# Preface

The objective of this book is to describe the methods of formulating continuum models for material behavior. The text is structured in a stepwise hierarchical fashion from basic to more advanced topics. The text begins with an introductory chapter that summarizes some aspects of creating mechanical models of material behavior and also describes different models for material object behavior; the particle, rigid object, lumped parameter, and continuum models. Chapters 2 through 6 contain a development of linear anisotropic continuum mechanics models: a development of basic continuum kinematics is presented in Chap. 2, the continuum formulations of conservation laws is recounted in Chap. 3, the process of modeling material symmetry is explained in Chap. 4, the steps in the formulation of constitutive equations are enumerated in Chap. 5; and four linear continuum theories: flow through rigid porous media, elasticity, viscous fluid theory, and viscoelasticity, are described in Chap. 6. These four continuum models are combined in different ways and applied at the microstructural level in the remainder of the book. Chapter 7 concerns the modeling of material microstructure. Chapters 8 and 9 present developments of the theories of quasi-static and dynamic poroelasticity, respectively, while Chap. 10 presents a mixture theory approach to poroelasticity. The kinematics and mechanics of large elastic deformations are described in Chap. 11. Appendix A on matrices and tensors also contains short reviews of other mathematical topics that occur in the development of the text material. The material in the Appendix has been added to aid the students in remembering what they once knew. It is now presented at the start of the course.

The presentations in the text differ from the customary presentations of these topics in many aspects, two of which are worth pointing out. First, all continuum models are developed for the anisotropic cases rather than the isotropic cases because most tissues are anisotropic in their material properties. Second, a slightly unconventional tensor-matrix notation is employed in this presentation. Its objective is to represent fourth rank tensors as matrices that are composed of tensor components, something that the classical Voigt matrix notation for the anisotropic elasticity tensor does not achieve. In the notation employed here second and fourth rank tensors in three dimensions are represented as vectors and second rank tensors,

respectively, in six dimensions. Transformations in the six-dimensional space, corresponding to three-dimensional transformations, are six-by-six matrix multiplications that are easily entered and quickly computed with symbolic algebra software (Maple, Mathematica, MacSyma, and MatLab). In particular the three-dimensional fourth rank elasticity tensor is represented as a second rank tensor in a space of six dimensions. This notation is described in the Appendix on matrices and tensors.

The material in this text is covered in a Continuum Mechanics course by the author. The course regularly draws students from Chemical, Civil and Mechanical Engineering as well as Biomedical Engineering. The material in the Continuum Mechanics course, in the order covered, is Appendix A, then Chaps. 1 through 7. I cover the material on poroelasticity in a separate course I teach jointly with Luis Cardoso. I would very much appreciate readers communicating to me suggested revisions to this book. In particular any corrections, comments, suggestions of material to be included (or excluded) and suggested problems w/solutions for use as either examples or problems at the end of sections would be appreciated. Please email these materials to sccowin@gmail.com or cowin@ccny.cuny.edu. I will maintain a record of corrections, suggested additions, and suggested (HW) problems w/solutions.

A problem solutions manual is available from the author for instructors using this book in a course. For an instructor to obtain an e-copy, please email a request to sccowin@gmail.com or cowin@ccny.cuny.edu and enclose the name of the instructor, the name of the instructor's institution and course in which the book will be employed.

The contributions from the students who took the courses in which the content of the book was contained in handouts presented have been most helpful. Monte Mehrabadi has made substantial indirect contributions to the text through his 40-year collaboration with the author, as has Luis Cardoso in the last 5 years.

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