Math Lab III

Graphical Analysis Using LoggerPRO 3

Name ____ Box _____

Purpose: To learn - how to use the graphing features of ***Logger PRO3***; how to fit experimental data to theoretical functions; how to use the PAGE, GRAPH OPTIONS, and ANALYZE features; and how to interpret the parameters determined by such theoretical line fits.

Procedure:

1. Load the ***Logger PRO3*** program. It is located in your physics folder on the Windows Desktop.
   a) Login using your student ID and password.
   b) Double-click on your Physics folder
   c) Double-click on ***Logger PRO3.4.6***

   Always start with these few basic setup steps.
   i) Click on the OPTION menu and select graph options.
   ii) Add a check mark for Point Protectors
   iii) Remove the check mark for Connect Points – Click Done
   iv) Click on the INSERT menu
   v) Select Text
   vi) Click on the PAGE menu
   vii) Click on Auto Arrange

   If you would like to save a little time in making future graphs, then save this file on your H: Drive as “StarterGraph”.

   Then, the next time you need to make a new graph,
   viii) Start LoggerPro3
   ix) Click on the FILE menu
   x) Select Open
   xi) Navigate to the H: drive on the Pull-Down menu, if necessary
   xii) Select the file named StarterGraph
   xiii) Click OPEN.

   There is another little improvement that you can make to the StarterGraph file, if you like.
   i) Click on the FILE menu
   ii) Select Settings for StarterGraph
   iii) Select the Degrees Radio Button
   iv) Click on OK
   v) Be sure to save the StarterGraph file again after making this change.

   Remember that the text Box must contain the following information
   Your Name
   Lab Number
   Graph Number

2. If you are using your StarterGraph file to make a new graph, the first thing you must do is save it with a new name before you make any changes. For today's exercise let's name the file "Math Lab III Graphs". Now that you've saved it using an appropriate new name and your StarterGraph file is protected from accidental changes, we can proceed. Save the file often to protect the effort you have put into this work.

Click with the mouse on the X at the top of the first column and change the X to "Time" with units "s". Click on the Y at the top of the second column and change it to "Altitude" with units "m". Enter your name in the Text Box, along with your name, Math Lab III, and Graph #1.

(*Note: the independent variable is always listed second in the title and graphed on the horizontal axis. You can enter the data in any column. To select which data column will be serving as the independent variable, click on the title of the horizontal axis. You can do the same on the vertical axis. Simply select which column represents which variable.)*

3. Now enter this data and create your graph with time as the independent variable.

Graph #1--Altitude vs Time

Time (sec)	Altitude(meters)
-2	-14
0	-4
1	2.5
4	18
6	28
9	45

4. Make sure the connecting lines are turned off in the Graph Options window. If you created a StarterGraph file, then the connecting lines are already disabled, but you need to keep a mental eye out to make sure that they really are off.

5. Before you do anything else, save the file again. No other student can access the data files on your H: drive

6. Look at the graphed points. These will fall into one of the following categories.

A) Proportional	$y = Ax$
B) Linear	$y = mx + b$
C) Quadratic (parabolic opening up or down)	$y = A + Bx + Cx^2$
D) Polynomial	$y = A + Bx + Cx^2 + Dx^3 + \ldots$
E) Power (parabolic opening up, down, left or right)	$y = A x^B$
F) Variable power (parabolic opening up, down, left or right)	$y = A x^n$
G) Inverse or hyperbolic	$y = A / x$
H) Inverse square	$y = A / x^2$
I) Natural exponent (exponential decay)	$y = A e^{-Cx} + B$
J) Natural logarithm	$y = A \ln(Bx)$
K) Inverse exponent (exponential growth)	$y = A (1 - e^{-Cx})$

7. Click on the ANALYZE menu and select Curve Fit… . Choose the functions one at a time and see which you think best fits the data points.

8. Once you find the unique computer-generated line that most closely fits your points, then write the function name and the function equation in the blanks below.

Function name ____

Function equation _____________________________________

DAT filename ____ (Hint: See above)

(To create the equation, replace the ***x*** *in the function type with* "**t**" *[time]. We'll let* **y** *continue to stand for altitude in this case. Every other symbol must be replaced by a number. Remember that time was plotted on the horizontal axis, also called the x-axis, and that altitude was plotted on the vertical axis, also called the y-axis. That is why the substitutions must be made this way.)*

9. If the fit is not good, then clear the function box on the graph and try a different function. Print your best graph and hand it in. Save the DAT file one more time to your Documents folder.

\- -

10. Below are eight more sets of experimental data from which you will create nine more graphs. Two graphs (and two DAT files) will be created from the final data set.

Determine the function which best fits the data points in each of these graphs. You must correctly label the data columns and the graph (*Don't forget to include the graph number and your initials in the graph title, plus the graph number and your name in the text box*) and determine the correct function for each.

Then write down the correct equation for the data on this handout.

Don't forget to save each graph's data set as a DAT file with the appropriate name, according to our naming convention, in your Documents folder before you start on the next graph.

Don't forget to print out the best fit graph for each data set to turn in as part of this assignment.

The instructor will be checking your Documents folder and examining your saved data files. <u>Do not forget to save them with the proper names in the proper location.</u>

All ten graphs are due by the start of the second class period. Attach all ten graphs, in order, to the back of this handout. Each graph and its associated DAT file is worth half a point, except for graphs #9 and #10 and their DAT files which are worth one point each. The completed handout is worth four points. (For a total of 10 points. This score will be recorded as a lab grade.)

\- -

Hints: Using ***Logger PRO3*** makes many analytical jobs much simpler. However, its many features can be somewhat daunting. Practice and experience using the program will eventually make it seem much more user friendly. To give a helping hand with some of its other features, here are some suggestions that you should take to heart and adopt when creating other graphs for this course.

Show the origin (0,0). Showing the origin makes most graphs easier to understand. Your instructors will sometimes require that you show the origin but even when it is not required, it is still a good idea. By default a feature called Auto-Scaling is ON. This ensures that all the data points appear on the screen. We usually choose our coordinate system so that data appears in the first quadrant but with Auto-Scaling ON the origin may not be showing. Click on the lowest x-value with the mouse pointer. A box will appear around it and you may type any value you wish. Type zero and hit the enter key. Do the same with the lowest y-value.

A background grid of points will appear if you know where to look. Can you find the menu selection that turns on the grid points? Turn it ON when you find it.

When you print your graphs you have several options. You should always select Print from the FILE menu. That way, you will have the graph, the data-table and the text box all together on a single printout.

Those of you who would like to download a copy of ***Logger PRO3*** for personal use on your home computer may download a copy to install. This is a large (133 MB) file and requires high-speed internet access. An older program called ***Graphical Analysis*** works almost identically to ***Logger PRO3*** and comes in a small file (16 MB, as I recall)

CREATE A NEW PAGE FOR EACH OF THE FOLLOWING GRAPHS. SAVE OFTEN!!!

Graph #2--Light Intensity vs Distance

(This graph shows the intensity of a candle's light as you move away from it.)

Distance (m)	Light Intensity (Cd)
3	0.48
5	0.17
7.2	0.0835
9	0.0533
10	0.0443
13	0.0257

Function name ____

Function equation _____________________________________

(Remember when writing the function equation to replace ***y*** *in the equation with "I" [intensity] and* ***x*** *in the equation with "D" [distance]. Every other symbol must be replaced by a number.)*

Graph #3--Stun Gun Voltage vs Time

(This graph shows the voltage remaining on a stun gun (capacitor) as you discharge it.)

Time (sec)	Stun Gun Voltage (v)
3	0.908
5	0.366
7.2	0.144
9	0.065
10	0.0415
13	0.0112

Function name ____

Function equation _____________________________________

(Remember to replace ***y*** *in the equation with "V" [voltage] and* ***x*** *in the equation with "t" [time]. Every other symbol must be replaced by a number.)*

Graph #4--Free-falling Cat Velocity vs Time

(This graph shows you the velocity of a cat falling through the air.
Notice that the cat stops accelerating because its body has turned into a parachute.)

Time of fall (sec)	Velocity of Falling Cat (m/sec)
0	0
0.8	5.6
1.7	8.33
2.5	9.36
4.8	10.11
20	10.2

Function name ____

Function equation _____________________________________

(Remember to replace ***y*** *in the equation with "v" [velocity] and* ***x*** *in the equation with "t" [time]. Every other symbol must be replaced by a number.)*

Graph #5--Lung Volume vs External Pressure

(This graph shows you the volume of the air in your lungs as you dive deeper into water.)

Pressure of a Gas (Pa)	Volume of a gas (m^3)
45000	0.305
55000	0.255
65000	0.21
75000	0.185
85000	0.16
95000	0.145

Function name ____

Function equation _____________________________________

(Remember to replace ***y*** *in the equation with "V" [volume] and* ***x*** *in the equation with "P" [pressure]. Every other symbol must be replaced by a number.)*

Graph #6--Radioactive Contamination vs Time

(This graph shows the residual radioactivity readings following a nuclear spill over a period of time.)

time (days)	Radioactivity (rads)
0	122
2	112
5	100
8	89
12	76
40	25

Function name ____

Function equation ______________________________________

*(Remember to replace **y** in the equation with "R" [radioactivity] and **x** in the equation with "t" [time]. Every other symbol must be replaced by a number.)*

Graph #7--Bounce Recovery Time vs Vehicle Mass

(This graph shows you the time a car takes to bounce on its springs. Here is one of those cases where time is not the independent variable.)

mass (kg)	Time (s)
120	1.08
340	1.85
560	2.33
1340	3.65
5430	7.32
8450	9.1

Function name ____

Function equation ______________________________________

*(Remember to replace **y** in the equation with "t" [time] and **x** in the equation with "m" [mass]. Every other symbol must be replaced by a number.)*

Graph #8--Gravitational Acceleration vs Altitude + Radius of the Earth

(This graph shows the acceleration of gravity as you move farther from the center of the earth.)

Dist from Center of Earth (miles)	Accel (m/sec^2)
4000	9.81
5000	6.28
8000	2.46
12000	1.1
16000	0.611
22000	0.324

Function name ____

Function equation _____________________________________

(Remember to replace ***y*** *in the equation with "a" [acceleration] and* ***x*** *in the equation with "D" [Distance]. Every other symbol must be replaced by a number.)*

Graphs #9--Resistivity vs Temperature (K)
Graph #10--Temperature (K) vs Resistivity

(The data table on the next page will be used to create two graphs. These graphs show how the Resistivity of Tungsten varies with the Temperature of Tungsten.)

Fit the Resistivity vs Temperature data with two functions. Have them showing at the same time when you print this graph. Use the power fit and a fourth order polynomial fit. Interchange the two axes in order to create graph #10, which will be called Temperature vs Resistivity. Do the same two fits again.

(We'll be using these two graphs in a later lab so don't ever delete these files from your Documents Folder.)

Graph #9

Quartic polynomial function

Quartic polynomial equation ____________________________________

Power function

Power function equation ____________________________________

(Substitute T [temperature in Kelvin] for **x** *in both equations and* ρ *[rho] for the resistivity of tungsten (**y**) in both equations. Every other symbol must be replaced by a number in both equations.)*

Graph #10

polynomial function type _______________________________________

polynomial function equation ____________________________________

power function type _______________________________________

power function equation ____________________________________

DAT filename ____________________________

(Substitute ρ *[rho] for resistivity (***x***) in these equations and T [temperature in Kelvin] for* **y** *in both equations. Every other symbol must be replaced by a number in both equations.)*

Standard Data for Tungsten - Resistivity as a function of temperature (K). [from the CRC Handbook]

Resistivity (Ohm m)	Temperature (K)	Resistivity Ohm m	Temperature (K)
5.65E-08	300	8.104E-07	2700
8.06E-08	400	8.470E-07	2800
1.056E-07	500	8.833E-07	2900
1.323E-07	600	9.204E-07	3000
1.609E-07	700	9.576E-07	3100
1.900E-07	800	9.954E-07	3200
2.194E-07	900	1.033E-06	3300
2.493E-07	1000	1.072E-06	3400
2.794E-07	1100	1.111E-06	3500
3.098E-07	1200	1.150E-06	3600
3.408E-07	1300	1.171E-06	3655
3.719E-07	1400		
4.036E-07	1500		
4.355E-07	1600		
4.678E-07	1700		
5.005E-07	1800		
5.335E-07	1900		
5.667E-07	2000		
6.006E-07	2100		
6.348E-07	2200		
6.691E-07	2300		
7.039E-07	2400		
7.391E-07	2500		
7.749E-07	2600		

The resistivity of tungsten is almost, but not quite, a straight line when plotted against temperature.

Why does this table of standard resistivity data for tungsten stop at 3655 K?

____

____

____