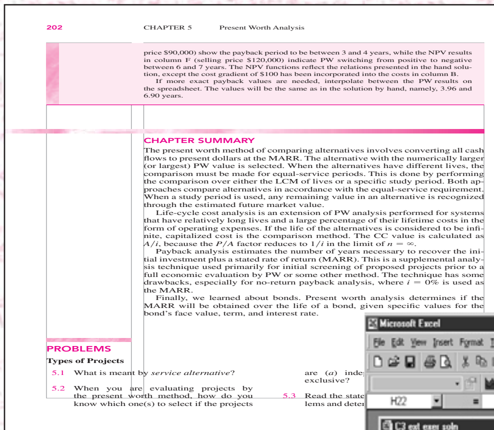
GUIDED TOUR

CHAPTER EXAMPLES AND EXERCISES

Users of this book have numerous ways to reinforce the concepts they've learned. The end-of-chapter *problems, in-chapter examples, extended exercises, case studies, and FE (Fundamentals of Engineering) review problems* offer students the opportunity to learn economic analysis in a variety of ways. The various exercises range from working relatively simple, one-step review problems to answering a series of comprehensive, in-depth questions based on real-world cases. In-chapter examples are also helpful in reinforcing concepts learned.



202 CHAPTER 5 Present Worth Analysis

price $90,000) show the payback period to be between 3 and 4 years, while the NPV results in column F (selling price $120,000) indicate PW switching from positive to negative between 6 and 7 years. The NPV functions reflect the relations presented in the hand solution, except the cost gradient of $100 has been incorporated into the costs in column B.

If more exact payback values are needed, interpolate between the PW results on the spreadsheet. The values will be the same as in the solution by hand, namely, 3.96 and 6.90 years.

CHAPTER SUMMARY

The present worth method of comparing alternatives involves converting all cash flows to present dollars at the MARR. The alternative with the numerically larger (or largest) PW value is selected. When the alternatives have different lives, the comparison must be made for equal-service periods. This is done by performing the comparison over either the LCM of lives or a specific study period. Both approaches compare alternatives in accordance with the equal-service requirement. When a study period is used, any remaining value in an alternative is recognized through the estimated future market value.

Life-cycle cost analysis is an extension of PW analysis performed for systems that have relatively long lives and a large percentage of their lifetime costs in the form of operating expenses. If the life of the alternatives is considered to be infinite, capitalized cost is the comparison method. The CC value is calculated as A/i, because the P/A factor reduces to $1/i$ in the limit of $n = \infty$.

Payback analysis estimates the number of years necessary to recover the initial investment plus a stated rate of return (MARR). This is a supplemental analysis technique used primarily for initial screening of proposed projects prior to a full economic evaluation by PW or some other method. The technique has some drawbacks, especially for no-return payback analysis, where $i = 0\%$ is used as the MARR.

Finally, we learned about bonds. Present worth analysis determines if the MARR will be obtained over the life of a bond, given specific values for the bond's face value, term, and interest rate.

PROBLEMS

Types of Projects

5.1 What is meant by *service alternative*?

5.2 When you are evaluating projects by the present worth method, how do you know which one(s) to select if the projects are (*a*) inde... exclusive?

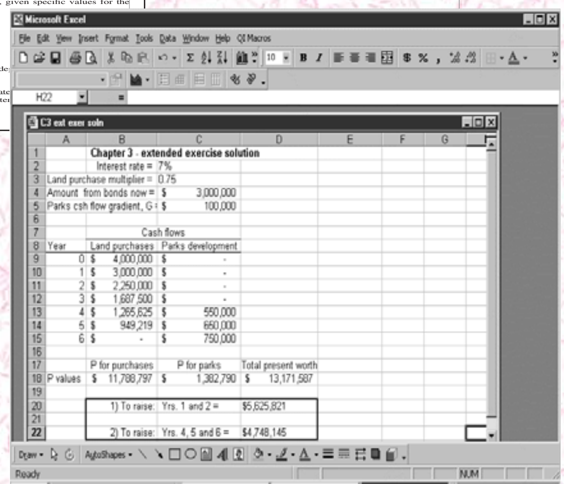
5.3 Read the state... lems and dete...

← END-OF-CHAPTER PROBLEMS

As in previous editions, each chapter contains many homework problems representative of real-world situations. Fully 80% of the end-of-chapter problems have been revised or are new to this edition.

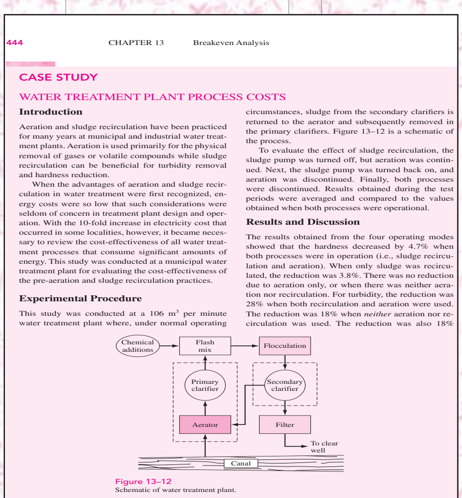
EXTENDED EXERCISES

The extended exercises are designed to require spreadsheet analysis with a general emphasis on sensitivity analysis. →



Microsoft Excel — C3 ext exer soln

	A	B	C	D
1	Chapter 3 - extended exercise solution			
2	Interest rate =	7%		
3	Land purchase multiplier =	0.75		
4	Amount from bonds now =	$ 3,000,000		
5	Parks csh flow gradient, G =	$ 100,000		
6				
7		Cash flows		
8	Year	Land purchases	Parks development	
9	0	$ 4,000,000	$ -	
10	1	$ 3,000,000	$ -	
11	2	$ 2,250,000	$ -	
12	3	$ 1,687,500	$ -	
13	4	$ 1,265,625	$ 550,000	
14	5	$ 949,219	$ 650,000	
15	6	$ -	$ 750,000	
16				
17		P for purchases	P for parks	Total present worth
18	P values	$ 11,788,797	$ 1,382,790	$ 13,171,587
19				
20		1) To raise: Yrs. 1 and 2 =	$5,625,821	
21				
22		2) To raise: Yrs. 4, 5 and 6 =	$4,748,145	



444 CHAPTER 13 Breakeven Analysis

CASE STUDY

WATER TREATMENT PLANT PROCESS COSTS

Introduction

Aeration and sludge recirculation have been practiced for many years at municipal and industrial water treatment plants. Aeration is used primarily for the physical removal of gases or volatile compounds while sludge recirculation can be beneficial for turbidity removal and hardness reduction.

When the advantages of aeration and sludge recirculation in water treatment were first recognized, energy costs were so low that such considerations were seldom of concern in treatment plant design and operation. With the 10-fold increase in electricity cost that occurred in some localities, however, it became necessary to review the cost-effectiveness of all water treatment processes that consume significant amounts of energy. This study was conducted at a municipal water treatment plant for evaluating the cost-effectiveness of the pre-aeration and sludge recirculation practices.

Experimental Procedure

This study was conducted at a 106 m³ per minute water treatment plant where, under normal operating circumstances, sludge from the secondary clarifiers is returned to the aerator and subsequently removed in the primary clarifiers. Figure 13–12 is a schematic of the process.

To evaluate the effect of sludge recirculation, the sludge pump was turned off, but aeration was continued. Next, the sludge pump was turned back on, and aeration was discontinued. Finally, both processes were discontinued. Results obtained during the test periods were averaged and compared to the values obtained when both processes were operational.

Results and Discussion

The results obtained from the four operating modes showed that the hardness decreased by 4.7% when both processes were in operation (i.e., sludge recirculation and aeration). When only sludge was recirculated, the reduction was 3.8%. There was no reduction due to aeration only, or when there was neither aeration nor recirculation. For turbidity, the reduction was 28% when both recirculation and aeration were used. The reduction was 18% when *neither* aeration nor recirculation was used. The reduction was also 18%

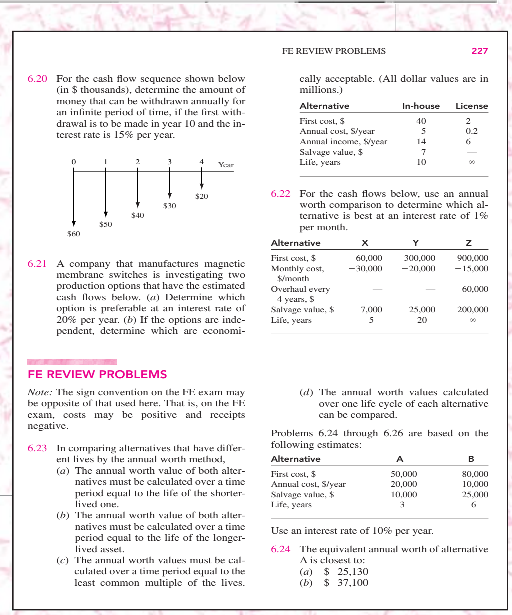
Figure 13–12
Schematic of water treatment plant.

↑ CASE STUDIES

All the case studies present real-world, in-depth treatments and exercises that cover the wide spectrum of economic analysis in the engineering profession.

FUNDAMENTALS OF ENGINEERING (FE) EXAM REVIEW PROBLEMS

The FE exam review problems cover the same topics as the FE exam and are written in the same multiple-choice format as the exam. *All of these problems are new to this edition.* →



FE REVIEW PROBLEMS 227

6.20 For the cash flow sequence shown below (in $ thousands), determine the amount of money that can be withdrawn annually for an infinite period of time, if the first withdrawal is to be made in year 10 and the interest rate is 15% per year.

6.21 A company that manufactures magnetic membrane switches is investigating two production options that have the estimated cash flows below. (*a*) Determine which option is preferable at an interest rate of 20% per year. (*b*) If the options are independent, determine which are economically acceptable. (All dollar values are in millions.)

Alternative	In-house	License
First cost, $	40	2
Annual cost, $/year	5	0.2
Annual income, $/year	14	6
Salvage value, $	7	—
Life, years	10	∞

6.22 For the cash flows below, use an annual worth comparison to determine which alternative is best at an interest rate of 1% per month.

Alternative	X	Y	Z
First cost, $	−60,000	−300,000	−900,000
Monthly cost, $/month	−30,000	−20,000	−15,000
Overhaul every 4 years, $	—	—	−60,000
Salvage value, $	7,000	25,000	200,000
Life, years	5	20	∞

FE REVIEW PROBLEMS

Note: The sign convention on the FE exam may be opposite of that used here. That is, on the FE exam, costs may be positive and receipts negative.

6.23 In comparing alternatives that have different lives by the annual worth method,
(*a*) The annual worth value of both alternatives must be calculated over a time period equal to the life of the shorter-lived one.
(*b*) The annual worth value of both alternatives must be calculated over a time period equal to the life of the longer-lived asset.
(*c*) The annual worth values must be calculated over a time period equal to the least common multiple of the lives.
(*d*) The annual worth values calculated over one life cycle of each alternative can be compared.

Problems 6.24 through 6.26 are based on the following estimates:

Alternative	A	B
First cost, $	−50,000	−80,000
Annual cost, $/year	−20,000	−10,000
Salvage value, $	10,000	25,000
Life, years	3	6

Use an interest rate of 10% per year.

6.24 The equivalent annual worth of alternative A is closest to:
(*a*) $−25,130
(*b*) $−37,100

IN-CHAPTER EXAMPLES

Examples within the chapters are relevant to all engineering disciplines that use this text, including industrial, civil, environmental, mechanical, petroleum, and electrical engineering as well as engineering management and engineering technology programs.

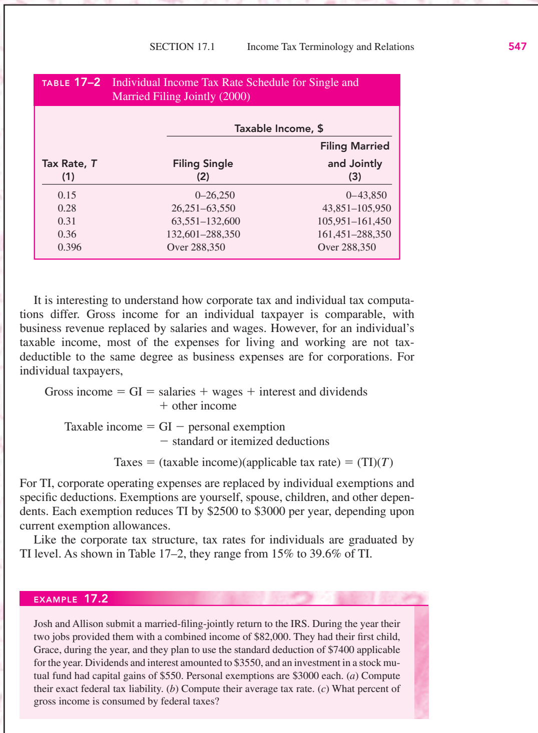

SECTION 17.1 Income Tax Terminology and Relations 547

TABLE 17–2 Individual Income Tax Rate Schedule for Single and Married Filing Jointly (2000)

Tax Rate, T (1)	Taxable Income, $ Filing Single (2)	Filing Married and Jointly (3)
0.15	0–26,250	0–43,850
0.28	26,251–63,550	43,851–105,950
0.31	63,551–132,600	105,951–161,450
0.36	132,601–288,350	161,451–288,350
0.396	Over 288,350	Over 288,350

It is interesting to understand how corporate tax and individual tax computations differ. Gross income for an individual taxpayer is comparable, with business revenue replaced by salaries and wages. However, for an individual's taxable income, most of the expenses for living and working are not tax-deductible to the same degree as business expenses are for corporations. For individual taxpayers,

Gross income = GI = salaries + wages + interest and dividends + other income

Taxable income = GI − personal exemption − standard or itemized deductions

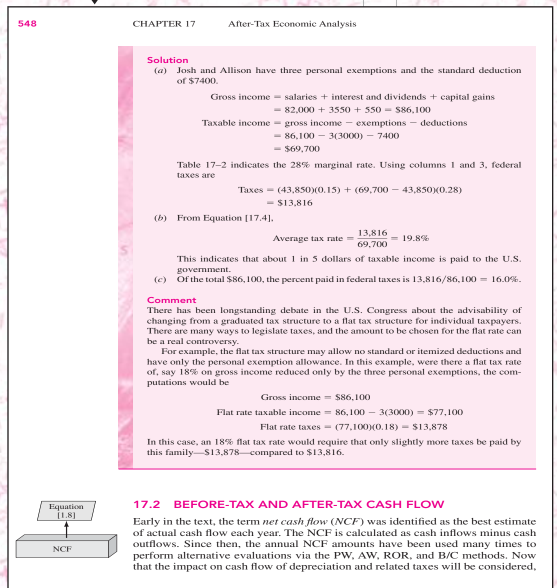
Taxes = (taxable income)(applicable tax rate) = (TI)(T)

For TI, corporate operating expenses are replaced by individual exemptions and specific deductions. Exemptions are yourself, spouse, children, and other dependents. Each exemption reduces TI by $2500 to $3000 per year, depending upon current exemption allowances.

Like the corporate tax structure, tax rates for individuals are graduated by TI level. As shown in Table 17–2, they range from 15% to 39.6% of TI.

EXAMPLE 17.2

Josh and Allison submit a married-filing-jointly return to the IRS. During the year their two jobs provided them with a combined income of $82,000. They had their first child, Grace, during the year, and they plan to use the standard deduction of $7400 applicable for the year. Dividends and interest amounted to $3550, and an investment in a stock mutual fund had capital gains of $550. Personal exemptions are $3000 each. (a) Compute their exact federal tax liability. (b) Compute their average tax rate. (c) What percent of gross income is consumed by federal taxes?


548 CHAPTER 17 After-Tax Economic Analysis

Solution

(a) Josh and Allison have three personal exemptions and the standard deduction of $7400.

Gross income = salaries + interest and dividends + capital gains = 82,000 + 3550 + 550 = $86,100

Taxable income = gross income − exemptions − deductions = 86,100 − 3(3000) − 7400 = $69,700

Table 17–2 indicates the 28% marginal rate. Using columns 1 and 3, federal taxes are

Taxes = (43,850)(0.15) + (69,700 − 43,850)(0.28) = $13,816

(b) From Equation [17.4],

$$\text{Average tax rate} = \frac{13{,}816}{69{,}700} = 19.8\%$$

This indicates that about 1 in 5 dollars of taxable income is paid to the U.S. government.

(c) Of the total $86,100, the percent paid in federal taxes is 13,816/86,100 = 16.0%.

Comment

There has been longstanding debate in the U.S. Congress about the advisability of changing from a graduated tax structure to a flat tax structure for individual taxpayers. There are many ways to legislate taxes, and the amount to be chosen for the flat rate can be a real controversy.

For example, the flat tax structure may allow no standard or itemized deductions and have only the personal exemption allowance. In this example, were there a flat tax rate of, say 18% on gross income reduced only by the three personal exemptions, the computations would be

Gross income = $86,100

Flat rate taxable income = 86,100 − 3(3000) = $77,100

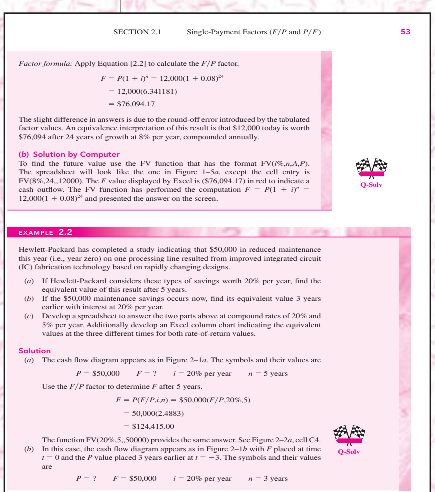
Flat rate taxes = (77,100)(0.18) = $13,878

In this case, an 18% flat tax rate would require that only slightly more taxes be paid by this family—$13,878—compared to $13,816.

Equation [1.8] → NCF

17.2 BEFORE-TAX AND AFTER-TAX CASH FLOW

Early in the text, the term *net cash flow* (*NCF*) was identified as the best estimate of actual cash flow each year. The NCF is calculated as cash inflows minus cash outflows. Since then, the annual NCF amounts have been used many times to perform alternative evaluations via the PW, AW, ROR, and B/C methods. Now that the impact on cash flow of depreciation and related taxes will be considered,


SECTION 2.1 Single-Payment Factors (F/P and P/F) 53

Factor formula: Apply Equation [2.2] to calculate the F/P factor.

$F = P(1+i)^n = 12{,}000(1+0.08)^{24} = 12{,}000(6.341181) = \$76{,}094.17$

The slight difference in answers is due to the round-off error introduced by the tabulated factor values. An equivalence interpretation of this result is that $12,000 today is worth $76,094 after 24 years of growth at 8% per year, compounded annually.

(b) Solution by Computer

To find the future value use the FV function that has the format FV(i%,n,A,P). The spreadsheet will look like the one in Figure 1–5a, except the cell entry is FV(8%,24,,12000). The F value displayed by Excel is ($76,094.17) in red to indicate a cash outflow. The FV function has performed the computation $F = P(1+i)^n = 12{,}000(1+0.08)^{24}$ and presented the answer on the screen.

Q-Solv

EXAMPLE 2.2

Hewlett-Packard has completed a study indicating that $50,000 in reduced maintenance this year (i.e., year zero) on one processing line resulted from improved integrated circuit (IC) fabrication technology based on rapidly changing designs.

(a) If Hewlett-Packard considers these types of savings worth 20% per year, find the equivalent value of this result after 5 years.

(b) If the $50,000 maintenance savings occurs now, find its equivalent value 3 years earlier with interest at 20% per year.

(c) Develop a spreadsheet to answer the two parts above at compound rates of 20% and 5% per year. Additionally develop an Excel column chart indicating the equivalent values at the three different times for both rate-of-return values.

Solution

(a) The cash flow diagram appears as in Figure 2–1a. The symbols and their values are

P = $50,000 F = ? i = 20% per year n = 5 years

Use the F/P factor to determine F after 5 years.

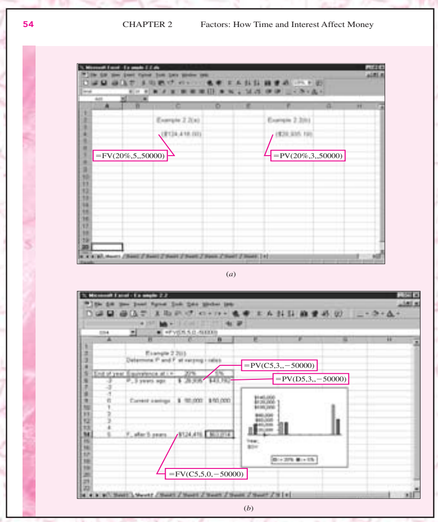
$F = P(F/P,i,n) = \$50{,}000(F/P,20\%,5) = 50{,}000(2.4883) = \$124{,}415.00$

The function FV(20%,5,,50000) provides the same answer. See Figure 2–2a, cell C4.

(b) In this case, the cash flow diagram appears as in Figure 2–1b with F placed at time t = 0 and the P value placed 3 years earlier at t = −3. The symbols and their values are

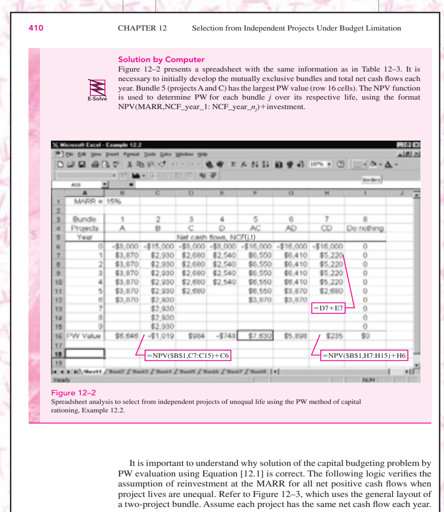
P = ? F = $50,000 i = 20% per year n = 3 years

Q-Solv


54 CHAPTER 2 Factors: How Time and Interest Affect Money

(a)

(b)


410 CHAPTER 12 Selection from Independent Projects Under Budget Limitation

Solution by Computer

Figure 12–2 presents a spreadsheet with the same information as in Table 12–3. It is necessary to initially develop the mutually exclusive bundles and total net cash flows each year. Bundle 5 (projects A and C) has the largest PW value (row 16 cells). The NPV function is used to determine PW for each bundle j over its respective life, using the format NPV(MARR,NCF_year_1: NCF_year_n_j)+investment.

E-Solve

Figure 12–2

Spreadsheet analysis to select from independent projects of unequal life using the PW method of capital rationing, Example 12.2.

It is important to understand why solution of the capital budgeting problem by PW evaluation using Equation [12.1] is correct. The following logic verifies the assumption of reinvestment at the MARR for all net positive cash flows when project lives are unequal. Refer to Figure 12–3, which uses the general layout of a two-project bundle. Assume each project has the same net cash flow each year.

USE OF SPREADSHEETS

The text integrates spreadsheets and shows both how easy they are to use in solving virtually any type of engineering economic analysis problem and how powerful they can be for altering estimates to achieve a better understanding of sensitivity and economic consequences of the uncertainties inherent in all forecasts. Beginning in Chapter 1, Blank and Tarquin illustrate their spreadsheet discussions with screenshots from Microsoft Excel™*.

When a single-cell, built-in Excel function may be used to solve a problem, a checkered flag icon labeled *Q-Solv* (for *quick solution*) appears in the margin.

The thunderbolt *E-Solve* icon indicates that a more complex, sophisticated spreadsheet is developed to solve the problem. The spreadsheet will contain data and several functions and possibly an Excel chart or graph to illustrate the answer and sensitivity analysis of the solution to changing data.

For both Q-Solv and E-Solve examples, the authors have included cells that show the exact Excel function needed to obtain the value in a specific cell. The E-Solve icon is also used throughout chapters to point out descriptions of how to best use the computer to address the engineering economy topic under discussion.

CROSS-REFERENCING

Blank and Tarquin reinforce the engineering concepts presented throughout the book by making them easily accessible from other sections of the book. Cross-reference icons in the margins refer the reader to additional section numbers, specific examples, or entire chapters that contain either foundational (backward) or more advanced (forward) information that is relevant to that in the paragraph next to the icon.

Sec. 7.4 → Multiple-root tests

4. Count the number of sign changes in the incremental cash flow series to determine if multiple rates of return may be present. If necessary, use Norstrom's criterion on the cumulative incremental cash flow series to determine if a single positive root exists.
5. Set up the PW equation for the incremental cash flows in the form of Equation [7.1], and determine Δi^*_{B-A} using trial and error by hand or spreadsheet functions.
6. Select the economically better alternative as follows:

Incremental ROR — Must Justify Incremental Investment

If Δi^*_{B-A} < MARR, select alternative A.
If $\Delta i^*_{B-A} \geq$ MARR, the extra investment is justified; select alternative B.

If the incremental i^* is exactly equal to or very near the MARR, noneconomic considerations will most likely be used to help in the selection of the "best" alternative.

In step 5, if trial and error is used to calculate the rate of return, time may be saved if the Δi^*_{B-A} value is bracketed, rather than approximated by a point value using linear interpolation, provided that a single ROR value is not needed. For example, if the MARR is 15% per year and you have established that Δi^*_{B-A} is in the 15 to 20% range, an exact value is not necessary to accept B since you already know that $\Delta i^*_{B-A} \geq$ MARR.

Figures 7–6 and 7–7 → Use of "guess" in IRR → App. A

The IRR function on a spreadsheet will normally determine one Δi^* value. Multiple guess values can be input to find multiple roots in the range −100% to ∞ for a nonconventional series, as illustrated in Examples 7.4 and 7.5. If this is not the case, to be correct, the indication of multiple roots in step 4 requires that the net-investment procedure, Equation [7.6], be applied in step 5 to make $\Delta i' = \Delta i^*$. If one of these multiple roots is the same as the expected reinvestment rate c, this root can be used as the ROR value, and the net-investment procedure is not necessary. In this case only $\Delta i' = \Delta i^*$, as concluded at the end of Section 7.5.

EXAMPLE 8.3

In 2000, Bell Atlantic and GTE merged to form a giant telecomm
named Verizon Communications. As expected, some equipment inco
rectified, especially for long distance and international wireless ar
item had two suppliers—a U.S. firm (A) and an Asian firm (B). App
of this equipment were needed. Estimates for vendors A and B are g

	A	B
Initial cost, $	−8,000	−13,000
Annual costs, $	−3,500	−1,600
Salvage value, $	0	2,000
Life, years	10	5

INTERNATIONAL APPEAL

The international dimensions of this book are more apparent throughout the sixth edition. Examples and new sections on international corporate depreciation and taxation considerations and international forms of contracts, such as the BOT method of subcontracting, are included. The impact of hyperinflation and deflationary cycles are discussed from an international perspective.

CFAT evaluation: As shown in the cell tag, CFAT estimates (column K) are calculated as GI − E − P − taxes, Equation [17.8]. The AW of CFAT (cell K21) again concludes that plan B is better and that plan A does not return the after-tax MARR of 12% (K10).

(*b*) What is the fundamental difference between the EVA and CFAT series in columns J and K? They are clearly equivalent from the time value of money perspective since the AW values are numerically the same. To answer the question, consider plan A, which has a constant CFAT estimate of $152,000 per year. To obtain the AW of EVA estimate of $−12,617 for years 1 through 4, the initial investment of $500,000 is distributed over the 4-year life using the A/P factor at 12%. That is, an equivalent amount of $500,000($A/P$,12%,4) = $164,617 is "charged" against the cash inflows in each of years 1 through 4. In effect, the yearly CFAT is reduced by this charge.

$$\text{CFAT} - (\text{initial investment})(A/P,12\%,4) = \$152{,}000 - 500{,}000(A/P,12\%,4)$$
$$152{,}000 - 164{,}617 = \$-12{,}617$$
$$= \text{AW of EVA}$$

This is the AW value for both series, demonstrating that the two methods are economically equivalent. However, the EVA method indicates an alternative's yearly estimated contribution to the *value of the corporation,* whereas the CFAT method estimates the actual cash flows to the corporation. This is why the EVA method is often more popular than the cash flow method with corporate executives.

Comment

The calculation $P(A/P,i,n)$ = $500,000($A/P$,12%,4) is exactly the same as the capital recovery in Equation [6.3], assuming an estimated salvage value of zero. Thus, the cost of invested capital for EVA is the same as the capital recovery discussed in Chapter 6. This further demonstrates why the AW method is economically equivalent to the EVA evaluation.

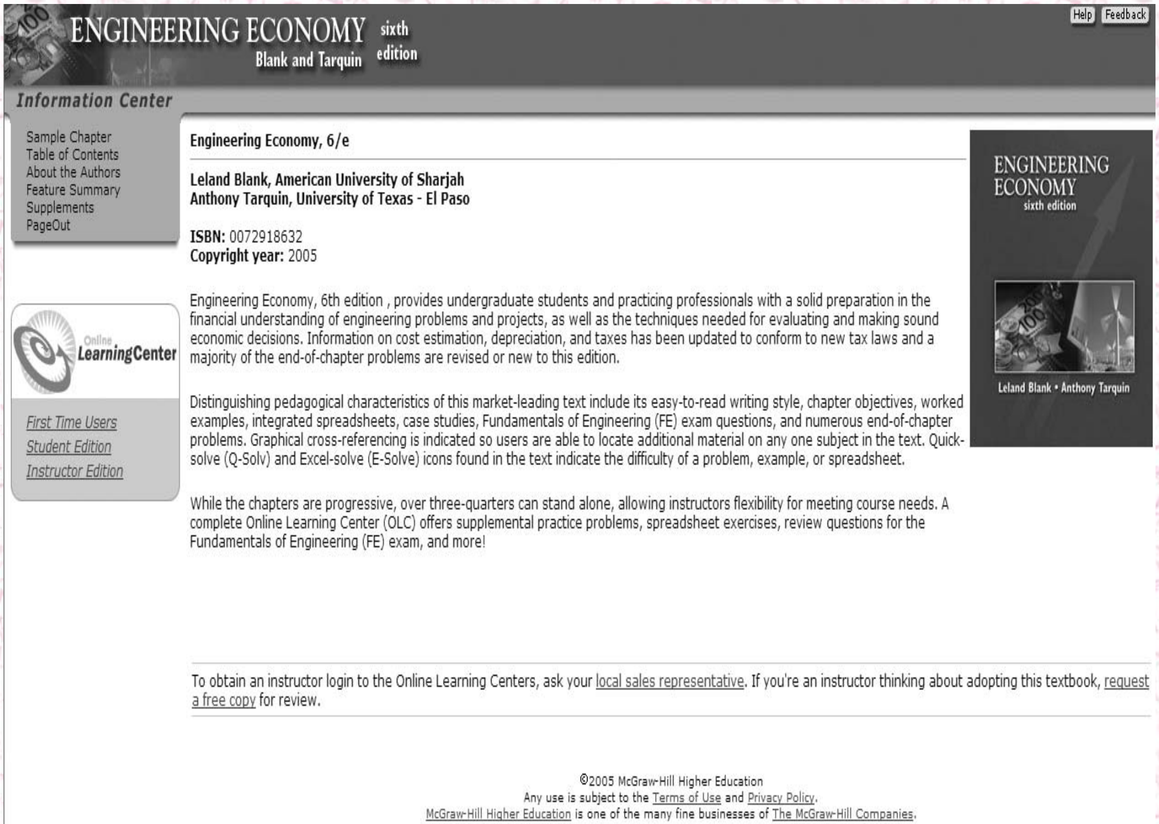
Sec. 6.2 → Capital recovery

17.9 AFTER-TAX ANALYSIS FOR INTERNATIONAL PROJECTS

Primary questions to be answered prior to performing a corporate-based after-tax analysis for international settings revolve on tax-deductible allowances—depreciation, business expenses, capital asset evaluation—and the effective tax rate needed for Equation [17.6], taxes = TI(T_e). As discussed in Chapter 16, most governments of the world recognize and use the straight line (SL) and declining balance (DB) methods of depreciation with some variations to determine the annual tax-deductible allowance. Expense deductions vary widely from country to country. By way of example, some of these are summarized here.

Canada

Depreciation: This is deductible and is normally based on DB calculations, although SL may be used. An equivalent of the half-year convention is applied in the first year of ownership. The annual tax-deductible allowance is termed *capital cost allowance (CCA).* As in the U.S. system,



SUPPLEMENTS The sixth edition of Blank and Tarquin features an Online Learning Center (OLC) available to students and professors who use the text. The URL for the site is http://www.mhhe.com/blank6.

The OLC will house the solutions to end-of-chapter problems, FE (Fundamentals of Engineering) exam prep quiz, spreadsheet exercises, matching and true/false quizzes, links to important websites, chapter objectives, lecture slides, end-of chapter summaries and more!

New to this edition is McGraw-Hill's new database management tool, Complete Online Solutions Manual Organization System (C.O.S.M.O.S.). C.O.S.M.O.S. is delivered via CD-ROM and helps instructors to organize solutions and distribute and track problem sets as they are assigned to students in the course. This helps instructors to quickly find solutions and keep a record of problems assigned, to avoid duplication of tests and quizzes in subsequent semesters. The ISBN for the *Engineering Economy* C.O.S.M.O.S. CD-ROM is 0–07–298450–3. Contact your McGraw-Hill representative to get a copy.