



# NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

**HYPERDRIVE: PRACTICAL, LOW COST, AND FUEL  
EFFICIENT TRAVEL TO THE STARS**

by

Anakin Skywalker  
Darth Vader

June 2104

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**HYPERDRIVE: PRACTICAL, LOW COST, AND FUEL EFFICIENT TRAVEL TO  
THE STARS**

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Submitted in partial fulfillment of the  
requirements for the degree of

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## **ABSTRACT**

The idea of Hyperdrive relies on the existence of a separate and adjacent dimension most commonly called “hyperspace,” though various other names have been used: “Drivespace,” “The Immaterium,” “slipspace,” “Space2,” “subspace,” “Zero-space,” etc. When activated, the hyperdrive shunts the starship into this other dimension, where it can cover vast distances in an amount of time greatly reduced from the time it would take in “real” space. Once it reaches the point in hyperspace that corresponds to its destination in real space, it re-emerges. Usually, hyperdrive refers to a method of travel in which it takes a measurable amount of time to go from one point to another. When the distance is covered instantaneously, the term jump drive is often used.

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# Table of Contents

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## List of Figures

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## List of Tables

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## Acknowledgements

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We want to thank everybody who helped us get to where we got today.

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# CHAPTER 1:

## Hyperspace Characteristics

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While in hyperspace, spaceships are typically isolated from the normal universe; they cannot communicate with nor perceive things in real space until they emerge. Often there can be no interaction between two ships even when both are in hyperspace. To people traveling in hyperspace, time typically moves at its normal pace, with little or no time dilation; 24 hours in hyperspace equates to 24 hours in real space. This is due to the fact that typical hyperdrive scenarios involve only changing the position of the craft, without altering its velocity (i.e., a ship will emerge with the same momentum, kinetic energy and direction of travel that it had upon entering hyperspace, thereby avoiding relativistic effects). One exception is David Brin's Uplift Universe; here, hyperspace is divided into "levels" where time passes at different rates. Hyperspace itself may be portrayed as swirling colors, total blackness, featureless gray, or as something that would drive a human mind insane should it be viewed. In much science fiction, hyperdrive jumps require a considerable amount of planning and calculation, with any error carrying a threat of dire consequences. Therefore, jumps may cover a much shorter distance than would actually be possible so that the navigator can stop to "look around"—take his bearings, plot position, and plan the next jump. The time it takes to travel in hyperspace also varies. Travel times may be in hours, days, weeks or more, and in those cases can provide a setting in itself for a story that takes place during an extremely long journey.

Hyperdrive is used extensively in the StarWars universe (Figure ??). Remember, in space no one can hear you scream.

### 1.1 Enhancing Drama

Hyperdrives allow for drama in science fiction by eliminating the single biggest problem with space as a setting for a story: the vast majority of space is empty and thus more or less uninteresting. As in most depictions of hyperspace, ships with hyperdrive can typically only interact with other ships while in "normal space," they would have to drop out of hyperspace to interact, and the chance of two ships appearing at the same location in deep space to take a navigation bearing at the same time is infinitesimal. Therefore, hyperdrive ships will encounter each other most often around contested planets or space stations, which can be light-years apart.

### **1.1.1 Dramatic Escapes**

Hyperdrive may also allow for dramatic escapes as the pilot “jumps” to hyperspace in the midst of battle to avoid destruction. Dramatic tension can also be evoked by the use of “Jump Calculations” in the same way. “Will the computer or crew be able to calculate the needed equations before being sucked into a black hole or before a group of missiles hits the ship?” Hyperspace also provides the means by which the literally astronomical distances between stars can be traversed in such a way that would enable an author to have a plot that deals with multiple star systems in a reasonable amount of time, something generally impossible if speeds less than the speed of light are observed. Authors that write about interstellar cultures without hyperdrives generally wind up with plots that last for centuries or more, something not all authors are willing to do.

### **1.1.2 Some Fiction**

In some science fiction, hyperspace travel is portrayed as potentially dangerous due to the chance that the route through hyperspace may take the ship too close to a celestial body with a large gravitational field, such as a star, or a black hole. In such scenarios, if a starship passes too close to a large gravitational field while in hyperspace, the ship is forcibly pulled out of hyperspace and reverts to normal space, or in some stories, is destroyed. Therefore, certain hyperspace “routes” may be mapped out that are safe, not passing too close to stars or other dangers. In some science-fiction universes, such as Star Wars, artificial gravity wells may be used to force another vessel to drop out of hyperspace. Other portrayals show less interaction between normal space and hyperspace, so that ships may actually pass through the position taken up by a celestial body in real space, without being affected. Given how critical transportation is to every human cultures without hyperdrives generally wind up with plots that last for centuries or more, something not all authors are willing to do.

### **1.1.3 More Fiction**

In some science fiction, hyperspace travel is portrayed as potentially dangerous due to the chance that the route through hyperspace may take the ship too close to a celestial body with a large gravitational field, such as a star, or a black hole. In such scenarios, if a starship passes too close to a large gravitational field while in hyperspace, the ship is forcibly pulled out of hyperspace and reverts to normal space, or in some stories, is destroyed. Therefore, certain hyperspace “routes” may be mapped out that are safe, not passing too close to stars or other dangers. In some science-fiction universes, such as Star Wars, artificial gravity wells may be



Figure 1.1: The Star Wars logo; Wikipedia says that this is public domain.

used to force another vessel to drop out of hyperspace. Other portrayals show less interaction between normal space and hyperspace, so that ships may actually pass through the position taken up by a celestial body in real space, without being affected. Given how critical transportation is to every human culture, it is unsurprising that in an interstellar culture, which must deal with distances orders of magnitude greater than terrestrial cultures, the unique ways in which interstellar travel is described in various fictional universes tends to create major plot elements in that universe.

## 1.2 FTL

An FTL, or “Faster Than Light,” Drive is a fictional propulsion technology from the re-imagined *Battlestar Galactica* television series that allows space ships to achieve superluminal travel. They are fuelled by a refined version of the fictional ore *tylium* [?]. The verb *jump* is commonly used to describe the process of travelling via FTL drive. Dialogue states that the drive itself is “spun up” prior to use. The term FTL is never used in the original *Battlestar Galactica* film and television series. The term “light speed” is used, even though within the context of the storyline, the *Galactica* and its fleet move at sub-light speeds and are described as being unable to travel faster than light. The term FTL is also commonly used when the show is being discussed by outside parties.

### 1.2.1 Physics

The exact nature of the FTL drives remains unexplained in the show; what information exists has been extrapolated from visual behavior and on-screen dialogue. Little time appears to pass on a ship during a jump and objects within a ship do not appear to exhibit the signs of momentum/inertia associated with acceleration/deceleration. Nausea is a noticeable side effect noted

in some humans, for example Specialist Cally.

According to producer interviews in the season one DVD release of the series, the special effects director indicated that the FTL is a dimensional transport effect, where the ships instantaneously teleport from one place to another. This method of travel was one of several FTL ideas the production crew had in mind for the show, however to keep things simple and focused to the story, (as well as staying within budget restraints), producers David Eick and Ronald D. Moore chose the straightforward dimensional jump effect over more complex ideas. Because of this however, the term “FTL” used to describe this dimensional transition is somewhat misleading as the ships do not technically move faster than light, but rather instantaneously relocate to a new position in space without a change in speed. The fact remains, however, that they get to their destination faster than light would.

### **1.2.2 Navigation**

Owing to difficulties navigating while using an FTL drive, ships wishing to make an FTL jump must calculate their speed, trajectory and jump duration prior to activating their FTL drive. Failure to do so can lead to ships jumping into poorly charted areas where sub-light navigation is difficult, or into dangerous areas such as those containing asteroid fields, gravity wells, or even inside a planet’s atmosphere. A ship making a properly calculated jump can arrive safely in planetary orbit, or alongside other ships or spaceborne objects. Ships using the same calculations can also safely jump together. Non-calculated jumps (known as a “blind jump”) are possible, as is risked by Admiral Cain aboard Pegasus during the Cylon sneak attack of the Scorpion Shipyards in the season two episode “Pegasus.” In “Razor,” Cain’s risky jump was shown in one of Kendra Shaw’s flashbacks—the ship jumped away just after undocking to the fleet-yard complex while under attack by Cylon Raiders. Because little is known about the physics of the FTL drive, it is not clear whether ships must plot a course around large physical objects, such as suns and gas giants, or if they have to adjust their course to take local gravitational variations into account, although the Galactica is shown in episode “Exodus” to be capable of making a successful jump whilst travelling through the atmosphere at immense speeds towards the surface of the planet New Caprica. Jump co-ordinates must be constantly updated to allow for changes in a ship’s position, and for stellar drift.

Large drives (fitted for example within a warship, such as a Battlestar and the larger civilian transports) allow them to travel greater distances than smaller craft, such as Raptors. A small ship, or ship with a less-capable FTL drive, must make several jumps in order to travel the same

Movie	Title
4	A New Hope
5	The Empire Strikes Back
6	Return of the Jedi

Table 1.1: The first set of movies. Remember, revenge is not the way of the Jedi.

Movie	Title
1	Something weird with Jar-Jar
2	I wish I could remember
3	This movie's name.

Table 1.2: The second set of movies.

distance as a larger ship. This approach can leave the craft vulnerable to detection or attack. Unlike Raptors, Vipers are not fitted with FTL drives. In order to initiate a jump, the crew must first initiate an automated start-up procedure, known as “spinning” the FTL drive, which can take several minutes to complete. This step is done just before a planned jump, presumably because it is impractical or impossible to keep the FTL drive in a “spun up” state of readiness for an extended period of time. The Cylons are capable of calculating more accurate jumps. In “Lay Down Your Burdens,” a Cylon Heavy Raider can make ten jumps in comparison to the *Galactica*’s 500 to jump to Caprica. Because of this, smaller Cylon ships (for example a Cylon Raider) can make longer jumps than Colonial craft of a similar size. The safe limit of FTL travel for the Twelve Colonies is known as the “Red Line.” A ship jumping beyond this line risks running into unknown navigational hazards, or going off course due to compound errors in its jump calculation. it Cylon technology

### 1.2.3 Cylon Technology

The Cylon FTL technology operated within the series is stated to be much more advanced than that operated by the Colonials, the superiority in FTL technology enables them to make much more accurate jumps of a longer range. Much like Colonial FTL technology the Cylons also make use of refined tylium ore as their fuel source. This advantage may lie primarily in the Cylon’s jump computers. Using a captured unit, a squad of *Galactica*’s Raptors were able to jump back to Caprica on a rescue mission in relatively few jumps. It is unclear whether this superior computing technology is solely responsible for the Cylon’s greater range, or if there is an additional advantage in drive technology itself.

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## CHAPTER 2:

### Dummy Chapter

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**2.2 Dummy Section2**

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## CHAPTER 3:

### Another Dummy Chapter

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**3.1 Dummy Section 3**

**3.2 Dummy Section 4**

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## CHAPTER 4:

# Introduction to L<sup>A</sup>T<sub>E</sub>X

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All kidding aside, this file `thesis.tex` is designed to show you how to use the NPS L<sup>A</sup>T<sub>E</sub>X thesis template.

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## CHAPTER 5:

# Introduction to $\text{\LaTeX}$

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$\text{\LaTeX}$  is a text formatting system created by Leslie Lamport in the early 1980s [?]. The program is based on the  $\text{\TeX}$  text formatting system created by Donald Knuth in 1978 [?]. With  $\text{\LaTeX}$  you author your document by editing a text input file using a program such as EMACS, vim, or another editor. You then give this input file to  $\text{\LaTeX}$  (or, more accurately, to a program such as `pdflatex` or `xelatex`).  $\text{\LaTeX}$  then transforms your input file(s) into an Adobe Portable Document Format (PDF) file.

Although most documents at NPS are prepared with Microsoft® Word,  $\text{\LaTeX}$  is widely used outside of NPS in the sciences to create conference papers, journal articles, and even full-length books.  $\text{\LaTeX}$  is especially popular in computer science. With the NPS template you can use  $\text{\LaTeX}$  to produce an NPS thesis that is consistent with NPS formatting requirements. Because  $\text{\LaTeX}$  provides for automated formatting, automatic updating of references, and the ability to directly embed experimental results, many students who write technical documents at NPS that use  $\text{\LaTeX}$  find that they save time—even when they take into account the time that they spend learning to use  $\text{\LaTeX}$  in the first place!

## 5.1 Reasons to use $\text{\LaTeX}$

There are many reasons to use  $\text{\LaTeX}$  for preparing a technical document:

- Formatting for paragraphs, quotations, lists, tables, and other elements is performed automatically. You can easily make changes to formatting and have them reflected throughout your document. The numbers used for numbered sections are automatically updated when new material is added or removed. As a result, formatting is more consistent with  $\text{\LaTeX}$  than with Microsoft Word.
- References within your document to numbered chapters, appendices, sections, figures, tables, equations and references are updated automatically each time a .pdf file is produced, assuring that they are correct.
- The Bib $\text{\TeX}$  system produces consistent citations and bibliography. References are pulled from a bibliographic database that is separately maintained and can be shared between many documents. Records for the bibliographic database can be downloaded from many

online services, helping to assure that they are consistent. The citation format is maintained separately from the citation contents, making it easy to change citation styles when submitting to different conferences or journals.

- $\text{\LaTeX}$  allows you to directly include other files at the time that the .pdf file is created. This makes it easy to automatically incorporate the results of experiments in tabular or graphical form, without having to manually copy results. Source code for programs can be included with pretty syntax from the original files, and line numbers can be automatically displayed as desired.
- `pdflatex`, the version of  $\text{\LaTeX}$  we recommend at NPS, also allows you to embed other files as attachments within your .pdf file. This makes it easy to preserve experimental data, spreadsheets, or other information in the final file that is distributed to sponsors and archived.
- Because the  $\text{\LaTeX}$  input file is plain ASCII, you can store your document using a revision control system such as Subversion (SVN) [?]. This allows multiple people to work on the same document at the same time; Subversion automatically merges the changes together. If you save your thesis work daily, it is possible retrieve previous revisions of your thesis and undo changes or mistakes—even many months after the fact.
- $\text{\LaTeX}$  is free software and runs on PCs, Macs, and Unix systems. This means that you can produce your documents on practically every computer you have, without having to purchase anything else.

NPS has developed this template for preparing NPS reports and theses. If you are using  $\text{\LaTeX}$  at NPS, there are many reasons for using the template:

- The template has been in use since 2007. Numerous NPS faculty members have worked with the NPS Thesis Processor to assure that the documents produced are acceptable for student and faculty use.
- The template supports the creation of unclassified, For Official Use Only (FOUO), and classified documents. In particular, the template supports classification labels for paragraphs, captions, and references.
- The cover page, signature page, and Standard Form 298 are automatically generated.
- Combined with the Subversion, the template makes it possible for students and their advisors to collaborate on a document without the need to pass files back and forth.

## 5.2 The Purpose of this Document

This document does not duplicate the depth of information available elsewhere on  $\text{\LaTeX}$ , but does provide you with the minimum amount of information required to use  $\text{\LaTeX}$  to produce a master's thesis or technical report at NPS.

If you wish to learn more about  $\text{\LaTeX}$ , there are many good reference books and online tutorials for  $\text{\LaTeX}$ .

We recommend these online resources:

1. <http://en.wikibooks.org/wiki/LaTeX>, a wikibook that discusses many aspects of  $\text{\LaTeX}$ .
2. <http://www.ctan.org/>, the Comprehensive  $\text{\TeX}$  Archive Network, a collection of modules and documentation for extending  $\text{\LaTeX}$ .
3. [http://en.wikipedia.org/wiki/Comparison\\_of\\_TeX\\_editors](http://en.wikipedia.org/wiki/Comparison_of_TeX_editors), a web page on Wikipedia that discusses different programs available for editing  $\text{\LaTeX}$  input files.
4. <http://tex.stackexchange.com/>, a question-and-answer website for  $\text{\TeX}$  and  $\text{\LaTeX}$  problems.

We also recommend these books. They are expensive, but worth it if you wish to become a  $\text{\LaTeX}$  master.

1. Guide to  $\text{\LaTeX}$  (4th Edition), by Patrick W. Daly. This is the comprehensive  $\text{\LaTeX}$  reference which will provide you with an astounding amount of  $\text{\LaTeX}$ -related information. Do not read Lamport's original book, as it is quite out of date.
2. The  $\text{\LaTeX}$  Companion (Tools and Techniques for Computer Typsetting), by Frank Mittelbach, Michel Gossens, Johannes Braams, David Carlisle and Chris Rowley.
3. The  $\text{\LaTeX}$  Graphics Companion, by Michael Gossens, Frank Mittelbach, Sebastian Rahtz, and Denis Roegel.

## 5.3 Installation

Before you can use  $\text{\LaTeX}$ , you will need to install two critical pieces of software:

1. The  $\text{\LaTeX}$  system itself.
2. A program for editing the `.tex` input files.

Here once again there are many options. For both  $\text{\LaTeX}$  and text editors there are both free and commercial distributions. This document makes specific recommendations that were known to work as of the document's date of publication. You are free to explore on your own as well.

### 5.3.1 Installation on MacOS 10.5 and above

The easiest way to get  $\text{\LaTeX}$  operational on a Mac is to download an installer for the most recent distribution from the  $\text{\TeX}$ Users's Group (TUG) at <http://www.tug.org/mactex>.

TUG's Mac $\text{\TeX}$  distribution will install  $\text{\LaTeX}$  in the `/usr/texbin/pdflatex` directory and will update your startup files to include this directory in your path. If you chose this strategy, be sure to click "Customize" in the installer and select all of the optional packages for installation.

You can also install the program from sources using the MacPorts or Fink installer system, but this is not recommended.

If you are using  $\text{\LaTeX}$  on a Mac, you should consider downloading and using *LaTeXiT*, an open-source program that allows you to type  $\text{\LaTeX}$  math and create PDFs for embedding in other applications. The created PDFs have the source  $\text{\LaTeX}$  code embedded, so you can re-edit them in LaTeXiT using the Mac "Services" feature. You may also consider the commercial program *Latexian*, which allows you to type a  $\text{\LaTeX}$  document in one window and see the PDF update in another window as you type.

### 5.3.2 Installing on Linux

For most Linux systems a complete  $\text{\LaTeX}$  distribution can be downloaded as part of the `texlive-latex3` package. This package can be downloaded in source from the <http://tug.org/> website and compiled locally, or installed directly using a package management command. In either case you will need to the installation as the superuser; this is typically done with the `sudo` command.

For Debian and Ubuntu Linux, use the `apt-get` command:

```
% sudo apt-get install texlive-latex3
```

For RedHat and Centos, use the `yum` command:

```
% sudo yum install texlive-latex3
```



We have noticed that the install command occasionally fails. If it fails for you, try it again two or three more times. If that still does not work, you will need to download and install from source.

While the Fedora distribution includes an old version of T<sub>E</sub>XLive from 2007, we don't advise using it. Fortunately, there is an ongoing official project keeping an up-to-date release of T<sub>E</sub>XLive available for Fedora. Directions for installing it are at <http://fedoraproject.org/wiki/Features/TeXlive>. Eventually, this release will be merged back to the main Fedora distribution.

### 5.3.3 Installation on Microsoft Windows

T<sub>E</sub>XLive is the most up-to-date distribution for Windows and can be downloaded from <http://www.tug.org/texlive/>. The distribution includes the T<sub>E</sub>XWorks editor for working with L<sup>A</sup>T<sub>E</sub>X documents. You can also use the T<sub>E</sub>Xlipse plugins for the Eclipse IDE at <http://texlipse.sourceforge.net/>.

Another of the popular distributions for Microsoft Windows machines is called MiK<sub>T</sub><sub>E</sub>X, which can be downloaded from <http://www.miktex.org/>. In most cases, this distribution of L<sup>A</sup>T<sub>E</sub>X will automatically download additional packages if needed. At this time, MiK<sub>T</sub><sub>E</sub>X is lagging T<sub>E</sub>XLive in frequency of updates.

### 5.3.4 Creating classified documents

If you are producing a classified thesis, you should ask a system administrator at the STBL or SCIF to provide you with a L<sup>A</sup>T<sub>E</sub>X installation on a computer authorized to handle classified information. With appropriate approvals you can alternatively set up an installation on a stand-alone machine. In the event that you are missing a package to create your thesis, the .sty files can be copied from the package on the CTAN website into your thesis directory. A system administrator should be consulted on the file transfer process.

## 5.4 Additional Applications for L<sup>A</sup>T<sub>E</sub>X

In addition to downloading and installing L<sup>A</sup>T<sub>E</sub>X, you will need an editor for editing the .tex input files. These programs are sometimes called *front ends*, although the term is imprecise and probably incorrect. You can use *any* editor for editing a .tex file, even Microsoft Word. Indeed, most of the front ends for L<sup>A</sup>T<sub>E</sub>X are really just text editors with syntax highlighting, although

some will automatically compile your document and even jump to errors in the input file when they are encountered.

### 5.4.1 Selection of an Editor

Text editors offer a variety of features. Some are easier for beginners, such as Notepad++, LEd, and TeXnicCenter. Advanced editors for skilled users include emacs, vim, and Texlipse. A thorough comparison of editors is available at [http://en.wikipedia.org/wiki/Comparison\\_of\\_TeX\\_editors](http://en.wikipedia.org/wiki/Comparison_of_TeX_editors). Learning about the various features of the text editors can help you to dramatically improve your writing efficiency.

If you are running L<sup>A</sup>T<sub>E</sub>X on MacOS, you already have a powerful editor installed on your computer: EMACS, which can be run from within the Macintosh Terminal application. You can run the tutorial for EMACS by starting Terminal, typing emacs and enter at the command prompt, and then typing control-h followed by a “t” to start the tutorial.

### 5.4.2 LyX: An alternative L<sup>A</sup>T<sub>E</sub>X system

LyX is a program that provides a WYSIWYG (What You See Is What You Get) graphical user interface for L<sup>A</sup>T<sub>E</sub>X. Instead of editing the .tex file directly, however, you edit an intermediate form which is a restricted set of L<sup>A</sup>T<sub>E</sub>X. LyX then runs L<sup>A</sup>T<sub>E</sub>X for you and produces the results.

While LyX is easier to use than L<sup>A</sup>T<sub>E</sub>X, it does not have the power or the flexibility.

LyX is free and open source and actively supported. LyX provides a GUI interface for floating figures and tables, formatting, fonts, labels, chapters, sections, subsections, math equations, tables, and much more. It also has built-in features for supporting Bib<sub>T</sub>E<sub>X</sub> bibliographies, citations, and cross-references, and generally supports anything that can be done with L<sup>A</sup>T<sub>E</sub>X.

LyX can be downloaded from <http://www.lyx.org/> and is available for Linux, MacOS and Windows. If you want spell-checking, you will also need to install the *aspell* package.

An NPS thesis and dissertation template developed by CDR Michael Bilzor is available for use with LyX. It can be obtained from <http://simson.net/npsthesis/lyxthesis.zip>.

Further information about the LyX template can be found in the Appendix.

## 5.5 Running L<sup>A</sup>T<sub>E</sub>X

The L<sup>A</sup>T<sub>E</sub>X system is actually a set of programs. For creating a thesis at NPS you will use several programs:

`pdflatex` This program reads the input file (e.g., `thesis.tex`) and produces a `.pdf` file (e.g., `thesis.pdf`) as an output. This program also produces a number of intermediate files (`thesis.aux`, `thesis.bbl`, `thesis.toc`, etc.).

`xelatex` is a version of L<sup>A</sup>T<sub>E</sub>X designed to process Unicode used in non-Roman languages. In some cases packages that are designed to work with L<sup>A</sup>T<sub>E</sub>X will not work with `xelatex`, which is why we do not recommend using it unless you have no other choice.

`latex` This is an older version of the `pdflatex` program that produces `.dvi` files. The `.dvi` file must then be transformed into either a `.ps` or a `.pdf` file. In practice you should not run `latex` unless you need to use a special graphics module called PStricks. That module is beyond the scope of this document.

`bibtex` This program reads the `thesis.bbl` file and produces a bibliography in a file called `thesis.bst` which includes the bibliography. The `thesis.bst` then gets read the next time `pdflatex` is run.

`authorindex.pl` This is a program in perl that produces the author index from the `thesis.bbl` file. The `authorindex` is saved in the file `thesis.ain`.

`fixerrors.py` It turns out that there is a bug in BibT<sub>E</sub>X which causes URLs longer than 53 characters to be improperly split. This program unsplit them. It also will correct `authorindex` errors. You do not need to use this program if you do not have these errors.

If you are processing a file *thesis.tex* to create a *thesis.pdf* file, you will typically execute these commands in this order:

1. `pdflatex thesis`
2. `bibtex thesis`
3. `python fixerrors.py thesis`
4. `pdflatex thesis`
5. `pdflatex thesis`

The first run of `pdflatex` creates the file `thesis.aux` (and any other `.aux` files that might be needed). A PDF file is also created, but if you have any backwards references in your document the PDF file will contain incorrect references. The subsequent runs read these `.aux` files and

generate correct back-references. Some editors, such as T<sub>E</sub>Xlipse, will run these commands as needed on behalf of the user. Each command has a thesis argument, which is referring to the file thesis.tex without the .tex file extension. In rare cases it may be necessary to delete the .aux files and re-run the pdf<sub>l</sub>atex command from the beginning.

## 5.6 Basic L<sub>A</sub>T<sub>E</sub>X formatting

Here is a simple L<sub>A</sub>T<sub>E</sub>X document:

```
\documentclass{article}
\begin{document}
Hello World!
\end{document}
```

Normally with L<sub>A</sub>T<sub>E</sub>X, you just type text and leave a blank line between each paragraph. L<sub>A</sub>T<sub>E</sub>X then formats it into beautiful paragraphs. L<sub>A</sub>T<sub>E</sub>X will ignore the space at the beginning of each line.

Here is a slightly more complex document:

```
\documentclass{article}
\begin{document}
In December 1951, in a move virtually unparalleled in the history of
academe, the Postgraduate School moved lock, stock and wind tunnel
across the nation, establishing its current campus in Monterey,
Calif.

    The coast-to-coast move involved 500 students, about 100
    faculty and staff and thousands of pounds of books and
    research equipment. Rear Adm.\ Ernest Edward Herrmann
    supervised the move that pumped new vitality into the
    Navy's efforts to advance naval science and technology.

% This is comment. Nobody will see it.
```

Today the school, known as the ‘‘Naval Postgraduate School,’’ is the

Navy's preeminent institution of graduate education and advanced research. Approximately 1 in 10 of the students are in the top 10\% of their classes.

```
\end{document}
```

L<sup>A</sup>T<sub>E</sub>X will format the above text into a document that looks like this:

In December 1951, in a move virtually unparalleled in the history of academe, the Postgraduate School moved lock, stock and wind tunnel across the nation, establishing its current campus in Monterey, Calif. The coast-to-coast move involved 500 students, about 100 faculty and staff and thousands of pounds of books and research equipment. Rear Adm. Ernest Edward Herrmann supervised the move that pumped new vitality into the Navy's efforts to advance naval science and technology.

Today the school, known as the "Naval Postgraduate School," is the Navy's preeminent institution of graduate education and advanced research. Approximately 1 in 10 of the students are in the top 10% of their classes.

This sample document illustrates a few important points about L<sup>A</sup>T<sub>E</sub>X:

- L<sup>A</sup>T<sub>E</sub>X will automatically re-wrap your text as necessary to format the paragraphs. Indentation is determined by the style of the current document, not by whether or not you actually indent the paragraph.
- L<sup>A</sup>T<sub>E</sub>X ignores space at the beginning of lines; breaks between paragraphs are marked with blank lines.
- What you type is not what you get! In particular, opening double quote marks are typed as two backquotes (‘ ‘) and closing double quote marks are entered as two apostrophes (’ ’). You will also note that the period following Rear Adm. Ernest Edward Herrmann's name is followed by a backslash (\) and a space, rather than just a space. This tells L<sup>A</sup>T<sub>E</sub>X that the period does not mark the end of a sentence.
- Commands begin with a backslash (\) and contain only uppercase and lowercase letters.
- A command can have zero or more arguments. The arguments are enclosed within braces ({}). The \documentclass command begins the document; its argument is the kind of document you are making.
- The \begin command introduces an *environment*. Every document has at least one environment, the document environment. Every \begin must have a matching \end that

names the same environment. Environments can be nested.

- Comments can be embedded in your document with a percent sign (%). Anything after the percent sign will not print. To print a percent sign, prefix it with a backslash (\%).

## 5.7 Typing Special Characters

This section provides information on how to type special characters in L<sup>A</sup>T<sub>E</sub>X. In each section we will have a table that shows what to type and how it displays in your final .pdf file. If the above text were put into a table, it would look like this:

Typed	Displayed	Typed	Displayed
‘ ‘	“	, ,	”

The left entry of the table is the backquotes, which shares the tilde key on the US keyboard. The right entry is the single quotes, which shares the double quote marks key.

### 5.7.1 Typing Quotes

To type quotes, you should not use the double-quote character. Instead, use the back quote (‘) and the forward quote (’) to type quotes:

Typed	Displayed	Typed	Displayed
don’t	don’t	3’2’	3’2”
‘ ‘this’ ’	“this”	‘is’	‘is’
‘ ‘\, ‘special’ \, ’ ’	“ ‘special’ ”		

### 5.7.2 Controlled Special Characters

Unlike Microsoft Word and other programs, L<sup>A</sup>T<sub>E</sub>X uses special characters embedded in your text to control formatting. The most common of these characters is the backslash (\). All of special characters are listed below:

Special Character	Why it is special
\	Introduces a command
{	Introduces arguments in commands or the start of a group
}	Closes arguments in commands or the end of a group
%	The comment character; $\text{\LaTeX}$ ignores the rest of the line
#	Used for parameter substitution inside macros
~	Enters a hard, non-breaking space
&	Used for delimiting columns in a table
\$	Turns on/off math mode (see §??)
_	Used for subscript in math mode
^	Used for superscript in math mode

To enter the special characters into your document you must use a special sequence that begins with a backslash. Most (but not all) of these special sequences are the character itself. If you are curious, inside  $\text{\LaTeX}$ , each of these sequences is implemented as a command that causes  $\text{\LaTeX}$  to output the character that has been quoted:

Typed	Displayed	Typed	Displayed
\\$	\$	\&	&
\{	{	\}	}
\%	%	\_	_
\#	#	\^{}	^
\~{}	~	\$\backslash\$	\

### 5.7.3 Accented, Dotless and Slashed Vowels

With  $\text{\LaTeX}$  most accented vowels are entered with a combining accent character and a vowel, although some (such as the angstrom symbol) are not, as shown below:

Typed	Displayed	Typed	Displayed
<code>\' {o}</code>	ó	<code>\~ {o}</code>	õ
<code>\' {o}</code>	ó	<code>\= {o}</code>	ō
<code>\^ {o}</code>	ô	<code>\. {o}</code>	ò
<code>\" {o}</code>	ö	<code>\d {o}</code>	ơ
<code>\c {o}</code>	ơ	<code>\u {o}</code>	ố
<code>\b {o}</code>	ơ		
<code>\aa</code>	å	<code>\AA</code>	Å
<code>\i</code>	ı	<code>\j</code>	■
<code>\o</code>	ø	<code>\O</code>	Ø
<code>\ae</code>	æ	<code>\AE</code>	Æ
<code>\oe</code>	œ	<code>\OE</code>	Œ
<code>\v {o}</code>	ů	<code>\H {o}</code>	ħ
<code>\t {oo}</code>	ö		

Note that `\i` displays a dotless i while `\j` displays a dotless j. Some fonts do not have some of these characters, and display a black box instead.

#### 5.7.4 Symbols

L<sup>A</sup>T<sub>E</sub>X has literally hundreds of symbols that you can include in your document. These symbols include the copyright symbol, currency symbols, foreign language characters, and many more. The symbols are placed in documents using macros, allowing a plain text document to support a large variety of non-standard text characters. A complete guide to the available symbols in L<sup>A</sup>T<sub>E</sub>X is available online at <http://mirror.ctan.org/info/symbols/comprehensive/symbols-letter.pdf>.

Here are some of the most common symbols you are likely to need for an NPS document:



Typed	Displayed	Typed	Displayed
<code>\l</code>	ł	<code>\L</code>	Ł
<code>\S</code>	§	<code>\ss</code>	ß
<code>\P</code>	¶	<code>\pounds</code>	£
<code>?‘</code>	¿	<code>\copyright</code>	©
<code>!‘</code>	¡	<code>\texttrademark</code>	™
<code>\euro</code>	€	<code>\textregistered</code>	®
<code>\dag</code>	†	<code>\ddag</code>	‡

(Note: The `\euro` command requires that the command `\usepackage{eurosym}` be part of the document’s *preamble* (the part before the `\begin{document}`). It is included as part of the `npsreport.cls` file.)

## 5.8 Fonts

Like Microsoft Word, L<sup>A</sup>T<sub>E</sub>X makes it easy to alter font, size, face, and weight of text. But unlike Word, these changes are typically done in a structured manner that lends itself to creating documents that have consistent font usage throughout.

### 5.8.1 Changing Font Size

Although L<sup>A</sup>T<sub>E</sub>X allows you to use fonts of any size, the built-in templates provides eleven built-in sizes. These sizes automatically adjust depending on if you are creating a document with 12-point font (NPS standard), 11-point font, or 10-point font.

When you change the font size, that change stays in effect until you change it again. You can confine your font change by placing the text you want resized within braces, sometimes called a *group* or a *block*, as shown in the examples in the following table:

Size	Point Size	Typed	Displayed
<code>\tiny</code>	6	<code>{\tiny This is tiny}</code>	<small>This is tiny</small>
<code>\scriptsize</code>	8	<code>{\scriptsize scriptsize}</code>	<small>scriptsize</small>
<code>\footnotesize</code>	10	<code>{\footnotesize footnotesize}</code>	<small>footnotesize</small>
<code>\small</code>	11	<code>{\small This is small}</code>	<small>This is small</small>
<code>\normalsize</code>	12	<code>{\normalsize normalsize}</code>	<small>normalsize</small>
<code>\large</code>	14	<code>{\large This is large}</code>	<b>This is large</b>
<code>\Large</code>	17	<code>{\Large Large}</code>	<b>Large</b>
<code>\LARGE</code>	20	<code>{\LARGE LARGE}</code>	<b>LARGE</b>
<code>\huge</code>	25	<code>{\huge huge}</code>	<b>huge</b>
<code>\Huge</code>	25	<code>{\Huge Huge}</code>	<b>Huge</b>

Notice that with the NPS template there is no difference between `\huge` and `\Huge`.

You can also pick an arbitrary size by using the `\fontsize` and `\selectfont` commands. The `\fontsize` command takes two arguments: the size of the font and the size of the leading, or the amount of space between lines. First the size is selected with the `\fontsize{i}{j}` command where *i* and *j* are expressed in points (there are 72.27 points in an inch). Next the font is selected with the `\selectfont` command, as shown below:

Typed	Displayed
<code>{\fontsize{4}{5}\selectfont very tiny}</code>	<small>very tiny</small>
<code>{\fontsize{64}{64}\selectfont Big}</code>	Big

## 5.8.2 Changing Font Style

L<sup>A</sup>T<sub>E</sub>X provides these macros for selecting font styles:

Typed	Displayed
<code>\textrm{This is Roman}</code>	This is Roman
<code>\textbf{This is bold}</code>	<b>This is bold</b>
<code>\texttt{This is typewriter}</code>	This is typewriter
<code>\textsc{This is small capitals}</code>	THIS IS SMALL CAPITALS
<code>\textsl{This is slanted}</code>	<i>This is slanted</i>
<code>\textsf{This is sans serif}</code>	This is sans serif
<code>\textit{Italics}</code>	<i>Italics</i>
<code>\emph{This is emphasized}</code>	<i>This is emphasized</i>
<code>\$\cal CALLIGRAPHICS\$</code>	<i>CALLIGRAPHICS</i>
<code>{\boldmath \$\cal BOLD CALIGRAPHICS\$}</code>	<b><i>BOLD CALIGRAPHICS</i></b>

Notice that the last two are surrounded by dollar signs as they require math mode (see §??).

If you just want to put something into italics, you should use `\emph{text}`, which will produce *text*. The reason to use `\emph{}` and not `\textit{}` is that `\emph{}` will nest as necessary. For example, this:

```
\emph{You can even \emph{emphasize} a word within a sentence
that is emphasized.}
```

typesets as this:

*You can even emphasize a word within a sentence that is emphasized.*

As you should in general avoid underlining text, we will not show you how to do it in this document.

### 5.8.3 Choosing an Arbitrary Font

There are many ways that you can request arbitrary fonts for small sections of your document, but they are all beyond the scope of this article. It is also possible to embed arbitrary Unicode within a  $\text{\LaTeX}$  document, either by using the Unicode-aware version of  $\text{\LaTeX}$  called  $\text{\XeTeX}$  (`xelatex`), or by saving your Unicode characters in a `.pdf` file and including that file with the `\includegraphics{}` command (as we did with the  $\text{\XeTeX}$  logo).

If you want to change the font for an entire document, please refer to the  $\text{\LaTeX}$  Font Catalogue at <http://www.tug.dk/FontCatalogue/> which provides documentation and examples. To change the font of the NPS template, refer to §??.

## 5.9 Math

Typesetting mathematics is one of the primary design goals of  $\text{\LaTeX}$ . The program has more features for typesetting math than typesetting text. There is also a powerful set of mathematical extensions by the American Mathematical Society called `amsmath`. For more detailed information, please see:

- The  $\text{\LaTeX}$  wikibook, <http://en.wikibooks.org/wiki/LaTeX/Mathematics>.
- The User's guide for the `amsmath` package is available at: <ftp://ftp.ams.org/ams/doc/amsmath/amslatex.pdf>
- The short math guide, available at <http://tinyurl.com/63w3mnu>.

What follows here is necessarily very brief.

### 5.9.1 Math Mode

To typeset math you must enter math mode. There are two easy ways to enter math mode.

- You can put your math between two dollar signs. For example, entering `$1+1=2$` in your document will produce  $1 + 1 = 2$ .
- You can put the equation on a line by itself in an *equation* environment (e.g., between `\begin{equation}` and `\end{equation}` commands). An equation environment creates a block that is typeset in math mode and includes a numbered equation. For example, this:

```
\begin{equation}
1+1=2
\end{equation}
```

produces this:

$$1 + 1 = 2 \qquad (5.1)$$

Math mode can also be used in paragraphs to add special math characters, such as the  $\pi$  symbol (using `\pi` here). In fact, many of the symbols that  $\text{\LaTeX}$  displays can only be displayed while in math mode.

## 5.9.2 Simple Math in Math Mode

As the examples above show, you can type simple math in math mode and get what you want. In general, variables (the letters a through z), the plus (+), minus (-) and equals (=) all typeset properly when you type them between dollar signs. But there are some caveats:

- If you wish to typeset a multiplication symbol, use `\times` instead of an asterisk (\*).
- If you wish to typeset division, use `\div` to enter a division symbol or the `\frac` command to create a fraction. Do not use / for division.
- Spaces are ignored in math mode. If you want a space, you probably should use multiple equations, with each equation in math mode but with a non-math mode space between them.

The table below shows some examples:

Typed	Displayed	Comments
<code>\$1+2=3\$</code>	$1 + 2 = 3$	
<code>\$10 * 10 = 100\$</code>	$10 * 10 = 100$	Don't use asterisks for multiplication.
<code>\$10\times10=100\$</code>	$10 \times 10 = 100$	Spaces don't matter
<code>\$10 \times 10 = 100\$</code>	$10 \times 10 = 100$	
<code>\$a=3\$</code>	$a = 3$	
<code>\$a=f/m\$</code>	$a = f/m$	Don't use the slash for division.
<code>\$a=f \div m\$</code>	$a = f \div m$	
<code>\$a=\frac{f}{m}\$</code>	$a = \frac{f}{m}$	
<code>\$f(x)=3x\$</code>	$f(x) = 3x$	
<code>\$a=2b\$ and <code>\$a+2=b+4\$</code></code>	$a = 2b$ and $a + 2 = b + 4$	

Use math mode when you need to enter math—it's worth the effort. For example, consider a function of  $t$ . You can certainly type this without math mode—witness  $f(t)$ —but doesn't it look much better when dollar signs are placed around the symbol, like this:  $f(t)$ ? Math mode adds clarity.

If you wish to discuss an important equation in your document, use the *equation* environment. This environment sets your equation off from the body text and gives it a number.

Using the equation environment, this:

```
\begin{equation}
a = 1+2
\end{equation}
```

typesets as:

$$a = 1 + 2 \tag{5.2}$$

### 5.9.3 Superscripts and subscripts

In math mode the caret (^) is used for superscript and the underbar (\_) is used for subscript (this is why the characters are special). The commands only superscript or subscript the following

character; if you want to superscript or subscript multiple characters you need to make them a group by enclosing them in braces.

Here are some examples:

Typed	Displayed
<code>\$a^2+b^2=c^2\$</code>	$a^2 + b^2 = c^2$
<code>\$2^{\{16\}}=65,535\$</code>	$2^{16} = 65,535$
<code>\$N_A\$ is Avogadro's constant</code>	$N_A$ is Avogadro's constant
<code>\$A^{\{B^C\}}\$</code>	$A^{B^C}$
<code>\$A^{\{B^{\{C^D\}}\}}\$</code>	$A^{B^{C^D}}$
<code>\$a_k\$ and \$b_k\$</code>	$a_k$ and $b_k$
<code>\$a_k\$ and \$b_k\$</code>	$a_k$ and $b_k$

### 5.9.4 Combining Symbols in Groups

Many math symbols use subscripts and superscripts to determine placement of specific equation elements. This includes `\int` which is used to create integrals and `\sum` which is used to create sums. Below are some examples with the Fourier series.

Typed	Displayed
<code>\$a_k=\frac{1}{\pi}\$ <code>\int_{-\pi}^{\pi}f(x)\cos(kx)dx\$</code></code>	$a_k = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \cos(kx) dx$
<code>\$b_k=\frac{1}{\pi}\$ <code>\int^{\pi}_{-\pi}f(x)\sin(kx)dx\$</code></code>	$b_k = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \sin(kx) dx$
<code>\$f(x)=\sum_{k=-\infty}^{\infty}\$ <code>c_k e^{-jkx}\$</code></code>	$f(x) = \sum_{k=-\infty}^{\infty} c_k e^{-jkx}$

The `\sum` and `\int` symbols display these elements differently in an *equation* environment:

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} [a_n \cos(nx) + b_n \sin(nx)] \quad (5.3)$$

We used this code to type Equation (??):

```
\begin{equation}
f(x)=\frac{a_0}{2} + \sum_{n=1}^{\infty}
\left[a_k \cos(kx) + b_k \sin(kx)\right]
\label{fourier}
\end{equation}
```

There are several important math mode conclusions to draw from these examples:

- Simple one letter subscripts and superscripts do not need to be enclosed by curly braces, but multiple character ones must.
- Subscripts and superscripts in math mode are to the right of the sum and integral characters; however, in the equation environment they are above and below. In the other uses (exponentials, etc.), the results are the same in either mode.
- The order of appearance of subscript than superscript or vice versa does not change the results.

The amsmath package has additional environments, symbols and commands such as provisions for non-numbered, multiple-lined and aligned equations. Its user guide is an excellent reference and provides many examples.

Although math mode may seem cumbersome at first, its syntax does become second nature and very sophisticated equations can be generated, if needed. Consult the user manuals and references provided in §??.

### 5.9.5 Parenthesis and Brackets

You can use regular parentheses in math mode, but they do not stack nicely:

Typed	Displayed
$\$((1))\$$	$((1))$
$\$[((1))]\$$	$[[((1))]]$

You probably want the outer brackets and parenthesis to be bigger than the inner ones. You can do that using the `\left` and `\right` commands. Following these macros is another character,



such as a parenthesis or bracket. These macros place the correctly sized specified character into the equation. They will automatically get bigger as necessary, especially in the *equation* environment.

For example, here is what you get with the conventional parenthesis:

```
\begin{equation}
A = ( \sum_{i=1}^{10} i \times \sin(i) )
\end{equation}
```

$$A = \left( \sum_{i=1}^{10} i \times \sin(i) \right) \quad (5.4)$$

And here is an example using `\left` and `\right`:

```
\begin{equation}
A = \left( \sum_{i=1}^{10} i \times \sin(i) \right)
\end{equation}
```

$$A = \left( \sum_{i=1}^{10} i \times \sin(i) \right) \quad (5.5)$$

This example seems silly, but shows how powerful `\left` and `\right` are:

```
\begin{equation}
\left(\frac{
\left(\frac{1}{2}\right)\{
\left(\frac{3}{4}\right)
\}\right)
\end{equation}
```

Produces this:

$$\left(\frac{\left(\frac{1}{2}\right)}{\left(\frac{3}{4}\right)}\right) \quad (5.6)$$

## 5.10 Spacing, Frameboxes, and Centering

L<sup>A</sup>T<sub>E</sub>X has a number of commands for controlling space, creating boxes, and centering text.

### 5.10.1 Controlling Spaces

You can use these commands for controlling how much space is inserted between words:

Typed	Displayed
<code>\,</code> (a slash followed by a comma)	produces a small space.
<code>\ </code> (a slash followed by a space)	produces a standard word space.
<code>\@</code> (a slash followed by an at sign)	produces an intersentence space.

The small space and standard word space are used between the words in the right column. An intersentence space is needed to correct the following error where a sentence ends in a capital letter.

### 5.10.2 Suppressing Orphans and Widows

When typesetting, paragraphs that have their last line on the following page are called *orphans*, and paragraphs that begin at the bottom of a page with a single line are called *widows*. Orphans and widows are considered ugly. Microsoft Word can be programmed to prevent widows and orphans by requiring that all paragraphs have at least 2, 3 or 4 lines on a page. Microsoft Word achieves this desired result by inserting spaces between paragraphs to balance out the page as necessary. L<sup>A</sup>T<sub>E</sub>X has no automatic control over orphans and widows. It is one of the major failings of the system.

NPS students working on their Master's thesis are frequently instructed by the Thesis Processor to modify their document so that there are no widows or orphans. One way to achieve such a result is to rewrite the text by inserting sentences or removing them. This may seem excessive to you. Another way you can control widows and orphans is by manually adding or removing space, or by stretching a page to allow additional lines on it.

You can force a blank line using `\\` and have the option to force a specific length using `\\[3pt]`:

Typed	Displayed
<code>This is\\ an example.</code>	This is an example.
<code>This is\\[3pt] an example.</code>	This is an example.

You can add or remove space on a page with the `\enlargethispage` command. For example, to squeeze another line onto the current page, insert this command onto the page:

```
\enlargethispage{1pc}
```

This command is useful when you need to manually enlarge a page so that the last line of a paragraph can fit on the present page without being pushed to the next page.

You can shorten a page by a line, forcing a widow onto the next page:

```
\enlargethispage{-1pc}
```

These commands are also useful when writing a conference paper that needs to fit within a certain page length.

### 5.10.3 Frameboxes and Centering

You can draw a box around text with:

```
\framebox[width]{textstring}
```

The `[width]` parameter is optional. Without it, the box defaults to the minimum size necessary to hold the `textstring`.

Here are an example to show what we mean. This text:

```
\framebox{This is an important statement.}\\
\framebox[15pc]{This is an important statement.}\\
\framebox[30pc]{This is an important statement.}
```

will typeset as this:

This is an important statement.
This is an important statement.
This is an important statement.

If you provide a space that is too small, the results will be ugly:

```
\framebox[5pc]{This is an important statement.}
```

This is an important statement.

You can center any text, table, figure, etc. with the *center* environment, using the following:

```
\begin{center}  
\framebox{$a^2 + b^2 = c^2$}  
\end{center}
```

Produces this:

$$a^2 + b^2 = c^2$$

If you are entering a number of equations in your document, you may want to use the *equation* environment, which will provide numbered equations:

```
\begin{equation}  
a^2 + b^2 = c^2  
\end{equation}
```

$$a^2 + b^2 = c^2 \tag{5.7}$$

Unlike many things in  $\text{\LaTeX}$ , the *framebox* and *equation* environments cannot be readily combined. That's because `\fbox` turns off math mode, so you need to manually turn it back on.

Type this:

```
\begin{equation}
\fbbox{$a^2 + b^2 = c^2$}
\end{equation}
```

To produce this:

$$\boxed{a^2 + b^2 = c^2} \quad (5.8)$$

## 5.11 Lists

There are three kinds of lists that you may wish to make:

**description** lists are used for definitions, where a short phrase is bolded and the remainder text is the standard font (like this list).

**enumerate** lists are lists where each item is numbered and the ordering is relevant, like the steps of a recipe.

**itemize** lists are lists where each item is of equal importance.

Lists are implemented as  $\text{\LaTeX}$  environments, which means that they begin with a `\begin{listname}` and end with an `\end{listname}`.

```
\begin{description}
\item[Earth] Third Planet.
\item[Mars] Fourth Planet.
\item[Venus] Second Planet.
\end{description}
```

**Earth** Third Planet.  
**Mars** Fourth Planet.  
**Venus** Second Planet.

```
\begin{enumerate}
\item Wake up.
\item Go to work.
\item Go home.
\item Go to sleep.
\item Repeat.
\end{enumerate}
```

1. Wake up.  
2. Go to work.  
3. Go home.  
4. Go to sleep.  
5. Repeat.

```

\begin{itemize}
\item Hamburgers
\item Hotdogs
\item Chips
\end{itemize}

```

- Hamburgers
- Hotdogs
- Chips

## 5.12 Labels and Captions

Labels are hidden markers in your .tex files created by the `\label{name}` command. These markers are never shown directly in the output files. However, correctly placing these markers in your file allows you to reference chapters, appendices, sections, figures, tables and equations. You may wish to give your marker names prefixes such as `chap:`, `sec:`, `fig:`, `tab:` and `eqn:` to logically identify the labels.

Captions are the text that appears below a figure or table to provide context for the information presented. Captions are indicated by the command `\caption{Sentence.}` Sometimes longer captions can look poorly in the Lists of Figures and Tables, so a caption for the table can also be specified by using `\caption[Short Sentence.]{Longer Sentence.}`

## 5.13 Tables

Tables provide a valuable means to display data in an organized manner. Using tables in  $\text{\LaTeX}$  is easy once the syntax is understood, although tables can be incredibly complex as well. To see plenty of examples and explanation of options, visit <http://en.wikibooks.org/wiki/LaTeX/Tables>. There are also *many* add-on packages which provide additional functionality.

Here is a very simple table:

```

\begin{center}
\begin{tabular}{cc}
Shape & Sides \\
\hline
Triangle & 3 \\
Square & 4 \\
\end{tabular}
\end{center}

```

Produces this:

Shape	Sides
Triangle	3
Square	4

This table has six things we have not seen before:

1. The `{cc}` is the table format specifier. Each “c” represents a column that is centered.
2. The `&` is used to separate columns of the table.
3. The `\\` is used to separate rows of the table.
4. The `\hline` is used to draw a horizontal line.
5. The table is drawn in a tabular environment.
6. The center environment is used to center the table.

Here is a slightly more complex table:

```
\begin{center}
\begin{tabular}{lcr}
Left Justified & Center Justified & Right Justified \\
\hline
Each & Column & Entry \\
Spaces & Do not & Matter \\
But & May & Assist you. \\
\end{tabular}
\end{center}
```

And here is how it formats:

Left Justified	Center Justified	Right Justified
Each	Column	Entry
Spaces	Do not	Matter
But	May	Assist you.

This table has three columns as identified by the format specification `lcr`. The first column is left-justified (“l”), the middle column is center justified (“c”) and the third column is right justified (“r”). The left side of the table has a vertical bar due to the pipe character (|). The `\hline` macro causes a horizontal line to be drawn across the table. Columns are indicated by the ampersands (&) and the amount of spaces used are not important. Thus, the spaces can be used to ensure your columns line up in your .tex file the way the table is intended to print. An empty cell is just ampersands separated by a space. To start a new row of the table, use the double backslash (\\); this can be done at the end of the current row.

Below is a more complex table:

```
\begin{center}
\begin{table}
\begin{tabular}[t]{l|l|r|r|r|r|r|r|r|}
\hline
Pulse  & Pulse  & PRF & Duty  & Coupler & Power & Average & Peak  & \\
Width  & Length &      & Cycle & Losses  & Meter & Power   & Power & \\
\hline
Long   & $1.0 * 10^{-6}$ s & $ & 750 Hz & $7.0 * 10^{-4}$ $ & & & & \\
        & 49.1 dB & 3.4 dBm & 52.5 dBm & 73 dBm & & & & \\
& & & 31.075 dB & & & 43 dBW & & \\
& & & & & & 227.7 kW & & \\
\hline
Medium & $3.0 * 10^{-7}$ s & $ & 1200 Hz & $2.0 * 10^{-4}$ $ & & & & \\
        & 49.1 dB & 0 dBm & 49.1 dBm & 83 dBm & & & & \\
& & & 34.29 dB & & & 53 dBW & & \\
& & & & & & 218.27 kW & & \\
\hline
Short  & $1.0 * 10^{-7}$ s & $ & 2400 Hz & $1.9 * 10^{-4}$ $ & & & & \\
        & 49.1 dB & -1 dBm & 48.1 dBm & 83 dBm & & & & \\
& & & 35.05 dB & & & 53 dBW & & \\
& & & & & & 206 kW & & \\
\hline
\end{tabular}
\end{center}
```



And here is the formatted table:

Pulse Width	Pulse Length	PRF	Duty Cycle	Coupler Losses	Power Meter	Average Power	Peak Power
Long	$1.0 * 10^{-6} s$	750 Hz	$7.0 * 10^{-4}$ 31.075 dB	49.1 dB	3.4 dBm	52.5 dBm	73 dBm 43 dBW 227.7 kW
Medium	$3.0 * 10^{-7} s$	1200 Hz	$2.0 * 10^{-4}$ 34.29 dB	49.1 dB	0 dBm	49.1 dBm	83 dBm 53 dBW 218.27 kW
Short	$1.0 * 10^{-7} s$	2400 Hz	$1.9 * 10^{-4}$ 35.05 dB	49.1 dB	-1 dBm	48.1 dBm	83 dBm 53 dBW 206 kW

## 5.14 Graphics

This section briefly describes how to embed graphics in a  $\LaTeX$  document. For alternative treatments we recommend Höppner’s “Strategies for including graphics in  $\LaTeX$  documents” [?], and the book *The LaTeX Graphics Companion* [?].

Graphics are embedded using the `\includegraphics` command. It looks like this:

```
\includegraphics[options]{filename}
```

Typical options that you can use are `width=XX` or `height=XX`. For example, to include an image, have it centered, and scale it to 3 inches, use this:

```
\begin{figure}
  \begin{center}
    \includegraphics[width=3in]{imagedirectory/file}
    \caption{Caption of the important figure.}
    \label{fig:importantfigure}
  \end{center}
\end{figure}
```

The `imagedirectory/file` notation indicates the images are in a subdirectory of `imagedirectory` and the file name is `file`. The file extensions (`.jpg`, etc.) are optional.

*Note:  $\LaTeX$  does not properly include graphics that have periods in their filenames in addition to the period that is used to denote the file type!*

There are two kinds graphics that you can include in a  $\LaTeX$  document:

**Vector graphics** are excellent for printing purposes. These images show up nicely on the computer screen and paper. The computer renders these dynamically. Several tools to generate vector graphics include Inkscape and asymptote. In general, you should convert vector graphics to a `.pdf` file and embed it in your document using `\includegraphics`.

**Raster graphics** include `.bmp`, `.jpg`, `.png`, and `.gif` images. Formats without compression, including `.bmp` files generally will make your thesis file much larger. Some of these images show up poorly or pixelated in print copy. You should convert these files to `.jpg` or `.png` and embed them in your document with `\includegraphics`.

Graphics can also be created with R, gnuplot, matplotlib, or the asymptote package.

Specific macros for including graphics provided by the `npsreport` template are discussed in Section ??.

## 5.15 Bib $\TeX$ and Citations

Bibliography and citation are important in your thesis. Each department has different expectations on citation styles. Even if you select the wrong style initially, changing the format to the correct option is only a one-line change for  $\LaTeX$ —unlike a complete nightmare for Microsoft Word users.

See [http://en.wikibooks.org/wiki/LaTeX/Bibliography\\_Management](http://en.wikibooks.org/wiki/LaTeX/Bibliography_Management) and <http://stefaanlippens.net/bibentry> for more information on Bib $\TeX$ .

Many common citation reference organizers and websites output Bib $\TeX$  formatted citations in `.bib` files. This is a time saver, as rather than retyping information, you can download the `.bib` file and copy its contents into your thesis master `.bib` file. The master `.bib` file contains all of your citations, even ones that you have not yet cited. When you reference these citations in your thesis, Bib $\TeX$  can generate the references list for you. To cite a specific reference use the `\cite{name}` command. After your first run of `pdflatex`, you follow with the `bibtex`

command as in §??.

## 5.16 Going Further

You are now on your way to becoming a  $\text{\LaTeX}$  expert and will find that many of the  $\text{\LaTeX}$  modules are already installed with your  $\text{\LaTeX}$ . You may find the following packages useful:

**multirow** Allows a single table cell to extend to multiple rows.

**ifthen** Allows you to put conditions in your thesis. It is a bit easier than using the `if` that's built in to  $\text{\TeX}$ .

**acronym** A great package for automatically generating acronym lists. It can track the usage of acronyms to correctly use the long name of the acronym on its first use.

**makeidx** For creating an index of key words and phrases in your document and what page the keywords appear on.

**mcode** Places a MATLAB `.m` file contents directly into the output. The package performs syntax highlighting and line numbering if desired. This package is not in the CTAN and documentation may be obtained from the MATLAB Central website at <http://tinyurl.com/3wgcufr>.

In learning about  $\text{\LaTeX}$ , you are likely to do searches on the Internet, learn about a new package, and want to learn more about it. You will probably be surprised to find that many of these packages are already part of your  $\text{\LaTeX}$  distribution. In most cases, the documentation for the packages is already on your hard drive as a `.pdf` file. We recommend reading package documentation; the documentation frequently has better information than the random pages you may find by using Google.

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## CHAPTER 6:

# The NPS Thesis Template

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Now that you know the basis of  $\text{\LaTeX}$ , this chapter will give you information on how to typeset your thesis with the NPS thesis template.

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# CHAPTER 7:

## The NPS L<sup>A</sup>T<sub>E</sub>X Template Package

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This chapter describes how to get the NPS report template and how to use it.

### 7.1 Getting the Template

Get a copy of the `npsthesis.zip` distribution from <http://simson.net/npsthesis/npsthesis.zip>. Unpack this into a directory on your computer. This is where we will be working for the remainder of this chapter.

#### 7.1.1 L<sup>A</sup>T<sub>E</sub>X Files Included in the Template Package

Below you will find the important files in the package.

These files are used for all document types:

**Makefile** The Makefile to make the thesis

**appendix1.tex** The example file for an appendix.

**authorindex.\*** The L<sup>A</sup>T<sub>E</sub>X authorindex package, for making the Referenced Authors page.

**chapter1.tex** The example file for each chapter.

**chngcntr.sty** The `chngcntr` package, for changing the way that L<sup>A</sup>T<sub>E</sub>X displays its counters.

**fixerrors.py** A python program that removes the breaks in the `.bbl` file inserted by Bib<sub>T</sub>E<sub>X</sub> and improper authorindex items.

**npsreport.cls** The style class file for NPS documents.

**nps-plain.bst** A Bib<sub>T</sub>E<sub>X</sub> style file that makes references in a style that is acceptable to NPS for which the references appear sorted by author's last name.

**nps-plain-unsorted.bst** A Bib<sub>T</sub>E<sub>X</sub> style file that makes references in a style that is acceptable to NPS for which the references appear in the order of appearance.

**nps-plain-classified.bst** A Bib<sub>T</sub>E<sub>X</sub> style file that makes references in a style that is acceptable to NPS for a classified thesis. References are sorted by last name.

**nps-plain-classified-unsorted.bst** A Bib<sub>T</sub>E<sub>X</sub> style file that makes references in a style that is acceptable to NPS for a classified thesis. References appear in the order of appearance.

**nps\_logo\_3clr\_cymk.pdf** NPS Logo, 3 color, in format suitable for printing

**thesis.tex** A skeletal thesis L<sup>A</sup>T<sub>E</sub>X template file

**thesis.bib** A skeletal thesis bibliography file

These files are skeletal files for creating your own documents. Use them as a template by removing our text and inserting your own:

**thesis.tex** A one-author thesis.

**thesis\_two.tex** A two-author thesis.

**thesis\_coadvisors.tex** A one-author thesis with two co-advisors.

**thesis.bib** A thesis BiB<sub>T</sub><sub>E</sub>X input file.

You will also find `techreport.tex`, which is the L<sup>A</sup>T<sub>E</sub>X source code for this document.

### 7.1.2 L<sup>A</sup>T<sub>E</sub>X Demonstration Files

In addition to the files in the `npsthesis.zip` file, we have made available a set of demonstration documents. These can be downloaded from <http://simson.net/npsthesis/demos.zip> and includes the following files:

**demo\_classified.tex** A demonstration classified master's thesis that shows how to use all of the macros we have created for labeling classified paragraphs, figures and references. To avoid confusion, this document is classified F//MM//SPECIAL//TOM FOOLERY (F is for Fun).

**demo\_fouo.tex** A demonstration For Official Use Only thesis. To avoid confusion this document is classified For Entertainment Use Only (FEUO).

**demo\_phd.tex** A demonstration PhD thesis.

**demo\_report.tex** A demonstration technical report.

**demo\_thesis.tex** A demonstration master's thesis.

**demo\_traditional.tex** A demonstration thesis in the traditional NPS master's thesis style.

**demo\_twoauthor.tex** A demonstration master's thesis with two authors.

## 7.2 Creating Your Document

The skeletal `thesis.tex` file consists of two main parts: the *prologue* (everything before the `\begin{document}`) and the *body* (everything between the `\begin{document}` and the `\end{document}`). The body is further split into two parts: the main body and the postmatter (the appendices, bibliography, and distribution list). You will typically create your thesis or technical report by editing each. Some students put their entire thesis into the `thesis.tex` file, while others put each chapter into its own `.tex` file and include them using the `\include{filename.tex}` command.



The remainder of this section will show a skeletal thesis template for each of these three parts (the prologue, the main body and the postmatter), and then will explain the purpose of each command.

### 7.2.1 The Thesis Prologue

Below is the thesis prologue from the `thesis.tex` file, with all of the comments removed:

```
\documentclass[twoside,thesis,authorindex]{npsreport}
\securitybanner{}
\title{[TITLE]}
\author{[AUTHOR]}
\degree{Master of Science in [DEGREE]}
\degreeabbreviation{MS}
\department{Department of [DEPARTMENT]}
\thesisadvisor{[ADVISOR]}
\secondreader{[SECOND READER]}
\departmentchair{[DEPARTMENT CHAIR]}
\rank{[RANK]}
\prevdegrees{[UNDERGRADUATE DEGREE]}
\degreedate{[DEGREE DATE]}
\distribution{Approved for public release; distribution is unlimited}
\abstract{
  [INSERT ABSTRACT HERE]
}
\ReportType{Master's Thesis}
\DatesCovered{2102-06-01---2104-10-31}
\SponsoringAgency{Department of the Navy}
\RPTpreparedFor{}
\ReportClassification{Unclassified}
\AbstractClassification{Unclassified}
\PageClassification{Unclassified}
\SupplementaryNotes{ The views expressed in this thesis are those of
  the author and do not reflect the official policy or position of the
  Department of Defense or the U.S. Government.
  \footnotesize IRB Protocol Number: XXXX}
\SignatureOne{\includegraphics[width=2in]{signature_picture}}
```

`\makeatletter\@removefromreset{footnote}{chapter}\makeatother`

The following explains each of these commands and options:

### **`\documentclass`**

The `documentclass` specifies that the document uses the `npsreport.cls` file and all settings contained therein. There are several optional parameters, each separated by comma:

**article, thesis, or dissertation** choose the appropriate one for the case.

**12pt, 11pt, or 10pt** Font size selection. With no option given, 12pt is the default.

**times, arial, or courier** Font selection. With no option given, times is the default.

**twoauthors, threeauthors, or fourauthors** use these options if you have several authors. Single authors need no option.

**twoadvisors** if you have two advisors rather than a second reader.

**twoside** prints on both sides of the same sheet of paper; recommended.

**classified** if you are using an approved computer system to write your thesis on sensitive research.

**authorindex** if you are including an author index page of your thesis references.

**index** if you are including a keyword index page of your thesis important terms.

**acronym** for a more sophisticated handling of acronyms. See `acronyms.tex` for additional information.

**traditional** prints the thesis in the style of the NPS Microsoft Word thesis template.

Although you are free to use this style, the newer style is approved and looks quite nice when no option is given.

**singlespace** if you prefer single-spaced paragraphs, though it may be a little harder to read. This is not approved for an NPS Masters Thesis, but is approved for NPS technical reports.

**tight** Causes the spacing between paragraphs and paragraph indentation to be smaller than standard.

### **`\securitybanner`**

Leave blank unless producing a FOUO or classified theses. Whatever text appears between the braces is placed at the top and bottom of each page of the document.

### **`\title`**

Your title

### **`\degree`**

Your planned NPS degree written out.

**\degreeabbreviation**

MA, MS, MBA, or other shorthand notation

**\prevdegrees**

Written out as “B.S., Degree, School, Year”

**\degreedate**

Written as “Month Year”

**\distribution**

One of the approved Department of Defense distribution statements (A through F or Export Control). These are listed out on the thesis release form that must also be submitted with your thesis.

**\abstract**

Your entire abstract goes here. Do not make it too big, as it must also fit on the SF298 form.

**\SponsoringAgency**

Your appropriate military department, such as Department of the Air Force, Department of the Navy, etc.

**\RPTpreparedFor**

This optional item can be used to specify the sponsor of the research.

**\SupplementaryNotes**

If your thesis does not have an Institutional Review Board (IRB) protocol number, replace the XXXX with N/A, otherwise fill in the appropriate number. This is needed for theses that use human subjects to collect data. Ask your advisor for more information if this applies.

**\SignatureOne, SignatureTwo, SignatureThree, and SignatureFour**

Each author’s signature line can show an image of the signature, if desired. Specifying the width as 2 inches is recommended. This is an optional feature.

## 7.2.2 The Thesis Main Body

Below is a thesis body, with all of the comments that appear on lines by themselves removed:

```
\begin{document}
\NPScover                % Cover
\NPSSftne                % SF298
\NPSthesistitle          % Title page
\NPSSabstractpage        % Abstract Page
```

```

\NPSfrontmatter          % NPS front matter follows
\renewcommand{\chaptermark}[1]{
  \markboth{\MakeUppercase{\chaptername}\ \thechapter.\ #1}{}
\NPStableOfContents
\NPSlistOfFigures
\NPSlistOfTables
\NPSlistOfAcronyms{
  \begin{description}
    \item[NPS] Naval Postgraduate School
    \item[USG] United States Government
  \end{description}
}
\NPSlistOfAcronymsFromFile{acronyms}
\NPSEXecsummary{
  [EXECUTIVE SUMMARY CONTENTS]
}
\NPSSacknowledgements{
  [ACKNOWLEDGEMENTS CONTENTS]
}
\NPSbody
\chapter{[CHAPTER ONE TITLE]}
[CHAPTER BODY]

This is the beginning of your thesis. Don't be a Micky
Mouse\cite{mm2}: Always have text between every head and subhead.
\section{Your First Section}
[Section One Body]
\section{Your Second Section}
[Section Two Body]
\section{Your Third Section}
[Section Three Body]
\chapter{[CHAPTER TWO TITLE]}
[CHAPTER BODY]

This is the beginning of the second chapter.
Always have text between every head and subhead.
\section{Your First Section}

```

```
[Chapter two Section One Body]
\section{Your Second Section}
[Chapter two Section Two Body]
\section{Your Third Section}
[Chapter two Section Three Body]
```

Now we describe each command:

**\NPScover**

Prints the coversheet page.

**\NPSsftne**

Prints the Standard Form 298 completely filled out with the provided information.

**\NPSthesistitle**

Prints the signature page.

**\NPSabstractpage**

Prints the abstract page.

**\NPSfrontmatter**

Applies some thesis settings for the remainder of the document.

**\NPStableOfContents**

Creates the Table of Contents that lists chapters and subsections.

**\NPSlistOfFigures and NPSlistOfTables**

These lists are automatically created based on the content of the thesis, using the *figure* and *table* environments.

**\NPSlistOfAcronyms**

Manual list of acronyms, useful for a very short list of acronyms. Use this or NPSlistOfAcronymsFromFile but not both.

**\NPSlistOfAcronymsFromFile**

Specifies the file of where the acronyms are stored, `acronyms.tex` in this instance. Using this separate file can keep your `thesis.tex` easier to read. Use this or NPSlistOfAcronyms but not both.

**\NPSexecsummary**

Used by the Electrical Engineering, Systems Engineering, and Operations Research departments.

**\NPSacknowledgements**

It is considered good form at NPS to formally thank your advisor as well as others at NPS

who have contributed in a positive manner to your time at the Institution. You are also free to thank family members, friends, team members, family pets, or anyone else you deem appropriate.

### **\NPSbody**

Thesis chapters follow.

## **7.2.3 The Postmatter**

The end of the document optionally has one or more appendices and a distribution list:

```
\def\showURL{}
\bibliographystyle{nps-plain-unsorted}
\bibliography{thesis}
\NPSappendixTOC{Appendix TITLE}
[APPENDIX BODY]
\NPSEND
\chapter*{Initial Distribution List}
\addcontentsline{toc}{chapter}{Initial Distribution List}
\inglespace
\begin{enumerate}
\item Defense Technical Information Center\\
    Ft. Belvoir, Virginia
\item Dudley Knox Library\\Naval Postgraduate School\\
    Monterey, California
\item Marine Corps Representative\\Naval Postgraduate School\\
    Monterey, California
\item Directory, Training and Education, MCCDC, Code C46\\
    Quantico, Virginia
\item Marine Corps Tactical System Support Activity
    (Attn: Operations Officer)\\Camp Pendleton, California
\end{enumerate}
\end{document}
```

Now we describe these commands:

### **\bibliographystyle**

Can be one of the provided styles (nps-plain, nps-plain-classified,

nps-plain-classified-unsorted, nps-plain-unsorted) or others commonly used (acm, acmtrans, amsalpha, amsplain, apa-good, ieeeetr, ieeeetrans, etc.)

### **`\bibliography`**

Specifies your master .bib file, in this case, thesis.bib. All cited references should be kept in this file.

### **`\NPSappendix`**

Use this for a single appendix thesis with an “Appendix” entry in the Table of Contents.

Add a `\chapter{title}` creates a lettered appendix “A.”

### **`\NPSappendixTOC{Appen TITLE}`**

Use this for a single appendix thesis with a single entry in the Table of Contents of “Appendix: Appen TITLE.” The appendix is not given an appendix letter. This is the preferred style for NPS single-appendix theses. Additionally, use `\section*{name}` rather than `\section{name}` to keep entries out of the Table of Contents.

### **`\NPSappendices`**

Use this for a multiple appendices thesis. Each appendix will need a `\chapter{title}`.

### **`\NPSEND`**

Includes the authorindex and index, if the option was specified in the documentclass. Concludes the content of the thesis.

## **7.3 Additional Commands Provided by the Template**

In addition to commands above, the NPS template provides additional commands designed to make it easier to have references, tables, figures, and embedded graphics.

### **7.3.1 Labels**

Recall from Section ?? that labels are hidden markers in your .tex files created by `\label{name}`. The NPS L<sup>A</sup>T<sub>E</sub>X template contains a number of commands for referencing labels in your text; they are presented below:

Built in to  $\text{\LaTeX}$ :

$\backslash\text{ref}\{l\}$  General reference of the label that places the label’s number in the document.

Provided by `npsreport.cls`:

$\backslash\text{chapref}\{l\}$	Chapter reference that formats as “Chapter 3”
$\backslash\text{chapvref}\{l\}$	Chapter reference that formats as “Chapter 3 on page 4”
$\backslash\text{secref}\{l\}$	Section reference that formats as “Section 3.” You can use this for sections, subsections, and so on.
$\backslash\text{secvref}\{l\}$	Section reference that formats as “Section 3 on page 4”
$\backslash\text{figref}\{l\}$	Figure reference that formats as “Figure 3”
$\backslash\text{figvref}\{l\}$	Figure reference that formats as “Figure 3 on page 4”
$\backslash\text{tabref}\{l\}$	Table reference that formats as “Table 3”
$\backslash\text{tabvref}\{l\}$	Table reference that formats as “Table 3 on page 4”
$\backslash\text{eqnref}\{l\}$	Equation reference that formats as “Equation (3.1)”
$\backslash\text{eqnvref}\{l\}$	Equation reference that formats as “Equation (3.1) on page 4”
$\backslash\text{eqnsref}\{l,m\}$	Equation reference that formats as “Equations (3.1) and (3.5)”
$\backslash\text{eqnsvref}\{l,m\}$	Equation reference that formats as “Equations (3.1) and (3.5) on page 4”
$\backslash\text{appref}\{l\}$	Appendix reference that formats as “Appendix 3”
$\backslash\text{appvref}\{l\}$	Appendix reference that formats as “Appendix 3 on page 4”

The `vref` commands can also automatically swap “on page 4” for “on the preceeding page” and other phrases.

### 7.3.2 Tables and Figures

Tables and figures are floating objects that  $\text{\LaTeX}$  moves around as necessary to make your thesis look better. Tables are inserted with the `\begin{table}` command while figures are inserted with `\begin{figure}`. Here are some rules to consider:

- Every table and figure should have a caption, created with the `\caption{text}` command.
- Every table and figure should have a unique label, created with the `\label{marker}` command.
- Every table and figure should be referred to in the main body of your text.  $\text{\LaTeX}$  provides a command called `\ref{marker}`; this template provides additional commands





Figure 7.1: Banner from the top of the NPS web site.

`\tabref{marker}` and `\figref{marker}`. All of the reference commands are shown in Section ??.

- Do not assume that figures and tables will be on the same text as your page. Always refer to the figures and tables by their numbering.

### 7.3.3 Including Photos and Figures

The NPS report template uses the  $\text{\LaTeX}$  `graphicx` package to embed photos and other graphics into the resulting document. You can include graphics directly with the `\includegraphics` command or use the commands described in this section.

By using the `\sgraphic{filename}{caption}` command provided by `npsreport.cls`, you can embed a photo from a given filename and give it a label and a caption. The label is set to be the filename. Use the `\figref{tag}` command to get an in-paragraph reference. Figure ?? shows an example of an embedded image using `\sgraphic`. The filename is `demos/demo_art/home_topimg`. It is embedded with the command:

```
\sgraphic{demos/demo_art/home_topimg}{Banner from the top of the NPS web site.}
```

The figure can then be referenced with the command:

```
\figref{demos/demo_art/home_topimg} shows an example  
of an embedded image using \verb+\sgraphic+.
```

The variants of `sgraphic` are `b` for box, `n` for no box, `o` for boxed but not a figure, and `on` for no box and not a figure.

```
\sgraphicb{file}{caption}
```



Figure 7.2: Using `sgraphicb` (box)



Figure 7.3: Using `sgraphicn` (no box)

`\sgraphicn{file}{caption}`

Each of the *sgraphic* commands have an optional parameter that you can use to modify the image. The `width` can be used to specify a dimension on the page such as 3 inches or 10 centimeters. The `scale` can be used with either a number between 0 and 1 to scale down the image or larger than 1 to magnify the image; magnification of bitmapped images may look pixelated and print poorly if you are not starting with an image that has sufficient resolution. If you need a larger image, you should find a way to make it larger before including it in your thesis. The image can be rotated with `angle`.



Figure 7.4: Using twofigures



Figure 7.5: A second caption.

```
\sgraphic[width=3in]{imagefile}{caption}
\sgraphicb[scale=0.5]{imagefile}{caption}
\sgraphickn[angle=270]{imagefile}{caption}
\sgraphico[width=2in]{imagefile}{caption}
\sgraphicon[width=10cm]{imagefile}{caption}
```

The `twofigures` command allows you to have two figures side-by-side, as shown in Figure ?? and Figure ??. An example of the `width1` and `width2` entries is 2.5in, 10cm, etc.

```
\twofigures{width1}{imagefile1}{caption1}
           {width2}{imagefile2}{caption2}

\twoimages{imagefile1}{imagefile2}{caption}
```

There are three additional commands to arrange text or images side by side. These are advanced features. See `npsreport.cls` for additional information.

```
\sidebyside{contents1}{contents2}{caption}{label}|
\tsidebyside{contents1}{contents2}{caption}{label}|
\threesidebyside{contents1}{contents2}{contents3}{caption}{label}
```

## 7.4 Ph.D. Dissertations

The NPS L<sup>A</sup>T<sub>E</sub>X template is also created for Ph.D. dissertations when using the `dissertation` option on the document class. The signature page is very different from a Master's thesis.



Figure 7.6: Using twoimages

Additional macros are available to make creating the signature page. The following macros would all be placed into your primary .tex document before the `\begin{document}` (as in the prologue of Section ??).

```
\advisorOne{[Person 1]}
\advisorTwo{[Person 2]}
\advisorThree{[Person 3]}
\advisorFour{[Person 4]}
\advisorFive{[Person 5]}
\advisorSix{[Person 6]}
```

Most Ph.D. committees have no more than 6 members. If your committee has more than this, you will still have to manually edit this signature page and expect difficulty in making everything fit on a single page.

The names of your committee members should be placed in these macros. Usually your primary advisor is in the One entry. You should still provide the `\thesisadvisor{[ADVISOR]}` macro as well for this person. Your committee may have guidance on the preferred order of appearance of the remaining members.

If your committee has 5 members, then use:

```
\NPSdissertationfivememberstrue
```

as this will mute the sixth member.

Each advisor can have up to four lines for the title (this does not include their name). However, to provide maximum control over the exact placement over each title, the lines are called out separately.

```
\advisorOneLineOne{Dissertation Advisor}  
\advisorOneLineTwo{Professor, Department of}  
\advisorOneLineThree{Computer Science}  
\advisorOneLineFour{}
```

When a line is to be empty, the macro does not need to be explicitly called out as in the above example; it was only provided for clarity. The above lines will wrap the text if the entry is made too long. This is undesirable in titles and that is why each line is called out specifically.

The other macros exist for advisorTwo, advisorThree, advisorFour, advisorFive and advisorSix.

Two additional signatures are needed for a Ph.D. signature page.

```
\assocprovost{[Associate Provost]}  
\departmentchair{[Department Chairman]}
```

You should speak to your primary advisor if you do not know the appropriate names to provide.

Ideally, the signature page will be completed with normal size 12 font. However, it is possible to have some excessively long titles that will not properly fit. To provide for this circumstance, the macros

```
\NPSSsignaturefontsize11  
\NPSSsignaturefontsizefootnote
```

give the option of size 11 and size 10 fonts, respectively. This font option only applies to the signature page font.

## 7.5 Macros for Creating Classified Documents

The NPS L<sup>A</sup>T<sub>E</sub>X template has been designed so that it can be used for creating documents that are For Official Use Only (FOUO) or classified at any classification level. As a general rule, you only create a classified document on a system that has been approved for processing classified data at a particular classification level. You should also arrange for the NPS security office to install L<sup>A</sup>T<sub>E</sub>X on the system, rather than installing it yourself. However, once you have a system that is appropriately set up, the template can save a substantial amount of time over the alternative.

In general, preparing a classified document requires a few changes from preparing an unclassified document:

1. The security banner must be set.
2. The SF-298 form must be properly labeled.
3. Each paragraph and caption must be labeled.
4. Citations must be appropriately classified.

### 7.5.1 Setting the Security Banner

The security banner is the notation that is printed at the top and bottom of each page of your classified or otherwise restricted document. Use the `\securitybanner{}` macro to set the banner. Here is an example from our fictitiously classified document:

```
\securitybanner{F//MM//SPECIAL//TOM FOOLERY}
```

This document is classified F (for FUN) and it contains three additional restrictions: MM (Mickey Mouse), SPECIAL, and TOM FOOLERY.

### 7.5.2 Labeling the SF-298

The NPS L<sup>A</sup>T<sub>E</sub>X template automatically creates a SF-298 form for you. When you create a classified document you need to determine the classification of the document's SF-298 form, its abstract, and the report itself. In order for the SF-298 to be unclassified the document's title and abstract must be unclassified. However it is possible to have a classified document with an unclassified abstract and an unclassified title. In this case the SF-298 may also be unclassified. However, before you make a determination, you may wish to speak with your sponsor or with the Site Security Officer.

The report classification, abstract classification, and classification of the SF-298 are indicated with these three macros:

```
\ReportClassification{Fun}  
\AbstractClassification{Jolly}  
\PageClassification{Amusing}
```

In this case the report is classified as Fun, the abstract is classified as Jolly, and the SF-298 is classified as Amusing. Of course, actual classified documents should be classified with actual classifications.

### 7.5.3 Labeling the paragraphs and caption

(U) Each paragraph of your document should be preceded with an appropriate classification level. For example, this paragraph is explicitly labeled as being unclassified. It appears in the source of this document as this:

```
(U) Each paragraph of your document should be preceded with an  
appropriate classification level. For example, this paragraph is  
explicitly labeled as being unclassified. It appears in the source  
of this document as this:
```

As you can see from the example above, paragraph classification labeling must be done manually. Captions must also be manually labeled.

### 7.5.4 Labeling Your References

When citing references in a classified document, use the `\citeafter{}` macro instead of the `\cite{}` macro.

When you use BiB<sub>T</sub><sub>E</sub>X to produce a classified document you should use either the bibliographic style `nps-plain-classified` or `nps-plain-classified-unsorted`. These styles have been modified to support an additional classification tag. Below, the `mm2` reference is classified F and is further within the MM compartment:

```
@misc{mm2,  
  title="Ears, Ears and More Ears",
```

```

publisher="Department of Departments",
author="Micky Mouse",
year=2013,
classification="(F//MM)"
}

```

## 7.6 Additional Files Included in the Template

There are several files included with the template that may be useful for your writing needs.

**Makefile** Included with the template is the Makefile that Mac and Linux users will readily enjoy. Typing make on the command prompt will perform all necessary commands to produce your document.

**build.py** An alternate build system for Windows users.

**authorindex.pl** This perl script is used to generate the authorindex. You will need to use this script if you are generating your document with the authorindex option (see §??). An additional install of a perl interpreter is required for Microsoft® Windows (ActivePerl® is recommended).

**fixerrors.py** This python script will correct .bib file entries for URLs that contain long URLs and also corrects errors in the authorindex .ain files.

**xls\_extract.py** This python script extracts all Excel terms from an NPS budget spreadsheet and write L<sup>A</sup>T<sub>E</sub>X variables. Although it is unlikely you will need to use the script exactly, it can be a reference of how to do something similar if needed for your document.

**xls\_covert\_to\_pdf.py** Converts the Excel workbook to PDF file. This program requires additional software to operate properly and can only be used on a Macintosh computer.

## 7.7 Additional Software

This section discusses additional software that you may find useful when preparing your document.

### 7.7.1 Citation Management Software

Organizing your thesis citations is critical to a successful thesis. Legacy techniques included using index cards. In modern times, software is available to help you accomplish this task. A complete list of the available options is at [http://en.wikipedia.org/wiki/Comparison\\_of\\_reference\\_management\\_software](http://en.wikipedia.org/wiki/Comparison_of_reference_management_software) . NPS has a site-license for Refworks. Other highly



recommended options are Zotero and Mendeley. See <http://www.zotero.org/> and <http://www.mendeley.com/> for additional details.

## 7.7.2 Revision Control Systems and Subversion

Revision control software such as subversion (svn), mercurial (hg), git, and others are excellent modern choices. Consult their websites to determine which one best suits your needs.

You will note that L<sup>A</sup>T<sub>E</sub>X creates many temporary files. These files should *not* be included in your subversion repository. Because they are generated on a per-machine basis, you can get conflicts if different files are created and then committed on different machines.

If you are using subversion to manage your thesis, you should instruct it to ignore these files. This can be done with the `make ignore` target in the Makefile.

```
ignore:
    svn propget svn:ignore . > /tmp/ignore
    echo thesis.pdf >> /tmp/ignore
    echo '*.ain' >> /tmp/ignore
    echo '*.aux' >> /tmp/ignore
    echo '*.asy' >> /tmp/ignore
    echo '*.bbl' >> /tmp/ignore
    echo '*.blg' >> /tmp/ignore
    echo '*.lof' >> /tmp/ignore
    echo '*.log' >> /tmp/ignore
    echo '*.lot' >> /tmp/ignore
    echo '*.sow' >> /tmp/ignore
    echo '*.toc' >> /tmp/ignore
    echo '*.zip' >> /tmp/ignore
    sort /tmp/ignore|uniq|grep .|svn propset svn:ignore -F - .
    @echo ""
    @echo Will ignore:
    svn propget svn:ignore .
    @/bin/rm -f /tmp/ignore
```

## 7.8 Going Further

If you are interested, feel free to review the file `npsthesis.cls`. A great deal of effort has gone into making this file both readable and understandable. You will find additional commands in this file and you may even have thoughts on changes to make. Please let us know what you come up with!

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## Initial Distribution List

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4. Directory, Training and Education, MCCDC, Code C46  
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PLI/PP&O/HQMC, Washington, DC