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Finding Patterns in Numbers (Lesson #3)

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ADAPT
Energy in Perspective Laboratory #3

Learning To Find Patterns in Numbers

Instructor's Comments:

The ADAPT physics labs were arranged to encourage students to develop formal reasoning as explained by Robert Karplus and Jean Piaget. Each lab is organized as a Karplus Learning Cycle. {Reference

A primary function of the labs was to get the students to develop their skills at finding patterns in the data they would get from the laboratory experiments.

This is the beginning of the data collecting laboratories. The students begin with a series of experiments that can give data that will result in a linear relationship between the variables. Then there follow experiments that yield power law relationships that can be shown as linear on log-log graph paper. Finally, the laboratories are experiments that can be exponential relationships which can be shown a linear on semi-log graphs.

The Exploration:

Each group of students, in teams of four, are given a set of eight data cards that have numerical data sets on each card. They are asked to sort them into groups by their similarities. The students are encouraged by the instructions to seek the relationship between the two variables. Some students will insist on only looking as the spacing, etc. between the numbers in one set of the numbers.

After the groups have sorted their numbers into batches that are similar, the source of the data sets can be given to the groups to help them evaluate their batching process.

Data Sets:

DATA SET #1

Variable A	Variable B
2.5 m	6.25 m^2
7.3 m	53.3 m^2
15.2 m	231 m^2
17.6 m	309.8 m^2
59.5 m	3540.25 m^2

DATA SET #2

Variable A	Variable B
0 cm	0
5 cm	24 cubic cm
10 cm	48 cubic cm
15 cm	72 cubic cm
20 cm	96 cubic cm

DATA SET #3

Variable A	Variable B
2.5 m	64 W/m^2
5 m	16 W/m^2
7.5 m	7 W/m^2
10.0 m	4 W/m^2
12.5 m	2.5 W/m^2

DATA SET #4

Variable A	Variable B
1	175 N
2	87.5 N
3	58.3 N
4	43.8 N
5	35 N

DATA SET #5

Variable A	Variable B
55	.220
72	.288
78	.312
83	.332
101	.404

DATA SET #6

Variable A	Variable B
12	70° C
10	60° C
8	50° C
6	15° C
4	-20° C

DATA SET #7

Variable A	Variable B
25 m.p.h.	75%
35 m.p.h.	68%
45 m.p.h.	41%
55 m.p.h.	28%
65 m.p.h.	20%

DATA SET #8

Variable A	Variable B
0	$ 9.25
2	$10.75
4	$12.25
6	$13.75
8	$15.25

Origins of the Data Sets:

Data Set #2

Variable A - Height of water in a glass measured the bottom of the glass.

Variable B - Amount of water poured into the glass.

Data Set #1

Variable A - Length of one side of a square.

Variable B - Area of the square.

Data Set #4

Variable A - Number of support legs on a special chair (one that can adjust from 1 to 5 legs)

Variable B - Amount of weight supported by each leg when a 175 Newton person sits on the chair.

Data Set #3

Variable A - Distance away from a loud vacuum cleaner.

Variable B - Sound intensity measured at each distance away from the sound source.

Data Set #6

Variable A - Average number of daylight hours in Nome, Alaska.

Variable B - Average daily temperature in Nome, Alaska.

Data Set #5

Variable A - Number of hits in 250 times at bat in a baseball season.

Variable B - Batting Average.

Data Set #8

Variable A - Number of long distance phone calls made in 1 month. (Each costing the same amount)

Variable B - Monthly phone bill.

Data Set #7

Variable A - Average speed of auto's involved in head-on crash.

Variable B - Average percentage of passenger survival.

What Were They Doing ?

Exploration Activity

Your group is given 8 sets of data collected by ADAPT students in 1975. Each set of data has five values of Variable A upon which a measurement, Variable B, depended. Your first set of tasks are:

1) Sort the 8 sets of data into 3 different categories. Write a short description of the characteristics of each category.

2) For each set of data, take the largest value of Variable A and compute a new value for Variable A which is 25% larger. Next, PREDICT the value of a new Variable B which you expect to correspond to the new Variable A.

When you have completed these activities, ask for the next page.

What Were They Doing ?

Perhaps Finding Patterns in Numbers
More on the Exploration Activity

Concept Invention

To categorize your data, you probably looked for relationships between variables that made **patterns**. A useful way of finding patterns is to make a graph of the data.

When quantitatively studying a system, one tries to hold all the variables constant except for the two that are to be studied. Throughout the study (i.e.. the experiment) one variable is manipulated in a controlled manner. The control variable is called the independent variable. The value of another variable which responds to each manipulation is recorded and is referred to as the dependent variable. A graph can now be made from the data. It is customary to use the horizontal axis for the independent variable and the vertical axis for the dependent variable.

Cartesian Graphs: The first type of graph we shall use is called a Cartesian graph. After selecting an appropriate scale for each axis, the axis is marked off in a linear fashion (i.e.. a scale of constant differences). The scale on the two axes need not be the same. An *ordered pair* of numbers (x, y) locates a particular point on the graph. x is the value of the independent variable. y is the value of the dependent variable.

Make a Cartesian graph (sized about 1/3 or 1/2 of a page) in your data sheets (preferably on graph paper) and plot the following points: (0, 0); (0, 10); (0, -30); (3, 0); (4, 30); (2, 0); (-3, 20).

When everyone in your group is finished, ask for the next page.

What Were They Doing ? Perhaps Finding Patterns in Numbers

Concept Invention (continued)

Relationships Between Variables

Graphing is a way of picturing how one variable changes in response to changes in another. Draw graphs A and B in your data sheets:

Data for Graph A:		Data for Graph B:	
x	y	x	y
1	16	1	6
2	8.0	2	9
3	5.3	3	12
4	4.0	4	15
5	3.3	5	18
6	2.7	6	21
7	2.3		
8	2.0		

Note: when drawing a graph, your choice of scales for the axes should be such that your graph fills the space you designated for the graph.

Answer the following questions in your data sheets:

1) From Graph A, what happens to y as x is increased?
2) From Graph A, what happens to x as y is decreased?
3) What type of relationship exists between x and y in Graph A?
4) From Graph B, what happens to y as x is increased?
5) From Graph B, what happens to x as y is decreased?
6) What type of relationship exists between x and y in Graph B?

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More Concept Invention

Slope:

All straight lines belong to the family of **linear** relationships. Their slope is defined as:

$$\textbf{slope} = \frac{\textbf{rise}}{\textbf{run}} = \frac{\textbf{change in vertical}}{\textbf{change in horizontal}} = \frac{\textbf{change in y}}{\textbf{change in x}} = \frac{y_2 - y_1}{x_2 - x_1}$$

Where (x_2, y_2) and (x_1, y_1) are points on a linear curve. (see Figure GR-3 below)

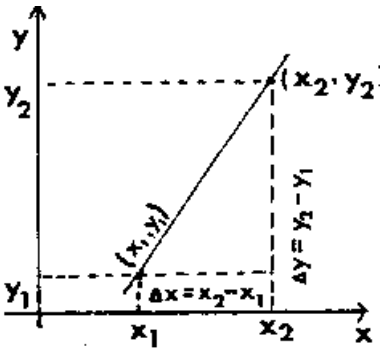

Figure GR-3

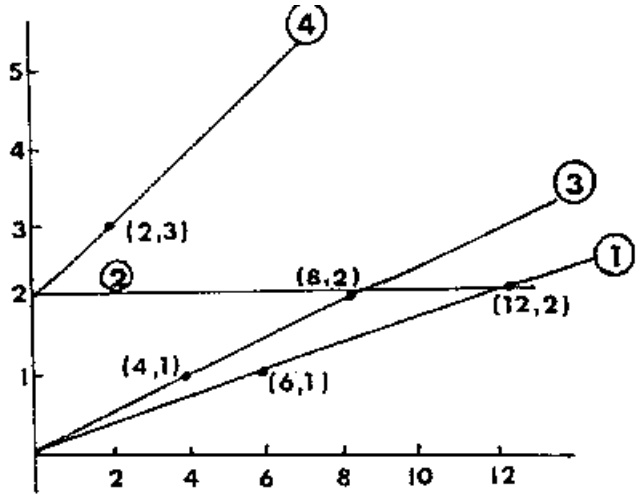

Figure GR-4

Examine the graph in Figure GR-4 above. Answer the following in your data sheets.

7) Which line has the greatest slope?

8) Which line has zero slope?

9) Calculate the slope of line 1 between points (0, 0); (6, 1) and between the points (6, 1); (12, 2). What did you notice about the slope?

10) Calculate the slope of line 3 between points (0, 0); (8, 2) and between the points (4, 1); (8, 2). What did you notice about the slope?

11) From 9 and 10, make a generalization of the slope of a linear graph.

12) For each of the lines 1, 3, and 4 write its mathematical expression.

When everyone in your group is finished, ask for the next page.

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Concept Application

Properties of Slinkies and Rubber Bands

Equipment: 2 Slinkies, 1 rubber band, 1 metre stick, standard masses

Slinky:

What must you do to stretch a Slinky? How can you measure the stretch?

Perform experiments to measure the elongation of a slinky as a function of another variable. Note that elongation is the amount of length is increased from its unstretched length. Use at least 6 different values for your controlled (independent) variable. Take data for:

1) Slinky #1 alone

2) Slinky #2 alone

3) Slinkies #1 and #2 hooked end to end

4) Slinkies #1 and #2 hooked side by side with the lower ends connected.

Make graphs of your data.

How are the two variables related? (linearly, partly linearly, or non-linear)

If the variables are linearly or partly linearly related, find the slopes of the linear portions of the graphs.

Do the slopes have dimensions? If so, find the SI units of the slope. What is the physical meaning of the slope for these experiments?

Rubber Band:

Perform the above experiment with a rubber band instead one of the Slinkies.

Make graphs of your data.

How are the two variables related? (linearly, partly linearly, or non-linear)

If the variables are linearly or partly linearly related, find the slopes of the linear portions of the graphs.

Do the slopes have dimensions? If so, find the SI units of the slope. What is the physical meaning of the slope for these experiments?

Compare the rubber band data to the Slinky data.

How are they the same?

How are they different?

Straighten up your workspace and about 20 minutes before the end of the lab we will distribute the write up page and, perhaps, an assessment activity.

Finding Patterns in Numbers

Write-up: Due at the beginning of the next lab period.

Write your own individual report on the Patterns in #'s lab. All members of your group should have the same data and results.

I PURPOSE AND INTRODUCTION
II DISCUSSION
- A) Write a brief summary of the lab.
- B) How was the exploration activity related to the rest of the lesson?
- C) Conclusions of the lab.

III GRAPHS OF EXPLORATION ACTIVITY DATA
- A) Draw a graph for each of the eight data sets used in the exploration activity.
- B) Briefly describe the relationship between the variables for the data sets in the exploration activity.
- C) Separate all the data you have in this lab into two classes: 1) linear relationships, and 2) anything else.
- D) For linear relationships, determine the mathematical expression for the relationship of the variables.

IV SLINKY AND RUBBER BAND DISCUSSION
- A) Discuss the relationship between elongation and mass.
- B) Refer to appropriate graphs in data sheets.

V DATA AND CALCULATIONS
Includes neat and organized raw data and calculations from class and any other calculations needed for the write up.

A Note on Labs

At the end of each lab write up, we have asked for the *data and calculations you performed in class (your raw data and calculations).* Recording your ideas *neatly* and in a *well organized* fashion will help you understand what is going on and boost your overall grade. Be sure to put thought into the organization of your collection of data and calculations. Don't just scribble notes down! Also, you should *collect all data and make all calculations on non-spiral notebook paper.* Don't use your handouts for note taking!