William G. SULLIVAN
Elin M. WICKS
C. Patrick KOELLING

ENGINEERING ECONOMY

SEVENTEENTH EDITION

75TH ANNIVERSARY

Pearson

CONTENTS

CHAPTER 14
Decision Making Considering Multiattributes 596

PREFACE

We live in a sea of economic decisions.

—Anonymous

Proudly serving engineering educators and students for over 75 years

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. This book is about how to make smart economic choices.

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.

MyLab™ Engineering

- MyLab Engineering is available with Engineering Economy, 17/e and provides a powerful homework and test manager which lets instructors create, import, and manage online homework assignments, quizzes, and tests that are automatically graded. You can choose from a wide range of assignment options, including time limits, proctoring, and maximum number of attempts allowed. The bottom line: MyLab Engineering means less time grading and more time teaching.

- Automatically graded and algorithmic-generated homework assignments, quizzes, and tests that directly correlate to the textbook.
- Automatic grading that tracks students' results.
- Assignable Auto-Graded Excel Projects let students master key Excel skills within the application and receive immediate feedback on their work.
- Interactive "Help Me Solve This" tutorials provide opportunity for point-of-use help and more practice.
- Learning Objectives mapped to ABET outcomes provide comprehensive reporting tools.
- Video Solutions are available to help explain concepts or walk students through example exercises from the book.

What's New to This Edition?

Our intent in revising the text is to continue integrating computer technology and realistic examples to facilitate learning engineering economy. Here are the highlights of changes made in the publication of the seventeenth edition:

- Approximately half of all end-of-chapter problems have been replaced with fresh, new problems.
- The "Try Your Skills" problem sets at the end of Chapters 1 through 8 have been doubled in problem count. "Try Your Skills" problem sets have also been added for Chapters 9 through 11.
- Appendix A, a description of accounting fundamentals, has been rewritten and added to the book.
- Group in-class problem exercises have been added to the majority of chapters in the seventeenth edition. These exercises are ideal for in-class, team-based problem solving with three to four students in each group.
- Appendix H, which features answers to selected end-of-chapter problems, has been added to this new edition.
- In Chapter 7 we provide an Excel template that allows students to change the effective income rate in problems affected by Congressional updates to the federal income tax law (most likely enacted in late 2017).
- Problem-solution videos have been updated and expanded. These videos provide students with step-by-step solution methods and demonstrate both by-hand and spreadsheet solutions. These complement the MyLab Engineering software that has been a popular feature of previous editions.

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.

This book is written to appeal to engineering students with a wide variety of personal interests and majors. Our students are like most college students, varied in their educational and career interests and eager for challenging work that will inspire them. The explanations and examples in the book are student-centered and eminently practical in real-life situations. In addition, multimedia resources are available online in MyLab Engineering for students and instructors looking to supplement the print book's contents.

As a textbook, the seventeenth 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.

Fundamentals of Engineering (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.

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.pearson.com` for more information.

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.

Icon Used in This Book

Throughout this book, one icon 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.

Assumptions, Precision, and Perspective

Engineering economy studies necessitate various assumptions (educated guesses) about the future. For example, we deal with predicted cash flows and interest rates over extended future periods of time. Most of the numerical examples in this book are generally rounded to the nearest dollar mainly because there is a lack of precision in our estimates involving future circumstances facing an organization.

Interest factors tabled in Appendixes C and D have been computed to four significant digits and may imply precision in engineering economy problems that is not, in fact, realistic. Students are reminded that rounding answers to problems in this book is entirely appropriate (for instance, to the nearest dollar, year, or any other value being solved for). We also strongly recommend solving problems from the viewpoint of the profit seeking owners of an organization (the shareholders and bondholders). Consequently, we assume that managers who act on economic analysis results are rational persons making decisions objectively to take advantage of feasible investment opportunities available to them.

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 and students for their many helpful suggestions (and critiques!) for this seventeenth edition of *Engineering Economy*. We owe an enormous debt of gratitude to numerous individuals who have contributed to this edition: Kathryn Abel (Stevens Institute of Technology), Farhad Azadivar (University of Massachusetts Dartmouth), Patrick A. Brunese (Purdue University), Tom Cassel (University of Pennsylvania), Jeya Chandra (Pennsylvania State University), Xin Chen (Southern Illinois University

Edwardsville), Hossein Hemati (San Diego State University), Bruce Janson (University of Colorado Denver), Solomon Leung (Idaho State University), and Christian M. Salmon (Western New England University). Also, we truly appreciate the invaluable assistance of folks at Pearson: Holly Stark, Erin Ault, and Amanda Brands, who have made invaluable improvements to this effort.

GREEN CONTENT

Chapter 1

Chapter 2

Pg 57 Problems 2-32
Pg 58 Problems 2-37
Pg 59 Problems 2-42
Pg 59 Problems 2-45
Pg 60 Problems 2-47
Pg 60 Spreadsheet Exercises 2-49

Chapter 3

Pg 62 Chapter 3 Opener
Pg 89 3.5 Case Study
Pg 97 Problems 3-1
Pg 97 Problems 3-4
Pg 97 Problems 3-6
Pg 98 Problems 3-11
Pg 98 Problems 3-12
Pg 98 Problems 3-14
Pg 98 Problems 3-15
Pg 103 FE Practice Problems 3-37
Pg 103 FE Practice Problems 3-40

Chapter 4

Pg 104 Chapter 4 Opener
Pg 112 Example 4-2
Pg 124 Example 4-10
Pg 137 Example 4-18
Pg 166 Try Your Skills 4-JJ
Pg 169 Try Your Skills 4-AAA
Pg 172 Problems 4-12
Pg 174 Problems 4-33
Pg 174 Problems 4-36
Pg 174 Problems 4-37
Pg 175 Problems 4-40
Pg 175 Problems 4-43
Pg 176 Problems 4-53
Pg 179 Problems 4-84
Pg 180 Problems 4-85
Pg 180 Problems 4-88

Chapter 5

Pg 188 Chapter 5 Opener
Pg 194 Example 5-2
Pg 199 Example 5-7
Pg 202 Example 5-10
Pg 219 Example 5-19
Pg 225 Try Your Skills 5-D
Pg 228 Try Your Skills 5-W
Pg 228 Try Your Skills 5-Y

Chapter 6

Chapter 7

Chapter 8

Chapter 9

Chapter 10

Chapter 11

Chapter 12

Chapter 13

Chapter 14

TABLE 4-2 Discrete Cash-Flow Examples Illustrating Equivalence

Example Problems (All Using an Interest Rate of $i = 10\%$ per Year—See Table C-13 of Appendix C)

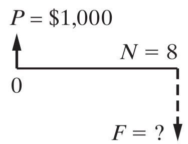
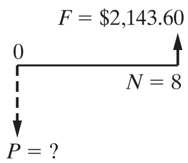
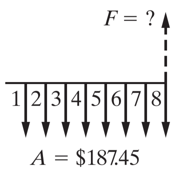
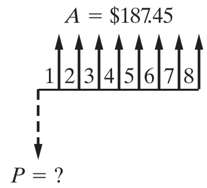
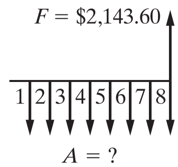
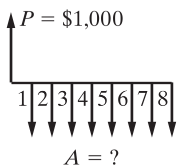
To Find:	Given:	(a) In Borrowing–Lending Terminology:	(b) In Equivalence Terminology:	Cash-Flow Diagram[a]	Solution
For single cash flows:					
F	P	A firm borrows \$1,000 for eight years. How much must it repay in a lump sum at the end of the eighth year?	What is the future equivalent at the end of eight years of \$1,000 at the beginning of those eight years?		$F = P(F/P, 10\%, 8)$ $= \$1,000(2.1436)$ $= \$2,143.60$
P	F	A firm wishes to have \$2,143.60 eight years from now. What amount should be deposited now to provide for it?	What is the present equivalent of \$2,143.60 received eight years from now?		$P = F(P/F, 10\%, 8)$ $= \$2,143.60(0.4665)$ $= \$1,000.00$
For uniform series:					
F	A	If eight annual deposits of \$187.45 each are placed in an account, how much money has accumulated immediately after the last deposit?	What amount at the end of the eighth year is equivalent to eight EOY payments of \$187.45 each?		$F = A(F/A, 10\%, 8)$ $= \$187.45(11.4359)$ $= \$2,143.60$

TABLE 4-2 *(Continued)*

P	A	How much should be deposited in a fund now to provide for eight EOY withdrawals of \$187.45 each?	What is the present equivalent of eight EOY payments of \$187.45 each?		$P = A(P/A, 10\%, 8)$ $= \$187.45(5.3349)$ $= \$1,000.00$
A	F	What uniform annual amount should be deposited each year in order to accumulate \$2,143.60 at the time of the eighth annual deposit?	What uniform payment at the end of eight successive years is equivalent to \$2,143.60 at the end of the eighth year?		$A = F(A/F, 10\%, 8)$ $= \$2,143.60(0.0874)$ $= \$187.45$
A	P	What is the size of eight equal annual payments to repay a loan of \$1,000? The first payment is due one year after receiving the loan.	What uniform payment at the end of eight successive years is equivalent to \$1,000 at the beginning of the first year?		$A = P(A/P, 10\%, 8)$ $= \$1,000(0.18745)$ $= \$187.45$

[a] The cash-flow diagram represents the example as stated in borrowing-lending terminology.

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
EUAC(i%)	equivalent uniform annual cost, calculated at i% interest
FW(i%)	future equivalent worth, calculated at i% interest, of one or more cash flows
IRR	internal rate of return, also designated i%
MARR	minimum attractive rate of return
N	length of the study period (usually years)
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
$\text{SD}(X)$	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

CHAPTER 1

Introduction to Engineering Economy

© Ollyy/Shutterstock

The purpose of Chapter 1 is to present the concepts and principles of engineering economy.

Green Engineering in Action

Energy conservation comprises an important element in environmentally-conscious (green) engineering. In a Southeastern 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.

The best alternative may be the one you haven't yet discovered.

—Anonymous

Icon Used in This Book

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.

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 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."* 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

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

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

PRINCIPLE 4 **Use a Common Unit of Measure**

Using a common unit of measurement to enumerate as many of the prospective outcomes as possible will simplify the analysis of the alternatives.

It is desirable to make as many prospective outcomes as possible *commensurable* (directly comparable). For economic consequences, a monetary unit such as dollars is the common measure. You should also try to translate other outcomes (which do not initially appear to be economic) into the monetary unit. This translation, of course, will not be feasible with some of the outcomes, but the additional effort toward this goal will enhance commensurability and make the subsequent analysis of alternatives easier.

What should you do with the outcomes that are not economic (i.e., the expected consequences that cannot be translated (and estimated) using the monetary unit)? First, if possible, quantify the expected future results using an appropriate unit of measurement for each outcome. If this is not feasible for one or more outcomes, describe these consequences explicitly so that the information is useful to the decision maker in the comparison of the alternatives.

PRINCIPLE 5 **Consider All Relevant Criteria**

Selection of a preferred alternative (decision making) requires the use of a criterion (or several criteria). The decision process should consider both the outcomes enumerated in the monetary unit and those expressed in some other unit of measurement or made explicit in a descriptive manner.

The decision maker will normally select the alternative that will best serve the long-term interests of the owners of the organization. In engineering economic analysis, the primary criterion relates to the long-term financial interests of the owners. This is based on the assumption that available capital will be allocated to provide maximum monetary return to the owners. Often, though, there are other organizational objectives you would like to achieve with your decision, and these should be considered and given weight in the selection of an alternative. These