PREFACE

TO THE STUDENT

This textbook is an introduction to the topic of **mechanics of materials,** an engineering subject that also goes by the names *mechanics of solids, mechanics of deformable bodies,* and *strength of materials.* You should already have a thorough background in **statics,** that is, you should know how to analyze the equilibrium of "rigid" bodies by constructing free-body diagrams and formulating and solving the appropriate equilibrium equations. In this course you will learn how to extend equilibrium analysis to **deformable bodies,** specifically to various members that make up structures and machines. This requires not only careful attention to equilibrium requirements, but also consideration of the behavior of the material (e.g., aluminum, steel, or wood) of which the member is made, and consideration of the geometry of deformation. Therefore, you will learn to apply the **three fundamental concepts of solid mechanics:** (1) *Equilibrium,* (2) *Force-Temperature—Deformation Behavior of Materials,* and (3) *Geometry of Deformation.*

You will learn a number of important new topics, such as: how the external forces that are applied to a body are distributed throughout the body, and whether the body will fail under the action of the applied forces (the topic of **stress**); how the body will deform under the action of the applied external forces and temperature changes (the topic of **strain**); what material properties affect the way that the body responds to the applied forces and temperature changes (the topic of **stress-strain-temperature behavior of materials**); and other important solid-mechanics topics.

With the aid of this textbook you will learn **systematic problem-solving methods,** including ways to assess the probable accuracy of your homework solutions. You will enjoy using the computer program **MDSolids** that is available for use with this textbook. Its intuitive graphical interface will help you develop problem-solving skills by showing you the important factors affecting various problem types, by helping you visualize the nature of internal stresses and member deformations, and by providing you an easy-to-use means of investigating a greater number of problems and variations. Nevertheless, the emphasis in this textbook remains on your developing an **understanding of the fundamentals of elementary solid mechanics,** not on writing computer programs or on using an existing computer program just to get immediate answers.

Please take time now to look at the color photographs that are included as a color-photo insert in Chapter 1. They illustrate how the **Finite Element Method,** a direct extension of this introduction to solid mechanics, is used to design and analyze everything from airplanes to cars, from skyscrapers and bridges to bicycle frames and tennis racquets, from offshore oil rigs to computer chips. The goal of this

book is to prepare you to study further courses in solids and structures that will enable you to carry out such complex analyses, opening the door to the exciting world of **Computer-Aided Engineering,** whether your application is to aerospace engineering, architectural engineering, civil engineering, mechanical engineering, petroleum engineering, or even to electrical engineering.

SPECIAL FEATURES

The philosophy guiding the development of this introductory solid-mechanics textbook has been that students learn engineering topics best: (1) when they are made aware of the *fundamental concepts* involved in the subject, (2) when they are taught *systematic problem-solving procedures* and are provided many *example problems* that are solved in a systematic manner and are complete, (3) when they have ample opportunity for *drill and practice* in solving problems and obtaining feedback, and (4) when they are given *real engineering examples* and shown the relevance of what they are studying. To implement this philosophy, the following features have been incorporated in this textbook.

- **A Strong Emphasis on the Three Basic Concepts of Deformable-Body Mechanics.** Throughout this book students are reminded that solid mechanics problems involve three fundamental concepts: **Equilibrium, Material Behavior,** and **Geometry of Deformation.** In the Example Problems, the equations that correspond to each of these three concepts are highlighted and identified by name, so that the student should thoroughly understand the important role played by each one of these three fundamental concepts.
- **A Four-Step Problem-Solving Procedure.** The following four steps are included in the solution of most of the Example Problems in this book.
  - State the Problem
  - Plan the Solution
  - Solve the Problem
  - Review the Solution

  Once an engineering student leaves the university environment and becomes a practicing engineer, with powerful computer programs to carry out the detailed solution of complex problems, the importance of being able to **Plan the Solution** and **Review the Solution** for probable accuracy will become readily apparent.
- **Example Problems; Systematic Problem-Solving Procedures.** In this textbook, **over 140 Example Problems** provide the student with detailed illustrations of systematic procedures for solving solid-mechanics problems. In addition, as part of the accompanying **MDSolids** software, there are an **additional 90 Example Problems,** with complete solutions provided in the same notation and style as the solutions in the textbook itself.

  As noted above, the distinct contribution of each of the three fundamental concepts—Equilibrium, Material Behavior, and Geometry of Deformation—is highlighted and identified by name. Once the basic equations have been written down, solutions are completed by combining these equations to obtain the final answer(s). **Procedure lists** indicate convenient and systematic procedures for solving problems, and **flow charts** summarize these procedures graphically. These problem-solving procedures, labeled the *Basic Force Method,* the *Displacement Method,* and the *Force Method,* are first presented in Chapter 3.

Sign conventions for forces, displacements, etc. are established and are consistently followed, and wherever **equilibrium equations** are required, a complete **free-body diagram** is drawn. Because equilibrium analysis plays such a central role in mechanics of solids, a special section in Chapter 1 is devoted to reviewing statics of rigid bodies and to introducing the concept of internal resultants for deformable bodies.

- **Computer Exercises and Computer Software.** Thirty computer exercises are included as homework problems; these are identified by a C-superscripted problem number. Students are presented the opportunity to develop their own computer programs, and the award-winning **MDSolids** software is available via download for use on PCs running the Windows operating system.[1] Appendix G describes the software that accompanies this textbook. To download the software, you must register on the Wiley Student Companion Site for this book at www.wiley.com/college/craig. For details, see the registration card provided in the book.
- **Design.** There is a multifaceted treatment of the topic of **design.** For example, Section 2.8 discusses the philosophy of design, introduces the student to straightforward allowable-stress design, and closes with an example of optimum (minimum-weight) design of a simple statically determinate truss. The final chapter, Chapter 12, discusses three special design-related topics: stress concentrations, failure theories, and fatigue and fracture. Throughout the text and among the special MDSolids Example Problems there are design-related examples. Homework problems with design content are identified by a D-superscripted problem number.
- **Accuracy.** Special efforts have been made to provide as error-free a book as possible. At least two independent solutions have been obtained for every homework problem, and the *Solutions Manual* was prepared directly by the author in order to insure consistency and accuracy.
- **Communication with the Authors.** Comments regarding the book or the *Solutions Manual* may be addressed to the author at the following e-mail address: roy_craig@mail.utexas.edu. Please address your comments or inquiries regarding MDSolids by e-mail to Dr. Timothy Philpot: philpott@mst.edu.

NEW IN THIS EDITION

This third edition of *Mechanics of Materials retains* the hallmark features of the first two editions—a strong emphasis on the three fundamental types of equations of solid mechanics and on systematic procedures for solving problems. Listed below are the new features of the Third Edition, followed by the major modifications that have been incorporated into this edition

- From the student's standpoint, the most significant new feature is the addition of a Chapter Review table at the end of each chapter. These Chapter Reviews summarize the key points of the chapter, and they include the major equations and figures from the chapter. In addition, students will find a list of problems that will be useful to them in reviewing the chapter and preparing for examinations.

[1]The **MDSolids** software suite, developed by Dr. Timothy A. Philpot, was awarded the 1998 Premier Award for Excellence in Engineering Education Courseware.

- Two new topics have been added in this edition—**Mechanical Properties of Composite Materials** as a new Section 2.14, and **Wire Rope** as a topic in Section 3.3. This new material was written by the author's colleague, Dr. Eric Taleff, Professor of Mechanical Engineering at The University of Texas at Austin.

Other modifications and additions that have been incorporated into this Third Edition include:

- There are over 1300 homework problems in this edition–approximately one-third of them are in US Customary Units, one-third are in SI Units, and one-third are stated in symbolic form. Approximately 30% of the problems in this edition are either completely new or are significantly modified versions of homework problems from the two previous editions.
- The theory of axial deformation in Sections 3.2 through 3.4 has been reorganized, with examples of nonuniform axial deformation now in Section 3.3, preceding the examples of statically determinate structures with uniform axial-deformation members.
- The steps that are used in solving various problems are summarized in **Procedure Lists,** and these steps are often summarized graphically in **Flow Charts** (e.g., p. 146).
- As in the previous edition, the topic of statically indeterminate structures is introduced in the "classical" way.[2] There is still a strong emphasis on the three distinct equations of deformable-body mechanics: *equilibrium, force-temperature-deformation behavior of materials, and geometry of deformations.*
- There has been a substantial re-organization of Chapter 3–*Axial Deformation*–with the derivation of the force-deformation behavior of uniform linearly elastic axial-deformation elements, including the definitions of **flexibility coefficient** and **stiffness coefficient,** moved into Section 3.2–*Basic Theory of Axial Deformation.*
- As in the previous edition, sections that introduce the **Displacement Method** (Sections 3.8 and 4.7) are not considered to be "optional" sections, since this topic forms the basis of courses that quite likely will follow Mechanics of Materials in the student's curriculum (e.g., Matrix Structural Analysis and/or Finite Element Analysis).
- The topic of **Shear-Force and Bending-Moment Diagrams** has been divided into two sections, one (Section 5.4) treating the "Equilibrium Method" and the other (Section 5.5) treating the "Graphical Method." This change, together with the table in Section 5.5, will permit instructors to place special emphasis on graphical procedures for constructing and interpreting Shear-Force and Bending-Moment Diagrams.

SUPPLEMENTS

MDSolids Software with 90 Special Example Problems. The MDSolids computer program, winner of the 1998 Premier Award for Excellence in Engineering Education Courseware, is available to students and instructors. MDSolids has a

[2]The so-called "classical" solution procedure consists of simultaneously solving the equations of equilibrium and the compatibility equations written in terms of forces. This is labeled the "Basic Force Method" because, as with the Force Method of Section 3.9, the quantities that are obtained first in a solution are the unknown forces.

superb graphical user interface, is extremely user friendly, and covers a very broad range of mechanics of materials topics. Ninety special MDSolids example problems are closely linked to the examples in the book and to homework problems. (See Appendix G for further description of MDSolids.)

Solutions Manual. As was the case for previous editions, the *Solutions Manual* for the third edition includes original problem statements and text figures in addition to complete solutions. Instructors who have adopted this textbook for their course can visit www.wiley.com/college/craig and click on the Instructor Companion Website to download the *Solutions Manual.*

Website The publisher maintains a website where additional descriptions, feedback, and ordering information are located. The URL is: www.wiley.com/college/craig.