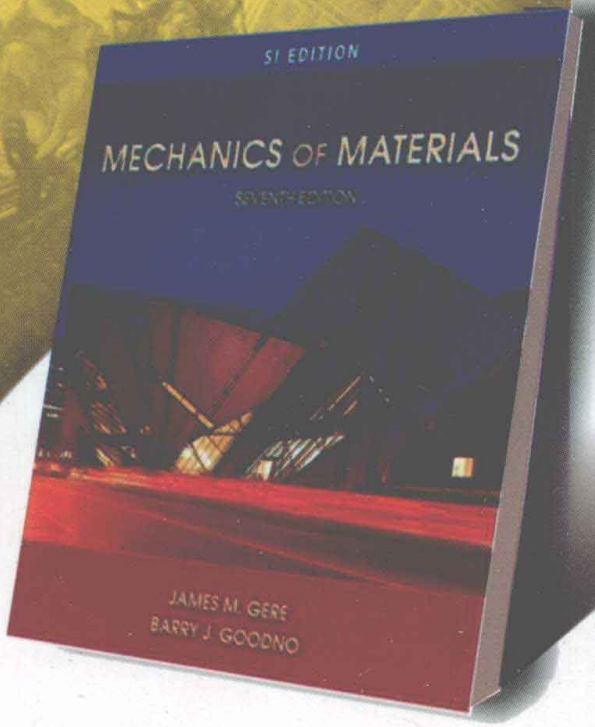
时代教育·国外高校优秀教材精选

材料力学

（英文版·原书第7版）

Strength of Materials

(美) 盖 尔 (James M. Gere)
古德诺 (Barry J. Goodno) 著



机械工业出版社
CHINA MACHINE PRESS

时代教育·国外高校优秀教材精选

材料力学

（英文版·原书第7版）

Strength of Materials

（美） 盖尔（James M. Gere）
古德诺（Barry J. Goodno） 著

机械工业出版社

Strength of Materials
James M. Gere, Barry J. Goodno

First published by CL - Engineering, a part of Cengage Learning.

图书在版编目（CIP）数据

材料力学：第7版：英文/（美）盖尔（Gere, J. M.）著；（美）古德诺（Goodno, B. J.）著.
—北京：机械工业出版社，2011.7
（时代教育：国外高校优秀教材精选）
书名原文：Strength of Materials
ISBN 978-7-111-35011-8

Ⅰ.①材… Ⅱ.①盖…②古… Ⅲ.①材料力学—高等学校—教材—英文 Ⅳ.①TB301

中国版本图书馆 CIP 数据核字（2011）第 109940 号

机械工业出版社（北京市百万庄大街 22 号 邮政编码 100037）
策划编辑：姜 凤 责任编辑：姜 凤
版式设计：霍永明 责任印制：乔 宇
封面设计：鞠 杨
三河市宏达印刷有限公司印刷
2011 年 7 月第 1 版第 1 次印刷
185mm × 240mm · 50 印张 · 950 千字
标准书号：ISBN 978-7-111-35011-8
定价：89.00 元

凡购本书，如有缺页、倒页、脱页，由本社发行部调换
电话服务 策划编辑：（010）88379778
社服务中心：（010）88361066 网络服务
销 售 一 部：（010）68326294 门户网：http://www.cmpbook.com
销 售 二 部：（010）88379649 教材网：http://www.cmpedu.com
读者服务部：（010）88379203 **封面无防伪标均为盗版**

国外高校优秀教材审定委员会

主任委员：

杨叔子

委员（按姓氏笔画为序）：

王先逵	王大康	白峰杉	史荣昌	朱孝禄
陆启韶	张润琦	张　策	张三慧	张福润
张延华	吴宗泽	吴　麒	宋心琦	李俊峰
佘远斌	陈文楷	陈立周	单辉祖	俞正光
赵汝嘉	郭可谦	翁海珊	龚光鲁	章栋恩
黄永畅	谭泽光			

出 版 说 明

随着我国加入WTO，国际间的竞争越来越激烈，而国际间的竞争实际上也就是人才的竞争、教育的竞争。为了加快培养具有国际竞争力的高水平技术人才，加快我国教育改革的步伐，国家教育部出台了一系列倡导高校开展双语教学、引进原版教材的政策。以此为契机，机械工业出版社推出了一系列国外影印版教材，其内容涉及高等学校公共基础课，以及机、电、信息领域的专业基础课和专业课。

引进国外优秀原版教材，在有条件的学校推动开展英语授课或双语教学，自然也引进了先进的教学思想和教学方法，这对提高我国自编教材的水平，加强学生的英语实际应用能力，使我国的高等教育尽快与国际接轨，必将起到积极的推动作用。

为了做好教材的引进工作，机械工业出版社特别成立了由著名专家组成的国外高校优秀教材审定委员会。这些专家对实施双语教学做了深入细致的调查研究，对引进原版教材提出许多建设性意见，并慎重地对每一本将要引进的原版教材一审再审，精选再精选，确认教材本身的质量水平，以及权威性和先进性，以期所引进的原版教材能适应我国学生的外语水平和学习特点。在引进工作中，审定委员会还结合我国高校教学课程体系的设置和要求，对原版教材的教学思想和方法的先进性、科学性严格把关，同时尽量考虑原版教材的系统性和经济性。

这套教材出版后，我们将根据各高校的双语教学计划，及时地将其推荐给各高校选用。希望高校师生在使用教材后及时反馈意见和建议，使我们更好地为教学改革服务。

机械工业出版社

高等教育分社

序

铁摩辛柯嫡传的《材料力学》体系迄今为止已经历了4个阶段：

1. 铁摩辛柯的俄文版阶段（Прочность материалов）；
2. 署名盖尔与铁摩辛柯的第1～4版（1972年、1984年、1990年、1998年）阶段；
3. 署名盖尔的第5～6版（2001年、2004年）阶段；
4. 署名盖尔与古德诺的第7版（2009年）阶段。

注意，这里所说的版本序号是从美国出版的Mechanics of Material算起的。这当中有一个令人遗憾的巧合：第1版刚刚出版后不久，盖尔的导师铁摩辛柯1972年就去世了，而盖尔作为古德诺的导师，在同自己学生合作的书出版前后的时间段，于2008年去世。

读者会注意到，机械工业出版社现在出版的是第7版原版，英文名采用了铁摩辛柯最早的书名“Strength of Mechanics”。关于这门课程究竟叫什么更为确切？也是笔者一直反复推敲的问题。

如果从现代材料科学的角度来看，其实这门课程称为材料力学或材料强度都不妥：材料的力学性质只在第1章中有详细论述，而其余11章都是关于杆系（bar, beam, column）的力学性能的内容。在材料—构件—结构的链条或层次上，“材料力学”课程实际集中在“构件”的层面上。

从力学研究对象由质点、刚体到变形体的发展历程，审视材料力学由无到有的发展过程，笔者越来越体会到：这是变形固体最初发展成形的学科，对象是一维构件（one dimensional component）或一维单元（one dimensional element），实际应当称之为“变形杆系力学”（Mechanics of Deformation Bars）或者从工程角度上称之为“构件力学”（Mechanics of Components）。注意，其中的bars包括了bar, beam, column三个类型的一维构件或一维单元。

为此，笔者再一次查阅了英汉词典，发现英文Material其实也含有“部件”的意思；为此，也许我们说英文的Mechanics of Material恰好有笔者理解的“部件”含义，但是，“材料”却是Material的英文主含义；尤其，译成汉语，已经切切实实地是指“材料力学”了。

当然，对于一个长期既定、约定俗成的命名，很少人会考虑进行更合理的称谓，或考虑予以更正，但是笔者相信，我们尽管可以不改变名称，但是关于它的反思，有助于我们加深对这门学科的本质进行认识。

至于用Strength代替Mechanics，实际研究的范围狭窄了，然而，我们姑且可以从Strengthen去理解：从工程角度看，不管对应力、变形、稳定还是对疲劳等的考虑，都皆在“强化”构件的力学性能，从而达到构件乃至结构安全的目标。因此，我们完全可以把它理解为广义的强度。

从变形杆系去理解材料力学研究对象的内涵加深与外延拓广，都是极为有意义的事情。我在为机械工业出版社出版的第5版原版书写中文序时是2002年，那时盖尔教授还健在，本应同大师的传人进行面对面的交流，可惜我未抓住机遇，实属今生之遗憾！

这本书较之以往的版本又集中了更多人的智慧，古德诺教授在他的前言中均有详细的感谢。这本书在中国的出版，对于参与材料力学课程双语教学的师生都有益处，同时对于广大力学教师也极有裨益，因为这是大师传承下来的一本不断完善着的经典著作。

我们在教学过程中如果能够细细研读，定会在教、研相长中获益。笔者作为站在材料力学本科讲堂上的教师，确有“磨刀不误砍柴工”的体会。

例如，笔者曾经由超静定桁架装配误差中获得灵感，形成智能桁架结构最优控制的原创思想，积极运用装配误差的概念，变害为利，通过控制作动器调整单元变形模拟，改变受力状态，用数学规划算法求解最优控制模型，其中关键技术是实现强度或刚度极大化，指导两位博士生和一位硕士生在这方面完成各自的学位论文。

又如，笔者还从第四强度理论即 von Mises 准则的畸变比能的本质出发，通过将应力约束转换成畸变能约束的途径，提出了连续体结构拓扑优化应力约束凝聚化的两种方法：应力全局化和应力约束集成化，建立了多工况下以重量为目标、以凝聚化应变能为约束的连续体结构拓扑优化模型，这些成了四位博士生的学位论文和一位博士后研究报告中的重要内容，极大地节省了应力敏度的计算量。

笔者深信，只要对材料力学有浓厚的兴趣，就会像铁摩辛柯与盖尔那样，把教学与科研都能够搞得好上加好。正如书中第 12 章之后参考文献和历史注记指出的：“铁摩辛柯是著名的科学家、工程师和教师。”这太难得了！盖尔在第二次世界大战期间有参军的经历，后来除了教学，还有进行机械、结构、抗震工程等研究的经历，对于材料力学的教学肯定都是有帮助的。这些，都值得我们的年轻教师认真借鉴。

1922 年，铁摩辛柯教授在自己 44 岁时，来到了美国，其实他在这以前就已经著述了俄文版的《材料强度》，如果从 1907—1921 年铁摩辛柯先后在基辅、圣彼得堡与南斯拉夫任教算起，铁摩辛柯嫡传的《材料力学》体系，经过三代人的传承，至今已经有 100 多年的历史了。中国有句老话：“十年磨一剑”，而他们的书已经切磋、琢磨了一百年！回头看看我们的某些“精品教材”，很短时间就能够完成，是不是有一点太快速、太稚嫩、太容易了呢？

其实，任何一门课程的教材都经历了如下 3 个阶段，材料力学课程也不例外：

1. 研究成果的原始积累阶段。发表的大量论文表达了成果由无到有发生的过程，为了简明扼要，不少归纳性的思考被演绎过程取代，不少生动活泼的思想看不见了。

2. 相关成果的初步总结阶段。等到该学科相关的论文发表到一定数量，就开始出现了学术专著，或出现了在学校课堂教学用的讲义，或者相关专著与讲义同时出现。

3. 反映成果的教材出版阶段。该课程的讲课教师根据论文、专著与讲义进行系统整合，撰写该课程的教材，并且正式出版，在使用的过程中不断的增补、删改和完善。

铁摩辛柯的《材料强度》或《材料力学》属于该课程中的早期教材，没有可以借鉴的蓝图，更没有可以参照的范本，因此要面对非常多的处理：基本概念是如何提出来的，具体问题是如何形成的，怎样解决了问题，如何克服了错误概念和错误方法，如何累积了实用的或具有启发性的习题……

在成果的发生阶段，必定涌现出探索者们富于启发性的原创思想，任何一本好的教材一定要在某种程度上体现出它们，如果不是因铁摩辛柯这样的“科学家、工程师和教师”三位

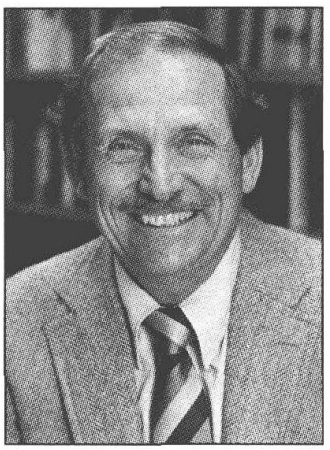
一体的大师的专心投入，那是难以完成上述目标的。后来又有了他的嫡传弟子和弟子的弟子予以精心的打造，才真正成了课程的精品。

我们可以说：铁摩辛柯嫡传的《材料力学》体系是有待我们悉心探索并且致力开采其瑰宝的经典宝藏，中国读者的收益绝不会仅仅是有一本基础力学双语教学的好教材。同时，笔者也衷心祝愿大师嫡传有人，该系列的教材能够代代相传，永葆精品！

隋允康

2011 年 6 月写于北京工业大学工程力学部

James Monroe Gere
1925–2008



James Monroe Gere, Professor Emeritus of Civil Engineering at Stanford University, died in Portola Valley, CA, on January 30, 2008. Jim Gere was born on June 14, 1925, in Syracuse, NY. He joined the U.S. Army Air Corps at age 17 in 1942, serving in England, France and Germany. After the war, he earned undergraduate and master's degrees in Civil Engineering from the Rensselaer Polytechnic Institute in 1949 and 1951, respectively. He worked as an instructor and later as a Research Associate for Rensselaer between 1949 and 1952. He was awarded one of the first NSF Fellowships, and chose to study at Stanford. He received his Ph.D. in 1954 and was offered a faculty position in Civil Engineering, beginning a 34-year career of engaging his students in challenging topics in mechanics, and structural and earthquake engineering. He served as Department Chair and Associate Dean of Engineering and in 1974 co-founded the John A. Blume Earthquake Engineering Center at Stanford. In 1980, Jim Gere also became the founding head of the Stanford Committee on Earthquake Preparedness, which urged campus members to brace and strengthen office equipment, furniture, and other contents items that could pose a life safety hazard in the event of an earthquake. That same year, he was invited as one of the first foreigners to study the earthquake-devastated city of Tangshan, China. Jim retired from Stanford in 1988 but continued to be a most valuable member of the Stanford community as he gave freely of his time to advise students and to guide them on various field trips to the California earthquake country.

Jim Gere was known for his outgoing manner, his cheerful personality and wonderful smile, his athleticism, and his skill as an educator in Civil Engineering. He authored nine textbooks on various engineering subjects starting in 1972 with *Mechanics of Materials*, a text that was inspired by his teacher and mentor Stephan P. Timoshenko. His other well-known text-books, used in engineering courses around the world, include: *Theory of Elastic Stability*, co-authored with S. Timoshenko; *Matrix Analysis of Framed Structures* and *Matrix Algebra for Engineers*, both co-authored with W. Weaver; *Moment Distribution*; *Earthquake Tables: Structural and Construction Design Manual*, co-authored with H. Krawinkler; and *Terra Non Firma: Understanding and Preparing for Earthquakes*, co-authored with H. Shah.

James Gere will be long remembered by all who knew him as a considerate and loving man whose upbeat good humor made aspects of daily life or work easier to bear. His last project (in progress and now being continued by his daughter Susan of Palo Alto) was a book based on the written memoirs of his great-grandfather, a Colonel (122d NY) in the Civil War.

Preface

Mechanics of Materials is a basic engineering subject that must be understood by anyone concerned with the strength and physical performance of structures, whether those structures are man-made or natural. The subject matter includes such fundamental concepts as stresses and strains, deformations and displacements, elasticity and inelasticity, strain energy, and load-carrying capacity. These concepts underlie the design and analysis of a huge variety of mechanical and structural systems.

At the college level, mechanics of materials is usually taught during the sophomore and junior years. The subject is required for most students majoring in mechanical, structural, civil, biomedical, aeronautical, and aerospace engineering. Furthermore, many students from such diverse fields as materials science, industrial engineering, architecture, and agricultural engineering also find it useful to study this subject.

About this Book

The main topics covered in this book are the analysis and design of structural members subjected to tension, compression, torsion, and bending, including the fundamental concepts mentioned in the first paragraph. Other topics of general interest are the transformations of stress and strain, combined loadings, stress concentrations, deflections of beams, and stability of columns.

Specialized topics include the following: Thermal effects, dynamic loading, nonprismatic members, beams of two materials, shear centers, pressure vessels, and statically indeterminate beams. For completeness and occasional reference, elementary topics such as shear forces, bending moments, centroids, and moments of inertia also are presented.

Much more material than can be taught in a single course is included in this book, and therefore instructors have the opportunity to select the topics they wish to cover. As a guide, some of the more specialized topics are identified in the table of contents by stars.

Considerable effort has been spent in checking and proofreading the text so as to eliminate errors, but if you happen to find one, no matter how trivial, please notify me by e-mail (bgoodno@ce.gatech.edu). Then we can correct any errors in the next printing of the book.

Examples

Examples are presented throughout the book to illustrate the theoretical concepts and show how those concepts may be used in practical situations. In some cases, photographs have been added showing actual engineering structures or components to reinforce the tie between theory and application. The examples vary in length from one to four pages, depending upon the complexity of the material to be illustrated.

When the emphasis is on concepts, the examples are worked out in symbolic terms so as to better illustrate the ideas, and when the emphasis is on problem-solving, the examples are numerical in character. In selected examples throughout the text, graphical display of results (e.g., stresses in beams) has been added to enhance the student's understanding of the problem results.

Problems

In all mechanics courses, solving problems is an important part of the learning process. This textbook offers more than 500 problems for homework assignments and classroom discussions. The problems are placed at the end of each chapter so that they are easy to find and don't break up the presentation of the main subject matter. Also, an unusually difficult or lengthy problem is indicated by attaching one or more stars (depending upon the degree of difficulty) to the problem number, thus alerting students to the time necessary for solution. In general, problems are arranged in order of increasing difficulty. Answers to all problems are listed near the back of the book.

References and Historical Notes

References and historical notes appear immediately after the last chapter in the book. They consist of original sources for the subject matter plus brief biographical information about the pioneering scientists, engineers, and mathematicians who created the subject of mechanics of materials.

Appendixes

Reference material appears in the appendixes at the back of the book. Much of the material is in the form of tables—properties of plane areas, properties of structural-steel shapes, properties of structural lumber, deflections and slopes of beams, and properties of materials (Appendixes D through H, respectively).

In contrast, Appendixes A and B are descriptive—the former gives a detailed description of the SI and USCS systems of units, and the latter presents the methodology for solving problems in mechanics. Included in the latter are topics such as dimensional consistency and significant digits. Lastly, as a handy time–saver, Appendix C provides a listing of commonly used mathematical formulas.

S.P. Timoshenko (1878–1972) and J.M. Gere (1925–2008)

Many readers of this book will recognize the name of Stephen P. Timoshenko—probably the most famous name in the field of applied mechanics. Timoshenko is generally recognized as the world's most outstanding pioneer in applied mechanics. He contributed many new ideas and concepts and became famous for both his scholarship and his teaching. Through his numerous textbooks he made a profound change in the teaching of mechanics not only in this country but wherever mechanics is taught. Timoshenko was both teacher and mentor to James Gere.

James Gere started as a doctoral student at Stanford in 1952 and retired from Stanford as a professor in 1988 having authored this and eight other well known and respected text books on mechanics, and structural and earthquake engineering. He remained active at Stanford as Professor Emeritus until his death in January of 2008.

A brief biography of Timoshenko appears in the first reference at the back of the book, and also in an August 2007 *STRUCTURE magazine* article entitled "*Stephen P. Timoshenko: Father of Engineering Mechanics in the U.S.*" by Richard G. Weingardt, P.E. This article provides an excellent historical perspective on this and the many other engineering mechanics textbooks written by each of these authors.

Acknowledgments

To acknowledge everyone who contributed to this book in some manner is clearly impossible, but I owe a major debt to my former Stanford teachers, especially my mentor and friend, and lead author, James M. Gere. I am also indebted to the many teachers of mechanics and reviewers of the book who have helped to shape this textbook.

I wish to also acknowledge my Structural Engineering and Mechanics colleagues at Georgia Institute of Technology: James Craig, Reggie DesRoches, Mulalo Doyoyo, Bruce Ellingwood, Leroy Emkin, Rami Haj-Ali, Larry Jacobs, Larry Kahn, Kim Kurtis, Roberto Leon, Yang Wang, Don White, Kenneth (Mac) Will, Arash Yavari, and Abdul-Hamid Zureick. I am especially grateful to Jim Craig, Rami Haj-Ali, Larry Jacobs, Larry Kahn, Roberto Leon, Don White, Mac Will and Abdul-Hamid Zureick, all of whom provided valuable advice on various aspects of the revisions and additions leading to this edition. It is a privilege to work with all of these educators and to learn from them in almost daily interactions and discussions about structural engineering and mechanics in the context of research and higher education.

Two of my graduate research assistants, Mr. Kanoknart Leelardcharoen and Ms. Jee-Eun Hur, provided invaluable assistance in evaluating and solving many of the new problems. Their careful attention to detail was an important contribution to the current edition.

The editing and production aspects of the book were always in skillful and experienced hands, thanks to the talented and knowledgeable personnel of Cengage Learning (formerly Thomson Learning). Their goal was the same as mine—to produce the best possible edition of this text, never compromising on any aspect of the book.

The people with whom I have had personal contact at Cengage Learning are Christopher Carson, Director, Global Engineering Program, Cengage Learning, who, along with Jim Gere, helped to involve me and then guide me through the project; Hilda Gowans, Senior Developmental Editor, Cengage Learning, Engineering, who was always available to provide information and encouragement; Nicola Winstanley who managed all aspects of new photo selection; Andrew Adams, who created the covers; Peter Papayanakis, who created the interior book design; and Lauren Betsos, Global Marketing Services Coordinator, who developed promotional material in support of the text. I would like to especially acknowledge the work of Rose Kernan of RPK Editorial Services, who edited the manuscript and laid out the pages. To each of these individuals I express my heartfelt thanks not only for a job well done but also for the friendly and considerate way in which it was handled.

I am deeply appreciative of the patience and encouragement provided by my family, especially my wife, Lana, throughout this project.

Finally, I am honored and extremely pleased to be involved in this endeavor, at the invitation of my mentor and friend of thirty eight years, Jim Gere, which extends this textbook toward the forty

year mark. I too am committed to the continued excellence of this text and welcome all comments and suggestions. Please feel free to provide me with your critical input at *bgoodno@ce.gatech.edu.*

BARRY J. GOODNO
Atlanta, Georgia

Contents

*Specialized and/or advanced topics

*Specialized and/or advanced topics

*Specialized and/or advanced topics