Preface

This second edition of *Physics of Continuous Matter* is, as the first, primarily an introduction to the basic ideas of continuum physics and their application to the wealth of macroscopic phenomena. The equations of continuum mechanics were developed between 1750 and 1850, and are so simple that they can be derived from Newtonian particle mechanics in a couple of pages. Unfortunately, they are generally unsolvable by analytic methods, although they have during the last half century yielded to direct numerical computation. Over the years many approximate methods have been developed that give insight into the rich physics hidden in the basic equations, and these methods take, as earlier, center stage in this book.

In this edition the main "story line" has been kept largely intact. Everywhere the physics arguments and their mathematical presentation have been rethought and to some extent rewritten to improve clarity and consistency. Some structural changes could not be avoided. An originally introductory chapter on Cartesian vector and tensor algebra has been moved into an appendix, while two chapters on gravity and stars have been dropped. The original chapter on ideal flow has been split into two chapters on, respectively, incompressible and compressible inviscid fluids. Conversely, the former chapter on lubrication is now joined with the chapter on creeping flow. A new chapter has been added on elasticity of slender rods, as well as two new chapters on, respectively, energy and entropy. After a single introductory chapter, this second edition proceeds immediately to the basics of continuum physics.

The book is aimed squarely at third-year undergraduate or older students. Although I originally taught second-year students from the first edition, much space and time were wasted on mathematical concepts that the students naturally would encounter in a second-year course on electromagnetism. Now these concepts are merely recapitulated in appendices that may be sampled as the need arises. The necessary mathematical tools are developed along with the physics on a "need-to-know" basis in order to avoid lengthy and boring mathematical preliminaries seemingly without purpose. Mathematical rigor is, as before, only used when it is necessary for a clear understanding of the physics.

The important thing to learn from this book is how to reason about physics, both qualitatively and—especially—quantitatively. Numerical simulations may be fine for obtaining solutions to practical problems, but are of very little aid in obtaining real understanding. Physicists must learn to think in terms of fundamental principles and generic methods. Solving one problem after another of a similar kind seems unnecessary and wasteful. This does not mean that the physicist should not be able to reach a practical result through calculation, but the physical principles behind equations and the conditions underlying approximations must never be lost from sight.

A structured text is, in my opinion, an important prerequisite for learning new material. Beyond parts, chapters, sections, subsections, and paragraphs, further structuring has been introduced in this edition by marking certain section and subsection headings with "Application" or "Case". These categories may be seen as "worked examples" and can mostly be included or left out according to the reader's preferences. Headers marked with an asterisk indicate that the subject matter is harder or falls outside the main line of presentation, and may be left out in a first reading without breaking the continuity of the study. The book is divided into six parts: Fluids at rest, Solids at rest, Fluids in motion, Balance and Conservation, Selected topics, and Appendices. The part headings now include a short description of the chapters contained in the part with some comments on what a minimal curriculum could contain.

Each chapter ends with a collection of problems that has been somewhat expanded in this edition. Most problems are meant to illustrate and further develop the physical and mathematical concepts introduced in the chapter text. Problems marked with an asterisk are generally harder than the unmarked ones. Answers to all odd-numbered problems are found in the back of the book. On request, a complete collection of solutions to all problems is available to course teachers, although my experience shows that such collections rapidly tend to leak into the hands of the students. Secrets are, as demonstrated many times, hard to keep in the age of the Internet. Anyway, students are strongly urged to try their hands on the problems before turning to the answers.

Illustrations have, as before, been included everywhere. Not only are there now more margin drawings to aid the understanding of the text, but also more photographs to lighten the presentation. Images resulting from simulations have been redone and improved. As in the first edition, micro-biographies of the major players in the historic development of continuum physics have been provided in the margin, and some have now been illustrated with portraits. The reader should again (and again) be warned that the history of continuum physics is much more complicated than can be learned here. Nevertheless, I believe that it is important for the understanding of this subject at least to be able to place the major contributors properly in time, space, and physics context.

The field of continuum physics is so highly developed that it cannot be given justice in a single textbook. Nearly every chapter in this book represents a separate subfield, each covered by a number of specialized textbooks and monographs, some of which are referred to in the list of references. There are numerous, more advanced topics that could—or perhaps should—have earned a place in this book, for example viscoelastic, anisotropic, and artificial materials; elasticity of membranes; non-linear elasticity; nonlinear surface waves; magneto- and plasma-hydrodynamics; turbulence modeling; finite volume numerics; and so on. What is and is not included reflects the intended level, my personal predilections and, of course, the limitations imposed by the size of the book[1]. But I hope that students of this book will have acquired the basic tools necessary for entering into topics not covered here.

My colleagues through many years John Renner Hansen, Poul Olesen, Poul Henrik Damgaard, and Mogens Høgh Jensen are thanked for their kind and generous support. Besides the persons mentioned in the first edition, special thanks go to Anders Andersen, Hassan Aref, Tomas Bohr, Predrag Cvitanovic, Joachim Mathiesen, and Niels Kjær Nielsen, and to all the students around the world who have sweated over it. Finally, I thank my wife Birthe Østerlund for her unwavering support during the ardors of the preparation of the second edition over the past two years.

The book is written for adults with a serious intention to learn physics. I have selected for readers what I think are the interesting topics in continuum physics, and presented these as pedagogically as I can without trying to cover everything. I sincerely hope that my own joy in understanding and explaining the physics shines through everywhere.

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[1] Extra material may be found at the book's homepage, which also contains the programs used for working out the figures, examples, cases, and applications. See `http://www.lautrup.nbi.dk/continuousmatter2`.