

STATISTICAL LABORATORY LaTeX TYPESETTING INTRODUCTION

Preamble

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From an end user point of view, LaTeX represents a typesetting language. LaTeX (Source) Files contain text and LaTeX instructions to format the text and place it on a virtual page, or "Document" in LaTeX terminology, as would be done by typesetters when preparing a printing template for a book, magazine or newspaper. Additionally, LaTeX allows mathematical formulae or equations to be specified, so they appear in mathematical notation on output. LaTeX sometimes described as a "Markup" language, but this should be reserved for cases where greater liberty is left to viewers as to displaying the Output, and with HTML and Web Browsers.

LaTeX has evolved through several Versions, the current being LaTeX 2e, or more exactly LaTeX 2 "Epsilon". LaTeX 3 remains to be released.

This basic course presents the major features of LaTeX Source Code, the main "environments" or modes available to the programmer, and some essential references where more details may be gathered. In the notes, the term "File" will refer to a computer File, while "Document" represents the outcome of LaTeX processing, eventually to be printed.

LaTeX Processing Outline

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LaTeX source Files normally use the 'tex' Extension. They need to be compiled before the Output may be viewed. This will be either a "DVI" aka "Device Independent" File, requiring a DVI Viewer on the computer system (in Unix and Linux, 'xdvi' would be the common viewer), or a (Adobe) "PDF" aka Portable Document Format File, which will need a PDF viewer, like Acrobat Reader ('acroread on Unix and Linux). On Unix and Linux systems, 'xpdf' will also display PDF Files. The 'dvips' Program on Unix and Linux will additionally allow Postscript versions of a DVI File to be saved. PDF output may also be produced from DVI Files with the 'dvi2pdf' conversion Program.

On Unix and Linux, the 'latex' Command compiles a 'tex' File to give DVI Output, while 'pdflatex' will provide PDF Output. The 'latex' Version of the Compiler predates 'pdflatex', so a lot of documentation will just refer to it, but generally, 'pdflatex' may be used instead. Some older LaTeX Files will have been written under the old LaTeX2.09 Version. Modern LaTeX Compilers should highlight this, together with suggestions as to what changes need be made to bring the File to the present LaTeX 2e (Epsilon) standard.

LaTeX and TeX implementations exist for Windows, where equivalents to the above Programs may be installed. However, Unix (or its PC Version, Linux) remains the best platform for processing LaTeX or TeX Documents.

Internally, LaTeX merely contains "Macros" for the TeX Program, which executes the typesetting proper. TeX offers less high level constructs than LaTeX so TeX Code will be longer and more technical. In some cases it allows programmers tasks not available as LaTeX Macros, so expert LaTeX programmers will often know how to write "raw" TeX as well. TeX is compiled into DVI form by the 'tex' Command on Unix and Linux, while the 'pdftex' Command will give PDF Output.

Essential LaTeX References - Part 1

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These notes will point to three Online references and the book from the creator of LaTeX, Leslie Lamport. A lot of other publications exist either online or in printed form. A Google search against 'LaTeX' gives the official site at the top, and its introduction text just below, with Wikipedia entry coming next.

Key Full Details

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LMP LaTeX, A Document Preparation System,
L. Lamport,
Addison-Wesley, 2nd. Ed, 1994, ISBN 0-201-52983-1.

NSO The Not So Short Introduction to LaTeX2e,
T. Oetiker, H. Partl, I. Hyna, E. Schlegl,
CTAN (LaTeX and TeX Archive), 2008,
<http://ctan.tug.org/tex-archive/info/lshort/english/lshort.pdf>.

WKI The LaTeX wiki book,
Various contributing Authors,
Wikibooks, 2008,
<http://upload.wikimedia.org/wikibooks/en/2/2d/LaTeX.pdf>.

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Essential LaTeX References - Part 2

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Command and Attribute Summaries :

Several are available, some in foreign languages. Use Google to search against "LaTeX Command Summary" and "LaTeX Cheat Sheet".

Two useful picks :

<http://www.ntg.nl/doc/biemesderfer/ltxcrib.pdf> = Command Summary
<http://www.cs.ust.hk/~golin/latexsheet.pdf> = "The" Cheat Sheet

For more Online material see these Web Sites :

<http://www.latex-project.org/intro.html> = Basic Introduction
<http://www.latex-project.org/guides/> = Links to more references
(see "Contributed Doc.")

The official TeX and LaTeX repository sits at '<http://ctan.tug.org/>', and is sometimes called "CTAN" or "tug" for TeX Users Group.

For more advanced use of LaTeX, the complement to LMP above :

The LaTeX Companion,
M. Goossens, F. Mittelbach, A. Samarin,
Addison-Wesley, 1994, ISBN 0-201-54199-8.

Several publications exist covering TeX, the key reference being that from the designer of TeX, the famous computer scientist Donald Knuth :

The TeXbook,
D.E. Knuth,
Addison-Wesley, 1996, ISBN 0-201-513448-9.

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LaTeX and related processing Commands :

Commands to process LaTeX (or TeX) 'tex' Source Files and resultant Output are listed below. They are Case Sensitive. For example the LaTeX compiler will not work with 'Latex' or 'LaTeX', only 'latex'.

Command	Task
latex	Compile LaTeX ('tex') File to DVI ('tex' Extension optional)
tex	'' TeX ('tex') '' '' DVI ('' '' '')
pdflatex	Compile LaTeX ('tex') File to PDF ('tex' Extension optional)
pdftex	'' TeX ('tex') '' '' PDF ('' '' '')
dvipdfm	Produce PDF ('pdf') File from DVI ('pdf' optional)
dvips	'' Postscript ('ps') '' '' DVI ('.ps' required)
xdvi	Show DVI ('dvi') File on Screen ('dvi' Extension optional)
acroread	Show PDF ('pdf') File on Screen (also on Windows)
xpdf	'' '' '' '' '' '' (quicker to start)
ghostview	Show Postscript ('ps') File on Screen (Extension optional)
gv	'' '' '' '' '' '' ('' '')
pdf2ps	Produce Postscript ('ps') File from PDF ('pdf')
ps2pdf	'' PDF ('pdf') '' '' Postscript ('ps')
lpr	Print File, normally Postscript ('ps')

Where an Extension is optional, the quoted Extension serves as Default. DVI Files can be printed with 'dvips -P pp', here on Printer 'pp', or written to Postscript with the '-o' Option and the Postscript File Name (like 'dvips -o test.ps test.dvi'). 'lpr' also needs a '-P pp' Printer.

Some systems will not offer all viewers, though 'xdvi' comes as part of the LaTeX bundle, likewise 'dvips'. Also, Because LaTeX calls TeX internally, the 'tex' Compiler will be present together with 'latex'.

Modern LaTeX implementations will include 'pdflatex' and 'pdftex', but those may be missing on older set ups. In this case use 'latex' (or 'tex') and then submit the DVI File to 'dvipdfm'.

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LaTeX and related File Naming conventions :

While not compulsory, the conventions listed below for File Name Extensions help identify File Types. On Unix or Linux, if in doubt about the actual Type of a File, enter 'file' followed by the File Name, like 'file test.tex', to get like 'LaTeX 2e document text', in this case indicating a LaTeX Source File.

Unix and Linux File Names are Case Sensitive. For example, 'latex' will not find 'Test.tex' or 'Test.Text' when the above 'test.tex' is to be compiled. 'latex test.tex' must be entered.

Compilation Commands, or conversion ones, like 'dvi2pdf', 'dvips', or 'pdf2ps' will never change their Input File, but will overwrite any existing Output File. For instance 'latex test.tex' will create a new 'test.dvi' when none existed, or write over an old File. In the same way, 'dvi2pdf test.dvi', or 'pdflatex test.tex' will write a new 'test.pdf' when none was present, but overwrite an old File with the fresh output.

When the Compiler encounters some errors, it will stall. Try :

"Enter" with no other input to try continuing,
'q' to carry on with no more interruptions,
'x' to abandon the compilation.

See WKI, Chapter 5, pages 35-38 for full details.

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Common File (Name) Extensions in LaTeX Document Processing :

Extension	File and Commands for processing
tex	LaTeX or TeX (sometimes called "Plain TeX") Source File : - Compile to DVI ('dvi') with 'latex' or 'tex', - ' ' ' ' PDF ('pdf') ' ' 'pdflatex' or 'pdftex'.
dvi	DVI Output from 'latex' or 'tex' compilation : - Display with 'xdvi', - Get conversion to PDF ('pdf') with 'dvi2pdf', - ' ' ' ' Postscript ('ps') ' ' 'dvips'.
pdf	PDF from 'pdflatex' or 'pdftex' compilation, or converted from DVI ('dvi') File with 'dvi2pdf' : - Display with 'acroread' or 'xpdf', - Get conversion to Postscript ('ps') with 'pdf2ps'.
ps	Postscript from 'dvips' or 'pdf2ps' conversion, or external File possibly to merge with other Postscript. - Display with 'gv' or 'ghostview', - Get conversion to PDF ('pdf') with 'ps2pdf'.
eps	Special "Encapsulated" Postscript (like pictures), which can be inserted in LaTeX Documents, via 'includegraphics' LaTeX Statements naming the File. - Can be displayed with 'gv' or 'ghostview'.
aux	Output by 'latex' or 'pdflatex', for cross referencing, and building Tables of contents or figures, which will need rerunning 'latex' or 'pdflatex' against Source File.
log	Copy of Screen output when 'latex' or 'pdflatex' run.

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Basic (typical) Sequence of Commands for LaTeX Processing :

The Commands below first copy the LaTeX Source for these Notes to a File in your own File Space where it may then be compiled. A Unix or Linux Computer is assumed.

Command	Effect
cd ~/elie/Dir/doc/sem/tex/	Change to Course Directory
ls -al	Show contents of Directory
cp LatNotes.tex \$HOME	Copy Course Source File to Home Dir.
cd	Return to Home Directory
file LatNotes.tex	Should tell File a LaTeX 2e Document
latex LatNotes.tex	Compiles LaTeX Source, giving DVI
xdvi LatNotes.dvi	Show Document in DVI Viewer Window
pdflatex LatNotes.tex	Compiles LaTeX Source, giving PDF
dvipdfm LatNotes.dvi	Produces 'LatNotes.pdf' PDF copy from DVI Output rather than Source
xpdf LatNotes.dvi	Show Document in PDF Viewer Window (alternatively, use 'acroread')
dvips -o LatNotes.ps LatNotes.dvi	Produces 'LatNotes.ps' Postscript
gv LatNotes.ps	Show Doc. in 'ps' Viewer Window (alternatively, use 'ghostview')
dvips -P ps8 LatNotes.dvi	Prints DVI on Printer 'ps8'
lpr -P ps8 LatNotes.ps	Prints Postscript on Printer 'ps8'
rm *.aux *.log	Delete unwanted 'aux' and Log Files
rm LatNotes.pdf LatNotes.ps	Delete PDF and Postscript for Space ('ps' and 'pdf' Files may be large)

For notes about the Unix (or Linux) Commands and a full list of their Options, enter 'man' followed by the Command Name, like 'man lpr' to be shown a description the the 'lpr' print Command and its Options.

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Modern Unix and Linux systems will support Command History processing. At the basic level, the Arrow Keys and a combination of the Control (labeled 'Ctrl') Key and another key will allow previous Commands to be brought back to the Command Line, possibly edited, and reentered. This allows repeated Edit - Compile - View cycles of a LaTeX Document.

Unix and Linux History Handling Summary :

Arrow Keys : Up and Down Keys bring Previous or Next History Entry.

Left and Right Keys place Cursor along Line shown.

Control Key : With 'p', 'n', same effect as Up, Down Arrow Keys.

With 'b', 'f', same effect as Left, Right Arrow Keys.

With 'a', 'e', move to Start or End of current Line.

With 'd', deletes current Character,
'k', deletes all Characters from current.

Backspace : Deletes Character to left of Current.

Delete Key : Deletes current Character.

!! : Resubmits Last Command.

!-n : Resubmits nth Previous Command in History.

!cnname : Resubmits last Command beginning with 'cname'.

Example LaTeX Processing Using History :

emacs LatNotes.tex = Edit LaTeX Source File with 'emacs' Editor
(Command would be 'vi LatNotes.tex' with 'vi')

latex LatNotes.tex = Compiles LaTeX Source, gives DVI
xdvi LatNotes.dvi = Show Document in DVI Viewer Window

Up Arrow three times then allow this triplet to be repeated.

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LaTeX Source ('tex') Files should contain only plain (ASCII) text.

LaTeX Source includes specially tagged Commands or Statements for the Compiler, specifying how the (Output) typeset Document should look.

While most text will be deemed "Data" to be output on the typeset Document, 10 of the 26 punctuation Characters (see list below) play a special role to flag LaTeX Commands or get the Compiler to act in a certain manner.

A mechanism exists (escaping) to tell the Compiler when a Special Character actually forms part of the Data and should appear on the typeset Document. Upper and Lower Case Letters and the 10 Digits will always be taken as Data.

Spaces and empty Lines are generally not affecting the processing and should be used to improve the layout (readability) of the Code. Where space does matter, these notes and all LaTeX or TeX references will state exactly how. To enforce space(s) in the typeset Document, enclose it (them) in Braces ('{ }') in the LaTeX Source File.

Carriage Returns will normally have no effect inside text or Maths, but empty lines will generate a Paragraph break in the typeset output and are not allowed in some environments.

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Special Characters in LaTeX processing :

Chr	Name	Special Role
%	Percent Sign	Begins Comment (rest of Line ignored by Compiler).
\$	Dollar Sign	Marks Entry or Exit from Maths Mode.
#	Hash	Macro Argument Mark and Table Separator.
&	Ampersand	Array or Table Item Separator.
{	Open Brace	Indicates beginning of Command Argument.
}	Close ''	'' end of Command Argument.
_	Underscore	In Maths Mode, Subscript Char. or text inside '{ }' follows.
^	Circumflex (or Caret)	In Maths Mode, Superscript Char. or text inside '{ }' follows.
~	Tilde	Non breakable Space (to separate words).
\	Backslash	LaTeX Command (for Compiler) Prefix, and Escape Character for first 7 Char. above.

To output any of '%', '\$', '#', '&', '{', '}', or '_', put a Backslash immediately before. For example '\&' makes '&' appear in the typeset Document, once compiled by 'latex' (or 'pdflatex').

To output a Caret ('^'), or Tilde ('~'), prefix it with a Backslash, and follow it with a pair of Braces, like '\^{ }' or '\~{ }'.

Output of Backslashes ('\') needs the Maths Mode '\backslash' Command, for each Backslash to appear in the typeset Document. For a single Backslash, write '\$\backslash\$'.

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LaTeX Commands :

LaTeX Commands (for the Compiler) are prefixed with a Backslash ('\'), except those invoked by some of the Special Characters listed above.

Commands themselves are specified in alphabetical Characters (letters).

Commands may include Arguments (Data for them to handle) given inside a pair of (curly) Braces ('{ }'). Arguments may be expanded over multiple Lines in a Source LaTeX File.

Commands may also accept Optional Arguments inside a pair of Square Brackets ('[]'). Any such Arguments must come before required Arguments which are presented inside Braces ('{ }').

Commands are ended with a Space or a non alphabetical Character.

Comments :

Comments include any text following a Percent ('%') Sign, to the end of the Line. Comments may appear anywhere in a LaTeX Source File. In particular, they allow Source File Lines to be split when a Space or Carriage Return is forbidden.

References :

In general, see Chapter 1 of NSO, WKI, and chapter 2 of LMP, Special Characters in pages 12-15 of LMP, 4-5 of NSO, 16 of WKI.

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Structure of LaTeX Documents (in Source Files) :

LaTeX Source Files start with a '`\documentclass`' Command, followed by optional general page and margin set up Commands, '`\usepackage`' Commands for any non default LaTeX "Packages", a '`\begin {document}`' Command, the body of the Document, its "Data" (text) and the LaTeX Commands to control the typesetting, and an '`\end {document}`' Command to finish processing (whatever follows in the File is ignored).

The '`\documentclass`' Command tells what type of Document is to be typeset. Common choices are 'article', 'letter' or 'report'. See the full list in the references (pages listed below).

Optionally, a default Font Size and type of Media (Paper and what type, but possibly other, like Transparency). Font Sizes are given in Points, a Unit in typesetting. 11 or 12 Point would be suitable in most cases. Typical paper in the U.K. would be A4 ('a4'), but in the U.S. Letter ('letter').

See LMP, pages 19-20 and 176-179, NSO, pages 7-12, WKI page 17-22, which all show the Compilation of a basic File and conversion of the DVI output to PDF or printing.

Commands to specify page Margins and the extent of the Page used for typesetting the text may follow the '`\documentclass`' Command. See the Template on the next page as an example.

Also, a '`\pagestyle`' may be present controlling the inclusion of a Header and a Footer area on the typeset pages. See NSO, page 13, and LMP, pages 88-90 and 179-182.

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Template LaTeX source File :

% Required as First Command :

```
\documentclass[12pt]{article}
```

% Page Offsets from Edges (of Media) :

```
\hoffset = -0.6 in
```

```
\voffset = -1.2 in
```

```
\hsize = 7.0 truein
```

```
\vsize = 11.0 truein
```

% Additional Commands for Text formatting on Page :

```
\addtolength {\parindent} {-15pt}
```

```
\addtolength {\textwidth} {1.5in}
```

```
\addtolength {\textheight} {2.5in}
```

% Useful extra LaTeX Packages for Verbatim, Maths and Graphics :

```
\usepackage {verbatim}
```

```
\usepackage {latexsym}
```

```
\usepackage {graphicx}
```

% Compulsory Command to mark start of Document typesetting :

```
\begin {document}
```

% Body of typeset Document, text and LaTeX typesetting Commands :

Output the Special Characters (Comment prevents Line Break) :

```
%
```

```
\%, \$, \#, \&, \{, \}, \_, \^{} }, \~{} }, \$\backslash$.
```

```
\end {document}
```

% No more LaTeX processing after an '\end {document}' Command.

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Basic text division in LaTeX Documents :

Text divides into Paragraphs on a LaTeX Document.

An empty Line forces a new Paragraph. LaTeX will enforce a vertical space between Paragraphs, irrespective of how many blank lines split them in Source Files. To force additional space, use one or more (or a combination) of :

```
\smallskip : About 1/4 Line Height,  
\medskip  : '' 1/2 '' '' ,  
\bigskip   : '' 1 '' '' ,.
```

or one of :

```
\vspace { nn mm } : Jump 'nn' millimetres,  
\vspace { nn in } : '' 'nn' inches (or "), 1" = 25.4 mm.
```

The '\vspace' Amount may include decimals, like '25.4 mm', and also be negative, to force resumption of typeset output higher up on the Page. This allows overlaid output. See LMP, pages 99-102.

The '\hspace' Command acts like '\vspace' but horizontally.

Carriage returns are ignored as regards the typeset Output. They should be used to keep Source Files neat (avoid lines in excess of 80 Characters wide, they make Files hard to read in standard Unix or Linux Editor Windows).

LaTeX Compilers set line breaks in the output, but may be overridden with '\newline' Commands. Words will sometimes be broken, a process called "hyphenation" (see NSO, page 20). This can be prevented for a length of text by enclosing it as the Argument to an '\mbox' Command, like '\mbox {no breaks in this passage}'.

Likewise, Page breaks are decided by the Compiler, but can be forced with '\newpage' Commands. See NSO, pages 17-20, or, at a more advanced level, LMP, pages 213-215.

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LaTeX Environments :

Beside ordinary text processing (see above), LaTeX offers several Environments, where the typesetting rules are altered to suit some special purpose. A switch of environment starts with a '`\begin`' Command where the Argument will name the new Environment. It ends (with return to ordinary text processing rules) with an '`\end`' Command, again followed by the Environment's label.

Main Environments supported (see NSO, pages 39-47) :

- description : Each '`\item`' Command starts a new Paragraph, with text given as Option to '`\item`' in bold Font.

- enumerate : Enumeration, splits text into numbered Paragraphs, where '`\item`' Commands appear in the LaTeX Source.

- itemize : Each '`\item`' Command starts a new Paragraph, Bullet Pointed, where each '`\item`' Command appears, or labeled as per Option to '`\item`', inside '['].

- center : Text centered on output page, with Line Breaks specified with '`\\`' Commands.

- flushleft : Text squashed against left Margin, with Line Breaks specified with '`\\`' Commands.

- flushright : Text squashed against right Margin, with Line Breaks specified with '`\\`' Commands.

- equation : Maths Mode. See after this page.

- tabbing : Emulates typewriter Tabs (see LMP, pages 60-61).

- tabular : To produce Tables
(see NSO, pages 42-44, LMP, pages 62-62 and 204-207, and in greater detail, WKI, Chapter 8, pages 59-74).

- verbatim : Source text reproduced exactly as in Source File, including all Spaces and Line Breaks.
See this File as an example of such processing.

- quote : Shows text as an indented Paragraph.

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LaTeX Maths Environment :

Latex supports all the standard Mathematical notation in its "Maths" Environment. Equations may be specified as passages in lines of ordinary text, between Dollar ('\$') Commands, or to appear in a separate Paragraph between "Double Dollar" ('\$\$') Pairs, or by using the '\begin {equation}' and '\end {equation}' Commands.

Alternatively, '\begin {math}' and '\end {math}' may be used for inline Equations, and '\begin {displaymath} and '\end {displaymath}', or '[' and '\]' instead of 'equation'. However, in the latter case, Equations will not be numbered whereby they are under 'equation'. The '\label' Command allows overriding the default numbering, which starts from "(1)", given to the first Equation in the Document.

Example of Inline (called "textstyle") Maths :

{ }The area a of a disk of radius r \,, is given by πr^2 \,.

where the 'r' shows in calligraphic style, and the Pi in Greek :

The area a of a disk of radius r , is given by πr^2 .

Equation example as a separate Paragraph (called "displaystyle") :

$a \text{ ; } = \text{ ; } \pi \text{ , } r^2 \text{ \quad } \{\mbox{Units ~ of ~ Area}\} \text{ ; } .$

which becomes :

$$a = \pi r^2 \text{ Units of Area .}$$

See details in LMP, pages 39-52, NSO, Chapter 3, pages 56-70 or WKI, Chapter 13, pages 129-150. The "Cheat Sheet", or pages 63-70 of NSO list all the common Mathematical Notation (including Greek) Commands.

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LaTeX Maths Environment processing :

Different "Math" Font.

Greek Letters with '`\ggg`' for the Greek Letter 'ggg' in "Lower" case, or '`\Ggg`' for the same letter in "Upper" Case, for example `\alpha` and `\Alpha` for Alpha. See example with Pi above.

Arithmetic Operators ('+', '-', '*', '/') are entered as such, but the '`\frac { } { }`' Command is needed for Fractions where the Numerator sits above the Denominator. These are given as Arguments.

The Special Characters '`_`' (Underscore) and '`^`' (Caret) serve to indicate Subscripts and Exponents. For multi Character Subscripts or Exponents, enclose them in '`{ }`', like '`rad^{ 2.1 }`'. Subscripted Subscripts and Exponentiated Exponents are valid but '`{ }`' must be used, like '`xx^{ 2^{ 3.1^4 } }`', or '`yy_{ 2_{ 3.1_{ 1.3 } } }`'

Enforce space with '`\,`' ("thin Space", also valid in ordinary text, that is, outside Maths Mode), '`\:`' ("medium Space"), '`\;`' ("thick Space"), '`\`' ("interword Space"), '`\quad`', '`\qquad`', from smallest to longest. The Tilde ('~') text spacer will also work. The earlier example Equations illustrate use of '`\,`', '`\;`', '`\quad`' and '~'.

A "Backspace" Command, '`\!`' reverses the effect of '`\,`' (thin Space).

The Delimiters '`()`' (Parentheses), '`{ }`' (Braces), '`|`' (Vertical Bar) may be progressively enlarged with the '`\big`' (least), '`\Big`', '`\bigg`' and '`\Bigg`' (largest) Commands, so '`\big($`' produces a larger open Parenthesis, or '`\Bigg\}`' a very large closing Brace.

Pages 63-70 of NSO list all the common Mathematical Notation.

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Inside Maths Mode, special (sub)Environments are available to lay Matrices or Determinants, with a selection of Delimiters, or none :

`array` : Lays Matrix, like the non Maths 'tabular' Environment, initiated with a '`\begin {array} { r r r }`' entry, where each 'r' corresponds to a Right aligned Column, and would be 'l' for Left and 'c' for Centre instead. Rows then typed with Ampersand ('&') Column Separators, and double Backslash Row endings except on last Row. and finally, an '`\end {array}`' closing the construct.

`\matrix` : Lays Matrix as 'array', but always with centered Columns, and occupying less width on page. Also, all Rows must end with a '`\cr`'. Written as '`\matrix { }`', with the Rows and Columns inside the pair of Curly Braces '{ }'.

Equation Mode coding	Resulting Output	Notes
<code>\begin {array} { c c }</code> 11 & 12 \\ 21 & 22 <code>\end {array}</code>	11 12 21 22	Centered Columns
<code>\matrix {</code> 11 & 12 \cr 21 & 22 \cr }	11 12 21 22	Apparently as above, but, see case with delimiters below.
<code>\left </code> <code>\begin {array} { c c }</code> 11 & 12 \\ 21 & 22 <code>\end {array} \right </code>	11 12 21 22	Delimiter entries showing before and after internal Row and Columns.
<code>\left \matrix {</code> 11 & 22 \cr 21 & 22 \cr }	11 12 11 12	Delimiters placed tighter around body of Determinant.
<code>\right </code>		

See NS0, pages 57-61 for more details and examples.

When several Equations need be aligned, the 'align' Environment may be entered rather than 'equation'. Then '&' (Ampersand) Marks serve to align the individual Equations in the "Paragraph of Equations".

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Latex permits the inclusion of externally generated "Encapsulated" or "EPS" Postscript Files, containing diagrams or Pictures. These will normally bear an 'eps' File Name Extension, and represent Postscript where no Media was specified, unlike ordinary 'ps' Postscript Files. Additionally, a Graphics Package must be loaded with, a '\usepackage' Command before the '\begin {document}' Command at the top of the File. The 'graphicx' Package is preferred, or, if this was not installed, the older 'epsfig'.

Template Latex Code to include an EPS Postscript File :

```
\begin {figure}

\centering                % Optionally forces centering.

\includegraphics { ffff.eps } % File 'ffff.eps' Shows in output.

\caption          { cccc }    % Caption 'cccc' shows under Picture.

\end {figure}
```

Note the picture will be treated as a "Floating Body" by the Compiler, and, depending on its size, and that of the neighbouring Paragraphs, it may not show exactly where the 'figure' Environment was entered, and either show a few Paragraphs sooner or later.

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The `'\includegraphics'` Command can be given a String of Options, between `'[]'` (Square Brackets), to control the Size and Orientation of the Picture :

`angle = nn` : Rotate the Picture by `'nn'` Degrees,

`width = n.d` : Width scaled by factor of `'n.d'`,

`height = n.d` : Height `'' '' '' '' 'n.d'`,

`scale = n.d` : Picture `'' '' '' '' 'n.d'`.

The `'scale'` Option equates to `'width'` and `'height'` with the same `'n.d'` Factor. The Options, when present must appear before the File name, like `'\includegraphics [angle = 30, scale = 0.5] { ffff.eps }'`.

The Scalings make be replaced by absolute sizes in inches or mmm, or followed by `'\textwidth'` or `'textheight'` to pick the text Size used in laying the typeset page.

See notes about Graphics Mode in NSO, Chapter 4, pages 71-73, or in much greater details in WKI, Chapter 9, pages 75-86.

Graphs and Plots may be constructed in LaTeX by assembling the base elements offered in the `'picture'` Environment. This can be long winded but allows self contained Source Files for a Document.