

Note:

CHAPTER 1: INTRO

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“Basics of Fluid Mechanics”

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DECEMBER 21, 2011

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Two/Multi phases flow	NSY	Tel-Aviv's notes	0.0.0	✗

NSY = Not Started Yet

Basics of Fluid Mechanics

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Version (0.3.1.1 December 21, 2011)

'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 (2.26), page 51
τ	The shear stress Tensor, see equation (6.7), page 176
ℓ	Units length., see equation (2.1), page 47
λ	bulk viscosity, see equation (8.101), page 258
\mathfrak{M}	Angular Momentum, see equation (6.38), page 193
μ	viscosity at input temperature T, see equation (1.17), page 12
μ_0	reference viscosity at reference temperature, T_{i0} , see equation (1.17), page 12
\mathbf{F}_{ext}	External forces by non-fluids means, see equation (6.11), page 177
\mathbf{U}	The velocity taken with the direction, see equation (6.1), page 175
Ξ	Martinelli parameter, see equation (10.43), page 347
A	The area of surface, see equation (4.136), page 108
a	The acceleration of object or system, see equation (4.0), page 71
B_f	Body force, see equation (2.9), page 49
<i>c.v.</i>	subscribe for control volume, see equation (5.0), page 148
C_p	Specific pressure heat, see equation (2.23), page 51
C_v	Specific volume heat, see equation (2.22), page 51
E_U	Internal energy, see equation (2.3), page 48

E_u	Internal Energy per unit mass, see equation (2.6), page 48
E_i	System energy at state i, see equation (2.2), page 48
G	The gravitation constant, see equation (4.67), page 90
g_G	general Body force, see equation (4.0), page 71
H	Enthalpy, see equation (2.18), page 50
h	Specific enthalpy, see equation (2.18), page 50
k	the ratio of the specific heats, see equation (2.24), page 51
k_T	Fluid thermal conductivity, see equation (7.3), page 202
L	Angular momentum, see equation (3.40), page 67
P_{atmos}	Atmospheric Pressure, see equation (4.104), page 101
q	Energy per unit mass, see equation (2.6), page 48
Q_{12}	The energy transferred to the system between state 1 and state 2, see equation (2.2), page 48
R	Specific gas constant, see equation (2.27), page 52
S	Entropy of the system, see equation (2.13), page 50
S_{uth}	Suth is Sutherland's constant and it is presented in the Table 1.1, see equation (1.17), page 12
T_τ	Torque, see equation (3.42), page 68
T_{i0}	reference temperature in degrees Kelvin, see equation (1.17), page 12
T_{in}	input temperature in degrees Kelvin, see equation (1.17), page 12
U	velocity, see equation (2.4), page 48
w	Work per unit mass, see equation (2.6), page 48
W_{12}	The work done by the system between state 1 and state 2, see equation (2.2), page 48
z	the coordinate in z direction, see equation (4.14), page 73
z_{says}	Subscribe says, see equation (5.0), page 148

The Book Change Log

Version 0.3.1.1

Dec 21, 2011 (3.6 M 452 pages)

- Minor additions to the Dimensional Analysis chapter.
- English and minor corrections in various chapters.

Version 0.3.1.0

Dec 13, 2011 (3.6 M 446 pages)

- Addition of the Dimensional Analysis chapter skeleton.
- English and minor corrections in various chapters.

Version 0.3.0.4

Feb 23, 2011 (3.5 M 392 pages)

- Insert discussion about Pushka equation and bulk modulus.
- Addition of several examples integral Energy chapter.
- English and addition of other minor examples in various chapters.

*Version 0.3.0.3***Dec 5, 2010 (3.3 M 378 pages)**

- Add additional discussion about bulk modulus of geological system.
- Addition of several examples with respect speed of sound with variation density under bulk modulus. This addition was to go the compressible book and will migrate to there when the book will brought up to code.
- Brought the mass conservation chapter to code.
- additional examples in mass conservation chapter.

*Version 0.3.0.2***Nov 19, 2010 (3.3 M 362 pages)**

- Further improved the script for the chapter log file for latex (macro) process.
- Add discussion change of bulk modulus of mixture.
- Addition of several examples.
- Improve English in several chapters.

*Version 0.3.0.1***Nov 12, 2010 (3.3 M 358 pages)**

- Build the chapter log file for latex (macro) process Steven from www.artofproblemsolving.com.
- Add discussion change of density on buck modulus calculations as example as integral equation.
- Minimal discussion of converting integral equation to differential equations.
- Add several examples on surface tension.
- Improvement of properties chapter.
- Improve English in several chapters.

*Version 0.3.0.0***Oct 24, 2010 (3.3 M 354 pages)**

- Change the emphasis equations to new style in Static chapter.
- Add discussion about inclined manometer

- Improve many figures and equations in Static chapter.
- Add example of falling liquid gravity as driving force in presence of shear stress.
- Improve English in static and mostly in differential analysis chapter.

Version 0.2.9.1

Oct 11, 2010 (3.3 M 344 pages)

- Change the emphasis equations to new style in Thermo chapter.
- Correct the ideal gas relationship typo thanks to Michal Zadrozny.
- Add example, change to the new empheq format and improve cylinder figure.
- Add to the appendix the differentiation of vector operations.
- Minor correction to to the wording in page 11 viscosity density issue (thanks to Prashant Balan).
- Add example to dif chap on concentric cylinders poiseuille flow.

Version 0.2.9

Sep 20, 2010 (3.3 M 338 pages)

- Initial release of the differential equations chapter.
- Improve the emphasis macro for the important equation and useful equation.

Version 0.2.6

March 10, 2010 (2.9 M 280 pages)

- add example to Mechanical Chapter and some spelling corrected.

Version 0.2.4

March 01, 2010 (2.9 M 280 pages)

- The energy conservation chapter was released.
- Some additions to mass conservation chapter on averaged velocity.
- Some additions to momentum conservation chapter.
- Additions to the mathematical appendix on vector algebra.

- Additions to the mathematical appendix on variables separation in second order ode equations.
- Add the macro protect to insert figure in lower right corner thanks to Steven from www.artofproblemsolving.com.
- Add the macro to improve emphases equation thanks to Steven from www.artofproblemsolving.com.
- Add example about the the third component of the velocity.
- English corrections, Thanks to Eliezer Bar-Meir

Version 0.2.3

Jan 01, 2010 (2.8 M 241 pages)

- The momentum conservation chapter was released.
- Corrections to Static Chapter.
- Add the macro ekes to equations in examples thanks to Steven from www.artofproblemsolving.com.
- English corrections, Thanks to Eliezer Bar-Meir

Version 0.1.9

Dec 01, 2009 (2.6 M 219 pages)

- The mass conservation chapter was released.
- Add Reynold's Transform explanation.
- Add example on angular rotation to statics chapter.
- Add the open question concept. Two open questions were released.
- English corrections, Thanks to Eliezer Bar-Meir

Version 0.1.8.5

Nov 01, 2009 (2.5 M 203 pages)

- First true draft for the mass conservation.
- Improve the dwarfing macro to allow flexibility with sub title.
- Add the first draft of the temperature-velocity diagram to the Therm's chapter.

Version 0.1.8.1

Sep 17, 2009 (2.5 M 197 pages)

- Continue fixing the long titles issues.
- Add some examples to static chapter.
- Add an example to mechanics chapter.

Version 0.1.8a

July 5, 2009 (2.6 M 183 pages)

- Fixing some long titles issues.
- Correcting the gas properties tables (thanks to Heru and Micheal)
- Move the gas tables to common area to all the books.

Version 0.1.8

Aug 6, 2008 (2.4 M 189 pages)

- Add the chapter on introduction to multi-phase flow
- Again additional improvement to the index (thanks to Irene).
- Add the Rayleigh–Taylor instability.
- Improve the doChap scrip to break up the book to chapters.

Version 0.1.6

Jun 30, 2008 (1.3 M 151 pages)

- Fix the English in the introduction chapter, (thanks to Touser).
- Improve the Index (thanks to Irene).
- Remove the multiphase chapter (it is not for public consumption yet).

Version 0.1.5a

Jun 11, 2008 (1.4 M 155 pages)

- Add the constant table list for the introduction chapter.
- Fix minor issues (English) in the introduction chapter.

*Version 0.1.5***Jun 5, 2008 (1.4 M 149 pages)**

- Add the introduction, viscosity and other properties of fluid.
- Fix very minor issues (English) in the static chapter.

*Version 0.1.1***May 8, 2008 (1.1 M 111 pages)**

- Major English corrections for the three chapters.
- Add the product of inertia to mechanics chapter.
- Minor corrections for all three chapters.

Version 0.1a April 23, 2008

*Version 0.1a***April 23, 2008**

- The Thermodynamics chapter was released.
- The mechanics chapter was released.
- The static chapter was released (the most extensive and detailed chapter).

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- **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, Dec, 2009

- **Nature of contribution:** LaTeX formatting, help on building the useful equation and important equation macros.
- **Nature of contribution:** In 2009 creating the exEq macro to have different counter for example.

Dan H. Olson

- **Date(s) of contribution(s):** April 2008
- **Nature of contribution:** Some discussions about chapter on mechanics and correction of English.

Richard Hackbarth

- **Date(s) of contribution(s):** April 2008
- **Nature of contribution:** Some discussions about chapter on mechanics and correction of English.

John Herbolenes

- **Date(s) of contribution(s):** August 2009
- **Nature of contribution:** Provide some example for the static chapter.

Eliezer Bar-Meir

- **Date(s) of contribution(s):** Nov 2009, Dec 2009
- **Nature of contribution:** Correct many English mistakes Mass.
- **Nature of contribution:** Correct many English mistakes Momentum.

Henry Schoumertate

- **Date(s) of contribution(s):** Nov 2009
- **Nature of contribution:** Discussion on the mathematics of Reynolds Transforms.

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Typo corrections and other "minor" contributions

- **R. Gupta**, January 2008, help with the original **img** macro and other (LaTeX issues).
- **Tousher Yang** April 2008, review of statics and thermo chapters.
- Corretion to equation (2.38) by Michal Zadrozny. (Nov 2010) Corretion to wording in viscosity density Prashant Balan. (Nov 2010)

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.

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 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–

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

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 the 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

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

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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.

related problems. The author has not found any technique that is more useful for this 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 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.

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These books are written in a similar manner to the open source software

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>)

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.

In the last 5 years three textbooks have been constructed which are available for download. These books contain innovative ideas which make some chapters the best in the world. For example, the chapters on Fanno flow and Oblique shock contain many original ideas such as the full analytical solution to the oblique shock, many algorithms for calculating Fanno flow parameters which are not found in any other book. In addition, Potto has auxiliary materials such as the gas dynamics tables (the largest compressible flow tables collection in the world), Gas Dynamics Calculator (Potto-GDC), etc.

The combined number downloads of these books is over half a million (December 2009) or in a rate of 20,000 copies a month. Potto books on compressible flow and fluid mechanics are used as the main textbook or as a reference book in several universities around the world. The books are used in more than 165 different countries around the world. Every month people from about 110 different countries download these books. The book on compressible flow is also used by “young engineers and scientists” in NASA according to Dr. Farassat, NASA Langley Research Center.

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

⁵ Data are not copyrighted.

Table -1. Books under development in Potto project.

Project Name	Progress	Remarks	Version	Availability for Public Download
Compressible Flow	beta		0.4.8.2	✓
Die Casting	alpha		0.0.3	✓
Dynamics	NSY		0.0.0	✗
Fluid Mechanics	alpha		0.1.1	✓
Heat Transfer	NSY	Based on Eckert	0.0.0	✗
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 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.

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

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 0.3.0.5 March 1, 2011

pages 400 size 3.5M

A look on the progress which occur in the two and half years since the last time this page has been changed, shows that the book scientific part almost tripled. Three new chapters were added including that dealing with integral analysis and one chapter on differential analysis. Pushka equation (equation describing the density variation in great depth for slightly compressible material) was added yet not included in any other textbook. While the chapter on the fluid static is the best in the world (according to many including this author⁸), some material has to be expanded.

The potto style file has improved and including figures inside examples. Beside the Pushka equation, the book contains material that was not published in other books. Recently, many heavy duty examples were enhanced and thus the book quality. The meaning heavy duty example refers here to generalized cases. For example, showing the instability of the upside cone versus dealing with upside cone with spesific angle.

Version 0.1.8 August 6, 2008

pages 189 size 2.6M

When this author was an undergraduate student, he spend time to study the wave phenomenon at the interface of open channel flow. This issue is related to renewal energy of extracting energy from brine solution (think about the Dead Sea, so much energy). The common explanation to the wave existence was that there is always a disturbance which causes instability. This author was bothered by this explanation.

⁸While this bragging is not appropriate in this kind of book it is to point the missing and additional further improments needed.

Now, in this version, it was proven that this wavy interface is created due to the need to satisfy the continuous velocity and shear stress at the interface and not a disturbance.

Potto project books are characterized by high quality which marked by presentation of the new developments and clear explanations. This explanation (on the wavy interface) demonstrates this characteristic of Potto project books. The introduction to multi-phase is another example to this quality. While it is a hard work to discover and develop and bring this information to the students, it is very satisfying for the author. The number of downloads of this book results from this quality. Even in this early development stage, number of downloads per month is about 5000 copies.

Version 0.1 April 22, 2008

pages 151 size 1.3M

The topic of fluid mechanics is common to several disciplines: mechanical engineering, aerospace engineering, chemical engineering, and civil engineering. In fact, it is also related to disciplines like industrial engineering, and electrical engineering. While the emphasis is somewhat different in this book, the common material is presented and hopefully can be used by all. One can only admire the wonderful advances done by the previous geniuses who work in this field. In this book it is hoped to insert, what and when a certain model is suitable than other models.

One of the difference in this book is the insertion of the introduction to multiphase flow. Clearly, multiphase is an advance topic. However, some minimal familiarity can be helpful for many engineers who have to deal with non pure single phase fluid.

This book is the third book in the series of POTTO project books. POTTO project books are open content textbooks so everyone are welcome to joint in. The topic of fluid mechanics was chosen just to fill the introduction chapter to compressible flow. During the writing it became apparent that it should be a book in its own right. In writing the chapter on fluid statics, there was a realization that it is the best chapter written on this topic. It is hoped that the other chapters will be as good this one.

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 Egret'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. Indeed, the previous book, on compressible flow, met its opposition. For example, anonymous Wikipedia user name EMBaero claimed that the material in the book is plagiarizing, he just doesn't know from where and what. Maybe that was the reason that he felt that is okay to plagiarize the book on Wikipedia. These criticisms will not change the future or the success of the ideas in 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 book is organized into several chapters which, as a traditional textbook, deals with a basic introduction to the fluid properties and concepts (under construction). The second chapter deals with Thermodynamics. The third book chapter is a review of mechanics. The next topic is statics. When the Static Chapter was written, this author did not realize that so many new ideas will be inserted into this topic. As traditional texts in this field, ideal flow will be presented with the issues of added mass and added forces (under construction). The classic issue of turbulence (and stability) will be presented. An introduction to multi-phase flow, not a traditional topic, will be presented next (again under construction). The next two chapters will deal with open channel flow and gas dynamics. At this stage, dimensional analysis will be present (again under construction).

How This Book Was Written

This book started because I needed an introduction to the compressible flow book. After a while it seems that is easier to write a whole book than the two original planned chapters. In writing this book, it was assumed that introductory book on fluid mechanics should not contained many new ideas but should be modern in the material presentation. There are numerous books on fluid mechanics but none of which is open content. 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.

The structure of Hansen, Streeter and Wylie, and Shames books were adapted and used as a scaffolding for this book. This author was influenced by Streeter and Wylie book which was his undergrad textbooks. The chapters are not written in order. The first 4 chapters were written first because they were supposed to be modified and used as fluid mechanics introduction in "Fundamentals of Compressible Flow." Later, multi-phase flow chapter was written.

The presentation of some of the chapters is slightly different from other books because the usability of the computers. The book does not provide the old style graphical solution methods yet provides the graphical explanation of things.

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 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 copyleft by him.

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, Basics of Fluid Mechanics, describes the fundamentals of fluid mechanics phenomena for engineers and others. This book is designed to replace all introductory textbook(s) or instructor's notes for the fluid mechanics in undergraduate classes for engineering/science students but also for technical peoples. 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.

The structure of this book is such that many of the chapters could be usable independently. For example, if you need information about, say, statics' equations, you can read just chapter (4). 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.¹⁰ Reading everything will, naturally, increase your understanding of the many aspects of fluid mechanics. Many in the industry, have called and emailed this author with questions since this book is only source in the world of some information. These questions have lead to more information and further explantion that is not found anywhre else.

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

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

¹⁰At the present, the book is not well organized. You have to remember that this book is a work in progress.

this information. This book contains many worked examples, which can be very useful for many. In fact, this book contains material that was not published anywhere else.

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@gmail.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. If you would like be "peer reviews" or critic to my new ideas please send me your comment(s). Even reaction/comments from individuals like David Marshall¹¹.

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 Touser Yang for their advices, ideas, and assistance.

The symbol META was added to provide typographical conventions to blurb as needed. This is mostly for the author's purposes and also for your amusement. There are also notes in the margin, but those are solely for the author's purposes, ignore them please. They will be removed gradually as the version number advances.

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".

¹¹Dr. Marshall wrote to this author that the author should review other people work before he write any thing new (well, literature review is always good, isn't it?). Over ten individuals wrote me about this letter. I am asking from everyone to assume that his reaction was innocent one. While his comment looks like unpleasant reaction, it brought or cause the expansion of the explanation for the oblique shock. However, other email that imply that someone will take care of this author aren't appreciated.

To Do List and Road Map

This book isn't complete and probably never will be completed. There will always new problems to add or to polish the explanations or include more new materials. Also issues that associated with the book like the software has to be improved. It is hoped the changes in T_EX and L^AT_EX related to this book in future will be minimal and minor. It is hoped that the style file will be converged to the final form rapidly. Nevertheless, there are specific issues which are on the "table" and they are described herein.

At this stage, many chapters are missing. Specific missing parts from every chapters are discussed below. These omissions, mistakes, approach problems are sometime appears in the book under the Meta simple like this

Meta

sample this part.

Meta End

You are always welcome to add a new material: problem, question, illustration or photo of experiment. Material can be further illuminate. Additional material can be provided to give a different angle on the issue at hand.

Properties

The chapter isn't in development stage yet.

Open Channel Flow

The chapter isn't in the development stage yet. Some parts were taken from Fundamentals of Die Casting Design book and are in a process of improvement.

