

How to write your master's thesis in

L^AT_EX

Dag Langmyhr
dag@ifi.uio.no



$\text{\TeX}$ and $\text{\LaTeX}$

$\text{\LaTeX}$ is a program for quality typesetting and ideal for creating your thesis.

Donald Knuth created $\text{\TeX}$ in 1974–82 to typeset his own books.

- It is free, open and well documented.
- It is programmable and extensible.
- It is particularly well suited for mathematics.
- You will be awarded if you find any bugs.

$\text{\LaTeX}$ is an extension of $\text{\TeX}$ with support for references, table of contents, extension packages etc.



Running $\text{\LaTeX}$

There are several possibilities for using $\text{\LaTeX}$ to write your master's thesis:

- Use one of Ifi's Linux computers in the Ole-Johan Dahl building
- Install $\text{\LaTeX}$ on your own personal computer
 - Linux: <https://www.tug.org/texlive/quickinstall.html>
 - Mac: <https://www.tug.org/mactex/>
 - Windows: <https://miktex.org/howto/install-miktex>

(All these are free.)

- Use *Overleaf*

Using a Linux computer at Ifi

Download a $\text{\LaTeX}$ base for your thesis and give it a suitable name. Then, you can process it with the command `ltx`.

```
$ wget -O mymaster.tex \  
    https://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/uiomasterthesis-base.tex  
$ ltx mymaster.tex
```

`mymaster.pdf` will now contain a first version of your thesis. You can use a PDF reader to check the result

```
$ preview mymaster.pdf &
```

On your own personal computer

First, you must fetch the document class for a UiO master's thesis. Start a web browser and go to

<https://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/index.html#UiO2022>

Download `uiotheses.zip` («Here are the files ...») and `uioMASTERfp.zip` («You will need these files») and unpack them:

```
$ unzip uiothesis.zip
$ unzip uiomasterfp.zip
```

You may want to give the base file a more suitable name. Then, you can process it with the `pdflatex` command or a graphical user interface. (I recommend TeXShop for Mac, Kile for Linux eller TeXworks for Windows.)

```
$ mv uiomasterthesis-base.tex mymaster.tex
$ pdflatex mymaster.tex
```



Using Overleaf

Overleaf is a commercial $\text{\LaTeX}$ platform. UiO has bought a site licence for its students and staff.

Go to https://www.overleaf.com/saml/ukamf/init?university_id=5045

- 1 Log in with your standard UiO username and password.
- 2 Select New project.
- 3 Select «University of Oslo».
- 4 Select «UiO Master's thesis» and «Open as Template».

Then, you can start writing your thesis. Remember to Recompile often.

Standard setup

Your $\text{\LaTeX}$ for your master's thesis should start like this:

```
\documentclass[UKenglish]{uiomasterthesis}
\usepackage[T1]{url} \urlstyle{sf}
\usepackage{babel, csquotes, graphicx, textcomp, uiomasterfp, varioref}
\usepackage[backend=biber,style=numeric-comp]{biblatex}
\usepackage[hidelinks, hypertexnames=false]{hyperref}

\title{The title of my thesis}
\subtitle{Any short subtitle}
\author{My Name}

\addbibresource{mybib.bib}

\begin{document}
:
\end{document}
```

L^AT_EX commands

In addition to ordinary text, a L^AT_EX file contains various commands. The notation used is:

- `\c` (for example: `\%`)
- `\name{}` (for example `\maketitle{}`)
 - `\name{param}` with one or more *parameters* (for example `\title{The title}`)
 - `\name[option]{param}` with *options* (which may be omitted) and *parameters* (for example `\usepackage[T1]{url}`)
- `\begin{name}...\end{name}` for commands with a lot of text (for example `\begin{document}...\end{document}`)



What kind of document

The command `\documentclass` specifies what kind of document we are writing. The most common document classes are:

uiomasterthesis is designed for master's theses at the University of Oslo.

article is for articles (typically 1-20 pages).

report is for longer reports.

beamer is for presentations (like this one).

Options

The document may be adapted using **options** i square brackets []:

UKenglish indicates that the thesis is writtes in British English – alternatives are USenglish, norsk, nynorsk and about 100 others.

noto changes the font for the whole document.



Packages

For additional adaption, import a **package**.

url provides the command `\url` making it easy to use URLs in your text. Always specify `\urlstyle{sf}`.

babel controls language-related stuff like fixed texts (“Figure”), hyphenation rules, date etc. The language **UKenglish** comes from the option given to `\documentclass`.

textcomp provides an extended set of symbols like `«°»`, `«µ»`, `«0/00»`, `«3/4»`, ...); see the list in <https://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/textcomp-symbols.pdf>.

uiomasterfp provides an official UiO front page.

hyperref creates clickable hyperlinks.

csquotes handles quotation marks in various languages; it is required by the biblatex package (see frame 31).

graphics makes it easy to import illustrations (see frame 37).

varioref allows almost-intelligent references (see frame 42).

Start of thesis

The thesis should start with the official front page:

```
\begin{document}

\uiomasterfp[program={Informatics:
  Programming and Systems Architecture},
supervisor={The Name},
long]
```

(For more information on the front page, see

<https://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/uiomasterfp-guide.pdf>.)

More standard elements in your thesis

```
\frontmatter{}  
\begin{abstract}  
  Here come 3--6 sentences describing your thesis.  
\end{abstract}  
  
\begin{xabstract}[Sammendrag]  
  Here comes the abstract in Norwegian.  
\end{xabstract}  
  
\tableofcontents{}  
\listoffigures{}  
\listoftables{}  
  
\begin{preface}  
  Here comes your preface, including acknowledgments and thanks.  
\end{preface}  
  
\mainmatter{}
```

The thesis text

Now we can start on the actual thesis.

Writing ordinary text

One nice aspect of $\text{\LaTeX}$ is that you can write most text just as ordinary text. Superfluous blanks are discarded. However, beware of these characters:

Char	Write
#	<code>\#</code>
\$	<code>\\$</code>
%	<code>\%</code>
{	<code>\{</code>

Char	Write
}	<code>\}</code>
&	<code>\&</code>
–	<code>_</code>

Char	Write
\	<code>\textbackslash{}</code>
^	<code>\textasciicircum{}</code>
~	<code>\textasciitilde{}</code>



Paragraphs

Use one or more blank lines to separate the paragraphs.

Comments

You use a % character to mark a comment to yourself. Everything from the percent sign to the end of the line is disregarded by $\text{\LaTeX}$.

Footnotes

Footnotes¹ are constructed using the command `\footnote{This is a footnote.}`.

Document structure

The following commands are used to indicate the thesis structure:

```
\part{...}
\chapter{...}      (not in articles)
\section{...}
\subsection{...}
\subsubsection{...}
\paragraph{...}
\subparagraph{...}
```

Lists

An itemized list uses bullet points.

- Such a list starts with `\begin{itemize}`.
- Each new item is indicated by `\item`.
- The list is terminated by `\end{itemize}`.
 - Lists inside other lists pose no problems.
 - Up to three levels are OK.

There are also numbered lists:

- 1 They start with `\begin{enumerate}`.
- 2 New items are also indicated by `\item`.

Different kinds of text

Words and short pieces of text may be emphasized in different ways:

Command	Result
---------	--------

<code>\emph{...}</code>	<i>Emphasized (usually in italics)</i>
-------------------------	--

<code>\textbf{...}</code>	Bold
---------------------------	-------------

<code>\textsc{...}</code>	CAPS AND SMALL CAPS
---------------------------	---------------------

<code>\textsf{...}</code>	Sans serif
---------------------------	------------

<code>\texttt{...}</code>	Typewriter
---------------------------	------------

These may be combined (if provided by the font):

Typewriter in bold italics.

Math

It seems odd to “program” mathematical formulas, but it is quite fast with a bit of training. I created this on in 2 min 3 sec:

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

- Programming formulas is actually faster than using point-and-click.
- It is easy to modify the formulas.
- You can extend the set of formula commands from various packages.
- $\text{\LaTeX}$ math notation is a de facto international standard.



There are *inline formulas* $\sum_{k=1}^{\infty} 2^{-k}$ used in ordinary lines of text, and *display formulas*

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

on separate lines. The commands for the two are the same, but $\text{\LaTeX}$ will format them differently.

Notations for inline and display formulas

In $\text{\LaTeX}$, inline formulas are written as $\$ \dots \$$, while $\backslash[\dots \backslash]$ is used for display formulas. In addition, there is $\backslash\text{begin}\{\text{equation}\} \dots \backslash\text{end}\{\text{equation}\}$ which produces numbered display formulas.

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

Typing mathematical formulas is according to special rules:

- Only a few standard $\text{\LaTeX}$ commands are available – instead, there are quite a few math commands.
- Spaces are ignored in math coding.



Mathematical symbols

There are hundreds of mathematical symbols. Here are the most important ones:

- Letters and numbers are written as usual:

Write	Result
-------	--------

<code>e</code>	e
----------------	-----

<code>122</code>	122
------------------	-------

- Greek letters are given by commands (if different from Latin ones):

Write	Result
-------	--------

<code>\alpha, \gamma, \omega</code>	α, γ, ω
-------------------------------------	--------------------------

<code>A, \Gamma, \Omega</code>	A, Γ, Ω
--------------------------------	---------------------

- Nearly all mathematical characters found on the keyboard may be used directly:

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

- You need commands for other symbols: kommandoer:

Write	Result
<code>\times, \cdot, \leq,</code>	$\times, \cdot, \leq$
<code>\geq, \neq, \wedge</code>	$\geq, \neq, \wedge$
<code>\lor, \in, \approx</code>	$\vee, \in, \approx$
<code>\forall, \exists, \notin</code>	$\forall, \exists, \notin$

- You may add a `\not` to most symbols:

Write	Result
<code>\not\approx</code>	$\napprox$

- There are also heaps of arrows available:

Write	Result
<code>\leftarrow, \leftrightarrow</code>	$\leftarrow, \leftrightarrow$
<code>\not\rightarrow, \uparrow</code>	$\nrightarrow, \uparrow$
<code>\longleftarrow</code>	$\longleftrightarrow$
<code>\leftrightsquigarrow</code>	$\leftrightsquigarrow$

- You may specify either a lower index using `_` or an upper index using `^` or both:

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

- Fractions are written using `\frac`:

Write

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

Result

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

- Square root and other roots need the command `\sqrt`:

Write

$$\texttt{\sqrt{\frac{1}{2+\frac{1}{n}}}} <$$

$$\texttt{\sqrt[n]{b+4c}}$$

Result

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

- For integrals and summations there are `\int` and `\sum`:

Write**Result**

$$\begin{array}{l} \text{\code{\int_{0}^{1} t \partial t} \approx \int_0^1 t \, \partial t} \\ \text{\code{\sum_{i=1}^n x_{i}}} \end{array} \approx \sum_{i=1}^n x_i$$

- Some prefer the integral limits typeset like this:

Write**Result**

$$\text{\code{\int\limits_{0}^{\infty} t \partial t}} \approx \int_0^{\infty} t \, \partial t$$

- Parentheses and brackets exist in various size:

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

A couple of examples:

Write

```
a^{n}=\underbrace{a\times
a\times\cdots\times a}
_{\text{$n$ times}}
```

Result

$$a^n = \underbrace{a \times a \times \cdots \times a}_{n \text{ times}}$$

Write

```
s_{n+1} = \begin{cases}
\frac{s_{n}}{2}&
\text{when } s_{n} \text{ is even} \\
3s_{n} + 1 &
\text{otherwise}
\end{cases}
```

Result

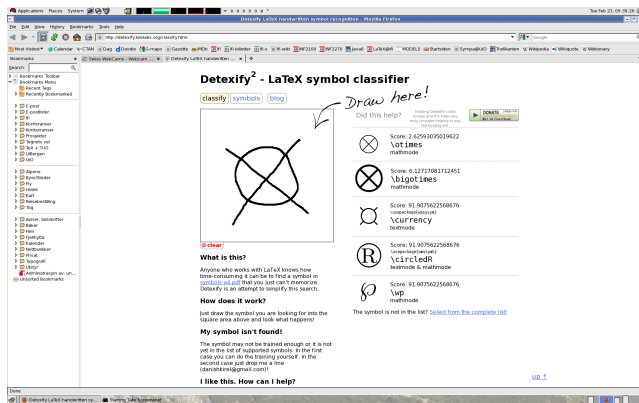
$$s_{n+1} = \begin{cases} \frac{s_n}{2} & \text{when } s_n \text{ is even} \\ 3s_n + 1 & \text{otherwise} \end{cases}$$



Symbols by the thousands

$\text{\LaTeX}$ knows more than
14 000 symbols.

Then, <http://detexify.kirelabs.org/classify.html> is useful.



Bibliographies

Every master's thesis must have a bibliography.

L^AT_EX is shipped with **BibL^AT_EX** which is an excellent tool for handling your bibliography.

First, you create a big database containing all the references you encounter, both the ones you intend to use as well as all others (which may come in handy later). This database is on a separate text file in the form of value-key pairs.

A Bib $\text{\LaTeX}$ database file looks like this:

```
@string {AW = {Addison"=Wesley}}

@book{TeX-book,
  author = "Donald Ervin Knuth",
  title = "The {\TeX}book",
  publisher = AW,
  year = 1991}

@book{CompanionII,
  author = "Frank Mittelbach and Michel Goossens",
  title = "The {\LaTeX} companion",
  publisher = AW,
  year = 2004,
  edition = 2}

@book{Kopka,
  author = {Helmut Kopka and Patrick Daly},
  title = {Guide to {\LaTeX}},
  publisher = AW,
  year = 2004,
  edition = 4}
```

Then, you can write your document

In your thesis, you use `\cite` to get the references you need:

```
\documentclass[a4paper, 12pt,norsk]{article}
\usepackage[utf8]{inputenc}
\usepackage[T1]{fontenc, url} \urlstyle{sf}
\usepackage{babel, textcomp, csquotes, noto}
\usepackage[backend=biber, style=numeric-comp]{biblatex}

\title{Viktige bøker om \TeX{} og \LaTeX{}}
\author{Dag Langmyhr\ Institut for informatikk\ [1mm]
\url{dag@ifi.uio.no}}

\addbibresource{mittbib.bib}

\begin{document}
\maketitle
\thispagestyle{empty}

\section{De viktigste}
Her er de viktigste bøkene om \LaTeX~\cite{CompanionII,Kopka}
og \TeX~\cite{TeX-book}.

\printbibliography
\end{document}
```

Then, you can write your document

Then, you process it using the program biber:

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

and the references are complete.

(Overleaf handles this automatically.)

Then, you can write your document

Viktige bøker om $\text{T}_\text{E}\text{X}$ og $\text{L}_\text{A}\text{T}_\text{E}\text{X}$

Dag Langmyhr
Institutt for informatikk
dag@ifi.uio.no

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1 De viktigste

Her er de viktigste bøkene om $\text{L}_\text{A}\text{T}_\text{E}\text{X}$ [2, 3] og $\text{T}_\text{E}\text{X}$ [1].

Referanser

- [1] Donald Ervin Knuth. *The $\text{T}_\text{E}\text{X}$ book*. Addison-Wesley, 1991.
- [2] Helmut Kopka og Patrick Daly. *Guide to $\text{L}_\text{A}\text{T}_\text{E}\text{X}$* . 4. utg. Addison-Wesley, 2004.
- [3] Frank Mittelbach og Michel Goossens. *The $\text{L}_\text{A}\text{T}_\text{E}\text{X}$ companion*. 2. utg. Addison-Wesley, 2004.

Advantages of using Bib $\text{\LaTeX}$

- 👍 You can build your database independently from the kind of documents you decide to write; biber will select which references are actually cited.
- 👍 The database contains only data and no formatting; Bib $\text{\LaTeX}$ will adapt the typography to the official rules.
- 👍 The numbering and sorting of author, year and name of article is done automatically.
- 👍 The Bib $\text{\LaTeX}$ database format is a de facto international standard.

Everybody need illustrations

Illustrations

$\text{\LaTeX}$ no built-in drawing program but can fetch illustrations made by other programs. The only requirement is that they are in one of these formats:
JPEG, PDF or PNG.

To include an illustration, we need the package `graphicx`:

```
\usepackage{graphicx}
```

The file `Donald_Knuth.jpg` contains the photo shoown on slide 2. We can insert it into our thesis using

```
\includegraphics[height=4cm] % The size  
{Donald_Knuth.jpg}           % The image file
```

Other useful options are

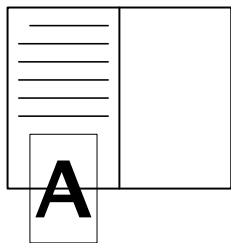
`angle=12` rotates the photo 12°.

`width=2.575cm` will make the photo 2,575 cm wide.

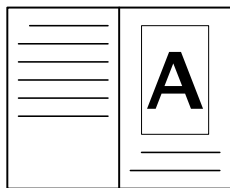


Floating illustrations

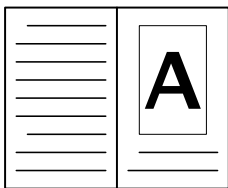
Sometimes, there is insufficient room for an illustration. What do we do then?



Problem



Poor solution



Good solutions

To avoid the problem of not having enough room for an illustration on a page, I recommend that you let it “float” using a figure environment.

```
\begin{figure}  
  \includegraphics[height=5.8cm]{Donald_Knuth.jpg}  
  \caption{Donald Knuth}  
\end{figure}
```

The figure will then appear on the same page (if there sufficient room) or float to the following page.

Note that the figure environment also provides a `\caption` command.

Strong recommendation!

Always let your figures float! That will save you a tremendous lot of worries.

Cross references

Since we don't know where a floating figure will end up, we cannot write
As we see in this graph:

Instead, we attach a label to the floating figure (placed inside the `\caption` argument):

```
\caption{Donald Knuth\label{knuth}}
```

Now, we can write

As we see in Graph~\vref{knuth}, ...

The result will then be

As we see in Graph 5 on the next page, ...

This feature may also be used to reference chapters and sections in the thesis (i.e., `\chapter`, `\section` etc).

Remember

The command `\vref` is found in package `varioref` so you need

`\usepackage[nospace]{varioref}`

Inserting source cocde

I recommend the **minted** package.

```
\usepackage{minted}
:
\inputminted{java}{Ohlson.java}
```

Resultatet blir

```
class Ohlson {
    // Standardprogrammet for å vise programmeringsspråk:
    public static void main (String[] args) {
        System.out.println("Hei, alle sammen!");
    }
}
```

What is good and not quite so good about $\text{\LaTeX}$?

Conclusion

Even $\text{\LaTeX}$ is not perfect.

👎 It takes a little bit of effort to be able to use $\text{\LaTeX}$ proficiently. (But also that goes for Word and many other programs.)

👎 In $\text{\LaTeX}$, you must change your mindset! You should not think
My thesis should look like this.

but rather

*My thesis contains this;
maybe $\text{\LaTeX}$ can make it look nice.*

👎 The error messages from $\text{\LaTeX}$ may be confusing.
(**Hint:** Look for the line numbers.)



Information on L^AT_EX

There are several books and lots of free information available.

L^AT_EX for nybeggynnere

(<https://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/latex-for-nybeggynnere.pdf>) is an easy introduction (in Norwegian).

The not so short introduction to L^AT_EX

(<https://mirror.ctan.org/info/lshort/english/lshort.pdf>) is a more thorough introduction.

Local guide to BibL^AT_EX

(<https://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/biblatex-guide.pdf>) teaches you how to use BibL^AT_EX.



Math mode

(<https://tug.ctan.org/obsolete/info/math/voss/mathmode/Mathmode.pdf>) tells you all you need to know about typesetting mathematics.

Informasjon om $\text{\LaTeX}$ med venner

(<https://www.mn.uio.no/ifi/tjenester/it/hjelp/latex/>) is an information page (in Norwegian) with particular emphasis on use at UiO.

CTAN (<https://www.tug.org/ctan.html>) contains *everything* of $\text{\LaTeX}$ software.

Before we way goodbye,

A few pieces of advice

Your walk with $\text{\LaTeX}$ will be a lot easier if you remember this:

- Think *structure* rather than *appearance*.
- Accept that $\text{\LaTeX}$ may want to do things differently from what you expected.
- You will waste hours and hours trying to force $\text{\LaTeX}$ to produce output exactly as you imagine it should look like. Please avoid this.
- Recompile/process often.
- Don't be afraid to ask others how to do things (but beware of Stack Exchange and AI).
- If you are stuck, you may send an e-mail to latexguru@ub.uio.no or to me (dag@ifi.uio.no).



Go ahead!

Good luck with your master's thesis!