

Software Drivers Training

Instructions in the basics of the software.

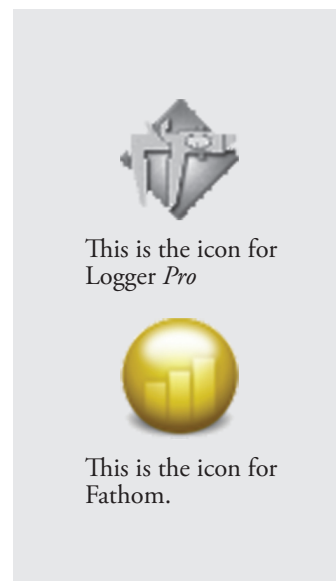
Students can do really terrific data analysis by hand. But in this book, we assume they use software for graphing and calculation.

These pages contain instructions in some of the basics of the two programs we used when we were designing this book: Fathom and Logger Pro. Both of these packages are easy to use. In addition, they support students making their own discoveries, constructing their own formulas, and setting up displays the way they want. They're powerful, too, in their attention to how people learn through data. And they don't just do it all for you; you still have to think.

Both programs are also visual, not just in their graphs but also in the interface—how users interact with the program. Learning these programs is not just learning *commands*; you learn *gestures* as well, dragging and dropping screen objects to accomplish what you want to do.

This makes it easy to do many things. But it makes it hard to write about.

Therefore, in the instructions for labs, *we have generally avoided including instructions about how to drive the computer*. The positive side of this decision is clear: you can use the lab with any future version of these or any other software packages. Even more important, the instructions are about data analysis and physics, not about the computer.



So how will students learn to use the software? Here are some things we have observed:

- ❖ Students learn very quickly from each other, but still need guidance.
- ❖ A ten-second demo by the teacher can save many minutes of step-by-step instructions.
- ❖ It's hard for many students to learn computer skills by reading about them. But they can use brief printed materials effectively as reminders.

Whence this section of the book. We have made brief instructions for most of the basic computer skills students will need, in a bilingual format (Fathom and Logger Pro; the text is English-only in this edition, alas). We suggest that you copy them for students to help them remember skills that you have demonstrated, especially if they have not seen the software in a while. Experiment!

What are these skills?

- ❖ Making new columns¹ and entering data into columns by hand.
- ❖ Making formulas to calculate values in a column.
- ❖ Making scatter plots.
- ❖ Rescaling axes.
- ❖ Plotting functions on scatter plots.
- ❖ Making variable parameters.
- ❖ Plotting straight lines on scatter plots.

In addition, if you use Fathom, you will want to know how to use residual plots and units effectively, and if you use Logger Pro, you will want to know how to use its automatic curve fitting. For both programs, there are countless tips and tricks that might fit—or not—with each individual's computational style. Many of these would just clutter a book like this.

Finally, software always changes.

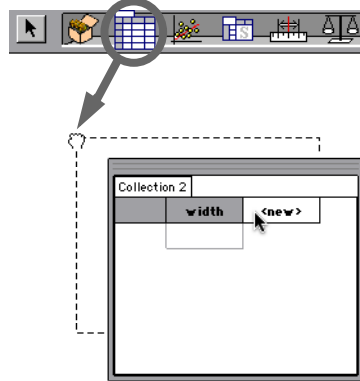
So visit <http://www.denofinquiry.com> to find additional instructions, tip reports, notes on the effect of software updates, and so forth.

¹ You can also think of *columns* as *variables*. Fathom calls them *attributes*. There are good (but relatively esoteric) reasons for all this confusion over what to call them.

Data Entry in Fathom

In Fathom, you enter data into a *case table*, which resembles a spreadsheet table.

- ❖ Start up Fathom and open a new Fathom document.



- ❖ Drag a case table off the shelf and put it in your document.
- ❖ Click where it says **<new>** to make a new column (or variable). Enter a name for the column (**width** in the example). Press **TAB**, **ENTER**, or **RETURN** to finish making that new column.
- ❖ Do the same to make another new column, **height** (or whatever variable name you need).
- ❖ Enter data into the appropriate cells. You can enter units right with the data. After you have entered the first case (the first row), Fathom remembers what units you are using.

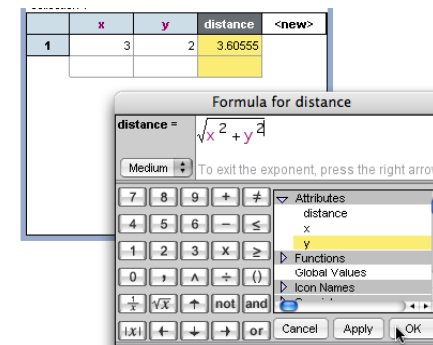
Context Menus

To get a “context menu,” point at an object and right-click (Windows) or **CONTROL**-click (Macintosh).

Calculated Columns in Fathom

First you make the new column, then you give it a formula.

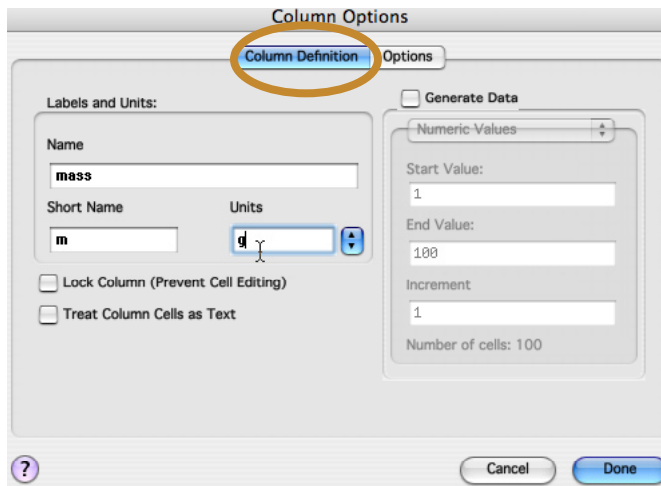
- ❖ To make a new column (a new variable or attribute) do one of the following:
 - Make a new column by clicking on a **<new>** column heading in the case table, or
 - Choose **New Attribute** from a case table’s context menu.
- ❖ Give the new column a name. Press **ENTER** or **RETURN**.
- ❖ Open the formula editor for the column by doing one of the following
 - Context-click (see the gray box below) on the name of the new attribute and choose **Edit Formula** from the context menu.
 - Double-click the cell in the “formula row” for that attribute. (Be sure **Show Formulas** is on; it’s in the table’s context menu.)
- ❖ Enter the formula for the column. You can enter variables and functions by typing or by double-clicking them in the “browser” pane.
- ❖ Close the formula editor by clicking **OK**.



Data Entry in Logger Pro

Logger Pro has a data table visible by default, with two columns, **X** and **Y**. You need to change their names and give them units if necessary.

- ✧ Double-click the **X** at the top of the column. The **Column Options** dialog appears. There, in the **Column Definition** panel (shown), you can edit the name and the short name of the variable, and enter its units. Press **Done** when you have it the way you want.
- ✧ Do the same for the **Y** column. In the illustration, we have changed **Y** to **mass** and given it units of grams (**g**)
- ✧ For additional columns, choose **New Manual Column** from the **Data** menu.



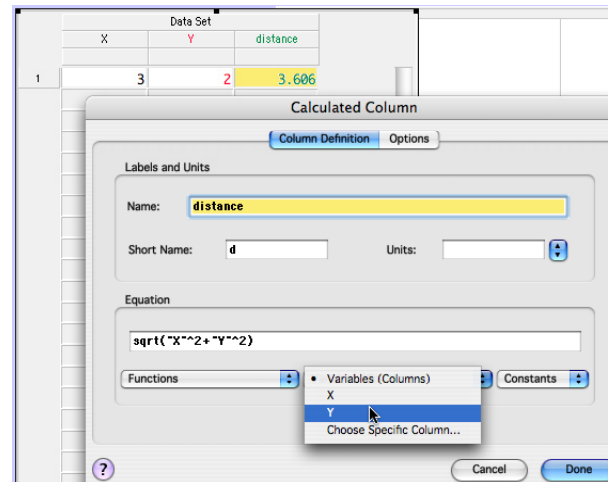
- ✧ Enter the data in the table cells. Do *not* include the units in the cells themselves.

Note: If you have an interface and probes attached to your computer, Logger Pro may detect the probes and you will not have the **X** and **Y** columns where you can enter data manually.

Calculated Columns in Logger Pro

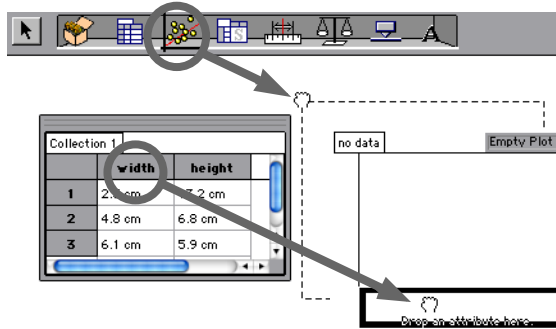
Make the new column and formula in one handy dialog box.

- ✧ Choose **New Calculated Column...** from the **Data** menu. Be sure you're looking at the **Column Definition** panel.
- ✧ In the dialog box, give your new column a name and (optionally) a short name and units.
- ✧ In the **Equation** field, enter its formula.
 - ▶▶ Note that other column names have to be enclosed in quotes, and that you enter only the part of the equation to the right of the equals sign.
 - ▶▶ If you wish, you can choose other variables (and functions) from the menus.
- ✧ Close the dialog box by pressing **Done**.
- ✧ To change an existing formula, double-click the column heading.



Scatter Plots in Fathom

Here is how you make a graph:



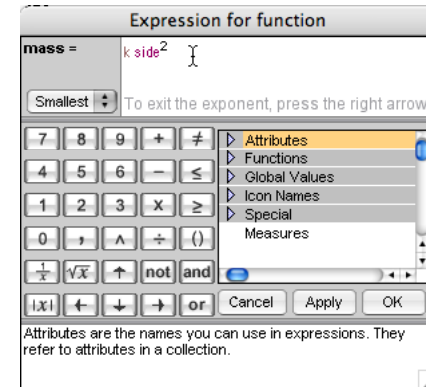
- ✧ Drag a new graph off the shelf. Put it in your document so that it does not overlap your case table. (You may have to make the table smaller.)

The graph starts out empty. You haven't told Fathom what to graph. Tell Fathom what to graph by *labeling your axes*.

- ✧ Drag the name of the horizontal-axis variable (**width** in the illustration) from the column heading in the case table to the horizontal axis of the graph.
- The correct area will highlight when you're there.
- ✧ Drop the name on the axis. A graph of all the widths appears.
 - ✧ Do the same with the vertical-axis variable; this creates a scatter plot.

Plotting Functions in Fathom:

- ✧ Point at the graph and right-click (Windows) or control-click (Macintosh) with the mouse. As you hold the button down, a context menu appears.
- ✧ Choose **Plot Function...** from the graph's context menu. It's way down at the bottom. The *formula editor* appears.



- ✧ Enter your function in the formula editor. Press **OK** or the ENTER key to plot your function. The formula editor goes away and the function appears on the graph.
- ✧ If the function is not right, double-click it where it appears at the bottom of the graph; the formula editor opens. Edit the function and click **OK**. (If you click **Apply**, the function changes but the editor stays open.)
- ✧ We used a variable parameter, **k**, in our function, instead of entering a constant. Use a slider to set the value of **k**; see *Variable Parameters* (page 24).
- ✧ When in doubt, use parentheses.

Note: As long as the formula editor is open, you can't do anything outside the editor. So sometimes when everything seems stuck, all you have to do is close the formula editor.

Scatter Plots in Logger Pro

In *Logger Pro*, you have a graph by default; the problem is making sure things get plotted the right way.

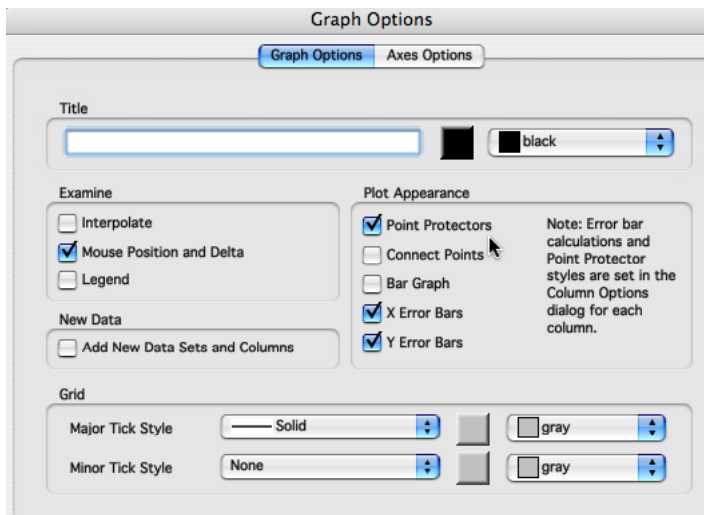
Your data should be in two columns in the table. By default, *Logger Pro* makes a line graph of the data with the first variable (the one that was originally **x**) on the horizontal axis.

If the variables are on the right axes, fine.


- ❖ If not, point at the name of the variable on the horizontal axis and hold the mouse button down. A menu appears; select the name of the variable you want there. Do the same for the vertical axis.

Now you need to get rid of the dot-to-dot lines and make the points bigger so you can see them.

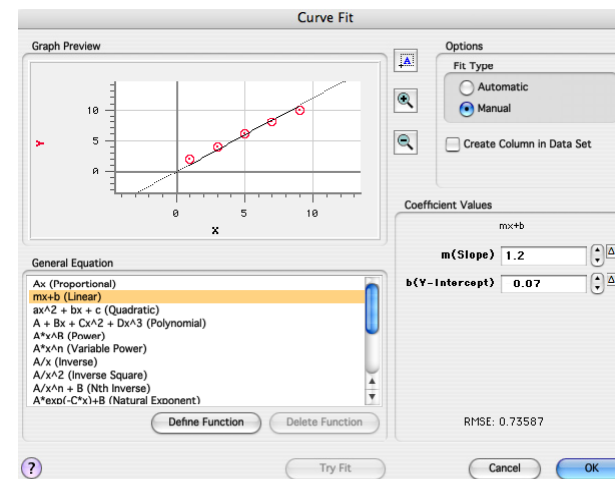
- ❖ Double-click the graph itself; a dialog box appears (see the figure). In the **Graph Options** panel (shown), select **Point Protectors** and deselect **Connect Points**. When you close this dialog, your graph will be the way you need it.




Plotting Functions in Logger Pro

- ❖ Select the graph, then press the **Curve Fit** button  in the tool bar. The **Curve Fit** dialog appears, where you can select a function from the list.
- ❖ Select a function (in the illustration we chose **mx + b**).
- ❖ Up at the top, choose the **Manual** option.

The dialog shows a thumbnail of the graph, and the values of whatever parameters (in this case, **m** and **b**) you need for your function.

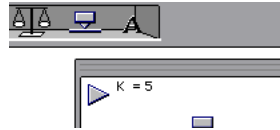


- ❖ Type in the values you want for the parameters, or change them using the up-down arrow buttons . The curve will change in the thumbnail graph.
- ❖ When the curve looks pretty good, press **OK** to leave that dialog. *Logger Pro* puts the function on the main graph, with a “callout” box. (You can refine the parameter values in version 3.4 or later.)
- ❖ If you don't see the function you want in the list, click the **Define Function...** button. Enter whatever you want. Its parameters appear on the right, in the panel under **Coefficient Values**.

Need more details? See page 26.

Variable Parameters in Fathom

- ✧ Drag a new slider off the shelf. Find an empty area to put it in.
- ✧ It's named **V1** already. Edit that name to give it a new name, such as **K**. Press ENTER or RETURN to tell Fathom you're done naming it.



- ✧ Change the value of the parameter by typing or by sliding the pointer.
- ✧ You can add units to a slider-parameter. Use **^** (SHIFT-6) for exponentiation.
- ✧ The number line is an axis, just like on a graph. If you run out of numbers, or need finer control, just rescale the axis (see the section at right).
- ✧ Use the slider's name in any formula; Fathom will update the results of the formula as you change the value.
- ✧ For example, to include a new parameter in a function, double-click the function where it appears at the bottom of a graph and edit the function to include the parameter name (e.g., change $H = 1/W$ to $H = K/W$).

If you're using slider-parameters in a function, you can create the sliders before or after you create the function. Fathom figures it out.

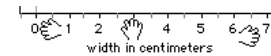
However, if you do the function first, the message you get may be misleading. Frequently, Fathom gives a **units incompatible** error when it really means **Name not recognized**.

Rescaling Axes in Fathom

To autoscale axes and show all the data, just re-choose **Scatter Plot** from the menu in the corner of the graph. Alternatively, choose **Rescale Graph Axes** from the graph's context menu.

But what if you want to scale the axes some other way?

Move the cursor—without clicking—over the numbers of an axis. You'll notice that the cursor changes shape. It's a hand that "points" in different directions.



With the cursor in each of these shapes, try "grabbing" the axis numbers and dragging parallel to the axis. The graph will rescale.

The basic rule is, if you need more values on the axis (i.e., zoom out), go to the end where you need the values, grab a number, and drag it to the middle. If you need fewer values on the axis (i.e., zoom in), grab a number near the end and shove it off the end of the axis to get rid of it. If you just want to change where the axis is centered (but have it view the same range of numbers) drag the axis numbers from the middle.

You can also just type in the axis bounds you want. Double-click the graph or slider to get that object's *inspector*. There you can type in values for the minimum and maximum.

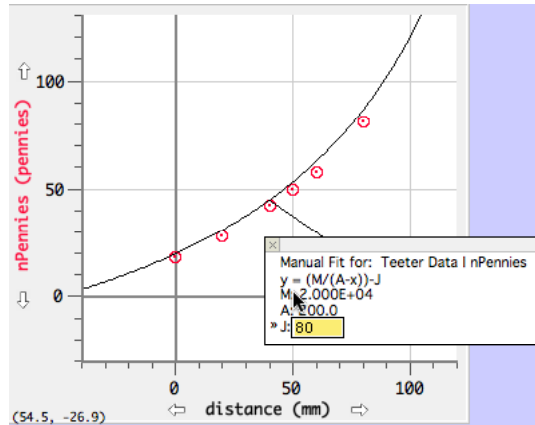
| Property | Value |
|---------------|-------|
| pointSize | 5 |
| xLower | -10 |
| xUpper | 230 |
| yLower | -1 |
| yUpper | 25 |
| xReverseScale | false |
| yReverseScale | false |
| xAutoRescale | true |
| yAutoRescale | true |

Zoom-in shortcut: hold down the **OPTION** key (**CONTROL** in Windows) and point at the axis numbers. The cursor changes to a magnifying glass. Click among the numbers to make the axis zoom in to that place on the axis.

Variable Parameters in Logger Pro

For this, you need at least Version 3.4.

Briefly, you can control the values of parameters that appear in the function “callouts” by clicking on them and then using the arrow keys.



In the illustration, look for the “»” indicator next to the value of **J**. If you click on the name of a parameter, that double-chevron (») appears, which indicates that you can adjust its value using the up/down arrow keys. If you click the value, you can edit it in place (the illustration shows that we can edit the current value of **J**, which is **80**).

If you double-click this “model” box, you get the **Modeling options** dialog, in which you can specify the *increment*, which is how much the value of each parameter changes with each press of an arrow key.

You can also (invisibly) change the increment by pressing the left and right arrow keys when the double-chevron is visible.

Rescaling Axes in Logger Pro





To autoscale a graph, press the autoscale button on the tool bar.



To zoom in, press the plus-magnifier.

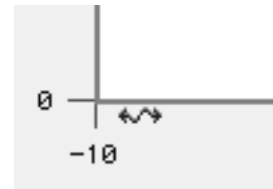


To zoom out, press the minus-magnifier.

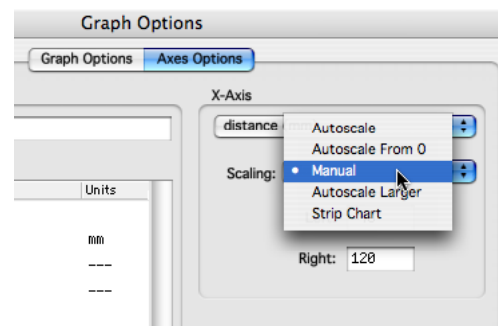
Often, pressing  and then  gets you a reasonable window.

If you don't want to autoscale, you have several choices:

- ❖ Click on the number at either end of the axis (or click where the number *would* be if there was one!). Type in a new number to change the limiting value there.
- ❖ Point near an axis, between the axis and the numbers. A springy cursor appears. Drag that cursor to change the scale.



- ❖ Double-click the graph to bring up the **Graph Options** dialog. Bring up the **Axes Options** panel. There you can control how each axis behaves.






Here is additional information about some of the trickier aspects of plotting functions on your Logger *Pro* scatter plots in version 3.4 or later.

Defining Columns

When you define a new column (**Data>New Manual Column** or **Data>New Computed Column**), give your variable a good name and a good short name. It's best if the short name is one letter long.

Defining Your Own Function

In this book, you will often need to define your own function. Press  for the **Curve Fit** dialog, then press the **Define Function...** button.

Then type the function into the box. Here you should be aware of a few things:

- ❖ The variable in your function must be the *short name* of the column on the horizontal axis.
- ❖ Any other letters you use become parameters.
- ❖ Use \wedge to express powers, as in $y = Ax^2 + C$. (Here, **A** and **C** are parameters.)
- ❖ You can use functions, with their arguments enclosed in parentheses. Common ones are **sin()**, **cos()**, **log()**, **sqrt()**, **ln()**, and **exp()**.
- ❖ Once you have defined a function, you can use it multiple times in the same graph. Each curve has its own values for the parameters.

User Parameters

You may see references to “user parameters.” Choose **User Parameters...** from the **Data** menu to see them and make new ones. Logger *Pro* comes with one already defined: **pi**.

You can most easily control the value of user parameters by choosing **Parameter Control** from the **Insert** menu. This makes a widget that looks like a meter, but has a control.

User parameters can be useful, but *they are not the same as the parameters in models* (such as the **A** in $y = Ax^2$). In particular:

- ❖ You can't use a user parameter as part of a function definition (e.g., as a coefficient, like a regular parameter). If you use the name in a function definition, you get a completely new parameter—with the same name but a different value. This can be confusing.
- ❖ You *can* use parameters in formulas in calculated columns. Then, changing the value of the parameter changes the data.

Therefore, consider using user parameters only for actual constants (such as **pi**), or parameters that affect the data (such as the diameter of a washer), and avoid them for parameters that affect models.

Comparison with Fathom

Fathom's sliders, in contrast, are true global values. Within a document, if you have a slider named **K**, its value is the same wherever you use it: in a calculated column, in a formula for a function, wherever—and changing the slider will affect everything. That's a good thing.

What you *cannot* do in Fathom, however, is use multiple functions having the same parameter but different values. If you want to show models with minimum and maximum plausible values for **g**, you need to make extra sliders for **gmin** and **gmax**. In Logger *Pro*, just make another function.