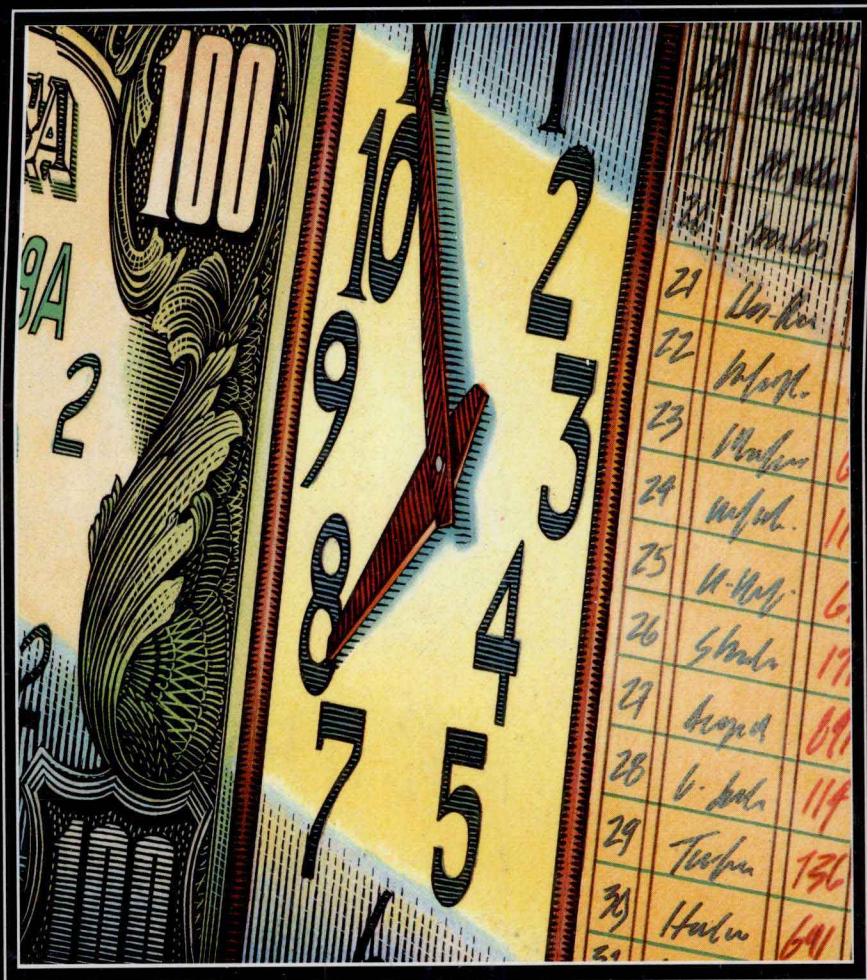


ENGINEERING ECONOMY

Applying Theory to Practice



ESCHENBACH

ENGINEERING ECONOMY

APPLYING THEORY TO PRACTICE

TED G. ESCHENBACH
University of Alaska Anchorage

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Senior sponsoring editor:	Richard T. Hercher, Jr.
Developmental editor:	Carol L. Rose
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Designer:	Mercedes Santos
Graphics supervisor:	Eurnice Harris
Compositor:	Publication Services
Typeface:	10/12 Times Roman
Printer:	R. R. Donnelley & Sons Company

Library of Congress Cataloging-in-Publication Data

Eschenbach, Ted.

Engineering economy: applying theory to practice / Ted G.

Eschenbach.

p. cm.

Includes index.

ISBN 0-256-11441-2

1. Engineering economy. I. Title.

TA177.4.E833 1995

658.15—dc20

94-12751

Printed in the United States of America

2 3 4 5 6 7 8 9 0 DO 1 0 9 8 7 6 5

*This book is dedicated with my loving thanks for her decades of
support and patience to my wife,*

Chris Helen Matiukas

PREFACE

This text introduces the basic theory and application of engineering economy. It is suitable for a first course in engineering economy, for self-study by practicing engineers, and for reference during the practice of engineering. This text includes enough material so that instructors have some choices in approach for a first course at the undergraduate level. At the graduate level, instructors might add supplementary material, such as *Cases in Engineering Economy* (by Ted Eschenbach; Wiley, 1989). Examples from all major engineering disciplines are included, with both private- and public-sector applications.

KEY FEATURES OF THE TEXT

Studying what other texts have done well, surveying nearly 250 teachers of engineering economy, planning carefully, and listening to the comments of four sets of reviewers provide this text with clear advantages. The following points are the text's foundation:

1. Conceptually linking theory and practice.
2. Breadth and depth of coverage matched to introductory courses.
3. Emphasis on constrained project selection.
4. Appropriate pedagogical support for the students.
5. Modern computational tools.

1. Conceptually Linking Theory and Practice. Often the realism of engineering economy texts stops with the numbers plugged into examples and problems. This text presents the theory, and then it examines common practical violations of theoretical assumptions.

For example, most texts define *payback period* and demonstrate its inferiority to time value of money measures. This text also explains why payback continues to be used and why its use does not lead to bankruptcy. Similarly, this text, like most, explains the assumptions of repeated lives or salvage values that are needed for valid present worth comparisons. This text also discusses the impact of failing to satisfy the assumption of identical cost repetition while using equivalent annual techniques.

I believe that understanding how and why basic principles are applied is more important and interesting than fine theoretical nuances. In practice and in this

text, ranking on the internal rate of return is used for constrained project selection, and present worth and equivalent annual cost are used for the selection of mutually exclusive alternatives. This text covers, but does not emphasize, integer programming models for capital budgeting, nor incremental internal rate of return and benefit/cost ratios for mutually exclusive alternatives.

Because students learn best when theory is clearly linked to real-world applications, the examples and homework problems are specifically chosen to illustrate practical realities and to include situations in which students can apply engineering economy concepts in their own lives.

2. Coverage Matched to Introductory Engineering Economy Courses. Engineering economy relies on concepts and tools that are developed in accounting, finance, management science, probability, and statistics. Many topics have far more depth than can be included in an introductory course, and many engineering economy courses have no specific prerequisites. To best choose what to include here, I analyzed a list of needs established by a survey of nearly 250 faculty members in engineering economy.

For example, depreciation methods, income taxes, and the distinction between assets and income are covered, but other accounting topics are not. Similarly, the weighted cost of capital is discussed, but finance models for risk and stock prices are not. Basic models for multiple criteria are included, while utility theory is not. The application of expected value and decision trees is included from probability, and learning-curve models for cost estimation from statistics; however, general forecasting models are omitted.

The survey led to a text that has slightly more material than most instructors will cover in one semester. Thus, instructors have choices in the topics they will cover. To support the course work best, topics that were found to be “elective” were presented as independently as possible. For example, the text includes cost estimating, inflation, sensitivity analysis, multiple criteria evaluation, and economic decision trees, but each presentation is completely independent. Appendices of more advanced material are also included with several chapters.

3. Emphasis on Constrained Project Selection. Most texts emphasize the choice between mutually exclusive alternatives with an externally defined discount rate. Capital budgeting is often relegated to the back of engineering economy texts, where the presentation focuses on theoretical models and advanced techniques that are rarely used.

However, the capital budgeting problem is often solved in the real world by ranking on internal rate of return. Discussing this constrained project selection problem in Chapter 9 provides a solid, intuitive foundation for selecting a discount rate. This is applied in Chapter 10 for the comparison of mutually exclusive alternatives.

The discussion of mutually exclusive alternatives focuses on the use of present worth and equivalent annual measures. Incremental internal rates of return and

benefit/cost ratios are covered, but not as the technique of choice for this category of problem.

4. Pedagogical Support. It is clear that students learn more when the structure of the presentation and the expectations are clear. Chapter objectives, key words and concepts, and lists of major points are used to facilitate student understanding.

Realistic examples can engage student interest, and problems drawn from student life can motivate high performance. These examples include factor-based solutions (the traditional basis of engineering economy) and newer spreadsheet-based solutions, which use computer power for more realistic models and more complete analysis. To support continuity of understanding and development of realistic problems, some examples and homework problems are carried through a sequence of chapters.

Exhibits are used liberally. Advances in computer power have made it possible and sometimes desirable to combine tables and graphics to form more powerful exhibits. A single numbering scheme for the exhibits is used to make it easier to find a referenced exhibit, whether table or figure.

5. Modern Computational Tools. Spreadsheets enhance the student's analytical capabilities, allow the inclusion of more realistic problems, and better prepare students to use engineering economy after graduation. For these reasons spreadsheets are used in the examples, and they can be applied to the homework problems. The power of spreadsheets allows students to learn more and to address problems in realistic detail. Real-world engineering economy almost universally relies on spreadsheets as an analytical tool.

Spreadsheets can be included in course work with this text in several ways: (1) spreadsheets can be an integral part of the course, including instruction on their construction and use; (2) spreadsheets can be required or encouraged for homework without requiring their use in class; (3) students can use spreadsheets on their own to do homework. The spreadsheet instruction and setup sections are placed at the ends of chapters, so that they may be skipped if desired.

While spreadsheets are very useful, I have long been a proponent of understanding a problem and using hand calculations rather than relying on computers to solve it. That is why some examples and problems are designed to show that calculators are the easiest tool and the best choice. This text offers a variety of hand-calculation and computer problems that reflect what is expected of the practicing engineering economist. It also incorporates spreadsheets throughout the text for complex problems, especially those related to inflation, sensitivity, and taxes.

For access to spreadsheet information see page xiii.

ORGANIZATION OF THE TEXT

The overall flow of the material is shown in Exhibit P.1. The first three parts are included in most courses, but the last chapter in each part (Chapters 4, 8, and 11) can be easily skipped without loss of continuity.

Exhibit P1 Organization of the text
(Dotted material can be skipped)

<p>Part One Basic Concepts and Tools 1 Making Economic Decisions 2 The Time Value of Money 3 Equivalence—A Factor Approach</p>		
<p>4 Geometric Gradients and Spreadsheets</p>	<p>Part Two Analyzing a Project 5 Present Worth 6 Equivalent Annual Worth 7 The Rate of Return</p>	
	<p>8 Benefit/Cost Ratios and Other Measures</p>	<p>Part Three Comparing Projects and Alternatives 9 Constrained Project Selection 10 Mutually Exclusive Choices</p>
<p>Part Four Enhancements for the Real World 12 Depreciation 13 Income Taxes 14 Public-Sector Engineering Economy 15 Inflation</p>	<p>Part Five Decision-Making Tools 16 Estimating Cash Flows 17 Sensitivity Analysis 18 Uncertainty and Probability 19 Multiple Objectives</p>	<p>11 Replacement Analysis</p>

Part One presents concepts that form the fundamental basis for engineering economic calculations. Part Two reinforces this material for increasingly complex cash flows. Part Three compares alternatives—those that are constrained by a limited budget and those that are mutually exclusive. Part Four includes the effect of income taxes on the private sector, special concerns of the public sector, and inflation. Part Five explains tools that are needed to deal with the complexities of the real world.

THE INSTRUCTOR'S MANUAL

The instructor's manual includes solutions to end-of-chapter problems, suggested course outlines, and transparency masters for all exhibits.

The end-of-text tables are also available in pamphlet form in quantity from the publisher for those instructors who do closed-book testing. Similar pamphlets of tables for continuous compounding and distributed cash flows are also available.

ACKNOWLEDGMENTS

I have had an enormous amount of help in completing this text. The authors of the numerous other texts that I have used have provided fine examples and shaped my understanding of the subject. Similarly, students at the University of Alaska Anchorage, the University of Missouri–Rolla, and Merrimack College have endured classroom testing of drafts and patiently pointed out where further work was needed.

Over 200 faculty members responded to a six-page survey about their current texts, courses, and desired material for an introductory text. Their responses directed me to the best and worst aspects of existing texts and provided great insight into their courses. Their responses specifically guided me in the addition and deletion of topics in my outline.

Other faculty members have provided material, reviewed the manuscript, or tested it in class. They have provided many helpful comments and criticisms. I would like to thank the following individuals in particular:

James A. Alloway, Jr.,
Syracuse University

Daniel L. Babcock,
University of Missouri–Rolla

Susan Burgess (deceased),
University of Missouri–Rolla

John R. Canada, *North
Carolina State University*

Barry Clemson, *Old
Dominion University*

William J. Foley, *Rensselaer
Polytechnic Institute*

Timothy J. Gallagher,
Colorado State University

Carol S. Gattis, *University
of Arkansas, Fayetteville*

Joseph E. Gust, Jr.,
Northern Arizona University

Kim Hazarvartian,
Merrimack College

Donald P. Hendricks,
Iowa State University

Ken Henkel, *California
State University, Chico*

Leonard Hom, *California
State University, Sacramento*

W. J. Kennedy,
Clemson University

Robert G. Lundquist,
Ohio State University

Richard W. Lyles,
Michigan State University

Anthony K. Mason,
*California Polytechnic State
University at San Luis Obispo*

Paul R. McCright,
Kansas State University

Nancy L. Mills, *University
of Southern Colorado*

Murl Wayne Parker,
Mississippi State University

Louis Plebani, *Lehigh University*

Jang W. Ra, *University
of Alaska Anchorage*

Herbert P. Schroeder,
University of Alaska Anchorage

Jack W. Schwalbe, *Florida*
Institute of Technology

Paul L. Shillings,
Montana State University

Sanford Thayer,
Colorado State University

David Veshosky,
Lafayette College

Ed Wheeler, *University*
of Tennessee, Martin

Bob White, *Western*
Michigan University

Henry Wiebe, *University*
of Missouri–Rolla

Ed Wheeler of the University of Tennessee, Martin not only reviewed drafts of the manuscript, he also contributed sets of problems for every chapter. Because engineering economy and finance are closely related subjects, Tim Gallagher, professor of finance at Colorado State University, reviewed the manuscript. Jarad Golkar, then of Texas A&M University, independently solved the end-of-chapter problems for over half of the text. His “review” of the solutions manual has helped ensure a clean first edition.

I would like to thank Bill Stenquist, who as my initial editor at Irwin convinced me that the effort to write a new text was worthwhile and who then helped me shape the text to meet the needs of the market delineated by the survey. My first developmental editor, Max Effenson, got me started on the right track. My second developmental editor, Becky Johnson, vastly improved both my written product and my writing skills and managed to keep me both smiling and moving along. My second editor, Tom Casson, asked the tough questions that forced me to search out the remaining weak points. Pat Soberanis, in spite of the sleepless nights she caused me, is the best copy editor I have ever had. At the final stage, the team of Dick Hercher, Carol Rose, Rita McMullen, and Mark Malloy set a standard of professional competence, good humor, and tact that I endeavored to match.

I have had support at the University of Alaska Anchorage as well. I would like to thank my boss, Will Nelson, and my support staff of Pinky Miranda, Paulette Jennings, Mindy Nichols, Angie Damberg, and Jeannie Carpenter. They have typed manuscript, revised spreadsheets and graphics, and made numerous copies.

My deepest appreciation goes to my wife, Chris Matiukas, for her unflagging support and patience. I would also like to thank Andrew and Kelsey for dragging me away from my computer to play and for accepting the many times I had to say that I couldn’t.

Ted Eschenbach
Anchorage, Alaska

SPREADSHEET SOFTWARE

Even though most of this text's problems can be solved with a handheld calculator and the tables in Appendix A and all of the theory can be understood without spreadsheets, I believe that using them enhances your understanding and provides a faster way to complete homework. Thus, I recommend that you use this course to improve or acquire spreadsheet mastery. That mastery will be useful for many other engineering applications that analyze and/or present numbers.

If you have any version of Excel™, or Quattro Pro™, or version 4 or later of Lotus 1-2-3™, the included financial functions can be used to quickly and easily solve most engineering economy problems. Current versions of all of these packages are sold at substantial academic discounts in university bookstores and through authorized educational resellers. I recommend taking advantage of this opportunity by:

1. Checking out your bookstore, since lower academic prices are available for volume purchases.

Then if necessary

2. Calling one of the following numbers.

Note: corporations do merge, change software distribution channels, or sell ownership of software packages, so the following information is subject to change. In November 1994, when this was written, PC Connection (800-800-0005) was authorized to sell all three packages to students who had faxed or mailed verification of their ID, and the prices were about \$85. Other software distributors have or will develop the same capability.

For Microsoft Excel, authorized academic resellers include:

Computer Discount Warehouse (CDW) 800-451-4239

PC Connection 800-800-0005

In November 1994, the recommended academic price for a single copy was \$100.

For Quattro Pro, by calling 800-321-3220 and providing your ZIP code, the authorized academic resellers closest to you can be identified. If none is nearby, there is provision for direct shipping with faxed verification of your student ID. In November 1994, the recommended academic price for a single copy was \$99.

For Lotus 1-2-3, authorized academic resellers can be identified by calling 800-343-5414. In November 1994, the recommended academic price for a single copy was \$100.

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