前　言

关于工程经济学

工程师的工作可以简单描述为“问题解决者”。广义地说，工程师的工作是运用所学知识提出解决问题的最优化方法。工程设计解决方案面临商业机遇复杂的大环境，绝不是与世隔绝。假设每个难题都存在多种方案，那么我们如何理性地选择设计使其利益最大化？工程经济学就是要解决这样的问题。工程经济学提出了评估竞争性设计方案经济要素的系统框架。就像工程师对支撑柱模型应力的密切重视或对汽轮机的热力学积极响应，他们也必须对所提建议进行经济影响分析的建模。

工程经济学到底是什么？为什么它那么重要？很多工科学生认为“其他人会解决好关于资金的问题，这并不是我需要担心的部分”，实际上任何工程项目都要做到技术上可行、经济上合理。

在现代社会，将经济学原理应用于工程学越来越重要。工程学不仅要关注产品质量提升、系统流程优化、问题的妥善解决，并且提出的方案必须在经济上可行。设计方案关系到多种有限的资源如时间、材料、劳动力、资本以及自然资源，方案的实施时间包括概念设计阶段和整个产品生命周期（例如：细节设计，制造和分销，服务，撤退和清理）。一个再伟大的方案，只要它无利可图也可能会失败。

新版本特点

本书再版的最初意图是加入一些计算机使用技术和实际案例来方便读者学习。第 15 版主要有下列变化：

- 绿色能源新增大量有关绿色工程的案例和思考习题。在常见环境中体现能源节约思想。能源节约、材料替代、循环利用以及其他绿色化行动，都属于工程经济学范畴。
- 充分利用多媒体。作者精挑细选了 75 个相关问题与案例，采用视频授课的方式帮助读者理解，从而提升问题解决能力。图标表示视频可观看，相关资源可在www.pearsonhighered.com/sullivan获得。书上的设计图标是为了让读者在一系列问题和案例的类比中加强课程的学习，同时也是为了鼓励学生好好利用这些资源。
- 增加了 200 多道习题。这些习题涵盖了作者个人兴趣领域和当前该学科的前沿问题。
- 扩展并加强了可视化辅助工具的应用。
- 缩写了部分章节使本书更简洁、更具可读性。
- 增加新的电子数据表模型。
- 习题的部分答案在附录 G 中给出。
- 本书同样支持在算法上有大量习题（包括答案）的 TestGen。教师可登录 www.pearsonhighered.com/sullivan 获得该资源。

本书的目标

本书主要有两个目标：（1）让学生了解工程经济学的基本原则、基础概念和方法；（2）让学生能熟练应用理性决策的方法去解决他们职业生涯中可能遇到的实际问题。有趣的是，工程经济学课程可能是大学中唯一学到系统评估可选择投资方案的机会。出于此考虑，本书意图作为课堂教学的教材和工程师在实践中的基础参考书。本书对从事技术活动的管理者同样适用。

作为一本教材，第 15 版的编写主要针对的是工程经济学的基础课程。每学期 3 学分课时可以完成本书大部分章节的授课，教师也可安排一定程度的拓展和深化教学以满足学生的个人需要。表 P-1 提供了具有代表性的每学期 3 学分或者 2 学分的教学大纲安排。另外，由于包括了一些工程经济学的前沿课题，本书同样可用于工程经济学的强化学习。

表 P-1　工程经济学课时安排

学期课程（3 学分）			学期课程（2 学分）		
章节	周次	课程主题	章节	课时数	课程主题
1	1	工程经济学概述	1	1	工程经济学概述
2	2	成本概念和设计经济学	2	4	成本概念，单变量权衡分析，现值经济分析
3	3	成本预测技术			
4	4~5	货币的时间价值	4	5	货币的时间价值
5	6	单一项目评估	1, 2, 4	1	测试 1
6	7	备选方案的比较与选择	3	3	现金流量和成本估计技术
	8	期中考试	5	2	单一项目评估
7	9	折旧与所得税	6	4	备选方案比较和选择
10	10	项目评估的收益—成本比率法	3, 5, 6	1	测试 2
8	11	价格变动与汇率	11	2	盈亏平衡分析与敏感性分析
11	12	盈亏平衡与敏感性分析	7	5	折旧和所得税
9	13	重置分析	14	1	多目标决策
12	14	概率风险分析			
13 ~ 14	15	资本预算过程，多目标决策	所有章节	1	期末考试
	15	期末考试			
课时数：45			课时数：30		

所有章节和附件都经过修订、更新，反映了工程经济学当前的发展趋势。大量涉及开放性问题和问题解决的技能练习贯穿始终。750 多道习题中的绝大部分是新增的，书中还包括很多在各种工程学科中提出的已经解决的案例。

在 21 世纪，美国正在掀开环境可持续发展的新篇章。我们致力于在案例和每章习题中体现这种精神。

本书还包括基础的工程考试习题，为准备该考试的学生提供帮助，基础的工程考试具有里程碑意义，因为它是迈向专业工程师的第一步。工科学生应该认真考虑成为职业工程师，因为这会带来很多就业机会且提高收入。

作者建议学生在高年级学习工程经济学。工程经济学涵盖了各科知识，要解决多种重复性问题、开放性问题。在设计评估可行的问题解决方案时，学生需具有创造性并能充分考虑在解决问题过程中的限制性因素（经济、美学、安全等），这些知识与能力需要学生在其他课程中学习和积累。

本书资源[①]

第 15 版《工程经济学》提供了 TestGen，这是一个拥有大量算法问题的测试生成器程序。该生成器包括大量精心编写的计算问题，这些问题都是本书中出现的典型问题。教师可以重新定义每个问题的变量，让学生书面或者在线计算最终结果。另外，教师可以查阅、挑选并编辑习题库或者创建自己的习题库。

本书还提供教师解答手册和其他教学资源。教师可登录 www.pearsonhighered.com/sullivan获取更多信息。

本书编辑了约 75 个视频资料，为学生提供关于案例和习题的解答。

① 书中提到的教辅资源，请联系培生教育出版集团北京办事处：Service.CN@pearson.com 咨询相关事宜。

工程经济投资组合报告

在很多工程经济学的课程中，学生要设计、开发并修改工程经济投资组合报告，以便真实展示学生所掌握的工程经济学知识。这通常是个人任务。在专业演讲中，清晰度、简短性以及创造性都是重要的评分标准，学生在编写工程经济投资组合报告时要充分考虑听众的需求。

工程经济投资组合报告包含大量内容。为了获得报告内容部分的高分，学生必须展示出他们的知识素养，简单地搜集整理一些资料并不能说明什么。为了获得资料搜集部分的高分，学生应该阅读每篇文章并做一个简短的总结。总结可以是解释文章如何与工程经济学相联系，可以是对文章的批评，或者是对文章中的经济计算进行验证和扩展。工程经济投资组合报告中需要包括总结和文章本身。在空白处对文章进行评论也是个不错的主意。其他对工程经济投资组合报告内容的建议有（鼓励学生有创造性）：

- 从其他学科（如电子工程或者建筑学）出发，提出问题或者解决一个关于工程经济的问题。
- 从社会或者学校中选择一个项目或相关问题，运用工程经济分析法提出一个甚至更多的解决方案。
- 为工程经济编写作业或测试问题，包括完整的解答过程。另外，陈述该问题要达到的课程目标。
- 思考并记录下你在这门课程的学习中的收获，可以包括与课程目标相比较的自我评价。
- 用一张图或者表格来叙述工程经济学的某些方面，并加上一个能解释相关内容的标题。
- 一个你已经完全理解的实际问题。使用不同颜色的字体来展示自己的解答与参考答案的不同。
- 重新计算答错的习题，包括对每个错误的解释。

（以上建议按照重要性排序）

同学们需要撰写一份介绍文档来解释工程经济投资组合报告的目的和结构，推荐采用表格、部分标记和小标题的形式。所有的引用材料要注明出处。工程经济投资组合报告可以展示学生对工程经济学的了解程度，我们应该更注重质量，而不是数量。

全书概述

本书主要讲解在众多具有竞争力的工程项目中做出最优化选择的方法。绝大多数决策涉及的现金流都是在未来的，所以我们致力于研究未来而不是过去。第 2 章在不考虑货币时间价值的情况下评估方案。第 3 章我们学习现金流的未来价值计算法。在第 4 章和接下来的章节中，我们关注当货币的时间价值是一个决定性因素情况下的投资机会选择问题。

在认真学习第 2 章、第 3 章以及之后的章节后，你将会发现生活中经常会运用这些知识。如毕业后工作的选择，手机或者汽车的购买选择，买房或者租房的选择以及其他很多实际问题。为了对同学们有所帮助，本书还包括了许多关于个人财务管理的问题。这些问题对同学们的个人或者事业的成功来说是及时并且相关的，同学们能在本书中学到相关的结构化问题解决方法。

第 4 章主要解释时间与货币的关系和经济等值的概念。在计算未来收入和成本时我们要考虑货币的时间价值。第 5 章介绍了评估方案经济效益和赢利性的常用方法，这些方法是第 6 章学习的基础。第 5 章还包括合适的项目分析期。第 4、5、6 章讲述了理解本书其他内容的基本方法，为学习税前工程经济分析奠定了基础。

第 7 章讲述了税后工程经济分析的具体内容。在私营单位中，绝大部分工程经济分析是基于税后展开的。第 7 章是对第 4、5、6 章基础方法的补充。

第 8 章主要讲述通货膨胀、价格变化和国际汇率变动的影响。从应用的角度全面阐述了在工程经济分析中处理价格变化和汇率变化的方法。

组织常常要分析现有设备能继续服务还是启用新设备来满足当前和未来的运作需求。第 9 章提出了解决这类问题的方法。因为设备的替代需要大量资金，所以这类决策十分重要。

第 10 章主要用收益—成本比率法评估公共项目。这种被广泛应用的项目评估法是由美国国会于 1936 年通过洪水控制法案所推广的。

在工程项目实践中必须控制不确定性和风险。在第 11 章中我们讨论了预期经济效益和实际结果之间可能存在的差距。我们利用盈亏平衡分析和敏感性技术来分析未来收益和成本存在的风险与不确定性。

第 12 章用概率模型分析了未来现金流的风险和不确定性并解释了其他相关因素。还包括了离散、连续概率的概念，以及蒙特卡洛模拟技术。

第 13 章主要讲述组织内部项目的适当识别和对资金的其他需求分析，相应地，还阐述了满足上述需求的融资方式和资本分配法。这些方法对组织生存发展十分重要，因为融资和资本分配会影响绝大部分运营成果，无论是当前产品的质量和服务有效性，还是未来在世界市场上的长期竞争力。最后，第 14 章提供了很多经过时间考验的方法，如工程经济分析中的非货币属性（无形资产）。

Preface

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. Given that every problem has multiple solutions, 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 ofmanyengineering 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, and 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.

What's New to This Edition?

The basic intent behind this revision of the text is to integrate computer technology and realistic examples to facilitate learning engineering economy. Here are the highlights of changes to the fifteenth edition:

- More than 160 green engineering examples and problems are new to this edition. Many incorporate energy conservation in commonly experienced situations. These elements pertain to engineering economy problems involving energy conservation, materials substitution, recycling, and other green situations. These green elements will be denoted with a vertical green rule and icon, as shown here.
- Tightly integrated hybrid media using videos of 75 selected problems and examples are featured to enhance problem solving and understanding. These videos are keyed to material in the text with this icon , showing that this resource can be accessed at www.pearsoninternationaleditions.com/sullivan. These icon-designated instances are intended to reinforce the learning of engineering economy through analogy with the marked problems and examples, and students are encouraged to take advantage of their availability.
- Over 200 new end-of-chapter problems have been added to this edition. Many are personal interest and current events types of problems.
- PowerPoint visual aids for instructors have been expanded and enhanced.
- A few chapters have been abbreviated to promote more concise and readable topical coverage.

- Many new spreadsheet models of engineering economy problems have been added to the fifteenth edition.
- Answers to selected end-of-chapter problems are included in Appendix G.
- We continue to support TestGen, which algorithmically generates a multitude of test questions (and answers). This useful resource for instructors may be accessed at www.pearsoninternationaleditions.com/sullivan.
- Student resources include access to the Video Solutions files which accompany this text, as well as additional student study resources. All end-of-chapter problems with this icon ▶ indicate the availability of some form of Video Solutions.

Strategies 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 making 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 fifteenth 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.

In the 21st century, America is turning over a new leaf for environmental sustainability.We have worked hard to capture this spirit in many of our examples and end-of-chapter problems. In fact, more than 160 "green" problems and examples have been integrated throughout this edition. They are listed in the Green Content section following the Preface.

FE exam–style questions are included 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.

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 fifteenth 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. In addition, PowerPoint visual aids are readily available to instructors. Visit www.pearsoninternationaleditions.com/sullivan for more information.

A series of approximately 75 video t utorials is available to students who desire extra explanation of selected examples and end-of-chapter problems in the book. Pearson offers many different products around the world to facilitate learning. In countries outside the United States, some products and services related to this textbook may not be available due to copyright and/or permissions restrictions. If you have questions, you can contact your local office by visiting www.pearsoninternationaleditions.com/sullivan or you can contact your local Pearson representative.

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		

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.

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.

We would like to extend a heartfelt “thank you” to our colleagues for their many helpful suggestions (and critiques!) for this fifteenth edition of *Engineering Economy*. We owe a special debt of gratitude to Richard Bernhard (North Carolina State University), Karen M. Bursic (University of Pittsburgh), J. Kent Butler (California Polytechnic State University), Thomas Cassel (University of Pennsylvania), Linda Chattin (Arizona State University), Michael Duffey (George Washington University), Thomas Keyser (Western New England College), and Lizabeth Schlemer (Cal Poly, San Luis Obispo).

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Chapter 1
Introduction to Engineering Economy（工程经济学概述）

The purpose of Chapter 1 is to present the concepts and principles of engineering economy.（本章目标是阐述工程经济学的概念和基本原理。）

Green Engineering in Action

Energy conservation comprises an important element in environmentally-conscious (green) engineering. In a Southeas-tern city, there are 310 traffic intersections that have been converted from incandescent lights to light-emitting diode (LED) lights. The study that led to this decision was conducted by the sustainability manager of the city. The wattage used at the intersections has been reduced from 150 watts to 15 watts at each traffic light. The resultant lighting bill has been lowered from $440,000 annually to $44,000 annually. When engineers went to check the traffic light meters for the first time, they were shocked by the low wattage numbers and the associated cost. One of them said, “We thought the meters were broken because the readings were so low.” The annual savings of $396,000 per year from the traffic light conversion more than paid for the $150,000 cost of installing the LED lights. Chapter 1 introduces students to the decision-making process that accompanies “go/no go” evaluations of investments in engineering projects such as the one described above.

绿色工程在行动

能源节约是环境友好型（绿色）工程中重要的元素。在东南部城市，可持续发展部部长经研究决定将 310 处十字路口的交通指示灯由白炽灯换成发光二极管（LED）灯。每盏交通指示灯的电力消耗从 150W 减少到了 15W，每年的电费也由 440 000 美元减少到 44 000 美元。工程师第一次去检测电路的时候被低消耗电能和低成本震惊了。其中一位工程师坦言：“我们以为是电路出问题了。”每年节约下来的 396 000 美元远远超过了安装这些 LED 灯的成本——15 000 美元。第 1 章介绍了如上述案例所示有关“做或者不做”的决策过程。

Icons Used in This Book

Throughout this book, these two icons will appear in connection with numerous chapter opening materials, examples, and problems:

This icon identifies environmental (green) elements of the book. These elements pertain to engineering economy problems involving energy conservation, materials substitution, recycling, and other green situations.

This icon informs students of the availability of video tutorials for the examples and problems so marked. Students are encouraged to access the tutorials at `www.pearsoninternationaleditions.com/sullivan`. These icon-designated instances are intended to reinforce the learning of engineering economy through analogy with the marked problems and examples.

1.1 Introduction

The technological and social environments in which we live continue to change at a rapid rate. In recent decades, advances in science and engineering have transformed our transportation systems, revolutionized the practice of medicine, and miniaturized electronic circuits so that a computer can be placed on a semiconductor chip. The list of such achievements seems almost endless. In your science and engineering courses, you will learn about some of the physical laws that underlie these accomplishments.

The utilization of scientific and engineering knowledge for our benefit is achieved through the *design* of things we use, such as furnaces for vaporizing trash and structures for supporting magnetic railways.

However, these achievements don't occur without a price, monetary or otherwise. Therefore, the purpose of this book is to develop and illustrate the principles and methodology required to answer the basic economic question of any design: Do its benefits exceed its costs?

The Accreditation Board for Engineering and Technology (美国工程技术认证委员会) states that engineering "is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind."[①] In this definition, the economic aspects of engineering are emphasized, as well as the physical aspects. Clearly, it is essential that the economic part of engineering practice be accomplished well. Thus, engineers use knowledge to find new ways of doing things economically.

Engineering economy involves the systematic evaluation of the economic merits of proposed solutions to engineering problems. To be economically acceptable (i.e., affordable), *solutions to engineering problems* must demonstrate a positive balance of long-term benefits over long-term costs, and they must also

- promote the well-being and survival of an organization,
- embody creative and innovative technology and ideas,
- permit identification and scrutiny of their estimated outcomes, and
- translate profitability to the "bottom line" through a valid and acceptable measure of merit.

Engineering economy is the dollars-and-cents side of the decisions that engineers make or recommend as they work to position a firm to be profitable in a highly competitive marketplace. Inherent to these decisions are trade-offs among different types of costs and the performance (response time, safety, weight, reliability, etc.) provided by the proposed design or problem solution. *The mission of engineering economy is to balance these trade-offs in the most economical manner*. For instance, if an engineer at Ford Motor Company invents a new transmission lubricant that increases fuel mileage by 10% and extends the life of the transmission by 30,000 miles, how much can the company afford to spend to implement this invention? Engineering economy can provide an answer.

A few more of the myriad situations in which engineering economy plays a crucial role in the analysis of project alternative come to mind:

1. Choosing the best design for a high-efficiency gas furnace
2. Selecting the most suitable robot for a welding operation on an automotive assembly line
3. Making a recommendation about whether jet airplanes for an overnight delivery service should be purchased or leased
4. Determining the optimal staffing plan for a computer help desk

From these illustrations, it should be obvious that engineering economy includes significant technical considerations. Thus, engineering economy involves technical analysis, with emphasis on the economic aspects, and has the objective of assisting decisions. This is true whether the decision maker is an engineer interactively analyzing alternatives at a computer-aided design workstation or the Chief Executive Officer (CEO) considering a new project. *An engineer who is unprepared to excel at engineering economy is not properly equipped for his or her job.*

1.2 The Principles of Engineering Economy

The development, study, and application of any discipline must begin with a basic foundation. We define the foundation for engineering economy to be a set of principles that provide a comprehensive doctrine for developing the methodology. These principles will be mastered by students as they progress through this book.

① Accreditation Board of Engineering and Technology, *Criteria for Accrediting Programs in Engineering in the United States* (New York; Baltimore, MD: ABET, 1998).

Once a problem or need has been clearly defined, the foundation of the discipline can be discussed in terms of seven principles.

PRINCIPLE 1 Develop the Alternatives

Carefully define the problem! Then the choice (decision) is among alternatives. The alternatives need to be identified and then defined for subsequent analysis.

A decision situation involves making a choice among two or more alternatives. Developing and defining the alternatives for detailed evaluation is important because of the resulting impact on the quality of the decision. Engineers and managers should place a high priority on this responsibility. Creativity and innovation are essential to the process.

One alternative that may be feasible in a decision situation is making no change to the current operation or set of conditions (i.e., doing nothing). If you judge this option feasible, make sure it is considered in the analysis. However, do not focus on the status quo to the detriment of innovative or necessary change.

PRINCIPLE 2 Focus on the Differences

Only the differences in expected future outcomes among the alternatives are relevant to their comparison and should be considered in the decision.

If all prospective outcomes of the feasible alternatives were exactly the same, there would be no basis or need for comparison. We would be indifferent among the alternatives and could make a decision using a random selection.

Obviously, only the differences in the future outcomes of the alternatives are important. Outcomes that are common to all alternatives can be disregarded in the comparison and decision. For example, if your feasible housing alternatives were two residences with the same purchase (or rental) price, price would be inconsequential to your final choice. Instead, the decision would depend on other factors, such as location and annual operating and maintenance expenses. This simple example illustrates Principle 2, which emphasizes the basic purpose of an engineering economic analysis: to recommend a future course of action based on the differences among feasible alternatives.

PRINCIPLE 3 Use a Consistent Viewpoint

The prospective outcomes of the alternatives, economic and other, should be consistently developed from a defined viewpoint (perspective).

The perspective of the decision maker, which is often that of the owners of the firm, would normally be used. However, it is important that the viewpoint for the particular decision be first defined and then used consistently in the description, analysis, and comparison of the alternatives.

As an example, consider a public organization operating for the purpose of developing a river basin, including the generation and wholesale distribution of electricity from dams on the river system. A program is being planned to upgrade and increase the capacity of the power generators at two sites. What perspective should be used in defining the technical alternatives for the program? The “owners of the firm” in this example means the segment of the public that will pay the cost of the program, and their viewpoint should be adopted in this situation.

Now let us look at an example where the viewpoint may not be that of the owners of the firm. Suppose that the company in this example is a private firm and that the problem deals with providing a flexible benefits package for the employees. Also, assume that the feasible alternatives for operating the plan all have the same future costs to the company. The alternatives, however, have differences from the perspective of the employees, and their satisfaction is an important decision criterion. The viewpoint for this analysis should be that of the employees of the company as a group, and the feasible alternatives should be defined from their perspective.