An introduction to LaTeX

a document preparation language

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(adapted from a lecture by Cedric Lacey)

- You can find these notes and some LaTeX examples on my web page:
- http://astro.dur.ac.uk/~cole/Intro_LaTeX_PG

What is LaTeX?

- A document preparation system in which the source file contains both text and markup commands
- Create source file using normal text editor
- Run LaTeX program to see result
- LaTeX program decides details of word spacing, line breaks, page breaks, position of figures & tables etc according to instructions in source file

Why use LaTeX?

- Produces high-quality output with uniform style
- Style can be changed simply by global commands or by loading different macro packages
- Very good for mathematics & equations
- Automatic numbering & cross-referencing of sections, equations, figures, tables etc
- Free! Runs on all operating systems
- THE STANDARD for publications in physics, astronomy, maths

Useful books

Guide to LATEX

by H. Kopka & P. Daly

- describes standard features & some additional ones – HIGHLY RECOMMENDED!

LATEX: A document preparation system

by Leslie Lamport

- describes basic features, but not many examples
- somewhat out of date

The LATEX Companion

by Goossens, Mittelbach & Samarin

- describes lots more optional/additional features

Useful websites:

A very brief overview to get you started:
http://www.tug.org/begin.html

A much more detailed introduction:
http://tug.ctan.org/pub/texarchive/info/beginlatex/html/beginlatex.html

Another general introduction:
http://amath.colorado.edu/documentation/ LaTex

More websites:

A primer for typesetting equations in LaTeX:
http://www.maths.tcd.ie/~dwilkins/LaTeXPrimer/

some hints about including graphics:
http://merkel.zoneo.net/Latex/index.php?lang=en

Latex beamer
http://gking.harvard.edu/files/beamerusrguidef.pdf

how to cite references using natbib package:
http://merkel.zoneo.net/Latex/natbib.php

references using BibTeX:
http://www.bibtex.org

Macros & tips for PhD theses in LaTeX

Durham PhD thesis macros:
http://maths.dur.acuk/Thesis/

another example, with useful hints:
http://amath.colorado.edu/documentation/LaTeX/thesis/sample/

LaTeX & TeX

- The LaTeX program is actually written in a lower-level typesetting language TeX
- If you want to install LaTeX on your own computer, have to install TeX first (or install TeX & LaTeX together)
- But normal user can use LaTeX without knowing anything about TeX
- Can use some TeX commands in LaTeX documents – but better to use LaTeX equivalents (added functionality, usually clearer & simpler)

How to install TeX & LaTeX

- If you want to install TeX & LaTeX on your own laptop:
- Linux: download teTeX distribution from
  www.tug.org/tetex
- Windows: try MiKTeX from
  www.miktex.org
  or TeXnicCenter from
  sourceforge.net/projects/texniccenter
- Mac OS X: try gwTeX from
  ii2.sourcefo
  or T ludes GUI) from
  htt oregon.edu/~koch/texshop

Or use macports or aquaemacs (integrated into editor)

How to run LaTeX under Linux/Unix

- Create a LaTeX source file with suffix '.tex', e.g. mypaper.tex, using a text editor
- Use an editor which provides special features for LaTeX files e.g. emacs
- Run LaTeX program: > latex mypaper.tex

  OR

  > latex mypaper (suffix .tex assumed!)
- Producing a file mypaper.dvi
- Can view on screen (if EPS figures) using

  > xdvi mypaper.dvi (OR > xdvi mypaper)

Producing Postscript output

- Postscript (PS) files, suffix '.ps', are designed to be printed, but can be viewed on screen, e.g. Using gv (ghostview)
- To produce .ps from .dvi:

  > dvips -o mypaper.ps mypaper.dvi
- For this to work, included figures/graphics must be Encapsulated Postscript (EPS) files, suffix '.eps'
- Then print: > lp mypaper.ps
- Or view on screen: e.g. > gv mypaper.ps

Producing PDF output

- Portable Document Format (PDF) files are designed to be viewed on screen, e.g. using acroread, but can be printed from a PDF viewer
- Three ways to make from LaTeX:
- (1) from .ps file (output: mypaper.pdf)

  > ps2pdf mypaper.ps
- (2) from .dvi file

  > dvipdf mypaper.dvi
- (3) directly from .tex file (output: mypaper.pdf)

  > pdflatex mypaper.tex
- For (3) to work, included figures/graphics must be either PNG (.png) or PDF (.pdf) (or JPEG (.jpeg, .jpg) in some versions)

Some other things....

- There are programs which can convert your figures/graphics between different formats, e.g, .eps to .png e.g. in Linux can use display or convert, on MAC use preview
- There are also programs which can convert your LaTeX files directly to HTML for web pages

How to run LaTeX under Windows

- Basic procedure same as in Linux, i.e.

  file.tex (latex) -> file.dvi (dvips) -> file.ps

OR

  file.tex (pdflatex) -> file.pdf

- Much easier if install editor with built-in features for LaTeX, e.g.
- WinShell (free) from www.winshell.de
- WinEdt (costs US$30 for students) from www.winedt.com

How to run LaTeX under Mac OS X

- Basic procedure same as in Linux, i.e.

  file.tex (latex) -> file.dvi (dvips) -> file.ps

OR

  file.tex (pdflatex) -> file.pdf

- More convenient to work with PDF rather than PS on Macs
- If you like a graphical front-end, try TeXShop from

  http://www.uoregon.edu/~koch/texshop

Or use editor with Latex built in (eg. AquaEmacs)

Now a simple example

- LaTeX demodoc.tex, with included figure fig.eps

Structure of a LaTeX file

\documentclass[*options*]{*class_name*}

% documentclass determines overall structure

preamble – global commands which affect whole document

\begin{document}

text

+ instructions for including figures

\end{document}

Standard document classes

- **article** : document has sections, subsections, sub-subsections, e.g. For paper in journal or conference proceeding
  \documentclass{article}
- **report** : also has chapters, title page, table of contents, e.g. For L4 or PhD thesis
- **book** : similar to report, but extra features for publication-quality book
- **letter** : for writing letter – letterhead but no sections

Other document classes

- Many people have created modified versions of standard classes. For these, you need class file, e.g. thesis.cls (modified report.cls), then

  \documentclass{thesis}

- Each journal has its own style. Download .cls file from journal webpage
- **MNRAS:** mn2e.cls (modified article.cls)
  \documentclass{mn2e}

  You will need the file mn2e.cls
- **ApJ, AJ:** aastex.cls \documentclass{aastex}

Document class for PhD thesis

- Many people have created modified versions of standard classes, e.g. for writing PhD theses
- For these, you need class file, e.g. duthesis.cls (modified report.cls) produces layout for Durham PhD thesis, which you can also use for L4 thesis
- Download duthesis.cls from

  http://maths.dur.ac.uk/Thesis/
- Then begin document with

  \documentclass{duthesis}
- See my example thesis_example.tex, also thesis_template.tex

Loading packages

- Packages are used to add additional features, or to modify standard features of class
- Need \usepackage command in preamble, e.g. \usepackage{amssymb}
  which adds extra math symbols
- Needs file amssymb.sty to be in current directory or elsewhere in LaTeX search path

Splitting a document into different files

- For long documents (e.g. PhD thesis) better to split into several files
- e.g. File main.tex could contain:

```
\documentclass{report}
\begin{document}
\input{chap1}
\input{chap2}
\end{document}
```

- Inputs chap1.tex, chap2.tex
- Effect is same as cutting & pasting chap1.tex etc into main.tex at position of \input command

Special characters for commands

- These characters are used in a LaTeX file in markup commands: \ % # $ & ~ _ ^ { }
- \ begins a command name
- % begins a comment
- {} delimit the arguments to commands and the range within which some commands act
- $ starts/ends math mode
- If you want %, &, $ to appear in document, need to type \%, \&, \$ in .tex file etc

Chapters, sections, etc

- e.g.

```
\chapter{The model}
\section{Dark matter halos}
\subsection{Density profiles}
\subsubsection{Some irritating details}
```

- Heading will be printed using text in {}
- Chapters, sections etc will be numbered automatically
- e.g. Chapter 1, Section 1.2, Subsection 1.2.5, etc

Lists

- LaTeX can make various kinds of lists, e.g.

```
\begin{itemize}
\item apples
\item oranges
\item bananas
\end{itemize}
```

  will list items preceded by bullet-points

- \begin{enumerate} etc will make list with items numbered 1,2,3 etc

Spaces!!

- Beware of special spaces…
  - ~ ties two words together (the line won't break here)
  - \ (\blank) insert space after a command
  - \/ a tiny bit of space (after italic letter)
  - \vspace{1cm} … one cm of vertical space
  - \vspace*{-1cm} … squeeze up by 1cm vertically (for telescope proposals!)
  - $\,$ a bit of space in maths model (eg. between numbers and units)

Font sizes & styles

- Can change overall fontsize using optional argument in \documentclass, e.g.

  \documentclass[12pt]{article}

- For italics use \em, e.g.

Some text {\em some text in italics} more text

- For boldface use \bf, e.g.

Some text {\bf text in bold} more text

- Greek characters available in math mode, e.g.

The α-elements

Defining your own commands

- Use \newcommand e.g.

  \newcommand{\etal}{{\em et al.}}

  equivalent to replacing every appearance of \etal in file with {\em et al.}
- Make new commands rather than typing complicated stuff in many times (its easy to change later!)

  \newcommand{\acool}{{\alpha_{\rm cool}}}
- Can also define commands with arguments

  \newcommand\Bold[1]{{\bf #1}}

  Then \Bold{sausages} is equivalent to {\bf sausages}

Equations

- In math mode, can have
- Greek characters, e.g. \alpha
- Other math symbols, e.g. \leq
- Fractions, integrals etc
- Subscripts, e.g. x_n
- Superscripts, e.g. y^2
- AMS-LaTeX package amsmath gives even more possibilities

  \usepackage{amsmath}

Text & displayed equations

- **Text equations** are embedded in normal text and start and end with $, e.g.

  We define $y=x^2$.....

- No equation numbers for text equations

Displayed equations appear on a separate line, and can have numbers, e.g.

```
\begin{equation}
    y = x^2
\end{equation}
```

- For multi-line equations, use \begin{eqnarray} etc

Equations: Example 1

- You type:

```
\begin{equation}
P_{\rm gal}(k)=\frac{1+Qk^{2}}{1+Ak}\,P_{\rm lin}(k),
\end{equation}
```

- You get:

$$P_{\rm gal}(k) = \frac{1+Qk^2}{1+Ak}\,P_{\rm lin}(k), \qquad (3.1)$$

Equations: Example 2

- You type:

```
\begin{eqnarray}
 1 - n_{\rm s} &=& 2\epsilon_1 + \epsilon_2 \\
 r &=& 16\epsilon_1.
 \end{eqnarray}
```

- You get:

$$1 - n_{\rm s} = 2\epsilon_1 + \epsilon_2 \quad (3.3)$$

$$r = 16\epsilon_1. \quad (3.4)$$

Including graphics

- Modern way to include graphics from file uses **graphicx** package: preamble must include

  \usepackage[dvips]{graphicx} (for dvips)

  OR

  \usepackage[pdftex]{graphicx} (for pdflatex)

- Then to include a graphics file

  \includegraphics[*key=value*,...]{*file_name*}

- e.g.

  \includegraphics[width=8.5cm]{myplot}

- Will load myplot.eps (for dvips) or myplot.png or myplot.pdf (for pdflatex) and rescale to width of 8.5cm

Floating figures

- \includegraphics command will try to insert figure at that point if space on page, otherwise on next page, leaving blank space on current page
- Better to let figure "float", using figure environment, e.g.

```
\begin{figure}
\includegraphics[scale=0.6]{lumfun}
\caption{The luminosity function}
\end{figure}
```

- This also gives the figure a caption and a number
- WARNING: may need to tune figure placement manually

Tables

- Make tables using \tabular environment, e.g.

```
\begin{tabular}{lcc}
    galaxy & magnitude & redshift \\
    NGC 891 & 15.5 & 0.02 \\
    M87 & 14.8 & 0.01
\end{tabular}
```

- Which left-justifies 1st column and centres 2nd and 3rd columns
- & separates columns and \\ separates lines

Tables: Example

- You type:

```
\begin{tabular}[t]{cc}
\hline\hline
Parameter          & Allowed range \\
\hline\hline
$\Omega_{k}$     & $-$0.3 -- 0.3    \\
$\omega_{\rm dm}$   & 0.01 -- 0.99    \\
$\omega_{\rm b}$    & 0.005 -- 0.1   \\
$f_{\rm \nu }$        & 0 -- 0.5    \\
$w_{\rm DE }$         & $-$2.  -- 0   \\
$\tau $               & 0 -- 0.8    \\
$n_{\rm s}$           & 0.5 -- 1.5     \\
$\log_{10}(10^{10}A_{\rm s})$ & 2.7 -- 4.0 \\
$r$                & 0 -- 1   \\
$b$                & marginalized   \\
$\Theta  $         & 0.5 -- 10    \\
\hline\hline
\end{tabular}
```

Tables: Example (continued)

- You get:

Parameter	Allowed range
Ω_k	$-0.3 - 0.3$
$\omega_{\rm dm}$	$0.01 - 0.99$
$\omega_{\rm b}$	$0.005 - 0.1$
f_ν	$0 - 0.5$
$w_{\rm DE}$	$-2. - 0$
τ	$0 - 0.8$
$n_{\rm s}$	$0.5 - 1.5$
$\log_{10}(10^{10} A_{\rm s})$	$2.7 - 4.0$
r	$0 - 1$
b	marginalized
Θ	$0.5 - 10$

Floating tables

- Usually make tables "float" (like figures) using table environment, e.g.

```
\begin{table}
 \caption{Galaxy magnitudes and redshifts}
\begin{tabular}{rlcc}

. . . . . .

\end{tabular}
\end{table}
```

- Which also gives the table a caption and a number

Cross-referencing

- Can cross-reference sections in a paper, equations, figures, tables using \label to create labels, and \ref to refer forward or back to them
- e.g. to label a section:

```
\section{Dark  halos}
\label{sec:halos}
```

- Then to refer to it:

```
We discuss the structure of dark halos in Section~\ref{sec:halos}
```

- LaTeX will insert actual section number
- Cross-referencing info written to .aux file
- **Must run LaTeX TWICE to get final document**

Cross-referencing figures & tables

- Works similarly for figures & tables, e.g.

```
\begin{figure}
            ..............
\caption{The luminosity function}
\label{fig:lumfun}
\end{figure}
```

- NB: \label inside figure environment after \caption
- Then to refer to it:

```
We show in Fig.~\ref{fig:lumfun} that....
```

- \ref{...} gets replaced by actual figure number in document

Cross-referencing equations

- Similarly for equations, e.g.

```
\begin{equation}
        P_a = \frac{y_3/x^2}
        \label{eq:p_a}
\end{equation}
```

- Then to refer to it:

```
$P_a$ is defined in eqn.~(\ref{eq:p_a}).....
```

- The brackets () here enclose the equation number in brackets, e.g. eqn. (3.2)

Bibliographic references – simple approach

- Use the **natbib** package:

  \usepackage{natbib}

- Create your bibliography (in alphabetical order):

  \begin{thebibliography}{}

  .....

  \bibitem[Smith \& Jones (1990)]{Smi90} Smith, A., \& Jones, B., 1990, ApJ 231, 506

  .....

  \end{thebibliography}

- One \bibitem for each article or book referred to
- LaTeX will typeset your bibliography

Refering to a paper in the bibliography (using natbib)

- Then to refer to a paper in the text, use \citet or \citep or \citeauthor or \citeyear, e.g.
- \citet{Smi90} produces "Smith & Jones (1990)"
- \citep{Smi90} produces "(Smith & Jones 1990)"
- \citeauthor{Smi90} produces "Smith & Jones"
- \citep[e.g.][chapter 3] produces (e.g. Smith & Jones 1990 chapter 3)
- See documentation on **natbib** for more possibilities

Bibliography with BibTeX

- A more sophisticated approach is to store all your bibliographic data in a separate (or multiple) BibTeX file(s)
- You then have to run the BibTeX program along with LaTeX
- But different LaTeX documents can share the same BibTeX files, so you only ever need to enter references in the database once
- See www.bibtex.org or "Guide to LaTeX" (Kopka & Daly) for more details
- Compatable with natbib citation package

Example BibTeX entry

- You create bibliographic database file, e.g. refs.bib
- example entry:

```
@ARTICLE{Almeida2007a
   author = {Almeida, C., Baugh, C.M. and Lacey, C.G.},
   title = {The structural properties of galaxies in CDM},
   journal = MNRAS,
   year = 2007,
   volume = 376,
   pages = {1711-1726}
}
```

- File begins...ends with \begin{thebibliography}...\end{thebibliography}
- ADS will create entries in BibTeX format for you

latexdiff

- Perl script for highlighting differences between two versions of a latex file

> latexdiff oldfile newfile > diff.tex

>latex diff.tex

➢ The resulting pdf/ps file shows the deleted text in red with a line through it and inserted text in blue underlined with a wavy line.

Running BibTeX with LaTeX

- Main LaTeX file (e.g. paper.tex) must specify (somewhere) bibliographic style, e.g.

\bibliographystyle{mn2e}

- loads file mn2e.bst

- And specify where bibliography to appear & which databases to load, e.g.

\bibliography{refs}

- loads file refs.bib

- Need to run LaTeX (e.g. latex paper), then BibTeX (bibtex paper) (creates file refs.bbl), then LaTeX again (TWICE)

Summary

- Latex sounds complicated
- But it is really good!
  - Files are simple text files. Easy to store, e-mail, diff, cut-and-paste, automate!
  - Robust. Doesn't crash out. Can store your document in small parts.
  - You focus on the text, not on making it look nice
  - Easy to type equations
  - You end up with a professionally typeset document!
- Bibtex is a little hard to start with
  - But makes it simple to compile the references for each paper