

Note:

CHAPTER 0: INTRO

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This chapter is part of the textbook:

“Fundamentals of Die Casting Design”

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APRIL 1, 2009

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Fundamentals of Die Casting Design

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'We are like dwarfs sitting on the shoulders of giants'

from The Metalogicon by John in 1159

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NOMENCLATURE

\bar{R}	Universal gas constant, see equation (2.36), page 20
ℓ	Units length., see equation (2.11), page 16
ρ	Density of the fluid, see equation (2.55), page 24
B	bulk modulus, see equation (2.62), page 24
B_f	Body force, see equation (2.19), page 17
c	Speed of sound, see equation (2.55), page 24
C_p	Specific pressure heat, see equation (2.33), page 19
C_v	Specific volume heat, see equation (2.32), page 19
E_U	Internal energy, see equation (2.13), page 17
E_u	Internal Energy per unit mass, see equation (2.16), page 17
E_i	System energy at state i, see equation (2.12), page 16
H	Enthalpy, see equation (2.28), page 19
h	Specific enthalpy, see equation (2.28), page 19
k	the ratio of the specific heats, see equation (2.34), page 20
M	Mach number, see equation (2.64), page 25
n	The poletropic coefficient, see equation (2.60), page 24
P	Pressure, see equation (2.57), page 24

q	Energy per unit mass, see equation (2.16), page 17
Q_{12}	The energy transferred to the system between state 1 and state 2, see equation (2.12), page 16
R	Specific gas constant, see equation (2.37), page 20
S	Entropy of the system, see equation (2.23), page 18
U	velocity , see equation (2.14), page 17
w	Work per unit mass, see equation (2.16), page 17
W_{12}	The work done by the system between state 1 and state 2, see equation (2.12), page 16

The Book Change Log

Version 0.1.2

April 1, 2009 (1.9M 263 pages)

- Irene Tan provided the English many corrections to dimensional analysis chapter.

Version 0.1.1

Feb 8, 2009 (1.9M 261 pages)

- Add Steve Spurgeon (from Dynacast England) corrections to pQ^2 diagram.
- Minor English corrections to pQ^2 diagram chapter (unfinished).
- Fix some figures and captions issues.
- Move to potto style file.

Version 0.1

Jan 6, 2009 (1.6M 213 pages)

- Change to modern Potto format.
- English corrections
- Finish some examples in Dimensionless Chapter (manometer etc)

Version 0.0.3

Nov 1, 1999 (3.1 M 178 pages)

- Initial book of Potto project.
- Start of economy, dimensional analysis, pQ^2 diagram chapters.

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All entries have been arranged in alphabetical order of surname (hopefully). Major contributions are listed by individual name with some detail on the nature of the contribution(s), date, contact info, etc. Minor contributions (typo corrections, etc.) are listed by name only for reasons of brevity. Please understand that when I classify a contribution as "minor," it is in no way inferior to the effort or value of a "major" contribution, just smaller in the sense of less text changed. Any and all contributions are gratefully accepted. I am indebted to all those who have given freely of their own knowledge, time, and resources to make this a better book!

- **Date(s) of contribution(s):** 1999 to present
- **Nature of contribution:** Original author.
- **Contact at:** barmeir at gmail.com

Steven from artofproblemsolving.com

- **Date(s) of contribution(s):** June 2005
- **Nature of contribution:** LaTeX formatting, help on building the useful equation and important equation macros.

Tousher Yang

- **Date(s) of contribution(s):** Mat 2008
- **Nature of contribution:** Major review of dimensional analysis and intro chapters.

Steve Spurgeon

- **Date(s) of contribution(s):** November 200x
- **Nature of contribution:** Correction to pQ^2 diagram derivations.

Irene Tan

- **Date(s) of contribution(s):** January, 2009
- **Nature of contribution:** Repair of dimensional analysis chapter.

Your name here

- **Date(s) of contribution(s):** Month and year of contribution
- **Nature of contribution:** Insert text here, describing how you contributed to the book.
- **Contact at:** my_email@provider.net

Typo corrections and other "minor" contributions

- **John Joansson** English corrections 1999
- **Adeline Ong** English corrections 1999
- **Robert J. Fermin** English corrections 1999
- **Mary Fran Riley** English corrections 1999
- **Joy Branlund** English corrections 1999
- **Denise Pfeifer** English corrections 1999
- **F. Monterey**, point to typos in the book 2000.
- **Irene Tan**, English correction to Fluid Mechanics chapter 2009.

About This Author

Genick Bar-Meir holds a Ph.D. in Mechanical Engineering from University of Minnesota and a Master in Fluid Mechanics from Tel Aviv University. Dr. Bar-Meir was the last student of the late Dr. R.G.E. Eckert. Much of his time has been spend doing research in the field of heat and mass transfer (related to renewal energy issues) and this includes fluid mechanics related to manufacturing processes and design. Currently, he spends time writing books (there are already three very popular books) and softwares for the POTTO project (see Potto Prologue). The author enjoys to encourage his students to understand the material beyond the basic requirements of exams.

Bar-Meir's books are used by hundred of thousands of peoples. His book on compressible is the most popular and preferred by practitioners and students. His books are used in many universities like Purdue, Caltech, Queens University in Canada, and Singapore. One reason that his books are so popular is that they contain up to date material much of it original work by Bar-Meir.

In his early part of his professional life, Bar-Meir was mainly interested in elegant models whether they have or not a practical applicability. Now, this author's views had changed and the virtue of the practical part of any model becomes the essential part of his ideas, books and software. He developed models for Mass Transfer in high concentration that became a building blocks for many other models. These models are based on analytical solution to a family of equations¹. As the change in the view occurred, Bar-Meir developed models that explained several manufacturing processes such the rapid evacuation of gas from containers, the critical piston velocity in a partially filled chamber (related to hydraulic jump), application of supply and demand to rapid change power system and etc. All the models have practical applicability. These models have been extended by several research groups (needless to say with large research grants). For example, the Spanish Comision Interministerial provides grants TAP97-0489 and PB98-0007, and the CICYT and the European Commission provides

¹Where the mathematicians were able only to prove that the solution exists.

1FD97-2333 grants for minor aspects of that models. Moreover, the author's models were used in numerical works, in GM, British industry, Spain, and Canada.

In the area of compressible flow, it was commonly believed and taught that there is only weak and strong shock and it is continue by Prandtl–Meyer function. Bar–Meir discovered the analytical solution for oblique shock and showed that there is a quiet buffer between the oblique shock and Prandtl–Meyer. He also build analytical solution to several moving shock cases. He described and categorized the filling and evacuating of chamber by compressible fluid in which he also found analytical solutions to cases where the working fluid was ideal gas. The common explanation to Prandtl–Meyer function shows that flow can turn in a sharp corner. Engineers have constructed design that based on this conclusion. Bar–Meir demonstrated that common Prandtl–Meyer explanation violates the conservation of mass and therefor the turn must be around a finite radius. The author's explanations on missing diameter and other issues in fanno flow and ““naughty professor's question”” are used in the industry.

In his book “Basics of Fluid Mechanics”, Bar–Meir demonstrated that fluids must have wavy surface when two different materials flow together. All the previous models for the flooding phenomenon did not have a physical explanation to the dryness. He built a model to explain the flooding problem (two phase flow) based on the physics. He also constructed and explained many new categories for two flow regimes.

The author lives with his wife and three children. A past project of his was building a four stories house, practically from scratch. While he writes his programs and does other computer chores, he often feels clueless about computers and programing. While he is known to look like he knows about many things, the author just know to learn quickly. The author spent years working on the sea (ships) as a engine sea officer but now the author prefers to remain on solid ground.

Prologue For The POTTO Project

Preface

This books series was born out of frustrations in two respects. The first issue is the enormous price of college textbooks. It is unacceptable that the price of the college books will be over \$150 per book (over 10 hours of work for an average student in The United States).

The second issue that prompted the writing of this book is the fact that we as the public have to deal with a corrupted judicial system. As individuals we have to obey the law, particularly the copyright law with the “infinite²” time with the copyright holders. However, when applied to “small” individuals who are not able to hire a large legal firm, judges simply manufacture facts to make the little guy lose and pay for the defense of his work. On one hand, the corrupted court system defends the “big” guys and on the other hand, punishes the small “entrepreneur” who tries to defend his or her work. It has become very clear to the author and founder of the POTTO Project that this situation must be stopped. Hence, the creation of the POTTO Project. As R. Kook, one of this author’s sages, said instead of whining about arrogance and incorrectness, one should increase wisdom. This project is to increase wisdom and humility.

The POTTO Project has far greater goals than simply correcting an abusive Judicial system or simply exposing abusive judges. It is apparent that writing textbooks especially for college students as a cooperation, like an open source, is a new idea³. Writing a book in the technical field is not the same as writing a novel. The writing of a technical book is really a collection of information and practice. There is always someone who can add to the book. The study of technical material isn't only done by having to memorize the material, but also by coming to understand and be able to solve related problems. The author has not found any technique that is more useful for this

²After the last decision of the Supreme Court in the case of *Eldred v. Ashcroft* (see <http://cyber.law.harvard.edu/openlaw/eldredvashcroft> for more information) copyrights practically remain indefinitely with the holder (not the creator).

³In some sense one can view the encyclopedia Wikipedia as an open content project (see http://en.wikipedia.org/wiki/Main_Page). The wikipedia is an excellent collection of articles which are written by various individuals.

purpose than practicing the solving of problems and exercises. One can be successful when one solves as many problems as possible. To reach this possibility the collective book idea was created/adapted. While one can be as creative as possible, there are always others who can see new aspects of or add to the material. The collective material is much richer than any single person can create by himself.

The following example explains this point: The army ant is a kind of carnivorous ant that lives and hunts in the tropics, hunting animals that are even up to a hundred kilograms in weight. The secret of the ants' power lies in their collective intelligence. While a single ant is not intelligent enough to attack and hunt large prey, the collective power of their networking creates an extremely powerful intelligence to carry out this attack⁴. When an insect which is blind can be so powerful by networking, So can we in creating textbooks by this powerful tool.

Why Volunteer?

Why would someone volunteer to be an author or organizer of such a book? This is the first question the undersigned was asked. The answer varies from individual to individual. It is hoped that because of the open nature of these books, they will become the most popular books and the most read books in their respected field. For example, the books on compressible flow and die casting became the most popular books in their respective area. In a way, the popularity of the books should be one of the incentives for potential contributors. The desire to be an author of a well-known book (at least in his/her profession) will convince some to put forth the effort. For some authors, the reason is the pure fun of writing and organizing educational material. Experience has shown that in explaining to others any given subject, one also begins to better understand the material. Thus, contributing to these books will help one to understand the material better. For others, the writing of or contributing to this kind of books will serve as a social function. The social function can have at least two components. One component is to come to know and socialize with many in the profession. For others the social part is as simple as a desire to reduce the price of college textbooks, especially for family members or relatives and those students lacking funds. For some contributors/authors, in the course of their teaching they have found that the textbook they were using contains sections that can be improved or that are not as good as their own notes. In these cases, they now have an opportunity to put their notes to use for others. Whatever the reasons, the undersigned believes that personal intentions are appropriate and are the author's/organizer's private affair.

If a contributor of a section in such a book can be easily identified, then that contributor will be the copyright holder of that specific section (even within question/answer sections). The book's contributor's names could be written by their sections. It is not just for experts to contribute, but also students who happened to be doing their homework. The student's contributions can be done by adding a question and perhaps the solution. Thus, this method is expected to accelerate the creation of

⁴see also in Franks, Nigel R.; "Army Ants: A Collective Intelligence," *American Scientist*, 77:139, 1989 (see for information <http://www.ex.ac.uk/bugclub/raiders.html>)

these high quality books.

These books are written in a similar manner to the open source software process. Someone has to write the skeleton and hopefully others will add “flesh and skin.” In this process, chapters or sections can be added after the skeleton has been written. It is also hoped that others will contribute to the question and answer sections in the book. But more than that, other books contain data⁵ which can be typeset in L^AT_EX. These data (tables, graphs and etc.) can be redone by anyone who has the time to do it. Thus, the contributions to books can be done by many who are not experts. Additionally, contributions can be made from any part of the world by those who wish to translate the book.

It is hoped that the books will be error-free. Nevertheless, some errors are possible and expected. Even if not complete, better discussions or better explanations are all welcome to these books. These books are intended to be “continuous” in the sense that there will be someone who will maintain and improve the books with time (the organizer(s)).

These books should be considered more as a project than to fit the traditional definition of “plain” books. Thus, the traditional role of author will be replaced by an organizer who will be the one to compile the book. The organizer of the book in some instances will be the main author of the work, while in other cases only the gate keeper. This may merely be the person who decides what will go into the book and what will not (gate keeper). Unlike a regular book, these works will have a version number because they are alive and continuously evolving.

What Has been So Far

The undersigned of this document intends to be the organizer–author–coordinator of the projects in the following areas:

Table -1. Books under development in Potto project.

Project Name	Progress	Remarks	Version	Availability for Public Download	Number Downloads
Compressible Flow	beta		0.4.8.4	✓	120,000
Die Casting	alpha		0.1	✓	60,000
Dynamics	NSY		0.0.0	✗	-
Fluid Mechanics	alpha		0.1.8	✓	15,000
Heat Transfer	NSY	Based on Eckert	0.0.0	✗	-

⁵ Data are not copyrighted.

Table -1. Books under development in Potto project. (continue)

Project Name	Progress	Remarks	Version	Availability for Public Download	Number DownLoads
Mechanics	NSY		0.0.0	✘	-
Open Channel Flow	NSY		0.0.0	✘	-
Statics	early alpha	first chapter	0.0.1	✘	-
Strength of Material	NSY		0.0.0	✘	-
Thermodynamics	early alpha		0.0.01	✘	-
Two/Multi phases flow	NSY	Tel-Aviv'notes	0.0.0	✘	-

NSY = Not Started Yet

The meaning of the progress is as:

- The Alpha Stage is when some of the chapters are already in a rough draft;
- in Beta Stage is when all or almost all of the chapters have been written and are at least in a draft stage;
- in Gamma Stage is when all the chapters are written and some of the chapters are in a mature form; and
- the Advanced Stage is when all of the basic material is written and all that is left are aspects that are active, advanced topics, and special cases.

The mature stage of a chapter is when all or nearly all the sections are in a mature stage and have a mature bibliography as well as numerous examples for every section. The mature stage of a section is when all of the topics in the section are written, and all of the examples and data (tables, figures, etc.) are already presented. While some terms are defined in a relatively clear fashion, other definitions give merely a hint on the status. But such a thing is hard to define and should be enough for this stage.

The idea that a book can be created as a project has mushroomed from the open source software concept, but it has roots in the way science progresses. However, traditionally books have been improved by the same author(s), a process in which books have a new version every a few years. There are book(s) that have continued after their author passed away, i.e., the *Boundary Layer Theory* originated⁶ by Hermann Schlichting but continues to this day. However, projects such as the Linux Documentation project

⁶Originally authored by Dr. Schlichting, who passed way some years ago. A new version is created every several years.

demonstrated that books can be written as the cooperative effort of many individuals, many of whom volunteered to help.

Writing a textbook is comprised of many aspects, which include the actual writing of the text, writing examples, creating diagrams and figures, and writing the \LaTeX macros⁷ which will put the text into an attractive format. These chores can be done independently from each other and by more than one individual. Again, because of the open nature of this project, pieces of material and data can be used by different books.

⁷One can only expect that open source and readable format will be used for this project. But more than that, only \LaTeX , and perhaps troff, have the ability to produce the quality that one expects for these writings. The text processes, especially \LaTeX , are the only ones which have a cross platform ability to produce macros and a uniform feel and quality. Word processors, such as OpenOffice, Abiword, and Microsoft Word software, are not appropriate for these projects. Further, any text that is produced by Microsoft and kept in "Microsoft" format are against the spirit of this project In that they force spending money on Microsoft software.

Prologue For This Book

Version 0.1 January 12, 2009

pages 213 size 1.5M

Die casting was my focus of my Ph.D. thesis which admittedly, is not my preferred choice. Dr. Eckert, my adviser, asked me to work on die casting and that is where I developed my knowledge. The first thing that I have done is a literature review which force me to realize that that there is very little scientific known about how to design the die casting process. I have reviewed works/papers by from of Ohio State University by A. Miller, Brevick, J. Wallace from Case Western, Murry from Australia etc. Scientists are categorized in the following categories, Free thinkers, Cathedral builder, research managers, dust collectors (important work but minor), and thus who should be in science and thus those who are very lucky. This author feel that he, in same sense, very luck that die casting research is infested with thus who should be in science.

Like moving from the stone age to modern time, this author is using this book as a tool in his attempt to convert die casting design process to be based on real scientific principles. I have found that the book early version (0.0.3) of the have been downloaded over 50,000. It is strange to me that the fact that many were using the economical part of the book to explain many other the economical problems of large scale manufacturing processes. As I am drifting towards a different field (renewal energy), I still have interest in this material but with different aspects will be emphasized. Subjects like Fanno Flow that was as written as appendix will be expanded. Moreover, material like the moving shock issue will be explained and add to process description was omitted in the previous version. While this topic is not directly affecting die casting, the issue of future value will be discussed.

Version 0.0.3 October 9, 1999

pages 178 size 3.2M

This book is the first and initial book in the series of POTTO project books. This book started as a series of articles to answer both specific questions that I have been asked, as well as questions that I was curious about myself. While addressing these questions, I realized that many commonly held "truths" about die-casting were scientifically incorrect. Because of the importance of these results, I have decided to make them available to the wider community of die-casting engineers. However, there is a powerful group of individuals who want to keep their monopoly over "knowledge" in the die-casting industry and to prevent the spread of this information.⁸ Because of this, I have decided that the best way to disseminate this information is to write a book. This book is written in the spirit of my adviser and mentor E.R.G. Eckert. Eckert, aside from his research activity, wrote the book that brought a revolution in the education of the heat transfer. Up to Eckert's book, the study of heat transfer was without any dimensional analysis. He wrote his book because he realized that the dimensional analysis utilized by him and his adviser (for the post doc), Ernst Schmidt, and their colleagues, must be taught in engineering classes. His book met strong criticism in which some called to "burn" his book. Today, however, there is no known place in world that does not teach according to Eckert's doctrine. It is assumed that the same kind of individual(s) who criticized Eckert's work will criticize this work. As a wise person says "don't tell me that it is wrong, show me what is wrong"; this is the only reply. With all the above, it must be emphasized that this book is not expected to revolutionize the field but change some of the way things are taught.

The approach adapted in this book is practical, and more hands-on approach. This statement really meant that the book is intent to be used by students to solve their exams and also used by practitioners when they search for solutions for practical problems. So, issue of proofs so and so are here only either to explain a point or have a solution of exams. Otherwise, this book avoids this kind of issues.

This book is divided into two parts. The first discusses the basic science required by a die-casting engineer; the second is dedicated to die-casting-specific science. The die-casting specific is divided into several chapters. Each chapter is divided into three sections: section 1 describes the "commonly" believed models; section 2 discusses why this model is wrong or unreasonable; and section 3 shows the correct, or better, way to do the calculations. I have made great efforts to show what existed before science "came" to die casting. I have done this to show the errors in previous models which make them invalid, and to "prove" the validity of science. I hope that, in the second edition, none of this will be needed since science will be accepted and will have gained validity in the die casting community. Please read about my battle to get the information out and how the establishment react to it.

⁸Please read my correspondence with NADCA editor Paul Bralower and Steve Udvardy. Also, please read the references and my comments on pQ².

Plea for L^AT_EX usage

Is it only an accident that both the quality of the typesetting of papers in die casting congress and their technical content quality is so low? I believe there is a connection. All the major magazines of the the scientific world using T_EX or L^AT_EX, why? Because it is very easy to use and transfer (via the Internet) and, more importantly, because it produces high quality documents. NADCA continued to produce text on a low quality word processor. Look for yourself; every transaction is ugly.

Linux has liberated the world from the occupation and the control of Microsoft OS. We hope to liberate the NADCA Transaction from such a poor quality word processor. T_EX and all (the good ones) supporting programs are free and available every where on the web. There is no reason not to do it. Please join me in improving NADCA's Transaction by supporting the use of L^AT_EX by NADCA.

Will I Be in Trouble?

Initial part

Many people have said I will be in trouble because I am telling the truth. Those with a vested interest in the status quo (North American Die Casting Association, and thus research that this author exposed there poor and or erroneous work). will try to use their power to destroy me. In response, I challenge my opponents to show that they are right. If they can do that, I will stand wherever they want and say that I am wrong and they are right. However, if they cannot prove their models and practices are based on solid scientific principles, nor find errors with my models (and I do not mean typos and English mistakes), then they should accept my results and help the die-casting industry prosper.

People have also suggested that I get life insurance and/or good lawyer because my opponents are very serious and mean business; the careers of several individuals are in jeopardy because of the truths I have exposed. If something does happen to me, then you, the reader, should punish them by supporting science and engineering and promoting the die-casting industry. By doing so, you prevent them from manipulating the industry and gaining additional wealth.

For the sake of my family, I have, in fact, taken out a life insurance policy. If something does happen to me, please send a thank you and work well done card to my family.

The Continued Struggle

It was exposed that second reviewer that appear in this book is Brevick from Ohio. It strange that in a different correspondence he say that he cannot wait to get this author futur work. This part is holding for some juicy details.

How This Book Was Written

This book started because I was frustrated with the system that promote erroneous research. Then, I realized that the book cannot be “stolen” if it under open content. The die casting process is interesting enough to insert my contributions. I have found that works or model in this area are lack of serious scientific principles. I have started to write class notes to my clients and I add my research work to create this book. During the writing I add the material on economy which I felt is missing piece of knowledge in the die casting engineering world.

Of course, this book was written on Linux (Micro\$oftLess book). This book was written using the vim editor for editing (sorry never was able to be comfortable with emacs). The graphics were done by TGIF, the best graphic program that this author experienced so far. The figures were done by grap but will be modified to gle. The spell checking was done by ispell, and hope to find a way to use gaspell, a program that currently cannot be used on new Linux systems. The figure in cover page was created by Genick Bar-Meir, and is copylefted by him.

Abstract

Die-casting engineers have to compete not only with other die-casting companies, but also against other industries such as plastics, and composite materials. Clearly, the "black art" approach, which has been an inseparable part of the engineer's tools, is in need of being replaced by a scientific approach. Excuses that "science has not and never will work" need to be replaced with "science does work". All technologies developed in recent years are described in a clear, simple manner in this book. All the errors of the old models and the violations of physical laws are shown. For example, the "common" pQ^2 diagram violates many physical laws, such as the first and second laws of thermodynamics. Furthermore, the "common" pQ^2 diagram produces trends that are the opposite of reality, which are described in this book.

The die casting engineer's job is to produce maximum profits for the company. In order to achieve this aim, the engineer must design high quality products at a minimum cost. Thus, understanding the economics of the die casting design and process are essential. These are described in mathematical form for the first time in this volume. Many new concepts and ideas are also introduced. For instance, how to minimize the scrap/cost due to the runner system, and what size of die casting machine is appropriate for a specific project.

The die-casting industry is undergoing a revolution, and this book is part of it. One reason (if one reason can describe the situation) companies such as Doehler Jorvis (the biggest die caster in the world) and Shelby are going bankrupt is that they do not know how to calculate and reduce their production costs. It is my hope that die-casters will turn such situations around by using the technologies presented in this book. I believe this is the only way to keep the die casting professionals and the industry itself, from being "left in the dust."

Preface

"In the beginning, the POTTO project was without form, and void; and emptiness was upon the face of the bits and files. And the Fingers of the Author moved upon the face of the keyboard. And the Author said, Let there be words, and there were words."⁹

This book, "Fundamentals of Die Casting Design," describes the fundamentals of die casting process design and economics for engineers and others. This book is designed to fill the gap and the missing book on economy and scientific principles of die casting. It is hoped that the book could be used as a reference book for people who have at least some basics knowledge of science areas such as calculus, physics, etc. It has to realized the some material is very advance and required knowledge of fluid mechanics particularly compressible flow and open channel flow. This author's popular book on compressible flow should provide the introductory in that area. The readers' reactions to this book and the usage of the book as a textbook suggested that the chapter which deals with economy should be expand. In the following versions this area will strength and expended.

The structure of this book is such that many of the chapters could be usable independently. For example, if you need information about, say, economy of the large scale productions, you can read just chapter (12). I hope this makes the book easier to use as a reference manual. However, this manuscript is first and foremost a textbook, and secondly a reference manual only as a lucky coincidence.

I have tried to describe why the theories are the way they are, rather than just listing "seven easy steps" for each task. This means that a lot of information is presented which is not necessary for everyone. These explanations have been marked as such and can be skipped. Reading everything will, naturally, increase your understanding of the many aspects of fluid mechanics.

⁹To the power and glory of the mighty God. This book is only to explain his power.

This book is written and maintained on a volunteer basis. Like all volunteer work, there is a limit on how much effort I was able to put into the book and its organization. Moreover, due to the fact that English is my third language and time limitations, the explanations are not as good as if I had a few years to perfect them. Nevertheless, I believe professionals working in many engineering fields will benefit from this information. This book contains many worked examples, which can be very useful for many.

I have left some issues which have unsatisfactory explanations in the book, marked with a Mata mark. I hope to improve or to add to these areas in the near future. Furthermore, I hope that many others will participate of this project and will contribute to this book (even small contributions such as providing examples or editing mistakes are needed).

I have tried to make this text of the highest quality possible and am interested in your comments and ideas on how to make it better. Incorrect language, errors, ideas for new areas to cover, rewritten sections, more fundamental material, more mathematics (or less mathematics); I am interested in it all. I am particularly interested in the best arrangement of the book. If you want to be involved in the editing, graphic design, or proofreading, please drop me a line. You may contact me via Email at barmeir at gmail dot com.

Naturally, this book contains material that never was published before (sorry cannot avoid it). This material never went through a close content review. While close content peer review and publication in a professional publication is excellent idea in theory. In practice, this process leaves a large room to blockage of novel ideas and plagiarism. For example, Brevick from Ohio State is one the individual who attempt to block this author idea on pQ^2 diagram. If you would like to critic to my new ideas please send me your comment(s). However, please do not hide your identity, it will cloud your motives.

Several people have helped me with this book, directly or indirectly. I would like to especially thank to my adviser, Dr. E. R. G. Eckert, whose work was the inspiration for this book. I also would like to thank to Jannie McRotien (Open Channel Flow chapter) and Tousher Yang for their advices, ideas, and assistance.

I encourage anyone with a penchant for writing, editing, graphic ability, \LaTeX knowledge, and material knowledge and a desire to provide open content textbooks and to improve them to join me in this project. If you have Internet e-mail access, you can contact me at "barmeir@gmail.com".