Using LaTeX for your master's thesis

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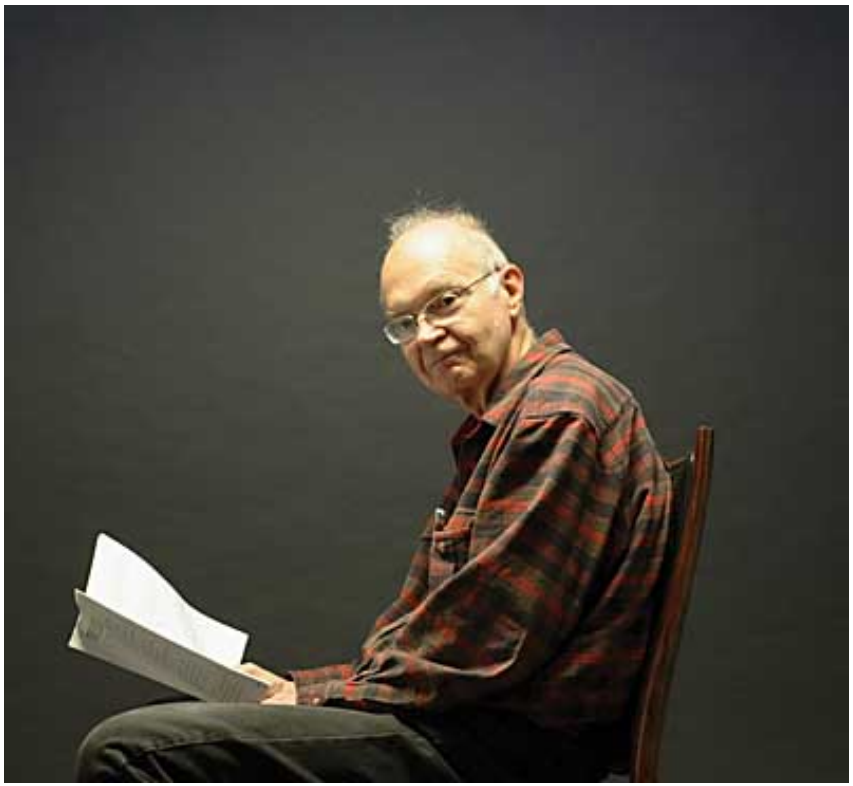
What is LaTeX?

LaTeX is a document processing system built on top of Donald Knuth's TeX.

- TeX is free and open.
- TeX runs on all computer systems.
- TeX is quite probably bug-free!
- TeX produces high quality documents.
- TeX is particularly good for mathematics.
- LaTeX uses a markup language (like XML and HTML) so your files are readable by humans.

The man behind it all



Donald Knuth created **TEX** in 1974–82, primarily to typeset his own books.

How to start

You edit your LaTeX documents using either

- a general text editor (like Emacs or Atom)
- a graphical editor (like Kile;
  see Wikipedia: *Comparison of TeX editors*)

A good basis

https://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/
mymaster.tex is a good starting point. Save a copy of that file.

Starting a LaTeX document

```
\documentclass[UKenglish]{ifimaster}  %% ... or USenglish or norsk or nynorsk
\usepackage[utf8]{inputenc}           %% ... or latin1
\usepackage[T1]{fontenc,url}
\urlstyle{sf}
\usepackage{babel,textcomp,csquotes,duomasterforside,graphicx}
\usepackage[nospace]{varioref}
\usepackage[backend=biber,style=numeric-comp]{biblatex}

\title{The title of my thesis}        %% ... or whatever
\subtitle{Any short subtitle}         %% ... if any
\author{My Name}                      %% ... or whoever

\addbibresource{mybib.bib}            %% ... or whatever

\begin{document}
\duoforside[dept={Department of Informatics},   %% ... or your department
  program={Network and system administration},  %% ... or your programme
  short]                                        %% ... or long

\frontmatter{}
\chapter*{Abstract}                   %% ... or Sammendrag or Samandrag

\tableofcontents{}
\listoffigures{}
\listoftables{}
```

Starting a LaTeX document

```
\chapter*{Preface}                          %% ... or Forord

\mainmatter{}
\part{Introduction}                         %% ... or Innledning or Innleiing

\chapter{Background}                        %% ... or Bakgrunn


\part{The project}                          %% ... or ??

\chapter{Planning the project}              %% ... or ??


\part{Conclusion}                           %% ... or Konklusjon

\chapter{Results}                           %% ... or ??


\backmatter{}
\printbibliography
\end{document}
```

Note!

A **%** in LaTeX signals that the rest of the line is a comment.

Running LaTeX

- On Ifi's Linux computers:

```
pdflatex mymaster.tex
biber mymaster
pdflatex mymaster.tex
```

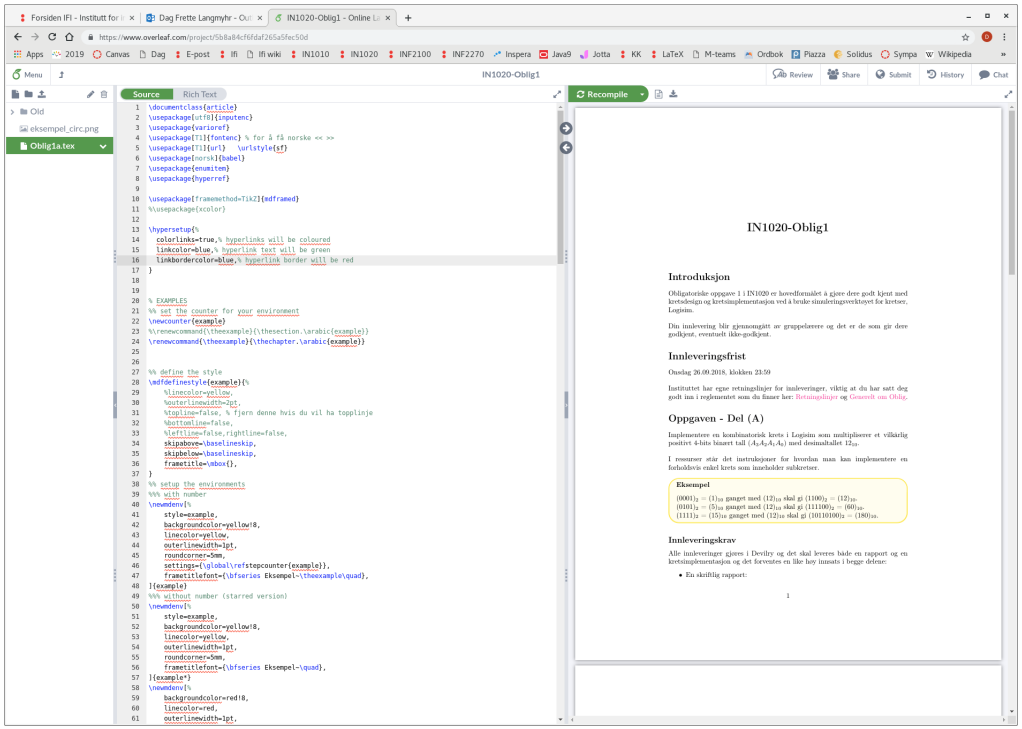
  and the result is mymaster.pdf.
  (On Ifi's Linux computers, I recommend **ltx** which runs LaTeX and various support programs.)
- On your own computer:

  Linux TeX Live (https://ctan.org/pkg/texlive)
  Mac TeXshop (https://pages.uoregon.edu/koch/texshop/)
  Windows MiKTeX (https://miktex.org/download)

How do I process a LaTeX file?

Overleaf

Another possibility is a cloud based commercial system called **Overleaf** (https://www.overleaf.com).



+ Free for limited private use.
+ A good user interface.
- No local features (UiO frontpage etc)

LaTeX file structure

A LaTeX file starts like this:

```
\documentclass[UKenglish]{ifimaster}
        %% ... or USenglish or norsk or nynorsk
```

From this we can learn:

- LaTeX markup consists of commands like \documentclass.
  - All commands start with a backslash (\).
  - Commands may have *options* in square brackets; these may be omitted.
  - Commands have zero or more *parameters* in curly braces; there should always be at least one pair.

The initial command

```
\documentclass[UKenglish]{ifimaster}
        %% ... or USenglish or norsk or nynorsk
```

specifies that

- The option **UKenglish** specifies the language used; you should change this if necessary.
- The parameter **ifimaster** is a document class suitable for a master's thesis. Other common document classes are:

article	for short articles
report	for longer reports
book	for books
beamer	for presentations

Then LaTeX will load some packages:

```
\usepackage[utf8]{inputenc}          %% ... or latin1
\usepackage[T1]{fontenc,url}
\urlstyle{sf}
\usepackage{babel,textcomp,csquotes,duomasterforside,graphicx}
\usepackage[nospace]{varioref}
\usepackage[backend=biber,style=numeric-comp]{biblatex}
```

- **inputenc** specifies the text encoding used in the source file.
- **fontenc** specifies the font encoding to use.
- **url** makes URLs easier. (Using sans serif (sf) URLs is a good idea.)
- **babel** handles language adaption.
- **textcomp** adds useful symbols; see https://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/textcomp-symbols.pdf.
- **csquotes** handles international quotation marks.
- **duomasterforside** defines an official University of Oslo frontpage.
- **graphicx** opens possibilities for including images.
- **varioref** provides \vref command.
- **biblatex** is for bibliographies.

Document elements (like the author's name) are specified without regard to how they should appear:

```
\title{The title of my thesis}          %% ... or whatever
\subtitle{Any short subtitle}           %% ... if any
\author{My Name}                        %% ... or whoever
```

The bibliography file mybib.bib must be specified:

```
\addbibresource{mybib.bib}                %% ... or whatever
```

Hint

Start with an empty .bib file.

Then we can start the document itself:

```
\begin{document}
\duoforside[dept={Department of Informatics},   %% ... or your department
  program={Network and system administration},  %% ... or your programme
  short]                                        %% ... or long

\frontmatter{}
```

Note!

A LaTeX document is always placed in a **LaTeX environment** \begin{document}...\end{document}.

- **\duoforside** produces the official UiO frontpage.
- **\frontmatter** specifies that we now start the initial part of the thesis.

The document itself

The title of my thesis

Any short subtitle

My Name

Thesis submitted for the degree of
Master in Network and system administration
30 credits

Department of Informatics
Faculty of mathematics and natural sciences

UNIVERSITY OF OSLO

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Then comes a short abstract.

```
\chapter*{Abstract}    %% ... or Sammendrag or Samandrag
The text of the abstract;
typically, 2--5~sentences.
```

Now it is time for the table of contents and other tables (if you have any):

```
\tableofcontents{}
\listoffigures{}
\listoftables{}
```

And, finally, the initial part ends with a preface:

```
\chapter*{Preface}                    %% ... or Forord

\mainmatter{}
```

How to structure your document

```
\part{...}
\chapter{...}
\section{...}
\subsection{...}
\subsubsection{...}
\paragraph{...}
\subparagraph{...}
```

Writing ordinary text

Basically, you just write your text as you would on a typewriter.

One or more blank lines start a new paragraph.

Some characters need special treatment:

Character	Write	Character	Write
#	\#	&	\&
$	\$	_	_
%	\%	\	\textbackslash{}
{	\{	^	\textasciicircum{}
}	\}	~	\textasciitilde{}

Hint

You can create your own commands for the long names:

```
\newcommand{\bsl}{\textbackslash}
```

You can emphasize particular words:

Command	**Result**
\emph{...}	*Emphasised text (italics)*
\textbf{...}	**Bold text**
\textit{...}	*Italic text*
\textsc{...}	CAPS AND SMALL CAPS
\textsf{...}	Sans serif
\texttt{...}	`Typewriter`

These may be combined: ***`Bold italic typewriter`***.

Diagrams and other pictures

LaTeX has no integrated drawing facilities; instead, it can import illustrations created by other programs, as long as they produce JPEG, PDF or PNG format. For this, the graphicx package is required.

```
\usepackage{graphicx}
```

The file Don.png contains the picture of Donald Knuth. It can be imported using

```
\includegraphics[height=2.42cm,angle=12.25]  % The size.
                 {Don.png}                   % The image file.
```

Useful options include

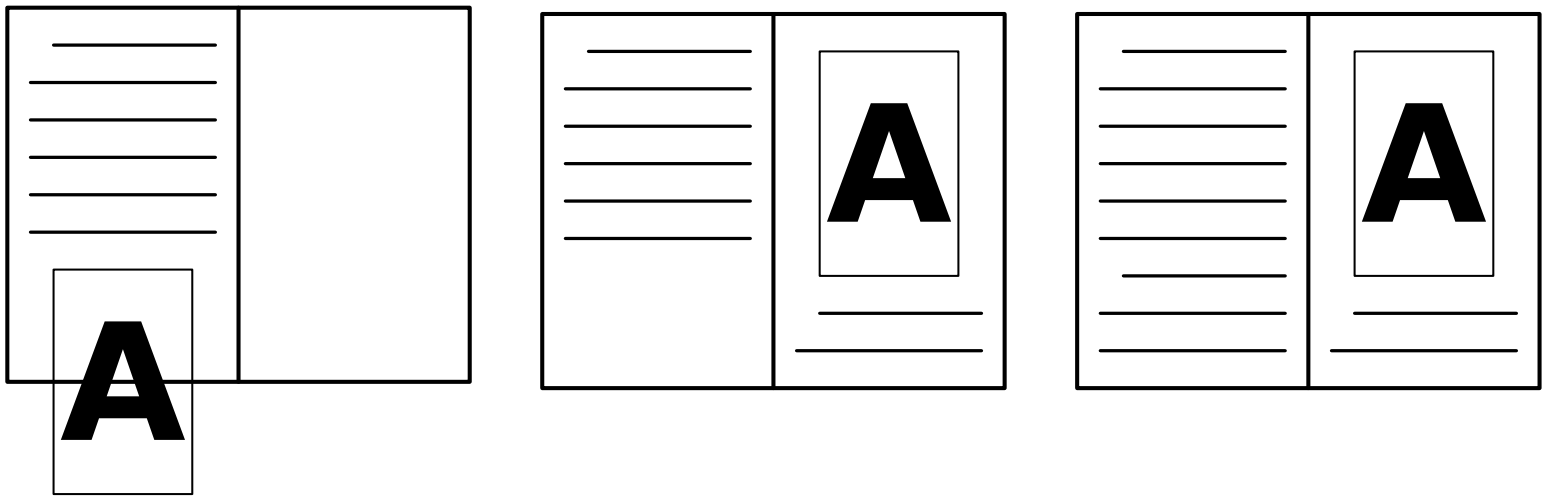
angle=*v* rotates the image v°.

height=*n.n*cm will scale the image.

width=*n.n*cm will also scale the image.

Floating figures

When inserting images, we often encounter problems:



Problem Poor solution Good solution

To avoid page break problems, a figure should be allowed to “float” to a suitable position.

This is specified using the **figure** environment:

```
\begin{figure}
  \includegraphics[height=5.8cm]{Don}
  \caption{\TeX{}'s creator Donald Knuth}
\end{figure}
```

An additional advantage is that we can add a *caption* to the illustration.

Cross references

Since we won't know exactly where a floating figure will land, we cannot write

. . . as we can see in this illustration:

Instead, we must attach a label to the figure (*inside* the \caption-command):

\caption{Donald Knuth\label{knuth}}

Now we can write

. . . as we can see in Figure~\vref{knuth}.

The result becomes something like

. . . as we can see in Figure 5 on the next page.

You can also assign labels to \section, \subsection etc.

Remember

The \vref command requires a package: \usepackage[nospace]{varioref}.

How do you create tables?

```
\begin{tabular}{cl}
  l& left justified\\
  c& centered\\
  r& right justified\\
\end{tabular}
```

l	left justified
c	centered
r	right justified

The size of columns and rows is automatically adjusted.

Tables can easily be framed:

```
\begin{tabular}{|r|l|}
  \hline
  Figures& \verb:\begin{figure}:\\
  \hline
  Tables& \verb:\begin{table}:\\
  \hline
\end{tabular}
```

Figures	\begin{figure}
Tables	\begin{table}

(\verb:...: is used for to turn formatting off.)

To float, tables are placed in \begin{table}...\end{table}. They may be given a \caption and a \label.

Matematical formulas

It may seem strange to «program» formulas, but it is easy and fast with a little training. I created the following formula in 2 min 3 sec:

$$\pi(n) = \sum_{m=2}^{n} \left\lfloor \left(\sum_{k=1}^{m-1} \left\lfloor (m(k)/\lceil m/k \rceil \right\rfloor \right)^{-1} \right\rfloor$$

- Writing LaTeX commands is actually faster than “point and click”.
- “Cut and paste” is easy.
- It is simple to modify a formula.
- You can make commands for formulas or formula parts.

There are *inline formulas* $\sum_{k=1}^{\infty} 2^{-k}$ which are intended to go among the ordinary text, and *display formulas*

$$\sum_{k=1}^{\infty} 2^{-k}$$

that appear on a line of their own. The commands are identical, but LaTeX will format them differently.

Environments for formulas

Inline formulas in LaTeX are written as \$...\$, while display formulas use \[...\]. We also have \begin{equation}... \end{equation} which gives numbered display formulas.

$$\sum_{k=1}^{\infty} 2^{-k} \tag{1}$$

Mathematical formulas follow special rules:

- Very few ordinary LaTeX commands work in this context; instead, there are math commands.
- Spaces are ignored in formulas.

Mathematical symbols

- Letters and digits are written as usual:

Write	Result
e	e
122	122

- We need commands for most Greek letters:

Write	Result
\alpha, \gamma, \omega	α, γ, ω
A, \Gamma, \Omega	A, Γ, Ω

- Mathematical symbols found on your keyboard can be used as they are:

Write	Result
+, -, /, <, >, =, '	$+, -, /, <, >, =, '$

- Other symbols need a command:

Write	Result
\times, \cdot, \leq,	$\times, \cdot, \leq$
\geq, \neq, \land	$\geq, \neq, \land$
\lor, \in, \approx	$\lor, \in, \approx$
\forall, \exists, \notin	$\forall, \exists, \notin$

- You can apply a \not to most symbols:

Write	Result
\not\approx	$\not\approx$

- There exist lots of arrows:

Write	Result
\leftarrow, \leftrightarrow	$\leftarrow, \leftrightarrow$
\not\Rightarrow, \uparrow	$\not\Rightarrow, \uparrow$
\longleftrightarrow	$\longleftrightarrow$
\leftrightsquigarrow	$\leftrightsquigarrow$

- You may add either a subscript using _ or a superscript using ^, or both:

Write	Result
n^{2}, \Theta^{x}	n^2, Θ^x
x_{1}, \pi_{a}, H_{2}O	x_1, π_a, H_2O
x_{1}^{2}, \Psi_{\xi_{1}}^{t+1}	$x_1^2, \Psi_{\xi_1}^{t+1}$

- Fractions are written using \frac:

Write	Result
\frac{1}{a} + \frac{22-4b+1}{n}	$\frac{1}{a} + \frac{22-4b+1}{n}$

- Square roots require a \sqrt:

Write	Result
\sqrt{\frac{1}{2+\frac{1}{n}}} < \sqrt[n]{b+4c}	$\sqrt{\frac{1}{2+\frac{1}{n}}} < \sqrt[n]{b+4c}$

- Integrals and sums are made using \int and \sum:

Write	Result
\int_{0}^{1} t \partial t \approx \sum_{i=1}^{n} x_{i}	$\int_0^1 t \, \partial t \approx \sum_{i=1}^{n} x_i$

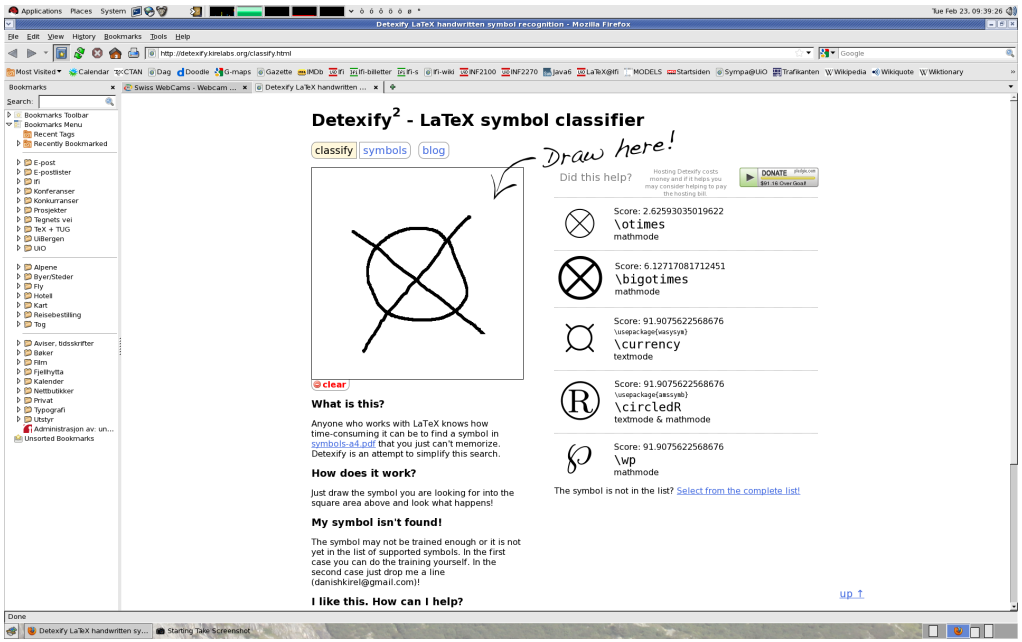
- There are various brackets:

Skriv	**Resultat**
f(x) \rightarrow A[x]	$f(x) \rightarrow A[x]$
\{x \mid x > 0\}	$\{x \mid x > 0\}$
\left(\sum_{0<k<n} \frac{2^{k}}{k!} \right)	$\left(\sum_{0<k<n} \frac{2^k}{k!} \right)$
\left\{ \int_{\alpha}^{\beta} \right\}_{\alpha+\beta=n}	$\left\{ \int_{\alpha}^{\beta} \right\}_{\alpha+\beta=n}$

A plethora of symbols

LaTeX knows approximately 6000 symboler.

Then we need http://detexify.kirelabs.org/classify.html.



LaTeX's strong points

- The user is free to concentrate on the contents.
- It usually produces a beautiful and well-structured result.
- The math notation has become a standard.
- It produces identical results on all systems.
- It will not change in the future.
- It is extensible.

Quality

Typographical quality is inherent in TeX og LaTeX (so the users do not have to worry about it), for instance

- Some letter pairs should be adjusted:

WAVERLY
WAVERLY

- There are several symbols for the square root:

$$1+\sqrt{1+\sqrt{1+\sqrt{1+\sqrt{1+\sqrt{1+1}}}}}$$

LaTeX's weaker points

- The error messages are difficult to understand.
- It is unsuited for non-structured documents.

More information

- "LaTeX for nybegynnere" in http://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/latex-for-nybegynnere.pdf
- The web page http://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/
- https://www.mn.uio.no/ifi/personer/vit/stray/overleaf-latex-guide-masteroppgave.html describes using Overleaf to write your thesis.
- E-mail to dag@ifi.uio.no

A last word of advice

To use LaTeX successfully,

- process your LaTeX file often.
- let your figures and tables float as they please.
- think **content** and **structure** and let LaTeX handle the **appearance**.