LaTeX workshop October 2019

How to use this lab sheet

Read these two files, starting from the top and alternating between reading the source file (including any comments which explain the LaTeX syntax used) and the resulting pdf. The text in the file is designed purely to introduce you to various LaTeX commands. There are a few ongoing 'typesetting' exercises, which you can do by making changes in the source file itself and then re-compiling (using the 're-compile' button on the overleaf screen). You are not expected to solve any maths problems; the focus is on learning to write, or typeset, maths correctly.

1 Basics

Font Families

I **love** maths! I also love reading comments in the source file!

I like large fonts compared to small or tiny fonts.
LaTeX (pronouced as 'Lah-tech' or 'Lay-tech') does *not* rhyme with "pay-checks". LaTeX is a document preparation system based on TeX typesetting program. It is not a 'what you see is what you get' editor like Microsoft WORD. Instead, you can type in the content in *any* editor as plain text and then let LaTeX compiler typeset the document.

Math Environments, Superscripts, and Subscripts

The numbers 3, 4, and 5 are a Pythagorean triple because $3^2 + 4^2 = 5^2$.

We all know that $(x^n)' = nx^{n-1}$, but what is $(x^x)'$, for $x > 0$? You need to take natural logarithm of both sides of $y = x^x$ and then use implicit differentiation.[1]

The recursive definition for the Fibonacci sequence is
$s_1 = 1$, $s_2 = 1$, and $s_n = s_{n-1} + s_{n-2}$ for all integers $n > 2$.
Compare $\frac{1}{a+b} \neq \frac{1}{a} + \frac{1}{b}$ to the following.

[1] You don't *actually* need to solve this. Just note how to typeset different inline equations *etc* in LaTeX. Incidently, this is how you write a footnote.

$$\frac{1}{a+b} \neq \frac{1}{a} + \frac{1}{b}$$

We can also display an equation midline by using "display-style": $\frac{1}{a+b} \neq \frac{1}{a} + \frac{1}{b}$.
Alternatively, we can use the *equation* environment which will also number the equation:

$$\frac{1}{a+b} \neq \frac{1}{a} + \frac{1}{b}. \tag{1}$$

The label uniquely identifies the equation for LaTeX. You can refer back to equation (1) later in the text. Even if you have added equations *before* this one, LaTeX will track the equation number change using the label.

2 Maths Symbols and Alignment

Useful Maths Symbols

We use `\mathbb` to display some common sets of numbers.
Natural numbers: $\mathbb{N}$
Rational numbers: $\mathbb{Q}$
Real numbers: $\mathbb{R}$
Positive real numbers: $\mathbb{R}^+$

Alignment

To align equations, we can use "align" environment from the amsmath package. To write text within a math environment (within an equation, say), use `\text`.

$$x + y = 3 \tag{2}$$
$$2x + y = 4. \tag{3}$$

Of course, equations (2)-(3) are quite easy to solve.

Exercise: Typeset in LaTeX any set of three simultaneous linear equations with three variables x, y and z. Remember to look back at the comments in the source file, which also gives you things to do.

3 Set Notation and Greek Letters

Let $S = \{\pi, \delta, \Delta\}$ and $T = \{\Omega\}$. Then $S \cup T = \{\pi, \delta, \Delta, \Omega\}$, $S \cap T = \emptyset$, and $S \times T = \{(\pi, \Omega), (\delta, \Omega), (\Delta, \Omega)\}$.

In set notation, the interval $(1, 3]$ is written as $\{x \in \mathbb{R} : 1 < x \leq 3\}$.

Note, $(2, 3] \subset (1, 4)$.

Is infinity a number? No! It's more like a state of mind $\cdots$, but $\mathbb{R} = (-\infty, \infty)$.

4 Spacing, Sizes and Fonts in math environment

Sometimes, we need large enough brackets to contain the mathematical symbols which are meant to be inside those braces. One way to deal with it is to use `\left` and `\right` as follows. Compare the following two equations:

$$\sum_{k=1}^{n} k^3 = 1^3 + 2^3 + 3^3 + ... + n^3 = [\frac{n(n+1)}{2}]^2$$

$$\sum_{k=1}^{n} k^3 = 1^3 + 2^3 + 3^3 + ... + n^3 = \left[\frac{n(n+1)}{2}\right]^2$$

Similarly, compare the following.

$$\int_e^\pi \frac{dx}{x(\ln x)^2} = -\frac{1}{\ln x}|_e^\pi$$

$$\int_e^\pi \frac{dx}{x(\ln x)^2} = -\left.\frac{1}{\ln x}\right|_e^\pi$$

Here, `\.` in the source file is a 'dummy' `\left` symbol, since we only needed the closing `\right` here.

One can add horizontal space in math environment using `\,` `\:`, `\;`, `\quad` and `\qquad`. Observe this:

$$a, b, c, d, \quad e, \qquad f.$$

5 Tables, Lists and Arrays

Tables

We can use the `\tabular` environment in a variety of ways. One is to enclose it inside `table` environment, which is numbered automatically and can be referenced through labels. The relationship (or lack thereof) between BMI and IQ can be seen in table 1 below.

Table 1: BMI vs IQ

Name	**BMI**	**IQ**
Possibly Paresh	22	125
Unlikely to be Paresh	26	100
Definitely not Paresh	30	120

Exercise: Try changing this table to another table with 5 columns, 4 rows and some entries involving mathematical symbols. You can make up entries as you like.

Lists

There are two key ways to make lists; a numbered list and a bullet point list. Each can be *nested*, just like in MS WORD. Here is an example (from a source mentioned later in this text):
If an author of a textbook wants to avoid giving a proof of a theorem he or she would say that

1. the proof is trivial.
2. the proof is left as an exercise for the reader.
3. This proof is omitted due to
   (a) lack of space;
   (b) lack of time;
   (c) lack of competence;
      (ϕ) by myself
      (γ) by my graduate assistant who was supposed to write it

(d) lack of application, inspiration, and remuneration.

The `itemize` environment provides those ever-popular bullet points. For example, only two of the following are true:

- Martins is a freaking awesome teacher;
- Both Paresh and Martins are very sympathetic when it comes to marking assignments;
- Paresh has an appalling sense of humour.

Arrays

Array environment is useful for typesetting vectors, matrices and similar structured data.

$$I_n = \begin{pmatrix} 1 & 0 & \cdots & 0 & 0 \\ 0 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & 1 & 0 \\ 0 & 0 & \cdots & 0 & 1 \end{pmatrix}$$

You might instead typeset matrices using `bmatrix` or `cmatrix`:

$$I_n = \begin{bmatrix} 1 & 0 & \cdots & 0 & 0 \\ 0 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & 1 & 0 \\ 0 & 0 & \cdots & 0 & 1 \end{bmatrix}$$

Exercise: Re-write your earlier set of three simultaneous linear equations using array environment, such that your x, y and z in each equation are correctly aligned. Also see what a matrix typeset using `cmatrix` looks like, by re-writing your linear equations in a matrix-vector form.

6 Importing graphics

Here is a graph that was created using matlab and then printed into a file called *thisplot.jpg* using `print -djpeg100 thisplot`. See matlab's help on print command, to check what djpeg100 means.

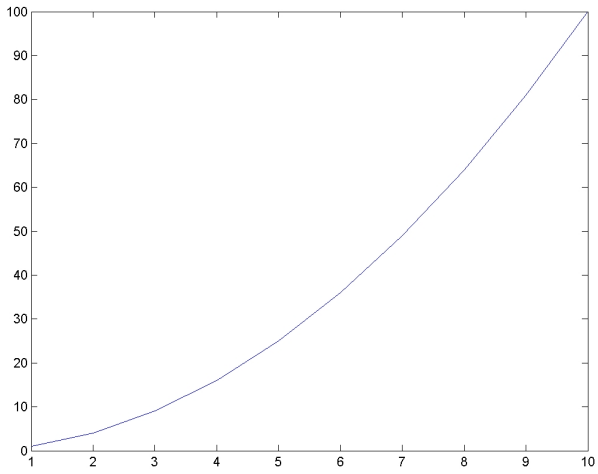

Figure 1: Plot of $y = x^2$

You can also include pdf figures in the same way. If the plot looks a bit funny on overleaf screen, you can change the overleaf pdf viewer from the menu on the top left, from 'built-in' to 'native'.
Exercise: Open matlab; generate and save a plot (*e.g.* of $y = e^{-x} \sin x$) as a jpg file; upload the file your project in overleaf. Then try including it into this source file using includegraphics command. Use a LaTeX environment other than `figure`, and try changing the scaling factor in the resizebox command.

7 Miscellaneous Commands

- A consequence of the Pythagorean Theorem is the fact that

  $$\sin^2 \theta + \cos^2 \theta = 1.$$

  Note the following integral (does it remind you of something from probability?):

  $$\int_{-\infty}^{\infty} e^{-\frac{x^2}{2}}\, dx = 2\sqrt{\pi}$$

- One may use different arrows in math environment:

  $$\Rightarrow, \quad \leftarrow, \quad \mapsto, \quad \Leftrightarrow .$$

- One can use `\underline` and `\overline` to underline and overline a word or a symbol. In math environment, one can use `\underbrace` or `overbrace`:

$$\underbrace{x^2 + y^2}_{z^2} = q.$$

Exercise: $\mathbb{E}$ is typically used to denote the expected value of a random variable. Write the derivation of $\mathbb{E}(x) = 0$, where x has standard normal distribution, by expressing the resulting integral as a sum of two integrals which have opposite sign and the same absolute value.

8 Further information and references

Some of the material here is based on [1] and some text is borrowed directly from this reference. There are many good sources of information about LaTeX including [2] and [3], both of which are available in the library. In fact, [2] will teach you everything you always wanted to know about (La)TeX* (*but were afraid to ask).

9 If overleaf is giving you trouble

I would strongly recommend that you download any work to your network drive at the end of each session. If the internet is down (the horror!) or if you have trouble with compiling on overleaf, there are alternatives. One is to use WinEdt editor/compiler on the Windows machine, if available. A better option is to download LaTeX from `miktex.org` on your laptop. It's free and comes with its own editor called *Texworks*. You can upload your project later on overleaf when you need to do so. You can then learn more about LaTeX in your spare time, and possibly even use it in real life for making presentations and fancy posters when needed.

References

[1] The Bates LaTeX Manual, `http://www.bates.edu/mathematics/resources/latex-manual/`, [accessed on 16th July 2019].

[2] Leslie Lamport, *LaTeX: A Document Preparation System*. Addison-Wesley, 1986.

[3] George A. Gratzer, *Practical LaTeX*. Springer, 2014.

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