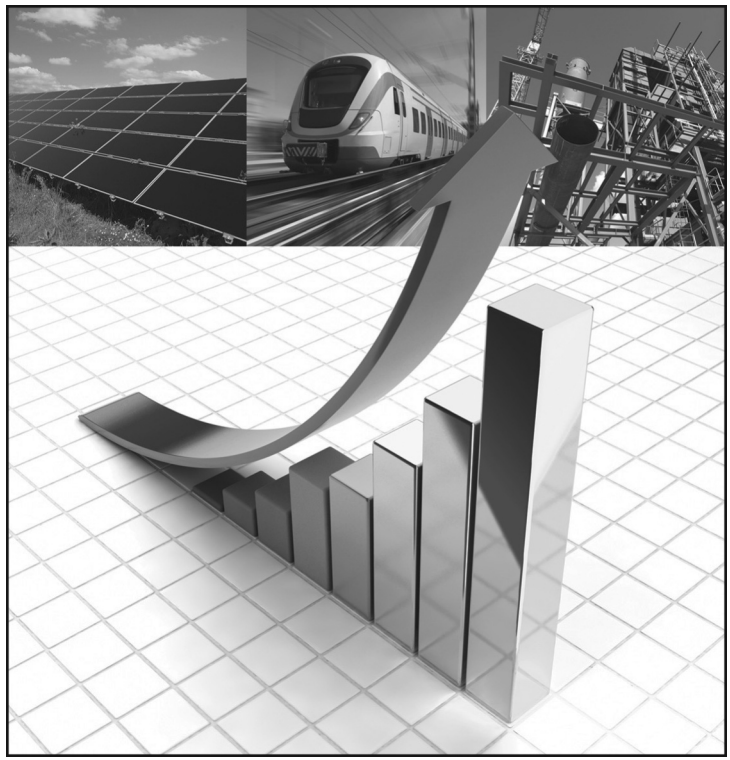
ENGINEERING ECONOMY

Fifteenth Edition

ENGINEERING ECONOMY

FIFTEENTH EDITION



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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. 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 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, 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:

1. Numerous 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.
2. Tightly integrated hybrid media using videos of 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.pearsonhighered.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.
3. Over 200 new end-of-chapter problems have been added to this edition. Many are personal interest and current events types of problems.
4. PowerPoint visual aids for instructors have been expanded and enhanced.
5. A few chapters have been abbreviated to promote more concise and readable topical coverage.
6. Many new spreadsheet models of engineering economy problems have been added to the fifteenth edition.
7. Answers to selected end-of-chapter problems are included in Appendix G.
8. 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.pearsonhighered.com/sullivan`.
9. Student resources include Pearson e-Text, a complete online version of the book that includes highlighting, note taking, and search capabilities and 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.pearsonhighered.com/sullivan` for more information.

A series of approximately 75 video tutorials is available to students who desire extra explanation of selected examples and end-of-chapter problems in the book.

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).

GREEN CONTENT

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Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

Chapter 8

Chapter 9

Chapter 10

Chapter 11

Chapter 12

Chapter 13

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