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Mechanical Engineering Design

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**MECHANICAL
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PREFACE

This book has been written for engineering students who are beginning a course of study in mechanical engineering design. Such students will have acquired a set of engineering *tools* consisting, essentially, of mathematics, computer languages, and the ability to use the English language to express themselves in the spoken and written forms. Mechanical design involves a great deal of geometry, too, therefore another useful tool is the ability to sketch and draw the various configurations which arise. Students will also have studied a number of basic engineering *sciences*, including physics, engineering mechanics, materials and processes, and the thermal-fluid sciences. These, the tools and sciences, constitute the foundation for the practice of engineering, and so, at this stage of undergraduate education, it is appropriate to introduce the professional aspects of engineering. These professional studies should integrate and use the tools and the sciences in the accomplishment of an engineering objective. The pressures upon the undergraduate curricula today require that we do this in the most efficient manner. Most engineering educators are agreed that mechanical design integrates and utilizes a greater number of the tools and the sciences than any other professional study. Mechanical design is also the very core of other professional and design types of studies in mechanical engineering. Thus studies in

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mechanical design seem to be the most effective and economical method of starting the student in the practice of mechanical engineering.

Books, like cars, always seem to grow larger and larger with each new edition. And books have been subjected to the same inflationary pressures as automobiles have in recent years, producing ever higher prices for them. In this edition I have attempted to buck this trend by trimming the fat and the frills wherever possible. The result is a leaner, more concise book that will cost the student less than one having more pages.

One of the principal reasons for writing a new edition now is the urgent need to introduce the International System of Units (SI) and the attendant rules into mechanical design studies. Accordingly about 50 percent of the illustrative examples and problems for student solution are expressed in SI units. In the case of gears, there are no metric standards in this country and so the examples and problems are mostly in English units.

It is especially important to note that the International System of Units (SI) is presented and used in this book *exactly* in accordance with the rules and recommendations as given in the National Bureau of Standards Special Publication 330, 1974 edition. To do otherwise could lead to great confusion because of the proliferation of units.

The pocket electronic calculator came along just in time to aid in the introduction of SI units into engineering. The scientific notation capability is just what is needed. But the calculator can be expected to affect the teaching and practice of design in many other ways. We can expect to see a decline in the use of charts, graphs, graphical computations, and tabular material in the very near future. Examples of this are to be found in Section 5-11, where it is found that the *S-N* diagram is no longer required, and in Sections 8-5 and 9-2.

There are a number of other features of this edition which should be noted. Singularity functions are introduced in Chapter 2 and are used there for shear and moment diagrams and in Chapter 3 for deflection analysis. Improved material on column analysis and design is presented in Chapter 3. In Chapter 6 additional material on both fatigue loading and shear loading of bolted joints is presented. Chapter 7 is a new chapter devoted to welded, brazed, and bonded joints. A feature of this chapter is the analytical approach used in the stress analysis of joints loaded in shear, torsion, and bending. Chapter 9 on antifriction bearings has been completely rewritten, and it contains new material on bearing life, reliability, bearing load, and tapered roller bearings. Chapter 13 on shafts has also been largely rewritten. It now contains the Sines and the Kececioglu methods of shaft design and analysis.

One cannot help but be gratified by the reception accorded the previous editions of this book. Nevertheless they did contain many unclear or glossed-over passages, examples that served no useful purposes, illustrations that did not illustrate, and problems for student solution that were poorly phrased and not well organized. So another of my objectives in writing this edition has been to remedy all these deficiencies. The illustrations and text have been checked very

carefully and redone or rewritten where desirable. Most of the illustrative examples have been replaced or revised. And most of the problems for student homework are new ones. But a few problems were retained from previous editions because they did such an excellent job of permitting self-instruction of the student. Most of these have been renumbered in this edition.

It is of course very pleasing to learn that previous editions of this book are used so much by design engineers in the practice of their profession. In many places, for this reason, the text addresses the practicing engineer separately from the student, recognizing that the engineer's needs are somewhat different and that more facilities may be available to him or her for use in the entire design process. The decisions made by an engineer in solving a design problem will depend upon those facilities, and hence may vary to some extent from one industry or one engineering department to another. The student, however, wants to get the right answer, which is the answer obtained by the professor. It has not been difficult to achieve this dual objective. The entire problem is explained to the practicing engineer so that, considering problem-solving constraints, an optimum approach can be chosen. And an appropriate course of action is specified or suggested for students. This method is of more use to students because it contains fewer ambiguities and optional courses of action for their purposes, and of greater value to practicing engineers because it provides them with the options.

I especially want to encourage the users of this edition to send me their comments and suggestions. Every chapter of this edition has been influenced by the users who have taken the time to write me concerning their use of the previous editions, and I am indeed appreciative of their interest.

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PART ONE

Fundamentals of Mechanical Design

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