

Appendix B: with Gnuplot

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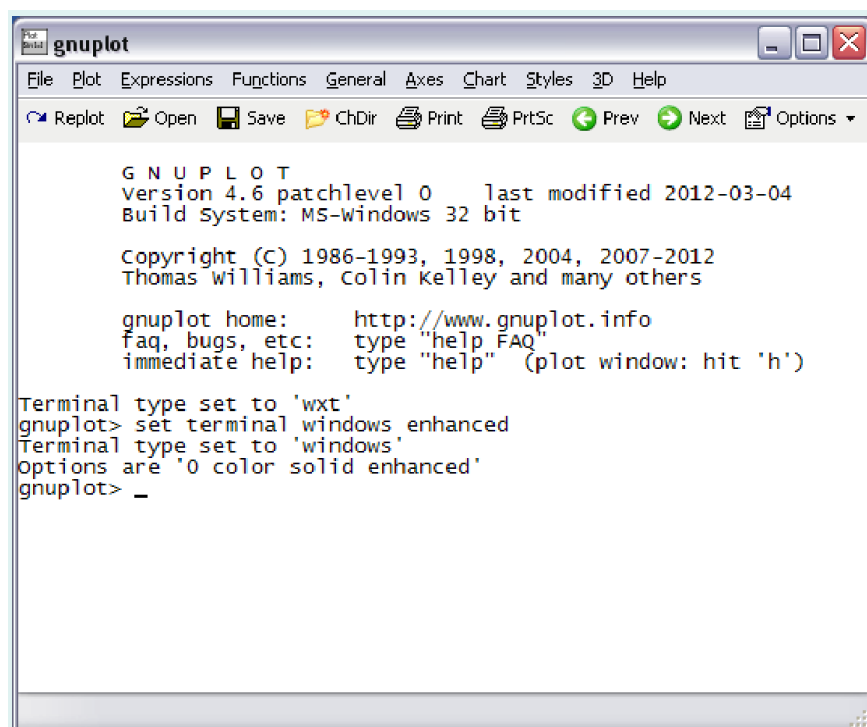
Gnuplot is a free, open-source software package for producing a variety of graphs. Versions are available for many operating systems. Below is a very brief tutorial on how to use Gnuplot to graph trigonometric functions.

INSTALLATION

1. Go to <http://www.gnuplot.info/download.html> (<http://www.gnuplot.info/download.html>), and follow the links to download the latest version for your operating system. For Windows, you should download the setup file with a name such as `gp460-win32-setup.exe`, which is version 4.6.0. All the examples discussed here will assume at least version 4.6.0, though they should work with earlier 4.x versions.
2. Install the downloaded file. For example, in Windows you would run the setup file you downloaded in Step 1, which installs Gnuplot in the `C:\Program Files\gnuplot` folder by default. You can accept the defaults during installation, though you should select the “Create a desktop icon” option in the **Select Additional Tasks** screen.
3. (Optional) Read the documentation at <http://gnuplot.info/documentation.html> (<http://gnuplot.info/documentation.html>).

RUNNING GNUPLOT

1. In Windows, run `wgnuplot.exe` from the `bin` folder where you installed Gnuplot (the default location is `C:\Program Files\gnuplot\bin\wgnuplot.exe`), or double-click the desktop icon if you selected that option during the installation. In Linux, just type `gnuplot` in a terminal window.
2. You should now get a Gnuplot terminal with a `gnuplot>` command prompt. In Windows this will appear in a new window, as shown in the picture on the next page. In Linux it will appear in the terminal window where the `gnuplot` command was run. For Windows, if the font is unreadable you can change it by right-clicking on the text part of the Gnuplot window and selecting the “Choose Font..” option. For example, the font “Courier”, style “Regular”, size “12” is usually a good choice (that choice can be saved for future sessions by right-clicking in the Gnuplot window again and selecting the option to update `wgnuplot.ini`).
3. At the `gnuplot>` command prompt you can now run graphing commands, which we will now describe.



GRAPHING FUNCTIONS

The usual way to create graphs in Gnuplot is with the `plot` command:

```
plot <range> <comma-separated list of functions>
```

For a function $y = f(x)$, `<range>` is the range of x values (and optionally the range of y values) over which to plot. To specify an x range, use an expression of the form $[a : b]$, for some numbers $a < b$. This will cause the graph to be plotted for $a \leq x \leq b$.

To specify an x range and a y range, use an expression of the form $[a : b][c : d]$, for some numbers $a < b$ and $c < d$. This will cause the graph to be plotted for $a \leq x \leq b$ and $c \leq y \leq d$.

Function definitions use the x variable in combination with mathematical operators, listed below:

Symbol	Operation	Example	Result
+	Addition	$2 + 3$	5
−	Subtraction	$3 - 2$	1
*	Multiplication	$2 * 3$	6
/	Division	$4 / 2$	2
**	Power	$2 ** 3$	$2^3 = 8$
$\exp(x)$	e^x	$\exp(2)$	e^2
$\log(x)$	$\ln x$	$\log(2)$	$\ln 2$
$\sin(x)$	$\sin x$	$\sin(\pi/2)$	1
$\cos(x)$	$\cos x$	$\cos(\pi)$	−1
$\tan(x)$	$\tan x$	$\tan(\pi/4)$	1

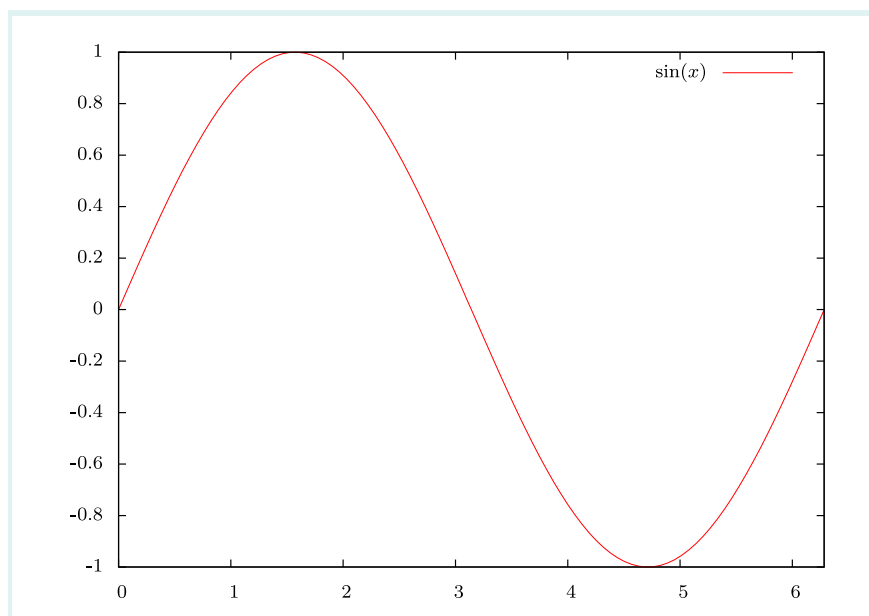
Note that we use the special keyword “pi” to denote the value of π .

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Example B.1. To graph the function $y = \sin x$ from $x = 0$ to $x = 2\pi$, type this at the `gnuplot>` prompt:

```
plot \symbol910:2*pi\symbol93 sin(x)
```

The result is shown below:



Notice that the x -axis is labeled with integers. To get the x -axis labels with fractions of π , you need to modify the `terminal` setting. In Windows, you would do this:

```
set terminal windows enhanced
```

In Linux you would do this:

```
set terminal wxt enhanced
```

You can then (provided the Symbol font is installed, which it usually is) set the x -axis to have multiples of $\pi/2$ from 0 to 2π as labels with this command (all on one line):

```
set xtics ('0' 0, '{/Symbol p}/2' pi/2, '{/Symbol p}' pi, '3{/Symbol p}/2' 3*pi/2,
          '2{/Symbol p}' 2*pi)
```

In the above example, to also plot the function $y = \cos 2x + \sin 3x$ on the same graph, put a comma after the first function then append the new function:

```
plot \symbol910:2*pi\symbol93 sin(x), cos(2*x) + sin(3*x)
```

By default, the x -axis is not shown in the graph. To display it, use this command *before* the `plot` command:

```
set zeroaxis
```

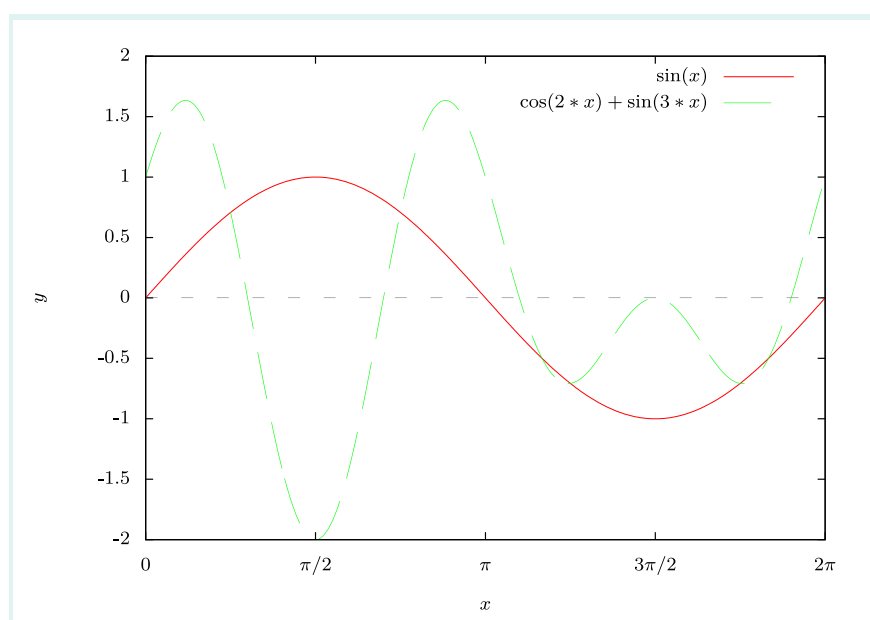
Also, to label the axes, use these commands:

```
set xlabel "x"
set ylabel "y"
```

The default sample size for plots is 100 units, which can result in jagged edges if the curve is complicated. To get a smoother curve, increase the sample size (to, say, 1000) like this:

```
set samples 1000
```

Putting all this together, we get the following graph:



PRINTING AND SAVING

In Windows, if you are using the `windows enhanced` terminal then to print a graph from Gnuplot click on the printer icon in the menubar of the graph's window. If you are using the default `wxt` terminal then select **Print** near the top of the main Gnuplot window and enter `png` in the *Terminal type?* textfield, then hit OK to get the Print Setup dialog.

In Windows, to save a graph, say, as a PNG file, go to the File menu on the main Gnuplot menubar, select "Output Device ...", and enter `png` in the *Terminal type?* textfield, hit OK. Then, in the File menu again, select the "Output ..." option and enter a filename (say, graph.png) in the *Output filename?* textfield, hit OK. Now run your plot command again and the file will be saved in the current directory, usually in your `My Documents` folder (it can also be found by selecting the "show Current Directory" option in the File menu).

In Linux, to save the graph as a file called graph.png run the following commands:

```
set terminal png
```

```
set output 'graph.png'
```

and then run your plot command. There are many terminal types (which determine the output format). Run the command `set terminal` to see all the possible types. In Linux, the **postscript** terminal type is popular, since the print quality is high and there are many PostScript viewers available.

To quit Gnuplot, type `quit` at the `gnuplot>` command prompt.