LaTeX Practice Assignment 2

Due: Week 4 Monday by 5:45pm (via Overleaf invite)

Setup:

1. Using the "folder" icon, create a new folder in your "MATH2794W YourName" project in Overleaf and title it "assignment2".
2. Download the files:
   - egunawan.github.io/math2794w/hw/02/intro2.tex
   - egunawan.github.io/math2794w/hw/02/Bib.bib
   - egunawan.github.io/math2794w/hw/02/fig1.pdf

   and upload these three files to your "assignment2" folder in Overleaf using the "Upload" icon on the top left.
3. To set the "intro2.tex" file as your main document, click on "Menu" on the top left, then go to "Settings".
4. Click "Recompile" to attempt to view the PDF. When you are done, the PDF output that gets created should match the PDF file

   "egunawan.github.io/math2794w/hw/02/templateintro2.pdf"

   exactly. If this does not happen, please ask during class or post on Piazza.

Assignment:

(1) Make the following changes, one at a time and in order, to the "intro2.tex" file in Overleaf. To monitor each change you make, click "Recompile" and view the PDF in "Full Screen" mode.

  (a) Change the title to "LaTeX Practice Assignment 2", change the author to your name (in "First Name Last Name" format), and change the date to the assignment due date (in "Month Day, Year" format).

  (b) **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."

(c) **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 the theorem goes."

(d) **Adding and labeling a figure.** Use the internet to find another Husky or a math-related JPEG (.jpg) file. Name and save a copy of this file to your "assignment2" folder. Your file name should 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 and type).

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

- **Editing a BIB file.** Within the BIB file, replace the first and last name of the author <u>of the book</u> by YOUR first and last name. Note that the format in the BIB file is "Last Name, First Name."
- **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 "Website2" 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 "Website2"), 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 "July 17, 2016" by the assignment due date).

(3) Click on the "intro2.tex" file in Overleaf.

- **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{Website2}". 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".

(4) **LaTeX Practice Finale.** 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 4-5 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, you can use a search engine, use detexify.kirelabs.org, and The Not So Short Introduction to LaTeX: tobi.oetiker.ch/lshort/lshort.pdf.

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!

Submitting LaTeX Practice Assignment: After completing all tasks, re-share your Overleaf project with me via my university email address. If it does not let you re-share a project, please send me an email with the share link (with edit permission) to your project.

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 $(1/2)! = \frac{\sqrt{\pi}}{2}$.

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 [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 recall 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,

$$D = \begin{pmatrix} a & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & c \end{pmatrix} \Longrightarrow D^3 = \begin{pmatrix} a^3 & 0 & 0 \\ 0 & b^3 & 0 \\ 0 & 0 & c^3 \end{pmatrix}.$$

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

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

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

References

[CL] J. C. Cha and C. Livingston. Knotinfo: Table of knot invariants. http://www.indiana.edu/~knotinfo. Accessed: 03-February-2019.

[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: 03-February-2019.