MAS115 Presentation Lab 4

IMPORTANT! If you are using MiKTeX or MacTex instead of Overleaf and 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!

Go to Overleaf and start a new project (or use TeXworks/TeXshop/TeXmaker if you prefer to work offline). Find the preamble template on the course 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).*

PGFplots

Let's create some graphs using `pgfplots`. Make sure `\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 semi-colon.*

1. See what happens to the axes when you add

   `axis lines=center,`

   below the `title={$y=\sin x$},` line, again making sure you include the comma.
2. Graphs won't be centered on the page by default. To change this, put the whole thing in a *center* environment.
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 are in degrees. The `deg(x)` function takes a number (in radians) and turns it into the value in degrees; that is, $\deg(x) = \frac{180x}{\pi}$. This is precisely what's needed to change the plot to radians.

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 PGFplots 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!

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, we'll make sure the axes are showing on the image. Go to the settings cog in the top-right, and click on "Show Axes".
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` somewhere you can find it on your computer. (If you are using MiKTeX/MacText, you must save it in the same folder as your LaTeX document.)

Return to your LaTeX document. If you are using Overleaf, click on the 'upload' symbol near the top-left, and upload the PDF file created by Geogebra from your computer. 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 in Overleaf, check that the name of the uploaded file is exactly the same in the `includegraphics` command as it is in the left-hand bar. Similarly, MiKTeX/MacTex users should make sure the file is saved in the same folder as the `.tex` file and the names match up precisely.*

12. Alter your LaTeX so that it reads `\includegraphics[scale=0.5]{...}` (where the `...` is your image file name). What's changed?
13. Try `\includegraphics[width=8cm]{...}`.
14. Try `\includegraphics[width=1\textwidth]{...}`.
15. Try `\includegraphics[width=0.8\textwidth]{...}`.
16. Put the image inside a *center* environment.

To do things properly, images should be placed inside the *figure* environment. Try this instead of using *center*, so that your LaTeX reads

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

The `[h]` can be changed to `[t]` or `[b]` to control where the figure appears if it is included amongst lots of text: `h` stands for ‘here’, `t` stands for ‘top’ and `b` stands for ‘bottom’. (You probably won’t notice much difference now unless you try including lots of text around your figure.)

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:geo
```

Process your file to see the figure being referenced automatically. If you include lots of figures in a document, this feature will help you to reference the right one.

Citations and references

Here we look at how to cite books or internet pages. Citations are important for attributing results to the people who did them and allowing the reader to check material themselves. Citations should appear naturally in the text. Here are some examples.

- **Theorem 4** (See [1].) *Let x be a number...*
- Wikipedia [2] provides some interesting biographical details about Newton.
- The following equation was first written down by Maxwell [3].

The citations refer to entries in the bibliography at the end of this lab-sheet (have a look!). Let's create a bibliography to cite from.

17. Create a section at the bottom of your document called 'Recommended fiction'. In it, type the sentence 'A friend recommended I read some Raymond Carver, starting with . . . '. (We'll replace the . . . in a minute.)

18. Enter the following at the end of your LaTeX document.

```
\begin{thebibliography}{99}

\bibitem{Carver:Cathedral}
R.~Carver,
\emph{Cathedral},
Vintage Classics,
2009.

\end{thebibliography}
```

19. Go back to your section on recommended fiction, and replace the `...` with `\cite{Carver:Cathedral}`. Process your document twice.
20. Think of a favourite book and find its details using Google. Add this to the bibliography, then add a sentence to your section on recommended fiction, referencing this new book.
21. Change the order of the two `\bibitem`s. Process the document twice.

Notice that the reference to the website in the bibliography in this document contains both the date it was visited and the date it was updated. This is to allow the reader to check out the exact pages that you are referring to.

Homework

Create a document with title 'MAS115: Homework 4' and your name on as author. Your task this week is to look up *Lagrange Interpolation* and to write a page or so of LaTeX explaining why the function

$$f(x) = \frac{(x-x_1)(x-x_2)}{(x_0-x_1)(x_0-x_2)}y_0 + \frac{(x-x_0)(x-x_2)}{(x_1-x_0)(x_1-x_2)}y_1 + \frac{(x-x_0)(x-}{(x_2-x_0)(x_2}$$

is a quadratic polynomial which passes through (x_0, y_0), (x_1, y_1) and (x_2, y_2). You could look on the internet, or in search the University library's digital collection (the theory is covered in [4], which is available to view online there, for example).

Things that you should include in your write-up:

- What is a quadratic polynomial? Why is $f(x)$ one?
- What is $f(x_0)$? And $f(x_1)$? And $f(x_2)$?
- As an example, use the points $(0, 0)$, $(\frac{\pi}{4}, \frac{1}{\sqrt{2}})$ and $(\frac{3\pi}{4}, \frac{1}{\sqrt{2}})$, and include the graph of $y = f(x)$ alongside $y = \sin x$.
- Make sure you reference the sources you use, including webpages.

Upload the PDF of your homework before next week's lab, as usual.

References

[1] A. Wiles, *Modular elliptic curves and Fermat's Last Theorem*, Annals of Mathematics **141** (1995) 443–551.

[2] Wikipedia contributors, *Isaac Newton*, Wikipedia. Visited 18 October 2011, updated 16 October 2011, `http://en.wikipedia.org/wiki/Isaac_Newton`.

[3] J. C. Maxwell, *A Treatise on Electricity and Magnetism Volume 1*, Dover Publications Inc., 3rd edition, 2003.

[4] K.A. Stroud, *Advanced Engineering Mathematics*, Palgrave Macmillan, 2011.