

MPS115/MPS116 PRESENTATION LAB 3

This week we'll use a different text editor as an alternative to TeXworks.

If you're using Linux or macOS, rather than Windows, then it is fine to stick with your usual editor in this lab. However, if you are feeling adventurous and on top of everything then you could always experiment with a different editor, such as Visual Studio Code with LaTeX Workshop; you should be able to find instructions online.

Remember, text editors are just software used to type in LaTeX commands, so all the things learnt so far still apply.

1. THE TEXMAKER EDITOR

On the Start Menu, search for *TeXmaker* and start it. If it's not there, install it from the Software Center.

If you can't get TeXmaker to work, you should just use TeXworks instead for this week.

Once TeXmaker has started, create a LaTeX document (using **File | New** on the menu bar). In TeXmaker you process a LaTeX file by pressing the blue arrow next to 'Quick build'.

2. TYPESETTING PRACTICE

If you haven't done so already, start a new file. Include the usual preamble (using `documentclass`, `begin` and `end document` commands etc). You could just cut and paste the preamble from the Lab 2 attempt on the website. Save it as `lab_3.tex`.

Add the title 'MPS115: Lab 3 Experiments'. Include the American Mathematical Society (AMS) packages with the commands in the preamble, before your `\begin{document}`.

```
\usepackage{amssymb}
\usepackage{amsthm}
```

- (1) Start a section called 'Typesetting practice'. Create an enumerate environment, starting with `\begin{enumerate}`, and typeset the following as the first `\item`.

The formula for the addition of velocities in relativistic mechanics is

$$f(u, v) = \frac{u + v}{1 + \frac{uv}{c^2}}.$$

Once you've typed it in, see what happens as you move your cursor past the brackets in the code.

- (2) Now you can look at some of the features of TeXmaker. By clicking on the small λ and $\Rightarrow$ buttons on the left-hand side of the screen (if you can't find the buttons you might have to click on 'Structure' at the bottom left of the window), typeset the following as the second `\item` on your list.

TeXmaker makes it easy to find Greek letters and to typeset things like

$$\Xi^{\Psi\Omega} = \frac{\theta}{\gamma}.$$

- (3) Explore the buttons on the left further to see if you can add another item with the following.

Pointing and clicking in TeXmaker also helps with things like

$$\underbrace{\circ \cdots \circ}_{n \text{ times}}$$

The construction you are trying to get here is called an ‘underbrace’. Getting text underneath something is usually done with the subscript underscore `_`. The command `\text{}` allows text in maths mode and should help with the ‘*n times*’. You get ‘ $\cdots$ ’ with `\cdots`.

- (4) The `amssymb` package allows you to use ‘Blackboard bold’ font which you will sometimes need. Can you typeset the following using the `\mathbb{}` command?

Typically we use $\mathbb{R}$ to denote the real numbers and $\mathbb{C}$ to denote the complex numbers.

There is an online tool called ‘Detexify’ that can help you find the LaTeX command for a given symbol. Try it.

3. THEOREMS

Start a new section called ‘The square-root of 2’. Here we’re going to experiment further with environments, in particular the ‘theorem-like’ environments provided by the `amsthm` package.

- (5) Start with the following.

We are going to investigate a solution of the equation

```
\begin{equation}
```

$$x^2=2.$$

```
\end{equation}
```

Process this. The `equation` environment creates a *numbered* equation.

- (6) We want to be able to refer to the equation we’ve just created. To do this, put `\label{eq:root-2}` after `\begin{equation}`.

- (7) Now type

The positive solution to equation~(\ref{eq:root-2}) is denoted $\sqrt{2}$.

and process the file. Does it work? If you see ‘??’ on your PDF, run it again. (LaTeX has to run twice to get autoreferencing to work.)

Now let’s make our first theorem. Add the following to the preamble after the line where you include the `amsthm` package.

```
\newtheorem{thm}{Theorem}[section]
```

This will create a new environment called `thm`, which is numbered inside sections. In the body of the document, write

```
\begin{thm}
```

The real number $\sqrt{2}$ is irrational.

```
\end{thm}
```

Process the file, and look at the output. The theorem should be numbered something like 2.1, where the 2 refers to the section number. Underneath the theorem, write

```
\begin{proof}
  We prove this by contradiction. First we assume
  that  $\sqrt{2}$  is rational and so can be written
  as  $a/b$  for  $\emph{coprime}$  integers  $a$  and  $b$ .
  Blah blah blah.
\end{proof}
```

*Here we've written a/b rather than $\frac{a}{b}$. Which looks better?
In this case, I don't think there's a right answer.*

We've started the proof by relying on a certain mathematical fact. Let's include this as a lemma: a *lemma* is a short, usually uninteresting result in its own right which is used as an intermediate step towards a proposition or theorem. In order of importance, theorems come above propositions, which come above lemmas.

To include the lemma, you should first add the following in the preamble after the `\newtheorem{thm}` command.

```
\newtheorem{lem}[thm]{Lemma}
```

This creates a new environment called `lem`, which is numbered the same as the `thm` environment. Using this new environment, put a lemma before the statement of the theorem that looks like the following.

Lemma 3.1. *Any rational number can be written in the form a/b with a and b coprime integers.*

Proof. Suppose that we have a rational number p/q where p and q are integers with $q \neq 0$. Blah blah blah. $\square$

When you process the file, notice how the numbering for the theorem automatically changes.

Add the following commands in the preamble after `\newtheorem{lem}`.

```
\theoremstyle{definition}
\newtheorem{defn}[thm]{Definition}
```

Now change the line where you defined $\sqrt{2}$ into a definition using `\begin{defn}` and `\end{defn}` to make the following.

Definition 3.2. The positive solution to equation (1) is denoted $\sqrt{2}$.

Again, the numbering will automatically change. Look carefully at how the lemma and the definition are typeset and see if you can find the difference that `\theoremstyle{definition}` has made.

Here the `amsthm` package is using the mathematical typesetting convention is that the statements of theorems, propositions and lemmas are typeset with *slanted* text, whereas definitions are typeset with *upright* text. Experiment with labelling and referencing your definition, lemma and theorem which is done in the same way as for equations.

You can read more about how the `\newtheorem` command works on the webpage <http://en.wikibooks.org/wiki/LaTeX/Theorems>.

HOMEWORK

Make sure you finish off the sheet. You can compare your work to the attempt provided on the module webpage. Also make sure you look at the 'model solution' to the previous homework.

Create a document with title 'MPS115: Homework 3' (or 'MPS116') and your name on as author. Using the work you started in this sheet, write a good account of what the square root of 2 is and why it is irrational by adding proper proofs of the lemma and theorem.

More specifically, you need to include a detailed proof of why any rational number can be written as a/b in such a way that a and b are coprime, and you also need a full proof that $\sqrt{2}$ is irrational.

- Write these proofs in your own words! You may be able to find versions of the proofs in your notes for other courses or on the web, so the idea is to first understand them, and then write your own accounts.
- Remember that rational numbers are defined to be those of the form p/q for integers p and q with $q \neq 0$, so the key is proving that they can be chosen to be *coprime*.
- Your document should read well from start to finish, so take care in how it's presented. Add some text between the definition, lemma and theorem to make it flow.
- Include a section title and write an introductory paragraph.
- Below you can find the relevant section from my attempt at this week's sheet which will give you a starting point for how to layout your work.

Hand in printouts of the PDF and LaTeX files at next week's lab, as usual.

4. THE SQUARE-ROOT OF 2 (MY LAB ATTEMPT!)

We are going to investigate a solution of the equation

$$(1) \quad x^2 = 2.$$

Definition 4.1. The positive solution to equation (1) is denoted $\sqrt{2}$.

Lemma 4.2. *Any rational number can be written in the form a/b with a and b coprime integers.*

Proof. Suppose that we have a rational number p/q where p and q are integers with $q \neq 0$. Blah blah blah. $\square$

Theorem 4.3. *The real number $\sqrt{2}$ is irrational.*

Proof. We prove this by contradiction. First we assume that $\sqrt{2}$ is rational and so can be written as a/b for *coprime* integers a and b . Blah blah blah. $\square$