The LaTeX Workshop

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Outline

Introduction

LaTeX is an open-source document preparation system that produces high-quality output. *It is not a word processor*

LaTeX is for everyone.

LaTeX Basics

LaTeX:

- is a type-sensitive language.
- is not WYSYG.
- is not a word processor.
- needs an editor for creating text files. [TeXStudio]
- needs external viewer to view output files. [Acrobat reader]

LaTeX Input

- We can use any text editor to edit LaTeX files. We will use `TeXStudio` for our examples.
- Whitespaces are mostly ignored by LaTeX.
- There are several reserved characters, which have special meaning e.g., `# $ % ^ & { } ~ \`
- Grouping is done by using braces.
- All LaTeX commands start with a backslash.
- Spaces after commands are ignored.
- Some commands requre parameter(s).
- Some parameters are optional.
- LaTeX comments preceded by %.

Basic Document Structure

Following is a general document structure for a LaTeX file.

```
% comments
\documentclass{...}

%
% definitions, macros, packages, etc
% come here
%

\begin{document}
% LaTeX document text comes here
\end{document}
```

Example Document

Example

```
\documentclass{article}

\begin{document}
\title{Hello, World!}
\author{Shahid Hussain}
\date{November 4, 2014}
\maketitle

\begin{abstract}
Showing off my new skills.
\end{abstract}
\section{Introduction}
Beginning with some math. Everyone
loves $E=mc^2$ and everyone knows
\[
1+2+\cdots + n = \sum_{j=1}^n =
\frac{n(n+1)}{2}.
\]
\end{document}
```

Output

Hello, World!

Shahid Hussain

November 4, 2014

Abstract

Showing off my new skills.

1 Introduction

Beginning with some math. Everyone loves $E = mc^2$ and everyone knows

$$1 + 2 + \cdots + n = \sum_{j=1}^{n} = \frac{n(n+1)}{2}.$$

Document Classes and Packages

Some useful/important classes.

`article`:	the most common LaTeX document class.
`report`:	for creating report like documents (theses).
`letter`:	for typesetting letters.
`book`:	for creating books.
`IEEEtran`:	IEEE transaction papers.

Some useful packages.

`geometry`:	for adjusting margins
`graphicx`:	for importing image files
`amsmath`:	for additional math commands

Sectioning Commands

Command	Level	
\part	-1	not for letters
\chapter	0	only for books and reports
\section	1	not for letters
\subsection	2	–
\subsubsection	3	–
\paragraph	4	–
\subparagraph	5	–

Line and Page Breaks

LaTeX handles **line breaks** and **page breaks** automatically. However, this can be forced e.g.,

- \\ will enforce new line
- \par will start new paragraph
- \newpage will enforce new page

Hyphenation

LaTeX puts hyphens automatically when and where needed and it does the job pretty well for English language words. It has an excellent algorithm for this. However for foreign or new words it can be told the correct way e.g.,

```
\hyphenation{Hy-phen-a-tion, Entscheidungs-prob-lem}
```

Special Character

-	Dash	open-source
--	En-dash	pp. 23–99
---	Em-dash	true—or false?
\$	Dollar sign	US$ 20
\~{}	Tilde	~34
\slash and /	Slash	I/O and 24 Mb/s
$\backslash$	Backslash	c:\windows

Handling Fonts

`\scriptsize`	Hello World!
`\footnotesize`	Hello World!
`\normalsize`	Hello World!
`\large`	Hello World!
`\Large`	Hello World!
`\LARGE`	Hello World!
`\huge`	Hello World!
`\Huge`	Hello World!

- It is possible to have fonts larger than `\Huge`.
- `\textbf{Hello World!}` gives **Hello World!**
- `\textit{Hello World!}` gives *Hello World!*
- `\texttt{Hello World!}` gives `Hello World!`
- `\textsf{Hello World!}` gives Hello World!

Ligatures

LaTeX automatically combines letters to produce ligatures i.e.,

$$\begin{aligned} \texttt{ff} &\rightarrow \text{ff} \\ \texttt{fi} &\rightarrow \text{fi} \\ \texttt{fl} &\rightarrow \text{fl} \\ \texttt{ffi} &\rightarrow \text{ffi} \end{aligned}$$

We can override the ligatures by inserting empty grouping instructions i.e., f{}i will produce fi instead of fi.

Typesetting Math

In-line math is entered between a pair of $ signs. For example
`$n^2 \log n + 3 n = o(n^3)$` gives us $n^2 \log n + 3n = o(n^3)$.

Displayed math is enclosed in `\[ \]`. For example
`\[ \lim_{n\to\infty} \sum_{j = 1}^n \frac{1}{2^j} = 2. \]`
gives us

$$\lim_{n\to\infty} \sum_{j=1}^{n} \frac{1}{2^j} = 2.$$

`$a^{b_{c^2}}_{d_f}$` : $a^{b_{c^2}}_{d_f}$

`$\frac{1}{1+\frac{1}{2}} = 2/3$`: $\frac{1}{1+\frac{1}{2}} = 2/3$

`$\displaystyle\frac{1}{1+\displaystyle\frac{1}{2}}=\frac{2}{3}$`:
$$\frac{1}{1+\frac{1}{2}} = \frac{2}{3}$$

More Math

The Greek alphabet:

```
\alpha, \beta,    \gamma, \delta, \epsilon, \zeta,
\eta,   \theta,   \iota,  \kappa, \lambda,  \mu,
\nu,    \xi,      o,      \pi,    \rho,     \sigma,
\tau,   \upsilon, \psi,   \omega.
```

$$\alpha, \beta, \gamma, \delta, \epsilon, \zeta, \eta, \theta, \iota, \kappa, \lambda, \mu, \nu, \xi, o, \pi, \rho, \sigma, \tau, \upsilon, \psi, \omega.$$

Math functions:

```
\sin,  \cos,  \tan,  \cot, \log, \ln,
\sinh, \cosh, \tanh, \exp, \max, \min,
\arccos, \arcsin, \arctan.
```

$$\sin, \cos, \tan, \cot, \log, \ln, \sinh, \cosh, \tanh,$$

$$\exp, \max, \min, \arccos, \arcsin, \arctan\,.$$

Arrows

- `$\leftarrow, \rightarrow, \leftrightarrow$`: $\leftarrow, \rightarrow, \leftrightarrow$
- `$\uparrow, \downarrow$`: $\uparrow, \downarrow$
- `$\nearrow, \nwarrow, \searrow, \swarrow$`: $\nearrow, \nwarrow, \searrow, \swarrow$

Dots and Lines

- `$A[1..n]$` : $A[1..n]$
- `$\{1, 2, \ldots, 10\}$` : $\{1, 2, \ldots, 10\}$
- `$a_1 \leq a_2 \leq \cdots \leq a_n$` : $a_1 \leq a_2 \leq \cdots \leq a_n$
- `$10.\overline{9}$`: $10.\overline{9}$
- `$\overbrace{\underbrace{2+2+\cdots+2}_n + n}^{n+1}=3n$` :

$$\overbrace{\underbrace{2+2+\cdots+2}_{n}+n}^{n+1}=3n$$

Math Fonts

Command	Font sample	Required package
\mathbbb	$\mathbb{ABCD}$	amsfonts, amssymb
\mathscr	$\mathscr{ABCD}$	mathrsfs
\mathcal	$\mathcal{ABCD}$	None
\mathfrak	$\mathfrak{ABCD}1234$	None
\mathit	$\mathit{ABCD1234}$	None
\mathrm	$\mathrm{ABCD1234}$	None
\mathbf	$\mathbf{ABCD1234}$	None
\mathnormal	$\mathnormal{ABCD}1234$	None

Delimiters

```
$\big( \Big( \bigg( \Bigg( \quad
\big\} \Big\} \bigg\} \Bigg\} \quad
\big\| \Big\| \bigg\| \Bigg\| \quad
\big\Downarrow \Big\Downarrow
\bigg\Downarrow \Bigg\Downarrow$
```

$$\big(\Big(\bigg(\Bigg(\quad \big\} \Big\} \bigg\} \Bigg\} \quad \big\| \Big\| \bigg\| \Bigg\| \quad \big\Downarrow \Big\Downarrow \bigg\Downarrow \Bigg\Downarrow$$

```
\[\sum_{k\in\mathbb{Z}}\exp\left[-\pi\cdot\left(\frac{k}{c}\right)^2\right]
=c\cdot\sum_{k\in\mathbb{Z}}\exp(-\pi\cdot(kc)^2)\]
```

$$\sum_{k\in\mathbb{Z}}\exp\left[-\pi\cdot\left(\frac{k}{c}\right)^2\right]=c\cdot\sum_{k\in\mathbb{Z}}\exp(-\pi\cdot(kc)^2)$$

Some Examples

```
\[ \int d^n x e^{-x^T Bx + v^Tx} = \frac{(\sqrt{\pi})^n}{\sqrt{\det B}}
\exp\left[\frac{1}{4}v^T B^{-1}v\right] \equiv \mathcal{M}.\]
```

$$\int d^n x e^{-x^T Bx + v^T x} = \frac{(\sqrt{\pi})^n}{\sqrt{\det B}} \exp\left[\frac{1}{4} v^T B^{-1} v\right] \equiv \mathcal{M}.$$

```
\[\Gamma(z) = \frac{e^{-\gamma z}}{z} \prod_{n=1}^\infty
\left(1 + \frac{z}{n}\right)^{-1} e^{z/n}\]
```

$$\Gamma(z) = \frac{e^{-\gamma z}}{z} \prod_{n=1}^{\infty} \left(1 + \frac{z}{n}\right)^{-1} e^{z/n}$$

```
DG}(a_n;s)=\prod_{p} \mathrm{BG}_p(a_n;p^{-s})
```

$$\mathrm{DG}(a_n; s) = \prod_{p} \mathrm{BG}_p(a_n; p^{-s})$$

More Examples

```
\[\mathcal{A}(n) = \displaystyle\frac{\displaystyle
\sum_{1 \leq i \leq n} f_i(n)}{\displaystyle
\sum_{1\leq j \leq n/2} g_j(n) \pm
\sum_{n/2 < k \leq n} h_k(n)}\]
```

$$\mathcal{A}(n) = \frac{\displaystyle\sum_{1 \leq i \leq n} f_i(n)}{\displaystyle\sum_{1\leq j \leq n/2} g_j(n) \pm \sum_{n/2 < k \leq n} h_k(n)}$$

```
\[\frac{\partial u}{\partial t} = 6u\frac{\partial u}{\partial x} -
 \frac{\partial^3 u}{\partial x^3}\]
```

$$\frac{\partial u}{\partial t} = 6u\frac{\partial u}{\partial x} - \frac{\partial^3 u}{\partial x^3}$$

```
\[i\hbar \frac{\partial}{\partial t}\Psi(\mathbf{r},\,t)=-
\frac{\hbar^2}{2m}\nabla^2\Psi(\mathbf{r},\,t)+ V(\mathbf{r})
\Psi(\mathbf{r},\,t)\]
```

$$i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},\,t) = -\frac{\hbar^2}{2m}\nabla^2\Psi(\mathbf{r},\,t) + V(\mathbf{r})\Psi(\mathbf{r},\,t)$$

Some Exercise

Typeset following:

1. $\dfrac{B(r)}{r^{\alpha}\Gamma(\beta)}\, n^{\beta-1}(1/r)^{n}.$
2. $\left.\dfrac{d^{p}T_{n}}{dx^{p}}\right|_{x=\pm 1} = (\pm 1)^{n+p}\prod_{k=0}^{p-1}\dfrac{n^{2}-k^{2}}{2k+1}.$
3. $\displaystyle\int T_{n}\,dx = \frac{1}{2}\left(\frac{T_{n+1}}{n+1} - \frac{T_{n-1}}{n-1}\right) = \frac{nT_{n+1}}{n^{2}-1} - \frac{xT_{n}}{n-1}.$
4. $\mathcal{F}^{-1}\{G(f)\} = \displaystyle\int_{-\infty}^{\infty}\left(\sum_{n=-\infty}^{\infty} G[n]\cdot\delta\left(f-\frac{n}{\tau}\right)\right)e^{i2\pi fx}\,df.$
5. $\mathfrak{X}^{-1}(f(\xi)) = \displaystyle\oint_{\partial\xi}\exp(-2f(x))\Xi(f(x))\,dx.$
6. $\mathscr{F}(z) = \dfrac{\displaystyle\int_{0}^{z/2} f(x)dx}{\prod_{i=1}^{z}\operatorname{seq}_{i}(z)}.$

More Examples[1]

1. $F\left(x_1, \ldots, x_n, u, \dfrac{\partial u}{\partial x_1}, \ldots, \dfrac{\partial u}{\partial x_n}, \dfrac{\partial^2 u}{\partial x_1 \partial x_1}, \ldots, \dfrac{\partial^2 u}{\partial x_1 \partial x_n}, \ldots, \right).$
2. $\psi_n(x) = \dfrac{2^{1/4}}{\sqrt{n!}} e^{-\pi x^2} \mathrm{He}_n(2x\sqrt{\pi}).$
3. $\displaystyle\int_{\mathbb{R}^n} f(x) \mathcal{F}g(x)\, dx = \int_{\mathbb{R}^n} \mathcal{F}f(x) g(x)\, dx.$
4. $\mathcal{L}(\phi, \nabla\phi) = -\rho(t, \mathbf{x})\phi(t, \mathbf{x}) - \dfrac{1}{8\pi G} \|\nabla\phi\|^2.$
5. $|\phi_1 \cdots \phi_N\rangle = \sqrt{\dfrac{\Pi_j N_j!}{N!}} \displaystyle\sum_{p \in S_N} |\phi_{p(1)}\rangle \otimes \cdots \otimes |\phi_{p(N)}\rangle.$

[1] Taken from Wikipedia

Matrices

$$A = \begin{pmatrix} 10 & 3 \\ 2 & 14 \end{pmatrix}, \quad B = \begin{bmatrix} -1 & 12 & 3 \\ 7 & 0 & 143 \end{bmatrix}, \quad C = \begin{vmatrix} -1 & 99 & 0.23 \\ 2 & 1 & 0.1257 \\ +8 & 54 & 6.1 \end{vmatrix}.$$

```
\[
A= \left(\begin{array}{cc}
             10 &  3\\
              2 & 14 \end{array}\right), \;\;
B = \left[\begin{array}{rrr}
             -1 & 12 &   3\\
              7 &  0 & 143\end{array}\right], \;\;
C = \left|\begin{array}{rcl}
             -1 & 99 & 0.23\\
              2 &  1 & 0.1257\\
             +8 & 54 & 6.1\end{array}\right|.
\]
```

Cases

```
|x| = \left\{ \begin{array}{rl}
-x & ; x < 0,\\
 0 & ; x = 0, \\
 x & ; \mbox{otherwise.}
\end{array}\right.
```

$$|x| = \begin{cases} -x & ; x < 0, \\ 0 & ; x = 0, \\ x & ; \text{otherwise.} \end{cases}$$

```
\left.\begin{array}{c}
a \\
b \\
c \\
d
\end{array} \right\} = f(z).
```

$$\left.\begin{array}{c} a \\ b \\ c \\ d \end{array} \right\} = f(z).$$

Equation Arrays

$$
\begin{aligned}
q_t(V) &= -\int_{\partial V} \mathbf{H}(x) \cdot \mathbf{n}(x)\, dS \\
&= \int_{\partial V} \mathbf{A}(x) \cdot \nabla u(x) \cdot \mathbf{n}(x)\, dS \\
&< \int_V \sum_{i,j} \partial_{x_i} \left(a_{ij}(x) \partial_{x_j} u(x,t) \right) dx + \kappa^{100}
\end{aligned}
$$

```
\begin{eqnarray*}
q_t(V)  &=& - \int_{\partial V} \mathbf{H}(x) \cdot \mathbf{n}(x) \, dS \\
&=& \int_{\partial V} \mathbf{A}(x) \cdot \nabla u (x) \cdot \mathbf{n}(x)\,dS \\
&<& \int_V \sum_{i, j} \partial_{x_i} \bigl( a_{i j}(x)
\partial_{x_j} u (x,t) \bigr)\,dx + \kappa^{100}
\end{eqnarray*}
```

Tables

Position	Name	Total Score	% Score
First	Abc D. Efg	200	100
Second	Xyz Xyz	198	96
Third	Ijk Lmno	150	75

Table 1 : Contest score and names

Tables

Position	Name	Total Score	% Score
First	Abc D. Efg	200	100
Second	Xyz Xyz	198	96
Third	Ijk Lmno	150	75

Table 1 : Contest score and names

```
\begin{table}[t]\centering
\begin{tabular}{|r|lcr|}\hline
{\bf Position} & {\bf Name} & {\bf Total Score} & {\bf \% Score} \\\hline
First & Abc D. Efg & 200 & 100 \\\hline
Second & Xyz Xyz & 198 &  96 \\\hline
Third & Ijk Lmno & 150 & 75 \\\hline
\end{tabular}
\caption{Contest score and names}\label{fig:c_score}
\end{table}

Here we refer Table~\ref{fig:c_score}.
```

Here we refer Table 1.

Tables

3.14159
16.2
123.456

```
\begin{tabular}{r@{.}l}
  3   & 14159 \\
  16  & 2     \\
  123 & 456   \\
\end{tabular}
```

Importing Pictures

- Add `\usepackage{graphicx}` in preamble.
- We can import `.pdf`, `.jpg`, `.png` files.

`\includegraphics{fish.jpg}`

`\includegraphics[angle=45]{fish.jpg}`

`\includegraphics[angle=90]{fish.jpg}`

Theorem and Lemmas

```
\newtheorem{name}[counter]{text}[section]
```
e.g. `\newtheorem{mytheorem}{My Theorem}[section]` used as

```
\begin{mytheorem}
My theorem says $1+1=2$.
\end{mytheorem}
```

will give us

My Theorem 4.1

My theorem says $1 + 1 = 2$.

Thank You

The End.