OSP resources for Data Analysis

Data Tool

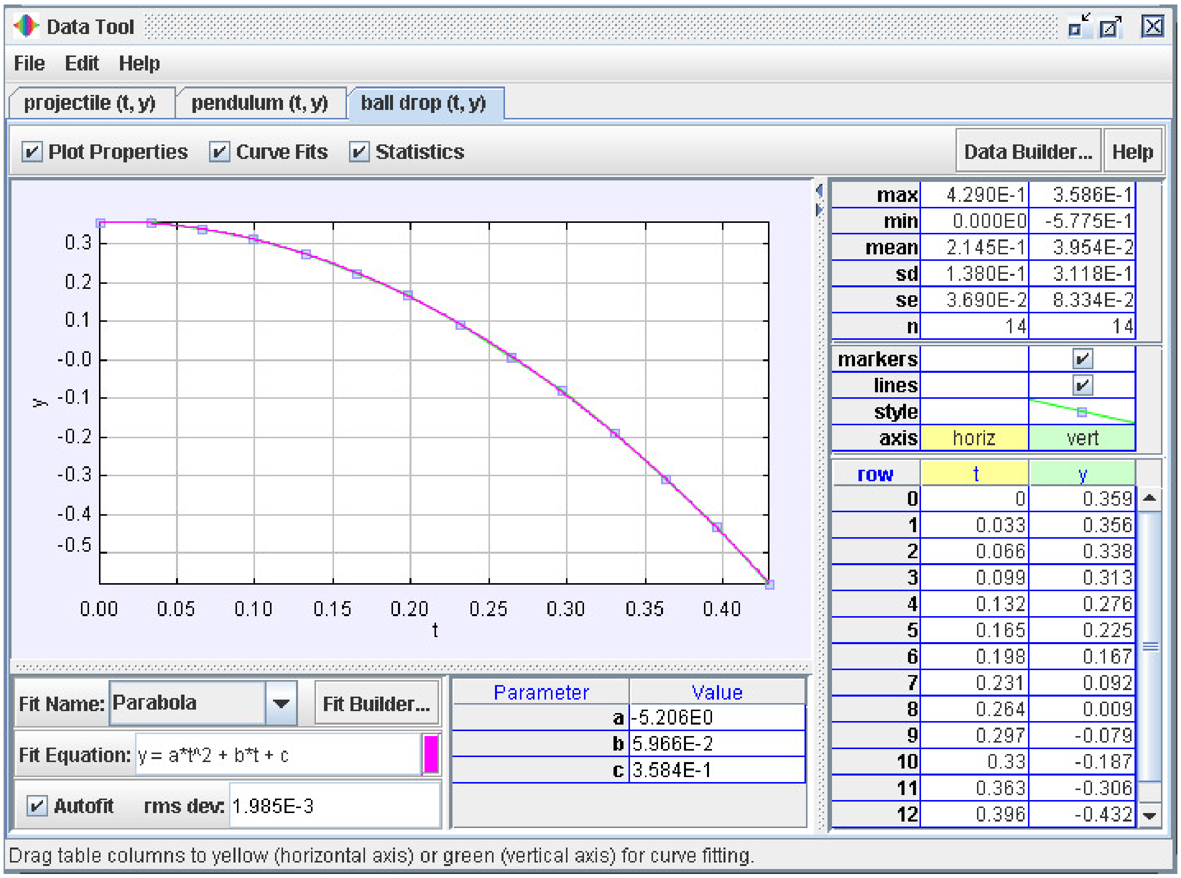


Figure 1: Using **Data Tool** to analyze a data set for a ball in projectile motion. Users can change plot properties, view statistics and fit the data.

Overview:

Data Tool is a data analysis tool for plotting and fitting data from laboratory experiments, simulations, video analysis, or any other data set organized into columns. A click of a checkbox in **Data Tool** allows the user to change the appearance of plots, see standard statistics for the data set or apply built-in linear, quadratic or cubic fits to the data set. **DataTool** also includes a number of standard mathematical functions that can be applied to the data set, allowing for further analysis and extending the range of potential fits to the data.

Although it is a stand-alone tool set, **Data Tool** is built on the Open Source Physics code library and integrated with OSP resources so that a right-click on plots generated by OSP simulations automatically imports the data set into the **Data Tool** for further analysis. This makes it easy to analyze and compare data from simulations, video analysis (especially using Tracker) and the laboratory.

DataTool is part of a suite of Open Source Physics tools. The program is distributed as a ready-to-run (compiled) Java archive. Double clicking the **osp_data_tool.jar** file will run the program if Java is installed on your computer. Additional programs can be found by searching ComPADRE for Open Source Physics.

Sample data files:
Included in the distribution file for **Data Tool** (**osp_data_tool_distribution.zip**), are files with the data shown in this documentation (search ComPADRE for this distribution if needed). If you want to explore **Data Tool** with one of these data sets, unzip the distribution folder and double-click on **osp_data_tool.jar** to run it. Once it is running, from **File → Open** navigate to where you extract the folders and open one of the data sets:

Figure 1: **data_tool_ball_drop.xml** (which came from **data_tool_projectile.xml**)
Figure 2: **data_tool_velocity_histogram.xml**
Figure 9: **data_tool_pendulum.xml**

Importing data:

1. From OSP simulations:

Right-click on the plot or from the Menu bar, choose **Tools** and then **Data Tool**. This automatically imports the data into the **Data Tool** for analysis.

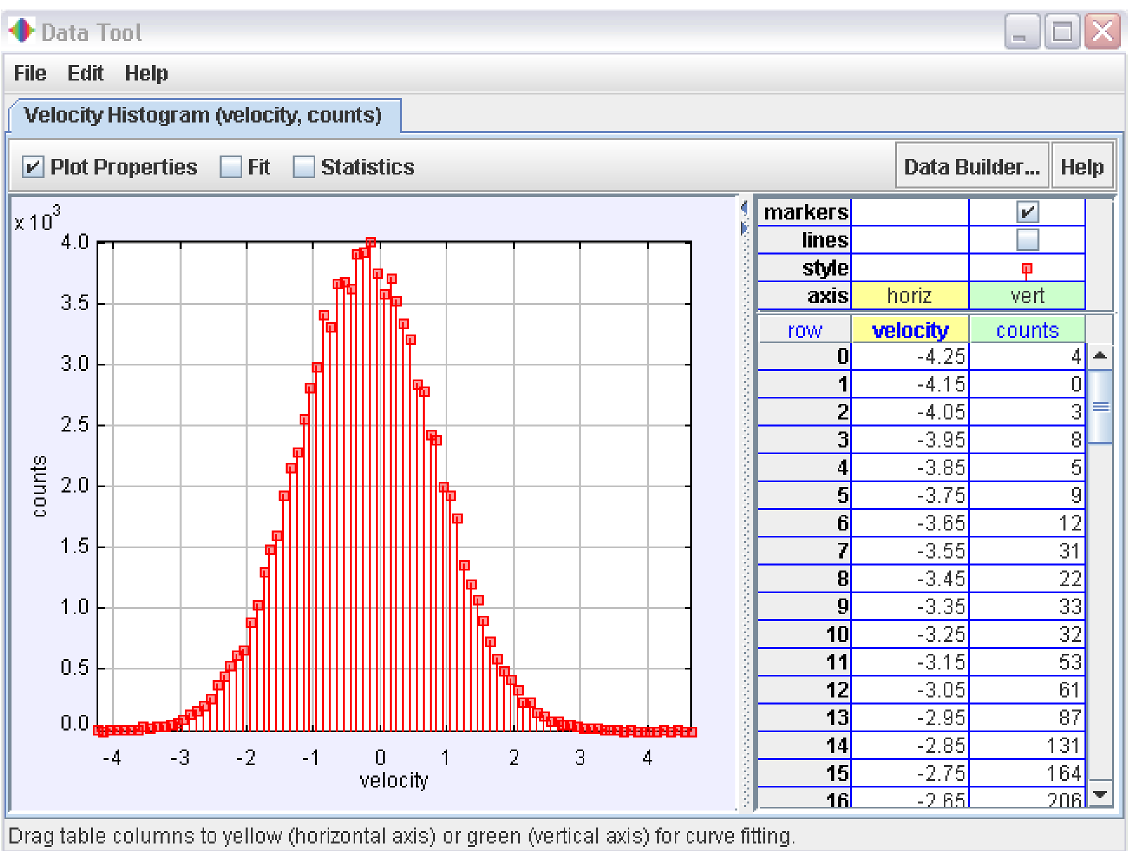


Figure 2: Data imported from another OSP program, **stp_Boltzmann.jar** showing the velocity distribution in an ideal gas.

2. Tab-delimited Columns (Excel, text files, other applications):

Copy the columns of data (if there are more than two data columns, add a heading to each column before copying the data). Then, in the **Data Tool**, from the Menu bar, choose **Edit → Paste → New Tab**. The data is automatically imported into **Data Tool** into separate columns.

Plot Properties:

To modify the appearance of a plot by changing the color and style of the markers or connecting lines, click on the **Plot Properties** check box. Above the data table, you will see the following summary of the **Plot Properties**.

markers		✔
lines		✔
style		
axis	horiz	vert

Figure 3: Plot Properties options.

Clicking on the marker in the **style box**, brings up a dialog box as follows that allows you to choose the size, shape and style of the markers and the connecting line:

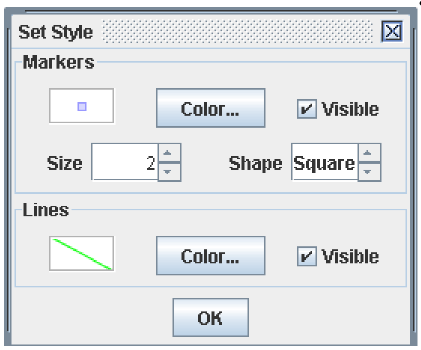


Figure 4: Dialog box to change the marker and line style.

Statistics:

Clicking on the Statistics check box, displays statistics for each column of data above the data. It displays the mean $\bar{x}$, maximum value, minimum value and the number of data points n. **Data Tool** also calculates the standard deviation, $\sigma = \sqrt{\overline{x^2} - \bar{x}^2}$ and the standard error $\sigma / \sqrt{N}$ which appear in the table of statistical data as **sd** and **se** respectively:

max	4.290E-1	3.586E-1
min	0.000E0	-5.775E-1
mean	2.145E-1	3.954E-2
sd	1.380E-1	3.118E-1
se	3.690E-2	8.334E-2
n	14	14

Figure 5: Statistics for plot shown in Figure 1.

Fits:

Clicking the **Fit** check box, provides the option to automatically fit data to a linear, quadratic or cubic equation (detail from Figure 1 above):

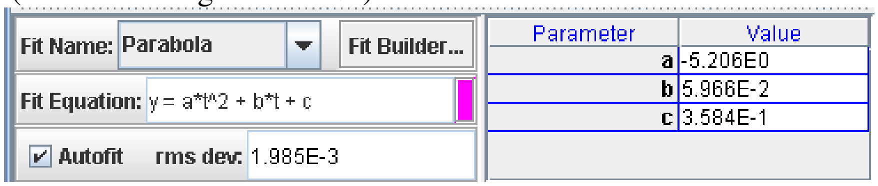
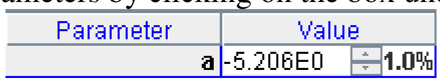


Figure 6: Quadratic fit for plot shown in Figure 1.

You can adjust any of the parameters by clicking on the box under **Value** and adjusting the values by 10%, 1% or 0.1% : 

Click in the box with the percentage to adjust the percentage change and use the up and down arrows to change the parameter itself.

Data Builder:

Sometimes it is useful to apply mathematical functions to the data to do further analysis. We might choose to do this so that the plot will be linear (or "linearize" the data). For the data set from Figure 1 showing the vertical position versus time for a ball in projectile motion, a plot of y versus t^2 would be linear. To create such a plot, click on **Data Builder** and the following dialog box appears:

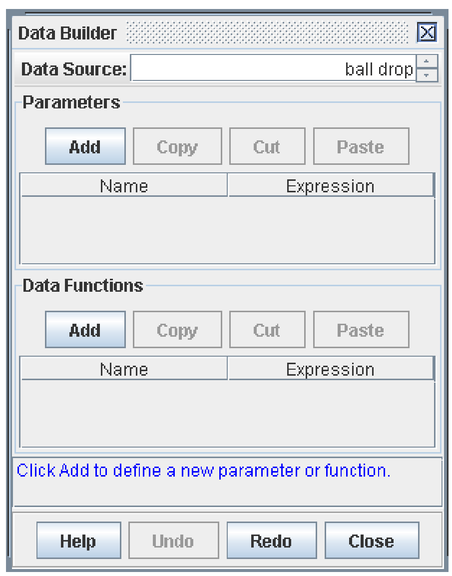
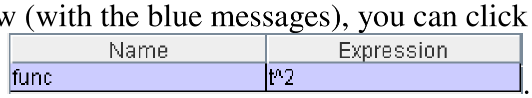


Figure 7: Data Builder dialog box.

Under **Data Functions**, click **Add**. When you click in the box under **Expression**, notice that in the message box below (with the blue messages), you can click on variables (or parameters) to add to the expression: 

. Double-clicking in the box below **Expression** will open up a window showing you the pre-defined mathematical functions that are available. You must push Enter for the program to record your input (so the box changes from yellow). Note that if the box turns red, you have inputed an undefined statement. Once you have defined the function **func**, you will see that data column. Drag that column to the **horiz** (horizontal) yellow column and then drag the **y**-data to the **vert** (vertical) green column and you can fit this plot to a line.

Or, using the data shown in Figure 2, if you take the natural log of the counts (plotted on the vertical axis) and then move that data into the **vert** axis, you can fit that data to a parabola:

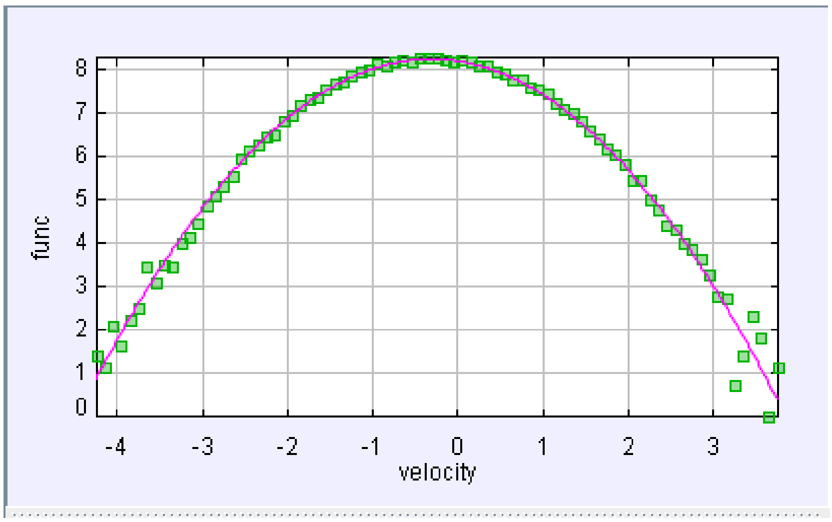


Figure 8: Data from **Figure 2**, after analysis showing that a plot of **ln(counts)** versus the **velocity** is parabolic.

Fit Builder:

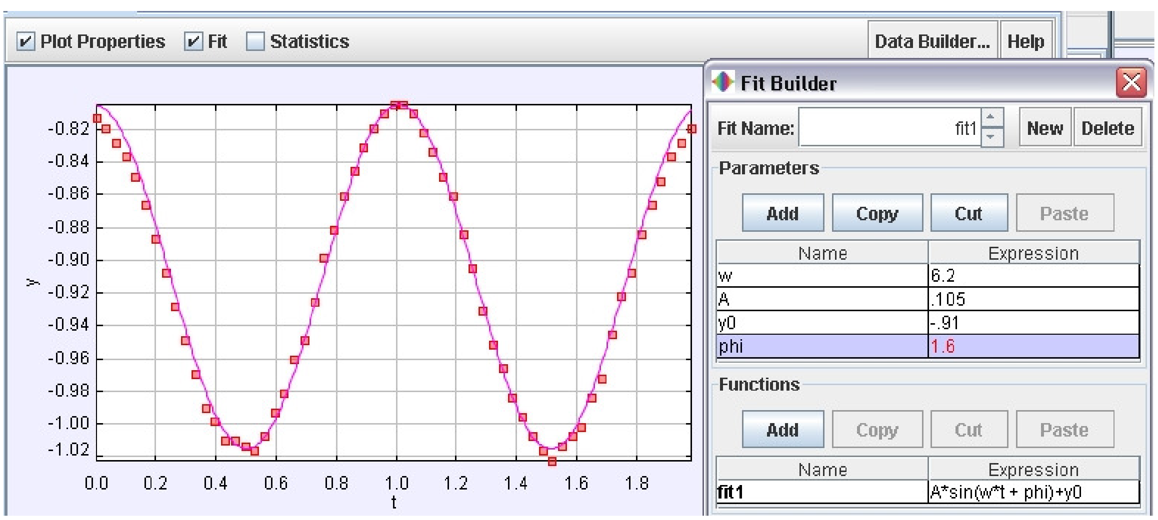


Figure 8: Oscillatory motion fit to a sine curve using **Data Tool.**

Additionally, users can fit data to functions besides linear, quadratic and cubic. Consider this data of the vertical position collected from a pendulum swinging in Tracker. By building a fit to a sinusoidal function, students can see how changing different parameters impacts the plot.

To build a fit, click on **Fit Builder**. Add the parameters needed (in this example the parameter are **w**, **A**, **y0** and **phi**). Then, **Add a Function**. Note that as you click in the **Expression** box, you can choose the available parameters and variables in the blue message box below by clicking on it. Also, double-clicking in the **Expression** box shows you the mathematical expressions defined within the **DataTool**. As you adjust the values of the parameters, the fit automatically adjusts.