Preface

Overview and Goals

This text is concerned with how engineering components and systems support loads without suffering failure or excessive deformation. Such topics are traditionally addressed in texts entitled *Strength of Materials* or *Mechanics of Materials*. The aim of this text is to develop a simple and comprehensive approach which recognizes today's wide range of technical applications and materials. Such an approach is well-suited to meet the demands of interdisciplinary and rapidly changing technologies.

The scale of engineering systems considered varies from 10^{-6} to 10^{3} meters. The basic concepts are applicable to micro-electromechanical systems (MEMS, ~10^{-6} m), piezoelectric devices, electronic and computer hardware, tools, machines, vehicles, buildings, space structures and bridges (~10^{3} m). The materials considered include metals, ceramics, polymers, composites, piezoelectric materials and shape memory alloys.

The work is intended as a basic text and learning tool for undergraduate and graduate students, and as a comprehensive resource – for review and introduction – for researchers, scientists and engineers of all fields.

With these goals in mind, an attempt is made to keep the approach simple, direct and concise. The initial chapters – ***Chapters 1*** through ***10*** – are developed by means of basic theory and illustrated with examples designed to solidify understanding of the fundamental principles. Mastering these basic principles is vital in solving practical problems and in creating innovative and safe designs.

Chapters 11 through ***16*** cover topics such as energy methods, plasticity, fracture, composites and smart systems, each usually the subject of specialized texts and upper division or graduate courses. As in the early chapters, these topics are approached in a succinct and straightforward manner so that the text is comprehensive to an advanced level.

Supplemental materials are included in an accompanying web site **www.ah-engr.com/strengthandstiffness**, referred to as ***Online Notes*** in the text. The ***Online Notes*** include: (1) basic interactive problems used to test basic knowledge and skills; (2) additional material and information, which while important in their own right, are not necessary for the development of the written text; and (3) basic computing tools, resources and data in support of the text.

Organization

The first ten chapters cover topics generally taught in a sophomore- or junior-level Strength of Materials course. These chapters can be broken into roughly four sections:

- ***Chapters 1-3***. *Chapter 1* is both an overview of the main topics of the text, and a review of topics studied in previous courses (e.g., units, significant figures). *Chapter 2* is a brief review of Statics; applying the conditions of equilibrium is usually the first step in solving any Strength of Materials problem. *Chapter 3* introduces the fundamental concepts of stress and strain, and the material laws that relate them.
- ***Chapters 4-6***. *Chapters 4* through *6* develop approaches to determine the stresses, strains and deformations in basic engineering components: axial members, pressure vessels, torsion members and beams. The first three sections of *Chapter 14* – basic bolted joints – may be studied directly after *Chapter 4*.
- ***Chapters 7-9***. *Chapter 7* considers situations when a structural member is loaded by a combination of loads: axial, torsion, and/or bending about one or two axes, primarily to determine the general state of stress at a material point. *Chapter 8* develops the stress and strain transformation equations. *Chapter 9* illustrates how to determine if a general state of stress causes material failure.
- ***Chapter 10*** covers the buckling of columns, including such topics as the effect of transverse forces, column shortening, and buckling on an elastic foundation.

The last six chapters cover advanced topics that may be taught at any class-level. Select chapters or sections may be included in a first Strength of Materials course, or the latter chapters may compose the curriculum of an advanced upper-division or graduate course. These chapters are succinct introductions to entire fields of study in engineering.

- ***Chapter 11*** covers energy methods, expanding on approaches briefly introduced in *Chapter 4*.
- ***Chapters 12*** considers the effect of plasticity (yielding) in ductile materials and its impact on design.
- ***Chapter 13*** introduces fracture mechanics, and the statistical approach used to evaluate the strength of ceramic components.
- ***Chapter 14*** covers stresses in bolted connections and adhesive joints.
- ***Chapter 15*** introduces unidirectionally-reinforced composite materials, including estimating the elastic properties of a single ply and of two-ply laminates, determining system integrity, and basic design considerations.
- ***Chapter 16*** introduces smart systems, including micro-electromechanical systems, piezoelectric devices and shape memory alloys.

Problems for the student to work out are all grouped together in a single “chapter” entitled ***Problems***, placed directly before the ***Appendix***.

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We have tried to eliminate errors, but as in any human endeavor, this text is not perfect. Comments and suggestions may be directed to domdalbello@yahoo.com.

For Liz,

F.A. Leckie

For my father and mother, J.J. and Irene,

D.J. Dal Bello

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Professor Leckie has taught a full range of Mechanical Engineering subjects (Statics, Dynamics, Strength of Materials, Materials, Thermodynamics, and Design), from large undergraduate classes to specialized graduate courses on advanced technology including MEMS. His research interests have included material performance and design at high temperature, material modeling and computation, and composite materials.

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