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工程力学（静力学）

第10版　影印版

ENGINEERING MECHANICS
STATICS
TENTH EDITION

R.C.HIBBELER

高等教育出版社

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Fundamental Equations of Statics

Cartesian Vector

$$\mathbf{A} = A_x\mathbf{i} + A_y\mathbf{j} + A_z\mathbf{k}$$

Magnitude

$$A = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

Directions

$$\mathbf{u}_A = \frac{\mathbf{A}}{A} = \frac{A_x}{A}\mathbf{i} + \frac{A_y}{A}\mathbf{j} + \frac{A_z}{A}\mathbf{k}$$
$$= \cos\alpha\mathbf{i} + \cos\beta\mathbf{j} + \cos\gamma\mathbf{k}$$
$$\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$$

Dot Product

$$\mathbf{A}\cdot\mathbf{B} = AB\cos\theta$$
$$= A_xB_x + A_yB_y + A_zB_z$$

Cross Product

$$\mathbf{C} = \mathbf{A}\times\mathbf{B} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

Cartesian Position Vector

$$\mathbf{r} = (x_2 - x_1)\mathbf{i} + (y_2 - y_1)\mathbf{j} + (z_2 - z_1)\mathbf{k}$$

Cartesian Force Vector

$$\mathbf{F} = F\mathbf{u} = F\left(\frac{\mathbf{r}}{r}\right)$$

Moment of a Force

$$M_O = Fd$$
$$\mathbf{M}_O = \mathbf{r}\times\mathbf{F} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$$

Moment of a Force About a Specified Axis

$$M_a = \mathbf{u}\cdot\mathbf{r}\times\mathbf{F} = \begin{vmatrix} u_x & u_y & u_z \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$$

Simplification of a Force and Couple System

$$\mathbf{F}_R = \Sigma\mathbf{F}$$
$$(\mathbf{M}_R)_O = \Sigma\mathbf{M} + \Sigma\mathbf{M}_O$$

Equilibrium

Particle

$$\Sigma F_x = 0, \Sigma F_y = 0, \Sigma F_z = 0$$

Rigid Body-Two Dimensions

$$\Sigma F_x = 0, \Sigma F_y = 0, \Sigma M_O = 0$$

Rigid Body-Three Dimensions

$$\Sigma F_x = 0, \Sigma F_y = 0, \Sigma F_z = 0$$
$$\Sigma M_{x'} = 0, \Sigma M_{y'} = 0, \Sigma M_{z'} = 0$$

Friction

Static (maximum) $F_s = \mu_s N$

Kinetic $F_k = \mu_k N$

$$r = \frac{}{\Sigma W}$$

Body

$$\bar{r} = \frac{\int \tilde{r}\, dW}{\int dW}$$

Area and Mass Moments of Inertia

$$I = \int r^2\, dA \qquad I = \int r^2\, dm$$

Parallel-Axis Theorem

$$I = \bar{I} + Ad^2 \qquad I = \bar{I} + md^2$$

Radius of Gyration

$$k = \sqrt{\frac{I}{A}} \qquad k = \sqrt{\frac{I}{m}}$$

Virtual Work

$$\delta U = 0$$

SI Prefixes

Multiple	*Exponential Form*	*Prefix*	*SI Symbol*
1 000 000 000	10^9	giga	G
1 000 000	10^6	mega	M
1 000	10^3	kilo	k
Submultiple			
0.001	10^{-3}	milli	m
0.000 001	10^{-6}	micro	μ
0.000 000 001	10^{-9}	nano	n

Conversion Factors (FPS) to (SI)

Quantity	*Unit of Measurement (FPS)*	*Equals*	*Unit of Measurement (SI)*
Force	lb		4.4482 N
Mass	slug		14.5938 kg
Length	ft		0.3048 m

Conversion Factors (FPS)

1 ft = 12 in. (inches)
1 mi. (mile) = 5280 ft
1 kip (kilopound) = 1000 lb
1 ton = 2000 lb

序　言

美国 R. C. Hibbeler 编著的 Engineering Mechanics——Statics 与 Dynamics 是美国工科大学广泛选用的工程力学课程教材之一。自 20 世纪 70 年代至今近 30 年，该教材修订出版了 10 次，足见其受到美国工科大学师生欢迎的程度。我国于 1983 年 4 月由人民教育出版社出版了该教材第 2 版的中文译本。对比该教材的基本体系结构和内容并没有太大的改变，但在例题、习题和指导学生学习方面作了补充调整，可以看出这套教材是比较稳定的。

该套教材的《静力学》分册共 11 章，内容包括：基本原理、力矢量、原点的平衡、力系的简化、刚体的平衡、结构分析、内力、摩擦、重心和形心、转动惯量、虚功；《动力学》分册共 11 章，内容包括：质点运动学、质点动力学——力和加速度、质点动力学——功和能、质点动力学——冲量和动量、刚体的平面运动学、刚体的平面动力学——力和加速度、刚体的平面动力学——冲量和动量、刚体空间运动学、刚体空间动力学、振动。教材中带*的内容，用于满足较高要求的课程。

这套教材是典型的美式教材，它具有以下一些特点：

1. 基本概念、基本原理的叙述简明、准确、便于掌握，在理论体系上不过分追求完整。

2. 强调理论的应用，每个内容都配有大量的例题和习题，而且很多来

自实际问题，有利于学生应用理论解决实际问题能力的培养。

3. 关注学生学习的指导，对各类问题的解决，详尽的介绍思路、方法、技巧，因此教材便于学生自学。这也充分体现了作者有着丰富的教学经验。

这套教材所对应的我国高等工科院校的课程是理论力学。我国的理论力学课程教材与这本教材在内容和体系上都有差别。阅读这本教材对于我国学习或讲授理论力学课程的学生和教师是很有帮助的。对于从事理论力学课程双语教学的师生，这也是以本很好的可供选择的教材。因此，出版这本教材的影印版，是一件很有价值的工作。

谢传锋

北京航空航天大学

2003 年 12 月

TO THE STUDENT

With the hope that this work will stimulate an interest in Engineering Mechanics and provide an acceptable guide to its understanding.

PREFACE

The main purpose of this book is to provide the student with a clear and thorough presentation of the theory and applications of engineering mechanics. To achieve this objective, the author has by no means worked alone; to a large extent, this book, through its 10 editions, has been shaped by the comments and suggestions of hundreds of reviewers in the teaching profession as well as many of the author's students.

New Features

Some unique features used throughout this tenth edition include the following:

- **Illustrations.** Throughout the book, new photorealistic illustrations have been added that provide a strong connection to the 3-D nature of engineering. In addition, particular attention has been placed on providing a view of any physical object, its dimensions, and the vectors applied to it in a manner that can be easily understood.
- **Problems.** The problems sets have been revised so that instructors can select both design and analysis problems having a wide range of difficulty. Apart from the author, two other professionals have checked all the problems for clarity and accuracy of the solutions. At the end of some chapters, design projects are included.
- **Review Material.** New end-of-chapter review sections have been added to help students recall and study key chapter points.

Of course, the hallmarks of the book remain the same: Where necessary, a strong emphasis is placed on drawing a free-body diagram, and the importance of selecting an appropriate coordinate system, and associated sign convention for vector components is stressed when the equations of mechanics are applied.

Contents

The book is divided into 11 chapters, in which the principles are applied first to simple, then to more complicated situations. Most often, each principle is applied first to a particle, then to a rigid body subjected to a coplanar system of forces, and finally to a general case of three-dimensional force systems acting on a rigid body.

Chapter 1 begins with an introduction to mechanics and a discussion of units. The notation of a vector and the properties of a concurrent force system are introduced in Chapter 2. This theory is then applied to the equilibrium of a particle in Chapter 3. Chapter 4 contains a general discussion of both concentrated and distributed force systems and the methods used to simplify them. The principles of rigid-body equilibrium are developed in Chapter 5 and then applied to specific problems involving the equilibrium of trusses, frames, and machines in Chapter 6, and to the analysis of internal forces in beams and cables in Chapter 7. Applications to problems involving frictional forces are discussed in Chapter 8, and topics related to the center of gravity and centroid are treated in Chapter 9. If time permits, sections concerning more advanced topics, indicated by stars (★) may be covered. Most of these topics are included in Chapter 10 (area and mass moments of inertia) and Chapter 11 (virtual work and potential energy). Note that this material also provides a suitable reference for basic principles when it is discussed in more advanced courses.

Alternative Coverage. At the discretion of the instructor, some of the material may be presented in a different sequence with no loss of continuity. For example, it is possible to introduce the concept of a force and all the necessary methods of vector analysis by first covering Chapter 2 and Section 4.2. Then after covering the rest of Chapter 4 (force and moment systems), the equilibrium methods of Chapters 3 and 5 can be discussed.

Special Features

Organization and Approach. The contents of each chapter are organized into well-defined sections that contain an explanation of specific topics, illustrative example problems, and a set of homework problems. The topics within each section are placed into subgroups defined by boldface titles. The purpose of this is to present a structured method for introducing each new definition or concept and to make the book convenient for later reference and review.

Chapter Contents. Each chapter begins with an illustration demonstrating a broad-range application of the material within the chapter. A bulleted list of the chapter contents is provided to give a general overview of the material that will be covered.

Free-Body Diagrams. The first step to solving most mechanics problems requires drawing a diagram. By doing so, the student forms the habit of tabulating the necessary data while focusing on the physical aspects of the problem and its associated geometry. If this step is performed correctly, applying the relevant equations of mechanics becomes somewhat methodical since the data can be taken directly from the diagram. This step is particularly important when solving equilibrium problems, and for this reason drawing free-body diagrams is strongly emphasized throughout the book. In particular, special sections and examples are devoted to show

how to draw free-body diagrams, and specific homework problems in many sections of the book have been added to develop this practice.

Procedures for Analysis. Found after many of the sections of the book, this unique feature provides the student with a logical and orderly method to follow when applying the theory. The example problems are solved using this outlined method in order to clarify its numerical application. It is to be understood, however, that once the relevant principles have been mastered and enough confidence and judgment have been obtained, the student can then develop his or her own procedures for solving problems.

Photographs. Many photographs are used throughout the book to explain how the principles of mechanics apply to real-world situations. In some sections, photographs have been used to show how engineers must first make an idealized model for analysis and then proceed to draw a free-body diagram of this model in order to apply the theory.

Important Points. This feature provides a review or summary of the most important concepts in a section and highlights the most significant points that should be realized when applying the theory to solve problems.

Conceptual Understanding. Through the use of photographs placed throughout the book, theory is applied in a simplified way in order to illustrate some of its more important conceptual features and instill the physical meaning of many of the terms used in the equations. These simplified applications increase interest in the subject matter and better prepare the student to understand the examples and solve problems.

Example Problems. All the example problems are presented in a concise manner and in a style that is easy to understand.

Homework Problems

- **Free-Body Diagram Problems.** Many sections of the book contain introductory problems that only require drawing the free-body diagram for the specific problems within a problem set. These assignments will impress upon the student the importance of mastering this skill as a requirement for a complete solution of any equilibrium problem.
- **General Analysis and Design Problems.** The majority of problems in the book depict realistic situations encountered in engineering practice. Some of these problems come from actual products used in industry and are stated as such. It is hoped that this realism will both stimulate the student's interest in engineering mechanics and provide a means for developing the skill to reduce any such problem from its physical description to a model or symbolic representation to which the principles of mechanics may be applied.

  Throughout the book, there is an approximate balance of problems using either SI or FPS units. Furthermore, in any set, an attempt has been made to arrange the problems in order of increasing difficulty. (Review problems at the end of each chapter are presented in random order.) The answers to all but every fourth problem are listed in the back of the book. To alert the user to a problem without a reported answer, an asterisk (*) is placed before the problem number.

- **Computer Problems.** An effort has been made to include some problems that may be solved using a numerical procedure executed on either a desktop computer or a programmable pocket calculator. Suitable numerical techniques along with associated computer programs are given in Appendix B. The intent here is to broaden the student's capacity for using other forms of mathematical analysis without sacrificing the time needed to focus on the application of the principles of mechanics. Problems of this type, which either can or must be solved using numerical procedures, are identified by a "square" symbol (■) preceding the problem number.
- **Design Projects.** At the end of some of the chapters, design projects have been included. It is felt that this type of assignment should be given only after the student has developed a basic understanding of the subject matter. These projects focus on solving a problem by specifying the geometry of a structure or mechanical object needed for a specific purpose. A force analysis is required and, in many cases, safety and cost issues must be addressed

Chapter Reviews. New chapter review sections summarize key points of the chapter, often in bulleted lists.

Appendices. The appendices provide a source of mathematical formula and numerical analysis needed to solve the problems in the book. Appendix C provides a set of problems typically found on the Fundamentals of Engineering Examination. By providing a partial solution to all the problems, the student is given a chance to further practice his or her skills.

Supplements

Hibbeler's robust supplements package supports students and instructors. The tenth edition features:

Instructor's Resource CD-ROM and Instructor Access Code This supplement includes Microsoft PowerPoint, .pdf, and .jpg files of text figures, PowerPoint slides of examples, as well as special "active learning" PowerPoint slides, student handouts, and teacher handouts created by Sudhir Mehta of North Dakota State University and Scott Danielson of Arizona State University.

The supplement also contains an instructor access code for www.prenhall.com/hibbeler. This codes lets professors download animations and pdf files of solutions, and provides instructor access to PH Grade Assist—Prentice Hall's on-line algorithmic homework and testing system.

Instructor's Solutions Manual *Statics* (0-13-141212-4); *Dynamics* (0-13-141682-0) Provides complete solutions supported by problem statements and problem figures. All solutions appear on either one or two pages.

***Statics* Study Pack** (0-13-141209-4) Improved for the tenth edition, this supplement now contains chapter-by-chapter study materials, a Free-Body Diagram Workbook and access to the Problems Website, containing practice problems with full solutions. All materials are organized in a chapter-by-chapter format.

- **Student Study Materials:** New chapter-by-chapter review includes key points, equations, and check up questions.
- **Free-Body Diagram Workbook:** 75-page workbooks that step students through numerous free-body diagram problems. Full explanations and solutions are provided.
- **www.prenhall.com/hibbeler:** This password-protected website provides 1000 statics/dynamics problems with solutions. Problems and solutions are supplemented and do not appear in the tenth edition. Solutions contain both math and associated free-body diagrams. Students can use these for practice before quizzes and tests, as well as self-drill. The site also contains MATLAB and Mathcad mechanics tutorials keyed to the text, and mechanics AVIs and simulations. An access code for the site is printed on a card bound into the *Statics* Study pack. This same code provides student access to PH Grade Assist.

PH Grade Assist Available for both *Statics* and *Dynamics*, Prentice Hall's on-line algorithmic homework system is available at www.prenhall.com/hibbeler. Professors use this system to assign on-line homework keyed to the text. Students receive algorithmically generated versions of each problem that they work, answer, and are graded by PHGA. Sample solutions are provided as feedback. Results are recorded in the Professors gradebook. PHGA allows students to print their homework assignments for work offline—when students return to PHGA they can retrieve and answer these questions. Access codes are printed in Student Study Packs. Students may also work problems in non-graded practice mode. Instructor's access codes come in the Instructor's Resource CD/Access Code Package.

Student Study Guide *Statics* (0-13-141211-6); *Dynamics* (0-13-141679-0) Students may purchase a further Study Guide containing more worked problems. Problems are partially solved and designed to help guide students through difficult topics.

Companion Website www.prenhall.com/hibbeler. This password-protected website provides 1000 statics/dynamics problems with solutions. Problems and solutions are supplemented and do not appear in the tenth edition. Solutions contain both math and associated free-body diagrams. Students can use these for practice before quizzes and tests, as well as self-drill. The site also contains MATLAB and Mathcad mechanics tutorials keyed to the text, and mechanics AVIs and simulations. An access code for the site is printed on a card bound into the *Statics* Study pack. This same code provides student access to PH Grade Assist.

Course Management Options Available for both *Statics* and *Dynamics*, WebCT, Blackboard, and CourseCompass classes are available, with extensive Statics and Dynamics Next Generation resources that help encourage "active learning" in the class. For more information, please visit cms.prenhall.com.

Acknowledgments

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I would greatly appreciate hearing from you if at any time you have any comments, suggestions, or problems related to any matters regarding this edition.

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