CNS Institute for Physics Teachers

Title:	**Seeing Math: An Introduction to Graphing**
Initial Version **Revision:**	7 September 2008 10 September 2011
Authors:	Jim Overhiser, Dwight "Buzz" Putnam
Appropriate Level:	High School Physics
Abstract:	A series of guided activities that will illustrate various mathematical relationships seen in a standard physics course of study. Students will collect data and use EXCEL to create scatter graphs.
Time Required:	120 minutes lab period
NY Standards Met:	STANDARD 1 M1.1 Use algebraic or geometric representations to describe and compare data. • Represent physics quantities in graphical form • Construct graphs of real-world data (scatter plots, line or curve best-fit) M2.1 Use deductive reasoning to construct and evaluate conjectures and arguments, recognizing that patterns and relationships in mathematics assist them in arriving at these conjectures and arguments • Interpret graphs to determine the mathematical relationship between the variables. M3.1 Apply algebraic and geometric concepts and skills to the solution of problems. • Explain the physical relevance of properties of a graphical representation of real-world data, e.g. slope, intercepts, area under the curve STANDARD 2. 1.1 Understand and use the more advanced features of word procession, spreadsheets, and database software.
Special Notes:	This activity assumes student access to computer with graphing and data base software installed.

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Behavioral Objectives:
Upon completion of this lab activity, students should be able to:

- Construct a labeled scatter graph using Microsoft EXCEL.
- Describe the mathematical relationship shown by a trend line on a graph.

Class Time Required:

- 120 minutes

Teacher Preparation Time:

- Minimal. Setting out materials and background reading.

Tips for the Teacher:

- Check all meters and batteries prior to lab.
- Study material defect information.
- Students need access to computers with graphing and data base software installed.

Assumed Prior Knowledge of Students:

- Independent vs dependent variable in data

Background Information for Teacher:
This activity is an introductory activity for a general High School Physics class and applies math skills. The physics content is very light and not significant to the performance and understanding in this activity.

Answers to Questions: send email to cipt_contact@cornell.edu to request answers

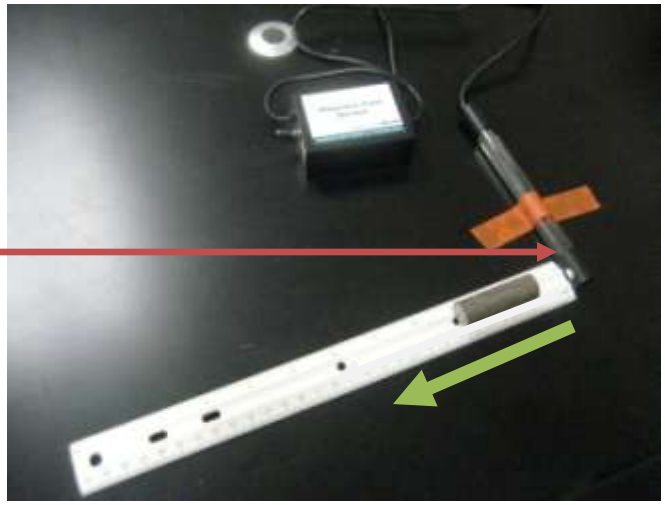
Seeing Math: An Introduction to Graphing

Quantity	Items
Station 1	
1	Vernier LabQuest
1	Vernier Magnetic Field Sensor
1	Magnet (cylindrical works best)
1	Metric ruler
Station 2	
1	Spring
1	Test tube clamp
1	Mass set with hook
1	Small ring stand (provided by teacher)
1	Meter stick (provided by teacher)
Station 3	
1	50-g mass
1	100-g mass
1	200-g mass
1	500-g mass
1	Protractor
1	String
1	Stop watch
1	Hook clamp
1	Small ring stand (provided by teacher)
1	Meter stick (provided by teacher)
Station 4	
1	Vernier LabQuest
1	Vernier Go-Motion® Detector
Station 5	
1	Vernier LabQuest
1	Vernier Go-Motion® Detector
1	Large coffee filter
1	2-meter stick (provided by teacher)

Station 1: Magnetic field meter

Materials:

- Magnet
- LabQuest or computer with Logger Pro software installed
- Vernier Magnetic field tester
- Metric ruler



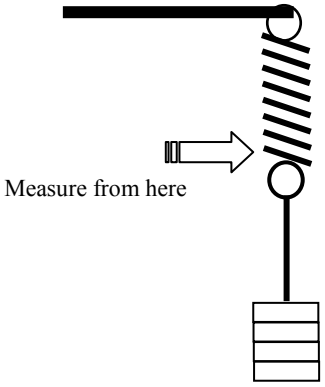
Directions:

- Record the magnetic field strength (Place the magnet right next to the probe at 1 cm mark to begin and record the field strength. ***NOTE: Record the absolute value for the magnetic field numbers (i.e. ignore the negative sign.)***
- Repeat the step increasing the distance by 1 cm up to 10 centimeters
- Graph the data of magnetic field strength vs distance using EXCEL
- Add a ***"Power"*** trendline to the graph and the equation
- Answer related questions on the student sheet.

Station 2: Spring force

Materials:

- Mass set with pan
- Spring
- Meter stick
- Small ring stand with test tube clamp

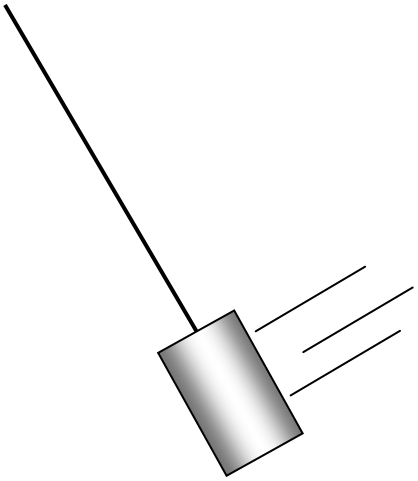


Directions:

- Add mass to the suspended spring as indicated in the chart to the right.
- Record the ***amount of stretch*** with each additional mass added.
- Record your data on the student sheet
- Graph the data using EXCEL
- Add a ***"Linear" trendline*** to the graph and the equation
- Answer related questions on the student sheet.

Force (grams)
50
100
150
200
250
300
350
400
450
500

Station 3: Pendulum

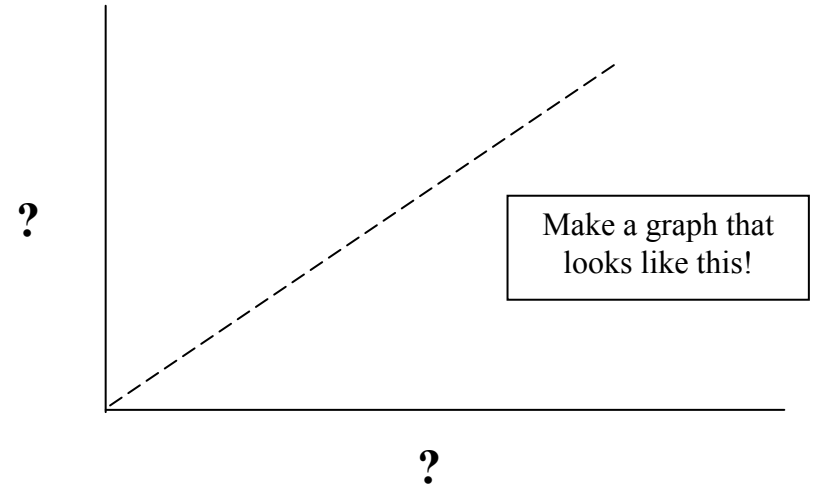


Materials:

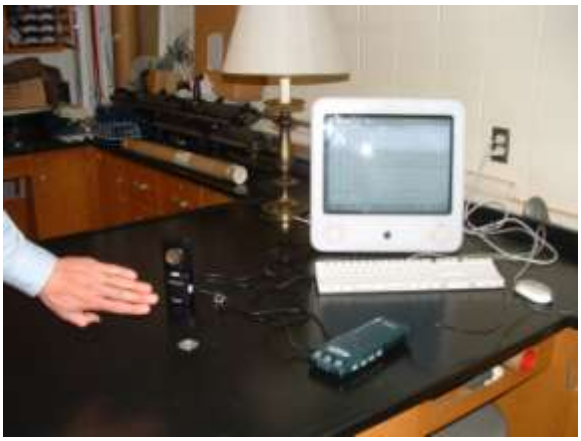
- 50-g mass
- 100-g mass
- 200-g mass
- 500-g mass
- protractor
- Meter stick
- Small ring stand with hook clamp
- String
- Stop watch

Directions:

- Using the materials listed, use the pendulum to create a data set that shows a direct linear relationship (x α y). Variables that you can measure:
  - Mass
  - String length
  - Starting angle
  - Time of a period
- Answer related questions on the student sheet.



Station 4: Go-Motion®



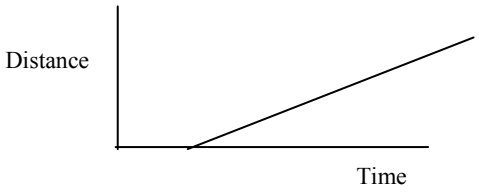
Materials:

- Vernier Go-Motion sensor
- LabQuest or computer with Logger Pro software installed

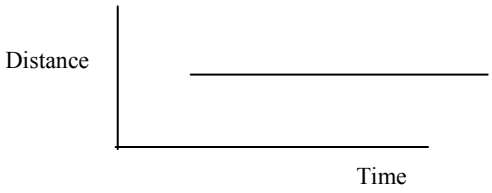
Directions:

- Describe the motion illustrated on the following plots.
  Record on Student Sheet

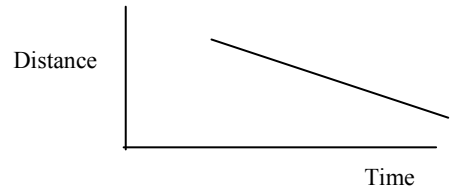
a.



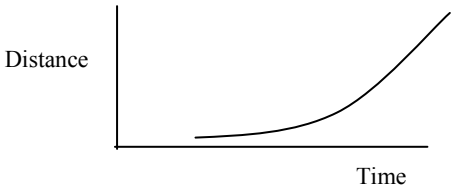
b.



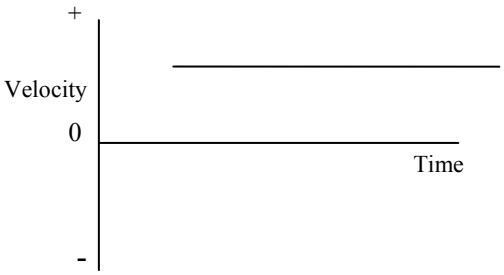
c.



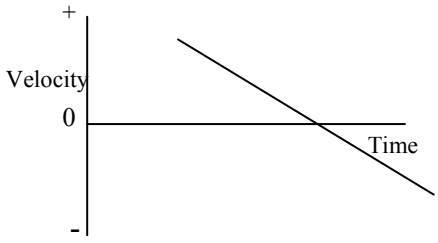
d.



e.



f.



Use the Go-Motion detector and the computer to test your answers.

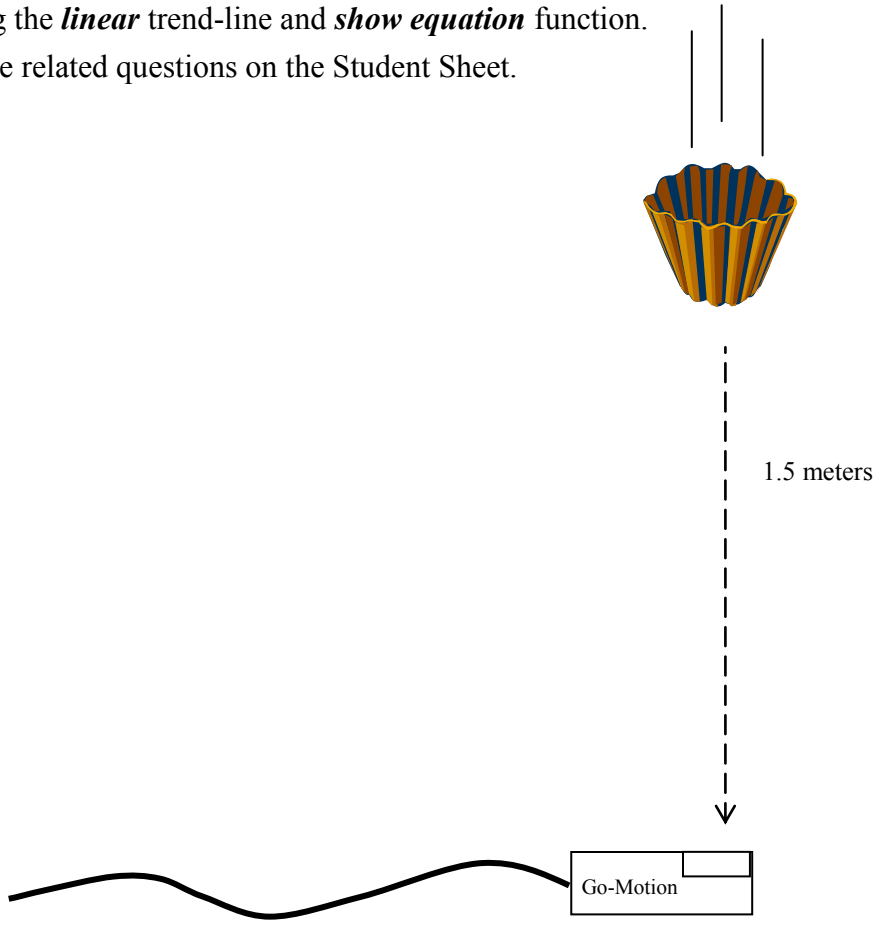
Station 5: Constant Velocity

Materials:

- Vernier Go-Motion® Detector
- Large coffee filters
- LabQuest or computer with Logger Pro software installed
- 2-m stick

Directions:

- Place the Go-Motion detector on the floor.
- Position a large coffee filter 1.5-m and directly above the motion detector.
- Start the data collecting in Logger Pro and drop the filter. (You must land on the screen on the motion detector - - repeat the activity until this occurs.)
- Highlight the region on the graph representing the start to the stop point for the falling filter. This will also highlight the data for the start and stop.
- On the data table for this activity, record the Distance vs Time data on the *Student Data sheet* (Record data for every $1/10^{th}$ of a second).
- Graph the data using EXCEL and determine the constant velocity (cm/second) of this filter using the ***linear*** trend-line and ***show equation*** function.
- Answer the related questions on the Student Sheet.



SEEING MATH: AN INTRODUCTION TO GRAPHING

Pre-lab questions

Name _____

1. Identify the variables in the slope formula. (y = mx + b)

   a. y=
   b. m=
   c. x=
   d. b=

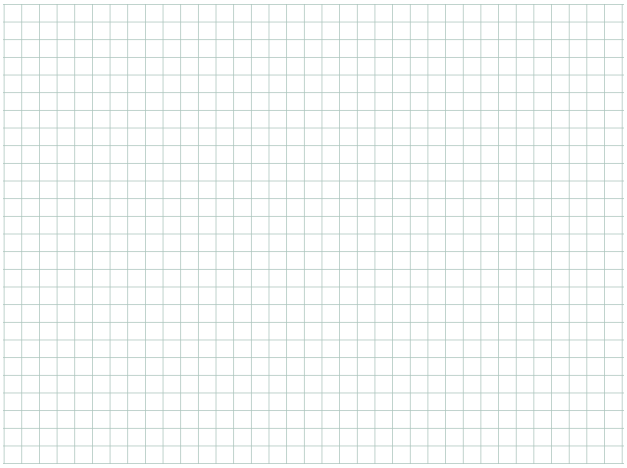
2. Slope is a derived formula. Explain what this means.

3. Explain what this means. **(X α Y)**

4. Plot the following data on the graph to the right or using EXCEL

Time (s)	Distance (m)
0	0
1	10
2	20
3	30
4	40
5	50
6	60
7	70
8	80

Distance



Time

5. What is the relationship between Time and Distance in this data?

6. Determine the slope of this graph.

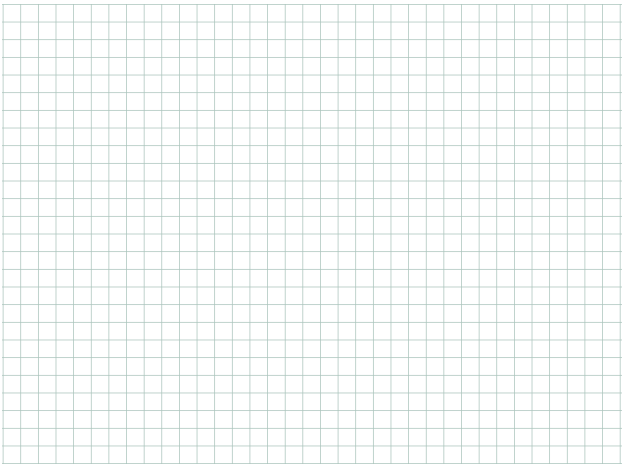
7. What does this slope value represent relative to the data?

8. Look at the equations on page 4 of this sheet and find three equations that show this relationship and write them in the space below. *(Circle the variables that show this relationship*.) **(X α Y)**

9. Plot the data below on the graph to the right.

Time(s)	Distance (m)
1	1.0
2	0.50
3	0.33
4	0.25
5	0.20
6	0.17
7	0.14
8	0.13
9	0.11

Distance



Time

10. How would you describe the relationship shown on the graph?

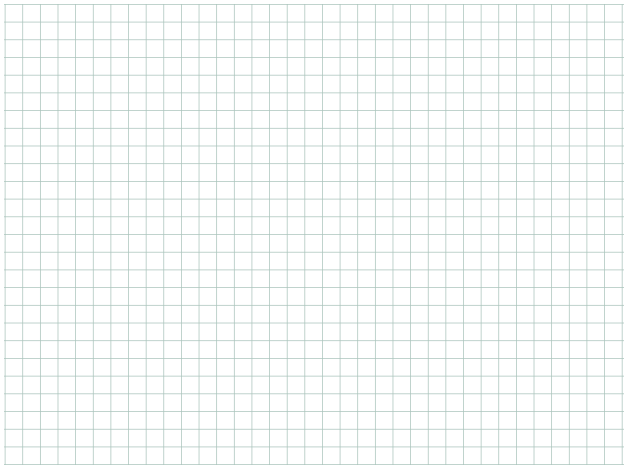
11. Describe this relationship in words.

12. Look at the equations on page 4 of this sheet and find three equations that show this relationship and write them in the space below. *(Circle the variables that show this relationship.)* **(X α 1/Y)**

13. Plot the data below on the graph to the right.

Time(s)	Distance (m)
1	1
2	4
3	9
4	16
5	25
6	36
7	49
8	64
9	81

Distance



Time

14. Mathematically describe the relationship between Y and X.

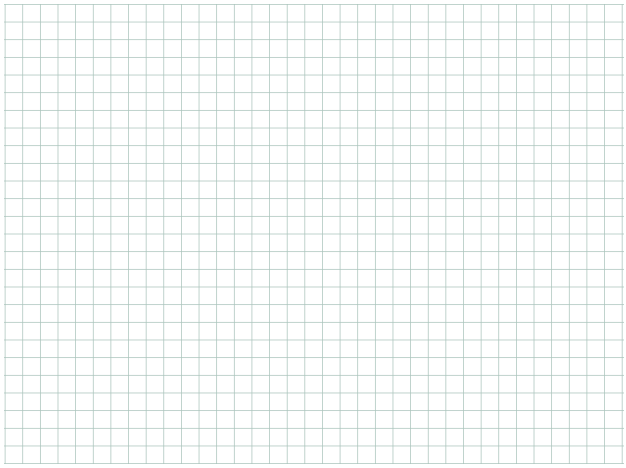
15. Describe the relationship in words.

16. Look at the equations on page 3 of this sheet and find three equations that show this relationship and write them in the space below. *(Circle the variables that show this relationship.)* **($X \propto 1/Y^2$)**

17. Plot the data below on the graph to the right.

Time(s)	Distance (m)
1	1.0
2	0.25
3	0.11
4	0.06
5	0.04
6	0.03
7	0.02
8	0.015
9	0.012

Distance



Time

18. How would you describe the relationship shown on the graph?

19. Study the following equation. Circle the variables that, if plotted, would show the same trend as you graphed in # 15.

$$KE = 1/2\ mv^2$$

20. Look at the equations in the right margin on the following page and find three equations that show the same trend as you graphed in # 15 and write them in the space below. *(Circle the variables that show this relationship.)* **($x \propto 1/y^2$)**

21. In the following questions, two variables from a common physics equation are listed. Determine the relationship between these variables in the equation and label the appropriate axis and fill-in the basic shape of the plot that shows this relationship.

a. ***a*** and ***m*** in F = ma

b. ***x*** and ***F*** in $F_s = kx$

c. r^2 and ***F*** in $F_g = \frac{Gm_1m_2}{r^2}$

d. x^2 and PE_s in $PE_s = \frac{1}{2}kx^2$

$$\bar{v} = \frac{d}{t}$$

$$a = \frac{\Delta v}{t}$$

$$v_f = v_i + at$$

$$d = v_i t + \frac{1}{2}at^2$$

$$v_f^2 = v_i^2 + 2ad$$

$$A_y = A \sin \theta$$

$$A_x = A \cos \theta$$

$$a = \frac{F_{net}}{m}$$

$$F_f = \mu F_N$$

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$g = \frac{F_g}{m}$$

$$p = mv$$

$$p_{before} = p_{after}$$

$$J = F_{net}t = \Delta p$$

$$F_s = kx$$

$$PE_s = \frac{1}{2}kx^2$$

$$F_c = ma_c$$

$$a_c = \frac{v^2}{r}$$

$$\Delta PE = mg\Delta h$$

$$KE = \frac{1}{2}mv^2$$

$$W = Fd = \Delta E_T$$

$$E_T = PE + KE + Q$$

$$P = \frac{W}{t} = \frac{Fd}{t} = F\bar{v}$$

SEEING MATH: AN INTRODUCTION TO GRAPHING
Lab Questions

Name _____

Purpose:

- Develop knowledge of graphs as a tool for representing physical relationships
- Relate graphical representation of data to mathematical relationships.

Station 1: Magnetic field meter

1. Data:

Distance (cm)	Magnetic Intensity (|**mT**|)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Record absolute values

2. In your own words, describe the relationship between the magnetic field intensity and the distance based on your experience and the graphical information.

3. According to the equation given for the plot, what is the relationship between Intensity and Distance for this activity?

4. The relationship between Intensity and distance for this activity is non-linear. What does this mean?

5. RESEARCH: Find another physics concept that has similar relationship to this activity. Explain in the space below, the similarity between the concepts.

Station 2: Spring force

6. Data:

Force (grams)	Stretch (cm)
50	
100	
150	
200	
250	
300	
350	
400	
450	
500	

7. In your own words, describe the relationship between the force and the spring stretch based on your experience and the graphical information.

8. According to the equation given for the plot, what is the relationship between force and the spring stretch for this activity?

9. The relationship between force and the spring stretch for this activity is linear. What does this mean?

10. What is the equation given for this line? _____
11. What is the slope of this line? _____

12. If you were given a stiffer spring, what would happen to the plot on this graph?

Station 3: Pendulum

13. Describe the activity that created the linear relationship for the pendulum.

14. On the graph below, draw the plot for a swinging pendulum relative to speed vs time.

Station 4: Go-Motion Detector

15. Describe the motion shown on the graphs:

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

Don't forget to use the Go-Motion detector to check your answers!

Station 5: Coffee Filters

16. DATA:

Time (s)	Distance (m)
0	
0.1	
0.2	
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	
0.9	
1.0	
1.2	
1.3	

17. Using the linear graph you made from the coffee filter drop, using the graphing program, determine the slope of the part of the drop where the velocity was constant.

18. Determine the constant velocity of the plot area you determined in question 17.