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Electronic Engineering

MERIT.jl: Julia's Version

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March 26, 2024

A Final Year Project submitted in partial fulfilment
of the requirements for the degree of
MAI (Electronic and Computer Engineering)

Declaration

I hereby declare that this Final Year Project is entirely my own work and that it has not been submitted as an exercise for a degree at this or any other university.

I have read and I understand the plagiarism provisions in the General Regulations of the University Calendar for the current year, found at <http://www.tcd.ie/calendar>.

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Abstract

MERIT aims to provide a software framework that is robust, easy to use and performant. It implements a variety of microwave imaging algorithms and a myriad of helper functions, all while leveraging the powerful features available in Julia. MERIT.jl also implements a "Scan" abstract datatype which allows users to subtype their own specialized datatype. Organizing the datatypes in this way means that MERIT.jl plays very well with Julia's own type hierarchy and also the other language features that depend on this. To encourage type safety, MERIT.jl implements a lightweight Points class which allows for efficient processing of coordinate points. In this way, collections of points won't simply be a matrix of Floats or Ints instead, they would be a Vector of the Points type. In this way, the Julia compiler will throw an error when Points aren't passed in the right argument, instead of providing a wrong output.

Acknowledgements

Thanks Everyone!

You should acknowledge any help that you have received (for example from technical staff), or input provided by, for example, a company.

Contents

1	Introduction	1
1.1	Headings, sections and subsections	1
1.1.1	Subsection name style	1
1.2	Length of the report	1
1.3	Contents of the Introduction	2
1.4	Contents of the background chapter	2
1.5	The Conclusions chapter	2
2	Figures, Tables, Referencing	3
2.1	Figures	3
2.2	Tables	4
2.3	Equations	4
2.4	Referencing published work	5
3	L^AT_EX	6
4	Evaluation	7
5	Conclusion	8
A1	Appendix	10
A1.1	Appendix numbering	10

List of Figures

2.1	Velocity distribution on the mid-plane for an inlet velocity for case 1.	3
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List of Tables

2.1	The effects of treatments X and Y on the four groups studied.	4
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1 Introduction

This document provides a template for the preparation of final year project reports. The objective is to provide clear guidance to you, the students, and also to provide uniformity to the project reports, to facilitate equitable grading. This LaTeX template uses a sans-serif font to aid accessibility..

The font colour for Chapter headings is “Pantone Blue”, which is the colour used in TCD documents. The page number appears at the bottom of each page starting at 1 on the first page of the Introduction chapter. If you are not familiar with concepts like styles, captioning, cross-referencing, and how to generate tables of contents, figures etc. in LaTeX, the Overleaf guides are a useful start at: https://www.overleaf.com/learn/latex/Learn_LaTeX_in_30_minutes

1.1 Headings, sections and subsections

Chapters should be divided into appropriate subsections. LaTeX makes the numbering much easier and it is all built in. Headings should incorporate the Chapter number into them as is done here.

1.1.1 Subsection name style

The subsections, if used, should be numbered sequentially within each section. You should really try to avoid using sub- subsections, but if you do they should not be numbered.

1.2 Length of the report

The page margins is set to 2.54 cm top, bottom, left and right. There may be a table or figure for which it is sensible to deviate from these margins, but in general the main text should be formatted within the specified margins. The body of the report should be organised into several chapters. There are a number of chapters that you must have: an introduction; a background or literature review chapter; and a conclusion chapter. The focus of the other chapters will depend on your specific project. Refer to the issued guidelines for the page limit. This limit does not usually include the front matter, references list and any appendices. In other words, from the first page of the Introduction to the last page of the Conclusions chapters must be less than the given limit for MAI. If you exceed these page limits or deviate significantly from this format, you will lose marks.

1.3 Contents of the Introduction

The introduction presents the nature of the problem under consideration, the context of the problem to the wider field and the scope of the project. The objectives of the project should be clearly stated.

1.4 Contents of the background chapter

The second chapter is typically a literature review, or survey of the state of the art, or a detailed assessment of the context and background for the project. The exact nature of this chapter depends on the topic and/or methods of the project. It is essential that the work of other people is properly cited. This will be discussed in detail in Chapter 2 below. Note that you should use references wherever is appropriate through the report, not just in the literature review chapter.

1.5 The Conclusions chapter

The final chapter should give a short summary of the key methods, results and findings in your project. You should also briefly identify what, if any, future work might be executed to resolve unanswered questions or to advance the study beyond the scope that you identified in Chapter 1.

2 Figures, Tables, Referencing

It is very important to properly refer in the text to any figures, tables or previously published work that you are discussing. Adequate and consistent referencing is one of the criteria which will be used to assess your project report.

2.1 Figures

Graphs, pictures and other images should be included in your report as a numbered, captioned figure. An example is given in Figure 2.1.

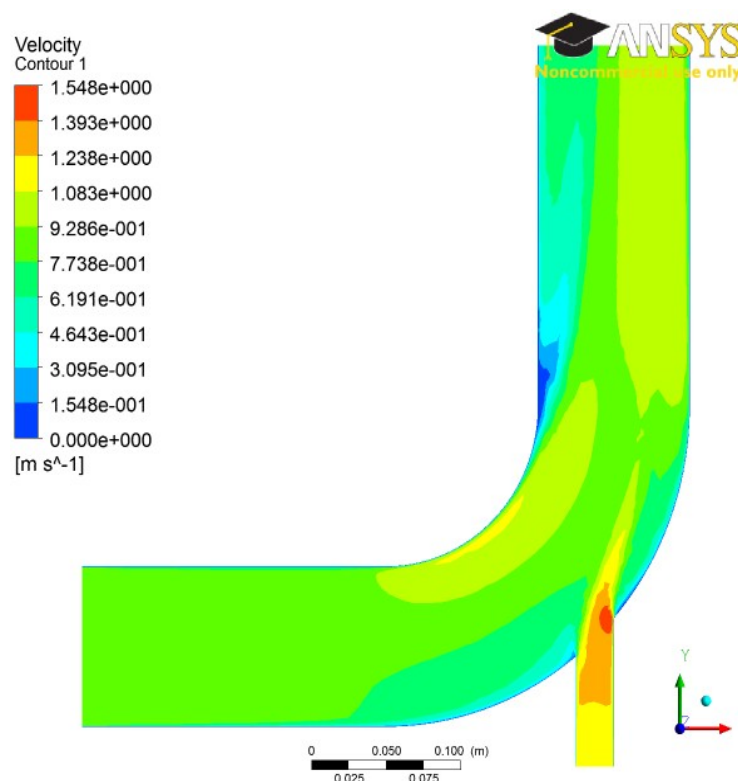


Figure 2.1: Velocity distribution on the mid-plane for an inlet velocity for case 1.

The figure and caption should be centred. The figure numbering starts at 1 at the beginning of each chapter. The caption should provide a brief description of what is being shown. The figure should appear in the document after it is referred to in the text. No figure should be included which is not referred to in the text. Ensure that the size and resolution of images imported from software are sufficient to read any text.

2.2 Tables

Tables are an important way of displaying your results. Table 2.1 is a sample table, adapted from the Master/Doctoral Thesis template at <http://www.latextemplates.com/cat/theses>, which was generated with this code:

```
\begin{table}[b]
\caption{The effects of treatments X and Y on the four groups studied.}
\label{tab:treatments}
\centering
\begin{tabular}{l l l}
\toprule
\textbf{Groups} & \textbf{Treatment X} & \textbf{Treatment Y} \\ \midrule
1 & 0.2 & 0.8 \\
2 & 0.17 & 0.7 \\
3 & 0.24 & 0.75 \\
4 & 0.68 & 0.3 \\
\bottomrule
\end{tabular}
\end{table}
```

Tables are numbered in the same way as figures. Typically tables also have a short caption, but this is not universally true. The number and caption appear above the table, not below as with figures. Again, no table should appear in the report which has not been referred to in the text. Tables should come after they are discussed in the text. The exact formatting of the table depends somewhat on the content of the table, but in general, the text in the table should be the same font and size as the main text.

2.3 Equations

All equations should be numbered sequentially. The numbering restarts automatically at the beginning of each chapter, and contains the number of the chapter alongside the equation number. Unlike figures and tables, you may not need to refer to every equation in the text. You should take care to format equations properly. Do not simply try to use plain text. Use the equation layout facilities. An example of how equations should appear is shown in (2.1). Here is the code for it:

```
\begin{equation}
\text{trm{div}}(\underline{u}) = \frac{\delta u}{\delta x} + \frac{\delta v}{\delta y} +
\frac{\delta w}{\delta z} = 0
\label{sampleequation}
\end{equation}
```

Table 2.1: The effects of treatments X and Y on the four groups studied.

Groups	Treatment X	Treatment Y
1	0.2	0.8
2	0.17	0.7
3	0.24	0.75
4	0.68	0.3

$$\text{div}(\underline{u}) = \frac{\delta u}{\delta x} + \frac{\delta v}{\delta y} + \frac{\delta w}{\delta z} = 0 \quad (2.1)$$

2.4 Referencing published work

It is important to give appropriate credit to other people for the work that they have shared through publications. In fact, you must sign a declaration in your report stating that you understand the nature of plagiarism. As well as avoiding plagiarism, citing results or data from the literature can strengthen your argument, provide a favourable comparison for your results, or even demonstrate how superior your work is.

There are many styles to reference published work. For example, the parenthetical style (which is also called the Harvard style) uses the author and date of publication (e.g. “Smith and Jones, 2001”). There is also the Vancouver style (or the citation sequence style). In the IEEE style, which is used in this document in the default setup, the publications are cited using bracketed numbers which refer to the list in the References section at the end of the report. The references are listed in the order that they are cited in the report. A variant is name sequence style, in which the publications are referenced by number, but the list is arranged alphabetically. The following paragraph shows the use of the IEEE style:

Several studies have examined the sound field around tandem cylinders generated by flow [1, 2], while other investigations have focused on the effect of an applied sound field on the flow [3]. Papers from conference proceedings [4], books [5] and technical reports [6] can be dealt with in the same style.

The IEEE style has the advantage that it is a little more compact in the text and does not distract from the flow of the sentence if there are a lot of citations. However, it has the disadvantage that it is not immediately clear to the reader what particular work has been referenced. You can use author names directly and discuss the work of Finnegan et al. [2] similar to this sentence to make it more readable.

It actually does not matter which particular referencing style is used as long as three important considerations are observed:

- the referencing style used throughout the document is consistent;
- all material used or discussed in the text is properly cited;
- nothing is included in the reference list that has not been cited.

Check with your supervisor as they may have a strong opinion on what you should use

This template has a suitable referencing style already set up – you should use it and use the built-in BibTeX system to manage your references. See above for examples of how to cite a reference and look in the `sample.bib` file to see BibTeX references. It is strongly recommended that you use a bibliographic tool, such as EndNote (check out <https://www.tcd.ie/library/support/endnote/>), as this will facilitate compliance with these three requirements. Endnote can help you build your .bib file. Remember Google Scholar and other search engines will give you BibTeX references for lots of academic publications. Be aware that Web of Science is more reliable for giving the full record for the BibTeX entry. Otherwise, you can easily make up your own based on the examples in that file.

3 L^AT_EX

L^AT_EX, or more properly “L^AT_EX 2_ε”, is a very useful document processing program. It is very widely used, widely available, stable and free. Famously, T_EX, upon which L^AT_EX is built, was originally developed by the eminent American mathematician Donald Knuth because he was tired of ugly mathematics books [7]. Although it has a learning curve (made much less forbidding by online tools and resources – see below), it allows the writer to concentrate more fully on the content, and takes care of most everything else.

While it can be used as a word processor, it is a typesetting system, and Knuth’s idea was that it could be used to produce beautiful looking books:

L^AT_EX is a macro package which enables authors to typeset and print their work at the highest typographical quality, using a predefined, professional layout.¹

L^AT_EX has great facilities for setting out equations and a powerful and very widely supported bibliographic system called BibT_EX, which takes the pain out of referencing.

Three useful online resources make L^AT_EX much better:

- (1) An excellent online L^AT_EX environment called “Overleaf” is available at <http://www.overleaf.com> and runs in a modern web browser. It’s got this template available – search for a TCD template. Overleaf can work in conjunction with Dropbox, Google Drive and, in beta, GitHub.
- (2) Google Scholar, at <http://scholar.google.com>, provides BibT_EX entries for most of the academic references it finds.
- (3) An indispensable and very fine introduction to using L^AT_EX called “The not so short introduction to L^AT_EX 2_ε” by [8] is online at <https://doi.org/10.3929/ethz-a-004398225>. Browse it before you use L^AT_EX for the first time and read it carefully when you get down to business.

Other tools worth mentioning include:

- Draw.io – an online drawing package that can output PDFs to Google Drive – see <https://www.draw.io>.

¹This is from [8]. Did we mention that you should minimise your use of footnotes?

4 Evaluation

5 Conclusion

Bibliography

- [1] J. Fitzpatrick, "Flow/acoustic interactions of two cylinders in cross-flow," Journal of Fluids and Structures, vol. 17, no. 1, pp. 97–113, 2003.
- [2] S. Finnegan, C. Meskell, and S. Ziada, "Experimental investigation of the acoustic power around two tandem cylinders," Journal of Pressure Vessel Technology, vol. 132, no. 4, p. 041306, 2010.
- [3] J. Hall, S. Ziada, and D. Weaver, "Vortex-shedding from single and tandem cylinders in the presence of applied sound," Journal of Fluids and Structures, vol. 18, no. 6, pp. 741–758, 2003.
- [4] P. Jordan, J. Fitzpatrick, and C. Meskell, "Array beam pattern control for measurement of propeller noise," in AIAA/CEAS Aeroacoustics Conference and Exhibit, Maastricht, Netherlands, 2001.
- [5] M. P. Païdoussis, S. J. Price, and E. De Langre, Fluid-structure interactions: cross-flow-induced instabilities. Cambridge University Press, 2010.
- [6] L. Reyes, "Power uprate program status report-secy-07-0090," Technical Report, US Nuclear Regulatory Commission, Tech. Rep., 2007.
- [7] L. Shustek and D. Interviewee-Knuth, "Interview donald knuth: A life's work interrupted," Communications of the ACM, vol. 51, no. 8, pp. 31–35, 2008.
- [8] T. Oetiker, H. Partl, I. Hyna, and E. Schlegl, "The not so short introduction to latex 2 ϵ ," Electronic Document, 2001, <http://www.tex.ac.uk/tex-archive/info/lshort>.

A1 Appendix

You may use appendices to include relevant background information, such as calibration certificates, derivations of key equations or presentation of a particular data reduction method. You should not use the appendices to dump large amounts of additional results or data which are not properly discussed. If these results are really relevant, then they should appear in the main body of the report.

A1.1 Appendix numbering

Appendices are numbered sequentially, A1, A2, A3. . . The sections, figures and tables within appendices are numbered in the same way as in the main text. For example, the first figure in Appendix A1 would be Figure A1.1. Equations continue the numbering from the main text.