LaTeX Practice 2

Goal: The purpose of this assignment is to give you "hands-on" practice with how things typed in the TEX file correspond to the PDF output and vice versa.

Submission:

- Keep all your source code in the Overleaf project (which I have shared with you) called "math2794w portfolio of Your Name"
- Download the PDF file of your work and email the it to me. Email subject line: "math2794w LaTeX Practice 2 of YourName".

(Task 1)

(a) Go to https://www.overleaf.com.

(b) Go to the project which I have shared with you, called "math2794w portfolio of Your Name."

(c) Use the "New Folder" icon (shaped like a folder) on the top left to create a new folder and title your folder "latex2". Make sure there are no whitespaces, as Overleaf has a bug related to this.

(d) Download these three files:

- egunawan.github.io/writing/hw/tex/02/intro2.tex
- egunawan.github.io/writing/hw/tex/02/Bib.bib
- egunawan.github.io/writing/hw/tex/02/fig1.pdf

and upload these three files to your "latex2" folder in Overleaf using the "Upload" icon on the top left.

(e) Click "Menu" on the top left.

- Scroll down to "Main Document" and select the .tex file as your main document (as opposed to the .bib file).
- Scroll down to "Spell Check", and make sure that the setting is set to "English (American)". This will permanently turn on spell check.
- Scroll down to "auto-complete" and set it to "on". If this becomes annoying, you can turn it off later.
- Scroll down to "auto-close brackets" and set it to "on". If you prefer, you can turn this off later.

Keep all the other settings as they are, unless you are familiar with Overleaf.

(f) In your new "latex2" folder, click on the "intro2.tex" file on the left and then press "Recompile" button. There should be no error (let me know if you see an error). You can also download either the source code or the PDF of this project by clicking on "Menu" on the top left and "Download".

(Task 2) Make the following changes, one at a time and in order, to the "intro2.tex" file in Overleaf. Note that every change made in Overleaf is autosaved. Click "Recompile" (or set auto-compile to on) after every change you make and view the PDF in "full screen" to see the change. Use the handout "A quick guide to LaTeX", Learn LaTeX in 30 minutes, and Google (or an alternative search engine) to look up how to use various features of LaTeX.

(2a) Change the title to "LaTeX Practice 2".

(2b) Change the author to your name (in "First Name Last Name" format).

(2c) Change the date to the assignment due date (in "Month Day, Year" format).

(2d) Replace the bullet point list in the "Introduction" section by a numbered list (using "enumerate"). In the same list, replace the words in italic text with the same words in boldface text.

(2e) Replace both occurrences of the equation $x^2 + y^2 = z^2$ in the "Math Mode Stuff" subsection with the inequality $b \leq a^4 + a^2 + \frac{1}{5}$.

(2f) Replace

$$\left(\frac{\pi^2}{2} + 0 - \pi\right) - \left(\frac{\pi^2}{8} + 1 - \frac{\pi}{2}\right)$$

with

$$\left[\frac{\pi^2}{2} + 0 - \pi\right] - \left[\frac{\pi^2}{8} + 1 - \frac{\pi}{2}\right].$$

(2g) Replace

$$\frac{3\pi^2}{8} - 1 - \frac{\pi}{2}$$

with the equivalent expression

$$\frac{3\pi^2 - 4\pi - 8}{8}$$

(2h) Change the width of Figure 1 to 5 inches. Change the caption under Figure 1 to a different sentence, for example, "An illustration of a planar graph".

(2i) Add a fourth column to Table 1. Call the new column "Column 4" and make its entry be w^2. In the same table, center all four of the columns of your new Table 1. Hint: Determine what the "r", "c", and "l" do to each of the three original columns of the table.

(Task 3) (3a) In the "Bib.bib" file in Overleaf AND in Section 3.1 of your "intro2.tex" file in Overleaf, replace "Article" by "Article1" and replace "Book" by "Book1". This is to show you how to change the names of the labels given to each of the three references.

(3b) Recompile your finalized "intro2.tex" file and make sure everything on your PDF file looks correct.

(3c) Check for errors or warnings and fix them.

(3d) Click "Menu" on the top left and, from the top "Download" menu, click on "Source". This will download a zipped folder that can be saved in your computer for backup.

More advanced tasks

(Task 4) (4a) **Creating and labeling a theorem.** Start a new paragraph at the end of Section 1, which is the "Introduction" section. This is done by skipping a line in the LaTeX file and starting a new paragraph. Type the sentence "The main result of this paper is given below." After this sentence, add a theorem using "\begin{theorem}" and "\end{theorem}." Label your theorem as "introthm" using "\label{introthm}." Let the statement of your theorem be "This is where the statement of the theorem goes."
Optional: Find a theorem that you like which has a very short proof and write the statement here.

(4b) **Referencing a theorem and creating a proof.** Start a new paragraph at the end of Section 2.2. Type the sentence "We are now ready to prove Theorem~\ref{introthm} from the introduction." After this sentence, add a proof using

"\begin{proof}[Proof of Theorem~\ref{introthm}]"

and "\end{proof}". Let the content of your proof be "This is where the proof of Theorem~\ref{introthm} goes."
Optional: You can type in an actual explanation for the theorem.

(4c) **Adding and labeling a figure.** Use the internet to find a Husky or a math-related JPEG (.jpg) file. Upload a copy of this file to your "latex2" folder. Rename the image file so that it does NOT contain any spaces. At the end of Section 2.5, add this figure as a NEW figure. Label your figure as "Figure2" and make the width of the figure be 3 inches. You can copy and paste the LaTeX code from Figure 1, BUT you need to make sure to change the label name (replacing "Figure1" by "Figure2"), change the file name (replacing "fig1.pdf" with your new file name).

(Task 5) Click on the "Bib.bib" file in Overleaf.

(5a) **Editing a BIB file.** Within the BIB file, replace the first and last name of the author of the book by YOUR first and last name. Note that the format in the BIB file is "Last Name, First Name."

(5b) **Adding a new entry to a BIB file.** At the end of the BIB file, add a NEW reference entry that is a second website. Do a Google search to find a website article (that is available for free) titled "Math's Beautiful Monsters" by Adam Kucharski. Use "Kucharski" as the label for this reference. You can copy and paste the LaTeX code for the first website reference, BUT you need to make sure to change the label name (replacing "Website" by "Kucharski"), change the author name (replacing "Cha, J. C. and Livingston, C." with the name of the author

of the new website), change the title name (replacing "KnotInfo: Table of Knot Invariants" by the title of the new website article), change the website under "howpublished" (replacing "http://www.indiana.edu/∼knotinfo" by the URL for the new website article), and change the date of access (replacing "January 21, 2020" by the assignment due date).

Click on the "intro2.tex" file in Overleaf.

(5c) **Citing a new entry to a BIB file in the TEX file.** In the first sentence at the beginning of Section 3.1 of your "intro2.tex" file, replace "\cite{Website}" with "\cite{Kucharski}". This is replacing the label for the citation of the first website in the BIB file with the label for the citation of the new website you just added in the previous task. Click on "Recompile". Make sure that now the sentence is citing the website containing the article "Math's Beautiful Monsters".

(Task 6) **LaTeX Practice Finale (see two alternative tasks below).** After the end of Section 4, start three new section using "\section{TITLE}" and title them "Analytic Equations", "Areas", and "Matrix Equations". Your task is to use LaTeX to type up the excerpts (given on pages 5–6 of this handout guide) from sample papers, trying to fully re-create these excerpts using correct LaTeX commands and correct LaTeX mathematical notation and conventions.

It will be useful to carefully read and use the file you downloaded earlier (intro2.tex). In particular, note the following:

- Variables such as P are always placed in math mode.
- Definitions, numbered equations, and theorems need to be labeled using LaTeX so they can be referenced at a later point, and definitions, numbered equations, and theorems need to be referenced using, for example, Definition∼\ref{label}.
- The lowercase Greek letter "chi" is used in the excerpt. You will need to look up how to create this symbol in LaTeX. For example, try detexify.kirelabs.org.

Disclaimer: The equation and theorem numbers below will be different for you because you will be typing this excerpt into a different LaTeX document with different pre-existing equations, theorems, and sections!

(Alt B to Task 6) If you already know how to type in LaTeX, you can choose to instead typeset the excerpt but using Beamer. Use the following Guide to Beamer created by Overleaf: overleaf.com/learn/latex/Beamer

(Alt A to Task 6) Instead of typesetting what I have given you, you can look for a two-page document that you are more interested in (for example, from a textbook or article for a technical class you are currently taking or for your job). The writing should include some math equations, theorems, definitions, and matrices. Please check with me first before you start typing.

Excerpts

1 Analytic Equations

The famous formula of Leibniz involving π is

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \cdots = \sum_{k \geq 0} \frac{(-1)^k}{2k+1}. \tag{1}$$

However, (1) converges far too slowly to be a practical method of approximating π.

Euler's integral formula for $n!$ is

$$n! = \int_0^\infty x^n e^{-x}\, dx.$$

The right side makes sense at $n = 1/2$ and can be evaluated explicitly:

$$\int_0^\infty \sqrt{x} e^{-x}\, dx = \frac{\sqrt{\pi}}{2}.$$

This suggests defining $(1/2)! = \dfrac{\sqrt{\pi}}{2}$.

For $a \in \mathbb{R}$ and a function $f\colon \mathbb{R} \to \mathbb{R}$, the *derivative* of f at a is

$$\begin{aligned} f'(a) &= \lim_{h \to 0} \frac{f(a+h) - f(a)}{h} \\ &= \lim_{x \to a} \frac{f(x) - f(a)}{x - a} \end{aligned}$$

and the formula for differentiation under the integral sign says that under suitable conditions,

$$\frac{d}{dt} \int_a^b f(x,t)\, dx = \int_a^b \frac{\partial f}{\partial t}(x,t)\, dx.$$

More formulas like this can be found in the book [Rud76].

2 Areas

If we are dealing with lattice polygons that are not simple, then we can use the following extension of Pick's Theorem.

Theorem 2.1. *For a lattice polygon P containing h holes with a boundary of $h+1$ simple closed curves, its area is given by*

$$A(P) = I(P) + \frac{B(P)}{2} + h - 1,$$

where $I(P)$ is the number of interior lattice points of P and $B(P)$ is the number of boundary lattice points of P.

We now review the definition of Euler characteristic for a convex polyhedron.

Definition 2.2. The *Euler characteristic* of a convex polyhedron P with V vertices, E edges, and F faces is $\chi(P) = V - E + F$.

Next, we recall Euler's formula.

Theorem 2.3 (Euler's Formula)**.** *For any convex polygon P with Euler characteristic $\chi(P)$, we have that*

$$\chi(P) = 2. \tag{2}$$

We will now generalize Theorem 2.1 by incorporating the Euler characteristic, which will allow us to find the area $A(P)$ of any lattice polygon P that is the union of a finite number of simple lattice polygons. This more general area formula is given by

$$A(P) = V - \frac{1}{2}E_B - \chi(P), \tag{3}$$

where V is the total number of vertices (lattice points) of P, where E_B is the number of boundary points on the edges of P, and where $\chi(P)$ is the Euler characteristic of P.

Note that, by Definition 2.2, the Euler characteristic of a simple lattice polygon (one with no holes) is $\chi(P) = 1$ and, by definition, $E_B = B(P)$. Furthermore, the Euler characteristic of a lattice polygon P containing h separate holes can be shown to be $\chi(P) = 1 - h$. We will now use Equation (2) to prove the generalized area formula given by Equation (3).

3 Matrix Equations

Operations on diagonal matrices are easy. For instance,

$$D = \begin{pmatrix} x & 0 & 0 \\ 0 & y & 0 \\ 0 & 0 & z \end{pmatrix} \Longrightarrow D^3 = \begin{pmatrix} x^3 & 0 & 0 \\ 0 & y^3 & 0 \\ 0 & 0 & z^3 \end{pmatrix}.$$

The transpose of a row vector $\mathbf{a} = (a_1, a_2, \ldots, a_n)$ is

$$\mathbf{a}^\top = \begin{pmatrix} a_1 \\ a_2 \\ \vdots \\ a_{n-1} \\ a_n \end{pmatrix}.$$

Remark 3.1. If you want to use LaTeX to edit a math page on Wikipedia, look at [Wik19].

References

[Rud76] Walter Rudin. *Principles of mathematical analysis*. McGraw-hill New York, 1976.

[Wik19] Wikipedia. https://en.wikipedia.org/wiki/Help:Displaying_a_formula, 2019. Accessed: 21-January-2020.