



**Trinity College Dublin**

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SCHOOL OF COMPUTER SCIENCE AND STATISTICS

# **MODERN DELAY-TOLERANT EMAIL**

DENG PAN

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MARCH 24, 2025

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF  
M.SC. COMPUTER SCIENCE - FUTURE NETWORKED SYSTEMS

# 1 | Introduction - Chapter

## 1.1 Email Protocol

- **MUA (Mail User Agent):** Also known as the email client, used by end users to send and receive emails.
- **MSA (Mail Submission Agent):** Receives emails from the MUA and forwards them to the MTA.
- **MTA (Mail Transfer Agent):** Transfers email between servers.
- **MDA (Mail Delivery Agent):** Delivers the email to the recipient's mailbox.
- Note: Dovecot refers to the MDA as **LDA (Local Delivery Agent)**.

Table 1.1: Common Email Protocols and Their Port Numbers

Protocol	Description	Port
<b>IMAP</b>	Internet Message Access Protocol	143
<b>IMAPS</b>	IMAP over SSL/TLS	993
<b>POP3</b>	Post Office Protocol v3	110
<b>POP3S</b>	POP3 over SSL/TLS	995
<b>SMTP</b>	Simple Mail Transfer Protocol	25
<b>SMTPS</b>	SMTP over SSL/TLS	465

### 1.1.1 STARTTLS Support

**STARTTLS** is a command that upgrades a plaintext connection to a secure one using SSL/TLS, without changing the default ports. It can be used with:

- IMAP on port 143
- POP3 on port 110
- SMTP on port 25

## 1.2 Email Server

```
docker-compose up -d

# Send email
docker exec -it mail1 bash
echo "Hello from mail1" | mail -s "Test Email" mail2@mail2.example.com

docker exec -it mail2 bash
cat /var/mail/mail2

# Reply email
echo "Reply from mail2" | mail -s "Test Reply" mail1@mail1.example.com

cat /var/mail/mail1

docker-compose down -v
```

Listing 1.1: Run Email Server Using Docker

## 1.3 Section

### 1.3.1 Subsection

Paragraph As specified in (1), (2), (3), (4), (5), (6), (7), (8), (9), (10), the Bundle Protocol defines...

**Subparagraph**

## **1.3.2 Subsection**

**Subsubsection**

## **2 | Literature Review**

### **2.1 Materials**

### **2.2 Synthetic Procedures**

#### **2.2.1 Parameters Varied**

### **2.3 Characterisation Techniques**

#### **2.3.1 A**

#### **2.3.2 B**

#### **2.3.3 C**

#### **2.3.4 D**

## **3 | Experimental Methods**

### **3.1 Materials**

### **3.2 Synthetic Procedures**

#### **3.2.1 Parameters Varied**

### **3.3 Characterisation Techniques**

#### **3.3.1 A**

#### **3.3.2 B**

#### **3.3.3 C**

#### **3.3.4 D**

## 4 | Results and Discussion

## 5 | **Conclusions and Future Work**



## 6 | 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.

### 6.1 Figures

Graphs, pictures and other images should be included in your report as a numbered, captioned figure. An example is given in Figure 6.1.

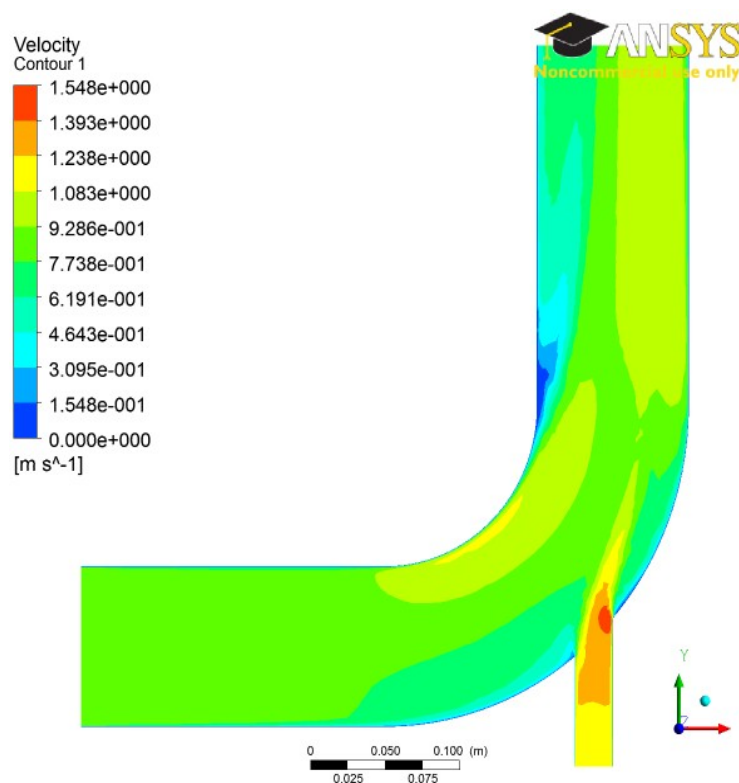


Figure 6.1: Velocity distribution on the mid-plane for an inlet velocity for case 1.

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.

## 6.2 Tables

Tables are an important way of displaying your results. Table 6.1 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.

## 6.3 Equations

All equations should be numbered sequentially. Do not restart the numbering at the beginning of each chapter. 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 Equation 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}
```

$$\text{div}(\underline{u}) = \frac{\delta u}{\delta x} + \frac{\delta v}{\delta y} + \frac{\delta w}{\delta z} = 0 \quad (1)$$

## 6.4 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

Table 6.1: 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

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*), which is used in this document. In the Vancouver style, 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 Vancouver style:

Several studies have examined the sound field around tandem cylinders generated by flow(11, 12), while other investigations have focused on the effect of an applied sound field on the flow(13). Papers from conference proceedings(14), books(15) and technical reports(16) can be dealt with in the same style.

The Vancouver 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.

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.

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.

Remember Google Scholar and other search engines will give you BibTeX references for lots of academic publications. Otherwise, you can easily make up your own based on the examples in that file.

## 7 | L<sup>A</sup>T<sub>E</sub>X

L<sup>A</sup>T<sub>E</sub>X, or more properly “L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>”, is a very useful document processing program. It is very widely used, widely available, stable and free. Famously, T<sub>E</sub>X, upon which L<sup>A</sup>T<sub>E</sub>X is built, was originally developed by the eminent American mathematician Donald Knuth because he was tired of ugly mathematics books (17). 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<sup>A</sup>T<sub>E</sub>X is a macro package which enables authors to typeset and print their work at the highest typographical quality, using a predefined, professional layout.<sup>1</sup>*

L<sup>A</sup>T<sub>E</sub>X has great facilities for setting out equations and a powerful and very widely supported bibliographic system called BibT<sub>E</sub>X, which takes the pain out of referencing.

Three useful online resources make L<sup>A</sup>T<sub>E</sub>X much better:

- (1) An excellent online L<sup>A</sup>T<sub>E</sub>X 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.

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<sup>1</sup>This is from Oetiker et al. (18). Did we mention that you should minimise your use of footnotes?

- (2) Google Scholar, at <http://scholar.google.com>, provides BibTeX entries for most of the academic references it finds.
- (3) An indispensable and very fine introduction to using L<sup>A</sup>T<sub>E</sub>X called “*The not so short introduction to L<sup>A</sup>T<sub>E</sub>X 2 $\epsilon$* ” by Oetiker et al. (18) is online at <https://doi.org/10.3929/ethz-a-004398225>. Browse it before you use L<sup>A</sup>T<sub>E</sub>X 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>.

# Bibliography

- [1] Scott Burleigh, Kevin Fall, and Edward J. Birrane. Bundle Protocol Version 7. RFC 9171, January 2022. URL <https://www.rfc-editor.org/info/rfc9171>.
- [2] Leigh Torgerson, Scott C. Burleigh, Howard Weiss, Adrian J. Hooke, Kevin Fall, Dr. Vinton G. Cerf, Keith Scott, and Robert C. Durst. Delay-Tolerant Networking Architecture. RFC 4838, April 2007. URL <https://www.rfc-editor.org/info/rfc4838>.
- [3] Dave Crocker. Internet Mail Architecture. RFC 5598, July 2009. URL <https://www.rfc-editor.org/info/rfc5598>.
- [4] David M'Raihi, Johan Rydell, Mingliang Pei, and Salah Machani. TOTP: Time-Based One-Time Password Algorithm. RFC 6238, May 2011. URL <https://www.rfc-editor.org/info/rfc6238>.
- [5] Dick Hardt. The OAuth 2.0 Authorization Framework. RFC 6749, October 2012. URL <https://www.rfc-editor.org/info/rfc6749>.
- [6] Scott Kitterman. Sender Policy Framework (SPF) for Authorizing Use of Domains in Email, Version 1. RFC 7208, April 2014. URL <https://www.rfc-editor.org/info/rfc7208>.
- [7] Murray Kucherawy, Dave Crocker, and Tony Hansen. DomainKeys Identified Mail (DKIM) Signatures. RFC 6376, September 2011. URL <https://www.rfc-editor.org/info/rfc6376>.



- [8] Kevin Fall. A delay-tolerant network architecture for challenged internets. In *Proceedings of the 2003 conference on Applications, technologies, architectures, and protocols for computer communications*, pages 27–34, 2003.
- [9] Sushant Jain, Kevin Fall, and Rabin Patra. Routing in a delay tolerant network. In *Proceedings of the 2004 conference on Applications, technologies, architectures, and protocols for computer communications*, pages 145–158, 2004.
- [10] Dr. John C. Klensin. Simple Mail Transfer Protocol. RFC 5321, October 2008. URL <https://www.rfc-editor.org/info/rfc5321>.
- [11] JA Fitzpatrick. Flow/acoustic interactions of two cylinders in cross-flow. *Journal of Fluids and Structures*, 17(1):97–113, 2003.
- [12] SL Finnegan, C Meskell, and S Ziada. Experimental investigation of the acoustic power around two tandem cylinders. *Journal of Pressure Vessel Technology*, 132(4):041306, 2010.
- [13] JW Hall, S Ziada, and DS Weaver. Vortex-shedding from single and tandem cylinders in the presence of applied sound. *Journal of Fluids and Structures*, 18(6):741–758, 2003.
- [14] Peter Jordan, John Fitzpatrick, and Craig Meskell. Array beam pattern control for measurement of propeller noise. In *AIAA/CEAS Aeroacoustics Conference and Exhibit, Maastricht, Netherlands*, 2001.
- [15] Michael P Paidoussis, Stuart J Price, and Emmanuel De Langre. *Fluid-structure interactions: cross-flow-induced instabilities*. Cambridge University Press, 2010.
- [16] L Reyes. Power uprate program status report-secy-07-0090. Technical report, Technical Report, US Nuclear Regulatory Commission, 2007.
- [17] Len Shustek and Donald Interviewee-Knuth. Interview donald knuth: A life’s work interrupted. *Communications of the ACM*, 51(8):31–35, 2008.

- [18] Tobias Oetiker, Hubert Partl, Irene Hyna, and Elisabeth Schlegl. The not so short introduction to latex 2 $\epsilon$ . *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.