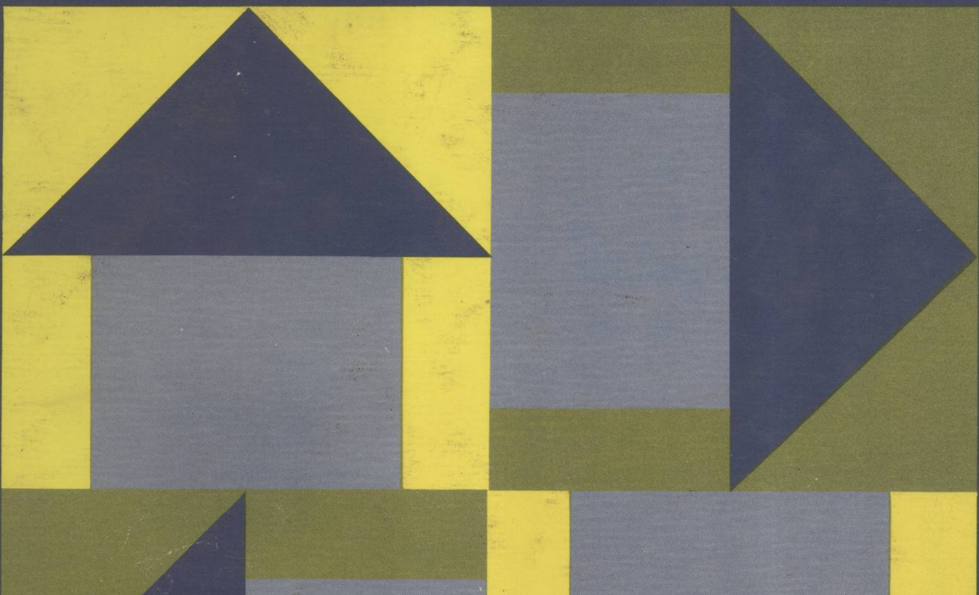
JENSEN · CHENOWETH · SMAIL · STASSEN

APPLIED ENGINEERING MECHANICS

FIRST CANADIAN S.I. METRIC EDITION



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FIRST CANADIAN S.I. METRIC EDITION

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PREFACE TO THE FIRST CANADIAN S.I. METRIC EDITION

In response to the growing demand for S.I. Metric texts in Canadian post-secondary institutions, we have converted the text and problems of the third American edition to S.I. units without other major changes.

All problems have been reworked and some explanatory material added. Every attempt has been made to adhere to S.I. standards and usage presently being adopted in Canada.

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APPLIED ENGINEERING MECHANICS

FIRST CANADIAN S.I. METRIC EDITION

PREFACE TO THE THIRD AMERICAN EDITION

The object of this third edition of *Applied Engineering Mechanics* is to provide students who intend to enter the engineering profession with the basic engineering mechanics knowledge that is so essential to their education, regardless of the branch of engineering they eventually may follow.

As in the previous editions, the text material is based upon easily and commonly understood physical concepts and principles, rather than upon the more abstract mathematical relationships that often are not as well understood. For greater clarity, the text refers in a few places (especially in the appendixes) to the principles of calculus. However, all the text material is so simply stated and the mathematical formulas so carefully developed that nothing more than an understanding of high school mathematics is required. In this respect, this new edition is similar to its companion volume, "Applied Strength of Materials," also written by us.

Our primary aim has been to develop and to present the material in an easily understood manner in order to make the text suitable in content and approach both for college students in engineering and architecture and for those in junior colleges, technical institutes, and in many industrial training and Armed Services programs. Furthermore, we believe the text will be a continuing aid to the many practicing engineers and engineering aides who, in the past, have found the previous editions useful as a reference text.

The book is divided into two parts: statics and dynamics. In statics, the problems most often occurring in practice are given more than usual emphasis. Analytical and graphical solutions are presented side by side in order to show their close relationship and to encourage students to use them concurrently, one as a check upon the other. Experience has shown that graphical solutions enable a student to *visualize* force analysis and that they definitely better the students' understanding of corresponding processes in analytical solutions.

In arranging and developing the subject matter in both sections, we have proceeded very gradually from the elementary problems to those more difficult, in the honest belief that, by such gradation, students learn more quickly and easily. Our experience has been that students learn more efficiently by thoroughly mastering one step at a time and later integrating the various steps and concepts into a completed whole.

New material in the third edition includes a "three-dimensional" approach to space frames, V-belt theory and problems, jackscrews, and a section on the coriolis acceleration. This latter concept leads to some very interesting problems.

Practical problems are used in the text wherever possible, because they stimulate the student's interest and often lie within his personal experience or observation. However, many practical problems, especially in dynamics, appear confusing and complex: when stripped of its complexities, the actual object may be reduced to a mere block, or simply "a body," and the problem is then of the so-called academic type. Such a problem, however, has definite teaching value, because it enables the student to concentrate entirely on the theory involved and to apply this in the solution, leaving any minor complexities for later study.

In the solution of analytical problems, great emphasis is placed on the *complete* free-body diagram. Students are encouraged to develop this diagram gradually as the solution progresses until, upon completion of the problem, it shows all forces or their components. Simple arithmetical summations then prove the correctness of the solution without further computation.

The content is divided into 21 chapters, each composed of several articles. Each article presents additional theory, a new concept, or a different aspect and contains one or more completely solved problems illustrating the application of some theory or concept. A number of problems follow, carefully arranged in order of difficulty. Each chapter closes with a summary of the important points and formulas covered in the chapter; this summary affords students a quick review of the essential parts. The summary, too, is followed by a series of review problems and by a number of review questions carefully arranged to test the student's grasp of the subject matter.

Despite all reasonable efforts by us, the publishers, and the printer, some errors may creep into the first printing of any book: we shall be grateful to all who report any errors they may discover; subsequent printings will benefit greatly.

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Contents

PART 1

Statics

CHAPTER 1

Introduction

1-1 DEFINITION OF MECHANICS

The science of **mechanics** is the study of motion, forces, and the effects of forces on the bodies upon which they act.

Applied engineering mechanics concerns itself mainly with applications of the principles of mechanics to the solution of problems commonly met within the field of engineering practice.

Mechanics is generally divided into two main branches of study: (1) statics and (2) dynamics. **Statics** is that branch which deals with forces and with the effects of forces acting upon rigid bodies at rest. The subject of statics, therefore, is essentially one of *force analysis*; that is, a study of force systems and of their solutions. **Dynamics** deals with motion and with the effects of forces acting on rigid bodies in motion. Dynamics is divided into two branches: (1) **kinematics,** the study of motion without consideration of the forces causing the motion, and (2) **kinetics,** the study of forces acting on rigid bodies in motion and of their effect in changing such motion.

1-2 PROBLEMS IN APPLIED MECHANICS

Engineers conceive, plan, design, and construct buildings, machines, airplanes, and countless other objects, for the comfort and use of the human race. Each of these objects serves a definite and useful purpose; behind each lies an absorbingly interesting story of engineering skill and achievement.

Having in mind a definite purpose for the object to be constructed, the engineer then conceives its appropriate form, either entirely new, or an improvement upon one already in existence. Next he must analyze and determine the forces, known and unknown, acting on the object, and the motions, if any, of its various related parts.

To do this successfully *the engineer must have a thorough knowledge and understanding of the principles of mechanics, and of their applications to his particular problem.* Having thus determined the forces and the motions involved, he may proceed with the design of the object, using available materials of suitable strength and other requisite properties. The final size and shape of the object, and of each of its separate parts, may then be expressed in blueprints, after which the object is ready for production.

From this brief analysis of the work of the engineer, we see clearly that *a knowledge of mechanics is as fundamental to success in the fields of engineering as is an understanding of the alphabet to those who would learn to read and write their own language.* The extent of his knowledge of mechanics may have an important bearing on the opportunities that will open to the student in this great field of work. Certainly without some knowledge and training in mechanics he would have little or no chance of entering the engineering profession.

1-3 PROCEDURES IN THE SOLUTION OF MECHANICS PROBLEMS

Successful and efficient solution of any engineering problem calls for a well-organized and logical method of attack, involving a number of steps, each of which must first be well understood and then carefully executed. Among these steps, the following five include in a general way the entire process of solving any problem:

1. Analyze carefully the given data and ascertain the known quantities and the unknown quantities to be determined.
2. Recognize all the acting forces, known and unknown.
3. Decide on a suitable type of solution to use to determine the unknown quantities.
4. Formulate the steps to be taken to complete this solution.
5. Execute these steps, using available methods of checking the results.

The necessity for checking intermediate as well as final results as the solution progresses cannot be overemphasized, and yet it is most difficult to impress this fact on students, especially during the early part of their training; too many insist on dashing on to some answer, often finding it to be wrong and then, on a recheck, discovering some foolish or careless mistake which a second glance at the proper time would have quickly revealed.

1-4 STANDARDS OF WORKMANSHIP IN PROBLEM SOLUTION

Because of the great responsibility that attaches to the practice of engineering, high standards of workmanship are demanded by the profession. These standards call for clear and neat figures and letters, and for uncrowded and logical arrangement of all computations and diagrams. Squared paper, and a straightedge for drawing diagrams are recommended. All diagrams must be complete; that is, they must show all forces, dimensions, and other items that are parts of the problem.

In order that computations may readily be checked, as they must be, all work except the simplest additions, subtractions, multiplications, and divisions must be shown. Of course, if the slide rule or a calculator is used, no multiplications or divisions need be shown, but the processes must be indicated. One of the best ways of checking data and computations is to glance over them *as soon as they are completed*, to see that no mistake has been made and that the result obtained so far is *reasonable*. Often an absurd answer or a misplaced decimal point is thus quickly detected. The use of scratch paper encourages sloppy work and should, therefore, not be allowed.

In most engineering computations, a *degree of accuracy* to three significant figures is considered satisfactory. (The numbers 64 800 and 0.0648 both contain three significant figures, 6, 4, and 8.) The process of learning the subject matter and of attaining the required standards of workmanship is progressive. Students are encouraged, therefore, to file completed problems in a loose-leaf notebook which should always be available for ready reference.