**Data table.** This table, in the upper left corner of the screen, can be used in two ways. Either data can be entered manually into the cells under X and Y, or data from our other labs can be pasted into the box below. Entering numbers by hand is convenient when dealing with a small amount of data, such as with the Simple Pendulum lab. You can type the numbers into the cells and navigate from cell to cell using the TAB key or the mouse cursor. The graphs are automatically updated for every data point that has both an X and Y value entered (you'll have to move to a new cell or click elsewhere to have the Grapher recognize the final number you enter). You may have to hit the AUTO button in the zoom options to see all of your points after you've entered them. If you need additional space for more numbers when entering manually, you can hit the Add Row button as many times as you need.

Most likely, you'll want to paste larger sets of data from our other labs, such as our Dynamics Track. When available, these labs will have "Copy Data To Clipboard" options. Use those buttons and then come directly to the Grapher and click in the data box shown, not in the data table itself. Hit Ctrl and V at the same time, or Cmd + V on Mac, to paste the data into this box, and that's it. If successful, your data will automatically populate into the data table and the graphs. This method will also automatically calculate and show the first and second derivatives in the data table.

The table and graphs may populate differently depending on which lab you pull data from. For instance, the Momentum lab uses two sets of data, a time/position graph for each cart. When this is pasted into Grapher, both of these graphs will be visible and it will go into a special mode where the additional graph options are turned off. To revert, just refresh your browser on the Grapher or hit the Clear button under the data table.
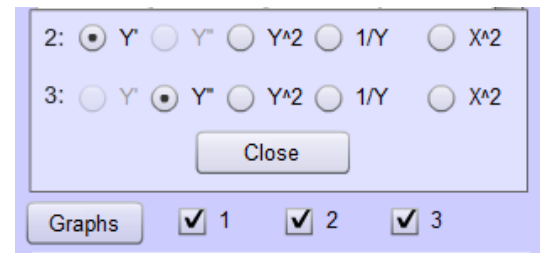
Data can also be copied from other sources, but the success of this depends on the source. Usually copying X/Y data from spreadsheet programs such as Excel works well. Sometimes doing the same from a word processor like Word has problems. If possible, try getting the data from a spreadsheet program or typing it in by hand if you are having trouble.

| X | Y | Y' | Y" |
|---|---|---|---|
| 1.1875 | 0.9212 | 1.0272 | -1.3312 |
| 1.2188 | 0.9527 | 0.984 | -1.4336 |
| 1.25 | 0.9827 | 0.9376 | -1.4592 |
| 1.2813 | 1.0113 | 0.8928 | -1.3824 |
| 1.3125 | 1.0385 | 0.8512 | -1.3312 |
| 1.3438 | 1.0645 | 0.8096 | -1.3568 |
| 1.375 | 1.0891 | 0.7664 | -1.3568 |
| 1.4063 | 1.1124 | 0.7248 | -1.3568 |
| 1.4375 | 1.1344 | 0.6816 | -1.3568 |
| 1.4688 | 1.155 | 0.64 | -1.3056 |

Click in the box below and hit Ctrl+V to paste data.

Add Row

Clear

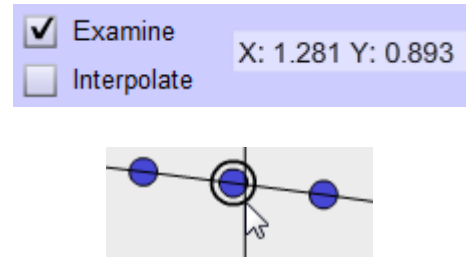| | |
|---|---|
| **Graphs.** Up to 3 graphs at a time can be displayed on the Grapher. You can choose which of these are visible by clicking on the checkboxes labeled 1, 2, and 3. Graph #1 is always at the top, is always in blue, and is always the primary data – X and Y. Graphs 2 and 3 are variable and can be changed to a few different things. By default, they are X/Y' and X/Y'', and are red and green respectively.<br><br>Clicking on the GRAPHS button will bring up the rest of the options. Graphs 2 and 3 can also be changed to X/Y², X/Y⁻¹, or X²/Y, each of which have their own unique color schemes. | 2: ⦿ Y'  ○ Y''  ○ Y^2  ○ 1/Y   ○ X^2<br><br>3: ○ Y'  ⦿ Y''  ○ Y^2  ○ 1/Y   ○ X^2<br><br>Close<br><br>Graphs  ☑ 1   ☑ 2   ☑ 3 |
| **Connect.** This option simply connects the dots. There is no best fit or interpretation here, just a straight line between data points. And when lots of data points are present a smooth figure is produced with this function. | ☑ Connect |
| **Examine and Interpolate.** When either of these options is selected, you can move your mouse cursor over data points on the graphs to see their values displayed in the box to the right of the checkbox. The difference between the two is that Examine will only show your actual data points, whichever one is closest to your cursor, while Interpolate will either show the actual data points or an approximation between two points depending on where the cursor is located. | ☑ Examine    X: 1.281 Y: 0.893<br>☐ Interpolate |
| **Tangent.** When selected, this feature shows a small tangent line on the graph when the mouse is moved along the x-axis. The slope of this tangent line is displayed in the text box to the right of the checkbox. Regardless of the selections above, the tangent is only shown for actual data points and not for interpolations in between. | ☑ Tangent    Slope: 0.49201 |
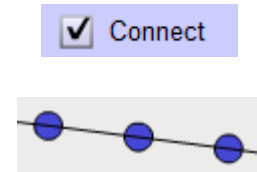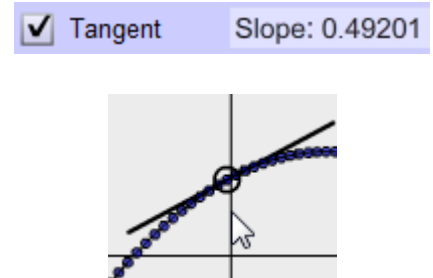
**Integrate.** When this box is checked, the area under the curve of in the graph is calculated and shown. This is also the first option that lets you choose parts of the graph to analyze. When selected, click and drag a selection area in a graph to only integrate that section. The blue under the graph will only appear where you select, and the calculated area is displayed in the textbox. By default, and when you single-click somewhere else in the graph, the entire displayed graph is integrated. You may have to adjust this if you are zooming in and out of the graph.

**IMPORTANT.** The Grapher allows for viewing up to 3 graphs at a time, but there is not enough screen space to display stats for all 3 at once. You will notice that when you hover over a graph it will glow a certain color, and the area in the bottom left corner of the screen will glow in the corresponding color. Some things, like the tangent, are easier to follow because your mouse must be over the graph for this to display anything. But other things, like the Integrated Area or Stats will always display the data for the active graph no matter where the cursor is at the time. Make sure you are looking at the correct data for the graph you want to analyze. Blue for blue, red for red, etc. To make a graph active just hover the mouse anywhere over it.
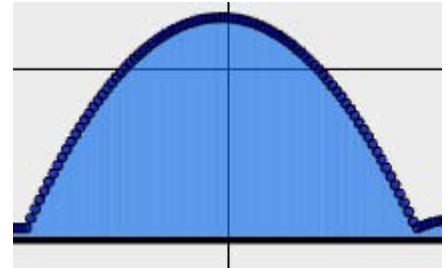


**Stats.** Various statistical calculations will appear when this is selected. The number of samples shown, the minimums and maximums and their locations, the mean, the median, and the standard deviation. **IMPORTANT.** This is for the data shown and not necessarily the full data table. If you are zoomed in and some of the data points aren't visible, they will not be factored into these calculations. Make sure to hit the AUTO zoom button before selecting Stats if you want to analyze the full set. Similarly to the Integrate function, you can click and drag over a selection area and that will give statistical information for only the selected area.



**Linear Fit.** This option will calculate and display a linear best fit for all the graphs on screen. The linear fit is shown as a pink line, and the corresponding equations for it are shown in the box to the right of the checkbox. The slope, y-intercept, and RMSE are all calculated and shown. Like the options above, make sure you are aware of which graph's information you are looking at by noting the color of the box around this area.

To perform a linear fit on a specific section of the graph, click and drag on the graph to highlight a portion with a light grey box.
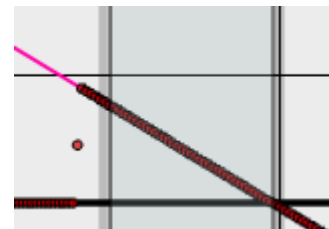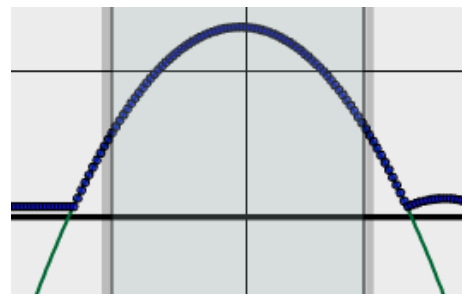
**Quadratic Fit.** Very similar to the linear fit, this option finds a best fit for the data and displays the equation in the box and a green curve on the graphs. The fit will be performed on the whole visible graph by default, or can be done on a section by clicking and dragging with the area to select a region.

**Zooming.** Each graph on the screen has its own zooming options which include AUTO, IN, OUT, and MANUAL. AUTO will do its best to show your data, no more and no less, with sensible minimums, maximums, and divisions in between. IN and OUT will simply zoom in and out from your current position. These options are more difficult to get a perfect picture with since the center of the zooming changes depending on the scale.

The fourth option, MANUAL, is the most useful if you are unhappy with the results provided by AUTO. Clicking the MANU button will bring up a menu allowing you to manually enter the minimum and maximum values for both axes. When done, hit the Submit button to update the graph, and the Close button to hide the menu. NOTE: You can leave any of these spaces blank and they will either remain at their current values or change slightly to allow for better divisions. It is also possible to reverse the axis if you enter a larger minimum value than your maximum value.

**Titles and Labels.** The graphs' titles and axis labels can all be customized simply by clicking on them and typing. The graph titles themselves can be moved on the screen by clicking and dragging them. You can use the Titles and Labels buttons to hide or show these options.
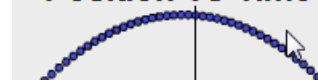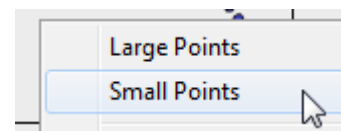
| | |
|---|---|
| **Data Point Size.**  Right-clicking on the graphs will bring up a large menu, with the top two options being Large Points and Small Points.  This refers to the size of the data points on the graph itself.  By default the manually entered table has larger points, and when data is pasted into the Grapher it turns the small size on.  You can change this setting at any time in the right-click menu. |  |
| **Snapshot.**  As with most of our labs, you can take a screenshot of any portion of the screen by clicking on the Snapshot icon and then clicking and dragging a box around what you want to capture.  A dialog will then appear asking you what you want to call the image and where you want to save it.  In most labs, a timestamp will be added to the image to keep track of it better. |  |