AN ABSTRACT OF THE THESIS OF

Woozy Amadeus Spinorfield for the degree of Doctor of Philosophy in Mathematics presented on January 1, 2010.

Title: Report From the Rings of Möbius: Returning Jacobian Scouts Insist, "Everything's Upsidedown!"

Abstract approved: _____

Oblah D. Obladah

As a Ph.D. student, your abstract—which should be placed in exactly this location—is limited (by Valley Library decree) to 350 words—it certainly can (and probably will) extend to another page. "Make it so, Number Two."

Report From the Rings of Möbius: Returning Jacobian Scouts Insist, "Everything's Upsidedown!"

by

Woozy Amadeus Spinorfield

A THESIS

submitted to

Oregon State University

in partial fulfillment of
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Presented January 1, 2010
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Doctor of Philosophy thesis of Woozy Amadeus Spinorfield presented on January 1, 2010

APPROVED:

Major Professor, representing Mathematics

Chair of the Department of Mathematics

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Woozy Amadeus Spinorfield, Author

ACKNOWLEDGEMENTS

Academic

I am indebted to ...

Personal

I wish to thank ...

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REPORT FROM THE RINGS OF MÖBIUS: RETURNING JACOBIAN SCOUTS INSIST, "EVERYTHING'S UPSIDEDOWN!"

1. INTRODUCTION

1.1. A Brief History of the Wretched Donut

1.1.1 From Double-Periodicity to Dough-Handler's Cruelty

Obviously, a few of these titles are pure silliness. The point is to allow the user to see how the *Table of Contents* should appear, and to provide a "skeletal LaTeX structure" which conforms to the OSU Grad School's *Standard Document Format*, and satisfies all of the basic requirements outlined in the Grad School's *Online Thesis Guide 2003-04* (`http://oregonstate.edu/dept/grad school/thesis/thesisguide.pdf`). All of the preceding *Pretext pages*, along with the *Bibliography*, *Appendices* and (optional) *Index* "passed" the Grad School Thesis-Editor's requirements, as of September 2004. You can write as many sections and subsections as you wish. I have given several examples of how to enter terms into the Index (*double-periodicity* and *wretched donut* are now entries). If you write " ... theory of functions ... ", and you want *functions* to appear in the index, then—near to where it appears in the text (so you can locate it if you wish to make any changes), just type: \index {functions}. There are many (often involved) variations on indexing. For a very good LaTeX reference, I recommend [1], though [2] is also useful. Finally, as complex analysis played a heavy role in my own studies, I gave (what I think is) a fairly good, graduated (in the sense of from least to most sophisticated) collection of references in the sample *Bibliography*: from [3] to [33].

This LaTeX file was designed to satisfy the OSU Grad School's requirements for the Graduate Thesis document. It logically depends on the following separate (external) files:

- The "document-class file": *gthesis2.cls*
- The "use-package file": *thesis2.sty*
- And the three (10pt, 11pt, 12pt) "class option files" : *gsize10.clo* , *gsize11.clo* and *gsize12.clo* .

Each of the above five files—originally written by Tolga Acar—*must* accompany this template for compiling—though, really, one need only include that particular class option file selected by the user (*gsize11.clo*, for example, the one presently invoked).

There is one rather unfortunate consequence of the way Tolga Acar originally constructed *gthesis.cls*:

There will be consistent abberations in the numbering of all Theorem-like Commands (e.g, Theorem, Lemma, Corollary, Definition, etc) at the "part-level" and at the "section-level". (Go to the Preamble and try replacing "subsection" with "section" in the optional argument for \newtheorem{theorem}{Theorem} and see what happens in Chapter 4.)

However, the good news is that in the present configuration (renamed) *gthesis2.cls*, *the numbering works perfectly at the "subsection-level".* (The "subsubsection-level" has been disabled by the way gthesis.cls was originally written.) Indeed, you will note that I have already *preset* the optional argument, *[subsection]*, for each of the Theorem-like ("\newtheorem") commands in the *Preamble.* Consequently, numbering of your Theorems, Definitions, etc will work just fine if you adhere to the following *global constraint*:

Constraint *Always restrict the presentation of your Propositions, Lemmas, Theorems, Corollaries, Definitions, Statements, Comments, Conventions, (etc) to (and only to) the "subsection-level".*

Changing this requires *careful* re-programming of the *gthesis2.cls* file. (Good luck!!) I give examples of these "potential abberations"—and the fact that things work-out using the above constraint—in Chapter (actually, Part) 4.

If you want to create a "subsubsection" level, here is an acceptable *template* (via example)—though, such will neither be numbered nor appear in the Table of Contents:

. . . And thus, what eventually became known as "Abel's Impossibility Theorem" put an end to any hope of solving the general quintic by purely algebraic means.

Hermite and the General Quintic

Although there are special cases in which the quintic may be solved "by radicals" (namely, when the corresponding *Galois group* is *solvable*), Charles Hermite was the first to fully solve the general quintic in 1858, using necessarily *transcendental* methods. (Soon thereafter, Leopold Kronecker and Francesco Brioschi each independently derived the same general solution.) Following a preliminary transformation (developed by Erland S. Bring in 1786), Hermite reduced the general quintic to the *Bring quintic form*: $x^5 - x + \alpha = 0$, and then solved this equation[1] using two of the four *theta functions* of Carl Jacobi. . . .

---

[1]For a complete account, see the concluding sections of the 1997 book by V. Prasolov and Y. Solovyev, *Elliptic Functions and Elliptic Integrals: Translations of Mathematical Monographs, Vol 170*, AMS, Providence. A quick peek at the solution-formulae may be gleaned online at `http://mathworld.wolfram.com/QuinticEquation.html`

1.1.2 The Connection to Analytic Function Theory

(Samples for the Index:) ... harmonic functions ... the class of analytic functions ... the special subclass of the univalent functions.

1.1.3 Generalizations and Recent Developments

(Another for the Index:) ... holomorphic vector-fields .

1.2. Statement of the Problem

This is something everyone is happy to find in the Table of Contents. Make this statement concise, clear and *no more than two pages.*

1.3. Organization of this Thesis

Suggestion: Unless everything is already clearly mapped-out, write your dissertation first, *then* come back and fill-in this page.

2. MATHEMATICAL BACKGROUND

2.1. An Overview of Meromorphic Functions

2.1.1 Isolated Singular Points

3. METHODS AND CONSTRUCTIONS

3.1. Method One

3.1.1 Subsection on First Method

4. RESULTS AND EXAMPLES

The following is an example of how the numbering will appear if you "forget" and begin writing your Theorems (or any LaTeX Theorem-like Command) at the "part-level":

Theorem 4.0.1.1 (Liouville I) *Any function, bounded and analytic over the complex plane, must be a constant.*

Theorem 4.0.1.2 (Liouville II) *Any elliptic function on the complex plane with no poles in its period-parallelogram must be a constant.*

Theorem 4.0.1.3 (Bernstein's Special) *The Gauss map of any $\mathcal{C}^2$ entire solution of the minimal surface equation in the plane*[2] *must be a constant.*

4.1. Result One

The following is an example of how the numbering will appear if you start writing your Theorems (or Definitions, Lemmas, etc.) at the "section-level":

Theorem 4.1.0.4 (Liouville I) *Any function, bounded and analytic over the complex plane, must be a constant.*

Theorem 4.1.0.5 (Liouville II) *Any elliptic function on the complex plane with no poles in its period-parallelogram must be a constant.*

Theorem 4.1.0.6 (Bernstein's Special) *The Gauss map of any $\mathcal{C}^2$ entire solution of the minimal surface equation in the plane must be a constant.*

[2]That is, $f = f(x, y)$ satisfies: $(1 + (f_y)^2)f_{xx} - 2f_x f_y f_{xy} + (1 + (f_x)^2)f_{yy} = 0$, for all $(x, y) \in \mathbb{R}^2$.

4.1.1 First Subsection on Results

First note that we are in *part 4*, *section 1*, *subsection 1*. In the way in which I have modified Tolga's *gthesis.cls* (to eliminate a bizarre problem involving "double-dotting"), the numbering sequences-out correctly for any Theorem-like Command if and only if you are at the "subsection-level" (as we now are):

Theorem 4.1.1.1 (Liouville I) *Any function, bounded and analytic over the complex plane, must be a constant.*

Theorem 4.1.1.2 (Liouville II) *Any elliptic function on the complex plane with no poles in its period-parallelogram must be a constant.*

Theorem 4.1.1.3 (Bernstein's Special) *The Gauss map of any $\mathcal{C}^2$ entire solution of the minimal surface equation in the plane must be a constant.*

5. DISCUSSION

5.1. Meditation On the Discourse

5.1.1 Meditation One

6. CONCLUSIONS

6.1. Conclusion One

6.1.1 Summary of First Conclusion

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APPENDICES

A APPENDIX A Characteristic Trio in Principal Minor

The following three nifty formulae are given solely to demonstrate how equations throughout this Appendix get numbered "from A", as is the standard[3]—well, I am also particularly fond of them. Let $\mathbb{M}$ be any $N \times N$ matrix—with $N \geq 2$. Let $\|\mathbb{M}\|_i^{\{N-1\}}$ denote the "i-th", $(N-1) \times (N-1)$ *principal minor*[4] of $\mathbb{M}$. Similarly, for $N = 4$, let $\|\mathbb{M}\|_{(i,\,j)}^{\{2\}}$ denote the $(i,\,j)$-th 2×2 principal minor[5] of $\mathbb{M}$. Then, respectively, for $N = 2,\, 3,\, 4$, we have the *characteristic equations*

$$\lambda^2 \,-\, \mathrm{Tr}(\mathbb{M})\,\lambda \,+\, \det(\mathbb{M}) \;=\; 0 \tag{A.1}$$

$$\lambda^3 \,-\, \mathrm{Tr}(\mathbb{M})\,\lambda^2 \,+\, \left(\sum_{i\,=\,1}^{3} \|\mathbb{M}\|_i^{\{2\}} \right) \lambda \,-\, \det(\mathbb{M}) \;=\; 0 \tag{A.2}$$

$$\lambda^4 \,-\, \mathrm{Tr}(\mathbb{M})\,\lambda^3 \,+\, \left(\sum_{1\,\leq\, i\,<\,j\,\leq\,4}^{6} \|\mathbb{M}\|_{(i,\,j)}^{\{2\}} \right) \lambda^2 \,-\, \left(\sum_{i\,=\,1}^{4} \|\mathbb{M}\|_i^{\{3\}} \right) \lambda \,+\, \det(\mathbb{M}) \;=\; 0 \tag{A.3}$$

For any $N \geq 2$, probably the only memorable pieces in the expansion are contained within:

$$\lambda^N \,-\, \mathrm{Tr}(\mathbb{M})\,\lambda^{N-1} \,+\, \cdots \,-\, (-1)^N \left(\sum_{i\,=\,1}^{N} \|\mathbb{M}\|_i^{\{N-1\}} \right) \lambda \,+\, (-1)^N \det(\mathbb{M}) \;=\; 0 \tag{A.4}$$

Without computer guidance, however, about all one can say about the "eigen-space" beyond the $N = 4$ sector is: *here there be monsters.*

---

[3]Prior to "fiddling" with Tolga's gthesis.cls file—I added lines 374 and 375—all the equations in this Appendix had a "0 prefix"—so rather than (A.1), (A.2) , ... you would get (0.1), (0.2) , ...

[4]So obtained by deleting the i-th row, the i-th column and then taking the determinant.

[5]This is obtained by deleting the i-th row, the i-th column, the j-th row, the j-th column and then taking the determinant. Of course, $i \neq j$.

B APPENDIX A Fuchsian Quartet in 2nd-Order

For one final sample Appendix (involving equations), we consider the first four second-order, Fuchsian ODE's (for an excellent general treatment, see Vol 2 of [24]). The second-order *Fuchsian* equation with *one* singular point has the degenerate form:

$$y'' + \frac{2}{z}\, y' \;=\; 0 \quad , \tag{B.1}$$

while a second-order Fuchsian equation with *two* singular points—one placed at $z_1 = 0$, the other at $z_2 = \infty$—gives the classic *Cauchy-Euler* equation (with A, $B \in \mathbb{C}$):

$$y'' + \frac{A}{z}\, y' + \frac{B}{z^2}\, y \;=\; 0 \quad . \tag{B.2}$$

Placing the singularities at $(\,0,\, 1,\, \infty\,)$ gives the standard Fuchsian equation with *three* singularities—"a.k.a." the *hypergeometric* equation (with a, b and c fixed parameters):

$$y'' + \left(\frac{[\,a+b+1\,]\,z - c}{z(z-1)} \right) y' + \frac{ab}{z(z-1)}\, y \;=\; 0 \quad . \tag{B.3}$$

Lastly, if the singular points are placed at $(\,0,\, 1,\, \alpha,\, \infty\,)$, for some arbitrary but fixed $\alpha \in \mathbb{C} - \{\,0,\, 1\,\}$, the standard Fuchsian equation with *four* singular points, called *Heun's equation*, is obtained (where $\Lambda_o := a + b + 1$, γ and q are fixed parameters):

$$y'' + \left(\frac{\Lambda_o\, z^2 - [\,\Lambda_o + \gamma(\alpha-1) + \alpha c\,]\, z + \alpha c}{z(z-1)(z-\alpha)} \right) y' + \frac{abz - q}{z(z-1)(z-\alpha)}\, y \;=\; 0 \quad . \tag{B.4}$$

(Letting $\alpha \longrightarrow 0$, $q \longrightarrow 0$, and $\gamma \longrightarrow \Lambda_o - c$ takes *Heun's* equation to the *hypergeometric* equation.)

C APPENDIX Obtaining a LaTeX Package for Your Windows PC

A Disclaimer: All of the following points of view are mine, and none officially represent any of those held by Oregon State University, or the Department of Mathematics at Oregon State University.

With that out of the way, if you presently have (or eventually obtain) a Windows-based PC, you should definitely consider obtaining a version of LaTeX , with an accompanying editor, both structurally designed for use in Windows. I would strongly recommend the following set-up, which can be obtained for no more than $60.00 ($30.00 if you have fast downloading—or are particularly stubborn with dial-up).

1. Make sure you have an Adobe Reader installed (you can freely download one at: `http://www.adobe.com/products/acrobat/readstep2.html`

2. Download and install both AFPL Ghostscript (which generates a *postscript* = *ps* file and a GSview program (which allows one to view the *ps* file). You can freely download (the most recent version of) both from: `http://www.cs.wisc.edu/~ghost`

3. Then download and install the (Total) MiKTeX program—a free version of LaTeX specifically designed for Windows PC's—from: `http://www.miktex.org` . (For a "donation" of $30.00, you can have the CD mailed to you from Germany—especially nice if you have only a "dial-up" modem: It's a big file, about 250 MB's).

4. Finally, after installing all of the above programs, go to The WinEdt product page: `http://www.winedt.com` , and download and install the most recent version of WinEdt, which is a Windows editor specifically designed to work with MiKTeX. (It is "shareware", so you can obtain it freely, and later "register" it for a *student fee* of $30.00.)

It is important that Adobe, AFPL Ghostscript, GSview, and MiKTeX are (each) already installed in your PC *before* you install the WinEdt program, as WinEdt automatically plugs-in to each of them, allowing one to utilize *pdf* and *ps*, as well as *dvi*. (MiKTeX comes with a *dvi*-viewer: YAP = Yet Another Viewer; but it is an ugly thing to gaze upon for too long.) If you try to install, say Adobe, later, you will have to write several lines of code to activate it within WinEdt—an unpleasant task I do not recommend.

Other LaTeX Editors and Links

There is a free LaTeX editor (about which, I know nothing), called LyX, and obtainable at: `http://www.lyx.org` . However, all the other PC-LaTeX editors (at least those I am aware of) are fairly expensive. Some of these include:

- Scientific Word/Workplace: `http://www.sciword.demon.co.uk` .
- TrueTex: `http://www.truetex.com` .
- PCTeX: `http://www.pctex.com/index.html` .
- VisualTex: `http://www.micropress-inc.com/index.html` .
- Y&Y Inc.: `http://www.yandy.com` .

(This last, Y&Y , is something of the "Rolls Royce" of PC-LaTeX editors, and can easily run into the $400.00 range.) One should also consider visiting

- CTAN (Comprehensive TeX Archive Network): `http://www.ctan.org`
- LaTeX Project Homepage: `http://www.latex-project.org`
- Beginner's Introduction to Typesetting with LaTeX : `http://www.ctan.org/tex-archive/info/beginlatex/html/index.html`

- LaTeX Help Page:

  http://www.ctan.org/tex-archive/info/latex2e-help-texinfo/latex2e.htm .

D APPENDIX The Valley Library's (Thesis) Rules. Paper & Binding

As of September 2004, this Thesis-template (LaTeX-file), and (modified) "Tolga-Package" accompanying it, satisfied all the technical requirements (pretext-page order and structure, Table of Content format, margins, Appendix structure, etcetera) set forth by the Grad School (actually, the Valley Library). Beyond this, here are the remaining rules imposed by the Library (as of September 2004): Library copies will be returned for correction if they do *not* adhere to the following standards:

- Your document must comprise *white*, cotton bond paper with a 25% minimum cotton fiber content and 16 lbs minimum thickness. Each page must have a watermark stating the cotton fiber content .

- Your document must meet copy requirements of unblemished photocopying or laser-printing on one side only. You may not use water-soluble ink (no ink-jet). Test the quality of your copy, as pages with bleeding ink will be returned.

- Numbering pretext pages is optional: Use small Roman numerals if you choose to do this. Pretext pages using any other numberings will be returned. [All the page numbers should be located in the upper right-hand corner, at least one inch from the top and not invading the margins. There should be at least one (carriage) return between the page number and the text].

- Your document must have all original signatures, except the Dean of the Grad School, in place—that means your signature, your Advisor's and the Department Chair's.

- Your document must be packaged in a suitably sized clasp-envelope. Fasten a copy of the Title page to the outside. Write a phone number\e-mail address where you

can be reached on the front of this envelope. You must submit two copies in two separate envelopes to the Valley Library.

- Ph.D. students must submit an extra Abstract with an original signature for archiving. Include three extra Title pages for certification processing. Remember to submit your Microfilm form, Cashier Receipt, Advanced Degree Recipient Exit Survey, and Survey of Earned Doctorates. If you choose not to complete the survey write your name on it and the word 'Declined' across the cover.

Contact **OSU Copying Services** about printing your thesis:

100 Cascade Hall, Oregon State University

Phone: 541 737–4941

email: copy.services@oregonstate.edu

web: `http://oregonstate.edu/admin/printing/copy/copy.htm` .

One brand of very high-quality (white, 8.5 x 11 inch) **cotton-bond thesis paper** is *Eaton Archival Quality Thesis Paper*, by Southworth (`http://www.southworth.com`):

Cotton: 100% (also comes in 25%), Woven Finish

Watermarked, Security/Date-Coded and Acid Free

Weight: 20 lb, Laser and copier guaranteed .

For **local Thesis-Binding**:

B & J Bookbinding

200 NW 2nd Street, Corvallis, OR 97330

Phone: (541) 757-9861 Fax: (541) 757-6144

email: bjbookbinding@cognisurf.com

web: `http://www.bjbookbinding.com/thesisbind.html` .

E APPENDIX A Curriculum Vitae Template for OSU Math Ph.D.'s

You will notice in the source-file that I have "commented-out" several commands within this short tex-file (so as to include it within the larger template). Also, this document looks peculiar (excessive spacing, for instance) because it is presently being read by the *gthesis2.cls* (documentclass) file, rather than the intended *article* (documentclass) file. (You will obviously want to copy and paste the template below to a separate LaTeX file, "un-comment" the indicated commands, and fill-in your own data.) Also apparent is the fact that gthesis2.cls has "cut-off" the lower part of the first page—that detailing "Other Skills", "Honors" and "Publications". Not to worry: these will "reappear" in the article documentclass. This template was made public domain by Martin Mohlenkamp and Peter Jones (of the Yale Math Dept). Use it in good health. Additionally, you may also want to consider the following websites regarding employment:

YALE MATH GRAD RESOURCES: `http://www.math.yale.edu/pub/grad.resources`
AMS COVER SHEET: `http://www.ams.org/coversheet`
AMS EMPLOYMENT SITE: `http://www.ams.org/employment`
THE NOTICES: `http://www.ams.org/notices` .

FIRST MIDDLE LAST

Address:	Department of Mathematics
	Oregon State University
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Web:	http://oregonstate.edu/% 7USERNAME

Born:	MONTH DATE, YEAR; in LOCATION.
Education:	Ph.D. Oregon State University, MONTH, YEAR (expected);
	M.A. YOUR University, MONTH, YEAR;
	B.A. YOUR University, MONTH, YEAR.
Research Area:	FIELD
Dissertation Title:	TITLE
Thesis Advisor:	ADVISOR
References:	ADVISOR (OSU) ADVISOR@math.orst.edu;
	TWO (PLACE) TWO@math.orst.edu;
	THREE (PLACE) THREE@math.orst.edu;
	OPTIONAL(PLACE) OPTIONAL@math.orst.edu;
	LAST (PLACE) LAST@math.orst.edu.
Teaching Experience:	Math 25X (Calculus X) QUARTER, YEAR;
	Math 25X (Calculus X) QUARTER, YEAR;
	Math 25X (Calculus X) QUARTER,YEAR;

Research Interests

I work in *VERY* GENERAL DISCUSSION OF FIELD. THE READER IS NOT IN YOUR FIELD. My perspective on the field is most influenced by researchers such as DROP NAMES OF CURRENT RESEARCHERS SO THEY KNOW WHERE YOU ARE COMING FROM. The main tools currently used STUFF. FIELD IS COOL BECAUSE ... THE OBJECTIVE OF THIS PART IS TO GIVE THE READER AN IDEA OF WHO IN THE DEPARTMENT TO PASS YOUR APPLICATION ALONG TO.

My thesis problem was to resolve BLAH. This was done using BLAH. The techniques used strongly resemble those used in BLAH BLAH BLAH. A full abstract follows:

Abstract: THESIS TITLE

ABSTRACT. NOT TOO LONG.

Future Plans

In the short term, there are several applications of my work which need to be explored. BLAH BLAH BLAH.

I also plan to work on the following problems: *MUST* BE A LIST OF AT LEAST 3 SPECIFIC THINGS. REMEMBER, YOU DON'T HAVE TO ACTUALLY DO THEM.

1. FIRST
2. SECOND
3. THIRD

Teaching Experience

Teaching is important and I find it to be enjoyable and rewarding. As a graduate student, I have had several opportunities to teach. I am currently the instructor for a section of Math25X, TYPE OF Calculus. In WHEN, I was an instructor for Math25X, TYPE OF Calculus. As an instructor, I do all the lecturing, hold office hours, assign homework, help in the construction and grading of the common exams, and determine final grades.

These opportunities have given me significant teaching experience. This experience is complemented by ongoing formal and informal teacher training. Before teaching my first course, I received training from the Mathematics department. During WHEN, I also participated in OTHER TEACH TRAINING, CONFERENCES, ETC.

We have begun integrating *Mathematica* into the Calculus sequence. OR SOME OTHER STUFF ABOUT HOW YOU ARE INTO THE LATEST PROGRESSIVE CALCULUS THING. OTHER STUFF LIKE THE MATH LEARNING CENTER, OR THE MATH CLUB.

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