Chapter 6: Data Analysis

In physics, relationships between physical quantities are determined experimentally and expressed mathematically. As such, it is important for any budding scientist to master the skills required to analyze physical data and determine what, if any, mathematical model relates the data. In this section, you will learn how to analyze data using a method known in math and science as regression analysis.

Computer Based Regression Analysis (Microsoft Excel)
ENTERING DATA

1. In order to create graphs you must first enter your data into a spreadsheet. To do this open MS Excel and type your independent variable in the first column and your dependent variable in the second column. On the first line in each column, label the quantity and state the units. (see below)

| t(sec)	x(m)
0	0
1	5
2	20
3	45
4	80
5	125

PLOTING DATA POINTS

2. Once you have entered the data you are ready to plot the data on the graph. To do so, use your mouse to highlight the two columns of data, excluding the labels.

t(sec)	x(m)
0	0
1	5
2	20
3	45
4	80
5	125

3. Once the data is highlighted as shown above, click the pull down menu INSERT at the top of the window and choose CHART from the menu. This will open what is called the "Chart Wizard" which will allow you to choose some of the basic features of your plot.
4. Once the Chart Wizard has popped up, click XY SCATTER from the chart type list and choose the default chart sub-type as seen below and then click NEXT.
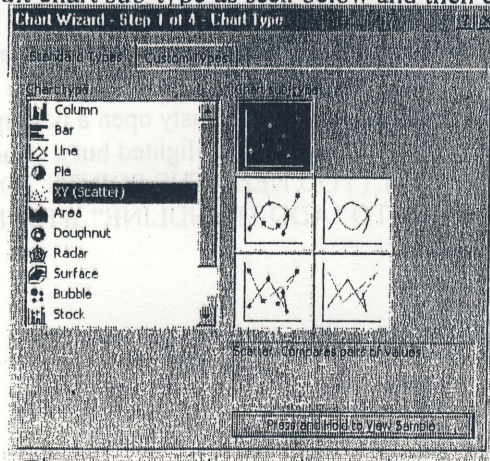
5. You should now see a plot in the Chart Wizard screen that represents your data (see below). Once again click NEXT.
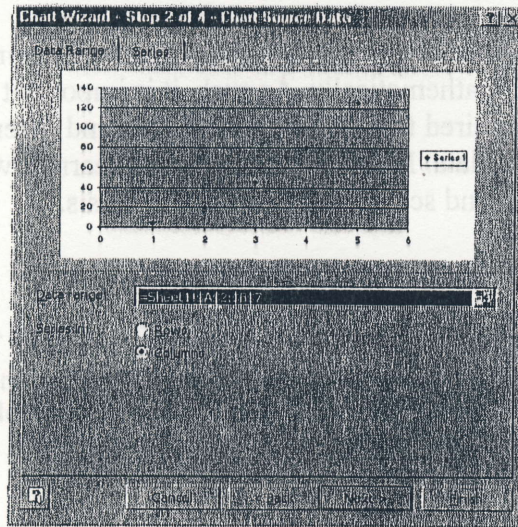
6. In the Chart Wizard window, you will now have the option to customize your graph. Be sure to add an appropriate title and to label your axes.
- Your title should be written as follows: "Dependent variable" (symbol) vs. "Independent Variable" (symbol) for "Scenario"

  Ex. Position (x) vs. Time (t) for a Ball Rolling Down a Ramp
- If your x-axis values were time measured in seconds, you would type " Time (s)" in the space titled *Value (X) Axis*. Do the same for your y axis. DO NOT PRESS NEXT!

7. Using the tabs at the top of the Chart Wizard window, feel free to customize you graph however you feel appropriate. Below are a few suggestions to improve your graph
- To delete the "Series" boxes at the left of your plot, click on the LEGEND tab and uncheck "Show Legend"
- Go to the GRIDLINES tab and make sure "Major Gridlines" is checked under both the X and Y axis.

   When you are done click NEXT.

8. You are now at the last page of the Chart Wizard. Click the option to place chart "As New Sheet" and type a fitting name for the new sheet in the field to the right. Once you have given it a name click FINISH and your graph will be shown. Notice at the bottom of the page that your graph is located on an entirely different sheet from your data (sheet 1). To move between the data and your graph simply click on the appropriate tabs at the bottom of the screen.

PLOTTING THE REGRESSION LINE
9. In almost all cases you will need to find a mathematical function (regression line) that models your data. To do this, right click on any one of the data points on your plot. Doing so will highlight all of your data points and simultaneously open a pop up menu next to your mouse pointer. If your data points are NOT highlighted but a window has popped up, press the ESC key and try again. (YOU NEED THE POINTS TO BE HIGHLIGHTED TO BE GIVEN THE OPTION TO "ADD TRENDLINE" WHICH WILL FIT THE DATA WITH A CURVE.)

10. From the pop up menu, choose "Add Trendline...". Choose the type of regression that will best model the scenario you are analyzing and click OK. You should now see the regression line plotted on your graph. Note: Almost all physical relationships are linear or quadratic (polynomial of order 2)

11. Now that you have your curve, you will want to show the numerical equation that describes it. To do this, double-click somewhere on the regression line itself. This will open a window called "Format Trendline". At the top of the Format Trendline window, choose the OPTIONS tab and check the "Display Equation on Chart" box. Now click OK.

12. You should now see the equation of the regression line displayed on your graph. If it is difficult to read it where it is located, click the equation and drag it to another place. If you double click on the equation it will allow you to format the font size an number format. Note: When reporting your regression equation, be sure to name the type of mathematical relationship represented and also to replace x and y with the appropriate physical variables (ex. t and x).

Calculator Based Regression Analysis (TI 83/TI 84/TI 84+)
ENTERING DATA
All regression is completed only after the data has been entered into the lists via the EDIT Mode. The EDIT Mode is found by pushing <STAT> and <EDIT>. To clear the lists, place the cursor on top of the list and press <CLEAR> <ENTER>. Do this to each list to be cleared.

Enter the data and take note which list has the independent variable (horizontal or x-variable), and which has the dependent (vertical or y variable). Generally, place the x-variable in L_1 and the y-variable in L_2 unless these lists are in use; this makes analysis easier.

PLOTTING THE DATA ON THE CALCULATOR
After the data has been entered, press <2nd> <STATPLOT> and turn on the Stat Plot. Choose the scatter plot, and select the lists with the corresponding variables in them. Select a mark. (do NOT select the dot, frop it is hard to see on the graph)

Press <ZOOM> <ZOOMSTAT> and the graph is drawn with proper window values. RE: you must turn off or clear all graphs listed in the Y= Menu, otherwise these will be automatically graphed also.

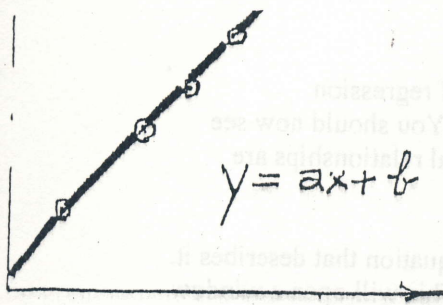### DETERMINATION OF THE REGRESSION EQUATION
To complete the Regression Analysis, examine the graph. Then select the best regression fit consulting your Regression Analysis paper. Press <STAT> <CALC> and select the regression type which fits your graphed data. Move the cursor to the regression, and press <ENTER>. Then type the lists separated by a comma where the independent (x) and dependent (y) were stored, respectfully. Then hit <ENTER> Ex. PwrReg L_1, L_2 <ENTER>

The Generic Regression Equation and variables are shown on the screen. These should be copied or written down. The r-value designates the accuracy of the equation's fit of the data.
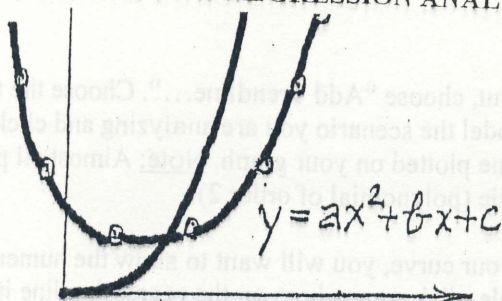
PLOTTING THE REGRESSION EQUATION
To get the calculator to superimpose the curve onto the data, follow these steps: After you complete the regression above, press <Y=> and turn off or clear all of the equations in the menu. Place your cursor in the first empty space in the Y= menu and press <VARS> <STATISTICS>. Move cursor to <EQ> and press <RegEQ> and <GRAPH>. The regression equation should be superimposed onto the points plotted from the original lists via STATPLOT.
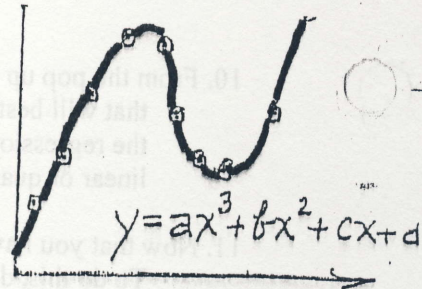
$$y = ax + b$$

Straight line - Linear

$$y = ax^2 + bx + c$$

Parabolas

$$y = ax^3 + bx^2 + cx + d$$
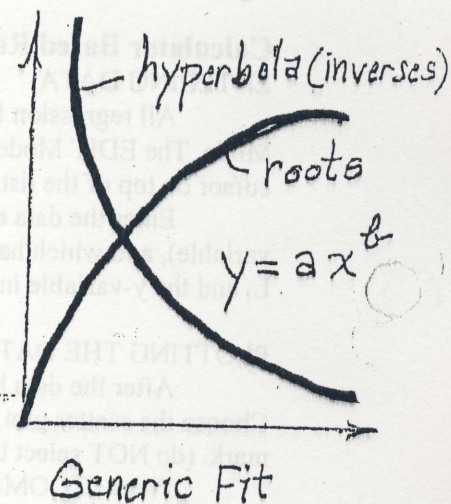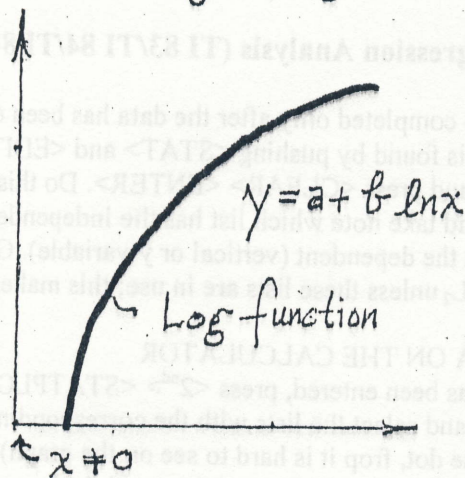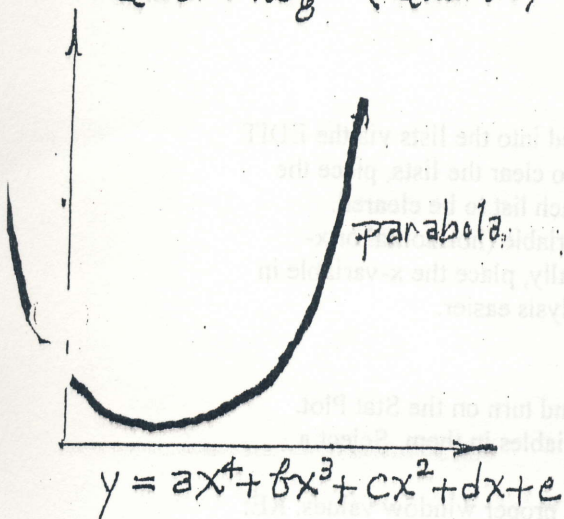
GUIDELINES for REGRESSION ANALYSIS
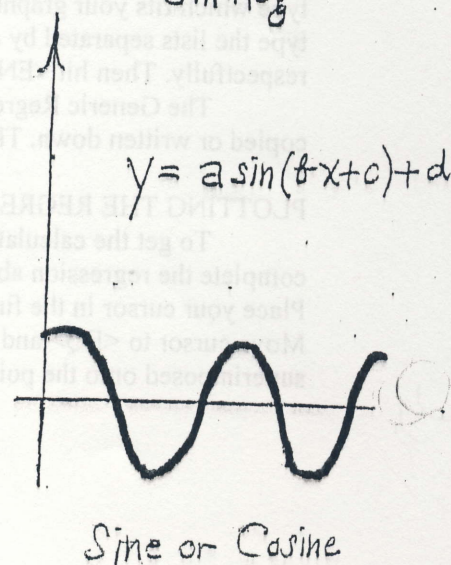
Quart Reg (Quartic)

Ln Reg (Logarithmic)

Pwr Reg (Power)
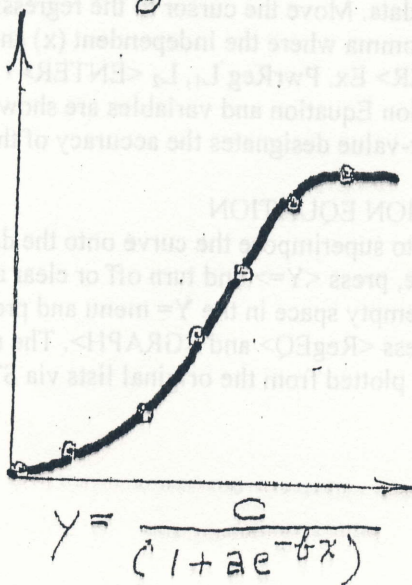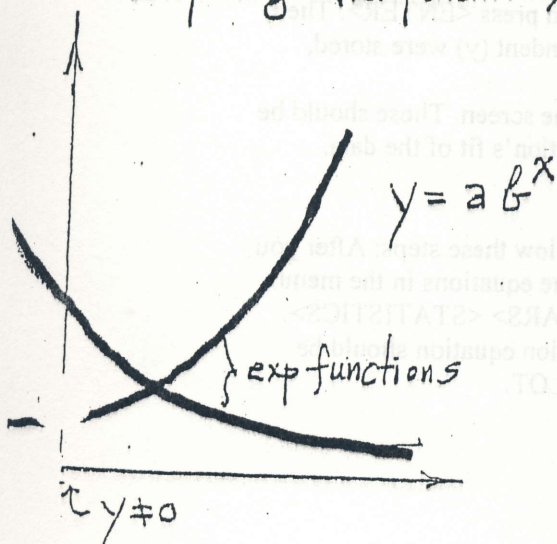
Parabola

$$y = ax^4 + bx^3 + cx^2 + dx + e$$

$$y = a + b \ln x$$

Log function

$$x \neq 0$$

hyperbola (inverses)

roots

$$y = ax^b$$

Generic Fit

Exp Reg (Exponential)

Logistic

Sin Reg

$$y = ab^x$$

exp functions

$$y \neq 0$$

$$y = \frac{c}{(1 + ae^{-bx})}$$

$$y = a\sin(bx + c) + d$$

Sine or Cosine

Chapter 7: Lab Reports

The Physics laboratory report is a formal document and will be written in proper format utilizing correct formal English and proper spelling. The report should be word processed except for graphs, sample calculations, and charts/tables. The following sections should be included (in the order below) in every lab report. Each section should be written in past tense third person.

TITLE PAGE: should include the name of the lab as written on the lab instructions, the date it was performed, and the names of the members of the lab group.

PURPOSE: should list the reasons the lab was performed. It is assumed in the purpose section that the reader will imply the words "The purpose of the lab is", so your purpose statements should be written as infinitive phrases beginning "To + a verb"
Ex. To determine the effects of a constant force on the velocity of an object.

APPARATUS: a detailed list of the tools/materials used in the experiment and in analysis of the experiment. List must indicate the precision of each instrument used.

PROCEDURE: cookbook set of instructions of how the experiment was done and how the data was analyzed. These must be precise. This may be written in paragraph or outline form.

DATA: contains both raw and manipulated data. Data is placed in tables and/or graphs that accurately represent the information gathered during experimentation. Graphs/tables are given titles, are clearly and accurately labeled, and regression equations are shown with proper variables. NOTE: All graphs must have properly labeled axes (quantity and units), a title indicating independent and dependent variables, and the equation that describes the curve (when appropriate) written with the appropriate "physical quantity" variables.

SAMPLE CALCULATIONS: shows an example of each type of calculation done throughout the lab. Sample calculations must include correct units and significant digits.

MANUAL QUESTIONS/RESULTS: answers to any lab manual questions and/or an explanation how the data was analyzed. All answers/results must be supported by the data and calculations.

ERROR ANALYSIS: must include a listing of significant errors inherent to the experiment. Errors may be human, instrumental, or systematic. A list of errors is not enough; a discussion of the impacts of the errors must also be included as well as recommendations as to how errors could be reduced/eliminated in the future.

CONCLUSIONS: this section must include a summary of the final results, including all qualitative findings and mathematical relationships (calculated values, equations etc.). It must also contain a summary of the most significant errors. Lastly, this section must discuss what you have learned by performing this lab and must provide all information necessary to relate the results/findings to the purpose of lab.

Word processing, spreadsheets, computer graphing software, and spelling/grammar checks all aid in producing lab reports. Please use them! Some additional things to remember when writing lab reports:

1. Contractions are NOT allowed in formal writing.
2. Never write on the backs of report pages.
3. Answer the manual questions by incorporating the question into the answer and supporting it with data from the experiment.

A fine quality laboratory analysis/report is difficult to write. It takes time and input from the experimenter(s). ALL LAB REPORTS ARE DUE ONE WEEK FROM COMPLETION OF THE LAB! PLEASE USE THIS TIME WISELY! Writing lab reports is one of the most valuable skills you can learn in this class, and completing them properly can help your grade immensely. Please do your best and do not get discouraged. It will take time and practice to master this skill!!! GOOD LUCK!