SAMPLE THESIS CREATED BY USING LyX

By
Ahmed Mohamed Rashed Desoki

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE
in
Aerospace Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
July, 2017

Proudly created by

Except for the figures created by Matlab[1], this thesis has been created by *open source software* (OSS) packages. Special thanks go to the numerous generous developers behind the following projects:

GNU project free software, mass collaboration project aiming to give users freedom

LaTeX document markup language

TeX Live cross-platform LaTeX distribution

MiKTeX LaTeX distribution for Windows

LyX cross-platform LaTeX-based document preparation system

Beamer LaTeX class for creating presentation slides and handouts

Inkscape cross-platform vector graphics editor

TeX Text Inkscape plugin for creating and editing LaTeX formulae

Other great projects I failed to mention ...

Other software packages

Other software packages that greatly helped me during this research include:

Areca cross-platform incremental backup package

pdfcrop a Perl program for removing white margins of a pdf file; indispensable for exported Matlab figures

GoldenDict cross-platform feature-rich dictionary lookup program

[1] For your information, NumPy + SciPi + Matplotlib + Spyder offer very competitive alternative to Matlab. For Windows, all these packages and more are distributed by *Python(x,y)*.

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SAMPLE THESIS CREATED BY USING LYX

Key Words:

Keyword1; Keyword2; Keyword3; Keyword4; Keyword5; Keyword6; Keyword7; Keyword8; Keyword9; Keyword9; Keyword10.

Summary:

This abstract is incomplete. Refer to the complete abstract on page i.

Word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word.

Word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word word.

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Abstract

I'm Ahmed Mohamed Rashed Desoki, an assistant professor at Aerospace Engineering Department, Cairo University.

I created this thesis template to show you how you can create a professional thesis using Open Source Software (OSS). Chapters of this template themselves concisely explain the necessary background you need to know about LaTeX, LyX, floating figures and tables, equations, references management, vector graphics, Inkscape, including program codes and others.

I strongly urge you to prepare your thesis file from the very beginning of your research. This is invaluable since it enables you to immediately document and cite every piece of new information you learn. I strongly urge you to stick to immediate documentation and citation as you learn. Citation itself expresses the value of your writing. You will find your citations invaluable especially after you read and learn a lot. At this time you will really fail to remember from where you learned every information.

This template is hosted at https://github.com/ahmed-rashed/ThesisTemplate. Usage of this template is licensed under GNU GPLv3[1]. If you just want to use this template, simply download it as a zip file using https://github.com/ahmed-rashed/ThesisTemplate/archive/master.zip and proceed. While you are using this template, if you faced problems, try hard to read, learn and dig for solutions by yourself. If you improved/corrected/debugged/extended this template, then please *clone* the template repository using **Git** by `$ git clone https://github.com/ahmed-rashed/ThesisTemplate.git`, and kindly[2] send me your modifications as a *pull request*. If you don't know what is **Git**, you can find concise explanation to revision control using **Git** in chapter 10, or in [1].

Finally, foreign languages usually causes some problems to LaTeX documents. Arabic is not an exception. So if you faced a strange problem that you cannot solve, try disabling the Arabic parts of this thesis to check if the problem is related to the Arabic language[3]. To do so, just use the **Thesis_English.lyx** file. If disabling Arabic solved your problem, please try hard to find a solution and reactivate the Arabic again. **Arabic scientists cannot help their nations using any language other than Arabic.**

[1] www.gnu.org/licenses/quick-guide-gplv3.en.html

[2] In fact, you have to share your improvements according to the GNU GPLv3 license.

[3] Mostly the problem is not specific to Arabic, but to several other languages as well.

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Acknowledgments

Thanks to the Allah who helped me completing this template. I ask him to accept it from me for the sake of his mercy.

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Table of Contents

List of Tables

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List of Figures

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List of Codes

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Nomenclature

DAG	Directed acyclic graph, page 43
GUI	Graphical User Interface, page 44
IDE	Integrated Development Environment, page 6
IRF	Impulse Response Function, page 15
MS	Microsoft, page 1
ode	ordinary differential equation, page 13
OSS	Open Source Software, page i
PR	Pull Request, page 41
SCM	Source Code Management, page 35
SDOF	Single Degree Of Freedom, page 12
SHA-1	Secure Hash Algorithm 1, page 43
TF	Transfer Function, page 14
VCS	Version Control System, page 42

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Chapter 1

Word Processors; LaTeX vs MS Word

Usually there are two categories of word processing software packages; table 1.1

- What You See Is What You Get (WYSIWYG)
- What You See Is What You Mean (WYSIWYM)

Roughly, you can compare LaTeX to Word as you compare Matlab to Excel. Figure 1.1 visualizes the effort and time consumption needed.

By the way, if you are annoyed by the existence of table 1.1 and figure 1.1 at the following page, this is explained in http://tex.stackexchange.com/questions/66293/strange-behaviour-with-figure-on-chapter-first-page

WYSIWYG	WYSIWYM
Microsoft Word LibreOffice Writer AbiWord Calligra Words	LaTeX LyX

Table 1.1: LaTeX vs Microsoft Word

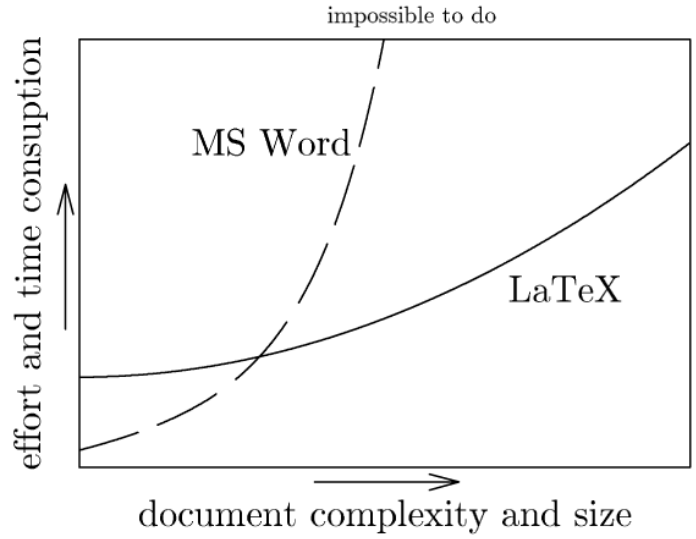


Figure 1.1: Effort and time consumption of MS Word as compared to LaTeX.

Chapter 2

LaTeX; a Document Markup Language

LaTeX is a document markup language.

- Simply you can think of it as similar to HTML[1]
- In order to create a document in LaTeX, a **.tex** file must be created using some **text editor**
- The **.tex** file is then **compiled** to produce the document
- LaTeX can generate several document formats including "pdf"

LaTeX is Free

Although being free is an advantage, but it is a drawback at the same time! Free implies:

- Slow download server
- No clean official documentation
- Several alternatives to do the same thing

However; LaTeX is very mature and widely used by professional/enterprise publishers

- Also it has a big user community
  - when you encounter a problem, google it. Most likely you will find others had encountered it and found a solution

2.1 LaTeX Editors

- To write C/C++ code, any text editor can be used
  - But using a good IDE can greatly ease your job
- LaTeX is similar
  - Any text editor is OK, but a dedicated LaTeX editor is strongly recommended
- A dedicated LaTeX editor

[1] (HyperText Markup Language)

LaTeX 2_ε Cheat Sheet

Document classes

`book`	Default is two-sided.
`report`	No `\part` divisions.
`article`	No `\part` or `\chapter` divisions.
`letter`	Letter (?).
`slides`	Large sans-serif font.

Used at the very beginning of a document: `\documentclass{`*class*`}`. Use `\begin{document}` to start contents and `\end{document}` to end the document.

Common `documentclass` options

`10pt/11pt/12pt`	Font size.
`letterpaper/a4paper`	Paper size.
`twocolumn`	Use two columns.
`twoside`	Set margins for two-sided.
`landscape`	Landscape orientation. Must use `dvips -t landscape`.
`draft`	Double-space lines.

Usage: `\documentclass[`*opt,opt*`]{`*class*`}`.

Packages

`fullpage` Use 1 inch margins.
`anysize` Set margins: `\marginsize{`*l*`}{`*r*`}{`*t*`}{`*b*`}`.
`multicol` Use *n* columns: `\begin{multicols}{`*n*`}`.
`latexsym` Use LaTeX symbol font.
`graphicx` Show image: `\includegraphics[width=`*x*`]{`*file*`}`.
`url` Insert URL: `\url{`*http://...*`}`.

Use before `\begin{document}`. Usage: `\usepackage{`*package*`}`

Title

`\author{`*text*`}`	Author of document.
`\title{`*text*`}`	Title of document.
`\date{`*text*`}`	Date.

These commands go before `\begin{document}`. The declaration `\maketitle` goes at the top of the document.

Miscellaneous

`\pagestyle{empty}`	Empty header, footer and no page numbers.
`\tableofcontents`	Add a table of contents here.

Document structure

`\part{`*title*`}`
`\chapter{`*title*`}`
`\section{`*title*`}`
`\subsection{`*title*`}`
`\subsubsection{`*title*`}`
`\paragraph{`*title*`}`
`\subparagraph{`*title*`}`

Use `\setcounter{secnumdepth}{`*x*`}` suppresses heading numbers of depth $> x$, where `chapter` has depth 0. Use a `*`, as in `\section*{`*title*`}`, to not number a particular item—these items will also not appear in the table of contents.

Text environments

`\begin{comment}`	Comment (not printed). Requires `verbatim` package.
`\begin{quote}`	Indented quotation block.
`\begin{quotation}`	Like `quote` with indented paragraphs.
`\begin{verse}`	Quotation block for verse.

Lists

`\begin{enumerate}`	Numbered list.
`\begin{itemize}`	Bulleted list.
`\begin{description}`	Description list.
`\item` *text*	Add an item.
`\item[`*x*`]` *text*	Use *x* instead of normal bullet or number. Required for descriptions.

References

`\label{`*marker*`}`	Set a marker for cross-reference, often of the form `\label{sec:item}`.
`\ref{`*marker*`}`	Give section/body number of marker.
`\pageref{`*marker*`}`	Give page number of marker.
`\footnote{`*text*`}`	Print footnote at bottom of page.

Floating bodies

`\begin{table}[`*place*`]`	Add numbered table.
`\begin{figure}[`*place*`]`	Add numbered figure.
`\begin{equation}[`*place*`]`	Add numbered equation.
`\caption{`*text*`}`	Caption for the body.

The *place* is a list valid placements for the body. `t`=top, `h`=here, `b`=bottom, `p`=separate page, `!`=place even if ugly. Captions and label markers should be within the environment.

Text properties

Font face

Command	*Declaration*	*Effect*
`\textrm{`*text*`}`	`{\rmfamily` *text*`}`	Roman family
`\textsf{`*text*`}`	`{\sffamily` *text*`}`	Sans serif family
`\texttt{`*text*`}`	`{\ttfamily` *text*`}`	`Typewriter family`
`\textmd{`*text*`}`	`{\mdseries` *text*`}`	Medium series
`\textbf{`*text*`}`	`{\bfseries` *text*`}`	**Bold series**
`\textup{`*text*`}`	`{\upshape` *text*`}`	Upright shape
`\textit{`*text*`}`	`{\itshape` *text*`}`	*Italic shape*
`\textsl{`*text*`}`	`{\slshape` *text*`}`	*Slanted shape*
`\textsc{`*text*`}`	`{\scshape` *text*`}`	Small Caps shape
`\emph{`*text*`}`	`{\em` *text*`}`	*Emphasized*
`\textnormal{`*text*`}`	`{\normalfont` *text*`}`	Document font
`\underline{`*text*`}`		Underline

The command (`ttt`) form handles spacing better than the declaration (*ttt*) form.

Font size

`\tiny`	tiny	`\Large`	Large
`\scriptsize`	scriptsize	`\LARGE`	LARGE
`\footnotesize`	footnotesize	`\huge`	huge
`\small`	small	`\Huge`	Huge
`\normalsize`	normalsize		
`\large`	large		

These are declarations and should be used in the form `{\small ...}`, or without braces to affect the entire document.

Verbatim text

`\begin{verbatim}`	Verbatim environment.
`\begin{verbatim*}`	Spaces are shown as ␣.
`\verb!text!`	Text between the delimiting characters (in this case '`!`') is verbatim.

Justification

Environment	*Declaration*
`\begin{center}`	`\centering`
`\begin{flushleft}`	`\raggedright`
`\begin{flushright}`	`\raggedleft`

Miscellaneous

`\linespread{`*x*`}` changes the line spacing by the multiplier *x*.

Text-mode symbols

Symbols

&	`\&`	_	`\_`	...	`\ldots`	•	`\textbullet`
$	`\$`	^	`\^{}`	|	`\textbar`	\	`\textbackslash`
%	`\%`	~	`\~{}`	#	`\#`	§	`\S`

Accents

ò	`\‘o`	ó	`\’o`	ô	`\^o`	ō	`\^o`	ō	`\=o`
ȯ	`\.o`	ö	`\"o`	o̧	`\c o`	ǒ	`\v o`	ő	`\H o`
ç	`\c c`	o̤	`\d o`	o͟	`\b o`	o͡o	`\t oo`	œ	`\oe`
Œ	`\OE`	æ	`\ae`	Æ	`\AE`	å	`\aa`	Å	`\AA`
ø	`\o`	Ø	`\O`	ł	`\l`	Ł	`\L`	ı	`\i`
ȷ	`\j`	¡	`~‘`	¿	`?‘`				

Delimiters

‘	‘	“	‘‘	{	\{	[	[	(	(	<	`\textless`
’	’	”	’’	}	\}	]	]	)	)	>	`\textgreater`

Dashes

Name	*Source*	*Example*	*Usage*
hyphen	-	X-ray	In words.
en-dash	--	1–5	Between numbers.
em-dash	---	Yes—or no?	Punctuation.

Line and page breaks

`\\`	Begin new line without new paragraph.
`\\*`	Prohibit pagebreak after linebreak.
`\kill`	Don't print current line.
`\pagebreak`	Start new page.
`\noindent`	Do not indent current line.

Miscellaneous

`\today`	February 25, 2014.
`$\sim$`	Prints ∼ instead of `\~{}`, which makes ˜.
`~`	Space, disallow linebreak (`W.J.~Clinton`).
`\@.`	Indicate that the `.` ends a sentence when following an uppercase letter.
`\hspace{`*l*`}`	Horizontal space of length *l* (Ex: $l =$ `20pt`).
`\vspace{`*l*`}`	Vertical space of length *l*.
`\rule{`*w*`}{`*h*`}`	Line of width *w* and height *h*.

Tabular environments

`tabbing` environment

`\=` Set tab stop. `\>` Go to tab stop.

Tab stops can be set on "invisible" lines with `\kill` at the end of the line. Normally `\\` is used to separate lines.

(a) Page 1

Figure 2.1: LaTeX cheat sheet *(continued in the next page)*

tabular environment

```
\begin{array}[pos]{cols}
\begin{tabular}[pos]{cols}
\begin{tabular*}{width}[pos]{cols}
```

tabular column specification

`l`	Left-justified column.
`c`	Centered column.
`r`	Right-justified column.
`p{`*width*`}`	Same as `\parbox[t]{`*width*`}`.
`@{`*decl*`}`	Insert *decl* instead of inter-column space.
`|`	Inserts a vertical line between columns.

tabular elements

`\hline`	Horizontal line between rows.
`\cline{`x-y`}`	Horizontal line across columns x through y.
`\multicolumn{`n`}{`*cols*`}{`*text*`}`	A cell that spans n columns, with *cols* column specification.

Math mode

For inline math, use `\(...\)` or `$...$`. For displayed math, use `\[...\]` or `\begin{equation}`.

Superscript x^y	`^{x}`	Subscript x_y	`_{x}`
$\frac{x}{y}$	`\frac{x}{y}`	$\sum_{k=1}^{n}$	`\sum_{k=1}^n`
$\sqrt[n]{x}$	`\sqrt[n]{x}`	$\prod_{k=1}^{n}$	`\prod_{k=1}^n`

Math-mode symbols

$\leq$	`\leq`	$\geq$	`\geq`	$\neq$	`\neq`	$\approx$	`\approx`
$\times$	`\times`	$\div$	`\div`	$\pm$	`\pm`	$\cdot$	`\cdot`
$\circ$	`^{\circ}`	$\circ$	`\circ`	$\prime$	`\prime`	$\cdots$	`\cdots`
∞	`\infty`	$\neg$	`\neg`	$\wedge$	`\wedge`	$\vee$	`\vee`
$\supset$	`\supset`	$\forall$	`\forall`	$\in$	`\in`	$\rightarrow$	`\rightarrow`
$\subset$	`\subset`	$\exists$	`\exists`	$\notin$	`\notin`	$\Rightarrow$	`\Rightarrow`
$\cup$	`\cup`	$\cap$	`\cap`	$\mid$	`\mid`	$\Leftrightarrow$	`\Leftrightarrow`
$\dot{a}$	`\dot a`	$\hat{a}$	`\hat a`	$\bar{a}$	`\bar a`	$\tilde{a}$	`\tilde a`
α	`\alpha`	β	`\beta`	γ	`\gamma`	δ	`\delta`
ϵ	`\epsilon`	ζ	`\zeta`	η	`\eta`	ε	`\varepsilon`
θ	`\theta`	ι	`\iota`	κ	`\kappa`	ϑ	`\vartheta`
λ	`\lambda`	μ	`\mu`	ν	`\nu`	ξ	`\xi`
π	`\pi`	ρ	`\rho`	σ	`\sigma`	τ	`\tau`
υ	`\upsilon`	ϕ	`\phi`	χ	`\chi`	ψ	`\psi`
ω	`\omega`	Γ	`\Gamma`	Δ	`\Delta`	Θ	`\Theta`
Λ	`\Lambda`	Ξ	`\Xi`	Π	`\Pi`	Σ	`\Sigma`
Υ	`\Upsilon`	Φ	`\Phi`	Ψ	`\Psi`	Ω	`\Omega`

Bibliography and citations

When using BibTeX, you need to run `latex`, `bibtex`, and `latex` twice more to resolve dependencies.

Citation types

`\cite{`*key*`}`	Full author list and year. (Watson and Crick 1953)
`\citeA{`*key*`}`	Full author list. (Watson and Crick)
`\citeN{`*key*`}`	Full author list and year. Watson and Crick (1953)
`\shortcite{`*key*`}`	Abbreviated author list and year. ?
`\shortciteA{`*key*`}`	Abbreviated author list. ?
`\shortciteN{`*key*`}`	Abbreviated author list and year. ?
`\citeyear{`*key*`}`	Cite year only. (1953)

All the above have an `NP` variant without parentheses; Ex. `\citeNP`.

BibTeX entry types

`@article`	Journal or magazine article.
`@book`	Book with publisher.
`@booklet`	Book without publisher.
`@conference`	Article in conference proceedings.
`@inbook`	A part of a book and/or range of pages.
`@incollection`	A part of book with its own title.
`@misc`	If nothing else fits.
`@phdthesis`	PhD. thesis.
`@proceedings`	Proceedings of a conference.
`@techreport`	Tech report, usually numbered in series.
`@unpublished`	Unpublished.

BibTeX fields

`address`	Address of publisher. Not necessary for major publishers.
`author`	Names of authors, of format ....
`booktitle`	Title of book when part of it is cited.
`chapter`	Chapter or section number.
`edition`	Edition of a book.
`editor`	Names of editors.
`institution`	Sponsoring institution of tech. report.
`journal`	Journal name.
`key`	Used for cross ref. when no author.
`month`	Month published. Use 3-letter abbreviation.
`note`	Any additional information.
`number`	Number of journal or magazine.
`organization`	Organization that sponsors a conference.
`pages`	Page range (`2,6,9--12`).
`publisher`	Publisher's name.
`school`	Name of school (for thesis).
`series`	Name of series of books.
`title`	Title of work.
`type`	Type of tech. report, ex. "Research Note".
`volume`	Volume of a journal or book.
`year`	Year of publication.

Not all fields need to be filled. See example below.

Common BibTeX style files

`abbrv`	Standard	`abstract`	`alpha` with abstract
`alpha`	Standard	`apa`	APA
`plain`	Standard	`unsrt`	Unsorted

The LaTeX document should have the following two lines just before `\end{document}`, where `bibfile.bib` is the name of the BibTeX file.

```
\bibliographystyle{plain}
\bibliography{bibfile}
```

BibTeX example

The BibTeX database goes in a file called *file*`.bib`, which is processed with `bibtex file`.

```
@String{N = {Na\-ture}}
@Article{WC:1953,
  author  = {James Watson and Francis Crick},
  title   = {A structure for Deoxyribose Nucleic Acid},
  journal = N,
  volume  = {171},
  pages   = {737},
  year    = 1953
}
```

Sample LaTeX document

```
\documentclass[11pt]{article}
\usepackage{fullpage}
\title{Template}
\author{Name}
\begin{document}
\maketitle

\section{section}
\subsection*{subsection without number}
text \textbf{bold text} text. Some math: $2+2=5$
\subsection{subsection}
text \emph{emphasized text} text. \cite{WC:1953}
discovered the structure of DNA.

A table:
\begin{table}[!th]
\begin{tabular}{|l|c|r|}
\hline
first  &  row  &  data \\
second &  row  &  data \\
\hline
\end{tabular}
\caption{This is the caption}
\label{ex:table}
\end{table}

The table is numbered \ref{ex:table}.
\end{document}
```


(b) Page 2

Figure 2.1: *(continued)* LaTeX cheat sheet

  - can highlight and auto complete LaTeX keywords
  - has several LaTeX templates for several types of documents
  - facilitates compiling and debugging
  - ...

- Sample LaTeX editors are:

  Texstudio; cross-platform

  Kile; for Linux

  and many others

2.2 Porting a LaTeX Document

Usually LaTeX source files reference images and other external files. Hence, if you want to move/copy your LaTeX document to another computer, you have to move/copy all the referenced files as well.

2.3 Arabic Support

Thanks to[1] the "Arabi" package, Arabic and Farsi languages are supported with the "Babel" package.

However, since Arabic users are few, "Arabi" package is not mature enough and some minor bugs do exist. Googling about these bugs, usually you find the similar bugs do exist in other languages as well, and hence you can infer solutions/workarounds. During preparing this thesis, I have done my best to solve/work-around all the bugs I have faced.

2.4 Installing LaTeX

To install and use LaTeX, basically you need two things; (1) LaTeX implementation and (2) Integrated Development Environment (IDE).

For MS Windows users, proText[2] is a TeX/LaTeX distribution that includes:

- MiKTeX: LaTeX Implementation for MS Windows
- TexStudio: cross-platform TeX/LaTeX IDE

For Linux and MAC OS, TeX Live is a cross platform LaTeX implementation[3], and there is a wide range of IDE's including TexStudio.

Keep Concentrating

Due to its WYSIWYM nature, I feel more concentrating while using **LaTeX** as compared to **Ms-Word**

[1] Thanks to GOD at first of course.

[2] www.tug.org/protext/

[3] That is, it is a cross-platform alternative to MiKTeX.

Chapter 3

LyX; a Graphical Front-End to LaTeX

LyX is a graphical front-end to LaTeX

- You can think of the LyX-LaTeX relationship as similar to the Visual Studio-C++ compiler relationship
- Unlike LaTeX, LyX comes with tidy and very good documentation
- Also it has a big community, i.e.,
  - it is mature enough
  - when you encounter a problem, google it. Most likely you will find others had encountered it and found a solution

Keep your concentration

Due to its WYSIWYM nature, I feel very concentrating while using **LyX** as compared to **Ms-Word**.

3.1 Installing LyX

Windows installer is available at www.lyx.org/

There are two installer variants:

1. Installer (recommended)
   This needs a pre-installed LaTeX distribution
2. Bundle
   It includes a minimal LaTeX distribution

I recommend installing as follows:

1. Install Inkscape
   - Confirm path to inkscape.exe is added to the "PATH" environment variable
2. Install MiKTeX (or TeX Live)

3. Install LyX (Installer option)
4. Modify LyX configurations to use Inkscape as graphics translator, as explained in figure 3.1. That is, Tools ▷ Preferences ▷ Converters

   SVG -> EPS: `inkscape --export-area-drawing $$i --export-eps=$$o`

   SVG -> PDF (graphics): `inkscape --export-area-drawing $$i --export-pdf=$$o`

   SVG -> PNG: `inkscape --export-area-drawing $$i --export-png=$$o`
5. Enable continuous spell checking

   Tools ▷ Preferences ▷ Language Settings ▷ Spellchecker ▷ Spellcheck continuously

Linux packages are usually available in most Linux distributions' repositories

3.2 Learning LyX

Explore style-list, menus and toolbars

Help menu includes very good manuals

- Manuals themselves are LyX documents
  - So they are essentially very good LyX examples
- You may begin with:
  1. Introduction
  2. Tutorial
- Then if needed, read necessary sections of:
  1. User's Guide
  2. rest of manuals ...

lyx\examples folder contains wide variety of very good examples

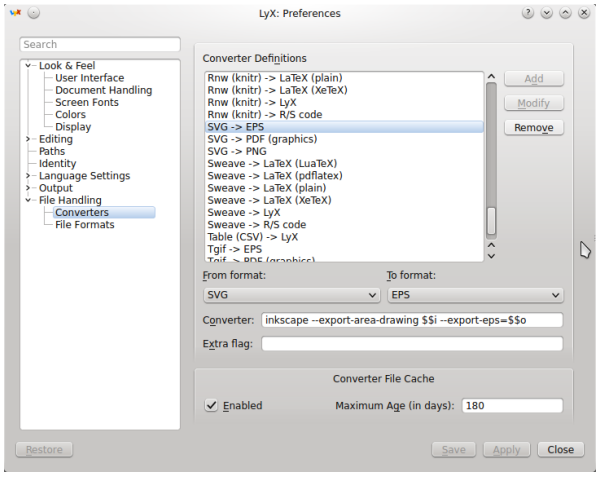
3.3 Porting a LyX Document

Similar to LaTeX files, LyX files usually reference images and other external files. Hence, if you want to move/copy your LyX document to another computer, you have to move/copy all the referenced files as well.

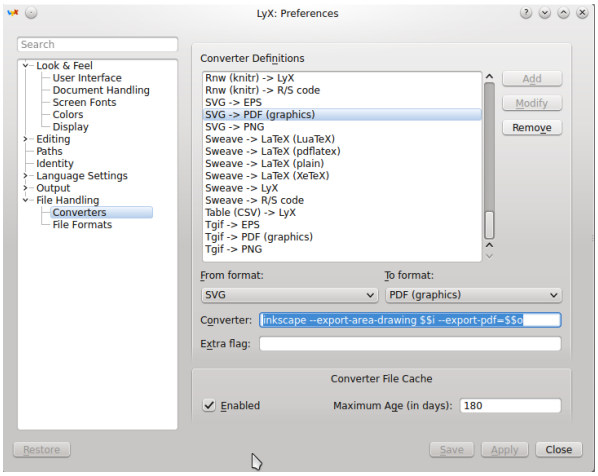
LyX greatly simplifies collecting the referenced files by the command LyX ▷ File ▷ Export ▷ LyX Archive

3.4 Arabic Support

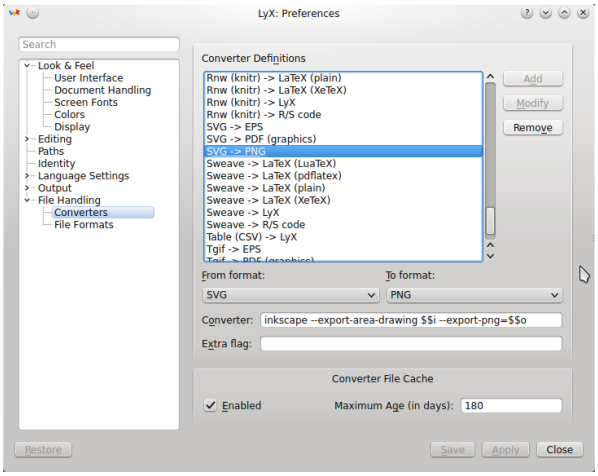
Arabic is supported in LyX, as shown in the following. For more details, refer to section 2.3.



(a) To convert svg to eps



(b) To convert svg to pdf



(c) To convert svg to png

Figure 3.1: Correcting svg converters in Inkscape

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Chapter 4

Floats, Figures, Tables and Equations

4.1 Concept of Floating Graphics, Tables

For those users familiar with MS World, they expect figures and tables are placed where you put them. This however does not look professional. Therefore, LaTeX, and consequently LyX, uses floats for placing figures and tables. Sample simple floating figures are figures 1.1, 7.1

For more information about this topic, refer to [2] and [3, sec. 4.6].

4.2 Compound Figures

Figures composed of sub-figures can be created in by using the subcaption LaTeX package. Sample compound figures are figures 2.1, 3.1, 4.1, 6.1, 6.2, 7.2 and 7.3.

4.2.1 Subfigure and Subtable

Have a look at figure 4.1.

4.3 Continued Floats

Figure 2.1 shows a sample float continued from a float to another.

4.4 Landscape Floats

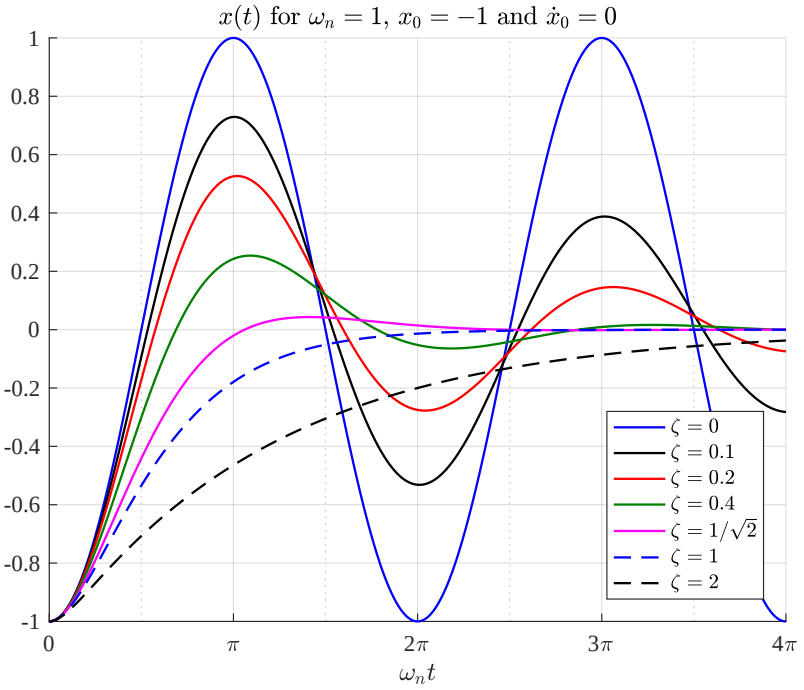
Have a look at figure 2.1.

4.5 Side-by-Side Facing Floats

Have a look at figures 6.1 and 6.2.

4.6 Free Inline Graphics without Captions

Have a look at graphics of chapter 10.



(a) Free vibration of a SDOF system

ρ_{ij}	$i = 1$	$i = 2$	$i = 3$	$i = 4$
$j = 1$	1.0000	-0.0000	-0.8328	-0.0010
$j = 2$	-0.0000	1.0000	-0.0000	-0.8328
$j = 3$	-0.8328	-0.0000	1.0000	-0.0000
$j = 4$	-0.0010	-0.8328	-0.0000	1.0000

(b) Correlation coefficient matrix

Figure 4.1: Figure composed of a subfigure and subtable

4.7 Tables

Table 4.1 shows a sample simple table, while table 4.2 shows a more complex table. Additional details are available in [3, sec. 4.5] and [2, chapter 2].

4.8 Equations

For details about equations, refer to [4]. The following is sample text with various types of equations.

4.8.1 SDOF Mass Spring System

Table 4.1: Table caption

	Conventional Transducer	This Transducer
Price	word word	word word
Size	word word	word word
Weight	word word	word word
Coupling	word word	word word
Material	word word	word word
Generation	word word	word word
Suitability	word word	word word
Restrictions	word word	word word
Action type	word word	word word

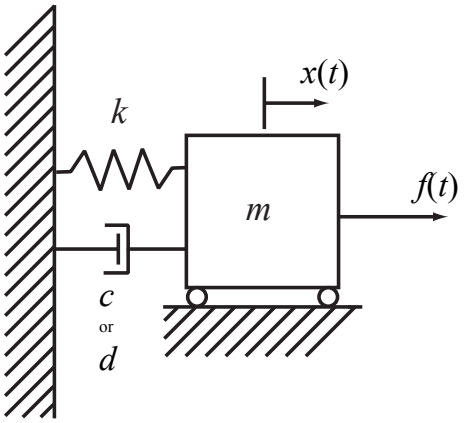


Figure 4.2: SDOF Mass Spring System

Governing Ordinary Differential Equation (ode)

$$m\ddot{x}(t) + c\dot{x}(t) + kx(t) = f(t) \tag{4.1}$$

Taking Laplace transform, the *ode* is transformed to the algebraic equation

$$m\left(s^2X(s) - sx_0 - \dot{x}_0\right) + c\left(sX(s) - x_0\right) + kX(s) = F(s)$$

where $x_0 \equiv x(t=0)$ and $\dot{x}_0 \equiv \dot{x}(t=0)$.

Rearranging yields

$$\left(ms^2 + cs + k\right)X(s) - \left(ms + c\right)x_0 - m\dot{x}_0 = F(s) \tag{4.2}$$

Dividing by m yields

$$\left(s^2 + 2\zeta\omega_{\text{n}}s + \omega_{\text{n}}^2\right)X(s) - \left(s + 2\zeta\omega_{\text{n}}\right)x_0 - \dot{x}_0 = \frac{F(s)}{m} \tag{4.3}$$

where the non-dimensional parameters ω_{n} and ζ are the ***natural frequency*** and ***damping ratio*** defined as

$$\boxed{\omega_{\text{n}} \equiv \sqrt{\frac{k}{m}}} \qquad \& \qquad \boxed{\zeta \equiv \frac{c}{c_{\text{c}}}} \tag{4.4}$$

Table 4.2: Comparison between somethings

	Type 1	Type 2	Type 3	Type 4
Feature 1	words words words words words words words	words words words words words words words	words words words words words words words	words words words words words words words
Feature 2	words words words words words words words	words words words words words words words	words words words words words words words	words words words words words words words
Feature 3	words words words words words words words	words words words words words words words	words words words words words words words	words words words words words words words
Feature 4	words words words words words words words	words words words words words words words	words words words words words words words	words words words words words words words

where c_c is the ***critical damping*** defined as

$$\boxed{c_\mathrm{c} \equiv 2\sqrt{km}} \tag{4.5}$$

By solving the algebraic equation (4.3), the response $X(s)$ is obtained as

$$\begin{aligned} X(s) &= \frac{F(s)}{m\left(s^2 + 2\zeta\omega_\mathrm{n}s + \omega_\mathrm{n}^2\right)} \\ &\quad + \frac{sx_0}{s^2 + 2\zeta\omega_\mathrm{n}s + \omega_\mathrm{n}^2} + \frac{2\zeta\omega_\mathrm{n}x_0 + \dot{x}_0}{s^2 + 2\zeta\omega_\mathrm{n}s + \omega_\mathrm{n}^2} \end{aligned}$$

or

$$X(s) = F(s)\,H(s) + \frac{sx_0}{s^2 + 2\zeta\omega_\mathrm{n}s + \omega_\mathrm{n}^2} + \frac{2\zeta\omega_\mathrm{n}x_0 + \dot{x}_0}{s^2 + 2\zeta\omega_\mathrm{n}s + \omega_\mathrm{n}^2} \tag{4.6}$$

where $H(s)$ is the *Transfer Function* (TF) defined as

$$H(s) \equiv \frac{X(s)|_{\text{zero initial conditions}}}{F(s)} \tag{4.7}$$

$$= \frac{1}{ms^2 + cs + k} \tag{4.8}$$

$$= \frac{1}{m\left(s^2 + 2\zeta\omega_\mathrm{n}s + \omega_\mathrm{n}^2\right)} \tag{4.9}$$

$$= \frac{1}{m\left(s - \left(-\zeta\omega_\mathrm{n} + \omega_\mathrm{n}\sqrt{\zeta^2 - 1}\right)\right)\left(s - \left(-\zeta\omega_\mathrm{n} - \omega_\mathrm{n}\sqrt{\zeta^2 - 1}\right)\right)} \tag{4.10}$$

Assuming the roots of $H(s)$ are complex, the TF is written as

$$H(s) = \frac{1}{m\left(s - \left(-\zeta\omega_\mathrm{n} + i\omega_\mathrm{n}\sqrt{1 - \zeta^2}\right)\right)\left(s - \left(-\zeta\omega_\mathrm{n} - i\omega_\mathrm{n}\sqrt{1 - \zeta^2}\right)\right)} \tag{4.11}$$

or

$$\boxed{H(s) = \frac{1}{m\left(s - \left(-\zeta\omega_{\mathrm{n}} + i\omega_{\mathrm{d}}\right)\right)\left(s - \left(-\zeta\omega_{\mathrm{n}} - i\omega_{\mathrm{d}}\right)\right)}} \tag{4.12}$$

where

$$\boxed{\omega_{\mathrm{d}} \equiv \omega_{\mathrm{n}}\sqrt{1-\zeta^2}} \tag{4.13}$$

Thus the response $x(t)$ can be obtained from equation (4.6) as

$$x(t) = \mathcal{L}^{-1}\left[X(s)\right] \tag{4.14}$$

where $\mathcal{L}^{-1}$ denotes inverse Laplace transform.

Assuming the TF roots are complex, i.e., $\zeta < 1$, inverse Laplace transform tables yield

$$\begin{aligned} x(t) =& \mathcal{L}^{-1}\left[F(s)\,H(s)\right] \\ &+ x_0 e^{-\zeta\omega_{\mathrm{n}}t}\left(\cos\left(\omega_{\mathrm{d}}t\right) - \frac{\zeta\omega_{\mathrm{n}}}{\omega_{\mathrm{d}}}\sin\left(\omega_{\mathrm{d}}t\right)\right) \\ &+ \left(2\zeta\omega_{\mathrm{n}}x_0 + \dot{x}_0\right)\, e^{-\zeta\omega_{\mathrm{n}}t}\frac{\sin\left(\omega_{\mathrm{d}}t\right)}{\omega_{\mathrm{d}}} \end{aligned} \tag{4.15}$$

Rearranging yields

$$\boxed{\begin{aligned} x(t) =& \mathcal{L}^{-1}\left[F(s)\,H(s)\right] \\ &+ e^{-\zeta\omega_{\mathrm{n}}t}\left[x_0\cos\left(\omega_{\mathrm{d}}t\right) + \left(\zeta\omega_{\mathrm{n}}x_0 + \dot{x}_0\right)\frac{\sin\left(\omega_{\mathrm{d}}t\right)}{\omega_{\mathrm{d}}}\right] \end{aligned}} \tag{4.16}$$

or from the convolution property

$$\begin{aligned} x(t) =& \left(f * h\right)(t) \\ &+ e^{-\zeta\omega_{\mathrm{n}}t}\left[x_0\cos\left(\omega_{\mathrm{d}}t\right) + \left(\zeta\omega_{\mathrm{n}}x_0 + \dot{x}_0\right)\frac{\sin\left(\omega_{\mathrm{d}}t\right)}{\omega_{\mathrm{d}}}\right] \end{aligned} \tag{4.17}$$

where

$$\boxed{h(t) \equiv \mathcal{L}^{-1}\left[H(s)\right] = \frac{e^{-\zeta\omega_{\mathrm{n}}t}}{m}\frac{\sin\left(\omega_{\mathrm{d}}t\right)}{\omega_{\mathrm{d}}}} \tag{4.18}$$

is the Impulse Response Function (IRF), and

$$\left(f * h\right)(t) \equiv \int_{-\infty}^{\infty} f(\tau)h(t-\tau)\,d\tau \tag{4.19}$$

$$= \int_{0}^{t} f(\tau)h(t-\tau)\,d\tau \quad ,: f(t) = h(t) = 0\ \forall t < 0 \tag{4.20}$$

is the convolution of $f(t)$ and $h(t)$, assuming stable, linear, physically possible and time invariant system.

4.8.2 Inverse Laplace Transform Derivation

Using Laplace transform property, inverse Laplace can be obtained as

$$\frac{\Omega\, s}{\left(s^2 + \Omega^2\right)\left(s^2 + 2\zeta\omega_{\mathrm{n}}s + \omega_{\mathrm{n}}^2\right)} \overset{\mathcal{L}}{\Longleftrightarrow} \dot{y}(t) + y(0) \tag{4.21}$$

where $y(t)$ is the inverse Laplace transform of

$$\frac{\Omega}{\left(s^2+\Omega^2\right)\left(s^2+2\zeta\omega_{\mathrm{n}}s+\omega_{\mathrm{n}}^2\right)}$$

previously derived as

$$y(t)=\frac{-2\zeta r\,\cos\left(\Omega t\right)+\left(1-r^2\right)\sin\left(\Omega t\right)+r\,e^{-\zeta\omega_{\mathrm{n}}t}\left[2\zeta\,\cos\left(\omega_{\mathrm{d}}t\right)+\omega_{\mathrm{n}}\left(2\zeta^2-\left(1-r^2\right)\right)\frac{\sin(\omega_{\mathrm{d}}t)}{\omega_{\mathrm{d}}}\right]}{\omega_{\mathrm{n}}^2\left(\left(1-r^2\right)^2+\left(2\zeta r\right)^2\right)} \tag{4.22}$$

Thus

$$y(0)=\frac{-2\zeta r+2\zeta r}{\omega_{\mathrm{n}}^2\left(\left(1-r^2\right)^2+\left(2\zeta r\right)^2\right)}=0 \tag{4.23}$$

and

$$\begin{aligned}
\dot{y}(t)=&\frac{\Omega}{\omega_{\mathrm{n}}^2}\,\frac{2\zeta r\,\sin\left(\Omega t\right)+\left(1-r^2\right)\cos\left(\Omega t\right)}{\left(1-r^2\right)^2+\left(2\zeta r\right)^2}+\frac{r}{\omega_{\mathrm{n}}^2\left(\left(1-r^2\right)^2+\left(2\zeta r\right)^2\right)}\\
&\times\left[\omega_{\mathrm{d}}e^{-\zeta\omega_{\mathrm{n}}t}\left(-2\zeta\,\sin\left(\omega_{\mathrm{d}}t\right)+\omega_{\mathrm{n}}\left(2\zeta^2-\left(1-r^2\right)\right)\frac{\cos\left(\omega_{\mathrm{d}}t\right)}{\omega_{\mathrm{d}}}\right)\right.\\
&\qquad\left.-\zeta\omega_{\mathrm{n}}e^{-\zeta\omega_{\mathrm{n}}t}\left(2\zeta\,\cos\left(\omega_{\mathrm{d}}t\right)+\omega_{\mathrm{n}}\left(2\zeta^2-\left(1-r^2\right)\right)\frac{\sin\left(\omega_{\mathrm{d}}t\right)}{\omega_{\mathrm{d}}}\right)\right]\\
=&\frac{r}{\omega_{\mathrm{n}}}\,\frac{\left(1-r^2\right)\cos\left(\Omega t\right)+2\zeta r\,\sin\left(\Omega t\right)}{\left(1-r^2\right)^2+\left(2\zeta r\right)^2}+\frac{r}{\omega_{\mathrm{n}}^2\left(\left(1-r^2\right)^2+\left(2\zeta r\right)^2\right)}\\
&\times\left[\left(\omega_{\mathrm{n}}\left(2\zeta^2-\left(1-r^2\right)\right)-2\zeta^2\omega_{\mathrm{n}}\right)\cos\left(\omega_{\mathrm{d}}t\right)\right.\\
&\qquad\left.+\left(-2\zeta\omega_{\mathrm{d}}-\frac{\zeta\omega_{\mathrm{n}}^2\left(2\zeta^2-\left(1-r^2\right)\right)}{\omega_{\mathrm{d}}}\right)\sin\left(\omega_{\mathrm{d}}t\right)\right]\\
=&\frac{r}{\omega_{\mathrm{n}}}\,\frac{\left(1-r^2\right)\cos\left(\Omega t\right)+2\zeta r\,\sin\left(\Omega t\right)}{\left(1-r^2\right)^2+\left(2\zeta r\right)^2}+\frac{re^{-\zeta\omega_{\mathrm{n}}t}}{\omega_{\mathrm{n}}^2\left(\left(1-r^2\right)^2+\left(2\zeta r\right)^2\right)}\\
&\times\left[-\omega_{\mathrm{n}}\left(1-r^2\right)\,\cos\left(\omega_{\mathrm{d}}t\right)\right.\\
&\qquad\left.+\left(-2\zeta\omega_{\mathrm{d}}^2-\zeta\omega_{\mathrm{n}}^2\left(2\zeta^2-\left(1-r^2\right)\right)\right)\frac{\sin\left(\omega_{\mathrm{d}}t\right)}{\omega_{\mathrm{d}}}\right]\\
=&\frac{r}{\omega_{\mathrm{n}}}\,\frac{\left(1-r^2\right)\cos\left(\Omega t\right)+2\zeta r\,\sin\left(\Omega t\right)}{\left(1-r^2\right)^2+\left(2\zeta r\right)^2}+\frac{re^{-\zeta\omega_{\mathrm{n}}t}}{\omega_{\mathrm{n}}^2\left(\left(1-r^2\right)^2+\left(2\zeta r\right)^2\right)}\\
&\times\left[-\omega_{\mathrm{n}}\left(1-r^2\right)\,\cos\left(\omega_{\mathrm{d}}t\right)\right.\\
&\qquad\left.+\zeta\omega_{\mathrm{n}}^2\left(-2\left(1-\zeta^2\right)-2\zeta^2+\left(1-r^2\right)\right)\frac{\sin\left(\omega_{\mathrm{d}}t\right)}{\omega_{\mathrm{d}}}\right]\\
=&\frac{r}{\omega_{\mathrm{n}}}\,\frac{\left(1-r^2\right)\cos\left(\Omega t\right)+2\zeta r\,\sin\left(\Omega t\right)}{\left(1-r^2\right)^2+\left(2\zeta r\right)^2}+\frac{re^{-\zeta\omega_{\mathrm{n}}t}}{\omega_{\mathrm{n}}^2\left(\left(1-r^2\right)^2+\left(2\zeta r\right)^2\right)}\\
&\times\left[-\omega_{\mathrm{n}}\left(1-r^2\right)\,\cos\left(\omega_{\mathrm{d}}t\right)+\zeta\omega_{\mathrm{n}}^2\left(-2+\left(1-r^2\right)\right)\frac{\sin\left(\omega_{\mathrm{d}}t\right)}{\omega_{\mathrm{d}}}\right]\\
=&\frac{r}{\omega_{\mathrm{n}}}\,\frac{\left(1-r^2\right)\cos\left(\Omega t\right)+2\zeta r\,\sin\left(\Omega t\right)}{\left(1-r^2\right)^2+\left(2\zeta r\right)^2}+\frac{re^{-\zeta\omega_{\mathrm{n}}t}}{\omega_{\mathrm{n}}\left(\left(1-r^2\right)^2+\left(2\zeta r\right)^2\right)}
\end{aligned}$$

$$\times \left[-\left(1-r^2\right)\,\cos\left(\omega_{\mathrm{d}}t\right) - \zeta\omega_{\mathrm{n}}\left(1+r^2\right)\frac{\sin\left(\omega_{\mathrm{d}}t\right)}{\omega_{\mathrm{d}}} \right] \tag{4.24}$$

Substituting equations (4.23) and (4.24) in (4.21) yields

$$\boxed{\begin{aligned} &\frac{\Omega\, s}{\left(s^2+\Omega^2\right)\left(s^2+2\zeta\omega_{\mathrm{n}}s+\omega_{\mathrm{n}}^2\right)} \overset{\mathcal{L}}{\Longleftrightarrow} \\ &\frac{r}{\omega_{\mathrm{n}}}\,\frac{\left(1-r^2\right)\cos\left(\Omega t\right)+2\zeta r\,\sin\left(\Omega t\right)-e^{-\zeta\omega_{\mathrm{n}}t}\left[\left(1-r^2\right)\,\cos\left(\omega_{\mathrm{d}}t\right)+\zeta\omega_{\mathrm{n}}\left(1+r^2\right)\frac{\sin(\omega_{\mathrm{d}}t)}{\omega_{\mathrm{d}}}\right]}{\left(1-r^2\right)^2+\left(2\zeta r\right)^2} \end{aligned}} \tag{4.25}$$

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Chapter 5

Reference Management Software

Reference management software [5] is citation management software or personal bibliographic management software is software for scholars and authors to use for recording and utilising bibliographic citations (references) [6]. Once a citation has been recorded, it can be used time and again in generating bibliographies, such as lists of references in scholarly books, articles and essays. The development of reference management packages has been driven by the rapid expansion of scientific literature. Among poular refence management software are:

JabRef, a BibTeX management cross-platform software for use with LaTeX/LyX.

Endnote, a management software suitable for use with MS Word

Zotero, a cross-platform web-based management software suitable for LaTeX/LyX, MS Word, LibreOffice and others.

Comparisons of these software are available in [7].

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Chapter 6

Vector Graphics

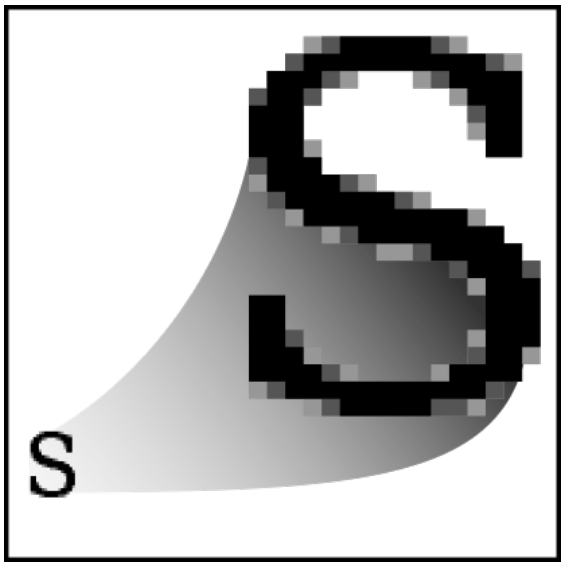
6.1 Raster vs Vector Graphics

Graphics Formats

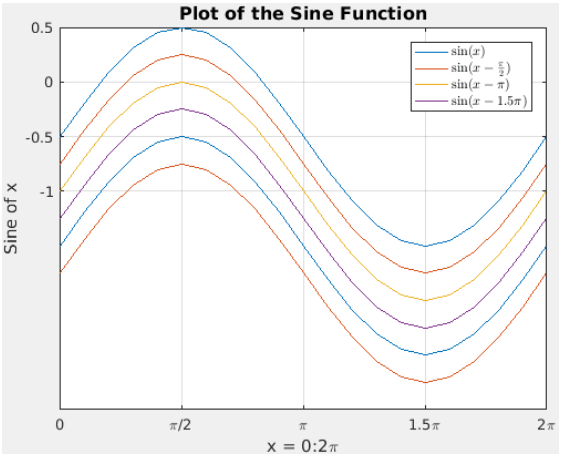
Raster		Vector	
.bmp	Uncompressed	.pdf	Compressed
.png	Loose-less compression	.eps	
.jpg	Lossy compression	.emf	Compatible with MS office
		.svg	
⋮		⋮	

6.2 Vector Graphics Editors

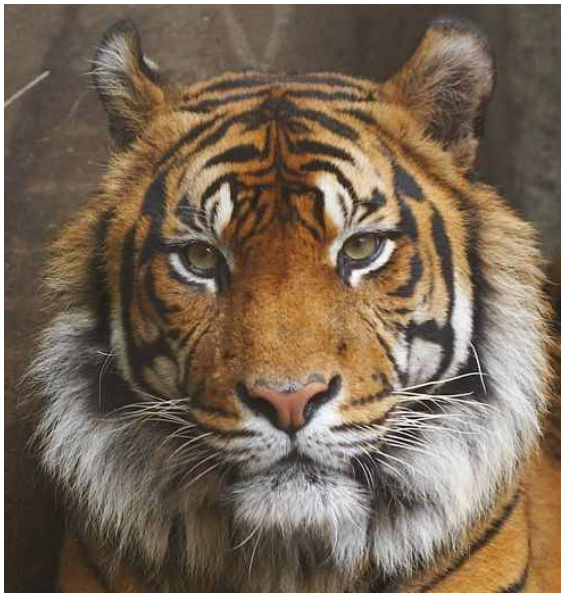
- Adobe Illustrator (*de facto* standard; bloated)
- Corel Draw (bloated)
- Inkscape (light, free, open source, cross-platform and popular; my favorite)
- LibreOffice Draw
- …



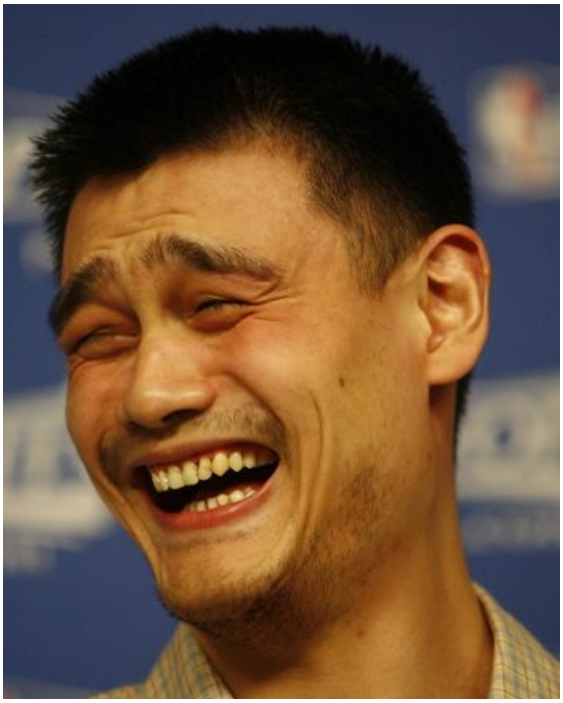
(a) Letter



(b) Matlab figure

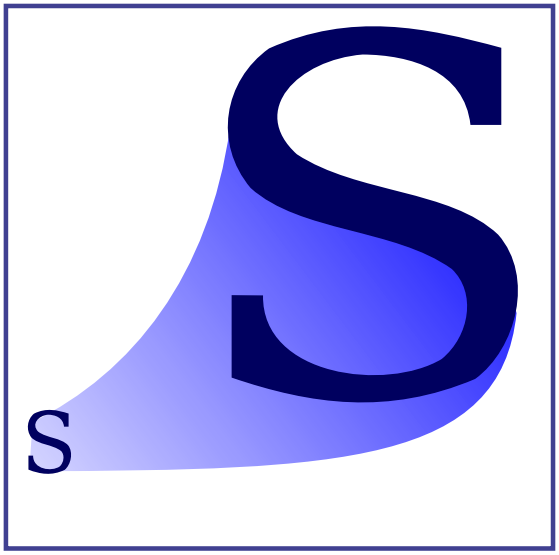


(c) Tiger

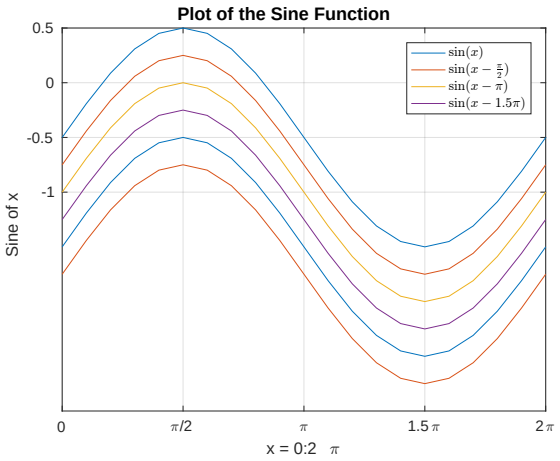


(d) Face

Figure 6.1: Sample raster graphics. This figure is forced to be on a left page for easier comparison with figure 6.2 on the opposite page.

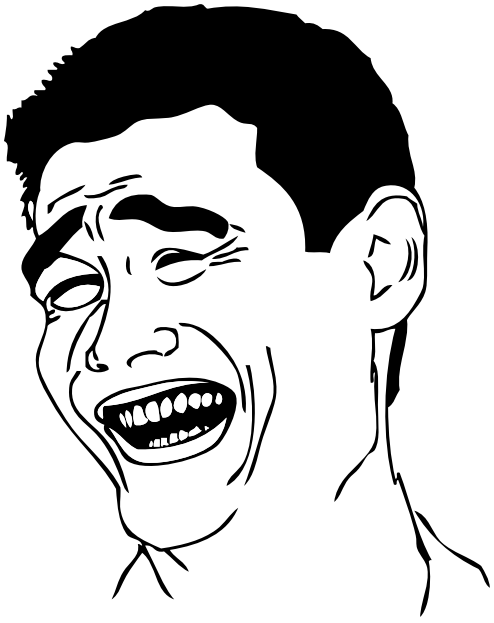


(a) Letter



(b) Matlab figure

(c) Tiger



(d) Face

Figure 6.2: Vector graphics version of figure 6.1

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Chapter 7

Inkscape; Free and Open Source Vector Graphics Editor

Inkscape Features

- Open source
- Cross platform
- Free
- Has a big community, i.e.,
  - it is mature enough
  - when you encounter a problem, google it. Most likely you will find others had encountered it and found a solution
- Much much powerful than Ms-Word or Ms-Power point sketching capabilities
- Has several plugins that greatly expand its capabilities

Inkscape Capabilities

Inkscape is based on brazier curves. That is, a curve is defined using four information, **start**, **end**, **start tangent** and **end tangent**.

- Additionally, you can draw and edit:
  - straight lines
  - circles/arcs/ellipses
  - text
  - LaTeX formulas
  - function curves
  - ...

7.0.1 Import Graphics from pdf

You can import vector graphics from pdf files, and even edit them, as shown in 7.1.

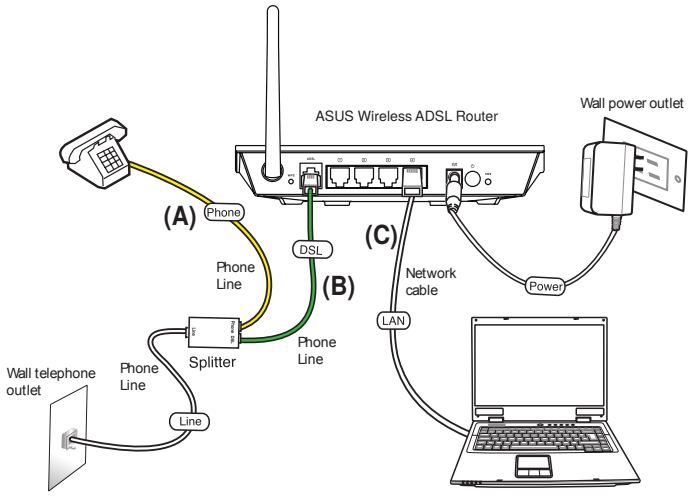


Figure 7.1: Vector graphic imported from the user guide of a home use ADSL router

7.1 Interesting Plug-ins

7.1.1 Function Plotter

- It is a built in plugins
- It uses brazier curves, same as Inkscape
- It calculates the function derivative and use it to adjust the curve slope
  - It produces very smooth curves using much less points than Matlab
  - You can still adjust/correct the curve manually

Figure 7.2 shows the plugin user interface, and the resulting curve. Figure 7.3 shows a more comprehensive example.

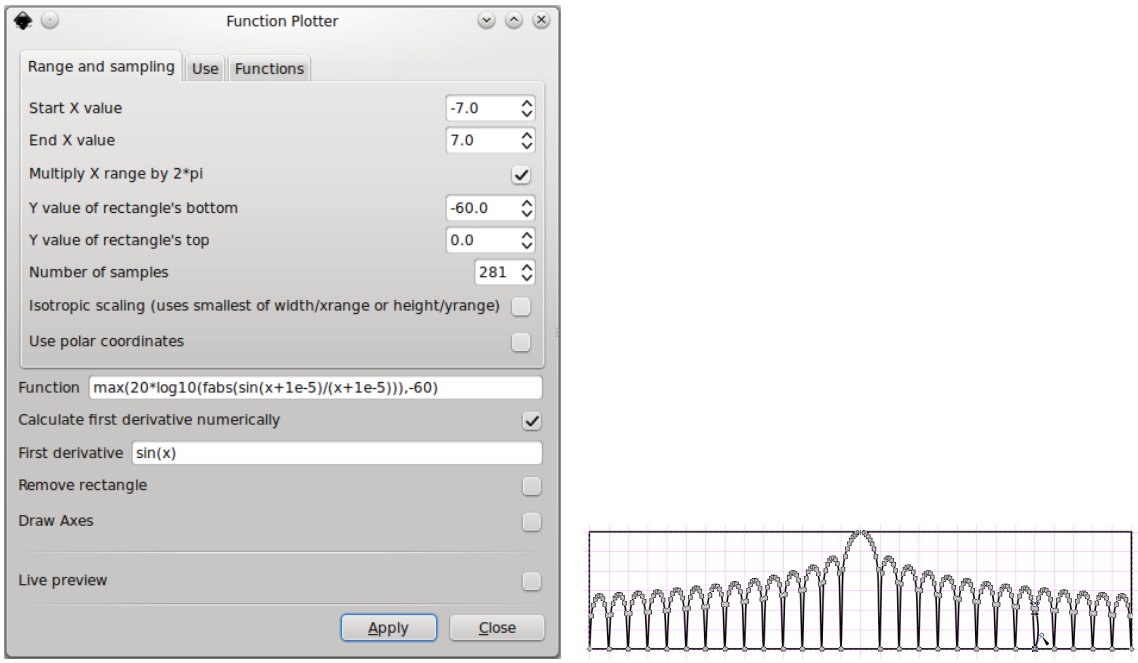
7.1.2 TexText

It allows you to write/edit LaTeX formulas inside Inkscape.

7.1.2.1 Installing TexText on MS Windows (all versions, including 32 & 64 bit)

Follow the instructions of http://people.orie.cornell.edu/jmd388/design/guides/textext.pdf. That is:

1. Install Inkscape (the 32-bit version)
2. Install TexText from https://pav.iki.fi/_downloads/textext-0.4.4.exe
3. Install 32 or 64 bit versions of ghostscript, imagemagick, pstoedit
4. Make sure the following paths are added to the the "Path" environment variable:
   - C:\Program Files\gs\gs9.xx\lib



(a) Function Plotter user interface

(b) Curve generated by Function Plotter

Figure 7.2: The Function Plotter plugin

- C:\Program Files\gs\gs9.xx\bin
- C:\Program Files\ImageMagick
- C:\Program Files\ghostgum\pstoedit

5. Download the file http://people.orie.cornell.edu/jmd388/design/guides/textext.zip
   (a) Replace the "C:\Program Files (x86)\Inkscape\share\extensions\textext.py" file with the file in the textext.zip file
   (b) Extract[1] the "site-packages.zip" file in the textext.zip file to "C:\Program Files (x86)\Inkscape\python\Lib\site-packages"

7.1.2.2 Installing TexText on Linux

Installation on Linux is too easy and straight forward. Just follow the instructions at TexText web page; https://pav.iki.fi/software/textext/.

7.2 Learning Inkscape

- **Explore** menus and toolbars
- **Official manual** [8] is very good and detailed
  - Chapters 2 includes 10 examples
    - The first 3 examples are enough for a good start

[1] You must have administrator privileges to to this.

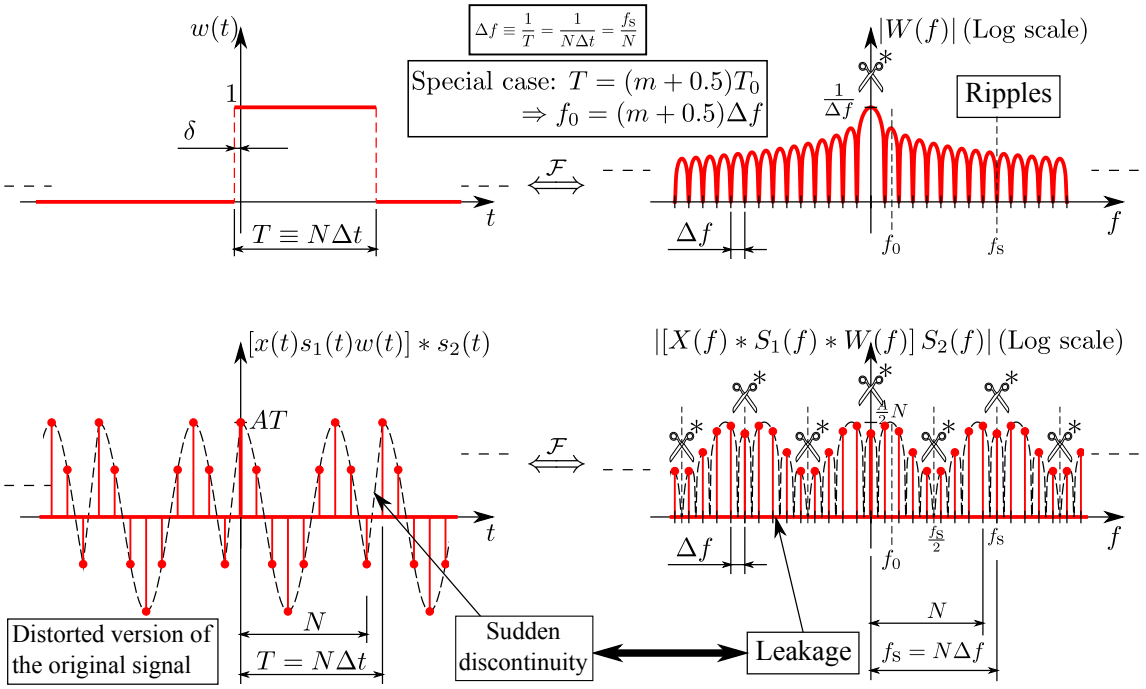


Figure 7.3: Figure illustrating the capabilities of “Function Plotter” and “TexText” plug ins.

  - Chapters 5 explains editing
    - Surf it fast

- **Help menu** includes tutorials, FAQ, ...
- http://inkscapetutorials.org/

Chapter 8

Including Program Codes

There is the listings LaTeX package which greatly simplifies adding program codes. Details are available in [2, chapter 8]. For example, codes A.1 and A.2 are used to plot figure 4.1(a).

Code A.3 on the other hand exports a Matlab figure a pdf file and crops it by removing white margins. Cropping is accomplished by calling a Perl program called "`pdfcrop`". This program, ships with both MiKTeX and TeX Live LaTeX implementations. To use this program, Perl is needed to be installed[1].

[1] "Strawberry Perl" is a sample open-source Perl implementation for Microsoft Windows.

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Chapter 9

About the Nomenclature

If you defined a nomenclature entry twice, it results in an error (Lonely \item–perhaps a missing list environment.).

9.1 Problems with Arabic

Nomenclature (and may be index too) sometimes causes problems in Arabic documents. As a workaround (assuming your thesis file name is "Thesis"):

1. pdflatex the Thesis.tex file twice (or as needed)
2. manually edit the *.nlo file and modify as follows

   modify lines similar to this

   ```
   \nomenclatureentry{aVI@[{VI}]\begingroup Visual
   Inspection\nomeqref {1.0}|nompageref}{\if@rlmain \I {1}\else
   \textLR {1}\fi }
   ```

   to this

   ```
   \nomenclatureentry{aVI@[{VI}]\begingroup Visual
   Inspection\nomeqref {1.0}|nompageref}{1}
   ```

3. Run the command

   ```
   makeindex 'Thesis.nlo' -s nomencl.ist -o 'Thesis.nls'
   ```

4. pdflatex the Thesis.tex file once more (or as needed)

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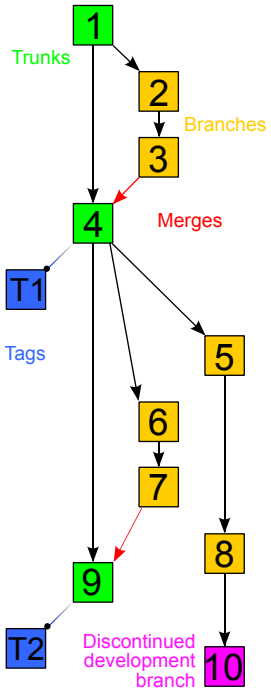
Chapter 10

Version Control Using Git

10.1 Revision Control System

Revision control systems are examples of tools that help centrally manage the source code files and the changes to those files for a software project.

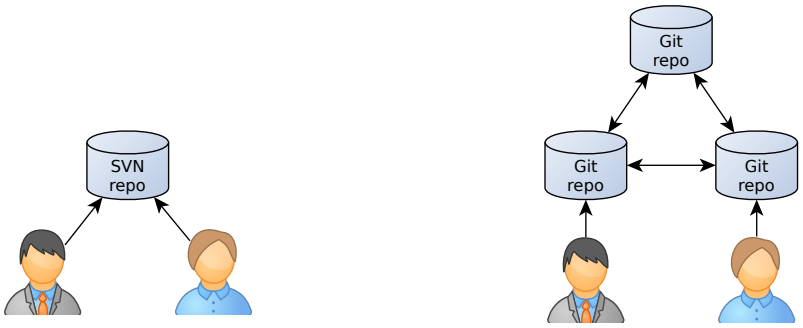
- It may be integrated with the IDE[1]
- Examples are:
  - Concurrent Versions System[2] (CVS)
  - Subversion (SVN)
  - Git
- For information about git vs svn, visit (www.findbestopensource.com/article-detail/git-vs-subversion).



10.2 Centralized vs Decentralized Revision Control

Centralized	Decentralized
CVS	Git
SVN	HG
...	...

[1] http://en.wikipedia.org/wiki/Comparison_of_revision_control_software
[2] Very old, widespread, but not so good



What version control systems are most important to you?

SVN (Subversion) (70%, 567 Votes)

Git (58%, 465 Votes)

CVS (Concurrent Versions System) (10%, 79 Votes)

Bazaar (12%, 94 Votes)

GNU Arch (1%, 5 Votes)

Perforce (1%, 10 Votes)

darcs (1%, 12 Votes)

Bitkeeper (0%, 2 Votes)

Mercurial (17%, 139 Votes)

Monotone (0%, 2 Votes)

Clearcase (1%, 11 Votes)

Other (0%, 0 Votes)

I don't use version control (1%, 5 Votes)

Total Voters: **808**

10.3 Introducing Git

Git is an open source program for tracking changes in text files. It was written by the author of the Linux operating system.

10.3.1 Git compared to other VCS

[https://www.git-tower.com/learn/git/ebook/en/command-line/advanced-topics/merge-conflicts#start]

- A great thing about having Git as your version control system is that it makes merging extremely easy: in most cases, Git will figure out how to integrate new changes.
- You can always undo a merge and go back to the state before the conflict occurred. You're always able to undo and start fresh.
  - If you're coming from another version control system like e.g. Subversion you might be traumatized: conflicts in **Subversion** have the (rightful) reputation of being incredibly complex and nasty. One reason for this is that Git, simply

stated, works completely different in this regard than Subversion. As a consequence, Git is able to take care of most things during a merge - leaving you with comparatively simple scenarios to solve.

– Also, a conflict will only ever handicap yourself. It will not bring your complete team to a halt or cripple your central repository. This is because, in Git, conflicts can only occur on a developer's local machine - and not on the server.

10.3.2 Git is Very Different

The first important thing to understand about Git is that it thinks about version control very differently than Subversion or Perforce or whatever Source Code Management (SCM) tool you may be used to.

Theorem 10.1 (the Forget theorem)**.** *It is often easier to learn Git by trying to **forget** your assumptions about how version control works and try to think about it in the Git way.*

10.3.3 How to Think Like Git? [9]

Let's start from scratch. Assume you are designing a new source code management system. How did you do basic version control before you used a tool for it? Chances are that you simply copied your project directory to save what it looked like at that point.

```
$ cp -R project project.bak
```

That way, you can easily revert files that get messed up later, or see what you have changed by comparing what the project looks like now to what it looked like when you copied it.

If you are really paranoid, you may do this often, maybe putting the date in the name of the backup:

```
$ cp -R project project.2010-06-01.bak
```

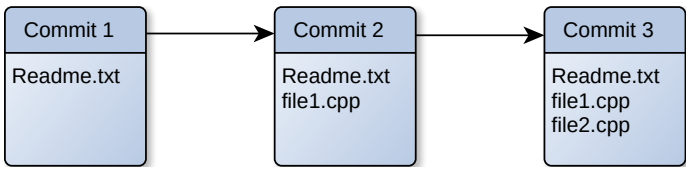
In that case, you may have a bunch of snapshots of your project that you can compare and inspect from. You can even use this model to fairly effectively share changes with someone. If you zip up your project at a known state and put it on your website, other developers can download that, change it and send you a patch pretty easily.

```
$ wget http://example.com/project.2010-06-01.zip
$ unzip project.2010-06-01.zip
$ cp -R project.2010-06-01 project-my-copy
$ cd project-my-copy
$ (change something)
$ diff project-my-copy project.2010-06-01 > change.patch
$ (email change.patch)
```

Now the original developer can apply that patch to their copy of the project and they have your changes. This is how many open source projects have been collaborated on for several years.

This actually works fairly well, so let's say we want to write a tool to make this basic process faster and easier. Instead of writing a tool that versions **each file individually**, like **Subversion**, we would probably write one that makes it easier to store **snapshots of the project** without having to copy the whole directory each time.

This is essentially what Git is. You tell Git you want to save a snapshot of your project with the git commit command and it basically records a manifest of what all of the files in your project look like at that point. Then most of the commands work with those manifests to see how they differ or pull content out of them, etc.



If you think about Git as a tool for storing and comparing and merging snapshots of your project, it may be easier to understand what is going on and how to do things properly.

10.4 Installing Git

Check `https://git-scm.com/downloads`.

10.5 Understanding the Workflow of Git

Check figures 10.1, 10.2 and 10.3.

10.6 Git Terminology Explained [10, 11]

The first step towards learning git is to understand the meaning of its terminology. The following terms is ordered from the most basic to the less likely to use/hear-about.

Repository consists of two things:

".git" directory is where Git stores the metadata and object database of the repository in a compressed format. It is what is copied when a repository is cloned.

working directory normally contains the contents of the *HEAD* commit, plus any local changes made.

- Reverting to older commit replaces the *working directory* with the snapshot of this commit.
- Also checkingout a *branch* replaces the *working directory* with the snapshot of the *HEAD* commit of the checkedout branch.

working copy is a synonym to *working directory*

working tree is a synonym to *working directory*

staging area is generally a file in *".git" directory* that stores information about what will be included into the next *commit*. It is also called *index*.

index is a synonym to *staging area*

stage adds files to the *staging area*, so that they are included in the next *commit*.

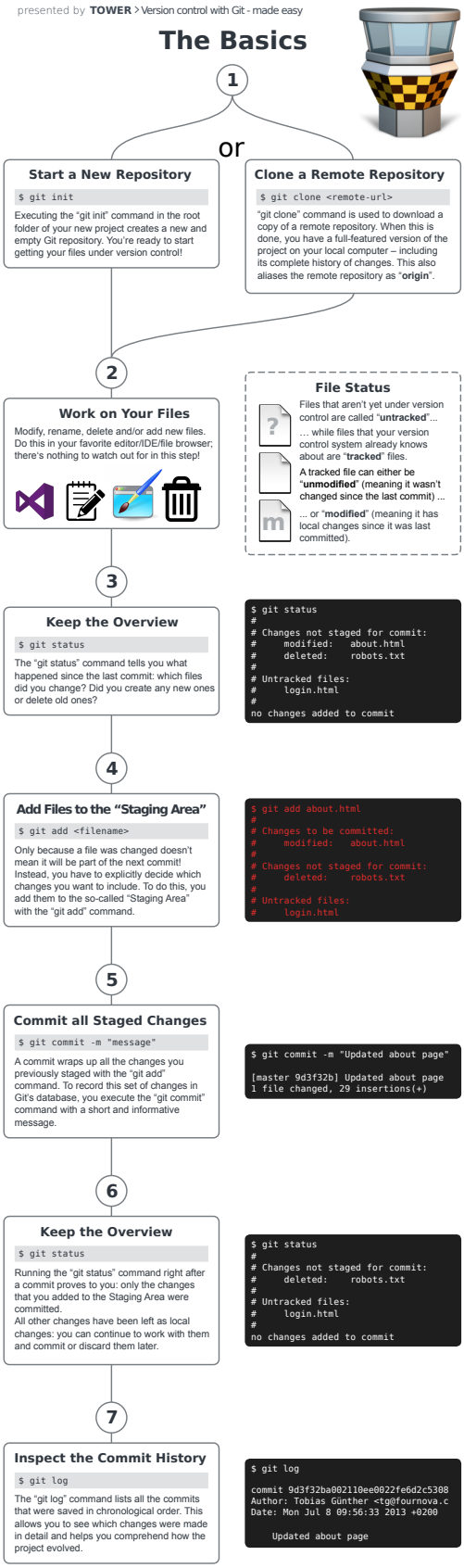


Figure 10.1: Git Basics [https://www.git-tower.com/learn/cheat-sheets/vcs-workflow with modifications]

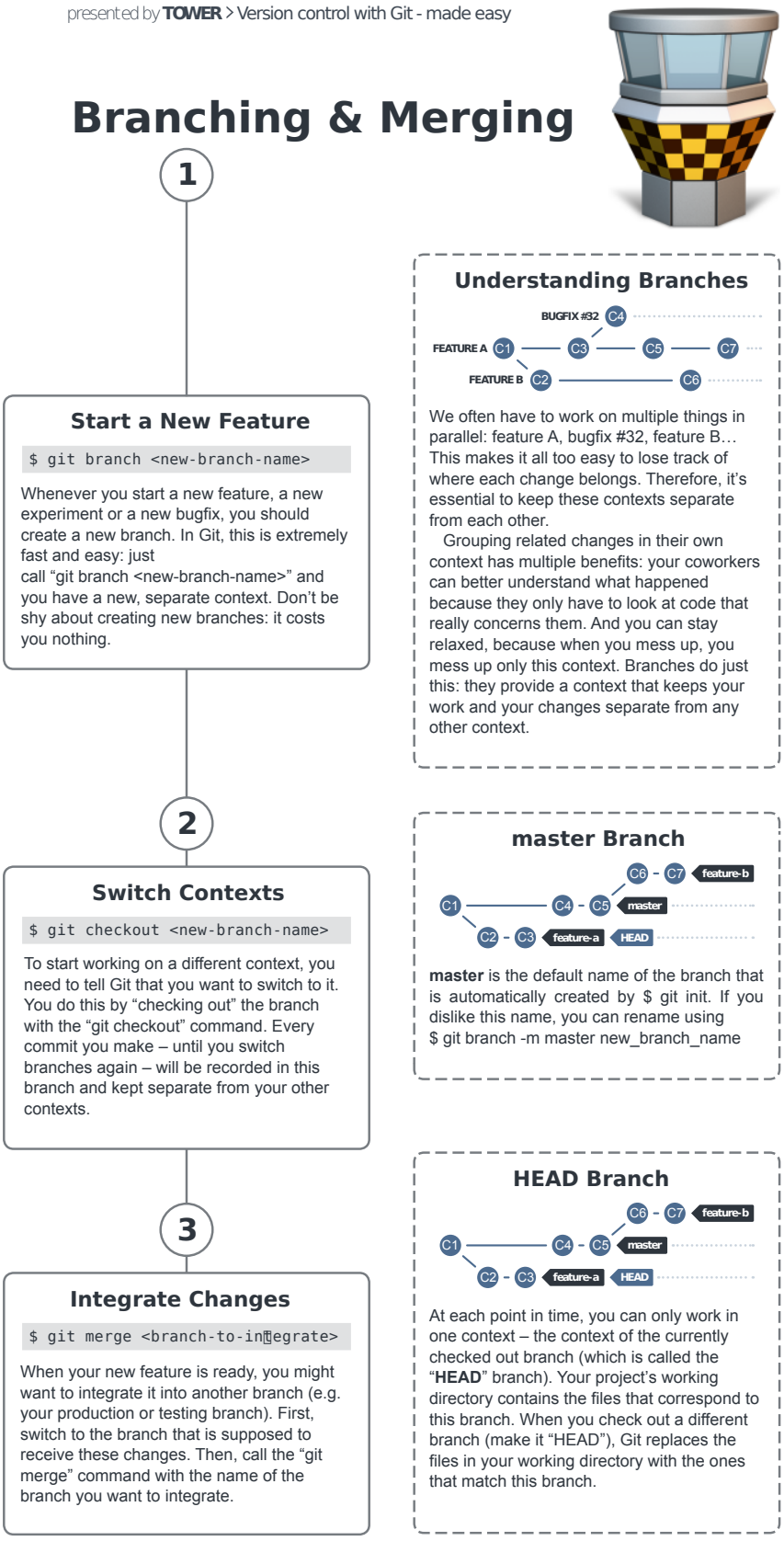


Figure 10.2: Git branching and merging [https://www.git-tower.com/learn/cheat-sheets/vcs-workflow with modifications]

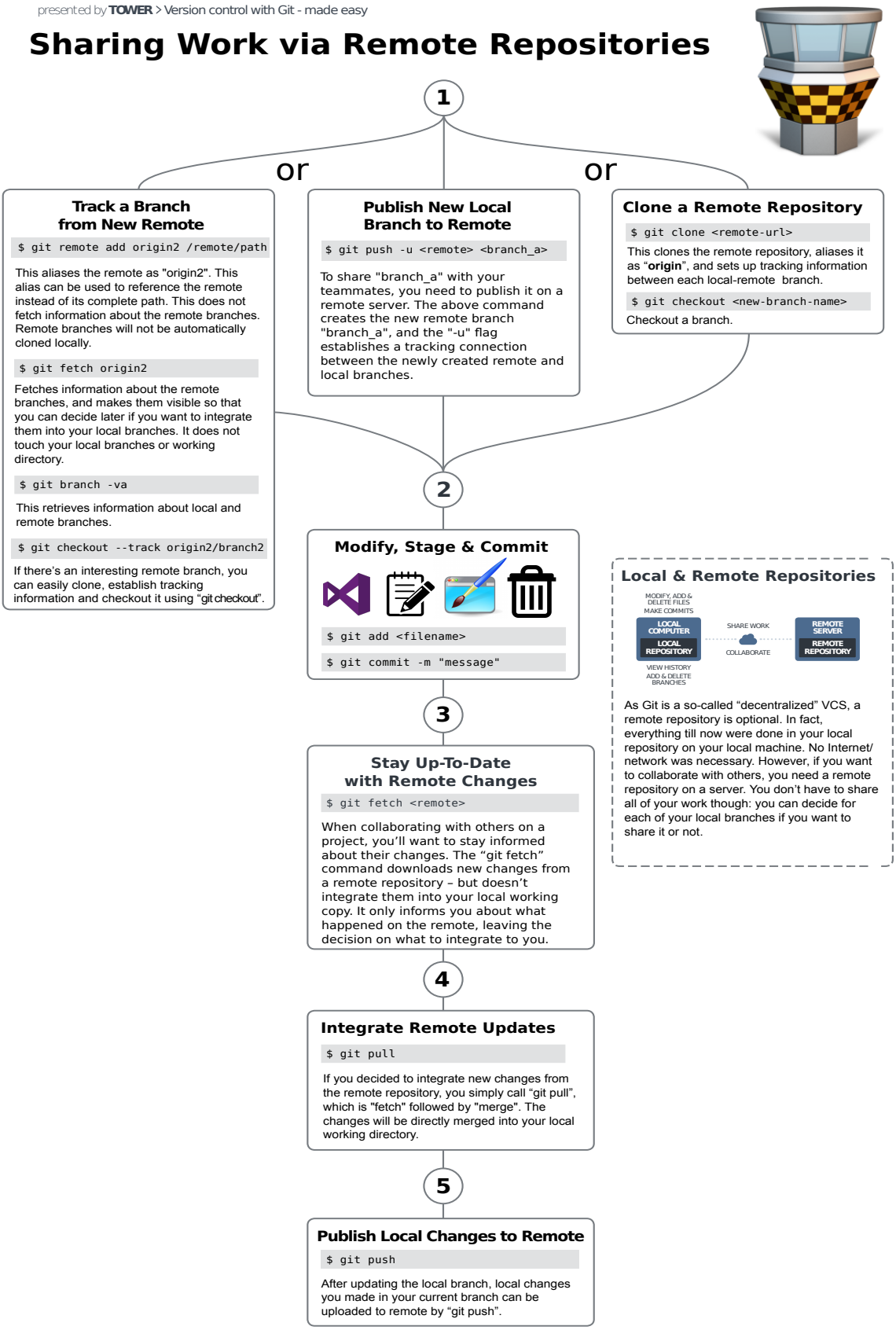
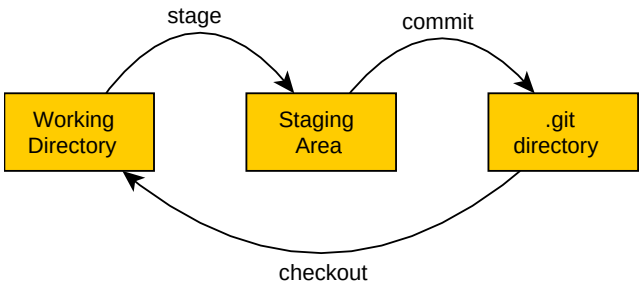


Figure 10.3: Git sharing work via remote repositories [https://www.git-tower.com/learn/cheat-sheets/vcs-workflow with modifications]

- Be warned that non-staged files may be removed (deleted) when checkingout a *branch* or reverting to older an *commit*.

add is a synonym to *stage*.

commit [1] record a snapshot of the current state of the *staging area*, marking a new version of your repository. Later on, you can revert the repository to any commit.



tag is most typically used to mark a particular *commit*.

head is a named reference to the last *commit* of a *branch*.

HEAD is a named reference to *head* of the *current branch*.

clone does the following:

1. creates a *local* copy of a *remote Repository*, including all of its *branches*,
2. sets up tracking information[2] between each *local-remote* (upstream) *branch*
3. checkout the *local* branch corresponding to the *remote's current* branch.

- `$ git clone <remote-url>` automatically aliases *remote Repository* as *origin*.
- If you prefer another alias for the *remote Repository*, clone using `$ git clone -o remote_alias <remote-url>`

remote is a repository that is used to track the local repository but resides somewhere else. Teams are using remote repositories to share & exchange data: they serve as a common base where everybody can publish their own changes and receive changes from their teammates.

- Remote repository may be usual or bare repository.
- Remotes can be managed using `$ git remote` command. Remote data can be updated/synced using with/from *local* repository using *fetch*, *pull* and *push*.
- You can have several of remotes.
- To see more information about a particular remote, use `$ git remote show [remote-name]`

[1] In other other revision control systems, the same thing is referred to as *revision* or *version*.

[2] This enables using `$ git push` and `$ git pull` commands without specifying further arguments identifying targeted local and remote branches.

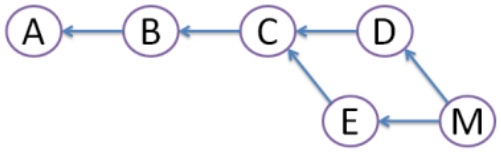
upstream refers to the *remote* with which the *local* syncs.

downstream refers to the *local*, as compared to *upstream*.

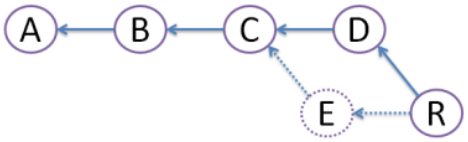
origin is the default name assigned to *remote* by `$ git clone`. If you dislike this name, you can rename using `$ git remote rename origin new_origin_name`

pull updates the *current local branch*, and hence the *working directory*, with the *upstream branch* modifications.

- `$ git pull` performs two operations: (1) *fetch* the *upstream branch* updates and (2) *merge* them into the *current local* branch. This is suitable for updating after a long time. However, this creates diamond shape, which many people find very confusing.



- `$ git pull --rebase` performs two operations: (1) *fetch* the *upstream branch* updates and (2) rebase the latest *local commit* on top of the *upstream branch*. This is suitable for updating after a short time. The diamond shape is avoided, and history stays nice straight line. Most developers love that! For more information, refer to [1, sec. Rebase as an Alternative to Merge].



push uploads all the new *commits* from the *current local branch* to the corresponding *upstream* branch. If the upstream branch was a **direct** ancestor to the local branch, push completes. Otherwise, the push is rejected. In this case, you have to *pull* the *upstream* branch first before you are can push.

- If the owner of the *local* repository does not have permission to *push* to *remote*, then *push*ing *local* to *remote* is not possible. In this case instead, the owner of the *local* repository sends a *pull request* to the owner of the *remote* repository.

pull request is a request from the owner of a *local* repository to the owner of the *remote* repository to pull his changes. *remote*'s owner can use *diff* to review the changes and may selectively accepted/rejected changes.

- If the owner of the *local* repository has permission to *push* to *remote*, he can instead directly *push local* to *remote*.
- *pull request*is an announcing method, and are not a feature of Git. So it depends on the hosting website[1] and has no Git command.

[1] Such as `GitHub.com` and `BitBucket.org`

fetch fetches *branches* from a *remote Repository*, along with the objects necessary to complete their histories.

- Fetch will not touch any of your *local branches* or your *working directory*. It just downloads data from the specified *remote* and makes them visible so that you can decide if you want to integrate new changes into your *local Repository*.

diff is the difference in changes between two commits, or saved changes. The diff will visually describe what was added or removed from a file since its last commit.

branch is a way to request a parallel isolated *working directory*, *staging area*, and *commit* history, so that you test new experimental features without disturbing the main branch[1]. A local branch that you create on your machine is kept private to you until you explicitly decide to publish it using *push*. This means that it's perfectly possible to keep some of your work private while sharing only certain other branches with the world.

checkout a branch means to switch to this branch, ***replace***[2] the *working directory* with the snapshot of the *head* of this branch and update the *staging area* and *HEAD* to point to this branch.

master is the default name of the branch that is automatically created by `$ git init`. If you dislike this name, you can rename using `$ git branch -m master new_branch_name`

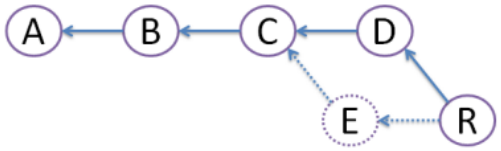
merge tries to merge a *branch* into the *current branch*. If there are merge conflicts, manual intervention may be required to complete the merge.

- Merge directly modifies files on the *current working directory*.
- Merge integrates a *branch*; not individual *commits*
- If the merged *branches* changed the same lines in that same file, or if one deleted it while the other modified it, Git simply cannot know what is correct. Git will then mark the file as having a *conflict* - which you'll have to solve before you can continue your work. More details are in [1, Dealing With Merge Conflicts].
- You can always undo a merge and go back to the state before the conflict occurred. You're always able to undo and start fresh.

rebase reapply a series of changes from a branch to a different base. For more information, refer to [1, sec. Rebase as an Alternative to Merge].

[1] In many VCS tools, *branching* a somewhat expensive process, often requiring creating a new copy of the source code directory, which can take a long time for large projects. Therefore, Git's branching model is referred to as a "*killer feature*" that sets superior in the VCS community. This is because Git branches in incredibly lightweight way, making branching operations nearly instantaneous, and switching back and forth between branches generally just as fast. Unlike many other VCSs, Git encourages workflows that *branch* and *merge* often, even multiple times in a day.

[2] Non committed, staged or stashed files may be removed (deleted). Therefore, it is advisable to *commit*/*stage*/*stash* your modifications before checkingout.

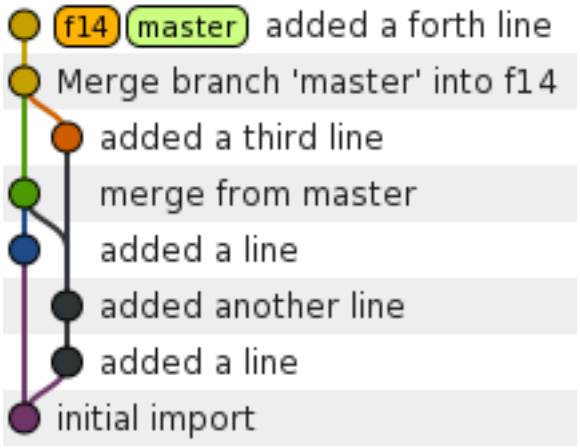


fast forward is a special type of *merge*, where you are merging a branch that happens to be descendant of your HEAD. In such a case, you do not make a new *merge commit* but instead just update to branch *HEAD*. Check figure 10.4 for visual explanation. For more information, refer to [1, sec. Rebase as an Alternative to Merge].

stash When you are developing some new feature and your work is not yet ready for a *commit*, and want to checkout another branch to work on something else, *stash* is designed to help you in this situation. *stash* saves your local modifications away and reverts the working directory to match the *HEAD* commit. After finishing, you can return and re-apply the stashed work and can continue on it.

cherry pick means to extract the change introduced by an existing commit and to record it based on the tip of the current branch as a new commit.

DAG Directed acyclic graph.



resolve is fixing up manually what a failed automatic *merge* left behind.

blame describes the last modification to each line of a file, which generally displays the revision, author and time. This is helpful, for example, in tracking down when a feature was added, or which commit led to a particular bug.

Fork fork is a copy of another repository that lives on your account. Forks allow you to freely make changes to a project without affecting the original. Forks remain attached to the original, allowing you to submit a pull request to the original's author to update with your changes. You can also keep your fork up to date by pulling in updates from the original.

SHA-1 (Secure Hash Algorithm 1) a cryptographic hash function used as a synonym for object name.

submodule is a repository inside another repository (the latter of which is called *super-project*).

superproject is a repository that references repositories of other projects in its working tree as *submodule*. The superproject knows about the names of (but does not hold copies of) commit objects of the contained submodules.

Hook is a script that runs automatically every time a particular event occurs in a Git repository. Hooks let you customize Git's internal behavior and trigger customizable actions at key points in the development life cycle.

prune removes unreachable objects.

bare repository is intended to be solely used as a *remote* repository. That is, it is not used for working on files, but rather for sharing and exchanging code between developers. Hence, a bare repository contains no *working directory* and stores git revision history in the root folder of the repository instead of in a *".git" directory*. Customarily, bare repositories are given a ".git" extension. A blank bare repository can be created with `$ git init --bare`. Alternatively, it can be cloned from a local repository with `$ git clone --bare`.

10.7 Git Cheat Sheet

Check figure 10.5.

10.8 Git Best Practices

Check figure 10.6.

10.9 Undoing Things

Check [1, sec. Undoing Things]

10.10 Dangerous Commands

- `$ git rm <filename>` unstage **and delete** a file. Use `$ git reset <filename>` instead to unstage the file.
- When checking-out a branch, non-committed, non-staged or non-stashed files may be removed (deleted). Therefore, it is advisable to *commit*/*stage*/*stash* your modifications before checking-out.

10.11 Git GUI

Check `https://git-scm.com/downloads/guis` for the complete list. Anyway, don't expect any GUI can replace Git commands altogether.

10.11.1 Tower

Tower (www.git-tower.com) seems to be the best GUI. Its documentation, notably [1] are concise and clear. Tower can be installed only on Mac and Windows. It is however expensive and not open source.

10.11.2 GitKraken

GitKraken (www.gitkraken.com) on the other hand seems similar to *Tower*. It is free, cross platform but, however, not open source!

10.11.2.1 GitKraken Cheat Sheets

- GitKraken Cheat Sheet; www.gitkraken.com/resources/gitkraken-cheat-sheet
- GitKraken for GitHub Users Cheat Sheet; www.gitkraken.com/resources/gitkraken-github-cheat-sheet

10.11.2.2 Tips Using GitKraken

If you use remotes on GitHub.com or BitBucket.org, make sure to authenticate as explained in https://support.gitkraken.com/integrations/github and https://support.gitkraken.com/integrations/bitbucket.

10.12 Good Reads

1. [1]
2. [9]
3. [12]
4. http://gitimmersion.com
5. https://yakiloo.com/getting-started-git/
6. http://ndpsoftware.com/git-cheatsheet.html

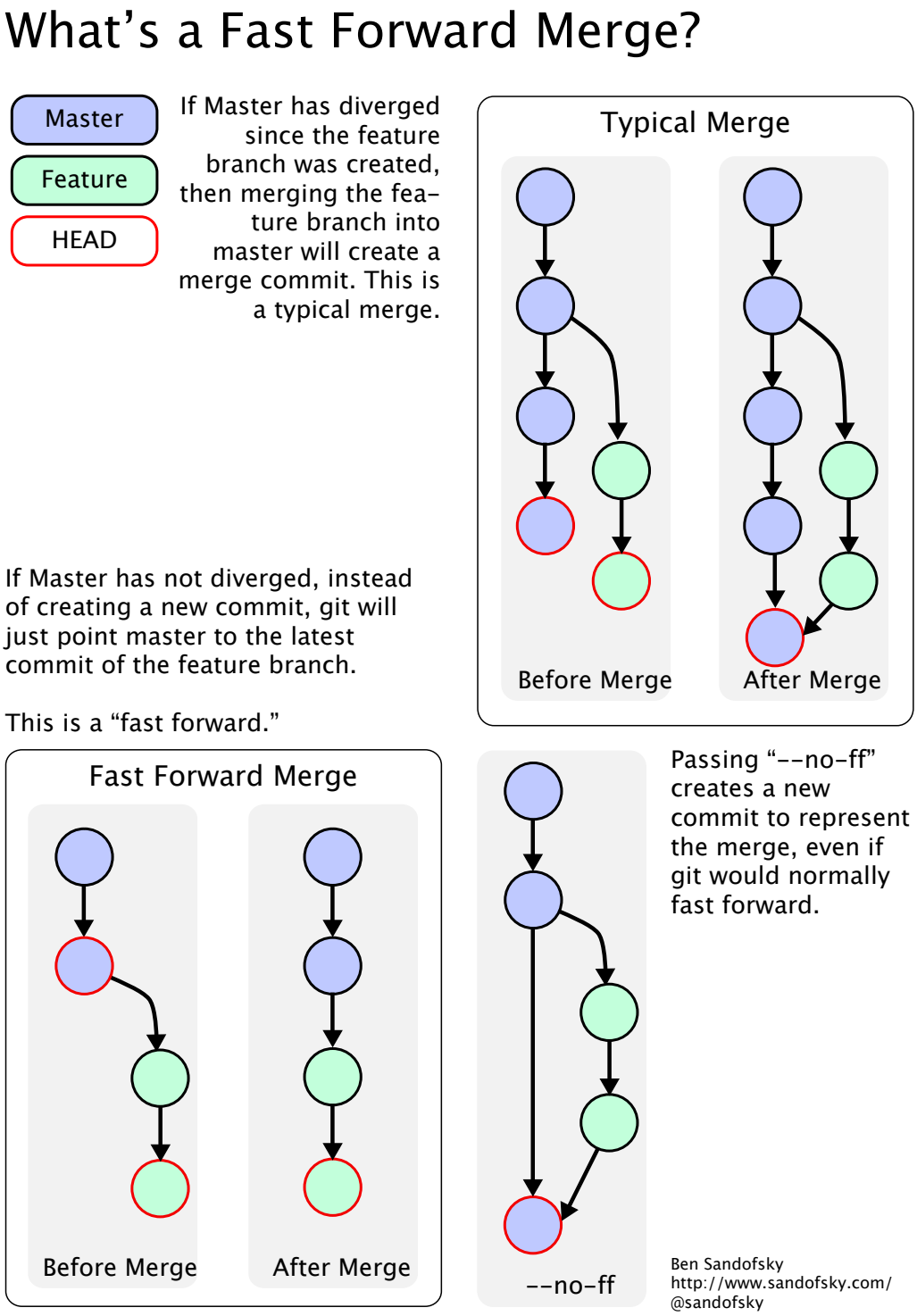


Figure 10.4: Fast Forward Merge [http://www.sandofsky.com]

GITCHEAT SHEET

presented by **TOWER** >Version control with Git - made easy

CREATE

Clone an existing repository

```
$ git clone ssh://user@domain.com/repo.git
```

Create a new local repository

```
$ git init
```

LOCAL CHANGES

Changed files in your working directory

```
$ git status
```

Changes to tracked files

```
$ git diff
```

Add all current changes to the next commit

```
$ git add .
```

Add some changes in <file> to the next commit

```
$ git add -p <file>
```

Commit all local changes in tracked files

```
$ git commit -a
```

Commit previously staged changes

```
$ git commit
```

Change the last commit

Don't amend published commits!

```
$ git commit --amend
```

COMMIT HISTORY

Show all commits, starting with newest

```
$ git log
```

Show changes over time for a specifcfile

```
$ git log -p <file>
```

Who changed what and when in <file>

```
$ git blame <file>
```

BRANCHES & TAGS

List all existing branches

```
$ git branch -av
```

Switch HEAD branch

```
$ git checkout <branch>
```

Create a new branch based on your current HEAD

```
$ git branch <new-branch>
```

Create a new tracking branch based on a remote branch

```
$ git checkout --track <remote/branch>
```

Delete a local branch

```
$ git branch -d <branch>
```

Mark the current commit with a tag

```
$ git tag <tag-name>
```

UPDATE & PUBLISH

List all currently confgured remotes

```
$ git remote -v
```

Show information about a remote

```
$ git remote show <remote>
```

Add new remote repository, named <remote>

```
$ git remote add <shortname> <url>
```

Download all changes from <remote>, but don't integrate into HEAD

```
$ git fetch <remote>
```

Download changes and directly merge/integrate into HEAD

```
$ git pull <remote> <branch>
```

Publish local changes on a remote

```
$ git push <remote> <branch>
```

Delete a branch on the remote

```
$ git branch -dr <remote/branch>
```

Publish your tag s

```
$ git push --tags
```

MERGE & REBASE

Merge <branch> into your current HEAD

```
$ git merge <branch>
```

Rebase your current HEAD onto <branch>

Don't rebase published commits!

```
$ git rebase <branch>
```

Abort a rebase

```
$ git rebase --abort
```

Continue a rebase after resolving conficts

```
$ git rebase --continue
```

Use your confgured merge tool to solve conficts

```
$ git mergetool
```

Use your editor to manually solve conficts and (after resolving) mark fileas resolved

```
$ git add <resolved-file>
$ git rm <resolved-file>
```

UNDO

Discard all local changes in your working directory

```
$ git reset --hard HEAD
```

Discard local changes in a specifcfile

```
$ git checkout HEAD <file>
```

Revert a commit (by producing a new commit with contrary changes)

```
$ git revert <commit>
```

Reset your HEAD pointer to a previous commit ...and discard all changes since then

```
$ git reset --hard <commit>
```

...and preserve all changes as unstaged changes

```
$ git reset <commit>
```

...and preserve uncommitted local changes

```
$ git reset --keep <commit>
```

Figure 10.5: Git Cheat Sheet [https://www.git-tower.com/learn/cheat-sheets/git]

VERSION CONTROL

BEST PRACTICES

COMMIT RELATED CHANGES

A commit should be a wrapper for related changes. For example, fxing two diferent bugs should produce two separate commits. Small commits make it easier for other developers to understand the changes and roll them back if something went wrong.
With tools like the staging area and the ability to stage only parts of a fle, Git makes it easy to create very granular commits.

TEST CODE BEFORE YOU COMMIT

Resist the temptation to commit something that you «think» is completed. Test it thoroughly to make sure it really is completed and has no side efects (as far as one can tell). While committing half-baked things in your local repository only requires you to forgive yourself, having your code tested is even more important when it comes to pushing/sharing your code with others.

USE BRANCHES

Branching is one of Git's most powerful features - and this is not by accident: quick and easy branching was a central requirement from day one. Branches are the perfect tool to help you avoid mixing up diferent lines of development. You should use branches extensively in your development workflows: for new features, bug fxes, ideas...

COMMIT OFTEN

Committing often keeps your commits small and, again, helps you commit only related changes. Moreover, it allows you to share your code more frequently with others. That way it's easier for everyone to integrate changes regularly and avoid having merge conficts. Having few large commits and sharing them rarely, in contrast, makes it hard to solve conficts.

WRITE GOOD COMMIT MESSAGES

Begin your message with a short summary of your changes (up to 50 characters as a guideline). Separate it from the following body by including a blank line. The body of your message should provide detailed answers to the following questions:
› What was the motivation for the change?
› How does it difer from the previous implementation?
Use the imperative, present tense («change», not «changed» or «changes») to be consistent with generated messages from commands like git merge.

AGREE ON A WORKFLOW

Git lets you pick from a lot of diferent workflows: long-running branches, topic branches, merge or rebase, git-flow... Which one you choose depends on a couple of factors: your project, your overall development and deployment workflows and (maybe most importantly) on your and your teammates' personal preferences. However you choose to work, just make sure to agree on a common workflow that everyone follows.

DON'T COMMIT HALF-DONE WORK

You should only commit code when it's completed. This doesn't mean you have to complete a whole, large feature before committing. Quite the contrary: split the feature's implementation into logical chunks and remember to commit early and often. But don't commit just to have something in the repository before leaving the ofce at the end of the day. If you're tempted to commit just because you need a clean working copy (to check out a branch, pull in changes, etc.) consider using Git's «Stash» feature instead.

VERSION CONTROL IS NOT A BACKUP SYSTEM

Having your fles backed up on a remote server is a nice side efect of having a version control system. But you should not use your VCS like it was a backup system. When doing version control, you should pay attention to committing semantically (see «related changes») - you shouldn't just cram in fles.

HELP & DOCUMENTATION

Get help on the command line

```
$ git help <command>
```

FREE ONLINE RESOURCES

http://www.git-tower.com/learn
http://rogerdudler.github.io/git-guide/
http://www.git-scm.org/

Figure 10.6: Git Best practices [https://www.git-tower.com/learn/cheat-sheets/git]

Appendix A

Matlab Codes

Code A.1: SDOF_Free_Response_Visc_main

```
function SDOF_Free_Response_Visc_main()
clc
close all

set(groot,'DefaultAxesColorOrder',[0,0,1;0,0,0;1,0,0;0,0.5,0;1,0,1])
set(groot,'DefaultAxesLineStyleOrder','-|--|-.')
set(groot,'DefaultLineLineWidth',1);
set(groot,'DefaultAxesFontName','Times')

w_n=1;
x0=-1;
v0=0;

zeta_vec=[0,.1,.2,.4,1/sqrt(2),1,2];
legend_string={'$\zeta = 0$','$\zeta = 0.1$','$\zeta = 0.2$','$\zeta = 0.4$','$\zeta=1/\sqrt{2}$','$\zeta = 1$','$\zeta = 2$'};

t_vec=linspace(0,4*pi,500);

figure
hold on
for n=1:length(zeta_vec)
    x_vec=SDOF_Free_Response_Visc(w_n,zeta_vec(n),x0,v0,t_vec);
    plot(w_n*t_vec,x_vec)
end

title('$x(t)$ for $\omega_{n}=1$, $x_{0}=-1$ and $\dot{x}_{0}=0$','interpreter','latex');
xlabel('$\omega_{n} t$','interpreter','latex');
legend(legend_string,'interpreter','latex','Location','SouthEast');

grid on
ax=gca;
ax.XTick=0:pi:4*pi;
```

```
ax.XTickLabel={'0','\pi','2\pi','3\pi','4\pi'};
ax.XAxis.MinorTickValues=setdiff(0:pi/2:4*pi,0:pi:4*pi);
ax.XMinorGrid='on';
ax.XLim=[0,4*pi];

set(groot,'DefaultAxesColorOrder','remove')
set(groot,'DefaultAxesLineStyleOrder','remove')
set(groot,'DefaultLineLineWidth','remove');
set(groot,'DefaultAxesFontName','remove')

export_figure(gcf,'',{'SDOF_FreeResponse'})
```

Code A.2: function SDOF_Free_Response_Visc.m

```
function x_vec=SDOF_Free_Response_Visc(w_n, zeta, x0, x_dot_0, t_vec)

if zeta~=1
    w_d=w_n*sqrt(1-zeta^2);
    x_vec=exp(-zeta*w_n*t_vec).*(x0*cos(w_d*t_vec)+(zeta*w_n*x0+
       x_dot_0)*sin(w_d*t_vec)/w_d);
else
    x_vec=exp(-w_n*t_vec).*(x0+(w_n*x0+x_dot_0)*t_vec);
end
```

Code A.3: function export_figure

```
function export_figure(fig_handle_vec, ...
                  Expand,filenames,resolution,pictureFormat) %
                     Optional arguments

if nargin<2
    Expand='';
end

if nargin<4
    resolution=600;
elseif isempty(resolution)
    resolution=600;
end

if nargin<5
    pictureFormat={'pdf'};
else
    if ~iscell(pictureFormat)
        error('pictureFormat must be cell array of strings.')
    end
end
```

```
printFlag=cell(size(pictureFormat));
for n=1:length(pictureFormat)
    if strcmpi(pictureFormat{n},'emf')
        if ispc
            printFlag{n}='meta';
        else
            error('Matlab cannot export emf except under Windows.');
        end
    else
        printFlag{n}=lower(pictureFormat{n});
    end
end

if min(size(fig_handle_vec,1),size(fig_handle_vec,2))~=1,
    error('h must be 1 D vector'),
end

if ~iscellstr(filenames)
    error('filenames must be a cell string of the same length as
       h_vec');
end

if nargin>2
    if length(fig_handle_vec)~=length(filenames)
        error('h & filenames must be of the same length');
    end
end

if ~isempty(Expand)
    if ischar(Expand)
        if (~strcmpi(Expand,'||') && ~strcmpi(Expand,'=='))
            error('you must input ''||'' or ''==''')
        end
    end
end

for i=1:length(fig_handle_vec)
    f_OriginalUnit=get(fig_handle_vec(i),'Units');
    set(fig_handle_vec(i),'papertype','A4');
    if ~isempty(Expand)
        if ischar(Expand)
            if strcmpi(Expand(1:2),'||')
                 set(fig_handle_vec(i), 'PaperOrientation', 'portrait'
                    );
            elseif strcmpi(Expand(1:2),'==')
               set(fig_handle_vec(i), 'PaperOrientation', 'landscape')
                  ;
            end
```

```
        end

        if ischar(Expand)
            if strcmpi(Expand,'||') || strcmpi(Expand,'==')
                a=get(fig_handle_vec(i),'papersize');
                set(fig_handle_vec(i), 'PaperPositionMode', 'manual');
                set(fig_handle_vec(i),'PaperPosition',[0 0 a(1) a(2)])
                    ;
                set(fig_handle_vec(i),'Units',get(fig_handle_vec(i),'
                   PaperUnits'));
                set(fig_handle_vec(i),'Position',[0 0 a(1) a(2)]);
                set(fig_handle_vec(i),'Units',f_OriginalUnit);
                set(0,'CurrentFigure',fig_handle_vec(i)),
                drawnow
            else
                set(fig_handle_vec(i), 'PaperPositionMode', 'auto');
            end
        elseif isnumeric(Expand)
            pos=get(fig_handle_vec(i),'PaperPosition');
            set(fig_handle_vec(i), 'PaperPositionMode', 'manual');
            set(fig_handle_vec(i),'PaperPosition',[pos(1:2),pos(3:4)*
               Expand]);

        end
    end
end

for i=1:length(fig_handle_vec),
    for n=1:length(printFlag)
        if nargin<3
           print(['-r',int2str(resolution)], '-painters', ['-d',
              printFlag{n}],['-f',int2str(double(fig_handle_vec(i)))
              ]);
           %print(['-r',int2str(resolution)], '-painters', ['-d',
              printFlag{n}],['-f',int2str(get(fig_handle_vec(i),'
              Number'))]);
        else
           print(['-r',int2str(resolution)], '-painters', ['-d',
              printFlag{n}],['-f',int2str(double(fig_handle_vec(i)))
              ],[filenames{i},['.',pictureFormat{n}]]);
% print(['-r',int2str(resolution)], '-painters', ['-d',printFlag{n
    }],['-f',int2str(get(fig_handle_vec(i),'Number'))],[filenames{i
    },['.',pictureFormat{n}]]);
        end
    end
end

% %If "strawberry perl" and Miketex is installed
```

```
if nargin>=3 %&& ispc
    temp_env=getenv('LD_LIBRARY_PATH');
    setenv('LD_LIBRARY_PATH', '')
    for n=1:length(pictureFormat)
        if strcmpi(pictureFormat{n},'pdf')
           for i=1:length(fig_handle_vec),
               system(['pdfcrop "',filenames{i},'.pdf" "',filenames{i
                  },'.pdf"']);
           end

           break;
        end
    end
    setenv('LD_LIBRARY_PATH', temp_env)
end
```

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