Introduction to Gnuplot

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Course aims

- Simple graphs
- 2D
- Plotting data
- Scripted process
- No manual work
What the course won't cover

Gnuplot can

- 3D plots
- Plotting functions
- Polar graphs
- Histograms

Gnuplot can't

- Manual artistry
What the course will cover

1. Introduction
2. Part one
3. Break
4. Part two
5. Questions

- Course contents
- Command line
- Viewing tool
  - eog
  - “Eye of Gnome”
What the course will cover

1. Introduction
2. Part one
3. Break
4. Part two
5. Questions

- Driving Gnuplot
- Basic settings
- Size
- Ranges of values
- Tick marks
What the course will cover

1. Introduction
2. Part one
3. Break
4. Part two
5. Questions

- Multiple graphs
- Colours
- Labels
- Frills
What the course will cover

1. Introduction
2. Part one
3. Break
4. Part two
5. Questions
Terminal

- Command line
- Gnome terminal
- Applications menu
Set up some files

- “Playground”
- Input files
- Gnuplot files
- Output files

> /ux/Lessons/Gnuplot/setup

Directory /home/y500/gnuplot created.

> cd ~/gnuplot
Test you can display graphics

> eog example01.png

Select image window
Close or Control-Q
Interactive use of Gnuplot

- Run interactively
- Direct commands
- Built-in help
  - Not very helpful
- X11 graphics

> `gnuplot`

GNUPL O T

Version 4.0 ...

Terminal type set to 'x11'

`gnuplot> plot "cubic.dat"

...`

`gnuplot> quit`

>`
Batch use of Gnuplot

- File of commands
- cubic.gplt
- Don't need a “quit”
- Just need end of file
- “Flash” of graph

> more cubic.gplt
plot "cubic.dat"
> gnuplot cubic.dat
>
Change output file format

- Want PNG
  - Portable Network Graphics
- Gnuplot “terminal”:
  set terminal png
- Want a file:
  set output "cubic.png"
- File names in quotes
- Before the plot

> more cubic.gplt
  set terminal png
  set output "cubic.png"
  plot "cubic.dat"

> gnuplot cubic.gplt
> eog cubic.png
A look at the output

- 640×480 pixels
- Series of crosses
- Graph range = data range
- “Ticks” every 0.5
- No zero axes
- No labels
- Key uses file name
- Red
Problems with the shape

Problems:
- Image file 640×480
- Graph isn't square

Want to set:
- Image dimensions
- Graph aspect ratio
Gnuplot commands

Image dimensions:

set terminal png picsize X Y  Image size in pixels
Gnuplot commands

Graph aspect ratio:
set size ratio \( r \)
Graph's aspect ratio
e.g. set size ratio +1:

Units' aspect ratio
e.g. set size ratio -1:
Next version of graph

set terminal png
picsize 512 512
set output "cubic.png"
set size ratio -1.0
plot "cubic.dat"
Problems with the curve

Problem:
• Set of crosses

Want to have:
• Set of line segments
Gnuplot commands

Curve made of points:
set style data points
• “points” may be crosses or other marks

Curve made of line segments:
set style data lines

Curve made of true dots:
set style data dots
Next version of graph

set terminal png picsize 512 512
set output "cubic.png"
set size ratio -1.0
set style data lines
plot "cubic.dat"
Problems with the range

Problem:
- Graph range = Data range
- $[-1.0,+1.0] \times [-1.0,+1.0]$

Want to have:
- Manual setting
- $[-1.5,+1.5] \times [-1.5,+1.5]$
Gnuplot commands

Setting range explicitly:

set xrange [-1.5:1.5]
set yrange [-1.5:1.5]

Partial specification:

set xrange [*:1.5]     data minimum to 1.5
set yrange [-1.5:*]    -1.5 to data maximum
Next version of graph

set size ratio -1.0
set style data lines
set xrange [-1.5:1.5]
set yrange [-1.5:1.5]
plot "cubic.dat"
Problems with the graph

Problem:
- Ticks every 0.5
- Ticks from -1.5 to 1.5

Want to have:
- Ticks every 0.25
- Ticks from -1.0 to 1.0
Gnuplot commands

Setting just the tick interval
set xtics 0.25
set ytics 0.25

Setting the interval and range
set xtics -1.0,0.25,1.0
set ytics -1.0,0.25,1.0
Next version of graph

... set xrange [-1.5:1.5] set yrange [-1.5:1.5] set xtics -1.0,0.25,1.0 set ytics -1.0,0.25,1.0 plot "cubic.dat"
Problems with the graph

Problem:
- No sub-ticks

Want to have:
- Sub-ticks every 0.05
- 5 sub-ticks to the tick
Gnuplot commands

“Minor ticks”

- Number of minor ticks for each major tick
  
  set mxtics 5

  set mytics 5
Next version of graph

... 
set xtics -1.0,0.25,1.0
set ytics -1.0,0.25,1.0
set mxtics 5
set mytics 5
plot "cubic.dat"
Problems with the graph

Problem:
- No axes

Want to have:
- Proper axes
- Running through (0,0)
Axes through the origin:

- A “zero axis”
- Defaults to being in grey
- Will consider colours later

```
set zeroaxis
```

or

```
set xzeroaxis
set yzeroaxis
```
Next version of graph

... set mxtics 5
set mytics 5
set zeroaxis
plot "cubic.dat"
Problems with the graph

Problem:
- Key in top right
- Key uses file name

Want to have:
- Key in top left
- Manually specified key
Gnuplot commands

Location of key:

• Only the corners are available

set key top left
set key bottom right
unset key
Gnuplot commands

Text for key:

• Option on `plot`

• “Title” of the data *not* the whole graph

```
plot "cubic.dat" title "cubes"
plot "cubic.dat" notitle
```
Next version of graph

... set xzeroaxis
set yzeroaxis
set key top left
plot "cubic.dat" title "cubes"
Half time exercise

• Fifteen minutes
• Create the graph
• Then have a break

lissajou1.dat + lissajou1.gplt
\[ \rightarrow \]
lissajou1.png
Welcome back

- lissajou1.gplt
- Any questions?
Second half

- Introduction
- Part one
- Break
- Part two
- Questions
- Multiple graphs
- Colours
- Labels
- Titles
Compound graph

- Single graph
- Several lines
- Single input file
  - Several columns
- Multiple input files
  - Two columns each
# x, x^3, x^5, x^7

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>-1.00</td>
<td>-1.00</td>
<td>-1.00</td>
<td>-1.00</td>
</tr>
<tr>
<td>-0.99</td>
<td>-0.97</td>
<td>-0.95</td>
<td>-0.93</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.99</td>
<td>0.97</td>
<td>0.95</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
## Properties of the data file

```plaintext
# x, x^3, x^5, x^7

-1.000000  -1.000000  -1.000000  -1.000000
-0.990000  -0.970299  -0.950990  -0.932065
...
```

- “#” introduces a comment line
- Ignored by Gnuplot
- Columns separated by whitespace
Gnuplot commands

• Extend the **plot** command
• Specify the columns to use
• Specify the data files to use
• Comma between curve definitions
• Continue lines with a backslash

```bash
plot "powers.dat" using 1:2, \ 
"powers.dat" using 1:3, \ 
"powers.dat" using 1:4
```
Problems with the graph

Problem:
- Key is very ugly

Want to have:
- Our line names
Gnuplot commands

- Same extension of the `plot` command
- Once per curve in the graph

```
plot "powers.dat" using 1:2 title "x^3", \\
    "powers.dat" using 1:3 title "x^5", \\
    "powers.dat" using 1:4 title "x^7"
```
Next version of graph

plot \ "powers.dat" using 1:2 \ title "x^3", \ "powers.dat" using 1:3 \ title "x^5", \ "powers.dat" using 1:4 \ title "x^7"
Don't have to use column 1

plot "powers.dat" \ using 4:2 \ title "x^(3/7)"
Problems with graph:

- Curve colours
- Red, Green, Blue

Want to have:

- Our curve colours
- Red, Purple, Blue
Colours we have seen so far

- Background (white)
- Borders (black)
- Axes (grey)
- Curve one (red)
- Curve two (green)
- Curve three (blue)
How Gnuplot uses colours

- Numbered colours for particular purposes
- Maximum of 256 colours

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Number</th>
<th>Default colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>0</td>
<td>White</td>
</tr>
<tr>
<td>Borders</td>
<td>1</td>
<td>Black</td>
</tr>
<tr>
<td>Axes</td>
<td>2</td>
<td>Grey</td>
</tr>
<tr>
<td>First curve</td>
<td>3</td>
<td>Red</td>
</tr>
<tr>
<td>Second curve</td>
<td>4</td>
<td>Green</td>
</tr>
</tbody>
</table>
Gnuplot commands

- Extension to `set terminal`
- List colours at end of command
- Hexadecimal specification: `xrrrggbb`

```
set terminal png picsize 512 512 \nffffff x000000 x404040 \nxff0000 x800080 x0000ff
```
# A few colours

<table>
<thead>
<tr>
<th>Colour</th>
<th>Hex Code</th>
<th>Hex Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>green</td>
<td>x00ff00</td>
<td>black</td>
</tr>
<tr>
<td>turquoise</td>
<td>x00ffff</td>
<td>grey</td>
</tr>
<tr>
<td>blue</td>
<td>x0000ff</td>
<td>grey</td>
</tr>
<tr>
<td>magenta</td>
<td>xff00ff</td>
<td>grey</td>
</tr>
<tr>
<td>red</td>
<td>xff0000</td>
<td>white</td>
</tr>
</tbody>
</table>
Next version of graph

set terminal png \
picsize 512 512 \
xffffff x000000 x404040 \
xff0000 xff00ff x0000ff

...
Problems with graph:

- No axis labels
- No main title

Want to have:

- Axis labels
- Main title
Gnuplot commands

Setting main title:

set title "Powers"

• Do not confuse with
plot ... title "x^3"
Gnuplot commands

Setting axis labels:

set xlabel "x"
set ylabel "power of x"
Next version of graph

... set title "Powers"
set xlabel "x"
set ylabel "powers of x"
plot "powers.dat"...
Problems with graph:

- Surround border

Want to have:

- Left border
- Bottom border
Gnuplot commands

Border edges: N = 1+2+4+8

1 | bottom
2 | left
4 | top
8 | right

set border N
Setting border not enough

- set border 3

- Set border correctly
- Free-floating ticks!
Gnuplot commands

Ticks:
Independent of borders!
set xtics   nomirror
set xtics   1.0 nomirror
set xtics   -1.0,0.5,1.0 nomirror
Final version of graph

... set border 3
set xtics nomirror
set ytics nomirror
plot "powers.dat"...
Recap: How to do a graph

1. Define the terminal

   set terminal png \
   picsize 512 512 …

   • Output format
   • Image size
   • Colour list
Recap: How to do a graph

1. Define the terminal
   - set output "…"

2. Output file
   - File name in quotes
   - Suffix matches format
Recap: How to do a graph

1. Define the terminal
2. Output file
3. Aspect ratio
   - +ve: Whole graph
   - -ve: Scale of units
Recap: How to do a graph

1. Define the terminal
   - set style data lines
2. Output file
   - set style data points
3. Aspect ratio
   - set style data dots
4. Points or lines

• Points are the default
Recap: How to do a graph

1. Define the terminal set key top left
2. Output file unset key
3. Aspect ratio
4. Points or lines • Default: top right
5. Place the key
Recap: How to do a graph

1. Define the terminal
2. Output file
3. Aspect ratio
4. Points or lines
5. Place the key
6. Graph title

set title "…"

• Title in quotes
Recap: How to do a graph

2. Output file
   set xlabel "…"

3. Aspect ratio
   set ylabel "…"

4. Points or lines

5. Place the key
   • Text in quotes

6. Graph title

7. Axis labels
Recap: How to do a graph

3. Aspect ratio
4. Points or lines
5. Place the key
6. Graph title
7. Axis labels
8. Set border

- set border 3
- 1+2+4+8
Recap: How to do a graph

4. Points or lines
5. Place the key
6. Graph title
7. Axis labels
8. Set border
9. Set data range

- set xrange [-1.5:1.5]
- set yrange [-1.5:1.5]
Recap: How to do a graph

5. Place the key
   set xtics -1.0,0.5,1.0

6. Graph title
   set ytics -1.0,0.5,1.0

7. Axis labels

8. Set border
   set xtics 0.25 nomirror

9. Set data range
   unset ytics

10. Set major ticks
Recap: How to do a graph

6. **Graph title**
   - set mxtics 5

7. **Axis labels**
   - set mytics 5

8. **Set border**

9. **Set data range**
   - set mxtics 5 nomirror

10. **Set major ticks**
    - unset mytics

11. **Set minor ticks**
    - Minor ticks per major
Recap: How to do a graph

7. Axis labels
8. Set border
9. Set data range
10. Set major ticks
11. Set minor ticks
12. Plot data sets

plot "…"
using x:y

title "…"

- File names in quotes
- Column specifiers
- Title in key
- Commas
- Backslashes
How to do a graph

1. Define the terminal
2. Output file
3. Aspect ratio
4. Points or lines
5. Place the key
6. Graph title
7. Axis labels
8. Set border
9. Set data range
10. Set major ticks
11. Set minor ticks
12. Plot data sets
Final exercise

- Create graph
- Details in notes

lissajou2.dat + lissajou2.gplt

↓

lissajou2.png