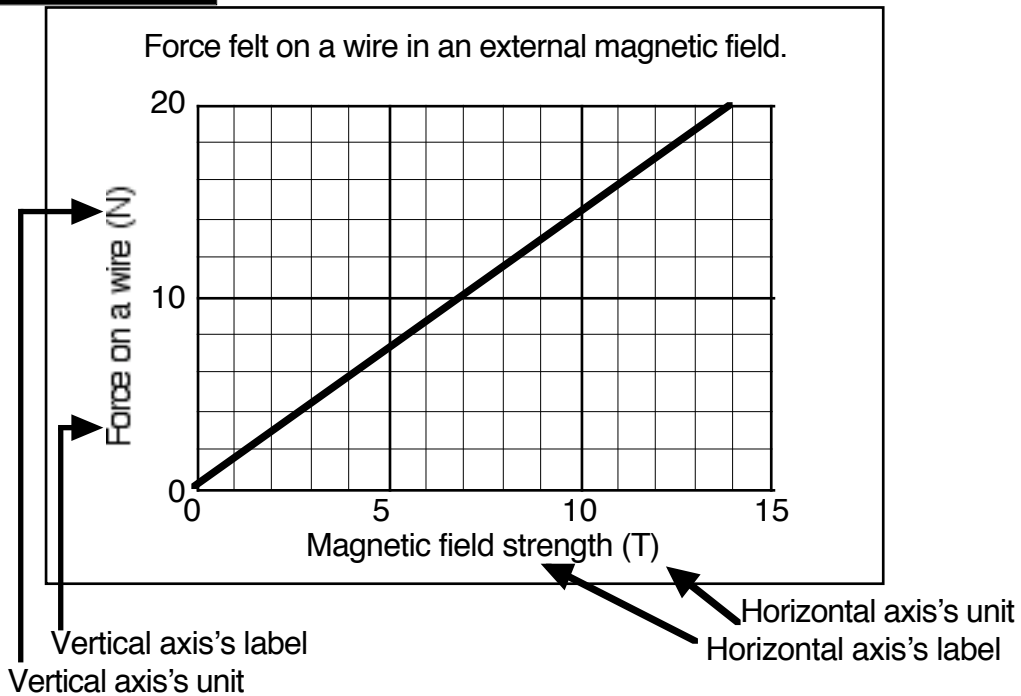
Measurement unit → its unit

- i. meters → m
- ii. seconds → s
- iii. kilograms → kg
- iv. Newtons → N
- v. Joules → J
- vi. Watt → W

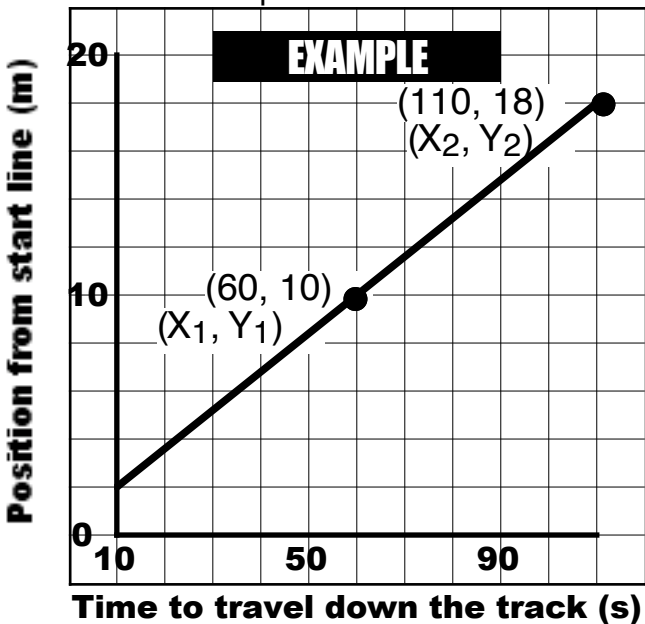
- c. Handy hint: When ever a unit is named after someone, it is capitalized, e.g., Sir Isaac Newton → N, James Prescott Joule → J, James Watt → W

# The, "You Can Learn a Lot from a Graph" Unit

## EXAMPLE



8. To calculate slope...



$$\text{Slope} = \frac{\Delta\text{Rise}}{\Delta\text{Run}} = \frac{\Delta y}{\Delta x} = \frac{(y_2 - y_1)}{(x_2 - x_1)}$$

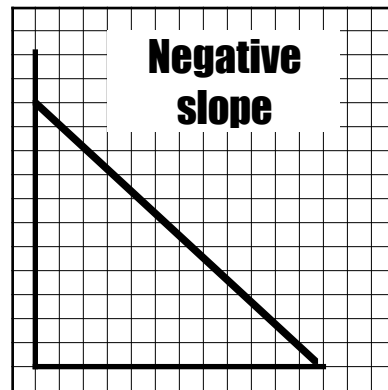
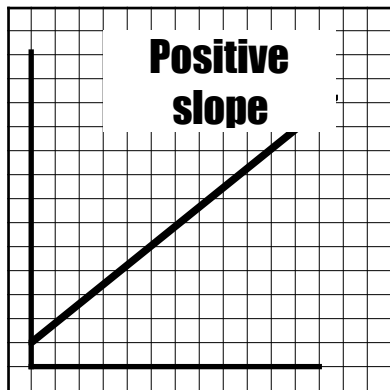
Note:  $x_1, y_2$  are always with the point farthest to the right. In other words, they are associated with the point later in time. These points can lie anywhere on the line. However, it is wise to choose locations at the corners of the grid.

$$\text{Slope} = \frac{(18 - 10)}{(110 - 60)} = \frac{8}{50} = \boxed{\frac{4}{25}}$$

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9. Slopes are positive and negative. On a typical graph...



10. The equation for a line on a graph is expressed in slope-intercept form.

$$y = mx + b$$

$y$  =  $y$ -coordinates for a point on the line

$x$  =  $x$ -coordinates for the same point on a line

$m$  = slope

$b$  =  $y$ -intercept ...where the line crosses the vertical axis

For the example graph above the equation is  $y = \left(\frac{4}{25}\right)x + b$ . It would be tempting to

look at the graph and call the  $y$ -intercept 2. **The problem with this interpretation is the fact that the graph's horizontal numbers do not start at zero. Therefore the axis at the left is not the  $y$ -axis. The  $y$ -axis is where  $x=0$ .**

11. To calculate the  $y$ -intercept, use  $y = mx + b$  and solve for  $b$ . Pick ANY point on the line to find  $x$  and  $y$ . Calculate the slope as shown above. Plug these values into  $y = mx + b$  and solve for  $b$ .

**EXAMPLE:** from the graph above.  $x = 60$ ,  $y = 10$  (that's the first point on the graph, from the data) and  $m = 4/25$ .

$$y = mx + b$$

$$10 = \left(\frac{4}{25}\right)60 + b$$

$$10 = \left(\frac{240}{25}\right) + b$$

$$\boxed{b = 0.4}$$

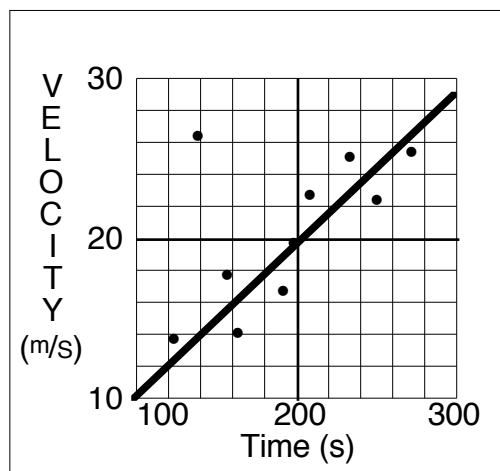
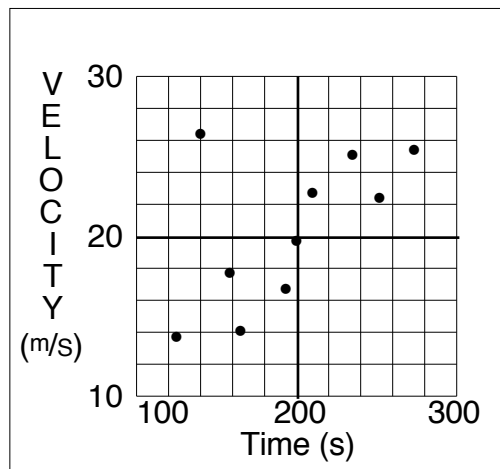
So the correct equation for the line is  $\boxed{y = \left(\frac{4}{25}\right)x + 0.4}$ .

12. Often in lab, you will generate graphs from data. Unlike math class, the points that are plotted will not line up perfectly. They should line up in a general direction as shown below.

If you held the graph far enough away so as to not see the dots clearly, you would see a fat line from the lower left to the upper right corner. This is the "general" direction of the line.

In this example there is a point in the upper left corner that is far away from the other points. This point does not follow the data and is called an "out lier." Out liers are due to errors in the lab. **Out liers are ignored.**

To represent this data, a line is drawn through the collection of data points, (as show to the right.) This line is a the, "regression line of best fit." This line is calculated by the least squares method. This line can be drawn by estimation by some students; however, we will use the graphing calculator to come up with an accurate line that will also describe how well the line represents the data.

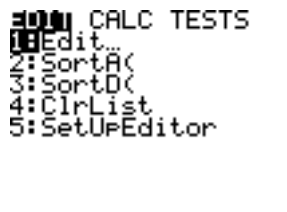
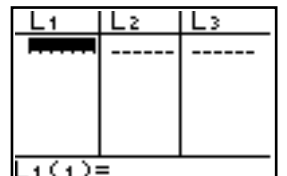
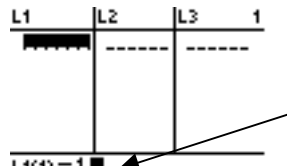
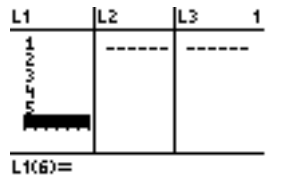
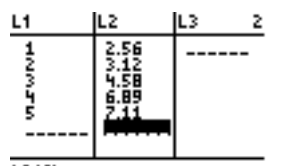
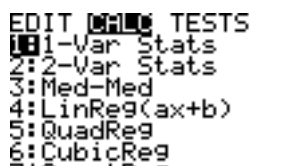
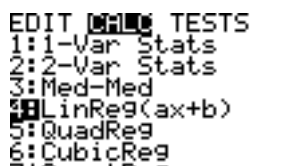


### Regression line of best fit background

When you get the regression line from the calculator, will give it to you in the standard form of  $y=mx+b$ . It will look like the picture to the right. "r" is the regression coefficient. " $r^2$ " is the regression coefficient squared. The closer  $r^2$  is to "1.00" the better the line represents the data. This gives a way to analyze the data. You will need to report " $r^2$ " for every line you calculate from a graph on a lab report.

```
InReg
y=ax+b
a=1.287
b=.991
r2=.9422387292
r=.9706898213
```

**Using your calculator.** All instructions shown below feature screen shots from a TI-84 calculator. The TI-82 and TI-83 look similar.

	<p><b>STATISTICS</b></p> <ul style="list-style-type: none"> <li>The goal is to find the average and plus or minus error of 2.56, 3.12, 4.58, 6.89 and 3.22.</li> <li>Press "Stat" in the 3rd row from the top and the 3rd column from the left. This is the menu you will see.</li> <li>Select "Edit"</li> </ul>
	<ul style="list-style-type: none"> <li>This is the screen you will see after selecting: "Edit."</li> </ul>
	<ul style="list-style-type: none"> <li>Type the first number, "1"</li> <li>Notice that the number shows up at the bottom of the screen</li> </ul>
	<ul style="list-style-type: none"> <li>After each number press enter.</li> <li>The list will look like this when all the numbers are entered.</li> <li>Note that the bottom of the list shows the entry number you are on.</li> </ul>
	<ul style="list-style-type: none"> <li>Move the cursor to the top of the second column.</li> <li>Begin entering the data.</li> </ul>
	<ul style="list-style-type: none"> <li>Press 2nd then Quit.</li> <li>Press the "STAT" button and use the arrow keys to move the cursor over to the menu item, CALC.</li> </ul>
	<ul style="list-style-type: none"> <li>Move the cursor down the list to LinReg (ax+b). This will generate an equation for the "best fit" line and some additional statistics.</li> </ul>

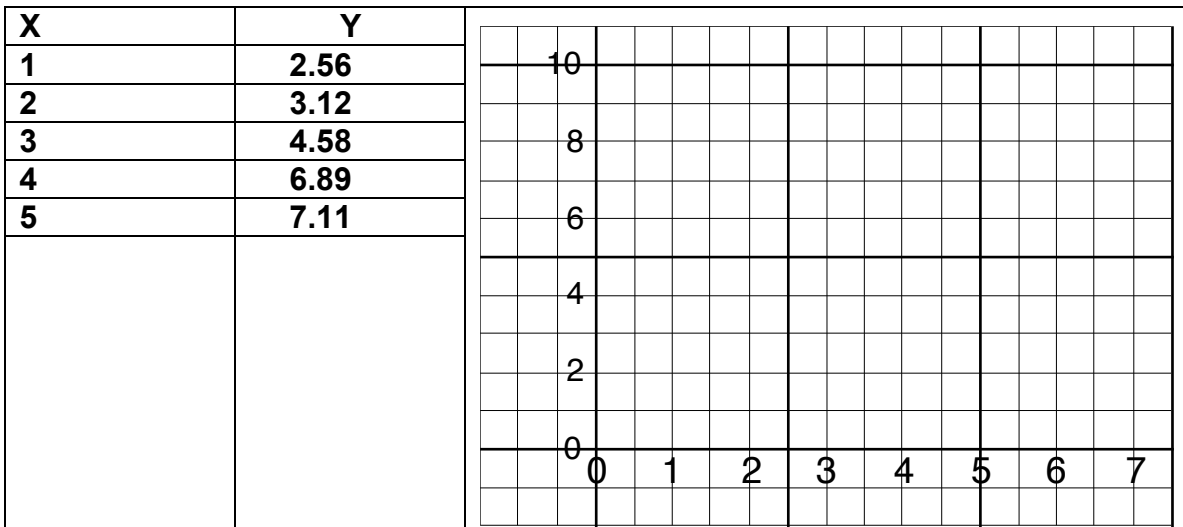
Continued on next page...

<pre>LinReg(ax+b) ■</pre>	<ul style="list-style-type: none"> <li>The command screen will look like this. Without touching any other buttons, the calculator will compare the items in L1 and L2.</li> </ul>																												
<pre>LinReg y=ax+b a=1.287 b=.991 r<sup>2</sup>=.9422387292 r=.9706898213 ■</pre>	<ul style="list-style-type: none"> <li>"a" is the slope</li> <li>"b" is the y-intercept</li> <li>"r<sup>2</sup>" is the regression coefficient squared. THIS IS IMPORTANT. The closer r<sup>2</sup> is to "1.00" the better your fits the data to minimize error.</li> </ul>																												
<pre>LinReg y=ax+b a=1.287 b=.991</pre>	<ul style="list-style-type: none"> <li>What if your screen looks like this instead?</li> <li>To remedy this, you will need to turn on the diagnostics. See the next row.</li> </ul>																												
<pre>CATALOG DependAsk DependAuto det( DiagnosticOff ▶DiagnosticOn dim( Disp</pre>	<ul style="list-style-type: none"> <li>Press 2<sup>nd</sup>, then CATALOG. "CATALOG" is above the 0,</li> <li>Scroll down to Diagnostics On.</li> <li>After selecting is press the enter key again. This will tell the calculator to calculate the regression coefficient</li> </ul>																												
<b>TIPS, TRICKS &amp; SHORTCUTS</b>																													
<pre>CATALOG DependAsk DependAuto det( DiagnosticOff ▶DiagnosticOn dim( Disp</pre>	<ul style="list-style-type: none"> <li>To scroll down to a letter section of the catalog listing, press the letter you want to jump to <u>WITHOUT</u> pressing the ALPHA key.</li> </ul>																												
<pre>EDIT [2ND] TESTS 1:1-Var Stats 2:2-Var Stats 3:Med-Med 4:LinReg(ax+b) 5:QuadReg 6:CubicReg 7:QuartReg</pre>	<ul style="list-style-type: none"> <li>Shortcut: If you press the number next the menu item, the calculator will automatically select this menu item.</li> </ul>																												
<pre>LinReg(ax+b) L1, L5</pre>	<ul style="list-style-type: none"> <li>Suppose you want to analyze the data in L1 as the "x" data and L5 as the "y" data. You would enter the two lists as shown with a comma between them.</li> </ul>																												
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">L1</th> <th style="width: 10%;">L2</th> <th style="width: 10%;">L3</th> <th style="width: 10%;">1</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2.56</td> <td>-----</td> <td></td> </tr> <tr> <td>2</td> <td>3.12</td> <td></td> <td></td> </tr> <tr> <td>3</td> <td>4.58</td> <td></td> <td></td> </tr> <tr> <td>4</td> <td>6.89</td> <td></td> <td></td> </tr> <tr> <td>5</td> <td>7.11</td> <td></td> <td></td> </tr> <tr> <td>-----</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <pre>L1=(1,2,3,4,5)</pre>	L1	L2	L3	1	1	2.56	-----		2	3.12			3	4.58			4	6.89			5	7.11			-----				<ul style="list-style-type: none"> <li>To clear a list of data, move the cursor to the top of the column, ABOVE THE NUMBERS. Press the CLEAR button followed by ENTER.</li> </ul>
L1	L2	L3	1																										
1	2.56	-----																											
2	3.12																												
3	4.58																												
4	6.89																												
5	7.11																												
-----																													

L1	L2	L3
-----	2.56	-----
-----	3.12	-----
-----	4.58	-----
-----	6.89	-----
-----	7.11	-----
L3 = L2 <sup>2</sup>		

- To perform a math operation, like squaring, on a list of numbers, move the cursor to the top of the list where the answer is to appear. Move the cursor above the numbers. Type the operation and press enter. In this screen shot, the numbers in list 2 have been squared and will be placed in list 3.

## STUDENT EXERCISE #2



12A. Using your calculator determine the equation for the line of best fit. Write it below.

\_\_\_\_\_

12B. What is the slope of the line of best fit?

\_\_\_\_\_

12C. At what point does the line cross the y-axis?

\_\_\_\_\_

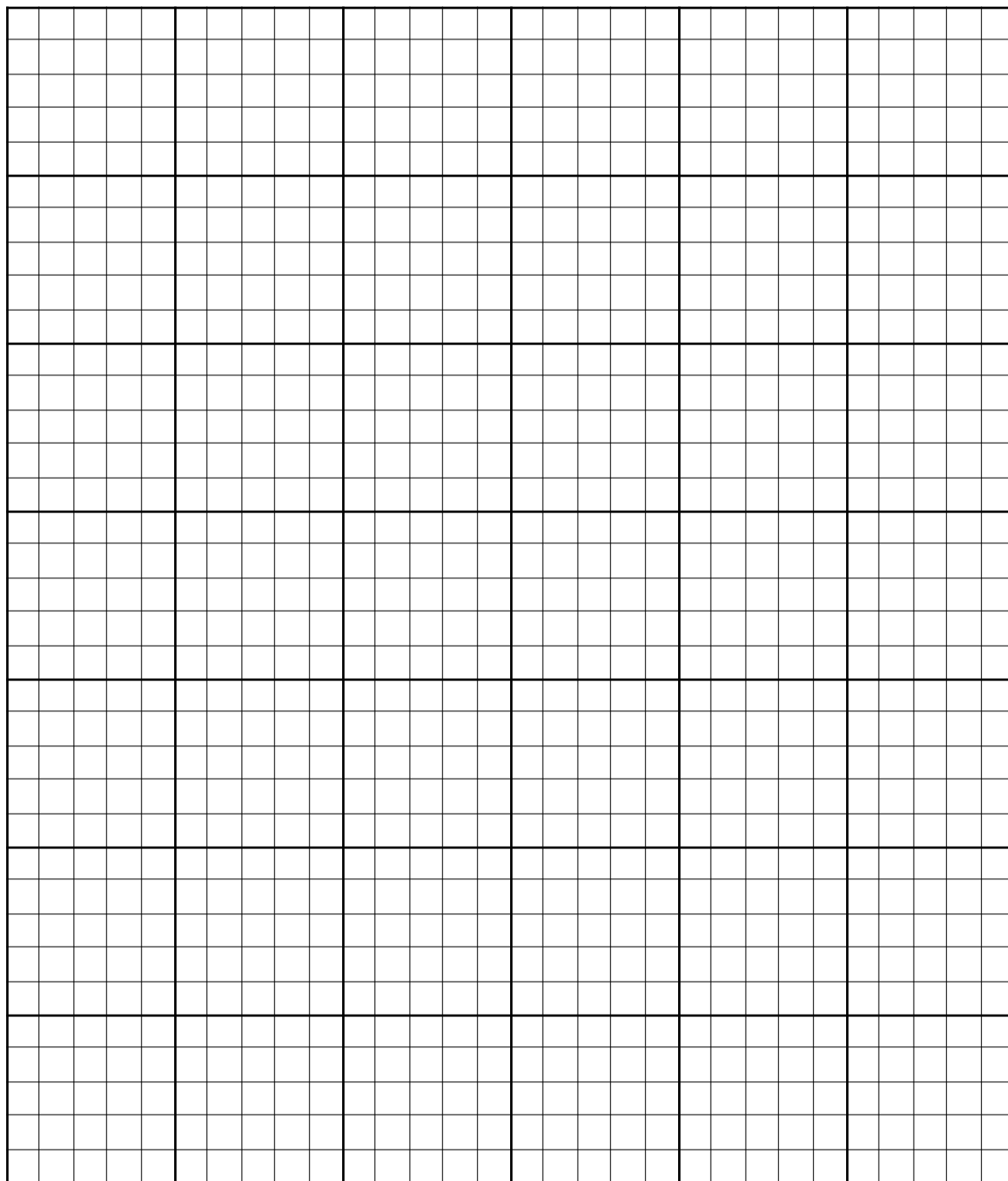
12D. How well does the line of best fit describe the data? In other words, what's "r<sup>2</sup>?"

\_\_\_\_\_

12E. Add labels and unit to the graph above, plot the data points and draw the line of best fit.

## **STUDENT EXERCISE #3**

In an experiment, a spring is stretched by a known force. The experimenter pulls spring with the following forces: 2N, 3N, 3.5 N, 5N, 5.5N. The spring stretches the following corresponding distances: 0.26m, 0.43m, 0.48m, 0.59m, and 0.64m by those forces.



Set up a correct graph, title, labels, and axes. Find the slope and line's best-fit equation using your calculator. Plot this line.

# The, "You Can Learn a Lot from a Graph" Unit

Using a graph to make a formula.

## The Language of Math

$y = mx + b$  .....  $y$  is directly proportional to  $x$ .

$y = mx^2 + b$  .....  $y$  is proportional to  $x^2$ .

$y = mx^3 + b$  .....  $y$  is proportional to  $x^3$ .

$y = m\left(\frac{1}{x}\right) + b$  .....  $y$  is inversely proportional to  $x$

$y = m\left(\frac{1}{x^2}\right) + b$  .....  $y$  is inversely proportional to  $x^2$ .

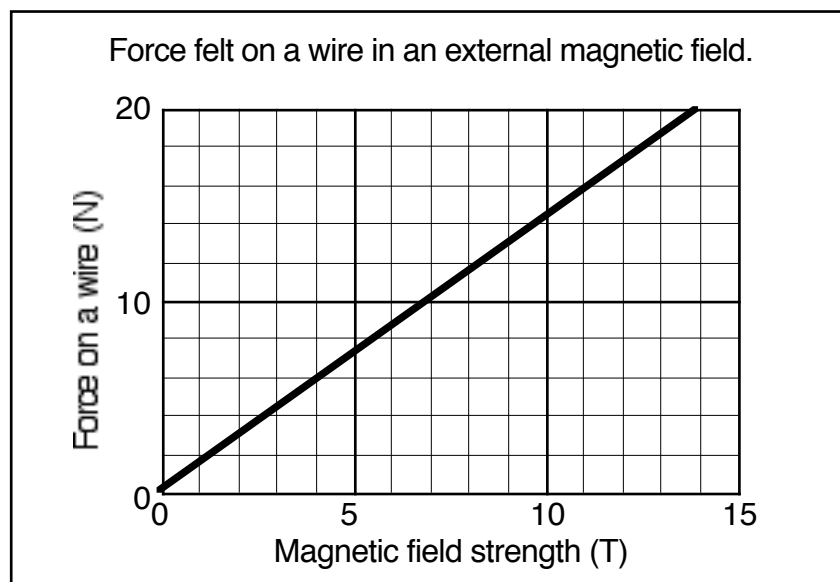
You are going to use these phrases to describe lab results all year in your conclusions whenever the objective to find the equation relating two variables to find the proportionality between two variables

## How to Figure Out an Equation.

The generic formula for a line is

$$y = mx + b$$

What this really means is that what every variable on the  $y$ -axis is related to the variable on the  $x$ -axis by "m." Where  $m$  is the slope of the line.



This graph says,

$$y = mx + b$$

therefore  $y = (0.43)x + 0$  ... (the slope of 0.43 can be calculated from the calculator.)

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And therefore  $y = (0.43)x$

The graph shows that the y-axis is "Force on a wire." The graph also shows that the x-axis is, "Magnetic field strength." If the variable for force is "F," and the variable for magnetic field is "M," then in the formula, "y" = F and "x" = M therefore the math equation of  $y=(0.43)x$  becomes (Force on a wire) = (0.43) (Magnetic field strength)

OR in variables

**F = (0.43)M** ...this is the is what will need to be reported in a lab with a **graph**. With this graph you can choose any value of M and calculate the force. THIS IS WHAT SCIENCE IS ABOUT –modeling and predicting behaviors.

### WORKING EXAMPLE Do what it says in this order.

Suppose you had the data shown below. Do you see the relationship between the two columns? The purpose of this exercise is to show you how to find the relationship between two variables from a graph.

1	2	3	4	5
Current through two wires (Amps)	Force of attraction (N)	Force of attraction squared ( $N^2$ )	Inverse Force of attraction squared ( $1/N$ )	Inverse Force of attraction squared ( $1/N^2$ )
1	0.50			
2	0.25			
3	0.17			
4	0.13			
5	0.10			
$r^2 =$				

1. Take each number in the force column, square it and place it in the third column.
2. Take each number in the force column, and inverse them, ( $1/N$ ), and place it in the fourth column.
3. Take each number in the force column and square then inverse them and place them in the fifth column.
4. Follow the instructions beginning on page 7 to type column 1 into L<sub>1</sub>, column two into L<sub>2</sub>, column three into L<sub>3</sub>, column 4 into L<sub>4</sub>, and column 5 into L<sub>5</sub>.
5. Use the linear regression instructions, also beginning on page 7, to find the line of best fit for the list pairs shown below. For each pair list the  $r^2$  value at the bottom of the column on this page.

LinReg(ax+b) L<sub>1</sub>,L<sub>2</sub>

LinReg(ax+b) L<sub>1</sub>,L<sub>3</sub>

LinReg(ax+b) L<sub>1</sub>,L<sub>4</sub>

LinReg(ax+b) L<sub>1</sub>,L<sub>5</sub>

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6. Which column has the  $r^2$  value closest to 1? This column has the math relationship.

7. Write the formula for this relationship using the axes of the graph that work;  $y = m(f(x)) + b$

Here is an example of what is meant from a different experiment. Each time you check a function, you create an equation choice. For this data here are the choices.

Force  $\rightarrow y = mx + b \rightarrow$  which becomes  $F = mA + b$  with this experiment's variables

Force<sup>2</sup>  $\rightarrow y^2 = mx + b \rightarrow$  which becomes  $F^2 = mA + b$  with this experiment's variables

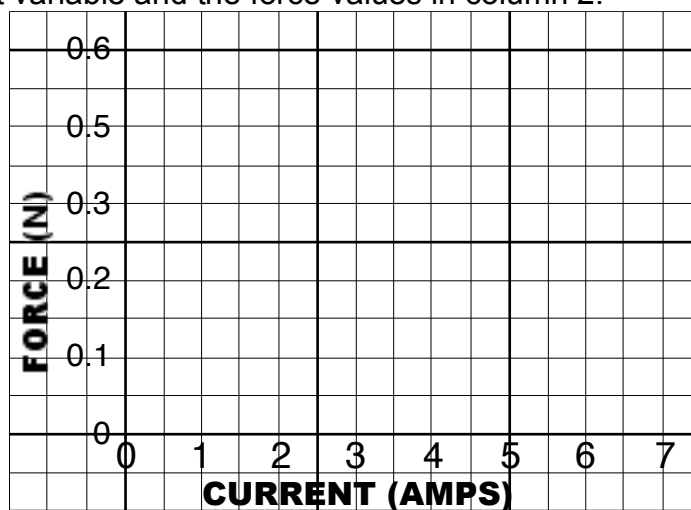
$\frac{1}{\text{Force}} \rightarrow \frac{1}{y} = mx + b \rightarrow$  which becomes  $\frac{1}{F} = mA + b$  with this experiment's variables

$\frac{1}{\text{Force}^2} \rightarrow \frac{1}{y^2} = mx + b \rightarrow$  which becomes  $\frac{1}{F^2} = mA + b$  with this experiment's variables

Now look at the  $r^2$  values. The one that is closest to 1 tells you relationship that works.

For example in a different experiment, two pieces of a data give me an  $r^2$  value of 0.999 were  $V^2$  for the dependent variable and  $K$  for the independent variable. This value is the closest one to 1. Then  $y = mx + b$  becomes  $V^2 = mK + b$ . If the LinReg command on my calculator gave me  $m = 4.58$  and  $b = -2.43$ . Then I would write the final relationship as  $V^2 = (4.58)K - 2.43$ .

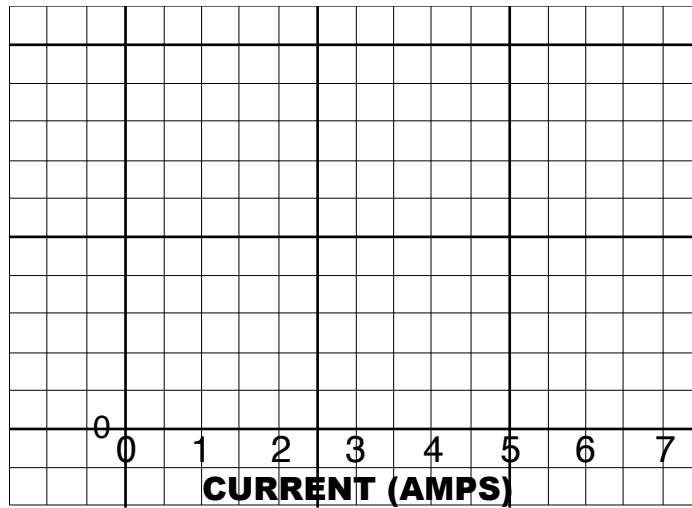
8. On the graph below, plot and draw the best fit line for the data from this experiment. Use the dependent variable and the force values in column 2.



9. Choose the column with the  $r^2$  value closest to 1 and complete the vertical axis and plot this column's data.

## The, "You Can Learn a Lot from a Graph" Unit

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10. What do you notice about the graph where  $r^2$  is closest to 1 versus the graph in #8?

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## The, “You Can Learn a Lot from a Graph” Unit

### CALCULATOR TRICKS & TIPS

#### How to plot data from the lists

<pre> EDIT  CALC  TESTS 1:Edit... 2:SortA( 3:SortD( 4:ClrList 5:SetUpEditor         </pre>	<p>To plot the data, press the “STAT” button.</p> <p>From the menu choices, select “EDIT” and “1:Edit.”</p>																												
<table border="1" style="font-family: monospace; border-collapse: collapse;"> <thead> <tr> <th>L1</th> <th>L2</th> <th>L3</th> <th>2</th> </tr> </thead> <tbody> <tr> <td>1.000</td> <td>1.000</td> <td></td> <td></td> </tr> <tr> <td>2.000</td> <td>2.000</td> <td></td> <td></td> </tr> <tr> <td>3.000</td> <td>4.000</td> <td></td> <td></td> </tr> <tr> <td>4.000</td> <td>8.000</td> <td></td> <td></td> </tr> <tr> <td>5.000</td> <td>16.000</td> <td></td> <td></td> </tr> <tr> <td>-----</td> <td>-----</td> <td></td> <td></td> </tr> </tbody> </table> <p>L2(D)=1</p>	L1	L2	L3	2	1.000	1.000			2.000	2.000			3.000	4.000			4.000	8.000			5.000	16.000			-----	-----			<p>Enter the data in two lists.</p>
L1	L2	L3	2																										
1.000	1.000																												
2.000	2.000																												
3.000	4.000																												
4.000	8.000																												
5.000	16.000																												
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<pre> STAT PLOTS 1:Plot1...On   ^ L1  L4  . 2:Plot2...Off   ^ L1  L2  . 3:Plot3...Off   ^ L1  L2  . 4↓PlotsOff         </pre>	<p>Press “2<sup>nd</sup>” and “STAT PLOT”</p> <p>Choose “1:Plot1.”</p>																												
<pre> Plot1 Plot2 Plot3 On Off Type: L1 L2 L3 L4 Xlist:L1 Ylist:L4 Mark:  .  +  ■         </pre>	<p>This is the preference screen for Plot1.</p> <p>Make sure it is turned on.</p> <p>Select the line plot. This is the middle “Type:” choice.</p> <p>Change “Xlist:” to contain the list of data for the x-axis.</p> <p>Change “Ylist” to contain the list of data for the y-axis.</p>																												

# The, "You Can Learn a Lot from a Graph" Unit

# PRACTICE

DATA SET 1		DATA SET 2		DATA SET 3	
Independent	Dependent	Independent	Dependent	Independent	Dependent
Speed an amusement park ride spins. (m/s)	Time to complete one cycle of motion. (s)	Mass of a boomerang (kg)	Radius of boomerang's orbit. (m)	Guitar string's frequency (Hz)	Force tightening the string (called tension). (N)
2	15.7	0.50	5.25	330	536.6
4	7.85	0.60	5.32	331	537.4
6	5.24	0.70	5.50	332	538.2
8	3.90	0.80	5.64	333	539.0
10	3.21	0.90	5.80	334	539.9

**RESULTS:** For each data set, list the "a" and "b" coefficients and the "r<sup>2</sup>" value

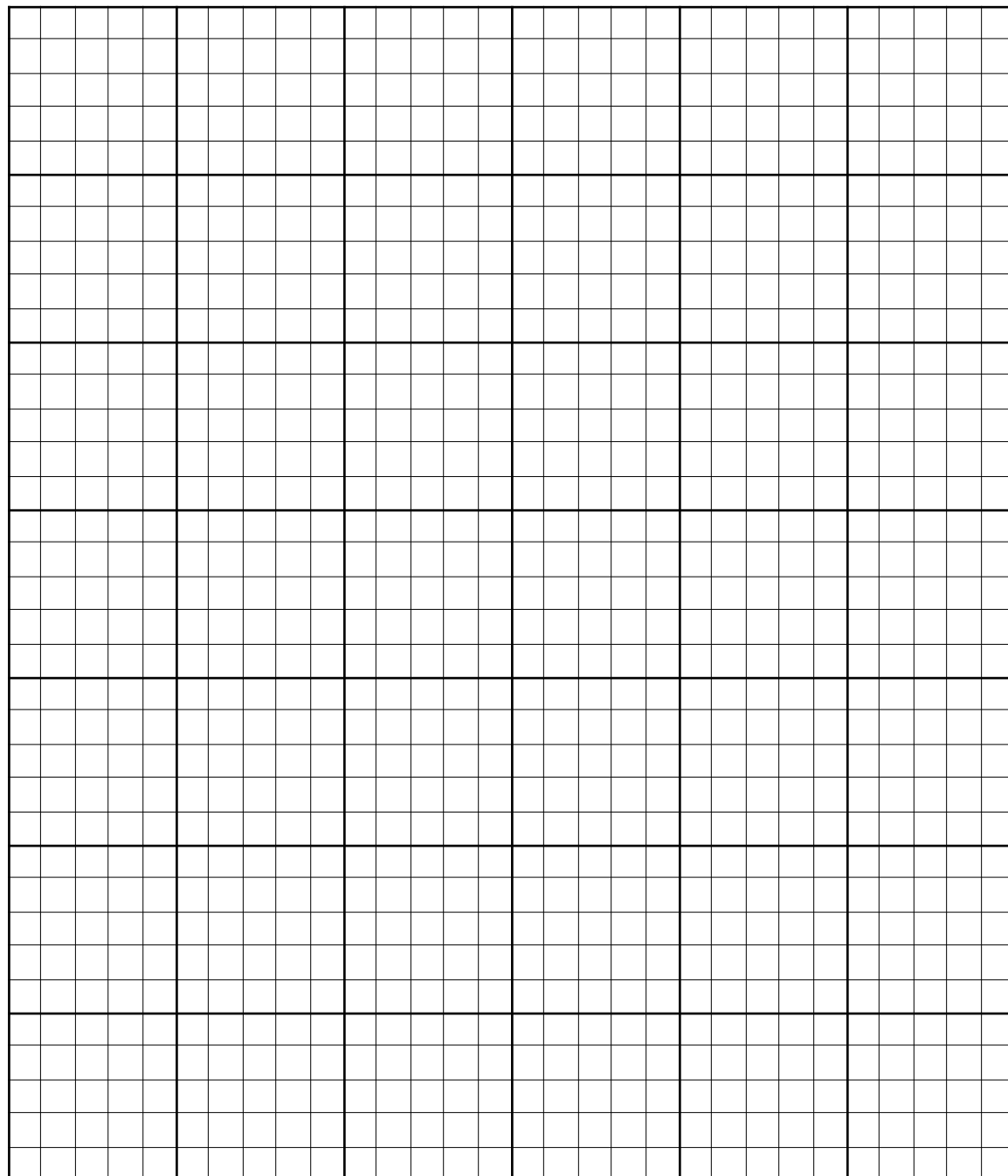
$x = y$	a = b = r <sup>2</sup> =		a = b = r <sup>2</sup> =		a = b = r <sup>2</sup> =
$x = y^2$	a = b = r <sup>2</sup> =		a = b = r <sup>2</sup> =		a = b = r <sup>2</sup> =
$x = \frac{1}{y}$	a = b = r <sup>2</sup> =		a = b = r <sup>2</sup> =		a = b = r <sup>2</sup> =
$x = \frac{1}{y^2}$	a = b = r <sup>2</sup> =		a = b = r <sup>2</sup> =		a = b = r <sup>2</sup> =
$x = \sqrt{y}$	a = b = r <sup>2</sup> =		a = b = r <sup>2</sup> =		a = b = r <sup>2</sup> =

Write out your equation and proportionality below

<b>DATA SET 1</b>	
<b>DATA SET 2</b>	
<b>DATA SET 3</b>	

## **WORKING EXAMPLE Continued**

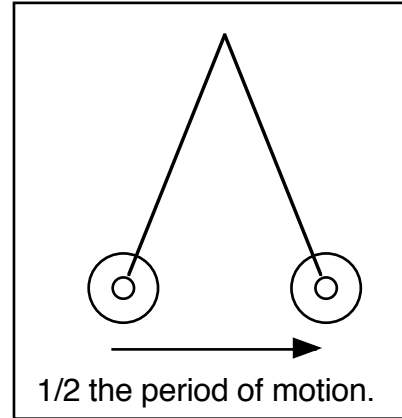
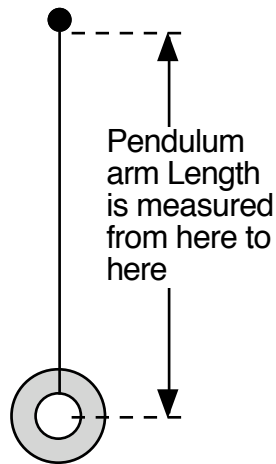
Using your **DATA SET 1** and your calculations, plot a graph of the data with the line of best fit.



Set up a correct graph, title, labels, and axes

**Objective:** To find the relationship between the length of the pendulum and the period of motion.

**Background:** The period of motion is the defined to be the time for the motion to repeat itself. The pendulum will swing back and forth. Pull it away from the vertical at ANY angle less then about 10° with the vertical. Let it swing back and forth 10 times then divide this time by 10 to get the period of motion for one swing back and forth.



**Materials:**

- Pendulum
- Stopwatch
- Meter stick

**Procedure:**

1. Measure the distance from the knot farthest way from the washer to the center of the washer in meters. This length is called the "pendulum arm."
2. Time the period of motion.
3. Fill out the data table.
4. Choose a new length and time it too.
5. After you have collected 5 trials, use your calculator to determine the relationship between the pendulum arm's length and the period of motion

DATA		
Trial	Pendulum arm's length (m)	Period of motion (s)
1		
2		
3		
4		
5		

length and the period of motion

RESULTS	a =
$y = x$	b = $r^2 =$
$y = x^2$	a = b = $r^2 =$
$y = \frac{1}{x}$	a = b = $r^2 =$
$y = \frac{1}{x^2}$	a = b = $r^2 =$
$y = \sqrt{x}$	a = b = $r^2 =$

6. If "T" is the symbol for the period of motion and "L" is the symbol for the pendulum arm's length. Write the proportionality statement. In the box below.

**Objective:** (1) To find the relationship between the number of C-clamps and the period of motion. (2) To use this equation to estimate the mass on an unknown object in terms of C-clamps.

**Background:** The period of motion is the defined to be the time for a motion to repeat itself. The pendulum will swing back and forth. You will pull it SIDEWAYS about 3 cm. Let it swing back and forth 10 times them divide this time by 10 to get the period of motion for one swing back and forth.

**Materials:**

Inertia Pendulum    Stopwatch    4 C-clamps    1-unknown mass

**Procedure:**

1. Without anything attached to the pendulum's tray, hold a piece of paper on one side of the tray; pull it SIDEWAYS 3 cm; Let it go and time how long it takes to hit the paper 11 times. Start timing on the first hit.
2. Divide this time by 10 to get the period of motion. It will move VERY fast. Record your data.
3. Attach 1 C-clamp as shown and time it again. Record your data.
4. Attach 2 C-clamps as shown and time it again. Record your data.
5. Attach 3 C-clamps as shown and time it again. Record your data.



DATA	
Number of clamps	Period of motion (s)
0	
1	
2	
3	
unknown	

7. After you have collected trials 0 through 3, use your calculator to determine the relationship between the number of clamps and the period of motion. If "T" is the symbol for the period of motion and "C" is the symbol for the C-clamp. Write the proportionality statement and equation in the box below.

RESULTS	
$y = x$	a = b = $r^2 =$
$y = x^2$	a = b = $r^2 =$
$y = \frac{1}{x}$	a = b = $r^2 =$
$y = \frac{1}{x^2}$	a = b = $r^2 =$
$y = \sqrt{x}$	a = b = $r^2 =$ $r^2 =$

**Objective:** To find the relationship velocity and stopping distance of the car.

**Background:** The car will speed towards the start or zero line at the entered speed. It will then lock up its brakes and skid to a stop.

**Materials:**  
Internet access.

**Procedure:**

1. Press the new experiment button.
2. After car skids to a stop record the data and adjust the speed as shown.
3. Stop collecting data once the car hits the wall.
4. After the car has hit the wall, use your calculator to determine the relationship between the car's speed and the stopping distance.

DATA	
Car speed (m/s)	Stopping Distance (m)
5	
10	
15	
20	
25	
30	
35	
40	
45	
50	
55	
60	

RESULTS	
$y = x$	a = b = $r^2 =$
$y = x^2$	a = b = $r^2 =$
$y = \frac{1}{x}$	a = b = $r^2 =$
$y = \frac{1}{x^2}$	a = b = $r^2 =$
$y = \sqrt{x}$	a = b = $r^2 =$

5. If "v" is the symbol for the car's speed and "d" is the symbol for the stopping distance, the write the proportionality statement in the box below.

**Objective:** To find the relationship hanging mass and the deflection of a ruler from the horizontal position.

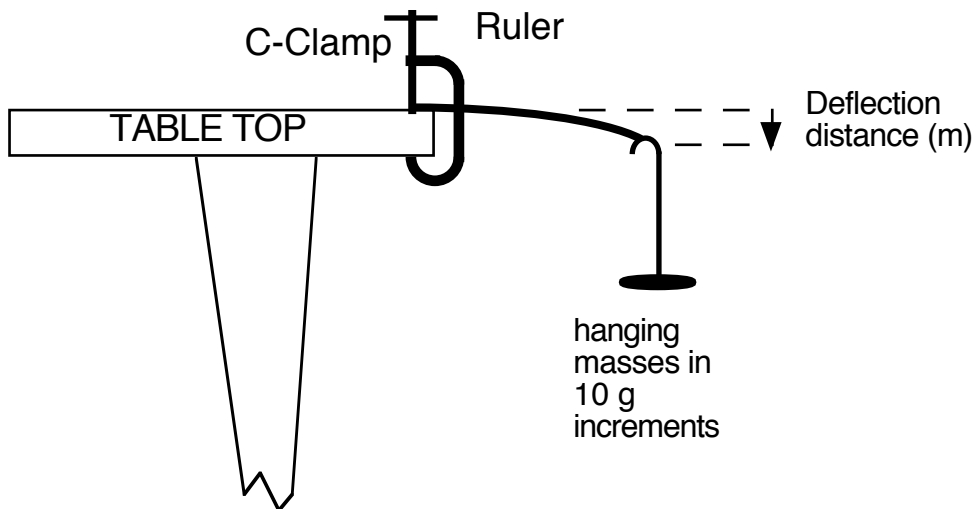
**Background:** By hanging a mass on the end of a ruler it will deflect, bend, downwards. This activity models springs on a car or a person on a diving board.

**Materials:**

Meter stick, 1-plastic ruler, 1 wooden ruler, C-clamp, paper clip, mass hangers with masses, table edge.

**Procedure:**

1. Clamp or hold the end of the plastic ruler on the table. Make sure a paper clip is attached to the end that hangs. Do not slide the ruler once in place. If you slide the ruler you must start over.
2. Attach different mass to the end of the ruler to bend it.
3. Hold a ruler next to this rule. Do not hand any mass on this second ruler.
4. With a third ruler, measure the distance below the second ruler. This is the deflection distance.
5. Repeat this process with different masses. Do not exceed 150 grams!!! Exceeding 150 grams could mess up your results.



DATA	
Hanging mass (g)	Deflection Distance (m)

RESULTS	
$y = x$	a = b = $r^2 =$
$y = x^2$	a = b = $r^2 =$
$y = \frac{1}{x}$	a = b = $r^2 =$
$y = \frac{1}{x^2}$	a = b = $r^2 =$
$y = \sqrt{x}$	a = b = $r^2 =$

If "m" is the symbol for the mass and "d" is the symbol for the deflection distance, write the proportionality statement and equation below.