

GLOBAL
EDITION



Contemporary Engineering Economics

SIXTH EDITION

Chan S. Park

ALWAYS LEARNING

PEARSON



MyEngineeringLab™

Right now, in your course, there are young men and women whose engineering achievements could revolutionize, improve, and sustain future generations.

Don't Let Them Get Away.

Contemporary Engineering Economics, Sixth Edition, together with MyEngineeringLab, is a complete solution for providing an engaging in-class experience that will inspire your students to stay in engineering, while also giving them the practice and scaffolding they need to keep up and be successful in the course.

Learn more at myengineeringlab.com

This page intentionally left blank

CONTEMPORARY ENGINEERING ECONOMICS

Sixth Edition

Global Edition

This page intentionally left blank

Sixth Edition

Global Edition

CONTEMPORARY ENGINEERING ECONOMICS

Chan S. Park

Department of Industrial
and Systems Engineering
Auburn University

PEARSON

Boston Columbus Indianapolis New York San Francisco Hoboken
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montréal Toronto Delhi Mexico
City São Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

Vice President and Editorial Director, ECS: *Marcia J. Horton*
Executive Editor: *Holly Stark*
Field Marketing Manager: *Demetrius Hall*
Senior Product Marketing Manager: *Bram van Kempen*
Marketing Assistant: *Jon Bryant*
Senior Managing Editor: *Scott Disanno*
Production Project Manager: *Rose Kernan*
Program Manager: *Erin Ault*
Senior Digital Producer: *Felipe Gonzalez*
Global HE Director of Vendor Sourcing and Procurement: *Diane Hynes*
Senior Acquisitions Editor, Global Edition: *Sandhya Ghoshal*
Associate Project Editor, Global Edition: *Sinjita Basu*
Media Production Manager, Global Edition: *Vikram Kumar*
Senior Manufacturing Controller, Production, Global Edition: *Trudy Kimber*
Director of Operations: *Nick Sklitsis*
Operations Specialist: *Maura Zaldivar-Garcia*
Full-Service Project Management: *Laserwords Pvt. Ltd.*
Cover Photo Source: *Shutterstock*
Cover Printer: *Ashford Colour Press*

Pearson Education Limited
Edinburgh Gate
Harlow
Essex CM20 2JE
England

and Associated Companies throughout the world

Visit us on the World Wide Web at:

www.pearsonglobaleditions.com

© Pearson Education Limited 2016

The rights of Chan S. Park to be identified as the author of this work have been asserted by him in accordance with the Copyright, Designs and Patents Act 1988.

Authorized adaptation from the United States edition, entitled Contemporary Engineering Economics, 6th edition, ISBN 978-0-134-10559-8 by Chan S. Park, published by Pearson Education © 2016.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without either the prior written permission of the publisher or a license permitting restricted copying in the United Kingdom issued by the Copyright Licensing Agency Ltd, Saffron House, 6–10 Kirby Street, London EC1N 8TS.

All trademarks used herein are the property of their respective owners. The use of any trademark in this text does not vest in the author or publisher any trademark ownership rights in such trademarks, nor does the use of such trademarks imply any affiliation with or endorsement of this book by such owners.

ISBN 10: 1-292-10909-2

ISBN 13: 978-1-292-10909-1

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

10 9 8 7 6 5 4 3 2 1

14 13 12 11 10

Typeset in 10.5/12, Times LT Pro by Laserwords Pvt. Ltd.

Printed by Ashford Colour Press in the United Kingdom.

For Sophie and Alexander

This page intentionally left blank

CONTENTS

Preface	21
---------	----

PART I BASICS OF FINANCIAL DECISIONS 31

Chapter 1 Engineering Economic Decisions 32

1.1 Role of Engineers in Business	33
1.1.1 Types of Business Organization	34
1.1.2 Engineering Economic Decisions	35
1.1.3 Personal Economic Decisions	36
1.1.4 Economic Decisions Versus Design Decisions	36
1.2 What Makes the Engineering Economic Decision Difficult?	37
1.3 Large-Scale Engineering Projects	38
1.3.1 Are Tesla's Plans for a Giant Battery Factory Realistic?	38
1.3.2 Impact of Engineering Projects on Financial Statements	40
1.4 Common Types of Strategic Engineering Economic Decisions	40
1.4.1 Equipment or Process Selection	41
1.4.2 Equipment Replacement	41
1.4.3 New Product or Product Expansion	42
1.4.4 Cost Reduction	42
1.4.5 Improvement in Service or Quality	42
1.5 Fundamental Principles of Engineering Economics	42
Summary	45
Short Case Studies	45

Chapter 2 Accounting and Financial Decision Making 46

2.1 Accounting: The Basis of Decision Making	48
2.2 Financial Status for Businesses	49
2.2.1 The Balance Sheet	51
2.2.2 The Income Statement	56
2.2.3 The Cash Flow Statement	57
2.3 Using Ratios to Make Business Decisions	64
2.3.1 Debt Management Analysis	65
2.3.2 Liquidity Analysis	67
2.3.3 Asset Management Analysis	68
2.3.4 Profitability Analysis	70

2.3.5	Market Value Analysis	72
2.3.6	Limitations of Financial Ratios in Business Decisions	73
	Summary	76
	Problems	76
	Short Case Studies	83

Chapter 3 Interest Rate and Economic Equivalence 84

3.1	Interest: The Cost of Money	85
3.1.1	The Time Value of Money	86
3.1.2	Elements of Transactions Involving Interest	87
3.1.3	Methods of Calculating Interest	91
3.2	Economic Equivalence	94
3.2.1	Definition and Simple Calculations	94
3.2.2	Equivalence Calculations: General Principles	96
3.3	Development of Formulas for Equivalence Calculations	101
3.3.1	The Five Types of Cash Flows	101
3.3.2	Single-Cash-Flow Formulas	103
3.3.3	Equal-Payment Series	111
3.3.4	Linear-Gradient Series	123
3.3.5	Geometric Gradient Series	129
3.3.6	Irregular (Mixed) Payment Series	135
3.4	Unconventional Equivalence Calculations	141
3.4.1	Composite Cash Flows	141
3.4.2	Determining an Interest Rate to Establish Economic Equivalence	147
3.4.3	Unconventional Regularity in Cash Flow Pattern	149
	Summary	150
	Problems	151
	Short Case Studies	160

Chapter 4 Understanding Money and Its Management 162

4.1	Nominal and Effective Interest Rates	163
4.1.1	Nominal Interest Rates	164
4.1.2	Effective Annual Interest Rates	164
4.1.3	Effective Interest Rates per Payment Period	167
4.1.4	Continuous Compounding	169

4.2	Equivalence Calculations with Effective Interest Rates	171
4.2.1	When Payment Period is Equal to Compounding Period	171
4.2.2	Compounding Occurs at a Different Rate than That at Which Payments are Made	172
4.2.4	Compounding is Less Frequent than Payments	176
4.3	Equivalence Calculations with Continuous Compounding	180
4.3.1	Discrete-Payment Transactions with Continuous Compounding	180
4.3.2	Continuous-Funds Flow with Continuous Compounding	182
4.4	Changing Interest Rates	187
4.4.1	Single Sums of Money	187
4.4.2	Series of Cash Flows	189
4.5	Debt Management	190
4.5.1	Commercial Loans	190
4.5.2	Loan versus Lease Financing	198
4.5.3	Home Mortgage	202
4.6	Investing in Financial Assets	209
4.6.1	Investment Basics	209
4.6.2	How to Determine Your Expected Return	209
4.6.3	Investing in Bonds	212
	Summary	220
	Problems	221
	Short Case Studies	230

PART 2 EVALUATION OF BUSINESS AND ENGINEERING ASSETS 233

Chapter 5 Present-Worth Analysis 234

5.1	Describing Project Cash Flows	236
5.1.1	Loan versus Project Cash Flows	236
5.1.2	Independent versus Mutually Exclusive Investment Projects	239
5.2	Initial Project Screening Method	240
5.2.1	Payback Period: The Time It Takes to Pay Back	240
5.2.2	Benefits and Flaws of Payback Screening	243
5.2.3	Discounted Payback Period	243
5.2.4	Where Do We Go From Here?	244

5.3	Discounted Cash Flow Analysis	245
5.3.1	Net-Present-Worth Criterion	245
5.3.2	Meaning of Net Present Worth	249
5.3.3	Basis for Selecting the MARR	252
5.4	Variations of Present-Worth Analysis	253
5.4.1	Future-Worth Analysis	253
5.4.2	Capitalized Equivalent Method	256
5.5	Comparing Mutually Exclusive Alternatives	261
5.5.1	Meaning of Mutually Exclusive and “Do Nothing”	261
5.5.2	Service Projects versus Revenue Projects	262
5.5.3	Application of Investment Criteria	262
5.5.4	Scale of Investment	263
5.5.5	Analysis Period	265
5.5.6	Analysis Period Matches Project Lives	266
5.5.7	Analysis Period Differs from Project Lives	269
5.5.8	Analysis Period is Not Specified	276
	Summary	279
	Problems	280
	Short Case Studies	293

Chapter 6 Annual Equivalent-Worth Analysis 294

6.1	Annual Equivalent-Worth Criterion	296
6.1.1	Fundamental Decision Rule	296
6.1.2	Annual-Worth Calculation with Repeating Cash Flow Cycles	298
6.1.3	Comparing Mutually Exclusive Alternatives	300
6.2	Capital Costs Versus Operating Costs	303
6.3	Applying Annual-Worth Analysis	306
6.3.1	Benefits of AE Analysis	306
6.3.2	Unit Profit or Cost Calculation	306
6.3.3	Make-or-Buy Decision—Outsourcing Decisions	308
6.3.4	Pricing the Use of an Asset	311
6.4	Life-Cycle Cost Analysis	312
6.5	Design Economics	320
	Summary	331
	Problems	331
	Short Case Studies	342

Chapter 7 Rate-of-Return Analysis 346

7.1	Rate of Return	348
7.1.1	Return on Investment	348
7.1.2	Return on Invested Capital	350
7.2	Methods for Finding the Rate of Return	351
7.2.1	Simple versus Nonsimple Investments	351
7.2.2	Predicting Multiple i^* s	353
7.2.3	Computational Methods	356
7.3	Internal-Rate-of-Return Criterion	363
7.3.1	Relationship to PW Analysis	363
7.3.2	Net-Investment Test: Pure versus Mixed Investments	363
7.3.3	Decision Rule for Pure Investments	366
7.3.4	Decision Rule for Mixed Investments	368
7.3.5	Modified Internal Rate of Return (MIRR)	377
7.4	Mutually Exclusive Alternatives	379
7.4.1	Flaws in Project Ranking by IRR	379
7.4.2	Incremental Investment Analysis	380
7.4.3	Handling Unequal Service Lives	387
	Summary	390
	Problems	391
	Short Case Studies	405

PART 3 ANALYSIS OF PROJECT CASH FLOWS 409

Chapter 8 Cost Concepts Relevant to Decision Making 410

8.1	General Cost Terms	412
8.1.1	Manufacturing Costs	413
8.1.2	Nonmanufacturing Costs	414
8.2	Classifying Costs for Financial Statements	415
8.2.1	Period Costs	415
8.2.2	Product Costs	415
8.3	Cost Classification for Predicting Cost Behavior	418
8.3.1	Volume Index	419
8.3.2	Cost Behaviors	419
8.3.3	Cost–Volume–Profit Analysis	424

8.4	Future Costs for Business Decisions	429
8.4.1	Differential Cost and Revenue	429
8.4.2	Opportunity Cost	433
8.4.3	Sunk Costs	435
8.4.4	Marginal Cost	435
8.5	Estimating Profit from Operation	441
8.5.1	Calculation of Operating Income	441
8.5.2	Annual Sales Budget for a Manufacturing Business	441
8.5.3	Preparing the Annual Production Budget	442
8.5.4	Preparing the Cost-of-Goods-Sold Budget	444
8.5.5	Preparing the Nonmanufacturing Cost Budget	445
8.5.6	Putting It All Together: The Budgeted Income Statement	447
8.5.7	Looking Ahead	449
	Summary	449
	Problems	450
	Short Case Studies	453

Chapter 9 Depreciation and Corporate Taxes 456

9.1	Asset Depreciation	458
9.1.1	Economic Depreciation	459
9.1.2	Accounting Depreciation	460
9.2	Factors Inherent in Asset Depreciation	460
9.2.1	Depreciable Property	460
9.2.2	Cost Basis	461
9.2.3	Useful Life and Salvage Value	463
9.2.4	Depreciation Methods: Book and Tax Depreciation	464
9.3	Book Depreciation Methods	464
9.3.1	Straight-Line Method	465
9.3.2	Declining Balance Method	466
9.3.3	Units-of-Production Method	473
9.4	Tax Depreciation Methods	474
9.4.1	MACRS Depreciation	474
9.4.2	MACRS Depreciation Rules	476
9.5	Depletion	481
9.5.1	Cost Depletion	482
9.5.2	Percentage Depletion	482
9.6	Repairs or Improvements Made to Depreciable Assets	485
9.6.1	Revision of Book Depreciation	485
9.6.2	Revision of Tax Depreciation	485

9.7	Corporate Taxes	487
9.7.1	Income Taxes on Operating Income	487
9.8	Tax Treatment of Gains or Losses on Depreciable Assets	490
9.8.1	Disposal of a MACRS Property	490
9.8.2	Calculations of Gains and Losses on MACRS Property	490
9.9	Income Tax Rate to Be Used in Economic Analysis	496
9.9.1	Incremental Income Tax Rate	496
9.9.2	Consideration of State Income Taxes	499
9.10	The Need For Cash Flow in Engineering Economic Analysis	500
9.10.1	Net Income versus Net Cash Flow	501
9.10.2	Treatment of Noncash Expenses	501
	Summary	504
	Problems	506
	Short Case Studies	514

Chapter 10 Developing Project Cash Flows 516

10.1	Cost–Benefit Estimation for Engineering Projects	518
10.1.1	Simple Projects	518
10.1.2	Complex Projects	519
10.2	Incremental Cash Flows	520
10.2.1	Elements of Cash Outflows	520
10.2.2	Elements of Cash Inflows	522
10.2.3	Classification of Cash Flow Elements	522
10.3	Developing Cash Flow Statements	524
10.3.1	When Projects Require Only Operating and Investing Activities	524
10.3.2	When Projects Require Working-Capital Investments	528
10.3.3	When Projects are Financed with Borrowed Funds	533
10.3.4	When Projects Result in Negative Taxable Income	535
10.3.5	When Projects Require Multiple Assets	539
10.4	Generalized Cash-Flow Approach	543
10.4.1	Setting up Net Cash-Flow Equations	543
10.4.2	Presenting Cash Flows in Compact Tabular Formats	544
10.4.3	Lease-or-Buy Decision	547
	Summary	553
	Problems	554
	Short Case Studies	563

PART 4 HANDLING RISK AND UNCERTAINTY 567

Chapter 11 Inflation and Its Impact on Project Cash Flows 568

11.1	Meaning and Measure of Inflation	570
	11.1.1 Measuring Inflation	570
	11.1.2 Actual versus Constant Dollars	575
11.2	Equivalence Calculations Under Inflation	578
	11.2.1 Market and Inflation-Free Interest Rates	578
	11.2.2 Constant-Dollar Analysis	578
	11.2.3 Actual-Dollar Analysis	579
	11.2.4 Mixed-Dollar Analysis	583
11.3	Effects of Inflation on Project Cash Flows	583
	11.3.1 Multiple Inflation Rates	587
	11.3.2 Effects of Borrowed Funds Under Inflation	589
11.4	Rate-of-Return Analysis Under Inflation	592
	11.4.1 Effects of Inflation on Return on Investment	592
	11.4.2 Effects of Inflation on Working Capital	596
	Summary	598
	Problems	600
	Short Case Studies	605

Chapter 12 Project Risk and Uncertainty 608

12.1	Origins of Project Risk	610
12.2	Methods of Describing Project Risk	610
	12.2.1 Sensitivity (What-if) Analysis	611
	12.2.2 Break-Even Analysis	616
	12.2.3 Scenario Analysis	620
12.3	Probability Concepts for Investment Decisions	622
	12.3.1 Assessment of Probabilities	622
	12.3.2 Summary of Probabilistic Information	627
	12.3.3 Joint and Conditional Probabilities	630
	12.3.4 Covariance and Coefficient of Correlation	632
12.4	Probability Distribution of NPW	634
	12.4.1 Procedure for Developing an NPW Distribution	634
	12.4.2 Aggregating Risk over Time	639
	12.4.3 Decision Rules for Comparing Mutually Exclusive Risky Alternatives	645

12.5	Risk Simulation	649
12.5.1	Computer Simulation	649
12.5.2	Model Building	650
12.5.3	Monte Carlo Sampling	654
12.5.4	Simulation Output Analysis	659
12.5.5	Risk Simulation with Oracle Crystal Ball	661
12.6	Decision Trees and Sequential Investment Decisions	664
12.6.1	Structuring a Decision-Tree Diagram	665
12.6.2	Worth of Obtaining Additional Information	669
12.6.3	Decision Making after Having Imperfect Information	673
	Summary	678
	Problems	679
	Short Case Studies	689

Chapter 13 Real-Options Analysis 692

13.1	Risk Management: Financial Options	693
13.1.1	Features of Financial Options	694
13.1.2	Buy Call Options When You Expect the Price to Go Up	695
13.1.3	Buy Put Options When You Expect the Price to Go Down	697
13.2	Option Strategies	699
13.2.1	Buying Calls to Reduce Capital That is at Risk	699
13.2.2	Protective Puts as a Hedge	702
13.3	Option Pricing	705
13.3.1	Replicating-Portfolio Approach with a Call Option	705
13.3.2	Risk-Free Financing Approach	708
13.3.3	Risk-Neutral Probability Approach	709
13.3.4	Put-Option Valuation	711
13.3.5	Two-Period Binomial Lattice Option Valuation	712
13.3.6	Multiperiod Binomial Lattice Model	713
13.3.7	Black–Scholes Option Model	716
13.4	Real-Options Analysis	718
13.4.1	How is Real Options Analysis Different?	718
13.4.2	A Conceptual Framework for Real Options in Engineering Economics	719
13.5	Simple Real-Option Models	724
13.5.1	Option to Defer Investment	724
13.5.2	Patent and License Valuation	727
13.5.3	Growth Option—Option to Expand	728

13.5.4	Scale-Up Option	730
13.5.5	Compound Options	733
13.6	Estimating Volatility at the Project Level	739
13.6.1	Mathematical Relationship between σ and σ_T	739
13.6.2	Estimating V_T Distribution	740
	Summary	746
	Problems	747
	Short Case Studies	751

PART 5 SPECIAL TOPICS IN ENGINEERING ECONOMICS 755

Chapter 14 Replacement Decisions 756

14.1	Replacement Analysis Fundamentals	757
14.1.1	Basic Concepts and Terminology	758
14.1.2	Opportunity Cost Approach to Comparing Defender and Challenger	760
14.2	Economic Service Life	763
14.3	Replacement Analysis when the Required Service is Long	768
14.3.1	Required Assumptions and Decision Frameworks	769
14.3.2	Replacement Strategies under the Infinite Planning Horizon	771
14.3.3	Replacement Strategies under the Finite Planning Horizon	776
14.3.4	Consideration of Technological Change	780
14.4	Replacement Analysis with Tax Considerations	780
	Summary	794
	Problems	795
	Short Case Studies	805

Chapter 15 Capital-Budgeting Decisions 810

15.1	Methods of Financing	812
15.1.1	Equity Financing	812
15.1.2	Debt Financing	814
15.1.3	Capital Structure	816
15.2	Cost of Capital	820
15.2.1	Cost of Equity	821
15.2.2	Cost of Debt	826
15.2.3	Calculating the Cost of Capital	827

15.3	Choice of Minimum Attractive Rate of Return	829
15.3.1	Choice of MARR when Project Financing is Known	829
15.3.2	Choice of MARR when Project Financing is Unknown	831
15.3.3	Choice of MARR under Capital Rationing	833
15.4	Capital Budgeting	837
15.4.1	Evaluation of Multiple Investment Alternatives	837
15.4.2	Formulation of Mutually Exclusive Alternatives	838
15.4.3	Capital-Budgeting Decisions with Limited Budgets	839
	Summary	847
	Problems	848
	Short Case Studies	852

Chapter 16 Economic Analysis in the Service Sector 858

16.1	What Is The Service Sector?	860
16.1.1	Characteristics of the Service Sector	860
16.1.2	Difficulty of Pricing Service	861
16.2	Economic Analysis in The Public Sector	862
16.2.1	What is Benefit–Cost Analysis?	863
16.2.2	Framework of Benefit–Cost Analysis	863
16.2.3	Valuation of Benefits and Costs	864
16.2.4	Quantifying Benefits and Costs	866
16.2.5	Difficulties Inherent in Public Project Analysis	871
16.3	Benefit–Cost Ratios	872
16.3.1	Definition of Benefit–Cost Ratio	872
16.3.2	Profitability Index (Net B/C Ratio)	875
16.3.2	Relationship Among B/C Ratio, Profitability Index, and NPW	876
16.3.4	Comparing Mutually Exclusive Alternatives: Incremental Analysis	877
16.4	Analysis of Public Projects Based on Cost-Effectiveness	881
16.4.1	Cost-Effectiveness Studies in the Public Sector	881
16.4.2	A Cost-Effectiveness Case Study	882
16.5	Economic Analysis in Health-Care Service	890
16.5.1	Economic Evaluation Tools	890
16.5.2	Cost–Effectiveness Analysis in the Healthcare Sector	891
16.5.3	Cost-Utility Analysis	896
	Summary	899
	Problems	900
	Short Case Studies	904

Appendix A	Fundamentals of Engineering Review Questions	911
Appendix B	Interest Factors for Discrete Compounding	931
Appendix C	Values of the Standard Normal Distribution Function	961
Index		965

PREFACE

What is “Contemporary” About Engineering Economics?

Decisions made during the engineering design phase of product development determine the majority of the costs associated with the manufacturing of that product (some say that this value may be as high as 85%). As design and manufacturing processes become more complex, engineers are making decisions that involve money more than ever before. Thus, the competent and successful engineer in the twenty-first century must have an improved understanding of the principles of science, engineering, and economics, coupled with relevant design experience. Increasingly, in the new world economy, successful businesses will rely on engineers with such expertise.

Economic and design issues are inextricably linked in the product/service life cycle. Therefore, one of my strongest motivations for writing this text was to bring the realities of economics and engineering design into the classroom and to help students integrate these issues when contemplating many engineering decisions. Of course, my underlying motivation for writing this book was not simply to address contemporary needs, but to address as well the ageless goal of all educators: to help students to learn. Thus, thoroughness, clarity, and accuracy of presentation of essential engineering economics were my aim at every stage in the development of the text.

New to the Sixth Edition

Much of the content has been streamlined to provide materials in depth and to reflect the challenges in contemporary engineering economics. Some of the highlighted changes are as follows:

- All the chapter opening vignettes—a trademark of *Contemporary Engineering Economics*—have been updated or completely replaced with more current and thought-provoking issues. Selection of vignettes reflects the important segment of global economy in terms of variety and scope of business as well. With more than 80% of the total GDP (Gross Domestic Product) in the United States provided by the service sector, engineers work on various economic decision problems in the service sector as well. For this reason, many engineering economic decision problems from the service sector are presented in this sixth edition.
- Excel spreadsheet modeling techniques are incorporated into various economic decision problems to provide many “what-if” solutions to key decision problems.
- About 20% of end-of-chapter problems are either new or revised. There are a total of 618 end-of-chapter problems and 65 short case-study questions. There are also 196 fully worked-out examples and 40 carefully selected and fully worked out Fundamentals of Engineering Exam Review Questions in Appendix A.

Chapter Opening Vignettes				
Chapters	Vignettes	Company	Sector	Industry
1	• Electric vehicles	Tesla	Consumer Goods	Auto Manufacturers
2	• Communication chips	Broadcom	Technology	Semiconductor—Integrated Circuits
3	• Powerball—Lottery winning	Cindy and Mark Hill	Services	Lottery
4	• Financing home mortgage	Personal Finance	Financial	Banking/Housing
5	• Football stadium expansion	University of Colorado	Services	Sports
6	• Industrial robots	Delta	Industrial	Manufacturing
7	• Investment in antique car	Personal	Personal	Automobile
8	• iPhone manufacturing	Apple	Consumer Goods	Electronic Equipment
9	• Airline baggage handling	Delta Airlines	Services	Airlines
10	• Aircraft manufacturing	Eclipse	Industrial Goods	Aerospace
11	• Big Mac index	Personal	Services	Restaurants
12	• Aluminum auto body	Alcoa	Basic Materials	Aluminum
13	• Insurance	Personal	Services	Travel
14	• Replacing absorption chiller	UCSF Medical Center	Healthcare	Hospitals
15	• Capital budgeting	Laredo Petroleum	Energy	Oil drilling
16	• Auto inspection program	State of Pennsylvania	Public	Government

- Some other specific changes in each chapter are summarized as follows:

Chapters	
1	• Revised Section 1.3 by providing one of contemporary issues—electric vehicle and battery manufacturing.
2	• Replaced all financial analyses (including financial ratios) based on the financial statements by Broadcom Corporation. • Provided two chapter examples and solutions to improve the understanding of financial analysis.
3	• Redesigned all Excel worksheets to take advantage of its financial functions in solving various economic equivalence problems.

Chapters	
4	<ul style="list-style-type: none"> • Revised Section 4.3.2 to enhance the understanding of continuous-funds flow with continuous compounding. • Revised Section 4.6.3 to reflect the current bond market.
5	<ul style="list-style-type: none"> • Revised all Excel worksheets. • Streamlined the presentation.
6	<ul style="list-style-type: none"> • Revised Section 6.3.3 with a new make-buy example. • Introduced a new example of HVAC retrofit life-cycle-costing analysis.
7	<ul style="list-style-type: none"> • Created a new section (7.3.5) on modified internal rate of return.
8	<ul style="list-style-type: none"> • Streamlined the presentation. • Updated all data related to cost of owning and operating a vehicle.
9	<ul style="list-style-type: none"> • Updated tax information. • Updated all Excel worksheets of generating depreciation schedules.
10	<ul style="list-style-type: none"> • Revised all cash flow statement tables by using Excel.
11	<ul style="list-style-type: none"> • Updated all data related to consumer price index as well as other cost data to reflect the current trend in inflation as well as deflation in various economic sectors. • Revised all cash flow statements by using Excel.
12	<ul style="list-style-type: none"> • Revised Excel worksheet related to sensitivity analysis.
13	<ul style="list-style-type: none"> • Revised all financial options examples by providing many graphical illustrations to explain complex conceptual financial as well as real option problems. • Extended Example 13.14 on how to estimate project volatility.
14	<ul style="list-style-type: none"> • Created a new graphical chart (Figure 14.8) to facilitate the understanding of overall replacement strategies under infinite planning horizon.
15	<ul style="list-style-type: none"> • Created a new figure (Figure 15.1) to illustrate the capital structure of a typical firm. • Extended Section 15.4.3 to include an example on how to find the optimal capital budget if projects cannot be accepted in part (Example 15.12).
16	<ul style="list-style-type: none"> • Streamlined the presentation. • Provide a new detailed vehicle inspection program on cost-benefit analysis. • Added a new section (16.5.3) on cost-utility analysis to improve the pedagogical aspect of healthcare decisions.

Overview of the Text

Although it contains little advanced math and few truly difficult concepts, the introductory engineering economics course is often curiously challenging for the sophomores, juniors, and seniors. There are several likely explanations for this difficulty.

- The course is the student's first analytical consideration of money (a resource with which he or she may have had little direct control beyond paying for tuition, housing, food, and textbooks).

- The emphasis on theory may obscure the fact that the course aims, among other things, to develop a very practical set of analytical tools for measuring project worth. This is unfortunate since, at one time or another, virtually every engineer—not to mention every individual—is responsible for the wise allocation of limited financial resources.
- The mixture of industrial, civil, mechanical, electrical, and manufacturing engineering students, as well as other undergraduates who take the course, often fail to “see themselves” using in the skills the course and text are intended to foster. This is perhaps less true for industrial engineering students for whom many texts take as their primary audience. But other disciplines are often motivationally shortchanged by a text’s lack of applications that appeal directly to their students.

Goal of the Text

This text aims not only to provide sound and comprehensive coverage of the concepts of engineering economic but also aims to address the difficulties of students as outlined previously, all of which have their basis in inattentiveness to the practical concerns of engineering economics. More specifically, this text has the following chief goals:

- To build a thorough understanding of the theoretical and conceptual basis upon which the practice of financial project analysis is built.
- To satisfy the very practical needs of the engineer toward making informed financial decisions when acting as a team member or project manager for an engineering project.
- To incorporate all critical decision-making tools—including the most contemporary, computer-oriented ones that engineers bring to the task of making informed financial decisions.
- To appeal to the full range of engineering disciplines for which this course is often required: industrial, civil, mechanical, electrical, computer, aerospace, chemical, and manufacturing engineering, as well as engineering technology.

Prerequisites

The text is intended for undergraduate engineering students at the sophomore level or above. The only mathematical background required is elementary calculus. For Chapters 12 and 13, a first course in probability or statistics is helpful but not necessary, since the treatment of basic topics there is essentially self-contained.

Taking Advantage of the Internet

The integration of computer use is another important feature of *Contemporary Engineering Economics*. Students have greater access to and familiarity with the various spreadsheet tools and instructors have greater inclination either to treat these topics explicitly in the course or to encourage students to experiment independently.

A remaining concern is that the use of computers will undermine true understanding of course concepts. This text does not promote the use of trivial spreadsheet applications as a replacement for genuine understanding of and skill in applying traditional solution methods. Rather, it focuses on the computer’s productivity-enhancing benefits for complex

project cash flow development and analysis. For spreadsheet coverage, the emphasis is on demonstrating a chapter concept that embodies some complexity that can be much more efficiently resolved on a computer than by traditional long-hand solutions.

MyEngineeringLab™

- MyEngineeringLab is now available with *Contemporary Engineering Economics*, Sixth Edition 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: MyEngineeringLab means less time grading and more time teaching.
- Algorithmic-generated homework assignments, quizzes, and tests that directly correlate to the textbook.
- Automatic grading that tracks students' results.
- Learning Objectives mapped to ABET outcomes provide comprehensive reporting tools. If adopted, access to MyEngineeringLab can be bundled with the book or purchased separately.

Resources for Instructors and Students

- MyEngineeringLab, myengineeringlab.com, which is also available as MyEngineeringLab with Pearson eText, a complete online version of the book. It allows highlighting, note taking, and search capabilities.
- Excel files of selected example problems from the text as well as end-of-chapter problems.
- Instructor's Solutions Manual in both WORD and PDF versions.
- PowerPoint lecture notes.

Acknowledgments

This book reflects the efforts of a great many individuals over a number of years. In particular, I would like to recognize the following individuals, whose reviews and comments on prior editions have contributed to this edition. Once again, I would like to thank each of them:

Kamran Abedini, *California Polytechnic—Pomona*
 James Alloway, *Syracuse University*
 Mehar Arora, *U. Wisconsin—Stout*
 Joel Arthur, *California State University—Chico*
 Robert Baker, *University of Arizona*
 Robert Barrett, *Cooper Union and Pratt Institute*
 Tom Barta, *Iowa State University*
 Charles Bartholomew, *Widener University*
 Richard Bernhard, *North Carolina State University*
 Bopaya Bidanda, *University of Pittsburgh*

James Buck, *University of Iowa*
Philip Cady, *The Pennsylvania State University*
Tom Carmichal, *Southern College of Technology*
Jeya Chandra, *The Pennsylvania State University*
Max C. Deibert, *Montana State University*
Stuart E. Dreyfus, *University of California–Berkeley*
Philip A. Farrington, *University of Alabama at Huntsville*
W.J. Foley, *RPI*
Jane Fraser, *University of Southern Colorado*
Terry L. Friesz, *Penn State University*
Anil K. Goyal, *RPI*
R. Michael Harnett, *Kansa State University*
Bruce Hartsough, *University of California–Davis*
Carl Hass, *University of Texas–Austin*
John Held, *Kansas State University*
T. Allen Henry, *University of Alabama*
R.C. Hodgson, *University of Notre Dame*
Scott Iverson, *University of Washington*
Peter Jackson, *Cornell University*
Philip Johnson, *University of Minnesota*
Harold Josephs, *Lawrence Tech*
Henry Kallsen, *University of Alabama*
Alla Kammerdiner, *Arizona State University*
W.J. Kennedy, *Clemson University*
Oh Keytack, *University of Toledo*
Wayne Knabach, *South Dakota State University*
Bahattin Koc, *University of Buffalo*
Stephen Kreta, *California Maritime Academy*
John Krogman, *University of Wisconsin–Platteville*
Dennis Kroll, *Bradley University*
Michael Kyte, *University of Idaho*
Gene Lee, *University of Central Florida*
William Lesso, *University of Texas–Austin*
Martin Lipinski, *Memphis State University*
Robert Lundquist, *Ohio State University*
Richard Lyles, *Michigan State University*
Gerald T. Mackulak, *Arizona State University*
Abu S. Masud, *The Wichita State University*
Sue McNeil, *Carnegie-Mellon University*
James Milligan, *University of Idaho*
Richard Minesinger, *University of Massachusetts–Lowell*
Gary Moynihan, *The University of Alabama*
Kumar Muthuraman, *University of Texas*
James S. Noble, *University of Missouri–Columbia*
Michael L. Nobs, *Washington University–St. Louis*
Kurt Norlin, *Laurel Tech Integrated Publishing Solutions*
Peter O’Grady, *University of Iowa*
Wayne Parker, *Mississippi State University*

Elizabeth Pate-Cornell, *Stanford University*
 Cecil Peterson, *GMI*
 George Prueitt, *U.S. Naval Postgraduate School*
 J.K. Rao, *California State University—Long Beach*
 Susan Richards, *GMI*
 Bruce A. Reichert, *Kansas State University*
 Mark Roberts, *Michigan Tech*
 John Roth, *Vanderbilt University*
 Stan Settle, *University of Southern California*
 Paul L. Schillings, *Montana State University*
 Bill Shaner, *Colorado State University*
 Fred Sheets, *California Polytechnic—Pomona*
 Dean Shup, *University of Cincinnati*
 David Sly, *Iowa State University*
 Milton Smith, *Texas Tech*
 Stephen V. Smith, *Drexel University*
 David C. Slaughter, *University of California—Davis*
 Charles Stavridge, *FAMU/FSU*
 Junius Storry, *South Dakota State University*
 Frank E. Stratton, *San Diego State University*
 George Stukhart, *Texas A&M University*
 Donna Summers, *University of Dayton*
 Joe Tanchoco, *Purdue University*
 Deborah Thurston, *University of Illinois at Urbana-Champaign*
 Lt. Col. James Treharne, *U.S. Army*
 L. Jackson Turaville, *Tennessee Technological University*
 Theo De Winter, *Boston University*
 Yoo Yang, *Cal Poly State University*

Special Acknowledgment

Personally, I wish to thank Professor Stan Settle of University of Southern California for his inputs to the sixth edition with a detailed list of suggestions for improvement. My special thanks are due to Kyongsun Kim, who served as an accuracy checker for many solutions to the end-of-chapter problems. Her technical knowledge as well as pointed comments improved the solutions manual in many directions. I would also like to thank Erin Ault, Program Manager at Pearson, who assumed responsibility for the overall project and Rose Kernan, my production editor at RPK Editorial Services, Inc., who oversaw the entire book production.

CHAN S. PARK
 AUBURN, ALABAMA

Global Edition Contributors and Reviewers

Pearson wishes to thank and acknowledge the following people for their work on the Global Edition:

Contributor and Reviewer

Anupam De, *National Institute of Technology, Durgapur*

Contributor

Abhik Kumar Mukherjee, *University of Burdwan*

Reviewers

Pradip Banerjee, *Indian Institute of Management, Indore*

Soheli Ghose, *St. Xavier's College, Kolkata*

Gagari Chakrabarti, *Presidency University, Kolkata*

CONTEMPORARY ENGINEERING ECONOMICS

Sixth Edition

Global Edition

This page intentionally left blank