

MPS115/MPS116 PRESENTATION LAB 4

IMPORTANT! If you are asked to install packages when processing your file, click ‘yes’ then wait. You may need to do this for multiple packages. At points it may look as though nothing is happening but your PDF should appear eventually. Interrupting the process can cause problems, so make sure you wait long enough!

Open TeXworks or TeXmaker or whichever editor you prefer. Find the preamble template on the ‘module webpage’ in the ‘Extras’ section, and copy and paste this to start this week’s document.

If your computer is unsure what to do with .tex files like the template on the course webpage, you can open it in any text editor (e.g. Notepad).

1. PGFPLOTS

Let’s start by creating some graphs using `pgfplots`. You need to ensure that `\usepackage{pgfplots}` is in your preamble; you will need to delete the comment symbol, % from the template. Start a new section called ‘Graphs created with PGFplots’ then enter the following.

```
\begin{tikzpicture}
  \begin{axis}[
    title={y=\sin x$},
    xlabel=$x$, ylabel=$y$]
    \addplot[smooth, domain=-360:360]{sin(x)};
  \end{axis}
\end{tikzpicture}
```

If you get errors here, check that you have recreated the text precisely, including commas and the semicolon.

- (1) See what happens to the axes when you add
`axis lines=center,`
below the line `title={y = \sin x$},`
- (2) Graphs won’t be centered on the page by default. To change this, put the whole `tikzpicture` environment inside a `center` environment. Note the US spelling of ‘center’.
- (3) Try changing `sin(x)` to `sin(deg(x))` and the domain to `-2*pi:2*pi`. What’s happened now? PGFplots’s trigonometric functions work in degrees: the `deg(x)` function takes a number (in radians) and turns it into the value in degrees; that is, $\deg(x) = \frac{180x}{\pi}$.

Try a 3D plot, using the following code.

```
\begin{tikzpicture}
  \begin{axis}[xlabel=$x$, ylabel=$y$]
    \addplot3[domain=-1.5:1.5, surf]{-exp(-x^2 - y^2)};
  \end{axis}
\end{tikzpicture}
```

- (4) What was the main difference in the code here compared to before?
- (5) What does the `surf` option do? (Try taking it out.)
- (6) What does putting `colormap/blackwhite` after `ylabel=$y$` do? (Note the US spelling of the word “color”.)

There are many more examples of graphs – with source code – on the PGF-plots website, <http://pgfplots.sourceforge.net/gallery.html>. If you need to make a graph, a combination of the simple techniques on this sheet and what you find at the link above should do the trick.

2. INCLUDING IMAGE FILES

Now let's try including an image from external software. Open a new tab in your browser and go to <https://www.geogebra.org/geometry>. Geogebra is a point-and-click geometry package which can do more than just create pictures for including in documents.

- (7) To start, make sure the axes are showing on the image: go to the settings cog in the top-right, and click on "Show Axes" if necessary.
- (8) Click on the calculator symbol at the top of the bar on the left, then the plus sign, and add an expression. Type $x^2 + y^2 = 9$ into the bar and press enter. A circle should appear.
- (9) Find the button to add a new point, and put it at $(-5, 0)$.
- (10) Find the 'Tangents' button, and follow the instructions to plot the two tangent lines to $x^2 + y^2 = 9$ which pass through $(-5, 0)$. Click on the calculator symbol to see the equations of these two lines.
- (11) Use the 'Move' button to drag your point around and see the tangents move.

Play around further if you like. Once you have a picture you are happy with, go to the options in the top-left, click Download As, then choose PDF as the file type and save the image as `geogebra_image.pdf` in the same folder as your $\text{\LaTeX}$ document.

Return to your $\text{\LaTeX}$ document. Put `\usepackage{graphicx}` in your preamble. Start a new section called 'Including image files' and put the command `\includegraphics{geogebra_image.pdf}` underneath. Your picture should appear though it may not fit properly at this stage. Convince yourself the picture stays smooth no matter how far you zoom in.

If you have problems, check that the name of the uploaded file is exactly the same in the `\includegraphics` command as it is in the filename, and make sure the file is saved in the same folder as the `.tex` file.

- (12) Now add an *optional parameter* to the `\includegraphics` command by changing `\includegraphics` to `\includegraphics[scale=0.5]`. What has changed?
- (13) Try `\includegraphics[width=8cm]`.
- (14) Try `\includegraphics[width=\textwidth]`.
- (15) Try `\includegraphics[width=0.8\textwidth]`.
- (16) Put the image inside a `center` environment.

Note that this might have resulted in an image where the labels are unreadable! You should always ensure that labels are legible. In this case you would have to go to geogebra and either alter the font size or else the range of the image that is exported. If you have lots of time in the lab, you should try to see how you can alter the font size in geogebra.

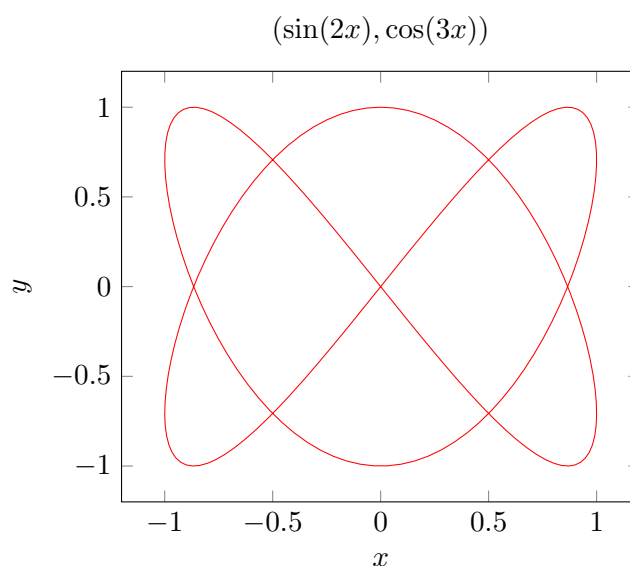


FIGURE 1. An example figure that can float around.

3. FIGURES AND FLOATS

To enable images to be referenced, they should be placed inside the `figure` environment; this will allow you to refer to Figure 1, for instance. Try this instead of using `center`, so that your $\text{\LaTeX}$ reads

```
\begin{figure}[tbh]
  \includegraphics[width=0.8\textwidth]{geogebra_image.pdf}
  \caption{A Geogebra picture}
\end{figure}
```

LaTeX will move figure environments around the document depending on the size of the figure and the space available. Environments like this are called ‘floats’ as they can float around the document. If you are looking this in a PDF document, you will see Figure 1 has ‘floated’ to the top of the page. You might find this behaviour annoying to start with, but it is the standard way to do things in professional documents.

The term `[tbh]` after `\begin{figure}` is telling LaTeX to put the figure at the **t**op of a page if there’s room, and if not try the **b**ottom of the page and then **h**ere, i.e., at the position it appears in the LaTeX document. Don’t fight this! Let LaTeX put floats where it thinks is sensible.

Now add `\label{fig:geogebra}` after the `\caption{...}` command, then write the following sentence underneath the figure environment

Geogebra creates good diagrams; see Figure~\ref{fig:geogebra}.

Process your file to see the figure being referenced automatically.

The tilde, `~`, puts in a space, but does not allow it to be split across lines. You should do this when using `\ref` as “Figure 1” looks good but “Figure 1” does not.

HOMEWORK

Finish off the sheet. If necessary look at the attempt at the lab given on the module webpage. You should also look at the module solution to last week's homework.

Create a document with title 'MPS115: Homework 4' (or MPS116) and your name on as author. Your task this week is to write about *Lagrange interpolation*, illustrating it with the example of a quadratic interpolation of $\sin(x)$. The work should consist of three short sections.

The first section, "An introduction to Lagrange interpolation", should consist of one or two paragraphs explaining what Lagrange interpolation is. You do not necessarily need to give lots of complicated formulas. You could look on the internet, or in search the University library's digital collection. For instance, the theory is covered in the book by Stroud listed below which is available to view online there. Note that you *must* write this in your own words, you *must not* copy directly from any other source. You must use at least two sources as per the lecture on plagiarism.

The second section should be called, "A quadratic interpolation of $\sin(x)$ ". The quadratic Lagrange interpolation through the points (x_0, y_0) , (x_1, y_1) and (x_2, y_2) in $\mathbb{R}^2$ is given by

$$f(x) := \sum_{i=1}^3 \left(\prod_{\substack{j=1 \\ j \neq i}}^3 \frac{x - x_j}{x_i - x_j} \right) y_i.$$

You should explain how you use this to get an interpolation function $f(x)$ for the function $\sin(x)$ which passes through the points $(0, 0)$, $(\frac{\pi}{4}, \frac{1}{\sqrt{2}})$ and $(\frac{3\pi}{4}, \frac{1}{\sqrt{2}})$. You should simplify $f(x)$ as much as you can but you do not need to show all of your working. Plot the graph of $y = f(x)$ alongside $y = \sin(x)$ on the same set of axes to show how your interpolating polynomial follows $y = \sin(x)$ fairly closely in the range in question.

In the third section, "References", you should reference all of the sources that you use, including webpages. There must be at least two sources. You could itemize them in a list at the end. We will do the proper way to reference in LaTeX during the next lab.

Print out and hand in the PDF and LaTeX file of your homework at next week's lab, as usual. Remember that this is assessed coursework so must be your own work.

If you have any questions do use the discussion forum or the office hour.

References.

- K. A. Stroud, Advanced engineering mathematics. Palgrave Macmillan, 2011.