

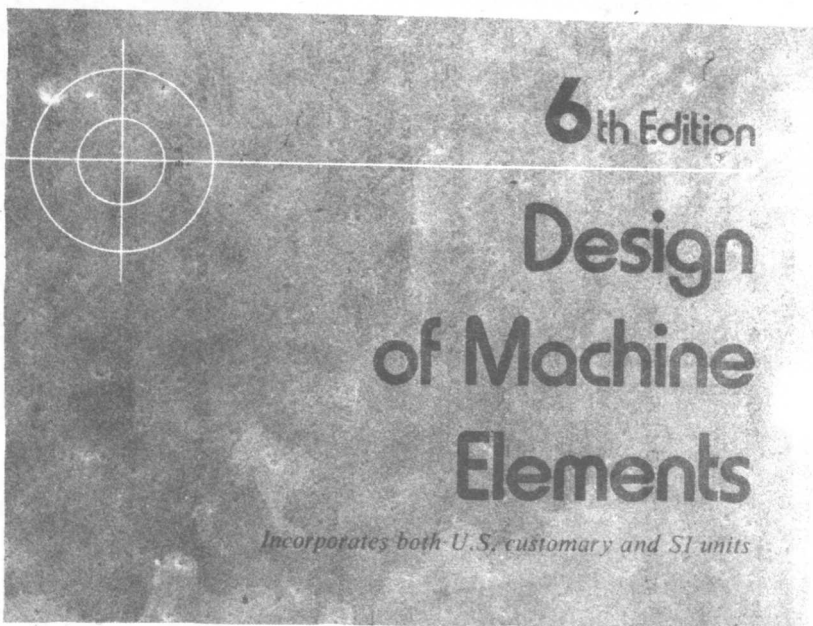
6th Edition

Design
of Machine
Elements

Incorporates both U.S. customary and SI units

M.F. Spotts

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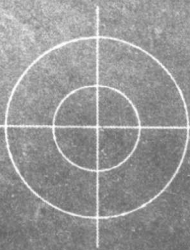
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Throughout the wide fields of engineering, the most fundamental requirement is a sound knowledge of the first principles of mechanics coupled with an intimate understanding of the properties of materials. More problems arise from weaknesses in mechanical design than from any other cause, impressing upon us the necessity of being well versed in the basic principles of mechanical engineering.

Sir George H. Nelson
Institution of Electrical Engineers



Preface

The essential features of the previous editions have been retained in this, the sixth edition. Improvements have been made throughout the book in simplifying design methods and making them more understandable and easier to use. Wherever appropriate, new material has been added to various chapters including over 200 new problems with answers.

(As for) previous editions the object of the book is to give training in the making of design calculations for the mechanical elements in universal use. In fact one cannot call oneself a mechanical engineer at the professional level unless familiar to some extent with basic theories of this kind. Much more, of course, could be included for each element, but space limitations have made it necessary to present what is felt to be the central and most important way to handle each of the design requirements. Special attention has been given to cases where the loads are continuously fluctuating and stress concentrations may be present. Almost all mathematical derivations have been given in full to make the book as practical and useful, as well as authoritative and adaptable, as possible.

Material on the (International System of Units), commonly called SI, has been retained, but in a form that can be easily omitted if not desired. Sufficient material is included to permit design calculations to be made in the metric system whenever needed. Helpful references are appended at the end of this preface.

After leaving school, students familiar with the methods presented here will be able to make adjustments necessary to fit the particular conditions with which they are faced. The book can also serve as preliminary training for more advanced study for those students who wish to become specialists in some chosen field of mechanical design.

The notation is simple and unified, and the chapters are largely independent of each other. They can be studied in any order with virtually no need of preceeding study. All principles are illustrated by worked-out numerical examples. Chapter 1 presents a review of the essentials of fundamental mechanics used throughout the book.

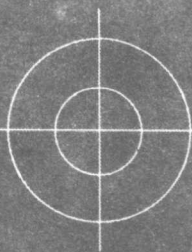
The book represents experience of over 30 years in industry and the classroom. The principles presented here are fundamental to the entire field of mechanical design.

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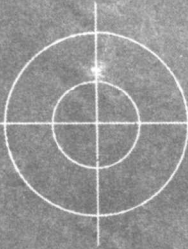
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Introduction

1. Machine Design

Machine design is the art of planning or devising new or improved machines to accomplish specific purposes. In general, a machine will consist of a combination of several different mechanical elements properly designed and arranged to work together, as a whole. During the initial planning of a machine, fundamental decisions must be made concerning loading, type of kinematic elements to be used, and correct utilization of the properties of engineering materials. Economic considerations are usually of prime importance when the design of new machinery is undertaken. In general, the lowest over-all cost is desired. Consideration should be given not only to the cost of design, manufacture, sale, and installation, but also to the cost of servicing. The machine should of course incorporate the necessary safety features and be of pleasing external appearance. The objective is to produce a machine which is not only sufficiently rugged to function properly for a reasonable life, but is at the same time cheap enough to be economically feasible.

The engineer in charge of the design of a machine should not only have adequate technical training, but must be a man of sound judgment and wide experience, qualities which are usually acquired only after considerable time has been spent in actual professional work. A start in this direction can be made with a good teacher while the student is yet at the university.

However, the would-be designer must expect to get a substantial portion of his training after leaving school through further reading and study, and especially by being associated in his work with competent engineers.

2. *Design of Machine Elements*

This book, as the title indicates, will not deal with the broader aspects of the design of complete machines, but will attempt to explain the fundamental principles required for the correct design of the separate elements which compose the machine.

The principles of design are, of course, universal. The same theory or equations may be applied to a very small part, as in an instrument, or to a larger but similar part used in a piece of heavy equipment. In no case, however, should mathematical calculations be looked upon as absolute and final. They are all subject to the accuracy of the various assumptions which must necessarily be made in engineering work. Sometimes only a portion of the total number of parts in a machine are designed on the basis of analytic calculations. The form and size of the remaining parts are then usually determined by practical considerations. On the other hand, if the machine is very expensive, or if weight is a factor, as in airplanes, design computations may then be made for almost all the parts.

The purpose of the design calculations is, of course, to attempt to predict the stress or deformation in the part (in order that) it may safely carry the loads which will be imposed upon it, and that it may last for the expected life of the machine. All calculations are, of course, dependent on the physical properties of the construction materials as determined by laboratory tests. A rational method of design attempts to take the results of relatively simple and fundamental tests such as tension, compression, torsion, and fatigue and apply them to all the complicated and involved situations encountered in present-day machinery.

In addition, it has been amply proved that such details as surface condition, fillets, notches, manufacturing tolerances, and heat treatment have a marked effect on the strength and useful life of a machine part. The design and drafting departments must specify completely all such particulars, and thus exercise the necessary close control over the finished product.

Training in rapid and accurate numerical work is invaluable to the designer. The designer should keep an accurate notebook, as it is frequently necessary for him to refer to work which he has done in the past. A sketch, carefully drawn to scale, is also a necessity, and provides a convenient place for putting down a portion of the data used in connection with the problem.