SEVENTH EDITION

ENGINEERING ECONOMY

LELAND BLANK · ANTHONY TARQUIN

Seventh Edition

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PREFACE TO SEVENTH EDITION

This edition includes the time-tested approach and topics of previous editions and introduces significantly new print and electronic features useful to learning about and successfully applying the exciting field of engineering economics. Money makes a huge difference in the life of a corporation, an individual, and a government. Learning to understand, analyze, and manage the money side of any project is vital to its success. To be professionally successful, every engineer must be able to deal with the time value of money, economic facts, inflation, cost estimation, tax considerations, as well as spreadsheet and calculator use. This book is a great help to the learner and the instructor in accomplishing these goals by using easy-to-understand language, simple graphics, and online features.

What's New and What's Best ● ● ●

This seventh edition is full of new information and features. Plus the supporting online materials are new and updated to enhance the teaching and learning experience.

New topics:

- **Ethics** and the economics of engineering
- **Service sector projects** and their evaluation
- **Real options** development and analysis
- **Value-added taxes** and how they work
- **Multiple rates of return** and ways to eliminate them using spreadsheets
- **No tabulated factors** needed for equivalence computations (Appendix D)

New features in print and online:

- **Totally new design** to highlight important terms, concepts, and decision guidelines
- **Progressive examples** that continue throughout a chapter
- **Downloadable online presentations** featuring voice-over slides and animation
- **Vital concepts and guidelines** identified in margins; brief descriptions available (Appendix E)
- **Fresh spreadsheet displays** with on-image comments and function details
- **Case studies** (21 of them) ranging in topics from ethics to energy to simulation

Retained features:

- **Many end-of-chapter problems** (over 90% are new or revised)
- **Easy-to-read language** to enhance understanding in a variety of course environments
- **Fundamentals of Engineering (FE) Exam** review questions that double as additional or review problems for quizzes and tests
- **Hand and spreadsheet solutions** presented for many examples
- **Flexible chapter ordering** after fundamental topics are understood
- **Complete solutions manual** available online (with access approval for instructors)

How to Use This Text ● ● ●

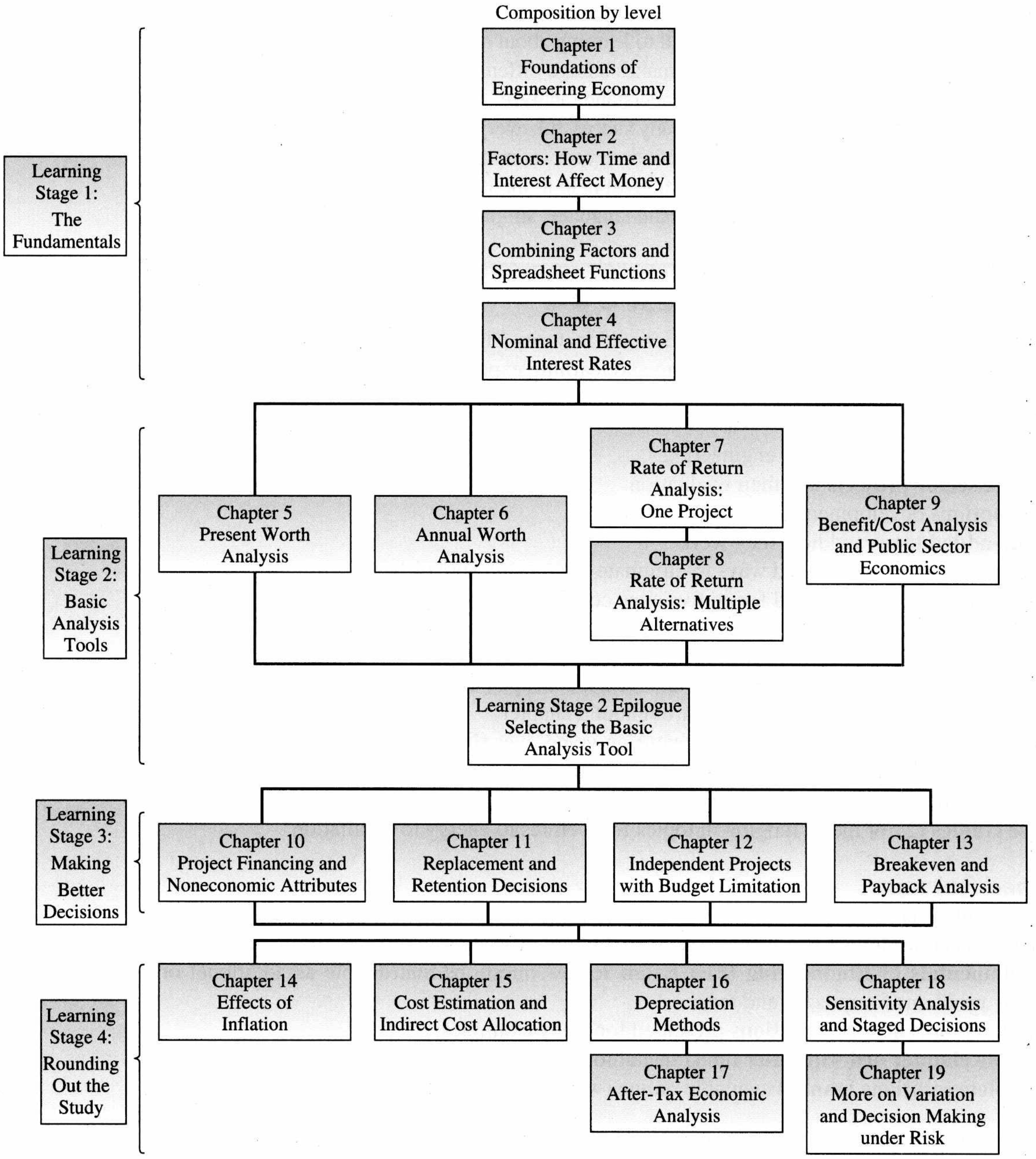
This textbook is best suited for a one-semester or one-quarter undergraduate course. Students should be at the sophomore level or above with a basic understanding of engineering concepts and terminology. A course in calculus is not necessary; however, knowledge of the concepts in advanced mathematics and elementary probability will make the topics more meaningful.

Practitioners and professional engineers who need a refresher in economic analysis and cost estimation will find this book very useful as a reference document as well as a learning medium.

Chapter Organization and Coverage Options ● ● ●

The textbook contains 19 chapters arranged into four learning stages, *as indicated in the flowchart* on the next page, and five appendices. Each chapter starts with a statement of purpose and a specific learning outcome (ABET style) for each section. Chapters include a summary, numerous

CHAPTERS IN EACH LEARNING STAGE



end-of-chapter problems (essay and numerical), multiple-choice problems useful for course review and FE Exam preparation, and a case study.

The appendices are important elements of learning for this text:

Appendix A Spreadsheet layout and functions (Excel is featured)

Appendix B Accounting reports and business ratios

Appendix C Code of Ethics for Engineers (from NSPE)

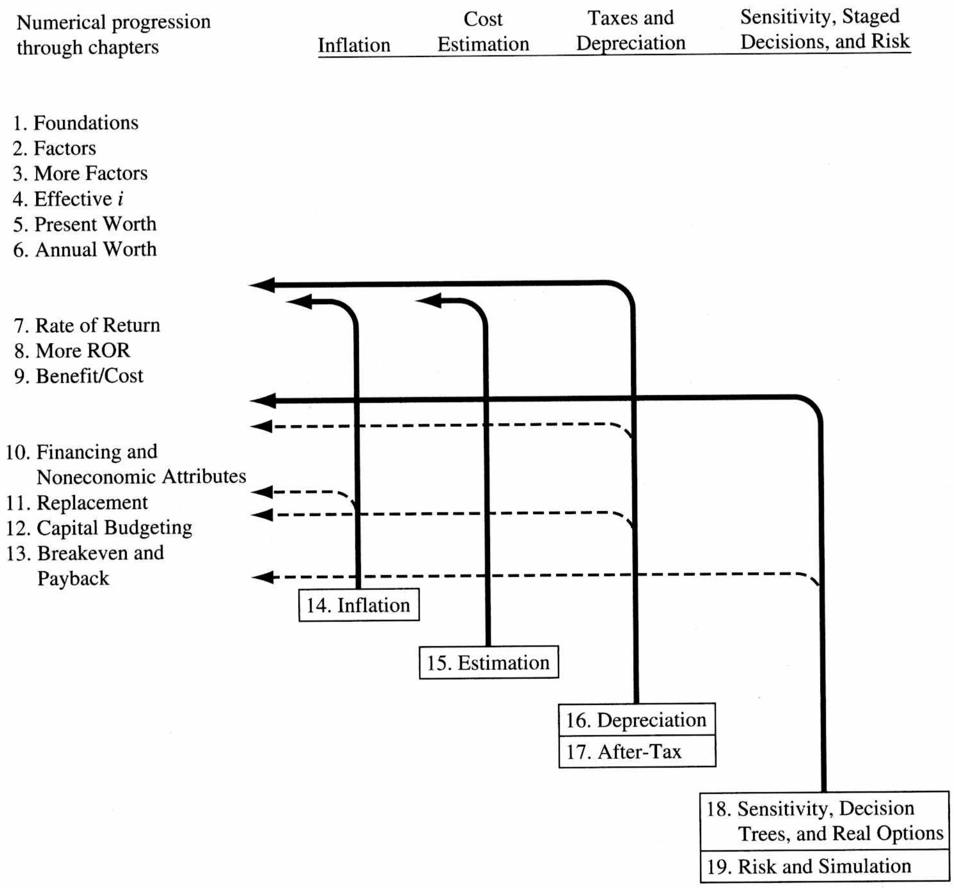
Appendix D Equivalence computations using calculators and geometric series; no tables

Appendix E Concepts, guidelines, terms, and symbols for engineering economics

There is considerable flexibility in the sequencing of topics and chapters once the first six chapters are covered, *as shown in the progression graphic* on the next page. If the course is designed to emphasize sensitivity and risk analysis, Chapters 18 and 19 can be covered immediately

CHAPTER AND TOPIC PROGRESSION OPTIONS

Topics may be introduced at the point indicated or any point thereafter
(Alternative entry points are indicated by ◄– – –)



after Learning Stage 2 (Chapter 9) is completed. If depreciation and tax emphasis are vitally important to the goals of the course, Chapters 16 and 17 can be covered once Chapter 6 (annual worth) is completed. The progression graphic can help in the design of the course content and topic ordering.

SAMPLE OF RESOURCES FOR

LEARNING OUTCOMES

Each chapter begins with a purpose, list of topics, and learning outcomes (ABET style) for each corresponding section. This behavioral-based approach sensitizes the reader to what is ahead, leading to improved understanding and learning.

LEARNING OUTCOMES

Purpose: Use multiple factors and spreadsheet functions to find equivalent amounts for cash flows that have nonstandard placement.

SECTION	TOPIC	LEARNING OUTCOME
3.1	Shifted series	• Determine the *P*, *F* or *A* values of a series starting at a time other than period 1.
3.2	Shifted series and single cash flows	• Determine the *P*, *F*, or *A* values of a shifted series and randomly placed single cash flows.
3.3	Shifted gradients	• Make equivalence calculations for shifted arithmetic or geometric gradient series that increase or decrease in size of cash flows.

CONCEPTS AND GUIDELINES

Time value of money

It is a well-known fact that money **makes** money. The time value of money explains the change in the amount of money **over time** for funds that are owned (invested) or owed (borrowed). This is the most important concept in engineering economy.

To highlight the fundamental building blocks of the course, a checkmark and title in the margin call attention to particularly important concepts and decision-making guidelines. Appendix E includes a brief description of each fundamental concept.

IN-CHAPTER EXAMPLES

Numerous in-chapter examples throughout the book reinforce the basic concepts and make understanding easier. Where appropriate, the example is solved using separately marked hand and spreadsheet solutions.

EXAMPLE 4.6

A dot-com company plans to place money in a new venture capital fund that currently returns 18% per year, compounded daily. What effective rate is this (*a*) yearly and (*b*) semiannually?

Solution

(*a*) Use Equation [4.7], with $r = 0.18$ and $m = 365$.

$$\text{Effective } i\% \text{ per year} = \left(1 + \frac{0.18}{365}\right)^{365} - 1 = 19.716\%$$

(*b*) Here $r = 0.09$ per 6 months and $m = 182$ days.

$$\text{Effective } i\% \text{ per 6 months} = \left(1 + \frac{0.09}{182}\right)^{182} - 1 = 9.415\%$$

PROGRESSIVE EXAMPLES

Several chapters include a progressive example—a more detailed problem statement introduced at the beginning of the chapter and expanded upon throughout the chapter in specially marked examples. This approach illustrates different techniques and some increasingly complex aspects of a real-world problem.

PE

Water for Semiconductor Manufacturing Case: The worldwide contribution of semiconductor sales is about $250 billion per year, or about 10% of the world's GDP (gross domestic product). This industry produces the microchips used in many of the communication, entertainment, transportation, and computing devices we use every day. Depending upon the type and size of fabrication plant (fab), the need for ultrapure water (UPW) to manufacture these tiny integrated circuits is high, ranging from 500 to 2000 gpm (gallons per minute). Ultrapure water is obtained by special processes that commonly include reverse osmosis/deionizing resin bed technologies. Potable water obtained from purifying seawater or brackish groundwater may cost from $2 to $3 per 1000 gallons, but to obtain UPW on-site for semiconductor manufacturing may cost an additional $1 to $3 per 1000 gallons.

A fab costs upward of $2.5 billion to construct, with approximately 1% of this total, or $25 million, required to provide the ultrapure water needed, including the necessary wastewater and recycling equipment.

A newcomer to the industry, Angular Enterprises, has estimated the cost profiles for two options to supply its anticipated fab with water. It is fortunate to have the option of desalinated seawater or purified groundwater sources in the location chosen for its new fab. The initial cost estimates for the UPW system are given below.

Source	Seawater (S)	Groundwater (G)
Equipment first cost, $M	−20	−22
AOC, $M per year	−0.5	−0.3
Salvage value, % of first cost	5	10
Cost of UPW, $ per 1000 gallons	4	5

Angular has made some initial estimates for the UPW system.

Life of UPW equipment	10 years
UPW needs	1500 gpm
Operating time	16 hours per day for 250 days per year

This case is used in the following topics (Sections) and problems of this chapter:

PW analysis of equal-life alternatives (Section 5.2)

PW analysis of different-life alternatives (Section 5.3)

Capitalized cost analysis (Section 5.5)

Problems 5.20 and 5.34

INSTRUCTORS AND STUDENTS

ONLINE PRESENTATIONS

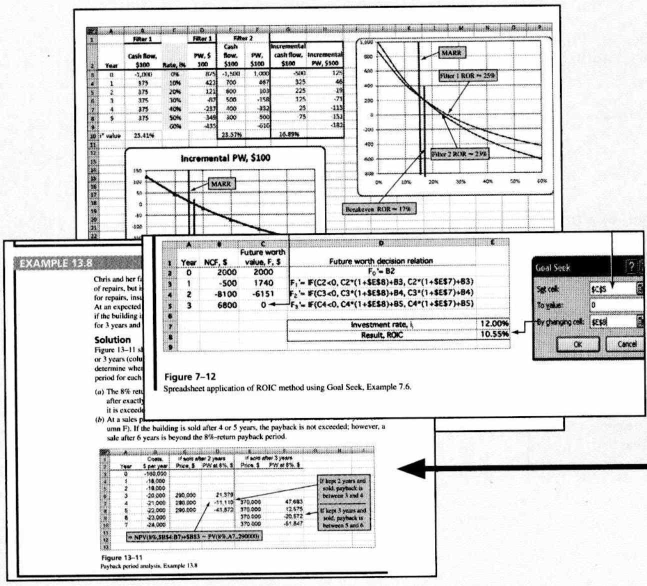
An icon in the margin indicates the availability of an animated voice-over slide presentation that summarizes the material in the section and provides a brief example for learners who need a review or prefer video-based materials. Presentations are keyed to the sections of the text.

3.1 Calculations for Uniform Series That Are Shifted ● ● ●

Online Presentation

When a uniform series begins at a time other than at the end of period 1, it is called a **shifted series**. In this case several methods can be used to find the equivalent present worth P. For example, P of the uniform series shown in Figure 3–1 could be determined by any of the following methods:

- Use the P/F factor to find the present worth of each disbursement at year 0 and add them.
- Use the F/P factor to find the future worth of each disbursement in year 13, add them, and then find the present worth of the total, using $P = F(P/F,i,13)$.
- Use the F/A factor to find the future amount $F = A(F/A,i,10)$, and then compute the present worth, using $P = F(P/F,i,13)$.
- Use the P/A factor to compute the "present worth" $P_3 = A(P/A,i,10)$ (which will be located in year 3, not year 0), and then find the present worth in year 0 by using the $(P/F,i,3)$ factor.



SPREADSHEETS

The text integrates spreadsheets to show how easy they are to use in solving virtually any type of engineering economic analysis problem. Cell tags or full cells detail built-in functions and relations developed to solve a specific problem.

FE EXAM AND COURSE REVIEWS

Each chapter concludes with several multiple-choice, FE Exam–style problems that provide a simplified review of chapter material. Additionally, these problems cover topics for test reviews and homework assignments.

ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

8.38 When conducting a rate of return (ROR) analysis involving multiple mutually exclusive alternatives, the first step is to:
(*a*) Rank the alternatives according to decreasing initial investment cost
(*b*) Rank the alternatives according to increasing initial investment cost
(*c*) Calculate the present worth of each alternative using the MARR
(*d*) Find the LCM between all of the alternatives

8.39 In comparing mutually exclusive alternatives by the ROR method, you should:
(*a*) Find the ROR of each alternative and pick the one with the *highest* ROR

8.43 For these alternatives, the sum of the incremental cash flows is:

Year	A	B
0	−10,000	−14,000
1	+2,500	+4,000
2	+2,500	+4,000
3	+2,500	+4,000
4	+2,500	+4,000
5	+2,500	+4,000

(*a*) $2500
(*b*) $3500
(*c*) $6000
(*d*) $8000

CASE STUDY

RENEWABLE ENERGY SOURCES FOR ELECTRICITY GENERATION

Background

Pedernales Electric Cooperative (PEC) is the largest member-owned electric co-op in the United States with over 232,000 meters in 12 Central Texas counties. PEC has a capacity of approximately 1300 MW (megawatts) of power, of which 277 MW, or about 21%, is from renewable sources. The latest addition is 60 MW of power from a wind farm in south Texas close to the city of Corpus Christi. A constant question is how much of PEC's generation capacity should be from renewable sources, especially given the environmental issues with coal-generated electricity and the rising costs of hydrocarbon fuels.

Wind and nuclear sources are the current consideration for the PEC leadership as Texas is increasing its generation by nuclear power and the state is the national leader in wind farm–produced electricity.

Consider yourself a member of the board of directors of PEC. You are an engineer who has been newly elected by the PEC membership to serve a 3-year term as a director-at-large. As such, you do not represent a specific district within the entire service area; all other directors do represent a specific district. You have many questions about the operations of PEC, plus you are interested in the economic and societal benefits of pursuing more renewable source generation capacity.

Information

Here are some data that you have obtained. The information is sketchy, as this point, and the numbers are very approximate. Electricity generation cost estimates are national in scope, not PEC-specific, and are provided in cents per kilowatt-hour (¢/kWh).

	Generation Cost, ¢/kWh	
Fuel Source	**Likely Range**	**Reasonable Average**
Coal	4 to 9	7.4
Natural gas	4 to 10.5	8.6
Wind	4.8 to 9.1	8.2
Solar	4.5 to 15.5	8.8

National average cost of electricity to residential customers: 11¢/kWh

PEC average cost to residential customers: 10.27 ¢/kWh (from primary sources) and 10.92 ¢/kWh (renewable sources)

Expected life of a generation facility: 20 to 40 years (it is likely closer to 20 than 40)

Time to construct a facility: 2 to 5 years

Capital cost to build a generation facility: $900 to $1500 per kW

You have also learned that the PEC staff uses the well-recognized *levelized energy cost* (LEC) method to determine the price of electricity that must be charged to customers to break even. The formula takes into account the capital cost of the generation facilities, the cost of capital of borrowed money, annual maintenance and operation (M&O) costs, and the expected life of the facility. The LEC formula, expressed in dollars per kWh for ($t = 1, 2, \ldots, n$), is

$$\text{LEC} = \frac{\displaystyle\sum_{t=1}^{t=n} \frac{P_t + A_t + C_t}{(1+i)^t}}{\displaystyle\sum_{t=1}^{t=n} \frac{E_t}{(1+i)^t}}$$

where P_t = capital investments made in year t
A_t = annual maintenance and operating (M&O) costs for year t
C_t = fuel costs for year t
E_t = amount of electricity generated in year t
n = expected life of facility
i = discount rate (cost of capital)

Case Study Exercises

1. If you wanted to know more about the new arrangement with the wind farm in south Texas for the additional 60 MW per year, what types of questions would you ask of a staff member in your first meeting with him or her?
2. Much of the current generation capacity of PEC facilities utilizes coal and natural gas as the primary fuel source. What about the ethical aspects of the government's allowance for these plants to continue polluting the atmosphere with the emissions that may cause health problems for citizens and further the effects of global warming? What types of regulations, if any, should be developed for PEC (and other generators) to follow in the future?

CASE STUDIES

New and updated case studies at the end of most chapters present real-world, in-depth treatments and exercises in the engineering profession. Each case includes a background, relevant information, and an exercise section.

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If you discover errors that require correction in the next printing of the textbook or in updates of the online resources, please contact us. We hope you find the contents of this edition helpful in your academic and professional activities.

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