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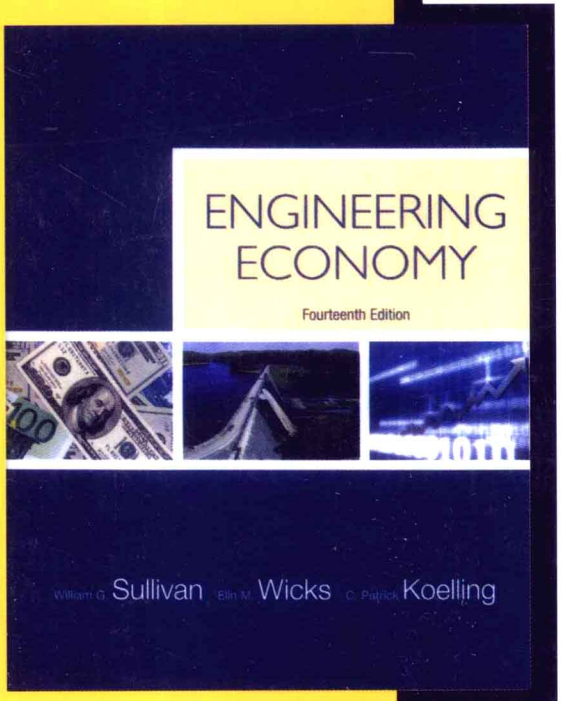
国外大学优秀教材——工业工程系列（影印版）

William G. Sullivan, Elin M. Wicks, C. Patrick Koelling

工程经济学

（第14版）



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工程经济学

（第4版）

Engineering Economy

Fourteenth Edition

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（第14版）

William G. Sullivan
Elin M. Wicks
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Abbreviations and Notation Summary

CHAPTER 4

APR	annual percentage rate (nominal interest)
EOY	end of year
$\bar{f}$	a geometric change from one time period to the next in cash flows or equivalent values
i	effective interest rate per interest period
r	nominal interest rate per period (usually a year)

CHAPTER 5

AW(i%)	equivalent uniform annual worth, computed at i% interest, of one or more cash flows
CR(i%)	equivalent annual cost of capital recovery, computed at i% interest
CW(i%)	Capitalized Worth (a present equivalent), computed at i% interest
FW(i%)	future equivalent worth, calculated at i% interest, of one or more cash flows
EUAC(i%)	Equivalent Uniform Annual Cost, calculated at i% interest
IRR	internal rate of return, also designated i%
MARR	minimum attractive rate of return
N	length of the study period (usually years)
O&M	equivalent annual operating and maintenance expenses
PW(i%)	present equivalent worth, computed at i% interest, of one or more cash flows

CHAPTER 6

$\Delta(B-A)$	incremental net cash flow (difference) calculated from the cash flow of Alternative B minus the cash flow of Alternative A (read: delta B minus A)

CHAPTER 7

ATCF	after-tax cash flow
BTCF	before-tax cash flow
EVA	Economic Value Added
MACRS	Modified Accelerated Cost Recovery System
NOPAT	Net Operating Profit After Taxes
WACC	Tax adjusted Weighted Average Cost of Capital

CHAPTER 8

A$	actual (current) dollars
f	general inflation rate
R$	real (constant) dollars

CHAPTER 9

EUAC	equivalent uniform annual cost
TC_k	total (marginal) cost for year k

CHAPTER 12

$E(X)$	mean of a random variable
$f(x)$	probability density function of a continuous random variable
$p(x)$	probability mass function of a discrete random variable
$SD(X)$	standard deviation of a random variable
$V(X)$	variance of a random variable

CHAPTER 13

CAPM	Capital Asset Pricing Model
R_F	Risk-Free rate of return
SML	Security Market Line
X_j	binary decision variable in capital allocation problems

Foreword

This textbook series is published at a very opportunity time when the discipline of industrial engineering is experiencing a phenomenal growth in China academia and with its increased interests in the utilization of the concepts, methods and tools of industrial engineering in the workplace. Effective utilization of these industrial engineering approaches in the workplace should result in increased productivity, quality of work, satisfaction and profitability to the cooperation.

The books in this series should be most suitable to junior and senior undergraduate students and first year graduate students, and to those in industry who need to solve problems on the design, operation and management of industrial systems.

Gavriel Salvendy

Department of Industrial Engineering, Tsinghua University
School of Industrial Engineering, Purdue University
April, 2002

序　言

本教材系列的出版正值中国学术界工业工程学科经历巨大发展，实际工作中对工业工程的概念、方法和工具的使用兴趣日渐浓厚之时。在实际工作中有效地应用工业工程的手段将无疑会提高生产率、工作质量、合作的满意度和效果。

该系列中的书籍对工业工程的本科生、研究生和工业界中需要解决工程系统设计、运作和管理诸方面问题的人士最为适用。

加弗瑞尔·沙尔文迪
清华大学工业工程系
普渡大学工业工程学院（美国）
2002 年 4 月

PREFACE

We live in a sea of economic decisions.

—Anonymous

About Engineering Economy

A succinct job description for an engineer consists of two words: *problem solver*. Broadly speaking, engineers use knowledge to find new ways of doing things economically. Engineering design solutions do not exist in a vacuum but within the context of a business opportunity. But every problem has multiple solutions, so the issue is, How does one rationally select the design with the most favorable economic result? The answer to this question can also be put forth in two words: *engineering economy*. Engineering economy provides a systematic framework for evaluating the economic aspects of competing design solutions. Just as engineers model the stress on a support column, or the thermodynamic response of a steam turbine, they must also model the economic impact of their recommendations.

Engineering economy—what is it, and why is it important? The initial reaction of many engineering students to these questions is, "Money matters will be handled by someone else. They are not something I need to worry about." In reality, any engineering project must be not only physically realizable but also economically affordable.

Understanding and applying economic principles to engineering have never been more important. Engineering is more than a problem-solving activity focusing on the development of products, systems, and processes to satisfy a need or demand. Beyond function and performance, solutions must also be viable economically. Design decisions affect limited resources such as time, material, labor, capital, natural resources, not only initially (during conceptual design) but also through the remaining phases of the life cycle (e.g., detailed design, manufacture and distribution, service, retirement and disposal). A great solution can die a certain death if it is not profitable.

Fourteenth Edition of *Engineering Economy* Highlights

New or enhanced features of this edition include the following:

- Fifty percent of end-of-chapter problems are new or revised.
- A bank of algorithmically generated test questions is available to adopting instructors.

- Fundamentals of Engineering (FE) exam-style questions are included among the end-of-chapter problem sets.
- Spreadsheet models are integrated throughout.
- An appendix on the basics of accounting is included in Chapter 2.
- Chapter 3 on Cost Estimation appears early in the book.
- An appendix for using Excel in engineering economy is available for reference.
- Numerous comprehensive examples and case studies appear throughout the book.
- Extended learning exercises appear in most chapters.
- Personal finance problems are featured in most chapters.
- Many pointers to relevant Web sites are provided.

Pedagogy of This Book

This book has two primary objectives: (1) to provide students with a sound understanding of the principles, basic concepts, and methodology of engineering economy; and (2) to help students develop proficiency with these methods and with the process for facilitating rational decisions they are likely to encounter in professional practice. Interestingly, an engineering economy course may be a student's only college exposure to the systematic evaluation of alternative investment opportunities. In this regard, *Engineering Economy* is intended to serve as a text for classroom instruction *and* as a basic reference for use by practicing engineers in all specialty areas (e.g., chemical, civil, computer, electrical, industrial, and mechanical engineering). The book is also useful to persons engaged in the management of technical activities.

As a textbook, the fourteenth edition is written principally for the first formal course in engineering economy. A three-credit-hour semester course should be able to cover the majority of topics in this edition, and there is sufficient depth and breadth to enable an instructor to arrange course content to suit individual needs. Representative syllabi for a three-credit and a two-credit semester course in engineering economy are provided in Table P-1. Moreover, because several advanced topics are included, this book can also be used for a second course in engineering economy.

All chapters and appendices have been revised and updated to reflect current trends and issues. Also, numerous exercises that involve open-ended problem statements and iterative problem-solving skills are included throughout the book. A large number of the 750-plus end-of-chapter exercises are new, and many solved examples representing realistic problems that arise in various engineering disciplines are presented. FE exam-style questions have been added to help prepare engineering students for this milestone examination, leading to professional registration. Passing the FE exam is a first step in getting licensed as a professional engineer (PE). Engineering students should seriously consider becoming a PE because it opens many employment opportunities and increases lifetime earning potential.

TABLE P-1 Typical Syllabi for Courses in Engineering Economy

Semester Course (Three Credit Hours)			Semester Course (Two Credit Hours)		
Chapter	Week of the Semester	Topic(s)	Chapter(s)	No. of Class Periods	Topic(s)
1	1	Introduction to Engineering Economy	1	1	Introduction to Engineering Economy
2	2	Cost Concepts and Design Economics	2	4	Cost Concepts, Single Variable Trade-Off Analysis, and Present Economy
3	3	Cost-Estimation Techniques			
4	4–5	The Time Value of Money	4	5	The Time Value of Money
5	6	Evaluating a Single Project	1, 2, 4	1	**Test #1**
6	7	Comparison and Selection among Alternatives	3	3	Developing Cash Flows and Cost-Estimation Techniques
	8	**Midterm Examination**	5	2	Evaluating a Single Project
7	9	Depreciation and Income Taxes	6	4	Comparison and Selection among Alternatives
10	10	Evaluating Projects with the Benefit–Cost Ratio Method	3, 5, 6	1	**Test #2**
8	11	Price Changes and Exchange Rates	11	2	Breakeven and Sensitivity Analysis
11	12	Breakeven and Sensitivity Analysis	7	5	Depreciation and Income Taxes
9	13	Replacement Analysis	14	1	Decision Making Considering Multiattributes
12	14	Probabilistic Risk Analysis			
13–14	15	The Capital Budgeting Process, Decision Making Considering Multiattributes	All the above	1	**Final Examination**
	15	**Final Examination**			
Number of class periods: 45			Number of class periods: 30		

It is generally advisable to teach engineering economy at the upper division level. Here, an engineering economy course incorporates the accumulated knowledge students have acquired in other areas of the curriculum and also deals with iterative problem solving, open-ended exercises, creativity in formulating and evaluating feasible solutions to problems, and consideration of realistic constraints (economic, aesthetic, safety, etc.) in problem solving.

Supplements to the Book

The fourteenth edition of *Engineering Economy* is proud to offer adopting instructors **TestGen**, a test generator program with an algorithmic bank of questions. The **TestGen** testbank consists of well-crafted assessment questions that are representative of problems found throughout the textbook. Instructors can regenerate algorithmically generated variables within each problem to offer students a virtually unlimited number of paper or online assessments. Additionally, instructors can view, select, and edit testbank questions or create their own questions. Also available to adopters of this edition is an instructor's Solutions Manual and other classroom resources, including PowerPoint images. Visit www.prenhall.com/sullivan for more information.

Engineering Economy Portfolio

In many engineering economy courses, students are required to design, develop, and maintain an engineering economy portfolio. The purpose of the portfolio is to demonstrate and integrate knowledge of engineering economy beyond the required assignments and tests. This is usually an individual assignment. Professional presentation, clarity, brevity, and creativity are important criteria to be used to evaluate portfolios. Students are asked to keep the audience (i.e., the grader) in mind when constructing their portfolios.

The portfolio should contain a variety of content. To get credit for content, students must display their knowledge. Simply collecting articles in a folder demonstrates very little. To get credit for collected articles, students should read them and write a brief summary of each one. The summary could explain how the article is relevant to engineering economy, it could critique the article, or it could check or extend any economic calculations in the article. The portfolio should include both the summary and the article itself. Annotating the article by writing comments in the margin is also a good idea. Other suggestions for portfolio content follow (note that students are encouraged to be creative):

- Describe and set up or solve an engineering economy problem from your own discipline (e.g., electrical engineering or building construction).
- Choose a project or problem in society or at your university and apply engineering economic analysis to one or more proposed solutions.
- Develop proposed homework or test problems for engineering economy. Include the complete solution. Additionally, state which course objective(s) this problem demonstrates (include text section).

- Reflect upon and write about your progress in the class. You might include a self-evaluation against the course objectives.
- Include a photo or graphic that illustrates some aspects of engineering economy. Include a caption that explains the relevance of the photo or graphic.
- Include completely worked out practice problems. Use a different color pen to show these were checked against the provided answers.
- Rework missed test problems, including an explanation of each mistake.

(The preceding list could reflect the relative value of the suggested items; that is, items at the top of the list are more important than items at the bottom of the list.)

Students should develop an introductory section that explains the purpose and organization of the portfolio. A table of contents and clearly marked sections or headings are highly recommended. Cite the source (i.e., a complete bibliographic entry) of all outside material. Remember, portfolios provide evidence that students know more about engineering economy than what is reflected in the assignments and exams. The focus should be on quality of evidence, not quantity.

Overview of the Book

This book is about making choices among competing engineering alternatives. Most of the cash-flow consequences of the alternatives lie in the future, so our attention is directed toward the future and not the past. In Chapter 2, we examine alternatives when the time value of money is not a complicating factor in the analysis. We then turn our attention in Chapter 3 to how future cash flows are estimated. In Chapter 4 and subsequent chapters, we deal with alternatives where the time value of money is a deciding factor in choosing among competing capital investment opportunities.

Students can appreciate Chapters 2 and 3 and later chapters when they consider alternatives in their personal lives, such as which job to accept upon graduation, which automobile or truck to purchase, whether to buy a home or rent a residence, and many other choices they will face. To be student friendly, we have included many problems throughout this book that deal with personal finance. These problems are timely and relevant to a student's personal and professional success, and these situations incorporate the structured problem-solving process that students will learn from this book.

Chapter 4 concentrates on the concepts of money–time relationships and economic equivalence. Specifically, we consider the time value of money in evaluating the future revenues and costs associated with alternative uses of money. Then, in Chapter 5, the methods commonly used to analyze the economic consequences and profitability of an alternative are demonstrated. These methods, and their proper use in the comparison of alternatives, are primary subjects of Chapter 6, which also includes a discussion of the appropriate time period for an analysis. Thus, Chapters 4, 5, and 6 together develop an essential part of the methodology needed for understanding the remainder of the book and for performing engineering economy studies on a before-tax basis.

In Chapter 7, the additional details required to accomplish engineering economy studies on an after-tax basis are explained. In the private sector, most engineering economy studies are done on an after-tax basis. Therefore, Chapter 7 adds to the basic methodology developed in Chapters 4, 5, and 6.

The effects of inflation (or deflation), price changes, and international exchange rates are the topics of Chapter 8. The concepts for handling price changes and exchange rates in an engineering economy study are discussed both comprehensively and pragmatically from an application viewpoint.

Often, an organization must analyze whether existing assets should be continued in service or replaced with new assets to meet current and future operating needs. In Chapter 9, techniques for addressing this question are developed and presented. Because the replacement of assets requires significant capital, decisions made in this area are important and demand special attention.

Chapter 10 is dedicated to the analysis of public projects with the benefit–cost ratio method of comparison. The development of this widely used method of evaluating alternatives was motivated by the Flood Control Act passed by the U.S. Congress in 1936.

Concern over uncertainty and risk is a reality in engineering practice. In Chapter 11, the impact of potential variation between the estimated economic outcomes of an alternative and the results that may occur is considered. Breakeven and sensitivity techniques for analyzing the consequences of risk and uncertainty in future estimates of revenues and costs are discussed and illustrated.

In Chapter 12, probabilistic techniques for analyzing the consequences of risk and uncertainty in future cash-flow estimates and other factors are explained. Discrete and continuous probability concepts, as well as Monte Carlo simulation techniques, are included in Chapter 12. Real options analysis is also briefly discussed.

Chapter 13 is concerned with the proper identification and analysis of all projects and other needs for capital within an organization. Accordingly, the capital financing and capital allocation process to meet these needs is addressed. This process is crucial to the welfare of an organization, because it affects most operating outcomes, whether in terms of current product quality and service effectiveness or long-term capability to compete in the world market. Finally, Chapter 14 discusses many time-tested methods for including nonmonetary attributes (intangibles) in engineering economy studies.

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We would like to extend a heartfelt "thank you" to our colleagues for their many helpful suggestions (and critiques!) for this fourteenth edition of *Engineering Economy*. We owe a special debt of gratitude to Jim Alloway (EMSQ Associates), Dick Bernhard (North Carolina State University), Karen Bursic (University of Pittsburgh), J. Kent Butler (California Polytechnic State University), R. Wai Kiong Chong (University of Kansas), Michael Harnett (Kansas State University), Randy Hudson (Oak Ridge National Laboratory), James Luxhoj (Rutgers University), Behnam Malakooti (Case Western University), Kumar Muthuraman (Purdue University), and Bob Taylor (Virginia Tech).

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William G. Sullivan
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