Preface

The objective of this book is to provide the concepts, procedures, data, and decision analysis techniques necessary to design machine elements commonly found in mechanical devices and systems. Students completing a course of study using this book should be able to execute original designs for machine elements and integrate the elements into a system composed of several elements.

This process requires a consideration of the performance requirements of an individual element and of the interfaces between elements as they work together to form a system. For example, a gear must be designed to transmit power at a given speed. The design must specify the number of teeth, pitch, tooth form, face width, pitch diameter, material, and method of heat treatment. But the gear design also affects, and is affected by, the mating gear, the shaft carrying the gear, and the environment in which it is to operate. Furthermore, the shaft must be supported by bearings, which must be contained in a housing. Thus, the designer should keep the complete system in mind while designing each individual element. This book will help the student approach design problems in this way.

This text is designed for those interested in practical mechanical design. The emphasis is on the use of readily available materials and processes and appropriate design approaches to achieve a safe, efficient design. It is assumed that the person using the book will be the designer, that is, the person responsible for determining the configuration of a machine or a part of a machine. Where practical, all design equations, data, and procedures needed to make design decisions are specified.

It is expected that students using this book will have a good background in statics, strength of materials, college algebra, and trigonometry. Helpful, but not required, would be knowledge of kinematics, industrial mechanisms, dynamics, materials, and manufacturing processes.

Among the important features of this book are the following:

1. It is designed to be used at the undergraduate level in a first course in machine design.
2. The large list of topics allows the instructor some choice in the design of the course. The format is also appropriate for a two-course sequence and as a reference for mechanical design project courses.
3. Students should be able to extend their efforts into topics not covered in classroom instruction because explanations of principles are straightforward and include many example problems.
4. The practical presentation of the material leads to feasible design decisions and is useful to practicing designers.
5. The text advocates and demonstrates use of computer spreadsheets in cases requiring long, laborious solution procedures. Using spreadsheets allows the designer to make decisions and to modify data at several points within the problem while the computer performs all computations. See Chapter 6 on columns, Chapter 9 on spur gears, Chapter 12 on shafts, Chapter 13 on shrink fits, and Chapter 19 on spring design. Other computer-aided calculation software can also be used.

6. References to other books, standards, and technical papers assist the instructor in presenting alternate approaches or extending the depth of treatment.
7. Lists of Internet sites pertinent to topics in this book are included at the end of most chapters to assist readers in accessing additional information or data about commercial products.
8. In addition to the emphasis on original design of machine elements, much of the discussion covers commercially available machine elements and devices, since many design projects require an optimum combination of new, uniquely designed parts and purchased components.
9. For some topics the focus is on aiding the designer in selecting commercially available components, such as rolling contact bearings, flexible couplings, ball screws, electric motors, belt drives, chain drives, clutches, and brakes.
10. Computations and problem solutions use both the International System of Units (SI) and the U.S. Customary System (inch-pound-second) approximately equally. The basic reference for the usage of SI units is IEEE/ASTM-SI-10 *Standard for Use of the International System of Units (SI): The Modern Metric System*, which has replaced ASTM E380 and ANSI/IEEE Standard 268-1992.
11. Extensive appendices are included along with detailed tables in many chapters to help the reader to make real design decisions, using only this text.

MDESIGN–MECHANICAL DESIGN SOFTWARE INCLUDED IN THE BOOK

The design of machine elements inherently involves extensive procedures, complex calculations, and many design decisions. Data must be found from numerous charts and tables. Furthermore, design is typically iterative, requiring the designer to try several options for any given element, leading to the repetition of design calculations with new data or new design decisions. This is especially true for complete mechanical devices containing several components as the interfaces between components are considered. Changes to one component often require changes to mating elements. Use of computer-aided mechanical design software can facilitate the design process by performing many of the tasks while leaving the major design decisions to the creativity and judgment of the designer or engineer.

We emphasize that users of computer software must have a solid understanding of the principles of design and stress analysis to ensure that design decisions are based on reliable foundations. We recommend that the software be used only after mastering a given design methodology by careful study and using manual techniques.

Included in this book is the MDESIGN mechanical design software created by the TEDATA Company. Derived from the successful MDESIGN mec software produced for the European market, the U.S. version of MDESIGN employs standards and design methods that are typically in use in North America. Many of the textual aids and design procedures come directly from this book, *Machine Elements in Mechanical Design*.

Topics for which the MDESIGN software can be used as a supplement to this book include:

Beam stress analysis	Beam deflections	Mohr's circle	Columns
Belt drives	Chain drives	Spur gears	Helical gears
Shafts	Keys	Power screws	Springs
Rolling contact bearings	Plain surface bearings	Bolted connections	Fasteners
Clutches	Brakes		

Special icons as shown on the preceding page are placed in the margins at places in this book where use of the software is pertinent. Also, the Solutions Manual, available only to instructors using this book in scheduled classes, includes guidance for use of the software.

FEATURES OF THE FOURTH EDITION

The practical approach to designing machine elements in the context of complete mechanical designs is retained and refined in this edition. An extensive amount of updating has been accomplished through the inclusion of new photographs of commercially available machine components, new design data for some elements, new or revised standards, new end-of-chapter references, listings of Internet sites, and some completely new elements. The following list summarizes the primary features and the updates.

1. The three-part structure that was introduced in the third edition has been maintained.
   - Part I (Chapters 1–6) focuses on reviewing and upgrading readers' understanding of design philosophies, the principles of strength of materials, the design properties of materials, combined stresses, design for different types of loading, and the analysis and design of columns.
   - Part II (Chapters 7–15) is organized around the concept of the design of a complete power transmission system, covering some of the primary machine elements such as belt drives, chain drives, gears, shafts, keys, couplings, seals, and rolling contact bearings. These topics are tied together to emphasize both their interrelationships and their unique characteristics. Chapter 15, **Completion of the Design of a Power Transmission**, is a guide through detailed design decisions such as the overall layout, detail drawings, tolerances, and fits.
   - Part III (Chapters 16–22) presents methods of analysis and design of several important machine elements that were not pertinent to the design of a power transmission. These chapters can be covered in any order or can be used as reference material for general design projects. Covered here are plain surface bearings, linear motion elements, fasteners, springs, machine frames, bolted connections, welded joints, electric motors, controls, clutches, and brakes.
2. **The Big Picture, You Are the Designer**, and **Objectives** features introduced in earlier editions are maintained and refined. Feedback about these features from users, both students and instructors, has been enthusiastically favorable. They help readers to draw on their own experiences and to appreciate what competencies they will acquire from the study of each chapter. Constructivist theories of learning espouse this approach.
3. Some of the new or updated topics from individual chapters are summarized here.
   - In Chapter 1, the discussion of the mechanical design process is refined, and several new photographs are added. Internet sites for general mechanical design are included that are applicable to many later chapters. Some are for standards organizations, stress analysis software, and searchable databases for a wide variety of technical products and services.
   - Chapter 2, **Materials in Mechanical Design**, is refined, notably through added material on creep, austempered ductile iron (ADI), toughness, impact energy, and the special considerations for selecting plastics. An entirely new section on materials selection has been added. The extensive list of Internet sites provides readers access to industry data for virtually all types of materials discussed in the chapter with some tied to new practice problems.

- Chapter 3, a review of **Stress and Deformation Analysis**, has an added review of force analysis and refinement of the concepts of stress elements, combined normal stresses, and beams with concentrated bending moments.
- Chapter 5, **Design for Different Types of Loading**, is extensively upgraded and refined in the topics of endurance strength, design philosophy, design factors, predictions of failure, an overview of statistical approaches to design, finite life, and damage accumulation. The recommended approach to fatigue design has been changed from the *Soderberg criterion* to the *Goodman method*. The *modified Mohr method* is added for members made from brittle materials.
- In Chapter 7, synchronous belt drives are added and new design data for chain power ratings are included.
- Chapter 9, **Spur Gear Design**, is refined with new photographs of gear production machinery, new AGMA standards for gear quality, new discussion of functional measurement of gear quality, enhanced description of the geometry factor *I* for pitting resistance, more gear lubrication information, and a greatly expanded section on plastics gearing.
- In Chapter 11, new information is provided for keyless hub to shaft connections of the Ringfeder® and polygon types, and the Cornay™ universal joint. The extensive listing of Internet sites provides access to data for keys, couplings, universal joints, and seals.
- Critical speeds, other dynamic considerations, and flexible shafts are added to Chapter 12, **Shaft Design**.
- An all-new section, Tribology: Friction, Lubrication, and Wear, is added to Chapter 16, **Plain Surface Bearings**. More data on *pV factors* for boundary lubricated bearings are provided.
- Chapter 17 has been retitled **Linear Motion Elements** and includes power screws, ball screws, and linear actuators.
- Refinements to Chapter 18, **Fasteners**, include the shear strength of threads, components of torque applied to a fastener, and methods of bolt tightening.

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