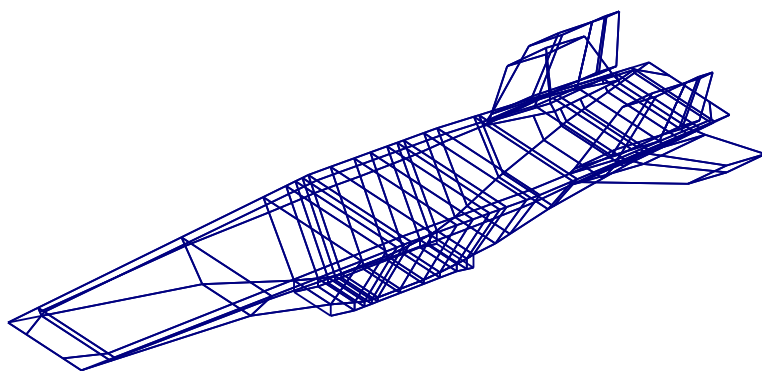# Solving Nonlinear Equations of One Variable

by

Derek J. Dalle

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Aerospace Engineering)
in the University of Michigan
2012

Doctoral Committee:

Professor James F. Driscoll, Chair
Professor Peter J. Olver, University of Minnesota

2012

This dissertation is in honor of Adlai Stevenson and William Jennings Bryan, who were both twice the Democratic nominee for President of the United States without winning either time. As an interesting side note, Adlai Stevenson's grandfather, Adlai E. Stevenson I, was William Jennings Bryan's running mate in the 1900 election.

A C K N O W L E D G M E N T S

It is imperative that I thank all of the authors of the dissertation template from the Department of Atmospheric, Oceanic and Space Sciences, which is available online at http://aoss.engin.umich.edu/. To my knowledge, the authors of that template include Jin Ji, Roque D. Oliveira, and Jason Gilbert. I also must thank Sara Spangelo for suggesting that this template be ready by the end of April 2011.

Preface

The text of this document is of course mainly meant to show how the template works. The topic is thus a basic problem which has been solved in a great number of ways. This sample topic, which is solving equations of one variable using iterative techniques, allows us to use sample equations and figures so that we can see how they will look in this template. In addition to this subject, the text also serves as a very unusual users' manual. The second chapter, which does not match the other chapters at all, gives instructions on the actual commands that are used with this template.

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CFD Computational Fluid Dynamics

ABSTRACT

Solving Nonlinear Equations of One Variable

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Chair: James F. Driscoll

We show that it is possible to get approximate solutions to analytically intractable equations using iterative methods. Thus we show that the author could pass an undergraduate class in numerical analysis. In addition, a unique extension to Brent's method is proposed that results in slight improvements in convergence.

Chapter 1

Introduction

The first part. For example in Computational Fluid Dynamics (CFD), which gives me a nice example of an abbreviation to demonstrate, the equation of state cannot be solved analytically when a perfect gas is not assumed.
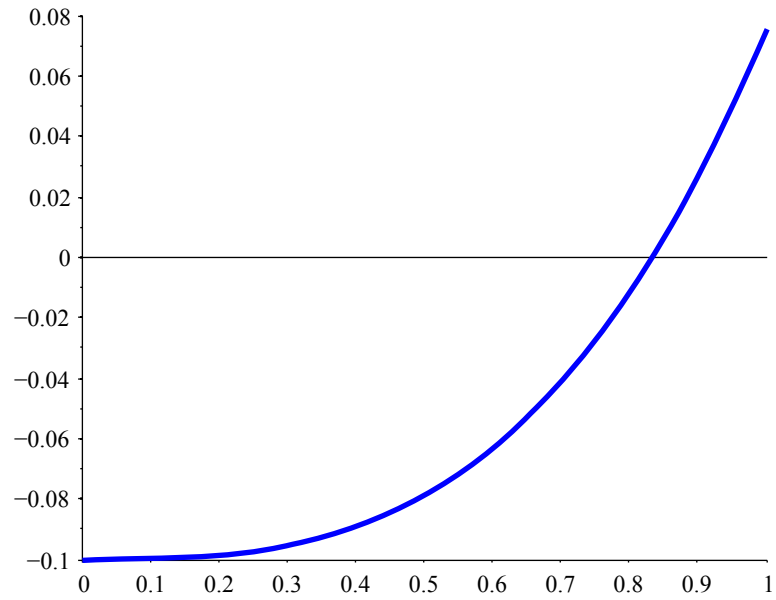
Figure 1.1: An example of a search function

And this should at least continue onto a second page. There are many texts that have a section on the subject, for instance [1].

Chapter 2

Using This Template

This chapter is stuck among the others as a brief users' manual for this template. The approach to this template is to result in LaTeX source code files (*i.e.* .tex files) that are as simple as possible. It also tries to do as much as possible automatically so that the user does not have to spend a lot of effort trying to match the confusing and arbitrary guidelines from Rackham. This is particularly useful for the first few pages, for example the title page, dedication, and abstract page, which are difficult to make in LaTeX and are supposed to go in a certain order.

In addition to the description in this chapter, anyone may, of course, also look at the source code for this file, thesis-sample.tex. That file contains all of the source for this .pdf in a single file, but it will work just as well with multiple input files combined with the `\input` command.

The final generic comment about this template is that it has been updated to take advantage of LaTeX's capabilities to create documents with links in them. Provided you are using a modern PDF viewer to view this document, you may have already noticed this. It creates a list of bookmarks, which can be used to quickly navigate what may be a long document. It also turns references within the text into links. The best examples in this file are the entries in the Table of Contents. Although the chapter and section names are shown in black (in accordance with the Rackham guidelines), clicking on them does navigate to the start of the chapter, section, *etc.*

2.1   General Usage

The way to invoke usage of this template is to put

```
\documentclass{thesis-umich.cls}
```

at the beginning of your preamble. This can also work if the thesis-umich.cls file is not in the same directory as your .tex file. To do so, just give the relative path.

```
\documentclass{./tex/thesis-umich.cls}
```

Much like a usual article or report in LaTeX, the user specifies the primary information about the document in the preamble with commands like

```
\author{Derek J. Dalle}
\chair{James F. Driscoll}
```

At the beginning of the document, *i.e.* wherever the user types `\begin{document}`, the title page will automatically be created and inserted at the beginning of the document. If you forget to declare any of the required fields, it will generate a title page with a message such as "Insert an author!"

However, the template does a lot more in the preamble than just create a title page. The preamble (that is, whatever comes before `\begin{document}` in the primary .tex file) is also the place for the user to specify a dedication, any acknowledgments, a foreword, *etc.* This is done in a manner very similar manner to declaring the author, title, and so on. Suppose that someone wants to have a simple dedication "To Mom" like the one in the Rackham guidelines, the following command is all that is needed.

```
\dedication{To Mom}
```

This will cause the document to have a dedication page with the corresponding text. If the `\dedication` command is not present, there will not be a dedication page. All the work of either having or not having a dedication has been compressed into a single command! Things other than simple text *are* allowed in the dedication, so feel free to put equations or whatever inside there. There are a few more commands that can be used to customize the appearance of the dedication page, and also for the other preamble text pages, but that is left to Section 2.2.2.

2.2 Front Matter

The LaTeXterm "frontmatter" refers to all of the pages that occur before the beginning of the first chapter. It is usually made clear to the reader because the pages in the front matter are numbered with lower-case Roman numerals instead of Arabic numerals.

The present template, thesis-umich.cls attempts to remove as much work associated with the front matter as possible. The template inserts all of the front matter pages automatically, so that there is not even a need to use a command like `\maketitle`. The first thing after `\begin{document}` should be the start of the first chapter.

ITEM	USAGE	COMMENT
Author	`\author{...}`	Works as in standard LaTeX
Chair	`\chair{...}`	Name of chair *without* any title or affiliation. This appears only on the abstract page, and only if there is no co-chair.
Co-chair	`\cochair{...}`	Names of all co-chairs *without* any titles or affiliations. This appears only on the abstract page. Note that by convention, it is not chair *and* co-chair, but just two co-chairs.
Committee	`\committee{...}`	Formatted names of committee members *with* the appropriate titles and university names. This will appear only on the title page.
Department	`\department{...}`	Title of department of student
Title	`\title{...}`	Works as in standard LaTeX
Year	`\year=2012`	Year that dissertation will be *completed*

Table 2.1: List of all identifier commands

2.2.1 Identifiers

The template is not able to read minds, of course, so there needs to be some way of inputting the relevant information. This section covers how to specify the author, title, and so on. For the most part, this works just like any other LaTeX document, but a dissertation has a few more identifiers than most documents (How many books or reports have a committee?). So there are a few extra commands provided by this template, and they work *almost* exactly like the standard commands.

A full list of the identifiers is given in Table 2.1. All of these commands are required except for `\chair` and `\cochair`. Those are only used if there is an in-dissertation abstract page, and in that case only one of the two commands needs to be used, depending on whether or not you have co-chairs. If the `\cochair` command is invoked, the chair will be ignored, and the co-chairs will be inserted on the abstract page.

The only command that is somewhat unusual to use is the `\committee` command. It requires the author to separate the different committee members manually using line-ending commands. In general, this will look something like

```
\committee{
Professor 1 \\
Professor 2, Other School \\
Professor 3}
```

If any of the required fields are not specified, the compilation does not crash, but rather a

reminder message (such as "Insert a Title!") will be placed on the title page in the place of whatever identifier is missing.

The last comment in this section is on the ability to refer to the fields of the commands in Table 2.1 automatically throughout the text. This can be done using commands like `\insertauthor`, `\insertyear`, *etc.* This is not Earth-shattering, but it may be convenient if, for example, you are not sure if you will finish your dissertation in December or January.

2.2.2 Copyright Page

2.2.3 Text Pages

The handling of the first few pages after the title page is one of the best features of this template.

2.2.4 Abstract Page

2.2.5 Lists of Things

Chapter 3

Setting

The second chapter has the good stuff.

3.1 Convergence Criteria

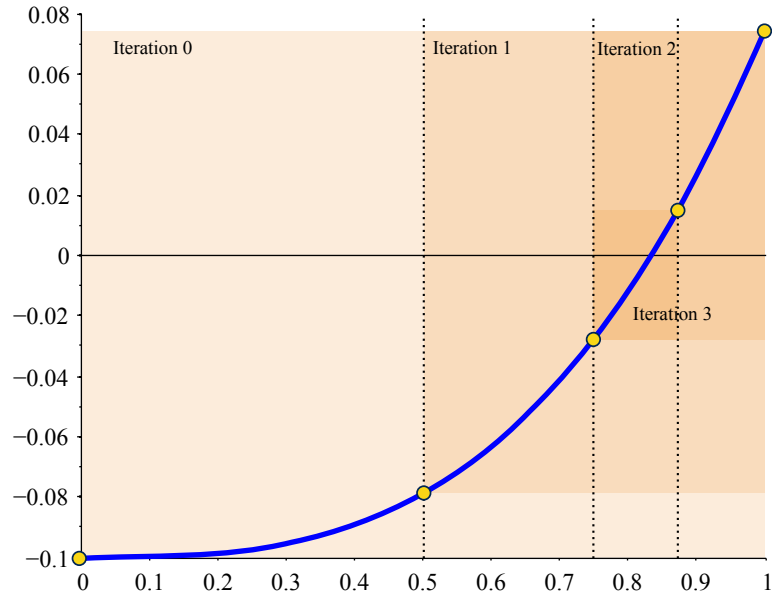Actually, it might have the worst stuff. But it is slightly easier to write than the material in Chapter 1.

Figure 3.1: Illustration of x- and y-tolerances for bisection iterations

It takes very little text to fill a page in this format, but there is even less text on most of these sample pages.

3.2 Why we are doing it

It is usually a good idea to give reasons for your research. If you do not, the people who payed you to waist all that time will feel really bad about it, and then they will not provide the same opportunity to future students.

I need this page to see what even-numbered pages look like.

Appendix A

Methods

Here is how to implement the methods.

A.1 Bisection

The easiest method.

$$x_k = \frac{a_k + b_k}{2} \tag{A.1}$$

A.2 False Position

The next one.

```
(A map of the United States)
```

Program A.1: Map of the United States

Appendix B

Using Appendices

BIBLIOGRAPHY

[1] Chapra, S. C. and Canale, R. P., *Numerical Methods for Engineers*, McGraw-Hill, 4th ed., 2002.