CHAPTER SUMMARY

Engineering economy is the application of economic factors and criteria to evaluate alternatives, considering the time value of money. The engineering economy study involves computing a specific economic measure of worth for estimated cash flows over a specific period of time.

The concept of *equivalence* helps in understanding how different sums of money at different times are equal in economic terms. The differences between simple interest (based on principal only) and compound interest (based on principal and interest upon interest) have been described in formulas, tables, and graphs. This power of compounding is very noticeable, especially over extended periods of time, and for larger sums of money.

The MARR is a reasonable rate of return established as a hurdle rate to determine if an alternative is economically viable. The MARR is always higher than the return from a safe investment and the cost to acquire needed capital.

Also, we learned a lot about cash flows:

End-of-year convention for cash flow location

Net cash flow computation

Different perspectives in determining the cash flow sign

Construction of a cash flow diagram

Difficulties with estimating future cash flows accurately

PROBLEMS

Basic Concepts

1.1 List the four essential elements involved in decision making in engineering economic analysis.

1.2 What is meant by (*a*) limited capital funds and (*b*) sensitivity analysis?

1.3 List three measures of worth that are used in engineering economic analysis.

1.4 Identify the following factors as either economic (tangible) or noneconomic (intangible): first cost, leadership, taxes, salvage value, morale, dependability, inflation, profit, acceptance, ethics, interest rate.

Ethics

1.5 Stefanie is a design engineer with an international railroad locomotive manufacturing company in Illinois. Management wants to return some of the engineering design work to the United States rather than export all of it to India, where the primary design work has been accomplished for the last decade. This transfer will employ more people locally and could improve the economic conditions for families in and around Illinois.

Stefanie and her design team were selected as a test case to determine the quality and speed of the design work they could demonstrate on a more fuel-efficient diesel locomotive. Neither she nor any of her team members have done such a significant design job, because their jobs had previously entailed only the interface with the subcontracted engineers in India. One of her team members had a great design idea on a key element that will improve fuel efficiency by approximately 15%. She told Stefanie it came from one of the Indian-generated documents, but that it would probably be okay for the team to use it and remain silent as to its origin, since it was quite clear the U.S. management was about to cancel the foreign contract. Although reluctant at first, Stefanie did go forward with a design that included the efficiency improvement, and no mention of the origin of the idea was made at the time of the oral presentation or documentation delivery. As a result, the Indian contract was canceled and full design responsibility was transferred to Stefanie's group.

Consult the NSPE Code of Ethics for Engineers (Appendix C) and identify sections that are points of concern about Stefanie's decisions and actions.

1.6 Consider the common moral precept that stealing is wrong. Hector is with a group of friends in a local supermarket. One of Hector's buddies takes a high-energy drink from a six-pack on the shelf, opens it, drinks it, and returns the empty can to the package, with no intention of paying for it. He then invites the others to do the same, saying, "It's only

tonozdayim.com/@Zedeleyici31

one drink. Others do it all the time." All the others, except Hector, have now consumed a drink of their choice. Personally, Hector believes this is a form of stealing. State three actions that Hector can take, and evaluate them from the personal moral perspective.

1.7 While going to work this morning off site from his office, an engineer accidently ran a stop sign and was in a car accident that resulted in the death of a 5-year-old child. He has a strong belief in the universal moral that it is wrong to do serious harm to another person. Explain the conflict that can arise for him between the universal moral and his personal moral about doing serious harm, given the accident was deemed his fault.

1.8 Claude is a fourth-year engineering university student who has just been informed by his instructor that he made a very low grade on his Spanish language final test for the year. Although he had a passing score prior to the final, his final grade was so low that he has now flunked the entire year and will likely have to extend his graduation another semester or two.

Throughout the year, Claude, who hated the course and his instructor, has copied homework, cheated on tests, and never seriously studied for anything in the course. He did realize during the semester that he was doing something that even he considered wrong morally and ethically. He knew he had done badly on the final. The classroom was reconfigured for the final exam in a way that he could not get any answers from classmates, and cell phones were collected prior to the exam, thus removing texting possibilities to friends outside the classroom who might help him on the final exam. Claude is now face to face with the instructor in her office. The question to Claude is, "What have you been doing throughout this year to make passing scores repeatedly, but demonstrate such a poor command of Spanish on the final exam?"

From an ethical viewpoint, what options does Claude have in his answer to this question? Also, discuss some of the possible effects that this experience may have upon Claude's future actions and moral dilemmas.

Interest Rate and Rate of Return

1.9 RKI Instruments borrowed $3,500,000 from a private equity firm for expansion of its manufacturing facility for making carbon monoxide monitors/controllers. The company repaid the loan after 1 year with a single payment of $3,885,000. What was the interest rate on the loan?

1.10 Emerson Processing borrowed $900,000 for installing energy-efficient lighting and safety equipment in its La Grange manufacturing facility. The terms of the loan were such that the company could pay *interest only* at the end of each year for up to 5 years, after which the company would have to pay the entire amount due. If the interest rate on the loan was 12% per year and the company paid only the interest for 4 years, determine the following:

(*a*) The amount of each of the four interest payments
(*b*) The amount of the final payment at the end of year 5

1.11 Which of the following 1-year investments has the highest rate of return?

(*a*) $12,500 that yields $1125 in interest,
(*b*) $56,000 that yields $6160 in interest, or
(*c*) $95,000 that yields $7600 in interest.

1.12 A new engineering graduate who started a consulting business borrowed money for 1 year to furnish the office. The amount of the loan was $23,800, and it had an interest rate of 10% per year. However, because the new graduate had not built up a credit history, the bank made him buy loan-default insurance that cost 5% of the loan amount. In addition, the bank charged a loan setup fee of $300. What was the effective interest rate the engineer paid for the loan?

1.13 When the inflation rate is expected to be 8% per year, what is the market interest rate likely to be?

Terms and Symbols

1.14 The symbol *P* represents an amount of money at a time designated as present. The following symbols also represent a present amount of money and require similar calculations. Explain what each symbol stands for: PW, PV, NPV, DCF, and CC.

1.15 Identify the four engineering economy symbols and their values from the following problem statement. Use a question mark with the symbol whose value is to be determined.

Thompson Mechanical Products is planning to set aside $150,000 now for possibly replacing its large synchronous refiner motors whenever it becomes necessary. If the replacement is not needed for 7 years, how much will the company have in its investment set-aside account, provided it achieves a rate of return of 11% per year?

1.16 Identify the four engineering economy symbols and their values from the following problem statement.

tonozdayim.com/@Zedeleyici31

Use a question mark with the symbol whose value is to be determined.

Atlas Long-Haul Transportation is considering installing Valutemp temperature loggers in all of its refrigerated trucks for monitoring temperatures during transit. If the systems will reduce insurance claims by $100,000 two years from now, how much should the company be willing to spend now, if it uses an interest rate of 12% per year?

1.17 Identify the four engineering economy symbols and their values from the following problem statement. Use a question mark with the symbol whose value is to be determined.

A green algae, *Chlamydomonas reinhardtii*, can produce hydrogen when temporarily deprived of sulfur for up to 2 days at a time. A small company needs to purchase equipment costing $3.4 million to commercialize the process. If the company wants to earn a rate of return of 10% per year and recover its investment in 8 years, what must be the net value of the hydrogen produced each year?

1.18 Identify the four engineering economy symbols and their values from the following problem statement. Use a question mark with the symbol whose value is to be determined.

Vision Technologies, Inc., is a small company that uses ultra-wideband technology to develop devices that can detect objects (including people) inside of buildings, behind walls, or below ground. The company expects to spend $100,000 per year for labor and $125,000 per year for supplies before a product can be marketed. At an interest rate of 15% per year, what is the total equivalent future amount of the company's expenses at the end of 3 years?

Cash Flows

1.19 What is meant by end-of-period convention?

1.20 Identify the following as cash inflows or outflows to commercial air carriers: fuel cost, pension plan contributions, fares, maintenance, freight revenue, cargo revenue, extra-bag charges, water and sodas, advertising, landing fees, seat preference fees.

1.21 Many credit unions use semiannual interest periods to pay interest on customer savings accounts. For a credit union that uses June 30 and December 31 as its semiannual interest periods, determine the end-of-period amounts that will be recorded for the deposits shown in the table.

Month	Deposit, $
Jan	50
Feb	70
Mar	—
Apr	120
May	20
June	—
July	150
Aug	90
Sept	—
Oct	—
Nov	40
Dec	110

1.22 For a company that uses a year as its interest period, determine the *net cash flow* that will be recorded at the *end of the year* from the cash flows shown.

Month	Receipts, $1000	Disbursements, $1000
Jan	500	300
Feb	800	500
Mar	200	400
Apr	120	400
May	600	500
June	900	600
July	800	300
Aug	700	300
Sept	900	500
Oct	500	400
Nov	400	400
Dec	1800	700

1.23 Construct a cash flow diagram for the following cash flows: $25,000 outflow at time 0, $9000 per year inflow in years 1 through 5 at an interest rate of 10% per year, and an unknown future amount in year 5.

1.24 Construct a cash flow diagram to find the present worth in year 0 at an interest rate of 15% per year for the following situation.

Year	Cash Flow, $
0	−19,000
1–4	+8,100

1.25 Construct a cash flow diagram that represents the amount of money that will be accumulated in 15 years from an investment of $40,000 now at an interest rate of 8% per year.

Equivalence

1.26 At an interest rate of 15% per year, an investment of $100,000 one year ago is equivalent to how much now?

tonozdayim.com/@Zedeleyici31

1.27 During a recession, the price of goods and services goes down because of low demand. A company that makes Ethernet adapters is planning to expand its production facility at a cost of $1,000,000 one year from now. However, a contractor who needs work has offered to do the job for $790,000 if the company will do the expansion now instead of 1 year from now. If the interest rate is 15% per year, how much of a discount is the company getting?

1.28 As a principal in the consulting firm where you have worked for 20 years, you have accumulated 5000 shares of company stock. One year ago, each share of stock was worth $40. The company has offered to buy back your shares for $225,000. At what interest rate would the firm's offer be equivalent to the worth of the stock last year?

1.29 A design/build engineering company that usually gives year-end bonuses in the amount of $8000 to each of its engineers is having cash flow problems. The company said that although it could not give bonuses this year, it would give each engineer two bonuses next year, the regular one of $8000 plus an amount equivalent to the $8000 that each engineer should have gotten this year. If the interest rate is 8% per year, what will be the total amount of bonus money the engineers should get next year?

1.30 University tuition and fees can be paid by using one of two plans.

Early-bird: Pay total amount due *1 year in advance* and get a 10% discount.

On-time: Pay total amount due when classes start.

The cost of tuition and fees is $10,000 per year.

(*a*) How much is paid in the early-bird plan?
(*b*) What is the equivalent amount of the savings compared to the on-time payment at the time that the on-time payment is made?

Simple and Compound Interest

1.31 If a company sets aside $1,000,000 now into a contingency fund, how much will the company have in 2 years, if it does not use any of the money and the account grows at a rate of 10% per year?

1.32 Iselt Welding has extra funds to invest for future capital expansion. If the selected investment pays simple interest, what interest rate would be required for the amount to grow from $60,000 to $90,000 in 5 years?

1.33 To finance a new product line, a company that makes high-temperature ball bearings borrowed $1.8 million at 10% per year interest. If the company repaid the loan in a lump sum amount after 2 years, what was (*a*) the amount of the payment and (*b*) the amount of interest?

1.34 Because market interest rates were near all-time lows at 4% per year, a hand tool company decided to call (i.e., pay off) the high-interest bonds that it issued 3 years ago. If the interest rate on the bonds was 9% per year, how much does the company have to pay the bond holders? The face value (principal) of the bonds is $6,000,000.

1.35 A solid waste disposal company borrowed money at 10% per year interest to purchase new haulers and other equipment needed at the company-owned landfill site. If the company got the loan 2 years ago and paid it off with a single payment of $4,600,000, what was the principal amount P of the loan?

1.36 If interest is compounded at 20% per year, how long will it take for $50,000 to accumulate to $86,400?

1.37 To make CDs look more attractive than they really are, some banks advertise that their rates are higher than their competitors' rates; however, the fine print says that the rate is a simple interest rate. If a person deposits $10,000 at 10% per year simple interest, what compound interest rate would yield the same amount of money in 3 years?

MARR and Opportunity Cost

1.38 Give three other names for minimum attractive rate of return.

1.39 Identify the following as either equity or debt financing: bonds, stock sales, retained earnings, venture capital, short-term loan, capital advance from friend, cash on hand, credit card, home equity loan.

1.40 What is the weighted average cost of capital for a corporation that finances an expansion project using 30% retained earnings and 70% venture capital? Assume the interest rates are 8% for the equity financing and 13% for the debt financing.

1.41 Managers from different departments in Zenith Trading, a large multinational corporation, have offered six projects for consideration by the corporate office. A staff member for the chief financial officer used key words to identify the projects and then listed them in order of projected rate of return as shown below. If the company wants to grow rapidly through high leverage and uses only 10% equity financing that has a cost of equity capital of 9% and 90% debt financing with a cost of debt

tonozdayim.com/@Zedeleyici31

capital of 16%, which projects should the company undertake?

Project ID	Projected ROR, % per year
Inventory	30
Technology	28.4
Warehouse	19
Products	13.1
Energy	9.6
Shipping	8.2

Spreadsheet Functions

1.42 State the purpose for each of the following built-in spreadsheet functions.
(*a*) PV(*i*%,*n*,*A*,*F*)
(*b*) FV(*i*%,*n*,*A*,*P*)
(*c*) RATE(*n*,*A*,*P*,*F*)
(*d*) IRR(first_cell:last_cell)
(*e*) PMT(*i*%,*n*,*P*,*F*)
(*f*) NPER(*i*%,*A*,*P*,*F*)

1.43 What are the values of the engineering economy symbols *P*, *F*, *A*, *i*, and *n* in the following functions? Use a question mark for the symbol that is to be determined.
(a) NPER(8%,−1500,8000,2000)
(*b*) FV(7%,102000,−9000)
(*c*) RATE(10,1000,−12000,2000)
(*d*) PMT(11%,20,,14000)
(*e*) PV(8%,15,−1000,800)

1.44 Write the engineering economy symbol that corresponds to each of the following spreadsheet functions.
(*a*) PMT (*b*) FV (*c*) NPER (*d*) PV (*e*) IRR

1.45 In a built-in spreadsheet function, if a certain parameter is not present, (*a*) under what circumstances can it be left blank and (*b*) when must a comma be entered in its place?

1.46 Sheryl and Marcelly both invest $1000 at 10% per year for 4 years. Sheryl receives simple interest and Marcelly gets compound interest. Use a spreadsheet and cell reference formats to develop relations that show a total of $64 more interest for Marcelly at the end of the 4 years. Assume no withdrawals or further deposits are made during the 4 years.

ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

1.47 The concept that different sums of money at different points in time can be said to be equal to each other is known as:
(*a*) Evaluation criterion
(*b*) Equivalence
(*c*) Cash flow
(*d*) Intangible factors

1.48 The evaluation criterion that is usually used in an economic analysis is:
(*a*) Time to completion
(*b*) Technical feasibility
(*c*) Sustainability
(*d*) Financial units (dollars or other currency)

1.49 All of the following are examples of cash outflows, *except*:
(*a*) Asset salvage value
(*b*) Income taxes
(*c*) Operating cost of asset
(*d*) First cost of asset

1.50 In most engineering economy studies, the best alternative is the one that:
(*a*) Will last the longest time
(*b*) Is most politically correct
(*c*) Is easiest to implement
(*d*) Has the lowest cost

1.51 The following annual maintenance and operation (M&O) costs for a piece of equipment were collected over a 5-year period: $12,300, $8900, $9200, $11,000, and $12,100. The average is $10,700. In conducting a sensitivity analysis, the most reasonable range of costs to use (i.e., percent from the average) is:
(*a*) ±5% (*b*) ±11% (*c*) ±17% (*d*) ±25%

1.52 At an interest rate of 10% per year, the equivalent amount of $10,000 *one year ago* is closest to:
(*a*) $8264 (*b*) $9091 (*c*) $11,000 (*d*) $12,000

1.53 Assume that you and your best friend each have $1000 to invest. You invest your money in a fund that pays 10% per year *compound* interest. Your friend invests her money at a bank that pays 10% per year *simple* interest. At the end of 1 year, the difference in the total amount for each of you is:
(*a*) You have $10 more than she does
(*b*) You have $100 more than she does
(*c*) You both have the same amount of money
(*d*) She has $10 more than you do

1.54 The time it would take for a given sum of money to double at 4% per year *simple* interest is closest to:
(*a*) 30 years (*b*) 25 years
(*c*) 20 years (*d*) 10 years

tonozdayim.com/@Zedeleyici31

1.55 All of the following are examples of equity financing, *except*:
(*a*) Mortgage
(*b*) Money from savings
(*c*) Cash on hand
(*d*) Retained earnings

1.56 To finance a new project costing $30 million, a company borrowed $21 million at 16% per year interest and used retained earnings valued at 12% per year for the remainder of the investment. The company's weighted average cost of capital for the project was closest to:
(*a*) 12.5% (*b*) 13.6% (*c*) 14.8% (*d*) 15.6%

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

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

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?

tonozdayim.com/@Zedeleyici31

CHAPTER SUMMARY

The breakeven point for a variable for one project is expressed in terms such as units per year or hours per month. At the breakeven amount Q_{BE}, there is indifference to accept or reject the project. Use the following decision guideline:

Single Project (Refer to Figure 13–2.)

Estimated quantity is *larger* than Q_{BE} → accept project
Estimated quantity is *smaller* than Q_{BE} → reject project

For two or more alternatives, determine the breakeven value of the common variable. Use the following guideline to select an alternative:

Two Alternatives (Refer to Figure 13–5.)

Estimated level is *below* breakeven → select alternative with higher variable cost (larger slope)
Estimated level is *above* breakeven → select alternative with lower variable cost (smaller slope)

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

PROBLEMS

Breakeven Analysis for a Project

13.1 A design-to-cost approach to product pricing involves determining the selling price of the product and then figuring out if it can be made at a cost lower than that. Banner Engineering's QT50R radar-based sensor features frequency-modulated technology to accurately monitor or detect objects up to 15 miles away while resisting rain, wind, humidity, and extreme temperatures. It has a list price of $589, and the variable cost of manufacturing the unit is $340.
(*a*) What could the company's fixed cost per year be in order for Banner to break even with sales of 9000 units per year?
(*b*) If Banner's fixed cost is actually $750,000 per year, what is the profit at a sales level of 7000 units per year?

13.2 Handheld fiber-optic meters with white light polarization interferometry are useful for measuring temperature, pressure, and strain in electrically noisy environments. The fixed costs associated with manufacturing are $800,000 per year. If a base unit sells for $2950 and its variable cost is $2075, (*a*) how many units must be sold each year for breakeven and (*b*) what will the profit be for sales of 3000 units per year?

13.3 A metallurgical engineer has estimated that the capital investment cost for recovering valuable metals (nickel, silver, platinum, gold, etc.) from the copper refinery's wastewater stream will be $12 million. The equipment will have a useful life of 15 years with no salvage value. Its operating cost is represented by the relation $(\$2{,}600{,}000)E^{1.9}$, where E is the efficiency of the metal recovery operation (in decimal form). The amount of metal currently discharged is 2880 pounds per year prior to recovery operations, and the efficiency of recovery is estimated at 71%. What must the average selling price per pound be for the precious metals that are recovered and sold in order for the company to break even at its MARR of 15% per year?

Problems 13.4 through 13.7 are based on the following information.

Hambry Enterprises produces a component for recycling uranium used as a nuclear fuel in power plant generators in France and the United States. Use the following cost and revenue figures, quoted in U.S. dollars per hundredweight (cwt), recorded for this year to calculate the answers for each plant.

Location	Fixed Cost, $ million	Revenue, $ per cwt	Cost, $ per cwt
France	3.50	8,500	3,900
United States	2.65	12,500	9,900

tonozdayim.com/@Zedeleyici31

13.4 Determine the breakeven point for each plant.

13.5 Estimate the minimum revenue per hundredweight required for next year if breakeven values and variable costs remain constant, but fixed costs increase by 10%.

13.6 During this year, the French plant sold 950 units in Europe, and the U.S. plant sold 850 units. Determine the year's profit (loss) for each plant.

13.7 Hambry's president has a goal of $1 million profit next year at each plant with no revenue or fixed cost increases. Determine the decreases *in dollar amounts and percentages* in variable cost necessary to meet this goal, if the number of units sold is the same as this year.

13.8 The National Highway Traffic Safety Administration raised the average fuel efficiency standard to 35.5 miles per gallon (mpg) for cars and light trucks by the year 2016. The rules will cost consumers an average of $926 extra per vehicle in the 2016 model year. Assume a person purchases a new car in 2016 that gets 35.5 mpg and keeps it for 5 years. If the person drives an average of 1000 miles per month and gets an extra 10 miles per gallon of gasoline, how much will the gasoline have to cost in order for the buyer to recover the extra investment in 5 years at an interest rate of 0.75% per month?

13.9 A call center in India used by U.S. and U.K. credit card holders has a capacity of 1,400,000 calls annually. The fixed cost of the center is $775,000 with an average variable cost of $1 and revenue of $2.50 per call.

(*a*) Find the percentage of the call capacity that must be placed each year to break even.

(*b*) The center manager expects to dedicate the equivalent of 500,000 of the 1,400,000 capacity to a new product line. This is expected to increase the center's fixed cost to $900,000 of which 50% will be allocated to the new product line. Determine the average revenue per call necessary to make 500,000 calls the breakeven point for only the new product. How does this required revenue compare with the current center revenue of $2.50 per call?

13.10 The addition of a turbocharger to a small V-6 engine that gets 18 miles per gallon of gasoline can boost its power to that of a V-8 engine and increase fuel efficiency at the same time. If Bill will pay $800 to turbocharge his engine and his fuel efficiency increases by 3 miles per gallon, how many miles will he have to drive each month for 3 years in order to break even? Assume the cost of gasoline is $3.25 per gallon and the interest rate is 1% per month.

13.11 Transporting extremely heavy patients (people who weigh more than 500 pounds) is much more difficult than transporting normal-weight patients. Various cities in Colorado, Nebraska, and Kansas charge $1421 for an extremely obese patient compared to $758 for a typical patient. The extra fees are justified by the ambulance companies on the basis of the specialty equipment required and the extra personnel involved. If it is assumed that 50 extremely obese patients are transported every year, how much could the ambulance companies afford to spend on the specialty equipment *now* and break even on the initial cost in 5 years just from the extra charges? Assume the extra costs are $400 per patient and the company's MARR is 10% per year.

13.12 High-profile vehicles have poor fuel efficiency because of increased wind resistance from their large front area. A number of companies make devices that they claim will significantly increase a vehicle's fuel efficiency. One company claims that by spending $560 on its friction-reducing device, the fuel efficiency of a pickup truck will increase by 25%. Assuming the device works as claimed, for a vehicle that currently gets 20 miles per gallon (mpg), how many miles would the owner have to drive each year to break even in 5 years? Assume the cost of gasoline is $3.50 per gallon and the interest rate is 10% per year.

13.13 As the price of gasoline goes up, people are willing to drive farther to fill their tank in order to save money. Assume you had been buying gasoline for $2.90 per gallon and that it went up to $2.98 per gallon at the station where you usually go. If you drive an F-150 pickup that gets 18 miles per gallon, what is the round-trip distance you can drive to break even if it will take 20 gallons to fill your tank? Use an interest rate of 8% per year.

13.14 An automobile company is investigating the advisability of converting a plant that manufactures economy cars into one that will make retro sports cars. The initial cost for equipment conversion will be $200 million with a 20% salvage value anytime within a 5-year period. The cost of producing a car will be $21,000, but it is expected to have a selling price of $33,000 to dealers. The production capacity for the first year will be 4000 units. At an interest rate of 12% per year, by what uniform amount will production have to increase each year in order for the company to recover its investment in 3 years?

tonozdayim.com/@Zedeleyici31

13.15 For the last 2 years, The Health Company has experienced a fixed cost of $850,000 per year and an $(r - v)$ value of $1.25 per unit for its multivitamin line of products. International competition has become severe enough that some financial changes must be made to keep market share at the current level.

(*a*) Perform a spreadsheet-based graphical analysis to estimate the effect on the breakeven point if the difference between revenue and variable cost per unit increases somewhere between 1% and 15% of its current value.

(*b*) If fixed costs and revenue per unit remain at their current values, what type of change must take place to make the breakeven point go down?

13.16 (This is an extension of Problem 13.15) Expand the analysis performed in Problem 13.15 by changing the variable cost per unit. The financial manager estimates that fixed costs will fall to $750,000 when the required production rate to break even is at or below 600,000 units. What happens to the breakeven points over the $(r - v)$ range of 1% to 15% increase as evaluated previously?

Breakeven Analysis Between Alternatives

13.17 Providing restrooms at parks, zoos, and other city-owned recreation facilities is a considerable expense for municipal governments. City councils usually opt for permanent restrooms in larger parks and portable restrooms in smaller ones. The cost of renting and servicing a portable restroom is $7500 per year. In one northeastern municipality, the parks director informed the city council that the cost of constructing a permanent restroom is $218,000 and the annual cost of maintaining it is $12,000. He remarked that the rather high cost is due to the necessity to use expensive materials and construction techniques that are tailored to minimize damage from vandalism that often occurs in unattended public facilities. If the useful life of a permanent restroom is assumed to be 20 years, how many portable restrooms could the city afford to rent each year and break even with the cost of one permanent facility? Let the interest rate be 6% per year.

13.18 A consulting engineer is considering two methods for lining ponds used for evaporating concentrate generated during reverse osmosis treatment of brackish groundwater for the Clay County Industrial Park. A geosynthetic bentonite clay liner (GCL) will cost $1.8 million to install, and if it is renovated after 4 years at a cost of $375,000, its life can be extended another 2 years. Alternatively, a high-density polyethylene (HDPE) geomembrane can be installed that will have a useful life of 12 years. At an interest rate of 6% per year, how much money can be spent on the HDPE liner for the two methods to break even?

13.19 An irrigation canal contractor wants to determine whether he should purchase a used Caterpillar mini excavator or a Toro powered rotary tiller for servicing irrigation ditches in an agricultural area of California. The initial cost of the excavator is $26,500 with a $9000 salvage value after 10 years. Fixed costs for insurance, license, etc. are expected to be $18,000 per year. The excavator will require one operator at $15 per hour and maintenance at $1 per hour. In 1 hour, 0.15 mile of ditch can be prepared. Alternatively, the contractor can purchase a tiller and hire 2 workers at $11 per hour each. The tiller costs $1200 and has a useful life of 5 years with no salvage value. Its operating cost is expected to be $1.20 per hour, and with the tiller, the two workers can prepare 0.04 mile of ditch in 1 hour. The contractor's MARR is 10% per year. Determine the number of miles of ditch per year the contractor would have to service for the two options to break even.

13.20 An effective method to recover water used for regeneration of ion exchange resins is to use a reverse osmosis system in a batch treatment mode. Such a system involves recirculation of the partially treated water back into the feed tank, causing the water to heat up. The water can be cooled using one of two systems: a single-pass heat exchanger or a closed-loop heat exchange system. The single-pass system, good for 3 years, requires a small chiller costing $920 plus stainless steel tubing, connectors, valves, etc. costing $360. The cost of water, treatment charges, electricity, etc. will be $3.10 per hour. The closed-loop system will cost $3850 to buy, will have a useful life of 5 years, and will cost $1.28 per hour to operate. What is the minimum number of hours per year that the cooling system must be used in order to justify purchase of the closed-loop system? The MARR is 10% per year, and the salvage values are negligible.

13.21 Samsung Electronics is trying to reduce supply chain risk by making more responsible make-buy decisions through improved cost estimation. A high-use component (expected usage is 5000 units per year) can be purchased for $25 per unit with delivery promised within a week. Alternatively, Samsung can make the component in-house and have it readily available at a cost of $5 per unit, if equipment costing $150,000 is purchased. Labor

tonozdayim.com/@Zedeleyici31

and other operating costs are estimated to be $35,000 per year over the study period of 5 years. Salvage is estimated at 10% of first cost and $i = 12\%$ per year. Neglect the element of availability (*a*) to determine the breakeven quantity and (*b*) to recommend making or buying at the expected usage level.

13.22 A partner in a medium-size A/E (architectural/engineering) design firm is evaluating two alternatives for improving the exterior appearance of the building they occupy. The building can be completely painted at a cost of $6500. The paint is expected to remain attractive for 4 years, at which time repainting will be necessary. Every time the building is repainted, the cost will be 20% higher than the previous time. Alternatively, the building can be sandblasted now and every 6 years at a cost 40% greater than the previous time. If the company's MARR is 10% per year, what is the maximum amount that could be spent now on the sandblasting alternative that would render the two alternatives indifferent over a study period of 12 years?

13.23 A junior mechanical engineering student is cooping this semester at Regency Aircraft, which customizes the interiors of private and corporate jets. Her first assignment is to develop the specifications for a new machine to cut, shape, and sew leather or vinyl covers and trims. The first cost is not easy to estimate due to many options, but the annual revenue and M&O costs should net out at $+15,000 per year over a 10-year life. Salvage is expected to be 20% of the first cost. Determine the breakeven first cost of the machine to just recover its first cost and a return of 8% per year under two scenarios:

I: No outside revenue will be developed by the machine.

II: Outside contracting will occur with estimated revenue of $10,000 the first year, increasing by $5000 per year thereafter.

Solve using (*a*) hand and (*b*) spreadsheet solutions.

13.24 Ascarate Fishing Club (a nonprofit organization dedicated to teaching kids how to fish) is considering two options for providing a heavily stocked pond for kids who have never caught a fish before. Option 1 is an above-ground swimming pool made of heavy vinyl plastic that will be assembled and disassembled for each quarterly event. The purchase price will be $400. Leaks from hooks piercing the fabric will be repaired with a vinyl repair kit at a cost of $70 per year, but the pool will have to be replaced when too many repairs have been made.

Option 2 is an in-ground pond that will be excavated by club members at no cost and lined with fabric that costs $1 per square foot. The pond will be 15 ft in diameter and 3 ft deep. Assume 300 ft^2 of liner will be purchased. A chain link fence at $10 per lineal foot will be installed around the pond (100 ft of fence). Maintenance inside the fence is expected to cost $20 per year. The park where the pond will be constructed has committed the land for only 10 years. At an interest rate of 6% per year, how long would the above-ground pool have to last to break even?

13.25 A rural subdivision has several miles of access roads that need a new surface treatment. Alternative 1 is a gravel base and pavement with an initial cost of $500,000 that will last for 15 years and has an annual upkeep cost of $100 per mile. Alternative 2 is to enhance the gravel base now at a cost of $50,000 and immediately coat the surface with a durable hot oil mix, which costs $130 per barrel applied. Annual reapplication of the mix is required. A barrel covers 0.05 mile. (*a*) If the discount rate is 6% per year, determine the number of miles at which the two alternatives break even. (*b*) A drive in a pickup indicates a total of 12.5 miles of road. Which is the more economical alternative?

13.26 A waste-holding lagoon situated near the main plant receives sludge daily. When the lagoon is full, it is necessary to remove the sludge to a site located 8.2 kilometers from the main plant. Currently, when the lagoon is full, the sludge is removed by pump into a tank truck and hauled away. This process requires the use of a portable pump that initially costs $800 and has an 8-year life. The company pays a contract individual to operate the pump and oversee environmental and safety factors at a rate of $100 per day, plus the truck and driver must be rented for $200 per day. The company has the option to install a pump and pipeline to the remote site. The pump would have an initial cost of $1600 and a life of 10 years and will cost $3 per day to operate. The company's MARR is 10% per year.

(*a*) If the pipeline will cost $12 per meter to construct and will have a 10-year life, how many days per year must the lagoon require pumping to justify construction of the pipeline?

(*b*) If the company expects to pump the lagoon once per week every week of the year, how much money can it afford to spend now on the 10-year life pipeline to just break even?

13.27 Lorraine can select from two nutrient injection systems for her cottage industry of hydroponic

tonozdayim.com/@Zedeleyici31

tomato and lettuce greenhouses. (*a*) Use an AW relation to determine the minimum number of hours per year to operate the pumps that will justify the Auto Green system, if the MARR is 10% per year. (*b*) Which pump is economically better if it operates 7 hours per day, 365 days per year?

	Nutra Jet (N)	Auto Green (A)
Initial cost, $	−4,000	−10,300
Life, years	3	6
Rebuild cost, $	−1,000	−2,200
Time before rebuild, annually or minimum hours	2,000	8,000
Cost to operate, $ per hour	1.00	0.90

13.28 An engineering practitioner can lease a fully equipped computer and color printer system for $800 per month or purchase one for $8500 now and pay a $75 per month maintenance fee. If the nominal interest rate is 15% per year, determine the months of use necessary for the two to break even. Show both (*a*) hand and (*b*) spreadsheet solutions.

13.29 The office manager of an environmental engineering consulting firm was instructed to make an eco-friendly decision in acquiring an automobile for general office use. He is considering a gasoline-electric hybrid or a gasoline-free, all-electric hatchback. The hybrid under consideration is GM's Volt, which will cost $35,000, will have a salvage value of $15,000 after 5 years, and will have a range of 40 miles on the electric battery, plus several hundred more miles when the gasoline engine kicks in. Nissan's Leaf, on the other hand, is a pure electric that will have a range of only 100 miles, after which its lithium ion battery must be recharged. The Leaf's relatively limited range creates a psychological effect known as *range anxiety* (RA), which has the company leaning toward purchasing the Volt. The Leaf can be leased for $349 per month after an initial $500 down payment.

The accountant for the consulting firm told the office manager that the Leaf is the better economic option based on an evaluation she performed earlier. If the office manager purchases the Volt anyway (instead of leasing the Leaf), what is the monthly equivalent (AW value) of the extra amount of money the company will be paying to eliminate range anxiety? Assume the operating costs will be the same for both vehicles and the MARR is 0.75% per month.

Payback Analysis

13.30 How long will you have to sell a product that has an income of $5000 per month and expenses of $1500 per month if your initial investment is $28,000 and your MARR is (*a*) 0% and (*b*) 3% per month? Solve by formula. (*c*) Write the spreadsheet functions to display the payback period for both 0% and 3% per month.

13.31 (*a*) Determine the payback period at an interest rate of 8% per year for an asset that initially cost $28,000, has a scrap value of $1500 whenever it is sold, and generates cash flow of $2900 per year.

(*b*) If the asset will be in service for 12 years, should it be purchased?

13.32 ABB purchased fieldbus communication equipment for a project in South Africa for $3.15 million. The net cash flow is estimated at $500,000 per year, and a salvage value of $400,000 is anticipated regardless of when it is sold. Determine the number of years the equipment must be used to obtain payback at MARR values of (*a*) 0% and 8% per year and (*b*) 15% and 16% per year. (*c*) Use a spreadsheet to plot the payback years for all four return values.

13.33 Sundance Detective Agency purchased new surveillance equipment with the following estimates. The year index is $k = 1, 2, 3, \ldots$.

First cost	$1050
Annual maintenance cost	$70 + 5$k$ per year
Extra annual revenue	$200 + 50$k$ per year
Salvage value	$600 for all years

(*a*) Calculate the payback period to make a return of 10% per year.

(*b*) For a preliminary conclusion, should the equipment be purchased if the actual useful life is 7 years?

13.34 Clarisa, an engineering manager, wants to purchase a resort accommodation to rent to skiers. She is considering the purchase of a three-bedroom lodge in upper Montana that will cost $250,000. The property in the area is rapidly appreciating in value because people anxious to get away from urban developments are bidding up the prices. If Clarisa spends an average of $500 per month for utilities and the investment increases at a rate of 2% per month, how long would it be before she could sell the property for $100,000 more than she has invested in it?

13.35 Laura's grandparents helped her purchase a small self-serve laundry business to make extra money during her 5 college years. When she completed her engineering management degree, she sold the business and her grandparents told her to keep the

tonozdayim.com/@Zedeleyici31

money as a graduation present. For the net cash flows listed below, determine the following:

(*a*) The percentage of the investment recovered during the 5 years

(*b*) The actual rate of return over the 5-year period

(*c*) How long it took to pay back the $75,000 investment in year 0, plus a 7% per year return

Year	0	1	2	3	4	5
NCF, $ per year	−75,000	−10,500	18,600	−2000	28,000	105,000

13.36 Buhler Tractor sold a tractor for $45,000 to Tom Edwards 10 years ago. (*a*) What is the uniform net cash flow that Tom must make each year to realize payback and a return of 5% per year on his investment over a period of 3 years? 5 years? 8 years? All 10 years? (*b*) If the net cash flow was actually $5000 per year, what is the amount Tom should have paid for the tractor to realize payback plus the 5% per year return over these 10 years?

13.37 National Parcel Service has historically owned and maintained its own delivery trucks. Leasing is an option being seriously considered because costs for maintenance, fuel, insurance, and some liability issues will be transferred to Pacific Leasing, the truck leasing company. The study period is no more than 24 months for either alternative. The annual lease cost is paid at the beginning of each year and is not refundable for partially used years. Use the first cost and net cash flow estimates to determine the payback in months with a nominal 9% per year return for the (*a*) purchase option and (*b*) lease option.

Purchase: $P = \$–30{,}000$ now
Monthly cost = $−1000
Monthly revenue = $4500

Lease: $P = \$-10{,}000$ at the beginning of each year (months 0 and 12)
Monthly cost = $−2500
Monthly revenue = $4500

13.38 Julian Browne, owner of Clear Interior Environments, purchased an air scrubber, HEPA vacuum, and other equipment for mold removal for $15,000 eight months ago. Net cash flows were $−2000 for each of the first 2 months, followed by $1000 per month for months 3 and 4. For the last 4 months, a contract generated a net $6000 per month. Julian sold the equipment yesterday for $3000 to a friend. Determine (*a*) the no-return payback period and (*b*) the nominal 18%-per-year payback period.

13.39 Explain why payback analysis may favor an alternative with a shorter payback period when it is not the better choice economically.

13.40 When comparing two alternatives, why is it best to use no-return payback analysis as a preliminary screening tool prior to conducting a complete PW or AW evaluation?

Spreadsheet Problems

13.41 Benjamin used regression analysis to fit quadratic relations to monthly revenue and cost data with the following results:

$$R = -0.007Q^2 + 32Q$$
$$\text{TC} = 0.004Q^2 + 2.2Q + 8$$

(*a*) Plot R and TC. Estimate the quantity Q_p at which the maximum profit should occur. Estimate the amount of profit at this quantity.

(*b*) The profit relation $P = R - \text{TC}$ and calculus can be used to determine the quantity Q_p at which the maximum profit will occur and the amount of the profit. The equations are

$$\text{Profit} = aQ^2 + bQ + c$$
$$Q_p = \frac{-b}{2a}$$
$$\text{Maximum profit} = \frac{-b^2}{4a} + c$$

Use these relations to confirm the graphical estimates you made in (*a*). (Your instructor may ask you to derive the relations above.)

13.42 The National Potato Cooperative purchased a deskinning machine last year for $150,000. Revenue for the first year was $50,000. Over the total estimated life of 8 years, what must the remaining equivalent annual revenues (years 2 through 8) equal to break even by recovering the investment and a return of 10% per year? Costs are expected to be constant at $42,000 per year, and a salvage value of $20,000 is anticipated.

Problems 13.43 and 13.44 are based on the following information.

Wilson Partners manufactures thermocouples for electronics applications. The current system has a fixed cost of $300,000 per year and a variable cost of $10 per unit. Wilson sells the units for $14 each. A newly proposed process will add onboard features that allow the revenue to increase to $16 per unit, but the fixed cost will now be $500,000 per year. The variable cost of the new system will be based on a $48 per hour rate with 0.2 hour required to produce each unit.

13.43 Determine the annual breakeven quantity for (*a*) the current system and (*b*) the new system.

13.44 Plot the two profit relations and estimate graphically the breakeven quantity between the two alternatives.

tonozdayim.com/@Zedeleyici31

Problems 13.45 through 13.48 are based on the following information.

Mid-Valley Industrial Extension Service, a state-sponsored agency, provides water quality sampling services to all business and industrial firms in a 10-county region. Just last month, the service purchased all necessary lab equipment for full in-house testing and analysis. Now an outsourcing agency has offered to take over this function on a per sample basis. Data and quotes for the two options have been collected. The MARR for government projects is 5% per year, and a study period of 8 years is chosen.

In-house: Equipment and supplies initially cost \$125,000 for a life of 8 years, an AOC of \$15,000, and annual salaries of \$175,000. Sample costs average \$25 each. There is no significant market value for the equipment and supplies currently owned.

Outsourced: Contractors quote sample cost averages of \$100 for the first 5 years, increasing to \$125 per sample for years 6 through 8.

13.45 Determine the breakeven number of tests between the two options.

13.46 Use a spreadsheet to graph the AW curves for both options for test loads between 0 and 4000 per year in increments of 1000 tests. What is the estimated breakeven quantity?

13.47 The service director has asked the outsource company to reduce the per sample costs by 25% across the board over the 8-year study period. What will this do to the breakeven point? (*Hint:* Look carefully at your graph from Problem 13.46 before answering.)

13.48 Assume the Extension Service can reduce its annual salaries from \$175,000 to \$100,000 per year and the per sample cost from \$25 to \$20. What will this do to the breakeven point? (*Hint:* Again, look carefully at your graph from the previous problem before answering.) What is the new annual breakeven test quantity?

ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

13.49 In linear breakeven analysis, if a company expects to operate at a point *above* the breakeven point, it should select the alternative:
(*a*) With the lower fixed cost
(*b*) With the higher fixed cost
(*c*) With the lower variable cost
(*d*) With the higher variable cost

13.50 A company is considering two alternatives to automate the pH of process liquids. Alternative A will have fixed costs of \$42,000 per year and will require 2 workers at \$48 per day each. Together, these workers can generate 100 units of product per day. Alternative B will have fixed costs of \$56,000 per year, but with this alternative, 3 workers will generate 200 units of product. If x is the number of units per year, the variable cost (VC) in \$ per year for alternative B is represented by:
(*a*) $[2(48)/100]x$
(*b*) $[3(48)/200]x$
(*c*) $[3(48)/200]x + 56{,}000$
(*d*) $[2(48)/100]x + 42{,}000$

13.51 When the variable cost is reduced for linear total cost and revenue lines, the breakeven point decreases. This is an economic advantage because:
(*a*) The revenue per unit will increase.
(*b*) The two lines will now cross at zero.
(*c*) The profit will increase for the same revenue per unit.
(*d*) The total cost line becomes nonlinear.

13.52 $AW_1 = -23{,}000(A/P,10\%,10) + 4000(A/F,10\%,10) - 3000 - 3x$

$AW_2 = -8{,}000(A/P,10\%,4) - 2000 - 6x$

For these two AW relations, the breakeven point x, in miles per year, is closest to:
(*a*) 1130
(*b*) 1224
(*c*) 1590
(*d*) 655

13.53 To make an item in-house, equipment costing \$250,000 must be purchased. It will have a life of 4 years, an annual cost of \$80,000, and each unit will cost \$40 to manufacture. Buying the item externally will cost \$100 per unit. At $i = 15\%$ per year, it is cheaper to make the item in-house if the number per year needed is:
(*a*) Above 1047 units
(*b*) Above 2793 units
(*c*) Equal to 2793 units
(*d*) Below 2793 units

13.54 A procedure at Mercy Hospital has fixed costs of \$10,000 per year and variable costs of \$50 per test. If the procedure is automated, its fixed cost will be \$21,500 per year, but its variable cost will be only \$10 per test. The number of tests that must be performed each year for the two operations to break even is closest to:
(*a*) 290 (*b*) 455 (*c*) 750 (*d*) Over 800

tonozdayim.com/@Zedeleyici31

13.55 An assembly process can be completed using either alternative X or Y. Alternative X has fixed costs of $10,000 per year with a variable cost of $50 per unit. If the process is automated per alternative Y, its fixed cost will be $5000 per year and its variable cost will be only $10 per unit. The number of units that must be produced each year in order for alternative Y to be favored is closest to:

(*a*) Y will be favored for any level of production
(*b*) 125
(*c*) 375
(*d*) X will be favored for any level of production

13.56 Two different methods are under consideration for building a bypass road. Material C will cost $100,000 per mile and last for 10 years. Its annual maintenance cost will be $10,000 per year per mile. Material D will cost $30,000 per mile and last for 5 years. At an interest rate of 6% per year, the annual maintenance cost for material D that will make the two methods cost the same is closest to:

(*a*) Less than $14,000 (*b*) $14,270
(*c*) $16,470 (*d*) $19,510

13.57 A construction company can purchase a piece of equipment for $50,000 and spend $100 per day in operating costs. The equipment will have a 5-year life with no salvage value. Alternatively, the company can lease the equipment for $400 per day. The number of days per year the company must require the equipment to justify its purchase at an interest rate of 8% per year is closest to:

(*a*) 10 days (*b*) 42 days
(*c*) 51 days (*d*) 68 days

13.58 A tractor has a first cost of $40,000, a monthly operating cost of $1500, and a salvage value of $12,000 in 10 years. The MARR is 12% per year. An identical tractor can be rented for $3200 per month (operating cost not included). If n is the minimum number of months per year the tractor must be used in order to justify its purchase, the relation to find n is represented by:

(*a*) $-40{,}000(A/P,1\%,10) - 1500n + 12{,}000(A/F,1\%,10) = 3200n$
(*b*) $-40{,}000(A/P,12\%,10) - 1500n + 12{,}000(A/F,12\%,10) = 3200n$
(*c*) $-40{,}000(A/P,1\%,120) - 1500n + 12{,}000(A/F,1\%,120) = 3200n$
(*d*) $-40{,}000(A/P,11.4\%,10) - 1500n + 12{,}000(A/F,11.4\%,10) = 3200n$

13.59 An anticorrosive coating for a chemical storage tank will cost $5000 and last 5 years if touched up at the end of 3 years at a cost of $1000. If an oil-base enamel coating could be used that will last 2 years, the amount the enamel coating can cost for the two to breakeven at $i = 8\%$ per year is closest to:

(*a*) $2120 (*b*) $2390
(*c*) $2590 (*d*) $2725

13.60 The price of a car is $50,000 today. Its price is expected to increase by $2400 each year. You now have $25,000 in an investment that is earning 20% per year. The number of years before you have enough money to buy the car, without borrowing any money, is closest to:

(*a*) 3 years (*b*) 5 years
(*c*) 7 years (*d*) 9 years

13.61 Process A has a fixed cost of $16,000 per year and a variable cost of $40 per unit. For process B, 5 units can be produced in 1 day at a cost of $125. If the company's MARR is 10% per year, the fixed cost of process B that will make the two alternatives have the same annual cost at a production rate of 1000 units per year is closest to:

(*a*) Less than $10,000
(*b*) $18,000
(*c*) $27,000
(*d*) Over $30,000

13.62 The profit relation for the following estimates at a quantity that is 20% above breakeven is:

Fixed cost = $500,000 per year
Variable cost per unit = $200
Revenue per unit = $250

(*a*) Profit = 200(12,000) − 250(12,000) − 500,000
(*b*) Profit = 250(12,000) − 500,000 − 200 (12,000)
(*c*) Profit = 250(12,000) − 200(12,000) + 500,000
(*d*) Profit = 250(10,000) − 200(10,000) − 500,000

13.63 Two methods of weed control in an irrigation canal are under consideration. Method A involves lining at a cost of $4000. The lining will last 20 years. The maintenance cost with this method will be $3 per mile per year. Method B involves spraying a chemical that costs $40 per gallon. One gallon will treat 8 miles, but the treatment must be applied 4 times per year. In determining the number of miles per year that would result in breakeven, the variable cost for method B is closest to:

(*a*) $5 per mile (*b*) $15 per mile
(*c*) $20 per mile (*d*) $40 per mile

13.64 How long will you have to maintain a business that has an income of $5000 per year and expenses of $1500 per year if your initial investment was $28,000 and your MARR is 10% per year?

(*a*) Less than 6 years (*b*) 8 years
(*c*) 12 years (*d*) 17 years

tonozdayim.com/@Zedeleyici31

	A	B	C	D
1				
2	**i value**	**10%**	**15%**	**20%**
3				
4	NPER function	`= NPER(10%,50,-200)	`= NPER(15%,50,-200)	`= NPER(20%,50,-200)
5				
6	**Result, years**	**5.36**	**6.56**	**8.83**
7				

Figure 2–26
Use of NPER function to find *n* values for various rate of return requirements, Example 2.15.

CHAPTER SUMMARY

Formulas and factors derived and applied in this chapter perform equivalence calculations for present, future, annual, and gradient cash flows. Capability in using these formulas and their standard notation manually and with spreadsheets is critical to complete an engineering economy study. Using these formulas and spreadsheet functions, you can convert single cash flows into uniform cash flows, gradients into present worths, and much more. Additionally, you can solve for rate of return i or time n.

PROBLEMS

Use of Interest Tables

2.1 Look up the numerical value for the following factors from the interest tables.
1. $(P/F,6\%,8)$
2. $(A/P,10\%,10)$
3. $(A/G,15\%,20)$
4. $(A/F,2\%,30)$
5. $(P/G,35\%,15)$

Determination of *F*, *P*, and *A*

2.2 How much can Haydon Rheosystems, Inc., afford to spend now on an energy management system if the software will save the company $21,300 per year for the next 5 years? Use an interest rate of 10% per year.

2.3 A manufacturer of off-road vehicles is considering the purchase of dual-axis inclinometers for installation in a new line of tractors. The distributor of the inclinometers is temporarily overstocked and is offering them at a 40% discount from the regular cost of $142. If the purchaser gets them now instead of 2 years from now, which is when they will be needed, what is the present worth of the savings per unit? The company would pay the regular price, if purchased in 2 years. Assume the interest rate is 10% per year.

2.4 The Moller Skycar M400 is a flying car known as a personal air vehicle (PAV) that is expected to be FAA-certified by December 31, 2011. The cost is $985,000, and a $100,000 deposit will hold one of the first 100 "cars." Assume a buyer pays the $885,000 balance 3 years after making the $100,000 deposit. At an interest rate of 10% per year, what is the effective total cost of the PAV in year 3?

2.5 A family that won a $100,000 prize on America's Funniest Home Videos decided to put one-half of the money in a college fund for their child who was responsible for the prize. If the fund earned interest at 6% per year, how much was in the account 14 years after it was started?

2.6 One of the biggest vulnerabilities in a control system is network devices, such as Ethernet-based network switches that are located in unsecured locations and accessible to everyone. DeltaX switches, manufactured by Dahne Security, allow the user to automatically lock and unlock the port access to all switches in the network. The company is considering expanding its manufacturing lines now or doing it in 3 years. If the cost now would be $1.9 million, what equivalent amount could the company afford to spend in 3 years? The interest rate is 15% per year.

2.7 A company that sells high-purity laboratory chemicals is considering investing in new equipment

tonozdayim.com/@Zedeleyici31

that will reduce cardboard costs by better matching the size of the products to be shipped to the size of the shipping container. If the new equipment will cost $220,000 to purchase and install, how much must the company save each year for 3 years in order to justify the investment, if the interest rate is 10% per year?

2.8 Red Valve Co. of Carnegie, Pennsylvania, makes a control pinch valve that provides accurate, repeatable control of abrasive and corrosive slurries, outlasting gate, plug, ball, and even satellite coated valves. How much can the company afford to spend now on new equipment in lieu of spending $75,000 four years from now? The company's rate of return is 12% per year.

2.9 If GHD Plastics purchases a new building now for $1.3 million for its corporate headquarters, what must the building be worth in 10 years? The company expects all expenditures to earn a rate of return of at least 18% per year.

2.10 CGK Rheosystems makes high-performance rotational viscometers capable of steady shear and yield stress testing in a rugged, compact footprint. How much could the company afford to spend now on new equipment in lieu of spending $200,000 one year from now and $300,000 three years from now, if the company uses an interest rate of 15% per year?

2.11 Five years ago a consulting engineer purchased a building for company offices constructed of bricks that were not properly fired. As a result, some of the bricks were deteriorated from their exposure to rain and snow. Because of the problem with the bricks, the selling price of the building was 25% below the price of comparable, structurally sound buildings. The engineer repaired the damaged bricks and arrested further deterioration by applying an extra-strength solvent-based RTV elastomeric sealant. This resulted in restoring the building to its fair market value. If the depressed purchase price of the building was $600,000 and the cost of getting it repaired was $25,000, what is the equivalent value of the "forced appreciation" today, if the interest rate is 8% per year?

2.12 Metso Automation, which manufactures addressable quarter-turn electric actuators, is planning to set aside $100,000 now and $150,000 one year from now for possible replacement of the heating and cooling systems in three of its larger manufacturing plants. If the replacement won't be needed for 4 years, how much will the company have in the account, if it earns interest at a rate of 8% per year?

2.13 Syringe pumps often fail because reagents adhere to the ceramic piston and deteriorate the seal. Trident Chemical developed an integrated polymer dynamic seal that provides a higher sealing force on the sealing lip, resulting in extended seal life. One of Trident's customers expects to reduce downtime by 30% as a result of the new seal design. If lost production would have cost the company $110,000 per year for the next 4 years, how much could the company afford to spend now on the new seals, if it uses an interest rate of 12% per year?

2.14 China spends an estimated $100,000 per year on cloud seeding efforts, which includes using antiaircraft guns and rocket launchers to fill the sky with silver iodide. In the United States, utilities that run hydroelectric dams are among the most active cloud seeders, because they believe it is a cost-effective way to increase limited water supplies by 10% or more. If the yields of cash crops will increase by 4% each year for the next 3 years because of extra irrigation water captured behind dams during cloud seeding, what is the maximum amount the farmers should spend now on the cloud seeding activity? The value of the cash crops without the extra irrigation water would be $600,000 per year. Use an interest rate of 10% per year.

2.15 The Public Service Board (PSB) awarded two contracts worth a combined $1.07 million to improve (i.e., deepen) a retention basin and reconstruct the spillway that was severely damaged in a flood 2 years ago. The PSB said that, because of the weak economy, the bids came in $950,000 lower than engineers expected. If the projects are assumed to have a 20-year life, what is the annual worth of the savings at an interest rate of 6% per year?

2.16 The National Highway Traffic Safety Administration raised the average fuel efficiency standard to 35.5 miles per gallon for cars and light trucks by the year 2016. The rules will cost consumers an average of $434 extra per vehicle in the 2012 model year. If a person purchases a new car in 2012 and keeps it for 5 years, how much must be saved in fuel costs each year to justify the extra cost? Use an interest rate of 8% per year.

2.17 In an effort to reduce childhood obesity by reducing the consumption of sugared beverages, some states have imposed taxes on soda and other soft drinks. A survey by Roland Sturm of 7300 fifth-graders revealed that if taxes averaged 4 cents on each dollar's worth of soda, no real difference in overall consumption was noticed. However, if taxes were increased to 18 cents on the dollar, Sturm calculated they would make a

tonozdayim.com/@Zedeleyici31

significant difference. For a student who consumes 100 sodas per year, what is the future worth of the extra cost from 4 cents to 18 cents per soda? Assume the student consumes sodas from grade 5 through graduation in grade 12. Use an interest rate of 6% per year.

2.18 The Texas Tomorrow Fund (TTF) is a program started in 1996 in Texas wherein parents could prepay their child's college tuition when the child was young. Actuaries set the price based on costs and investment earnings at that time. Later, the Texas legislature allowed universities to set their own tuition rates; tuition costs jumped dramatically. The cost for entering a newborn in 1996 was $10,500. If the TTF fund grew at a rate of 4% per year, while tuition costs increased at 7% per year, determine the state's shortfall when a newborn enters college 18 years later.

2.19 Henry Mueller Supply Co. sells tamperproof, normally open thermostats (i.e., thermostat closes as temperature rises). Annual cash flows are shown in the table below. Determine the future worth of the net cash flows at an interest rate of 10% per year.

Year	1	2	3	4	5	6	7	8
Income, $1000	200	200	200	200	200	200	200	200
Cost, $1000	90	90	90	90	90	90	90	90

2.20 A company that makes self-clinching fasteners expects to purchase new production-line equipment in 3 years. If the new units will cost $350,000, how much should the company set aside each year, if the account earns 10% per year?

Factor Values

2.21 Find the numerical value of the following factors using (*a*) interpolation and (*b*) the formula.
1. (*A*/*P*,13%,15)
2. (*P*/*G*,27%,10)

2.22 Find the numerical value of the following factors using (*a*) interpolation, (*b*) the formula, and (*c*) a spreadsheet function.
1. (*F*/*P*,14%,62)
2. (*A*/*F*,1%,45)

2.23 For the factor (*F*/*P*,10%,43), find the percent difference between the interpolated and formula-calculated values, assuming the formula-calculated value is the correct one.

2.24 For the factor (*F*/*A*,15%,52), find the percent difference between the interpolated and formula-calculated values, assuming the formula-calculated value is the correct one.

Arithmetic Gradient

2.25 Profits from recycling paper, cardboard, aluminum, and glass at a liberal arts college have increased at a constant rate of $1100 in each of the last 3 years. If this year's profit (end of year 1) is expected to be $6000 and the profit trend continues through year 5, (*a*) what will the profit be at the end of year 5 and (*b*) what is the present worth of the profit at an interest rate of 8% per year?

2.26 A report by the Government Accountability Office (GAO) shows that the GAO expects the U.S. Postal Service to lose a record $7 billion at the end of this year, and if the business model is not changed, the losses will total $241 billion by the end of year 10. If the losses increase *uniformly* over the 10-year period, determine the following:
(*a*) The expected increase in losses each year
(*b*) The loss 5 years from now
(*c*) The equivalent uniform worth of the losses at an interest rate of 8% per year

2.27 Rolled ball screws are suitable for high-precision applications such as water jet cutting. Their total manufacturing cost is expected to decrease because of increased productivity, as shown in the table. Determine the equivalent annual cost at an interest rate of 8% per year.

Year	1	2	3	4	5	6	7	8
Cost, $1000	200	195	190	185	180	175	170	165

2.28 Western Hydra Systems makes a panel milling machine with a 2.7-m-diameter milling head that emits low vibration and processes stress-relieved aluminum panels measuring up to 6000 mm long. The company wants to borrow money for a new production/warehouse facility. If the company offers to repay the loan with $60,000 in year 1 and amounts increasing by $10,000 each year through year 5, how much can the company borrow at an interest rate of 10% per year?

2.29 GKX Industries expects sales of its hydraulic seals (in inch and metric sizes) to increase according to the cash flow sequence $\$70 + 4k$, where k is in years and cash flow is in $1000.
(*a*) What is the amount of the cash flow in year 3?
(*b*) What is the future worth of the entire cash flow series in year 10? Let $i = 10\%$ per year.

tonozdayim.com/@Zedeleyici31

2.30 For the cash flows below, determine the amount in year 1, if the annual worth in years 1 through 9 is $601.17 and the interest rate is 10% per year.

Year	1	2	3	4	5	6	7	8	9
Cost, $1000	A	$A + 30$	$A + 60$	$A + 90$	$A + 120$	$A + 150$	$A + 180$	$A + 210$	$A + 240$

2.31 Apple Computer wants to have $2.1 billion available 5 years from now to finance production of a handheld "electronic brain" that, based on your behavior, will learn how to control nearly all the electronic devices in your home, such as the thermostat, coffee pot, TV, and sprinkler system. The company expects to set aside uniformly increasing amounts of money each year to meet its goal. If the amount set aside at the end of year 1 is $50 million, how much will the constant increase G have to be each year? Assume the investment account grows at a rate of 18% per year.

2.32 Tacozza Electric, which manufactures brush dc servomotors, budgeted $75,000 per year to pay for certain components over the next 5 years. If the company expects to spend $15,000 in year 1, how much of a uniform (arithmetic) increase each year is the company expecting in the cost of this part? Assume the company uses an interest rate of 10% per year.

Geometric Gradient

2.33 There are no tables in the back of your book for the geometric gradient series factors. Calculate the first two annual worth factor values, that is, A values for $n = 1$ and 2, that would be in a 10% interest table for a growth rate of 4% per year.

2.34 Determine the present worth of a geometric gradient series with a cash flow of $50,000 in year 1 and increases of 6% each year through year 8. The interest rate is 10% per year.

2.35 Determine the difference in the present worth values of the following two commodity contracts at an interest rate of 8% per year.

Contract 1 has a cost of $10,000 in year 1; costs will escalate at a rate of 4% per year for 10 years. Contract 2 has the same cost in year 1, but costs will escalate at 6% per year for 11 years.

2.36 El Paso Water Utilities (EPWU) purchases surface water for treatment and distribution to EPWU customers from El Paso County Water Improvement District during the irrigation season. A new contract between the two entities resulted in a reduction in future price increases in the cost of the water from 8% per year to 4% per year for the next 20 years. If the cost of water next year (which is year 1 of the new contract) will be $260 per acre-foot, what is the present worth of the savings (in $/acre-ft) to the utility between the old and the new contracts? Let the interest rate equal 6% per year.

2.37 Determine the present worth of a maintenance contract that has a cost of $30,000 in year 1 and annual increases of 6% per year for 10 years. Use an interest rate of 6% per year.

Interest Rate and Rate of Return

2.38 Gesky Industrial Products manufactures brushless blowers for boilers, food service equipment, kilns, and fuel cells. The company borrowed $18,000,000 for a plant expansion and repaid the loan in seven annual payments of $3,576,420, with the first payment made 1 year after the company received the money. What was the interest rate on the loan? Use hand and spreadsheet solutions.

2.39 If the value of Jane's retirement portfolio increased from $170,000 to $813,000 over a 15-year period, with no deposits made to the account over that period, what annual rate of return did she make?

2.40 A person's credit score is important in determining the interest rate on a home mortgage. According to Consumer Credit Counseling Service, a homeowner with a $100,000 mortgage and a 520 credit score will pay $110,325 more in interest charges over the life of a 30-year loan than a homeowner with the same mortgage and a credit score of 720. How much higher would the interest rate per year have to be in order to account for this much difference in interest charges, if the $100,000 loan is repaid in a single lump-sum payment at the end of 30 years?

2.41 During a period when the real estate market in Phoenix, Arizona, was undergoing a significant downturn, CSM Consulting Engineers made an agreement with a distressed seller to purchase an office building under the following terms: total price of $1.2 million with a down payment of $200,000 now and no payments for 4 years, after which the remaining balance of $1 million would

tonozdayim.com/@Zedeleyici31

be paid. CSM was able to make this deal because of poor market conditions at the time of purchase, and, at the same time, planning to sell the building in 4 years (when market conditions would probably be better) and move to a larger office building in Scottsdale, Arizona. If CSM was able to sell the building in exactly 4 years for $1.9 million, what rate of return per year did the company make on the investment?

2.42 A start-up company that makes hydraulic seals borrowed $800,000 to expand its packaging and shipping facility. The contract required the company to repay the investors through an innovative mechanism called *faux dividends*, a series of uniform annual payments over a fixed period of time. If the company paid $250,000 per year for 5 years, what was the interest rate on the loan?

2.43 Bessimer Electronics manufactures addressable actuators in one of its Maquiladora plants in Mexico. The company believes that by investing $24,000 each year in years 1, 2, and 3, it will avoid spending $87,360 in year 3. If the company does make the annual investments, what rate of return will it realize?

2.44 UV curable epoxy resins are used in sealing, in gap filling, and as a clear coating. Your boss saw a report submitted by the chief financial officer (CFO) that said the equivalent annual worth of maintaining the equipment used in producing the resins was $48,436 over the last 5 years. The report showed that the cost in year 1 was $42,000, and it increased arithmetically by $4000 each year. Your boss thought $48,436 was too high, so she asked you to determine what interest rate the CFO used in making the calculations. What was the interest rate?

Number of Years

2.45 Acme Bricks, a masonry products company, wants to have $600,000 on hand before it invests in new conveyors, trucks, and other equipment. If the company sets aside $80,000 per year in an account that increases in value at a rate of 15% per year, how many years will it be before Acme can purchase the equipment?

2.46 An engineer who was contemplating retirement had $1.6 million in his investment portfolio. However, a severe recession caused his portfolio to decrease to only 55% of the original amount, so he kept working. If he was able to invest his money at a rate of return of 9% per year after the recession ended, how many years did it take for his account to get back to the $1.6 million value?

2.47 You own a small engineering consulting company. If you invest $200,000 of the company's money in a natural gas well that is expected to provide income of $29,000 per year, how long must the well produce at that rate in order to get the money back plus a rate of return of 10% per year?

2.48 A perceptive engineer started saving for her retirement 15 years ago by diligently saving $18,000 each year through the present time. She invested in a stock fund that averaged a 12% rate of return over that period. If she makes the same annual investment and gets the same rate of return in the future, how long will it be from now (time zero) before she has $1,500,000 in her retirement fund?

2.49 A mechanical engineering graduate who wanted to have his own business borrowed $350,000 from his father as start-up money. Because he was family, his father charged interest at only 4% per year. If the engineer was able to pay his father $15,000 in year 1, $36,700 in year 2, and amounts *increasing* by $21,700 each year, how many years did it take for the engineer to repay the loan?

2.50 The energy costs of a company involved in powder coating of outdoor furniture are expected to increase at a rate of $400 per year. The cost at the end of the next year (year 1) is expected to be $13,000. How many years will it be from now before the equivalent annual cost is $16,000 per year, if interest is 8% per year?

2.51 In cleaning out some files that were left behind by the engineer who preceded you in your current job, you found an old report that had a calculation for the present worth of certain maintenance costs for state highways. The report contained the following equation (with cost in $1 million):

$$12\{1 - [(1 + 0.03)/(1 + 0.06)]^x\}/(0.06 - 0.03) = 140$$

The value of x that was used in the calculation was illegible. What is its value?

2.52 The equivalent annual worth of an increasing arithmetic gradient is $135,300. If the cash flow in year 1 is $35,000 and the gradient amount is $19,000, what is the value of n at an interest rate of 10% per year?

2.53 You are told that the present worth of an increasing geometric gradient is $88,146. If the cash flow in year 1 is $25,000 and the gradient increase is 18% per year, what is the value of n? The interest rate is 10% per year.

tonozdayim.com/@Zedeleyici31

ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

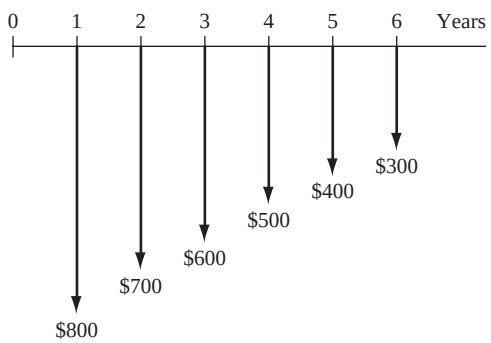
2.54 The amount of money that Diamond Systems can spend now for improving productivity in lieu of spending $30,000 three years from now at an interest rate of 12% per year is closest to:
(*a*) $15,700
(*b*) $17,800
(*c*) $19,300
(*d*) $21,350

2.55 A manufacturing company spent $30,000 on a new conveyor belt. If the conveyor belt resulted in cost savings of $4200 per year, the length of time it would take for the company to recover its investment at 8% per year is closest to:
(*a*) Less than 9 years
(*b*) 9 to 10 years
(*c*) 11 to 12 years
(*d*) Over 12 years

2.56 Levi Strauss has some of its jeans stone-washed under a contract with independent U.S. Garment Corp. If U.S. Garment's operating cost per machine is $22,000 for year 1 and increases by a constant $1000 per year through year 5, what is the equivalent uniform annual cost per machine for the 5 years at an interest rate of 8% per year?
(*a*) $23,850
(*b*) $24,650
(*c*) $25,930
(*d*) Over $26,000

2.57 The *F*/*G* factor values can be derived by multiplying:
(*a*) (*P*/*F*) and (*A*/*G*) factor values
(*b*) (*F*/*P*) and (*A*/*G*) factor values
(*c*) (*P*/*F*) and (*P*/*G*) factor values
(*d*) (*F*/*P*) and (*P*/*G*) factor values

2.58 At $i = 4\%$ per year, A for years 1 through 6 of the cash flows shown below is closest to:
(*a*) $300
(*b*) $560
(*c*) $800
(*d*) $1040



2.59 The value of the factor (*P*/*F*,*i*,10) can be found by getting the factor values for (*P*/*F*,*i*,4) and (*P*/*F*,*i*,6) and:
(*a*) Adding the values for (*P*/*F*,*i*,4) and (*P*/*F*,*i*,6)
(*b*) Multiplying the values for (*P*/*F*,*i*,4) and (*P*/*F*,*i*,6)
(*c*) Dividing the value for (*P*/*F*,*i*,6) by the value for (*P*/*F*,*i*,4)
(*d*) None of the above

2.60 A small construction company is considering the purchase of a used bulldozer for $61,000. If the company purchases the dozer now, the equivalent future amount in year 4 that the company is paying for the dozer at 4% per year interest is closest to:
(*a*) $52,143
(*b*) $65,461
(*c*) $71,365
(*d*) Over $72,000

2.61 The cost of lighting and maintaining the tallest smokestack in the United States (at a shuttered ASARCO refinery) is $90,000 per year. At an interest rate of 10% per year, the present worth of maintaining the smokestack for 10 years is closest to:
(*a*) $1,015,000
(*b*) $894,000
(*c*) $712,000
(*d*) $553,000

2.62 An enthusiastic new engineering graduate plans to start a consulting firm by borrowing $100,000 at 10% per year interest. The loan payment each year to pay off the loan in 7 years is closest to:
(*a*) $18,745
(*b*) $20,540
(*c*) $22,960
(*d*) $23,450

2.63 An engineer who believed in "save now and play later" wanted to retire in 20 years with $1.5 million. At 10% per year interest, to reach the $1.5 million goal, starting 1 year from now, the engineer must annually invest:
(*a*) $26,190
(*b*) $28,190
(*c*) $49,350
(*d*) $89,680

2.64 The cost of a border fence is $3 million per mile. If the life of such a fence is assumed to be 10 years, the equivalent annual cost of a

tonozdayim.com/@Zedeleyici31

10-mile-long fence at an interest rate of 10% per year is closest to:
(*a*) $3.6 million
(*b*) $4.2 million
(*c*) $4.9 million
(*d*) Over $5.0 million

2.65 An investment of $75,000 in equipment that will reduce the time for machining self-locking fasteners will save $20,000 per year. At an interest rate of 10% per year, the number of years required to recover the initial investment is closest to:
(*a*) 6 years
(*b*) 5 years
(*c*) 4 years
(*d*) 3 years

2.66 The number of years required for an account to accumulate $650,000 if Ralph deposits $50,000 each year and the account earns interest at a rate of 6% per year is closest to:
(*a*) 13 years
(*b*) 12 years
(*c*) 11 years
(*d*) 10 years

2.67 Aero Serve, Inc., manufactures cleaning nozzles for reverse-pulse jet dust collectors. The company spent $40,000 on a production control system that will increase profits by $13,400 per year for 5 years. The rate of return per year on the investment is closest to:
(*a*) 20%
(*b*) 18%
(*c*) 16%
(*d*) Less than 15%

2.68 Energy costs for a green chemical treatment have been increasing uniformly for 5 years. If the cost in year 1 was $26,000 and it increased by $2000 per year through year 5, the present worth of the costs at an interest rate of 10% per year is closest to:
(*a*) $102,900
(*b*) $112,300
(*c*) $122,100
(*d*) $195,800

2.69 In planning for your retirement, you expect to save $5000 in year 1, $6000 in year 2, and amounts increasing by $1000 each year through year 20. If your investments earn 10% per year, the amount you will have at the end of year 20 is closest to:
(*a*) $242,568
(*b*) $355,407
(*c*) $597,975
(*d*) $659,125

2.70 Income from a precious metals mining operation has been decreasing uniformly for 5 years. If income in year 1 was $300,000 and it decreased by $30,000 per year through year 4, the annual worth of the income at 10% per year is closest to:
(*a*) $310,500
(*b*) $258,600
(*c*) $203,900
(*d*) $164,800

2.71 If you are able to save $5000 in year 1, $5150 in year 2, and amounts increasing by 3% each year through year 20, the amount you will have at the end of year 20 at 10% per year interest is closest to:
(*a*) $60,810
(*b*) $102,250
(*c*) $351,500
(*d*) Over $410,000

CASE STUDY

TIME MARCHES ON; SO DOES THE INTEREST RATE

Background

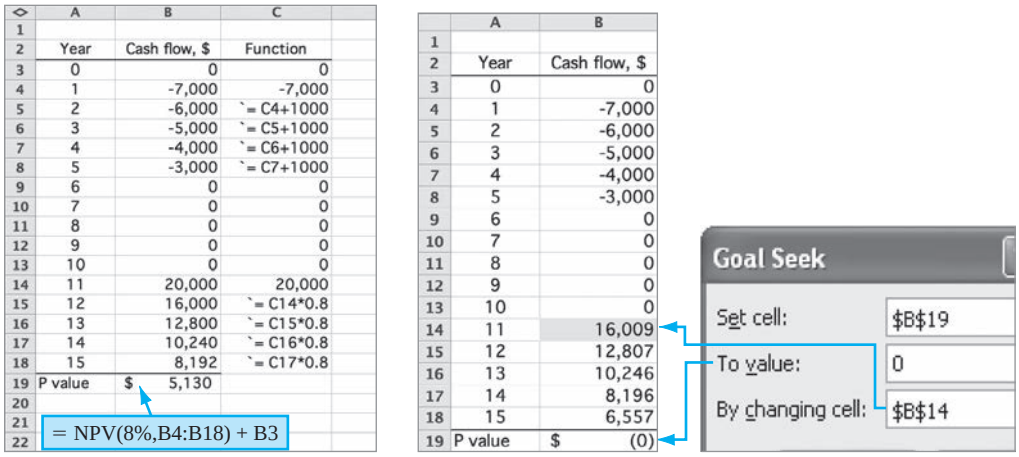
During the last week, Sundara has read about different situations that involve money, interest rate, and different amounts of time. She has gotten interested in the major effects that time and interest rates have on the amount of money necessary to do things and the significant growth in the amount of money when a large number of years are considered. In all cases, the interest focuses on the amount of money at the end of the time period.

Information

The four situations are described here.

A. Manhattan Island was purchased in 1626 for $24. After 385 years in 2011, at 6% per year compounded interest, the current value must be very large.
B. At the age of 22, if she saved only $2000 per year for the next 10 years (starting next year) and made a return of 6% per year, by today's standards, she would have accumulated a nice sum at the age of 70.

tonozdayim.com/@Zedeleyici31



	A	B	C
1			
2	Year	Cash flow, $	Function
3	0	0	0
4	1	-7,000	-7,000
5	2	-6,000	`= C4+1000
6	3	-5,000	`= C5+1000
7	4	-4,000	`= C6+1000
8	5	-3,000	`= C7+1000
9	6	0	0
10	7	0	0
11	8	0	0
12	9	0	0
13	10	0	0
14	11	20,000	20,000
15	12	16,000	`= C14*0.8
16	13	12,800	`= C15*0.8
17	14	10,240	`= C16*0.8
18	15	8,192	`= C17*0.8
19	P value	$ 5,130	
20			
21			
22		= NPV(8%,B4:B18) + B3	

(*a*)

	A	B
1		
2	Year	Cash flow, $
3	0	0
4	1	-7,000
5	2	-6,000
6	3	-5,000
7	4	-4,000
8	5	-3,000
9	6	0
10	7	0
11	8	0
12	9	0
13	10	0
14	11	16,009
15	12	12,807
16	13	10,246
17	14	8,196
18	15	6,557
19	P value	$ (0)

(*b*)

Figure 3–17
Spreadsheet solution, Example 3.8. (*a*) Cash flows and NPV function and (*b*) Goal Seek to determine initial withdrawal amount in year 11.

Solution by Spreadsheet

See Figure 3–17*a*. To determine if the investment series will cover the withdrawal series, enter the cash flows (in column B using the functions shown in column C) and apply the NPV function shown in the cell tag to display $P_T = \$+5130$ directly. As above, the + sign indicates that, from a time value of money perspective, there is more withdrawn than invested and earned.

The Goal Seek tool is very handy in determining the initial withdrawal amount that results in $P_T = 0$ (cell B19). Figure 3–17*b* shows the template and result $A_1 = \$16{,}009$ in year 11. Each succeeding withdrawal is 80% of the previous one.

Comment

If the withdrawal series is fixed as estimated initially and the investment series base amount A can be increased, the Goal Seek tool can be used to, again, set $P_T = 0$ (cell B19). However, now establish the entry in B4 as the changing cell. The response is $A = \$-8285$, and, as before, succeeding investments are \$1000 less.

CHAPTER SUMMARY

In Chapter 2, we derived the equations to calculate the present, future, or annual worth of specific cash flow series. In this chapter, we learned how to use these equations on cash flow series that are shifted in time from those for which the basic relations are derived. For example, when a uniform series does not begin in period 1, we still use the P/A factor to find the "present worth" of the series, except the P value is located one period ahead of the first A value, not at time 0. For arithmetic and geometric gradients, the P value is two periods ahead of where the gradient starts. With this information, it is possible to solve for P, A, or F for any conceivable cash flow series.

We have used the power of spreadsheet functions in determining P, F, and A values by single-cell entries and using cash flow estimates entered into a series of spreadsheet cells. Though spreadsheet solutions are fast, they do remove some of the understanding of how the time value of money and the factors change the equivalent value of money.

PROBLEMS

Present Worth Calculations

3.1 Industrial Electric Services has a contract with the U.S. Embassy in Mexico to provide maintenance for scanners and other devices in the building. If the first payment of \$12,000 is received *now*, what is the present worth of the contract, provided the company will receive a total of 10 payments (i.e., years 0 through 9) and the interest rate is 10% per year?

tonozdayim.com/@Zedeleyici31

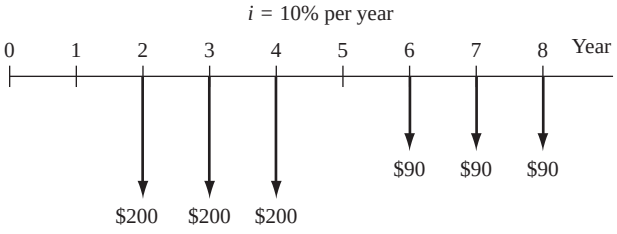
3.2 Civil engineering consulting firms that provide services to outlying communities are vulnerable to a number of factors that affect the financial condition of the communities, such as bond issues and real estate developments. A small consulting firm entered into a fixed-price contract with a large developer, resulting in a stable income of $260,000 per year in years 1 through 3. At the end of that time, a mild recession slowed the development, so the parties signed another contract for $190,000 per year for 2 more years. Determine the present worth of the two contracts at an interest rate of 10% per year.

3.3 The net cash flow associated with development and sale of a new product is shown. Determine the present worth at an interest rate of 12% per year. The cash flow is in $1000 units. Show (*a*) hand and (*b*) spreadsheet solutions.

Year	1	2	3	4	5	6	7	8	9
Cash Flow, $	−120	−100	−40	+50	+50	+80	+80	+80	+80

3.4 Standby power for water utility pumps and other electrical devices is provided by diesel-powered generators. As an alternative, the utility can use natural gas to power the generators, but it will be a few years before the gas is available at remote sites. The utility estimates that by switching to gas, it will save $22,000 per year, starting 3 years from now. At an interest rate of 8% per year, determine the present worth in year 0 of the projected savings that will occur in years 3 through 10.

3.5 Find the present worth at $i = 10\%$ per year for the cash flow series shown below.



3.6 The subsidized cost of producing water at the El Paso Water Utilities (EPWU) Kay Bailey Hutchison (KBH) desalting plant is $1.56 per 1000 gallons. Under a contract that EPWU has with Fort Bliss, the utility sells water to the Army post at a discounted price of $1.28 per 1000 gallons. (The KBH plant was built on Army property.) If Fort Bliss uses 2 billion gallons of water each year, what is the present worth of the discount for a 20-year period at an interest rate of 6% per year?

3.7 The rising cost of athletic programs at major universities has induced college presidents and athletic directors to devise innovative ways to finance cash-strapped sports programs. One of the latest schemes for big-time athletics is the "sports mortgage." At the University of Kansas, Jayhawk fans can sign up to pay $105,000 now, or over a 10-year period, for the right to buy top seats for football games during the next 30 years. In return, the seats themselves will stay locked in at current-year prices. Season tickets in tier 1 are currently selling for $350 each. A fan plans to purchase the sports mortgage along with a current-season ticket and pay for both *now*, then buy a ticket each year for the next 30 years. What is the total present worth of the pricing plan at an interest rate of 10% per year?

3.8 The cash flow associated with making self-locking fasteners is shown below. Determine the net present worth (year 0) at an interest rate of 10% per year.

Year	0	1	2	3	4	5	6	7	8	9
Income, $1000	20	20	20	20	30	30	30	30	30	30
Cost, $1000	8	8	8	8	12	12	12	12	12	25

3.9 Beckman Technologies, a relatively small manufacturer of precision laboratory equipment, borrowed $2 million to renovate one of its testing labs. In an effort to pay off the loan quickly, the company made four payments in years 1 through 4, with each payment being twice as large as the preceding one. At an interest rate of 10% per year, what was the size of the first payment?

Annual Worth Calculations

3.10 Revenue from the sale of ergonomic hand tools was $300,000 in years 1 through 4 and $465,000 in years 5 through 9. Determine the equivalent annual revenue in years 1 through 9 at an interest rate of 10% per year.

3.11 Two engineering graduates who recently got married are planning for their early retirement 20 years from now. They believe that they will need $2,000,000 in year 20. Their plan is to live on one of their salaries and invest the other. They already have $25,000 in their investment account. (*a*) How much will they have to invest each year if the account grows at a rate of 10% per year? (*b*) If the maximum they have available to invest each year is $40,000, will they reach their goal of $2 million by year 20?

3.12 Costs associated with the manufacture of miniature high-sensitivity piezoresistive pressure transducers are $73,000 per year. A clever industrial engineer found that by spending $16,000 now to reconfigure the production line and reprogram

tonozdayim.com/@Zedeleyici31

two of the robotic arms, the cost will go down to $58,000 next year and $52,000 in years 2 through 5. Using an interest rate of 10% per year, determine (*a*) the equivalent annual *cost* of the manufacturing operations and (*b*) the equivalent annual *savings* in years 1 through 5.

3.13 Calculate the equivalent annual cost in years 1 through 9 of the following series of disbursements. Use an interest rate of 10% per year. Show (*a*) hand and (*b*) spreadsheet solutions.

Year	Disbursement, $	Year	Disbursement, $
0	8000	5	4000
1	4000	6	5000
2	4000	7	5000
3	4000	8	5000
4	4000	9	5000

3.14 For the cash flows below, find the value of x that makes the equivalent annual worth in *years 1 through 7* equal to $300 per year. Use an interest rate of 10% per year. Show solutions (*a*) by hand and (*b*) using the Goal Seek tool.

Year	Cash Flow, $	Year	Cash Flow, $
0	200	4	x
1	200	5	200
2	200	6	200
3	200	7	200

3.15 Precision Instruments, Inc. manufactures high-sensitivity mini accelerometers designed for modal analysis testing. The company borrowed $10,000,000 with the understanding that it would make a $2,000,000 payment at the end of year 1 and then make equal annual payments in years 2 through 5 to pay off the loan. If the interest rate on the loan was 9% per year, how much was each payment in years 2 through 5?

3.16 A construction management company is examining its cash flow requirements for the next 7 years. The company expects to replace office machines and computer equipment at various times over the 7-year planning period. Specifically, the company expects to spend $6000 one year from now, $9000 three years from now, and $10,000 six years from now. What is the annual worth (in years 1 through 7) of the planned expenditures, at an interest rate of 10% per year?

3.17 Find the equivalent annual worth for the cash flows shown, using an interest rate of 12% per year. Monetary units are $1000.

Year	1	2	3	4	5	6	7	8	9
Cash Flow, $	20	20	20	20	60	60	60	60	60

3.18 Calculate the net annual worth in years 1 through 10 of the following series of incomes and expenses, if the interest rate is 10% per year.

Year	Income, $/Year	Expense, $/Year
0	0	−2500
1–4	700	−200
5–10	2000	−300

3.19 The city of El Paso gave the El Paso Tennis and Swim Club a 20-year lease to continue using a 10-acre arroyo park for its facilities. The club will pay $1000 per year plus make $350,000 in improvements at the park. In addition, the club will open its tennis courts to the public from 1 to 5 P.M. Monday through Thursday. If the club makes $100,000 worth of improvements now and then $50,000 worth each year for the next 5 years, what is the equivalent annual cost of the lease to the club at an interest rate of 10% per year?

3.20 Stadium Capital Financing Group is a Chicago company that conceived the so-called sports mortgage wherein fans agree to pay a relatively large amount of money over a 10- to 30-year period for the right to buy top seats for football games for up to the next 50 years. In return, season ticket prices stay locked in at current-year prices, and the package can be sold in the secondary market, while taking a tax write-off for donating to a school. Assume a fan buys a sports mortgage at West Virginia University for $150,000 that is to be paid over a 10-year period with the right to buy two season tickets for $300 each for the next 30 years. The first payment is made now (i.e., beginning-of-year payment), and an additional nine payments are to be made at the end of each year for the next 9 years. Assume the fan also purchases the two season tickets (also beginning-of-year payments). What is the total amount of the payment each year in years *0 through 9*? Use an interest rate of 10% per year.

Future Worth Calculations

3.21 The expansion plans of Acme Granite, Stone & Brick call for the company to add capacity for a new product in 5 years. The company wants to have $360,000 available before it announces the product. If the company sets aside $55,000 now and $90,000 in year 2, what uniform annual amount will it have to put in an account in years 3 through 5 to have the $360,000? Assume the account earns interest at 8% per year.

tonozdayim.com/@Zedeleyici31

3.22 For the cash flows shown, calculate the future worth in *year 8* using $i = 10\%$ per year.

Year	0	1	2	3	4	5	6
Cash Flow, $	100	100	100	100	100	300	300

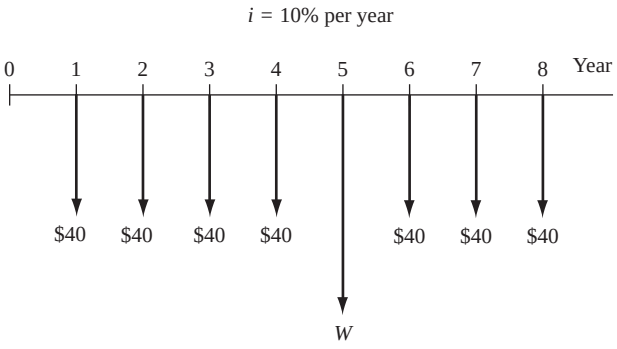
3.23 Assume you plan to start an annuity plan by making your first deposit *now*. If you make annual deposits of a uniform amount A into the account that earns interest at a rate of 7% per year, how many years from now will it be until the value of the account is equal to 10 times the value of a single deposit?

3.24 New actuator element technology enables engineers to simulate complex computer-controlled movements in any direction. If the technology results in cost savings in the design of amusement park rides, what is the future worth in year 5 of savings of $70,000 now and $20,000 per year in years 1 through 3 at an interest rate of 10% per year?

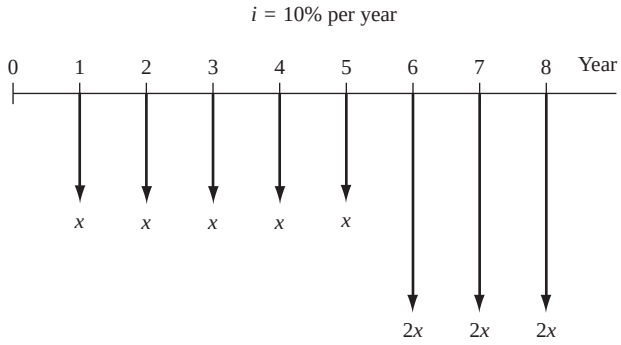
3.25 Austin Utilities is planning to install solar panels to provide some of the electricity for its groundwater desalting plant. The project would be done in two phases. The first phase will cost $4 million in year 1 and $5 million in year 2. This investment will result in energy savings (phase 2) of $540,000 in year 3, $546,000 in year 4, and amounts increasing by $6000 each year through year 10. Let $i =$ 10% per year.

(*a*) What is the future worth of the *savings*?
(*b*) Is the cost of the solar project justified by the savings? (Hint: Calculate the difference between savings and cost).

3.26 For the cash flow diagram shown, determine the value of W that will render the equivalent future worth in year 8 equal to $\$-500$ at an interest rate of 10% per year.



3.27 For the cash flows shown in the diagram, determine the value of x that will make the future worth in year 8 equal to $\$-70{,}000$.



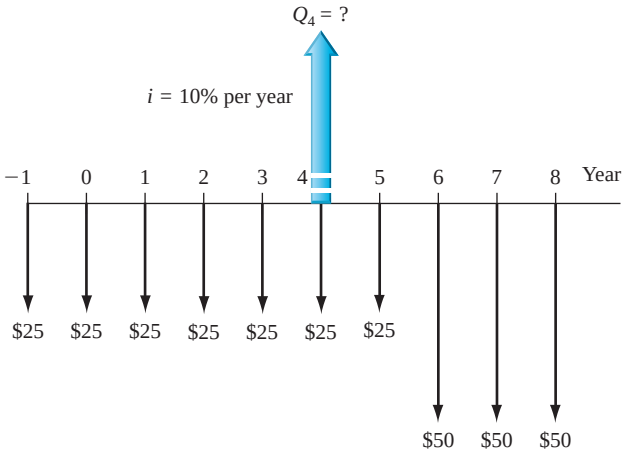
Random Single Amounts and Uniform Series

3.28 A small oil company is planning to replace its Coriolis flowmeters with Emerson Hastelloy flowmeters. The replacement process will cost the company $50,000 three years from now. How much money must the company set aside each year beginning *now* (year 0) in order to have the total amount available immediately after making the last deposit at the end of year 3? Assume the company can invest its funds at 15% per year.

3.29 A company that manufactures air-operated drain valve assemblies budgeted $74,000 per year to pay for plastic components over a 5-year period. If the company spent only $42,000 in year 1, what uniform annual amount should the company expect to spend in each of the next *4 years* to expend the entire budget? Assume the company uses an interest rate of 10% per year.

3.30 A recently hired chief executive officer wants to reduce future production costs to improve the company's earnings, thereby increasing the value of the company's stock. The plan is to invest $40,000 now and $40,000 in each of the next 2 years to improve productivity. By how much must annual costs decrease in years 3 through 7 to recover the investment plus a return of 12% per year?

3.31 Use the cash flow diagram to determine the single amount of money Q_4 in year 4 that is equivalent to all of the cash flows shown. Use $i = 10\%$ per year.



tonozdayim.com/@Zedeleyici31

3.32 For the following series of income and expenses, find the equivalent value in year 9 at an interest rate of 12% per year. Show (*a*) hand and (*b*) spreadsheet solutions.

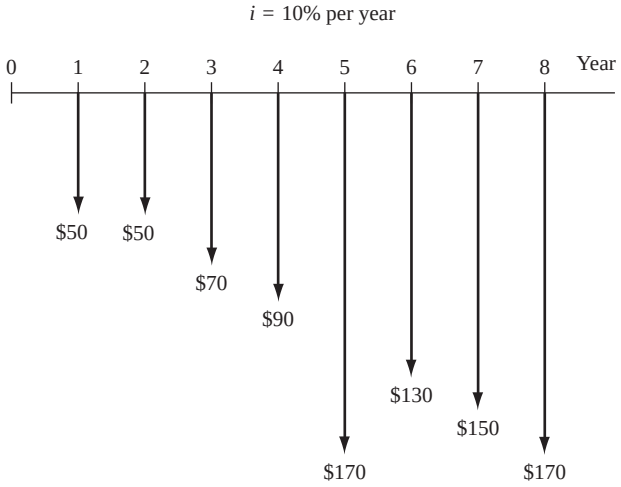
Years	Income, $	Expense, $
0	0	−70,000
1–6	9,000	−13,000
7–9	28,000	−14,000
10–16	38,000	−19,000

3.33 An investor just purchased property under a unique financing agreement with the seller. The contract price is $1.6 million. The payment plan is *Z* dollars now, 2*Z* dollars in year 2, and 3*Z* dollars in years 3 through 5. If the interest rate on the transaction is 10% per year, how much is the payment in year 2?

3.34 A foursome of entrepreneurial electrical engineering graduates has a plan to start a new solar power equipment company based on STE (solar thermal electric) technology. They have recently approached a group of investors with their idea and asked for a loan of $5 million. Within the agreement, the loan is to be repaid by allocating 80% of the company's profits each year for the first 4 years to the investors. In the fifth year, the company will pay the balance remaining on the loan in cash. The company's business plan indicates that they expect to make no profit for the first year, but in years 2 through 4, they anticipate profits to be $1.5 million per year. If the investors accept the deal at an interest rate of 15% per year, and the business plan works to perfection, what is the expected amount of the last loan payment (in *year 5*)?

Shifted Gradients

3.35 Find the present worth in year 0 for the cash flows shown. Let $i = 10\%$ per year.



3.36 For the cash flows shown, determine the present worth in year 0, if the interest rate is 12% per year.

Year	1	2	3	4	5	6	7	8	9	10
Cash Flow, $	13	13	13	13	16	19	22	25	28	31

3.37 A low-cost noncontact temperature measuring tool may be able to identify railroad car wheels that are in need of repair long before a costly structural failure occurs. If BNF Railroad saves $100,000 in years 1 through 5, $110,000 in year 6, and constant amounts increasing by $10,000 each year through year 20, what is the equivalent annual worth over the 20 years of the savings? The interest rate is 10% per year.

3.38 Determine the present worth in year 0 of the cash flows shown at an interest rate of 15% per year.

Year	1	2	3	4	5	6	7	8	9	10
Cash Flow, $	90	90	90	85	80	75	70	65	60	55

3.39 The Pedernales Electric Cooperative estimates that the present worth *now* of income from an investment in renewable energy sources is $12,475,000. There will be no income in years 1 and 2, but in year 3 income will be $250,000, and thereafter it will increase according to an arithmetic gradient through year 15. What is the required gradient, if the interest rate is 15% per year? Solve (*a*) by hand and (*b*) using a spreadsheet.

3.40 Calculate the annual cost in years 1 through 9 of the following series of disbursements. Use an interest rate of 10% per year.

Year	Disbursement, $	Year	Disbursement, $
0	5000	5	7500
1	5500	6	8000
2	6000	7	8500
3	6500	8	9000
4	7000	9	9500

3.41 The cost associated with manufacturing high-performance lubricants closely follows the cost of crude oil. For the last 10 years, a small, independent refiner had a cost of $3.4 million in years 1 through 3, after which the cost increased by 3% per year through this year. Determine the current equivalent worth (i.e., *now*) of the manufacturing cost, using an interest rate of 10% per year. Show both (*a*) hand and (*b*) spreadsheet solutions.

3.42 Find the future worth in year 10 of $50,000 in year 0 and amounts increasing by 15% per year through year 10 at an interest rate of 10% per year.

3.43 The cost of tuition at public universities has been steadily increasing for many years. One Midwestern university pledged to keep the tuition constant for

tonozdayim.com/@Zedeleyici31

4 years for all students who finished in the top 3% of their class. One such student who liked research planned to enroll at the university and continue there until earning a PhD degree (a total time of 9 years). If the tuition for the first 4 years will be $7200 per year and it increases by 5% per year for the next 5 years, what is the present worth of the tuition cost at an interest rate of 8% per year?

3.44 A private equity firm purchased a cable company and assumed the company's debt as part of the transaction. The deal was structured such that the private equity firm received $3 million immediately after the deal was closed (in year 0) through the sale of some assets. This year (year 1) income was $3.36 million, and it is projected to increase by 12% each year through expansion of the customer base. What was the present worth in the year of purchase of the income stream over a 10-year period? The firm's expected rate of return for any purchase is 15% per year.

3.45 Calculate the present worth in year 0 of a series of cash flows that starts at $150,000 in year 0 and increases by 10% per year through year 5. Assume $i = 10\%$ per year.

Shifted Decreasing Gradients

3.46 For the cash flows shown, determine the value of G such that the present worth in year 0 equals $16,000 at an interest rate of 10% per year.

Year	0	1	2	3	4	5
Cash Flow, $	0	8000	8000	8000−G	8000−2G	8000−3G

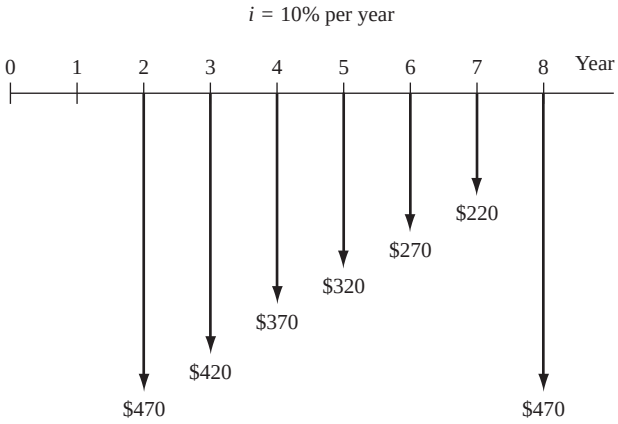
3.47 For these cash flows, find the equivalent annual worth in *years 1 through 7* at an interest rate of 10% per year.

Year	Cash Flow, $	Year	Cash Flow, $
0	850	4	650
1	800	5	600
2	750	6	550
3	700	7	500

3.48 The pumping cost for delivering water from the Ohio River to Wheeling Steel for cooling hot-rolled steel was $1.8 million for the first 3 years. An effective energy conservation program resulted in a reduced cost to $1.77 million in year 4, $1.74 million in year 5, and amounts decreasing by $30,000 each year through year 9. What is the equivalent annual worth of the pumping costs over the 9 years at an interest rate of 12% per year?

3.49 Income from the mining of mineral deposits usually decreases as the resource becomes more difficult to extract. Determine the future worth in year 10 of a mineral lease that yielded income of $14,000 in years 1 through 4 and then amounts that decreased by 5% per year through year 10. Use an interest rate of 18% per year. Show (*a*) hand and (*b*) spreadsheet solutions.

3.50 For the cash flows shown in the diagram, determine the future worth in year 8 at an interest rate of 10% per year.



3.51 Income from the sale of application software (apps) is usually constant for several years and then decreases quite rapidly as the market gets close to saturation. Income from one smart phone app was $38,000 in years 1 through 3 and then decreased geometrically by 15% per year through year 7. Determine the equivalent annual income in years 1 through 7, using an interest rate of 10% per year.

3.52 Determine the future worth in year 10 of a cash flow series that starts in year 0 at $100,000 and decreases by 12% per year. Use an interest rate of 12% per year.

tonozdayim.com/@Zedeleyici31

ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

3.53 A manufacturer of toilet flush valves wants to have $1,900,000 available 3 years from now so that a new product line can be initiated. If the company plans to deposit money each year, starting *now*, the equation that represents the deposit each year at 8% per year interest is:

(*a*) 1,900,000(A/F,8%,3)
(*b*) 1,900,000(A/F,8%,4)
(*c*) 1,900,000 + 1,900,000(A/F,8%,3)
(*d*) 1,900,000 + 1,900,000(A/F,8%,2)

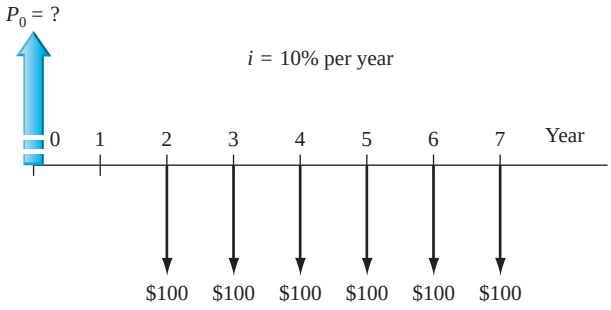
3.54 The present worth in year 0 of a lease that requires a payment of $9000 *now* and amounts increasing by 5% per year through year 10 at 8% per year interest is closest to:

(*a*) $73,652
(*b*) $79,939
(*c*) $86,335
(*d*) Over $87,000

3.55 For the diagram shown, the respective values of n for the following equation are:

$$P_0 = 100(P/A,10\%,n)(P/F,10\%,n)$$

(*a*) 6 and 1
(*b*) 6 and 2
(*c*) 7 and 1
(*d*) 7 and 2



3.56 Summit Metals is planning to expand its Wichita, Kansas, manufacturing operation 5 years from now at a cost of $10,000,000. If the company plans to deposit money into an account each year for 4 years beginning 2 years from now (first deposit is in year 2) to pay for the expansion, the equation that represents the amount of the deposit at 9% per year interest is:

(*a*) A = 10,000,000(A/F,9%,5)
(*b*) A = 10,000,000(A/F,9%,4)
(*c*) A = 10,000,000(A/P,9%,4)
(*d*) A = 10,000,000(A/F,9%,4)(P/F,9%,1)

3.57 The amount of money a person must deposit 3 years from now in order to withdraw $10,000 per year for 10 years beginning 15 years from now at an interest rate of 10% per year is closest to:

(*a*) $15,500 (*b*) $17,200
(*c*) $19,300 (*d*) $21,500

3.58 Cindy wants to deposit money for 4 consecutive years starting 3 years from now so she can withdraw $50,000 twelve years from now. Assume the interest rate is 8% per year. The annual deposit is closest to:

(*a*) $6990
(*b*) $7670
(*c*) $8530
(*d*) $10,490

3.59 The net present worth in year 0 of the following series of incomes and expenses at 8% per year is closest to:

Years	Income, $	Expenses, $
0	12,000	−1000
1–6	700	−100
7–11	900	−200

(*a*) $14,300 (*b*) $15,500
(*c*) $16,100 (*d*) $16,500

3.60 For the cash flows shown, the equivalent annual worth in periods 1 through 5 at an interest rate of 10% per year is closest to:

Annual Period	Amount, $
0	1000
1	1000
2	1000
3	1000
4	1000
5	1500

(*a*) $1120 (*b*) $1240
(*c*) $1350 (*d*) $1490

3.61 For the cash flows shown, the value of X that will make the present worth in year 0 equal to $5000 at an interest rate of 10% per year is closest to:

Year	0	1	2	3	4	5	6	7	8	9
Cash Flow, $	200	300	400	500	600	700	800	900	1000	X

(*a*) $2895 (*b*) $3125
(*c*) $3305 (*d*) $3765

3.62 In order to have cash available for unforeseen emergencies, Baring Systems, a military contractor, wants to have $2,000,000 in a contingency fund 4 years from now. The amount the company must deposit each year in years 0 through 4 at an interest rate of 10% per year is closest to:

(*a*) $420,100 (*b*) $327,600
(*c*) $284,600 (*d*) $206,900

tonozdayim.com/@Zedeleyici31

The m is the number of compounding periods (CP) per interest period. If interest compounding becomes more and more frequent, then the length of a CP approaches zero, continuous compounding results, and the effective i is $\boldsymbol{e^r - 1}$.

All engineering economy factors require the use of an effective interest rate. The i and n values placed in a factor depend upon the type of cash flow series. If only single amounts (P and F) are present, there are several ways to perform equivalence calculations using the factors. However, when series cash flows (A, G, and g) are present, only one combination of the effective rate i and number of periods n is correct for the factors. This requires that the relative lengths of PP and CP be considered as i and n are determined. The interest rate and payment periods must have the same time unit for the factors to correctly account for the time value of money.

From one year (or interest period) to the next, interest rates will vary. To accurately perform equivalence calculations for P and A when rates vary significantly, the applicable interest rate should be used, not an average or constant rate.

PROBLEMS

Nominal and Effective Rates

4.1 From the interest statement 18% per year, compounded monthly, determine the values for interest period, compounding period, and compounding frequency.

4.2 From the interest statement 1% per month, determine the values for interest period, compounding period, and compounding frequency.

4.3 Determine the number of times interest would be compounded in 6 months from the interest statements (*a*) 18% per year, compounded monthly, (*b*) 1% per month, and (*c*) 2% per quarter.

4.4 For an interest rate of 1% per 2 months, determine the number of times interest would be compounded in (*a*) 2 months, (*b*) two semiannual periods, and (*c*) 3 years.

4.5 Identify the compounding period for the following interest statements: (*a*) 3% per quarter; (*b*) 10% per year, compounded semiannually; (*c*) nominal 7.2% per year, compounded monthly; (*d*) effective 3.4% per quarter, compounded weekly; and (*e*) 2% per month, compounded continuously.

4.6 Identify the following interest rate statements as either nominal or effective: (*a*) 1.5% per month, compounded daily; (*b*) 17% per year, compounded quarterly; (*c*) effective 15% per year, compounded monthly; (*d*) nominal 0.6% per month, compounded weekly; (*e*) 0.3% per week, compounded weekly; and (*f*) 8% per year.

4.7 Convert the given interest rates in the left-hand column into the nominal rates listed in the right-hand column. (Assume 4 weeks/month.)

Given Interest Rate	Desired Interest Rate
1% per month	Nominal rate per year
3% per quarter	Nominal rate per 6 months
2% per quarter	Nominal rate per year
0.28% per week	Nominal rate per quarter
6.1% per 6 months	Nominal rate per 2 years

4.8 What nominal interest rate per year is equivalent to 11.5% per year, compounded monthly?

4.9 For a Federal Credit Union that offers an interest rate of 8% per year, compounded quarterly, determine the nominal rate per 6 months.

4.10 The Second National Bank of Fullertum advertises an APR of 14% compounded monthly for student loans. Determine the APY. Show hand and spreadsheet solutions.

4.11 For an effective annual rate i_a of 15.87% compounded quarterly, determine (*a*) the effective quarterly rate and (*b*) the nominal annual rate. (*c*) What is the spreadsheet function to find the nominal annual rate above?

4.12 High-tech companies such as IBM, AMD, and Intel have been using nanotechnology for several years to make microchips with faster speeds while using less power. A less well-known company in the chip business has been growing fast enough that the company uses a minimum attractive rate of return of 60% per year. If this MARR is an effective annual rate compounded monthly, determine the effective monthly rate.

4.13 An interest rate of 21% per year, compounded every 4 months, is equivalent to what effective rate per year? Show hand and spreadsheet solutions.

tonozdayim.com/@Zedeleyici31

4.14 An interest rate of 8% per 6 months, compounded monthly, is equivalent to what effective rate per quarter?

4.15 A small company that makes modular bevel gear drives with a tight swing ratio for optimizing pallet truck design was told that the interest rate on a mortgage loan would be an *effective* 4% per quarter, compounded monthly. The owner was confused by the terminology and asked you to help. What are (*a*) the APR and (*b*) the APY?

4.16 In 'N Out Payday Loans advertises that for a fee of only $10, you can immediately borrow up to $200 for one month. If a person accepts the offer, what are (*a*) the nominal interest rate per year and (*b*) the effective rate per year?

4.17 A government-required truth-in-lending document showed that the APR was 21% and the APY was 22.71%. Determine the compounding frequency at which the two rates are equivalent.

4.18 Julie has a low credit rating, plus she was furloughed from her job 2 months ago. She has a new job starting next week and expects a salary to start again in a couple of weeks. Since she is a little short on money to pay her rent, she decided to borrow $100 from a loan company, which will charge her only $10 interest if the $110 is paid no more than 1 week after the loan is made. What are the (*a*) nominal annual and (*b*) effective annual interest rates that she will pay on this loan?

Equivalence When PP ≥ CP

4.19 Assume you deposit 25% of your monthly check of $5500 into a savings account at a credit union that compounds interest semiannually. (*a*) What are the payment and compounding periods? (*b*) Is the payment period greater than or less than the compounding period?

4.20 Interest is compounded quarterly, and single-payment cash flows (that is, F and P) are separated by 5 years. What must the *compounding period* be on the interest rate, if the value of n in the P/F or F/P equation is (*a*) $n = 5$, (*b*) $n = 20$, or (*c*) $n = 60$?

4.21 When interest is compounded quarterly and a uniform series cash flow of $4000 occurs every 6 months, what time periods on i and n must be used?

4.22 Pinpoint Laser Systems is planning to set aside $260,000 now for possibly replacing its 4-pole, 38-MW synchronous motors when it becomes necessary. If the replacement is expected to take place in 3 years, how much will the company have in its investment set-aside account? Assume the company can achieve a rate of return of 12% per year, compounded quarterly.

4.23 Wheeling-Pittsburgh Steel is investigating whether it should replace some of its basic oxygen furnace equipment now or wait to do it later. The cost later (i.e., 3 years from now) is estimated to be $1,700,000. How much can the company afford to spend now, if its minimum attractive rate of return is 1.5% per month?

4.24 How much can Wells Fargo lend to a developer who will repay the loan by selling 6 view lots at $190,000 each 2 years from now? Assume the bank will lend at a nominal 14% per year, compounded semiannually.

4.25 How much will be in a high-yield account at the National Bank of Arizona 12 years from now if you deposit $5000 now and $7000 five years from now? The account earns interest at a rate of 8% per year, compounded quarterly.

4.26 Loadstar Sensors is a company that makes load/force sensors based on capacitive sensing technology. The company wants to have $28 million for a plant expansion 4 years from now. If the company has already set aside $12 million in an investment account for the expansion, how much more must the company add to the account next year (i.e., 1 year from now) so that it will have the $28 million 4 years from now? The account earns interest at 12% per year, compounded quarterly.

4.27 A structural engineering consulting company is examining its cash flow requirements for the next 6 years. The company expects to replace office machines and computer equipment at various times over the 6-year planning period. Specifically, the company expects to spend $21,000 two years from now, $24,000 three years from now, and $10,000 five years from now. What is the present worth of the planned expenditures at an interest rate of 10% per year, compounded semiannually?

4.28 Irvin Aerospace of Santa Ana, California, was awarded a 5-year contract to develop an advanced space capsule airbag landing attenuation system for NASA's Langley Research Center. The company's computer system uses fluid structure interaction modeling to test and analyze each airbag design concept. What is the present worth of the contract at 16% per year, compounded quarterly, if the quarterly cost in years 1 through 5 is $2 million per quarter?

tonozdayim.com/@Zedeleyici31

4.29 Heyden Motion Solutions ordered $7 million worth of seamless tubes for its drill collars from the Timken Company of Canton, Ohio. (A drill collar is the heavy tubular connection between a drill pipe and a drill bit.) At 12% per year, compounded semiannually, what is the equivalent uniform cost per semiannual period over a 5-year amortization period?

4.30 In 2010, the National Highway Traffic Safety Administration raised the average fuel efficiency standard to 35.5 miles per gallon (mpg) for cars and light trucks by the year 2016. The rules will cost consumers an average of $926 extra per vehicle in the 2016 model year. Assume Yolanda will purchase a new car in 2016 and plans to keep it for 5 years. How much will the monthly savings in the cost of gasoline have to be to recover Yolanda's extra cost? Use an interest rate of 0.75% per month.

4.31 Fort Bliss, a U.S. Army military base, contributed $3.3 million of the $87 million capital cost for a desalting plant constructed and operated by El Paso Water Utilities (EPWU). In return, EPWU agreed to sell water to Fort Bliss at $0.85 per 1000 gallons for 20 years. If the army base uses 200 million gallons of water per month, what is the Army's cost per month for water? The $3.3 million capital cost is amortized at an interest rate of 6% per year, compounded monthly.

4.32 Beginning in 2011, city hall, administrative offices, and municipal courts in the city of El Paso, Texas, will go on a 10 hour/day, 4-day workweek from the beginning of May through the end of September. The shortened workweek will affect 25% of the city's 6100 employees and will save $42,600 per month for those 5 months, because of reduced fuel, utility, and janitorial expenses. If this work schedule continues for the next 10 years, what is the future worth of the savings at the end of that time (i.e., end of year 2020)? Use an interest rate of 0.5% per month.

4.33 In October 2009, Wal-Mart started selling caskets on its website that undercut many funeral homes. Prices ranged from $999 for steel models such as *Dad Remembered* to $3199 for the *Sienna Bronze* casket. Part of the business model is to get people to plan ahead, so the company is allowing people to pay for the caskets over a 12-month period with no interest. An individual purchased a *Sienna Bronze* casket and made 12 equal monthly payments (in months 1 through 12) at no interest. How much did this person save each month compared to another person who paid an interest rate of 6% per year, compounded monthly?

4.34 NRG Energy plans to construct a giant solar plant in Santa Teresa, New Mexico, to supply electricity to West Texas Electric. The plant will have 390,000 heliostats to concentrate sunlight onto 32 water towers to generate steam. It will provide enough power for 30,000 homes. If the company spends $28 million per month for 2 years in constructing the plant, how much will the company have to make each month in years 3 through 22 (that is, 20 years) to recover its investment plus 18% per year, compounded monthly?

4.35 Many college students have Visa credit cards that carry an interest rate of "simple 24% per year" (that is, 2% per month). When the balance on such a card is $5000, the minimum payment is $110.25.

(*a*) What is the amount of interest in the first payment?

(*b*) How long will it take, in months, to pay off the balance, if the cardholder continues to make payments of $110.25 per month and adds no other charges to the card?

4.36 Bart is an engineering graduate who did not take the engineering economy elective during his B.S. degree course work. After working for a year or so, he found himself in financial trouble, and he borrowed $500 from a friend in the finance department at his office. Bart agreed to repay the loan principal plus $75 interest 1 month later. The two got separated doing different jobs, and 1 year went by. The friend e-mailed Bart after exactly 1 year and asked for the loan repayment plus the interest with monthly compounding, since Bart had made no effort to repay the loan during the year. (*a*) What does Bart now owe his friend? (*b*) What effective annual interest rate did Bart pay on this $500 loan?

4.37 AT&T announced that the early termination fee for smart phones will jump from $175 to $375. The fee will be reduced by $10 each month of the 2-year contract. Wireless carriers justify the fees by pointing out that the cost of a new phone is heavily discounted from what the carrier pays the manufacturer. Assume AT&T pays $499 for an iPhone that it sells for $199. How much profit would the company have to make each month (i.e., prior to the termination), if it wanted to make a rate of return of 1.5% per month on its $300 investment in a customer who terminates the contract after 12 months?

4.38 What is the future worth of a present cost of $285,000 to Monsanto, Inc. 5 years from now at an interest rate of 2% per month?

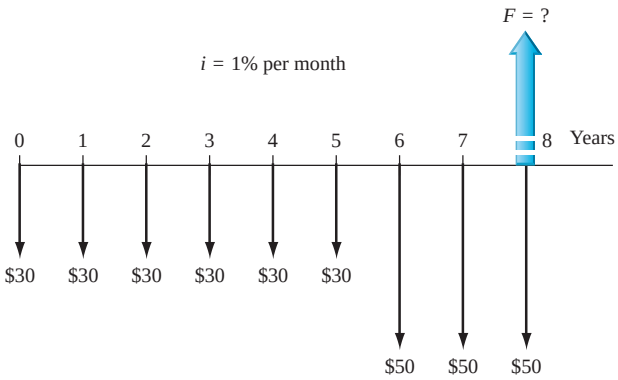
tonozdayim.com/@Zedeleyici31

4.39 Environmental recovery company RexChem Partners plans to finance a site reclamation project that will require a 4-year cleanup period. The company plans to borrow $3.6 million now. How much will the company have to get in a lump-sum payment when the project is over in order to earn 24% per year, compounded quarterly, on its investment?

4.40 For the cash flows shown below, determine the equivalent uniform worth in years 1 through 5 at an interest rate of 18% per year, compounded monthly.

Year	1	2	3	4	5
Cash Flow, $	200,000	0	350,000	0	400,000

4.41 For the cash flow diagram shown, solve for F, using an interest rate of 1% per month.



4.42 According to the Government Accountability Office (GAO), if the U.S. Postal Service does not change its business model, it will lose $480 million next month and $500 million the month after that, and the losses will increase by $20 million per month for the next 10 years. At an interest rate of 0.25% per month, what is the equivalent uniform amount per month of the losses through year 10?

4.43 Equipment maintenance costs for manufacturing explosion-proof pressure switches are projected to be $100,000 in year 1 and increase by 4% each year through year 5. What is the present worth of the maintenance costs at an interest rate of 10% per year, compounded quarterly?

Equivalence When PP < CP

4.44 If you deposit $1000 per month into an investment account that pays interest at a rate of 6% per year, compounded quarterly, how much will be in the account at the end of 5 years? There is no interperiod compounding.

4.45 Freeport McMoran purchased two model MTVS peristaltic pumps (to inject sulfuric acid and King Lee antiscalant) for use at its nanofiltration water conditioning plant. The cost of the pumps was $950 each. If the chemical cost is $11 per day, determine the equivalent cost *per month* at an interest rate of 12% per year, compounded monthly. Assume 30 days per month and a 3-year pump life.

4.46 Income from recycling paper and cardboard at the U.S. Army's Fort Benning Maneuver Center has averaged $3000 per month for 2½ years. What is the future worth of the income (after the 2½ years) at an interest rate of 6% per year, compounded quarterly? Assume there is no interperiod compounding.

4.47 The Autocar E3 refuse truck has an energy recovery system developed by Parker Hannifin LLC that is expected to reduce fuel consumption by 50%. Pressurized fluid flows from carbon fiber-reinforced accumulator tanks to two hydrostatic motors that propel the vehicle forward. (The truck recharges the accumulators when it brakes.) The fuel cost for a regular refuse truck is $900 per month. How much can a private waste-hauling company afford to spend now on the recovery system, if it wants to recover its investment in 3 years plus a return of 14% per year, compounded semiannually? Assume no interperiod compounding.

Continuous Compounding

4.48 What effective interest rate per year is equal to 1.2% per month, compounded continuously? Show hand and spreadsheet solutions.

4.49 What effective interest rate per quarter is equal to a nominal 1.6% per month, compounded continuously?

4.50 What nominal rate per month is equivalent to an effective 1.3% per month, compounded continuously?

4.51 Companies such as GE that have huge amounts of cash flow every day base their financial calculations on continuous compounding. If the company wants to make an effective 25% per year, compounded continuously, what nominal daily rate of return has to be realized? Assume 365 days per year.

4.52 U.S. Steel is planning a plant expansion that is expected to cost $13 million. How much money must the company set aside now in a lump-sum investment to have the money in 2 years? Capital funds earn interest at a rate of 12% per year, compounded continuously.

tonozdayim.com/@Zedeleyici31

4.53 Periodic outlays for inventory control software at Baron Chemicals are expected to be $150,000 immediately, $200,000 in 1 year, and $350,000 in 2 years. What is the present worth of the costs at an interest rate of 10% per year, compounded continuously?

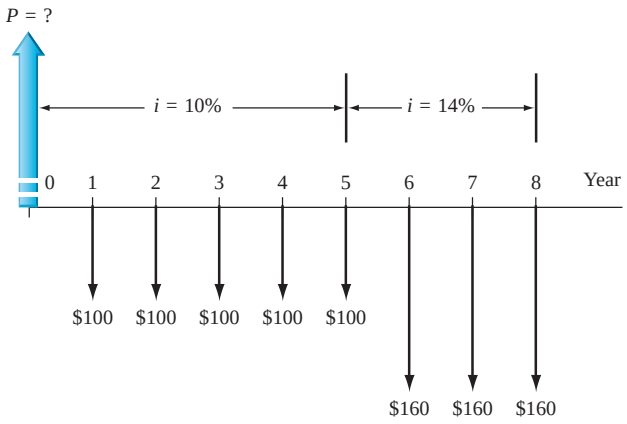
Varying Interest Rates

4.54 Many small companies use accounts receivable as collateral to borrow money for continuing operations and meeting payrolls. If a company borrows $300,000 now at an interest rate of 1% per month, but the rate changes to 1.25% per month after 4 months, how much will the company owe at the end of 1 year?

4.55 The maintenance cost for furnaces at a copper smelting plant have been constant at $140,000 per year for the past 5 years. If the interest rate was 8% per year for the first 3 years and then it increased to 10% in years 4 and 5, what is the equivalent future worth (in year 5) of the maintenance cost? Show hand and spreadsheet solutions.

4.56 By filling carbon nanotubes with miniscule wires made of iron and iron carbide, incredibly thin nanowires can be extruded by blasting the carbon nanotubes with an electron beam. If Gentech Technologies plans to spend $1.7 million in year 1, $2.1 million in year 2, and $3.4 million in year 3 to develop the technology, determine the present worth of the investments in year 0, if the interest rate in year 1 is 10% and in years 2 and 3 it is 12% per year.

4.57 Find (*a*) the present worth *P*, and (*b*) the equivalent uniform annual worth *A* for the cash flows shown below.



ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

4.58 The term *annual percentage rate* is the same as:
(*a*) Effective rate
(*b*) Nominal rate
(*c*) Annual percentage yield
(*d*) All of the above

4.59 An interest rate is an effective rate under all of the following conditions, *except when:*
(*a*) The compounding period is not stated
(*b*) The interest period and compounding period are the same
(*c*) The interest statement says that the interest rate is effective
(*d*) The interest period is shorter than the compounding period

4.60 An interest rate of nominal 12% per year, compounded weekly, is:
(*a*) An effective rate per year
(*b*) An effective rate per week
(*c*) A nominal rate per year
(*d*) A nominal rate per week

4.61 An interest rate of 1.5% per month, compounded continuously, is the same as:
(*a*) An effective 1.5% per month
(*b*) 4.5% per quarter, compounded continuously
(*c*) 6.0% per quarter, compounded continuously
(*d*) 9% per 6 months

4.62 An effective 12.68% per year, compounded monthly, is the closest to:
(*a*) 12% per year
(*b*) 12% per year, compounded annually
(*c*) 1% per month
(*d*) 1% per month, compounded annually

4.63 For an interest rate of 2% per month, the effective *semiannual* interest rate is:
(*a*) 2.02%
(*b*) 12.005%
(*c*) 12.31%
(*d*) 12.62%

4.64 If you make quarterly deposits for 3 years into an account that compounds interest at 1% per month, the value of *n* in the *F*/*A* factor that will determine *F* at the end of the 3-year period is:
(*a*) 3
(*b*) 12
(*c*) 36
(*d*) None of these

tonozdayim.com/@Zedeleyici31

4.65 Identify the following interest rates as nominal or effective.

Rate 1: 1.5% per quarter
Rate 2: 1.5% per quarter, compounded monthly

(*a*) Both are nominal rates.
(*b*) Rate 1 is nominal and rate 2 is effective.
(*c*) Rate 1 is effective and rate 2 is nominal.
(*d*) Both are effective.

4.66 In solving uniform series problems, *n* in the standard factor notation equation is equal to the number of arrows (i.e., cash flows) in the original cash flow diagram when:

(*a*) The payment period (PP) is longer than the compounding period (CP).
(*b*) The compounding period is equal to the payment period.
(*c*) Both (*a*) and (*b*) are correct.
(*d*) The compounding period is longer than the payment period.

4.67 An engineer who is saving for her retirement plans to deposit $500 every *quarter*, starting one quarter from now, into an investment account. If the account pays interest at 6% per year, compounded semiannually, the total she will have at the end of 25 years is closest to:

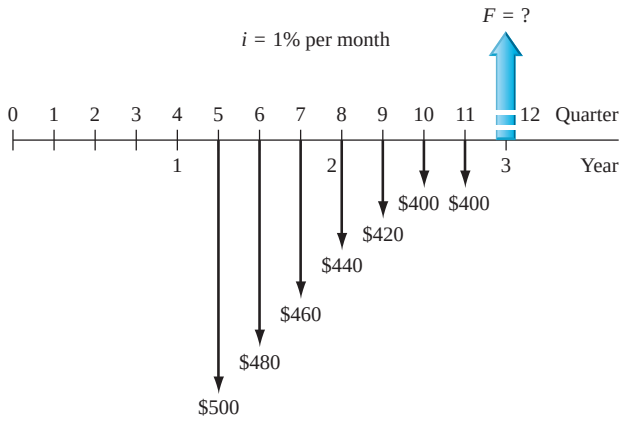
(*a*) $50,000 (*b*) $56,400
(*c*) $79,700 (*d*) $112,800

4.68 A company that makes flange-mount, motorized rotary potentiometers expects to spend $50,000 for a certain machine 4 years from now. At an interest rate of 12% per year, compounded quarterly, the present worth of the machine's cost is represented by the following equation:

(*a*) $P = 50{,}000(P/F, 3\%, 16)$
(*b*) $P = 50{,}000(P/F,$ effective i/6 months, 8)
(*c*) $P = 50{,}000(P/F,$ effective i/year, 4)
(*d*) Any of the above

4.69 For the cash flow diagram shown, the unit of the payment period (PP) is:

(*a*) Months (*b*) Quarters
(*c*) Semiannual (*d*) Years



4.70 A small company plans to spend $10,000 in year 2 and $10,000 in year 5. At an interest rate of *effective* 10% per year, compounded semiannually, the equation that represents the equivalent annual worth *A* in years 1 through 5 is:

(*a*) $A = 10{,}000(P/F,10\%,2)(A/P,10\%,5) + 10{,}000(A/F,10\%,5)$
(*b*) $A = 10{,}000(A/P,10\%,4) + 10{,}000(A/F,10\%,5)$
(*c*) $A = 10{,}000(P/F,5\%,2)(A/P,5\%,10) + 10{,}000(A/F,5\%,10)$
(*d*) $A = [10{,}000(F/P,10\%,5) + 10{,}000](A/F,10\%,5)$

4.71 Assume you make *monthly* deposits of $200 starting one month from now into an account that pays 6% per year, compounded semiannually. If you want to know the total after *4 years*, the value of *n* you should use in the F/A factor is:

(*a*) 2 (*b*) 4 (*c*) 8 (*d*) 12

4.72 The cost of replacing part of a cell phone videochip production line in 6 years is estimated to be $500,000. At an interest rate of 14% per year, compounded semiannually, the uniform amount that must be deposited into a sinking fund every 6 months is closest to:

(*a*) $21,335 (*b*) $24,825
(*c*) $27,950 (*d*) $97,995

tonozdayim.com/@Zedeleyici31

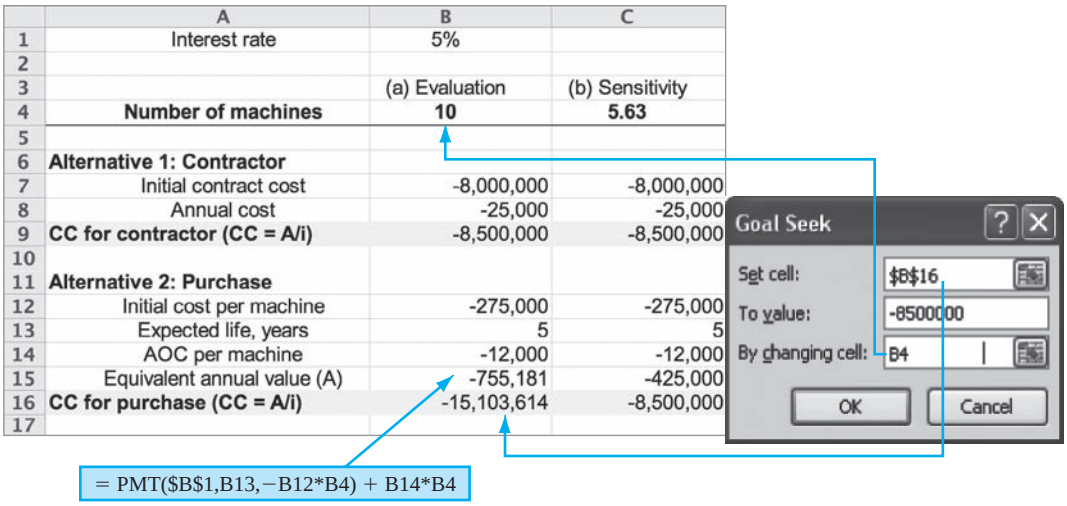


Figure 5–6
Spreadsheet solution of Example 5.8 using capitalized cost (*a*) for 10 recycling sites and (*b*) to determine the number of sites to make the alternatives economically equal.

must be an integer, *5 or fewer sites will favor purchasing the equipment* and 6 or more sites will favor contracting the separation services.

This approach to problem solution will be called *breakeven analysis* in later chapters of the text. By the way, another way to determine the number of sites is by trial and error. Enter different values in cell B4 until the CC values favor the purchase alternative.

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.

If the life of the alternatives is considered to be very long or 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 $n = \infty$.

PROBLEMS

Types of Projects

5.1 What is the difference between mutually exclusive alternatives and independent projects?

5.2 (*a*) What is meant by the do-nothing alternative?
(*b*) When is the do-nothing alternative *not* an option?

5.3 (*a*) How many alternatives are possible from four independent projects identified as W, X, Y, and Z?
(*b*) List all of the possibilities.

5.4 What is the difference between a revenue and a cost alternative?

tonozdayim.com/@Zedeleyici31

5.5 What is meant by the term *equal service?*

5.6 What two approaches can be used to satisfy the equal-service requirement?

Alternative Comparison—Equal Lives

5.7 A company that manufactures magnetic membrane switches is investigating two production options that have the estimated cash flows shown ($1 million units). Which one should be selected on the basis of a present worth analysis at 10% per year?

	In-house	Contract
First cost, $	−30	0
Annual cost, $ per year	−5	−2
Annual income, $ per year	14	3.1
Salvage value, $	2	—
Life, years	5	5

5.8 The manager of a canned food processing plant must decide between two different labeling machines. Machine A will have a first cost of $42,000, an annual operating cost of $28,000, and a service life of 4 years. Machine B will cost $51,000 to buy and will have an annual operating cost of $17,000 during its 4-year life. At an interest rate of 10% per year, which should be selected on the basis of a present worth analysis?

5.9 A metallurgical engineer is considering two materials for use in a space vehicle. All estimates are made. (*a*) Which should be selected on the basis of a present worth comparison at an interest rate of 12% per year? (*b*) At what first cost for the material *not selected above* will it become the more economic alternative?

	Material X	Material Y
First cost, $	−15,000	−35,000
Maintenance cost, $ per year	−9,000	−7,000
Salvage value, $	2,000	20,000
Life, years	5	5

5.10 To retain high-performing engineers, a large semiconductor company provides corporate stock as part of the compensation package. In one particular year, the company offered 1000 shares of either class A or class B stock. The class A stock was selling for $30 per share at the time, and stock market analysts predicted that it would increase at a rate of 6% per year for the next 5 years. Class B stock was selling for $20 per share, but its price was expected to increase by 12% per year. At an interest rate of 8% per year, which stock should the engineers select on the basis of a present worth analysis and a 5-year planning horizon?

5.11 The Murphy County Fire Department is considering two options for upgrading its aging physical facilities. Plan A involves remodeling the fire stations on Alameda Avenue and Trowbridge Boulevard that are 57 and 61 years old, respectively. (The industry standard is about 50 years of use for a station.) The cost for remodeling the Alameda station is estimated at $952,000 while the cost of redoing the Trowbridge station is $1.3 million. Plan B calls for buying 5 acres of land somewhere between the two stations, building a new fire station, and selling the land and structures at the previous sites. The cost of land in that area is estimated to be $366,000 per acre. The size of the new fire station would be 9000 square feet with a construction cost of $151.18 per square foot. Contractor fees for overhead, profit, etc. are expected to be $340,000, and architect fees will be $81,500. (Assume all of the costs for plan B occur at time 0.) If plan A is adopted, the extra cost for personnel and equipment will be $126,000 per year. Under plan B, the sale of the old sites is anticipated to net a positive $500,000 five years in the future. Use an interest rate of 6% per year and a 50-year useful life for the remodeled and new stations to determine which plan is better on the basis of a present worth analysis.

5.12 Delcon Properties is a commercial developer of shopping centers and malls in various places around the country. The company needs to analyze the economic feasibility of rainwater drains in a 60-acre area that it plans to develop. Since the development won't be started for 3 years, this large open space will be subject to damage from heavy thunderstorms that cause soil erosion and heavy rutting. If no drains are installed, the cost of refilling and grading the washed out area is expected to be $1500 per thunderstorm. Alternatively, a temporary corrugated steel drainage pipe could be installed that will prevent the soil erosion. The cost of the pipe will be $3 per foot for the total length of 7000 feet required. Some of the pipe will be salvageable for $4000 at the end of the 3-year period between now and when the construction begins. Assuming that thunderstorms occur regularly at 3-month intervals, starting 3 months from now, which alternative should be selected on the basis of a present worth comparison using an interest rate of 4% per quarter?

5.13 A public water utility is trying to decide between two different sizes of pipe for a new water main. A 250-mm line will have an initial cost of $155,000, whereas a 300-mm line will cost $210,000. Since there is more head loss through the 250-mm pipe, the pumping cost is expected to be $3000 more per year than for the 250-mm line. If the lines are

tonozdayim.com/@Zedeleyici31

expected to last for 30 years, which size should be selected on the basis of a present worth analysis using an interest rate of 10% per year?

5.14 The supervisor of a community swimming pool has developed two methods for chlorinating the pool. If gaseous chlorine is added, a chlorinator will be required that has an initial cost of $8000 and a useful life of 5 years. The chlorine will cost $650 per year, and the labor cost will be $800 per year. Alternatively, dry chlorine can be added manually at a cost of $1000 per year for chlorine and $1900 per year for labor. Which method should be used on the basis of a present worth analysis if the interest rate is 10% per year?

5.15 Anion, an environmental engineering consulting firm, is trying to be eco-friendly in acquiring an automobile for general office use. It is considering a gasoline-electric hybrid and a gasoline-free all-electric hatchback. The hybrid under consideration is GM's Volt, which will cost $35,000 and have a range of 40 miles on the electric battery and several hundred more miles when the gasoline engine kicks in. Nissan's Leaf, on the other hand, is a pure electric that will have a range of only 100 miles, after which its lithium-ion battery will have to be recharged. The Leaf's relatively limited range creates a psychological effect known as *range anxiety.* This fact alone has caused the company to lean toward purchasing the Volt, which is assumed to have a salvage value of $15,000 in 5 years. The Leaf could be leased for $349 per month (end-of-month payments) for 5 years after an initial $1500 down payment for "account activation." If the consulting company plans to ignore the range anxiety effect in making its decision, which automobile is the better option on the basis of a present worth analysis at an interest rate of 0.75% per month? Assume the operating cost will be the same for both vehicles.

5.16 A pipeline engineer working in Kuwait for the oil giant BP wants to perform a present worth analysis on alternative pipeline routings—the first predominately by land and the second primarily undersea. The undersea route is more expensive initially due to extra corrosion protection and installation costs, but cheaper security and maintenance reduces annual costs. Perform the analysis for the engineer at 15% per year.

	Land	Undersea
Installation cost, $ million	−215	−350
Pumping, operating, security, $ million per year	−22	−2
Replacement of valves and appurtenances in year 25, $ million	−30	−70
Expected life, years	50	50

Alternative Comparison—Different Lives

5.17 An electric switch manufacturing company has to choose one of three different assembly methods. Method A will have a first cost of $40,000, an annual operating cost of $9000, and a service life of 2 years. Method B will cost $80,000 to buy and will have an annual operating cost of $6000 over its 4-year service life. Method C will cost $130,000 initially with an annual operating cost of $4000 over its 8-year life. Methods A and B will have no salvage value, but method C will have some equipment worth an estimated $12,000. Which method should be selected? Use present worth analysis at an interest rate of 10% per year.

5.18 Midwest Power and Light operates 14 coal-fired power plants in several states around the United States. The company recently settled a lawsuit by agreeing to pay $60 million in mitigation costs related to acid rain. The settlement included $21 million to reduce emissions from barges and trucks in the Ohio River Valley, $24 million for projects to conserve energy and produce alternative energy, $3 million for Chesapeake Bay, $2 million for Shenandoah National Park, and $10 million to acquire ecologically sensitive lands in Appalachia. The question of how to distribute the money over time has been posed. Plan A involves spending $5 million now and the remaining $55 million equally over a 10-year period (that is, $5.5 million in each of years 1 through 10). Plan B requires expenditures of $5 million now, $25 million 2 years from now, and $30 million 7 years from now. Determine which plan is more economical on the basis of a present worth analysis over a 10-year period at an interest rate of 10% per year.

5.19 Machines that have the following costs are under consideration for a robotized welding process. Using an interest rate of 10% per year, determine which alternative should be selected on the basis of a present worth analysis. Show (*a*) hand and (*b*) spreadsheet solutions.

	Machine X	Machine Y
First cost, $	−250,000	−430,000
Annual operating cost, $ per year	−60,000	−40,000
Salvage value, $	70,000	95,000
Life, years	3	6

5.20 **Water for Semiconductor Manufacturing Case** PE

Throughout the present worth analyses, the decision between seawater and groundwater switched multiple times in Examples 5.2 and 5.4. A summary is given here in $1 million units.

tonozdayim.com/@Zedeleyici31

Seawater (S)				Groundwater (G)			
Life *n*, years	First cost, $	PW at 12%, $	Selected	Life *n*, years	First cost, $	PW at 12%, $	Selected
10	−20	−30.64	**Yes**	10	−22	−33.16	No
5	−20, plus −10 after 5 years	−36.31	No	10	−22	−33.16	**Yes**
5 (study period)	−20	−26.43	**Yes**	5 (study period)	−22	−28.32	No

The confusion about the recommended source for UPW has not gone unnoticed by the general manager. Yesterday, you were asked to settle the issue by determining the first cost X_S of the seawater option to ensure that it is the economic choice over groundwater. The study period is set by the manager as 10 years, simply because that is the time period on the lease agreement for the building where the fab will be located. Since the seawater equipment must be refurbished or replaced after 5 years, the general manager told you to assume that the equipment will be purchased anew after 5 years of use. What is the maximum first cost that Angular Enterprises should pay for the seawater option?

5.21 Accurate airflow measurement requires straight unobstructed pipe for a minimum of 10 diameters upstream and 5 diameters downstream of the measuring device. In a field application, physical constraints compromise the pipe layout, so the engineer is considering installing the airflow probes in an elbow, knowing that flow measurement will be less accurate but good enough for process control. This is plan 1, which will be in place for only 3 years, after which a more accurate flow measurement system with the same costs as plan 1 will be available. This plan will have a first cost of $26,000 with an annual maintenance cost estimated at $5000.

Plan 2 involves installation of a recently designed submersible airflow probe. The stainless steel probe can be installed in a drop pipe with the transmitter located in a waterproof enclosure on the handrail. The first cost of this system is $83,000, but because it is accurate and more durable, it will not have to be replaced for at least 6 years. Its maintenance cost is estimated to be $1400 per year plus $2500 in year 3 for replacement of signal processing software. Neither system will have a salvage value. At an interest rate of 10% per year, which one should be selected on the basis of a present worth comparison?

5.22 An engineer is considering two different liners for an evaporation pond that will receive salty concentrate from a brackish water desalting plant. A plastic liner will cost $0.90 per square foot initially and will require replacement in 15 years when precipitated solids will have to be removed from the pond using heavy equipment. This removal will cost $500,000. A rubberized elastomeric liner is tougher and, therefore, is expected to last 30 years, but it will cost $2.20 per square foot. If the size of the pond is 110 acres (1 acre = 43,560 square feet), which liner is more cost effective on the basis of a present worth comparison at an interest rate of 8% per year?

5.23 A sports mortgage is the brainchild of Stadium Capital Financing Group, a company headquartered in Chicago, Illinois. It is an innovative way to finance cash-strapped sports programs by allowing fans to sign up to pay a "mortgage" over a certain number of years for the right to buy good seats at football games for several decades with season ticket prices locked in at current prices. In California, the locked-in price period is 50 years. Assume UCLA fan *X* purchases a $130,000 mortgage and pays for it now to get season tickets for $290 each for 50 years, while fan *Y* buys season tickets at $290 in year 1, with prices increasing by $20 per year for 50 years. (*a*) Which fan made the better deal if the interest rate is 8% per year? (*b*) What should fan *X* be willing to pay up front for the mortgage to make the two plans exactly equivalent economically? (Assume he has no reason to give extra money to UCLA at this point.)

5.24 A chemical processing corporation is considering three methods to dispose of a non-hazardous chemical sludge: land application, fluidized-bed incineration, and private disposal contract. The estimates for each method are shown. Determine which has the least cost on the basis of a present worth comparison at 10% per year for the following scenarios:

(*a*) The estimates as shown

(*b*) The contract award cost increases by 20% every 2-year renewal

	Land Application	Incineration	Contract
First cost, $	−130,000	−900,000	0
Annual operating cost, $ per year	−95,000	−60,000	−120,000
Salvage value, $	25,000	300,000	0
Life, years	3	6	2

tonozdayim.com/@Zedeleyici31

5.25 An assistant to Stacy gave her the PW values for four alternatives they are comparing for the development of a remote control vibration control system for offshore platform application. The results in the table use a MARR of 14% per year. Determine which alternative(s) should be selected (*a*) if the alternatives are exclusive, and (*b*) if the projects are independent.

	I	J	K	L
Life *n*, years	3	4	12	6
PW over *n* years, $	16.08	31.12	−257.46	140.46
PW over 6 years, $	26.94	15.78	−653.29	140.46
PW over 12 years, $	39.21	60.45	−257.46	204.46

Future Worth Comparison

5.26 An industrial engineer is considering two robots for purchase by a fiber-optic manufacturing company. Robot *X* will have a first cost of $80,000, an annual maintenance and operation (M&O) cost of $30,000, and a $40,000 salvage value. Robot *Y* will have a first cost of $97,000, an annual M&O cost of $27,000, and a $50,000 salvage value. Which should be selected on the basis of a future worth comparison at an interest rate of 15% per year? Use a 3-year study period.

5.27 Two processes can be used for producing a polymer that reduces friction loss in engines. Process T will have a first cost of $750,000, an operating cost of $60,000 per year, and a salvage value of $80,000 after its 2-year life. Process W will have a first cost of $1,350,000, an operating cost of $25,000 per year, and a $120,000 salvage value after its 4-year life. Process W will also require updating at the end of year 2 at a cost of $90,000. Which process should be selected on the basis of a future worth analysis at an interest rate of 12% per year?

5.28 Compare the alternatives shown below on the basis of a future worth analysis, using an interest rate of 8% per year.

	P	Q
First cost, $	−23,000	−30,000
Annual operating cost, $ per year	−4,000	−2,500
Salvage value, $	3,000	1,000
Life, years	3	6

5.29 Two manufacturers supply MRI systems for medical imaging. St. Jude's Hospital wishes to replace its current MRI equipment that was purchased 8 years ago with the newer technology and clarity of a state-of-the-art system. System K will have a first cost of $1,600,000, an operating cost of $70,000 per year, and a salvage value of $400,000 after its 4-year life. System L will have a first cost of $2,100,000, an operating cost of $50,000 the first year with an expected increase of $3000 per year thereafter, and no salvage value after its 8-year life. Which system should be selected on the basis of a future worth analysis at an interest rate of 12% per year?

5.30 A retail shopping center developer signed a contract to build a $100 million high-end shopping center in City Center, because the city and county governments agreed to sales and tax rebates totaling $18.7 million over 10 years. The contract called for the developer to raze existing buildings 2 years from the date the contract was signed and to have the shopping center built by the end of year 3. However, due to a real estate–induced recession in the United States, the developer sought and was granted a new contract. The new contract required the developer to raze the existing buildings at the end of year 1, but the shopping center would not have to be completed for 7 years from the date the contract was signed. Assume that the cost for razing the existing buildings is $1.3 million and the developer does not build the shopping center until 7 years from now (at a cost of $100 million). Determine the difference in the future worth cost in year 7 of the two contracts at an interest rate of 10% per year.

Capitalized Cost

5.31 A wealthy businessman wants to start a permanent fund for supporting research directed toward sustainability. The donor plans to give equal amounts of money for each of the next 5 years, plus one now (i.e., six donations) so that $100,000 per year can be withdrawn each year forever, beginning in year 6. If the fund earns interest at a rate of 8% per year, how much money must be donated each time?

5.32 Bob, a philanthropist, is not sure what rate of return his gifts may realize once donated to his favorite charity. Determine the capitalized cost of $10,000 every 5 years *forever*, starting 5 years from now at an interest rate of (*a*) 3% and (*b*) 8% per year. (*c*) Explain the significant difference between the two capitalized costs.

5.33 Find the capitalized cost of a present cost of $300,000, annual costs of $35,000, and periodic costs every 5 years of $75,000. Use an interest rate of 12% per year.

5.34 **Water for Semiconductor Manufacturing Case** PE

It is anticipated that the needs for UPW (ultrapure water) at the new Angular Enterprises site will continue for a long time, as long as 50 years. This is the rationale for using capitalized cost as a basis for the economic decision between desalinated

tonozdayim.com/@Zedeleyici31

seawater (S) and purified groundwater (G). These costs were determined (Example 5.7) to be CC_S = \$−53.58 million and CC_G = \$−48.91 million. Groundwater is the clear economic choice.

Yesterday, the general manager had lunch with the president of Brissa Water, who offered to supply the needed UPW at a cost of \$5 million per year for the indefinite future. It would mean a dependence upon a contractor to supply the water, but the equipment, treatment, and other costly activities to obtain UPW on-site would be eliminated. The manager asks you to make a recommendation about this seemingly attractive alternative under the following conditions at the same MARR of 12% per year as used for the other analyses:

(*a*) The annual cost of \$5 million remains constant throughout the time it is needed.

(*b*) The annual cost starts at \$5 million for the first year only, and then it increases 2% per year. (This increase is above the cost of providing UPW by either of the other two methods.)

5.35 Compare the alternatives shown on the basis of their capitalized costs using an interest rate of 10% per year.

	Alternative M	Alternative N
First cost, \$	−150,000	−800,000
Annual operating cost, \$ per year	−50,000	−12,000
Salvage value, \$	8,000	1,000,000
Life, years	5	∞

5.36 The cost of maintaining a certain permanent monument in Washington, DC occurs as periodic outlays of \$1000 every year and \$5000 every 4 years. Calculate the capitalized cost of the maintenance using an interest rate of 10% per year.

5.37 Because you are thankful for what you learned in engineering economy, you plan to start a permanent scholarship fund in the name of the professor who taught the course. You plan to deposit money now with the stipulation that the scholarships be awarded beginning 12 years from now (which happens to be the exact time that your daughter plans to begin college). The interest that is accumulated between now and year 12 is to be added to the principal of the endowment. After that, the interest that is earned each year will be awarded as scholarship money. If you want the amount of the scholarships to be \$40,000 per year, how much must you donate now if the fund earns interest at a rate of 8% per year?

5.38 A patriotic group of firefighters is raising money to erect a permanent (i.e., infinite life) monument in New York City to honor those killed in the line of duty. The initial cost of the monument will be \$150,000, and the annual maintenance will cost \$5000. There will be an additional one-time cost of \$20,000 in 2 years to add names of those who were missed initially. At an interest rate of 6% per year, how much money must they raise now in order to construct and maintain the monument forever?

ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

5.39 One assumption inherent in the present worth method of analysis is that:

(*a*) The alternatives will be used only through the life of the *shortest-lived* alternative.

(*b*) The alternatives will be used only through the life of the *longest-lived* alternative.

(*c*) The cash flows of each alternative will change only by the inflation or deflation rate in succeeding life cycles.

(*d*) At least one of the alternatives will have a finite life.

5.40 When only one alternative can be selected from two or more, the alternatives are said to be:

(*a*) Mutually exclusive

(*b*) Independent alternatives

(*c*) Cost alternatives

(*d*) Revenue alternatives

5.41 For the mutually exclusive alternatives shown, the one(s) that should be selected are:

Alternative	PW, \$
A	−25,000
B	−12,000
C	10,000
D	15,000

(*a*) Only C

(*b*) Only A

(*c*) C and D

(*d*) Only D

5.42 The alternatives shown are to be compared on the basis of their present worth values. At an interest rate of 10% per year, the values of *n* that you should use in the uniform series factors to make a

tonozdayim.com/@Zedeleyici31

correct comparison by the present worth method are:

	Alternative A	Alternative B
First cost, $	−50,000	−90,000
Annual operating cost, $ per year	−10,000	−4000
Salvage value, $	13,000	15,000
Life, years	3	6

(*a*) $n = 3$ years for A and $n = 3$ years for B
(*b*) $n = 3$ years for A and $n = 6$ years for B
(*c*) $n = 6$ years for A and $n = 6$ years for B
(*d*) None of the above

5.43 The value of the *future worth* for alternative P at an interest rate of 8% per year is closest to:

	P	Q
First cost, $	−23,000	−30,000
Annual operating cost, $ per year	−4,000	−2,500
Salvage value, $	3,000	1,000
Life, years	3	6

(*a*) $FW_P = \$-88{,}036$
(*b*) $FW_P = \$-86{,}026$
(*c*) $FW_P = \$-81{,}274$
(*d*) $FW_P = \$-70{,}178$

5.44 The present worth of $50,000 now, $10,000 per year in years 1 through 15, and $20,000 per year in years 16 through infinity at 10% per year is closest to:
(*a*) Less than $−169,000
(*b*) $−169,580
(*c*) $−173,940
(*d*) $−195,730

5.45 A donor (you) wishes to start an endowment that will provide scholarship money of $40,000 per year beginning in year 5 and continuing indefinitely. If the university earns 10% per year on the endowment, the amount you must donate now is closest to:
(*a*) $−225,470
(*b*) $−248,360
(*c*) $−273,200
(*d*) $−293,820

Problems 5.46 through 5.48 are based on the following information.

	Alternative I	Alternative J
Initial cost, $	−150,000	−250,000
Annual income, $ per year	20,000	40,000
Annual expenses, $ per year	−9,000	−14,000
Salvage value, $	25,000	35,000
Life, years	3	6

The interest rate is 15% per year.

5.46 In comparing alternatives I and J by the present worth method, the value of n that must be used in $11{,}000(P/A,i,n)$ for alternative I is:
(*a*) 3
(*b*) 6
(*c*) 18
(*d*) 36

5.47 In comparing alternatives I and J by the present worth method, the equation that yields the present worth of alternative J is:
(*a*) $PW_J = -250{,}000 + 40{,}000(P/A,15\%,6) + 35{,}000(P/F,15\%,6)$
(*b*) $PW_J = -250{,}000 + 26{,}000(P/A,15\%,6) + 35{,}000(P/F,15\%,6)$
(*c*) $PW_J = -250{,}000 - 26{,}000(P/A,15\%,6) + 35{,}000(P/F,15\%,6)$
(*d*) $PW_J = -250{,}000 - 26{,}000(P/A,15\%,6) - 35{,}000(P/F,15\%,6)$

5.48 In comparing alternatives I and J by the present worth method, the equation that yields the present worth of alternative I is:
(*a*) $PW_I = -150{,}000 + 11{,}000(P/A,15\%,3) + 25{,}000(P/F,15\%,3)$
(*b*) $PW_I = -150{,}000 + 11{,}000(P/A,15\%,6) + 25{,}000(P/F,15\%,6)$
(*c*) $PW_I = -150{,}000 + 11{,}000(P/A,15\%,6) + 175{,}000(P/F,15\%,3) + 25{,}000(P/F,15\%,6)$
(*d*) $PW_I = -150{,}000 + 11{,}000(P/A,15\%,6) - 125{,}000(P/F,15\%,3) + 25{,}000(P/F,15\%,6)$

Problems 5.49 and 5.50 are based on the following information.

	Machine X	Machine Y
Initial cost, $	−80,000	−95,000
Annual operating cost, $ per year	−20,000	−15,000
Salvage value, $	10,000	30,000
Life, years	2	4

The interest rate is 10% per year.

5.49 The equation that will calculate the present worth of machine X is:
(*a*) $PW_X = -80{,}000 - 15{,}000(P/A,10\%,4) + 30{,}000(P/F,10\%,4)$
(*b*) $PW_X = -80{,}000 - 20{,}000(P/A,10\%,4) - 80{,}000(P/F,10\%,2) + 10{,}000(P/F,10\%,4)$
(*c*) $PW_X = -80{,}000 - 20{,}000(P/A,10\%,2) + 10{,}000(P/F,10\%,2)$
(*d*) $PW_X = -80{,}000 - 20{,}000(P/A,10\%,4) - 70{,}000(P/F,10\%,2) + 10{,}000(P/F,10\%,4)$

5.50 In comparing the machines on a present worth basis, the present worth of machine Y is closest to:
(*a*) $−112,320
(*b*) $−122,060
(*c*) $−163,040
(*d*) $−175,980

tonozdayim.com/@Zedeleyici31

5.51 The capitalized cost of $10,000 every 5 years *forever*, starting *now* at an interest rate of 10% per year, is closest to:
(*a*) $−13,520
(*b*) $−16,380
(*c*) $−26,380
(*d*) $−32,590

5.52 At an interest rate of 10% per year, the capitalized cost of $10,000 in year 0, $5000 per year in years 1 through 5, and $1000 per year thereafter forever is closest to:
(*a*) −$29,652
(*b*) −$35,163
(*c*) −$38,954
(*d*) −$43,221

CASE STUDY

COMPARING SOCIAL SECURITY BENEFITS

Background

When Sheryl graduated from Northeastern University in 2000 and went to work for BAE Systems, she did not pay much attention to the monthly payroll deduction for social security. It was a "necessary evil" that may be helpful in retirement years. However, this was so far in the future that she fully expected this government retirement benefit system to be broke and gone by the time she could reap any benefits from her years of contributions.

This year, Sheryl and Brad, another engineer at BAE, got married. Recently, they both received notices from the Social Security Administration of their potential retirement amounts, were they to retire and start social security benefits at preset ages. Since both of them hope to retire a few years early, they decided to pay closer attention to the predicted amount of retirement benefits and to do some analysis on the numbers.

Information

They found that their projected benefits are substantially the same, which makes sense since their salaries are very close to each other. Although the numbers were slightly different in their two mailings, the similar messages to Brad and Sheryl can be summarized as follows:

If you stop working and start receiving benefits . . .

At age 62, your payment would be about	$1400 per month
At you full retirement age (67 years), your payment would be about	$2000 per month
At age 70, your payment would be about	$2480 per month

These numbers represent a reduction of 30% for early retirement (age 62) and an increase of 24% for delayed retirement (age 70).

This couple also learned that it is possible for a spouse to take spousal benefits at the time that one of them is at full retirement age. In other words, if Sheryl starts her $2000 benefit at age 67, Brad can receive a benefit equal to 50% of hers. Then, when Brad reaches 70 years of age, he can discontinue spousal benefits and start his own. In the meantime, his benefits will have increased by 24%. Of course, this strategy could be switched with Brad taking his benefits and Sheryl receiving spousal benefits until age 70.

All these options led them to define four alternative plans.

A: Each takes early benefits at age 62 with a 30% reduction to $1400 per month.

B: Each takes full benefits at full retirement age of 67 and receives $2000 per month.

C: Each delays benefits until age 70 with a 24% increase to $2480 per month.

D: One person takes full benefits of $2000 per month at age 67, and the other person receives spousal benefits ($1000 per month at age 67) and switches to delayed benefits of $2480 at age 70.

They realize, of course, that the numbers will change over time, based on their respective salaries and number of years of contribution to the social security system by them and by their employers.

Case Study Exercises

Brad and Sheryl are the same age. Brad determined that most of their investments make an average of 6% per year. With this as the interest rate, the analysis for the four alternatives is possible. Sheryl and Brad plan to answer the following questions, but don't have time this week. Can you please help them? (Do the analysis for one person at a time, not the couple, and stop at the age of 85.)

1. How much in total (without the time value of money considered) will each plan A through D pay through age 85?
2. What is the future worth at 6% per year of each plan at age 85?
3. Plot the future worth values for all four plans on one spreadsheet graph.
4. Economically, what is the best combination of plans for Brad and Sheryl, assuming they both live to be 85 years old?
5. Develop at least one additional question that you think Sheryl and Brad may have. Answer the question.

tonozdayim.com/@Zedeleyici31

CHAPTER SUMMARY

The annual worth method of comparing alternatives is often preferred to the present worth method, because the AW comparison is performed for only one life cycle. This is a distinct advantage when comparing different-life alternatives. AW for the first life cycle is the AW for the second, third, and all succeeding life cycles, under certain assumptions. When a study period is specified, the AW calculation is determined for that time period, regardless of the lives of the alternatives.

For infinite-life (perpetual) alternatives, the initial cost is annualized simply by multiplying P by i. For finite-life alternatives, the AW through one life cycle is equal to the perpetual equivalent annual worth.

Life-cycle cost analysis is appropriate for systems that have a large percentage of costs in operating and maintenance. LCC analysis helps in the analysis of all costs from design to operation to disposal phases.

PROBLEMS

Annual Worth Calculations

6.1 If you are asked to provide an annual worth (AW) comparison of alternatives after a present worth (PW) comparison has already been done, what factor multiplied by the PW values provide the correct AW values?

6.2 List three assumptions that are inherent in the annual worth method of comparing alternatives.

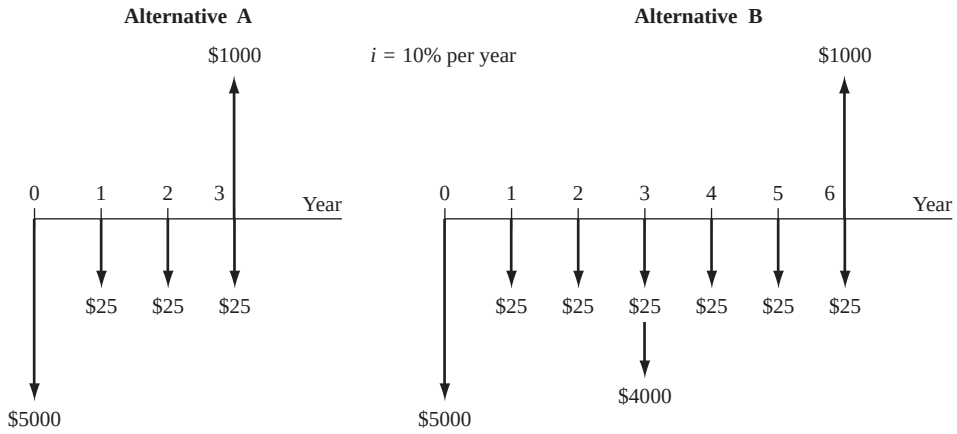
6.3 In the annual worth method of comparing alternatives that have different lives, why do you calculate the AW of the alternatives *over their respective life cycles* instead of over the least common multiple of their lives?

6.4 James developed the two cash flow diagrams shown at the bottom of this page. The cash flows for alternative B represent two life cycles of A. Calculate the annual worth value of each over the respective life cycles to demonstrate that they are the same. Use an interest rate of 10% per year.

6.5 An asset with a first cost of $20,000 has an annual operating cost of $12,000 and a $4000 salvage value after its 4-year life. If the project will be needed for 6 years, what would the market (salvage) value of the 2-year-old asset have to be for the annual worth to be the same as it is for one life cycle of the asset? Use an interest rate of 10% per year.

6.6 A sports mortgage is an innovative way to finance cash-strapped sports programs by allowing fans to sign up to pay a "mortgage" for the right to buy good seats at football games for several decades with season tickets locked in at current prices. At Notre Dame, the locked-in price period is 50 years. If a fan pays a $130,000 "mortgage" fee now (i.e., in year 0) when season tickets are selling for $290 each, what is the equivalent annual cost of the football tickets over the 50-year period at an interest rate of 8% per year?

6.7 If a fan buys a sports mortgage to USC football games by paying $130,000 in 10 equal payments *starting now*, and then pays a fixed price of $290 per year for 50 years (starting 1 year from now) for season tickets, what is the AW in years 1 through 50 of the season tickets at 8% per year interest?



tonozdayim.com/@Zedeleyici31

6.8 Eight years ago, Ohio Valley Trucking purchased a large-capacity dump truck for $115,000 to provide short-haul earthmoving services. The company sold it today for $45,000. Operating and maintenance costs averaged $10,500 per year. A complete overhaul at the end of year 4 cost an extra $3600. Calculate the annual cost of the truck at 8% per year interest.

6.9 A major repair on the suspension system of a 5-year-old car cost $2000 because the warranty expired after 3 years of ownership. The cost of periodic maintenance has been $800 every 2 years. If the owner donates the car to charity after 8 years of ownership, what is the equivalent annual cost of the repair and maintenance in the 8-year period of ownership? Use an interest rate of 8% per year, and assume that the owner paid the $800 maintenance cost immediately before donating the car in year 8.

Capital Recovery

6.10 Ten years ago, Jacobson Recovery purchased a wrecker for $285,000 to move disabled 18-wheelers. He anticipated a salvage value of $50,000 after 10 years. During this time his average annual revenue totaled $52,000. (*a*) Did he recover his investment and a 12% per year return? (*b*) If the annual M&O cost was $10,000 the first year and increased by a constant $1000 per year, was the AW positive or negative at 12% per year? Assume the $50,000 salvage was realized.

6.11 Sylvia has received a $500,000 inheritance from her favorite, recently deceased aunt in Hawaii. Sylvia is planning to purchase a condo in Hawaii in the same area where her aunt lived all her life and to rent it to vacationers. She hopes to make 8% per year on this purchase over an ownership period of 20 years. The condo's total first cost is $500,000, and she conservatively expects to sell it for 90% of the purchase price. No annual M&O costs are considered in the analysis. (*a*) What is the capital recovery amount? (*b*) If there is a real boom in rental real estate 10 years in the future, what sales price (as a percentage of original purchase price) is necessary at that time (year 10) to realize the same amount as the 8% return expected over the 20-year ownership period?

6.12 Humana Hospital Corporation installed a new MRI machine at a cost of $750,000 this year in its medical professional clinic in Cedar Park. This state-of-the-art system is expected to be used for 5 years and then sold for $75,000. Humana uses a return requirement of 24% per year for all of its medical diagnostic equipment. As a bioengineering student currently serving a coop semester on the management staff of Humana Corporation in Louisville, Kentucky, you are asked to determine the minimum revenue required each year to realize the expected recovery and return. Also, you are asked to draw two cash flow diagrams, one showing the MRI purchase and sale cash flow and a second depicting the required capital recovery each year.

Alternative Comparison

6.13 Polypropylene wall caps, used for covering exterior vents for kitchen cooktops, bathroom fans, dryers, and other building air exhausts, can be made by two different methods. Method X will have a first cost of $75,000, an operating cost of $32,000 per year, and a $9000 salvage value after 4 years. Method Y will have a first cost of $140,000, an operating cost of $24,000 per year, and a $19,000 salvage value after its 4-year life. At an interest rate of 10% per year, which method should be used on the basis of an annual worth analysis?

6.14 Nissan's all-electric car, the Leaf, has a base price of $32,780 in the United States, but it is eligible for a $7500 federal tax credit. A consulting engineering company wants to evaluate the purchase or lease of one of the vehicles for use by its employees traveling to job sites in the local area. The cost for leasing the vehicle will be $4200 per year (payable at the end of each year) after an initialization charge of $2500 paid now. If the company purchases the vehicle, it will also purchase a home charging station for $2200 that will be partially offset by a 50% tax credit. If the company expects to be able to sell the car and charging station for 40% of the base price of the car alone at the end of 3 years, should the company purchase or lease the car? Use an interest rate of 10% per year and annual worth analysis.

6.15 A new structural design software package is available for analyzing and designing three-sided guyed towers and three- and four-sided self-supporting towers. A single-user license will cost $6000 per year. A site license has a one-time cost of $22,000. A structural engineering consulting company is trying to decide between two alternatives: buy a single-user license *now* and one each year for the next 3 years (which will provide 4 years of service), or buy a site license now. Determine which strategy should be adopted at an interest rate of 10% per year for a 4-year planning period using the annual worth method of evaluation.

6.16 The city council in a certain southwestern city is considering whether to construct permanent restrooms in 22 of its smaller parks (i.e., parks of less

tonozdayim.com/@Zedeleyici31

than 12 acres) or pay for portable toilets on a year-round basis. The cost of constructing the 22 permanent restrooms will be $3.8 million. The 22 portable restrooms can be rented for $7500 each for 1 year. The service life of a permanent restroom is 20 years. Using an interest rate of 6% per year and an annual worth analysis, determine if the city should build the permanent restrooms or lease the portable ones.

6.17 A remotely located air sampling station can be powered by solar cells or by running an above ground electric line to the site and using conventional power. Solar cells will cost $16,600 to install and will have a useful life of 5 years with no salvage value. Annual costs for inspection, cleaning, etc., are expected to be $2400. A new power line will cost $31,000 to install, with power costs expected to be $1000 per year. Since the air sampling project will end in 5 years, the salvage value of the line is considered to be zero. At an interest rate of 10% per year, (*a*) which alternative should be selected on the basis of an annual worth analysis and (*b*) what must be the first cost of the above ground line to make the two alternatives equally attractive economically?

6.18 The cash flows for two small raw water treatment systems are shown. Determine which should be selected on the basis of an annual worth analysis at 10% per year interest.

	MF	UF
First cost, $	–33,000	–51,000
Annual cost, $ per year	–8,000	–3,500
Salvage value, $	4,000	11,000
Life, years	3	6

6.19 PGM Consulting is under contract to Montgomery County for evaluating alternatives that use a robotic, liquid-propelled "pig" to periodically inspect the interior of buried potable water pipes for leakage, corrosion, weld strength, movement over time, and a variety of other parameters. Two equivalent robot instruments are available. Robot Joeboy will have a first cost of $85,000, annual M&O costs of $30,000, and a $40,000 salvage value after 3 years. Robot Watcheye will have a first cost of $125,000, annual M&O costs of $27,000, and a $33,000 salvage value after its 5-year life. Assume an interest rate of 8% per year.

(*a*) Which robot is the better economic option?

(*b*) Using the spreadsheet Goal Seek tool, determine the first cost of the robot *not* selected in (*a*) so that it will be the economic selection.

6.20 TT Racing and Performance Motor Corporation wishes to evaluate two alternative CNC machines for NHRA engine building. Use the AW method at 10% per year to select the better alternative.

	Machine R	Machine S
First cost, $	−250,000	−370,500
Annual operating cost, $ per year	−40,000	–50,000
Salvage value, $	20,000	30,000
Life, years	3	5

6.21 The maintenance and operation (M&O) cost of front-end loaders working under harsh environmental conditions tends to increase by a constant $1200 per year for the first 5 years of operation. For a loader that has a first cost of $39,000 and first-year M&O cost of $17,000, compare the equivalent annual worth of a loader kept for 4 years with one kept for 5 years at an interest rate of 12% per year. The salvage value of a used loader is $23,000 after 4 years and $18,000 after 5 years.

6.22 You work for Midstates Solar Power. A manager asked you to determine which of the following two machines will have the lower (*a*) capital recovery and (*b*) equivalent annual total cost. Machine Semi2 has a first cost of $80,000 and an operating cost of $21,000 in year 1, increasing by $500 per year through year 5, after which time it will have a salvage value of $13,000. Machine Auto1 has a first cost of $62,000 and an operating cost of $21,000 in year 1, increasing by 8% per year through year 5, after which time it will have a scavenge value of $2000. Utilize an interest rate of 10% per year to determine both estimates.

Permanent Investments

6.23 The State of Chiapas, Mexico, decided to fund a program for literacy. The first cost is $200,000 now, and an update budget of $100,000 every 7 years *forever* is requested. Determine the perpetual equivalent annual cost at an interest rate of 10% per year.

6.24 Calculate the perpetual equivalent annual cost (years 1 through infinity) of $5 million in year 0, $2 million in year 10, and $100,000 in years 11 through infinity. Use an interest rate of 10% per year.

6.25 A Pennsylvania coal mining operation has installed an in-shaft monitoring system for oxygen tank and gear readiness for emergencies. Based on maintenance patterns for previous systems, there are no maintenance costs for the first 2 years, they

tonozdayim.com/@Zedeleyici31

increase for a time period, and then they level off. Maintenance costs are expected to be $150,000 in year 3, $175,000 in year 4, and amounts increasing by $25,000 per year through year 6 and remain constant thereafter for the expected 10-year life of the system. If similar systems with similar costs will replace the current one, determine the perpetual equivalent annual maintenance cost at $i = 10\%$ per year.

6.26 Compare two alternatives for a security system surrounding a power distribution substation using annual worth analysis and an interest rate of 10% per year.

	Condi	Torro
First cost, $	−25,000	−130,000
Annual cost, $ per year	−9,000	−2,500
Salvage value, $	3,000	150,000
Life, years	3	∞

6.27 A new bridge across the Allegheny River in Pittsburgh is expected to be permanent and will have an initial cost of $30 million. This bridge must be resurfaced every 5 years at a cost of $1 million. The annual inspection and operating costs are estimated to be $50,000. Determine its equivalent annual worth at an interest rate of 10% per year.

6.28 For the cash flows shown, use an annual worth comparison and an interest rate of 10% per year.

(*a*) Determine the alternative that is economically best.

(*b*) Determine the first cost required for each of the two alternatives not selected in (*a*) so that all alternatives are equally acceptable. Use a spreadsheet to answer this question.

	X	Y	Z
First cost, $	−90,000	−400,000	−650,000
Annual cost, $ per year	−40,000	−20,000	−13,000
Overhaul every 10 years, $	—	—	−80,000
Salvage value, $	7,000	25,000	200,000
Life, years	3	10	∞

Life-Cycle Cost

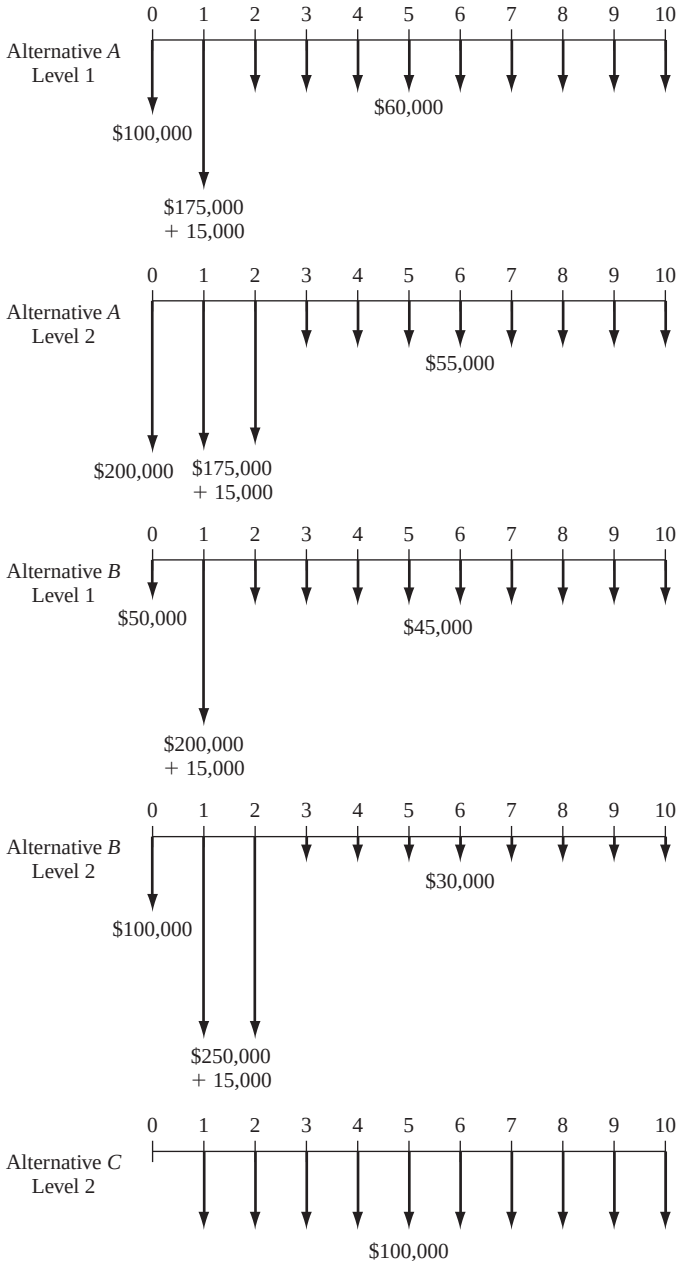
6.29 Blanton Agriculture of Santa Monica, California, offers different types and levels of irrigation water conservation systems for use in areas where groundwater depletion is a serious concern. A large farming corporation in India, where depletion is occurring at an alarming rate of 1.6 inches (4 centimeters) per year due to exponential growth in usage for crop irrigation, is considering the purchase of one of the Blanton systems. There are three options with two levels of automation for the first two options. The estimated costs and associated cash flow diagrams over a 10-year period are summarized below and on the next page, respectively, for each of the five alternatives. Costs are categorized as design (Des), development (Dev), and operation (Oper). For alternatives A and B, there is an extra cost of $15,000 per installation year to maintain the manual system in place now. Level 2 development costs are distributed equally over a 2-year period. Alternative C is a retrofit of the current manual system with no design or development costs, and there is no level 1 option. At an interest rate of 10% per year and a 10-year study period, determine which alternative and level has the lowest LCC.

Alternative	Cost Component	Level 1	Level 2
A	Des	$100,000	$200,000
	Dev	175,000	350,000
	Oper	60,000	55,000
	Install time	1 year	2 years
B	Des	$ 50,000	$100,000
	Dev	200,000	500,000
	Oper	45,000	30,000
	Install time	1 year	2 years
C	Oper		$100,000

6.30 The Pentagon asked a defense contractor to estimate the life-cycle cost for a proposed light-duty support vehicle. The list of items included the following categories: R&D costs (R&D), nonrecurring investment costs (NRI), recurring upgrade costs (RU), scheduled and unscheduled maintenance costs (Maint), equipment usage costs (Equip), and phaseout/disposal costs (Po/D). Use the cost estimates (shown in $1 million) for the 20-year life cycle to calculate the annual LCC at an interest rate of 7% per year.

Year	R&D	NRI	RU	Maint	Equip	Po/D
0	5.5	1.1				
1	3.5					
2	2.5					
3	0.5	5.2	1.3	0.6	1.5	
4		10.5	3.1	1.4	3.6	
5		10.5	4.2	1.6	5.3	
6–10			6.5	2.7	7.8	
11 on			2.2	3.5	8.5	
18–20						2.7

tonozdayim.com/@Zedeleyici31



Cash flow diagrams for Problem 6.29

6.31 A manufacturing software engineer at a major aerospace corporation has been assigned the management responsibility of a project to design, build, test, and implement AREMSS, a new-generation automated scheduling system for routine and expedited maintenance. Reports on the disposition of each service will also be entered by field personnel, then filed and archived by the system. The initial application will be on existing Air Force in-flight refueling aircraft. The system is expected to be widely used over time for other aircraft maintenance scheduling. Once it is fully implemented, enhancements will have to be made, but the system is expected to serve as a worldwide scheduler for up to 15,000 separate aircraft. The engineer, who must make a presentation next week of the best estimates of costs over a 20-year life period, has decided to use the life-cycle cost approach of cost estimations. Use the following information to determine the current annual LCC at 6% per year for the AREMSS scheduling system.

tonozdayim.com/@Zedeleyici31

Cost Category	Cost in Year ($ millions) 1	2	3	4	5	6 on	10	18
Field study	0.5							
Design of system	2.1	1.2	0.5					
Software design		0.6	0.9					
Hardware purchases			5.1					
Beta testing		0.1	0.2					
Users manual development		0.1	0.1	0.2	0.2	0.06		
System implementation				1.3	0.7			
Field hardware			0.4	6.0	2.9			
Training trainers			0.3	2.5	2.5	0.7		
Software upgrades						0.6	3.0	3.7

6.32 The U.S. Army received two proposals for a turnkey design-build project for barracks for infantry unit soldiers in training. Proposal A involves an off-the-shelf "bare-bones" design and standard grade construction of walls, windows, doors, and other features. With this option, heating and cooling costs will be greater, maintenance costs will be higher, and replacement will be sooner than for proposal B. The initial cost for A will be $750,000. Heating and cooling costs will average $72,000 per year, with maintenance costs averaging $24,000 per year. Minor remodeling will be required in years 5, 10, and 15 at a cost of $150,000 each time in order to render the units usable for 20 years. They will have no salvage value.

Proposal B will include tailored design and construction costs of $1.1 million initially, with estimated heating and cooling costs of $36,000 per year and maintenance costs of $12,000 per year. There will be no salvage value at the end of the 20-year life. Which proposal should be accepted on the basis of an annual life-cycle cost analysis, if the interest rate is 6% per year?

6.33 A medium-size municipality plans to develop a software system to assist in project selection during the next 10 years. A life-cycle cost approach has been used to categorize costs into development, programming, operating, and support costs for each alternative. There are three alternatives under consideration, identified as M, N, and O. The costs are summarized below. Use an annual life-cycle cost approach to identify the best alternative at 8% per year.

Alternative	Component	Estimated Cost
M	Development	$250,000 now, $150,000 years 1–4
	Programming	$45,000 now, $35,000 years 1, 2
	Operation	$50,000 years 1–10
	Support	$30,000 years 1–5
N	Development	$10,000 now
	Programming	$45,000 year 0, $30,000 years 1–3
	Operation	$80,000 years 1–10
	Support	$40,000 years 1–10
O	Operation	$175,000 years 1–10

ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

6.34 All of the following are fundamental assumptions for the annual worth method of analysis *except*:

(*a*) The alternatives will be needed for only *one* life cycle.
(*b*) The services provided are needed for at least the LCM of the lives of the alternatives.
(*c*) The selected alternative will be repeated for the succeeding life cycles in exactly the same manner as for the first life cycle.
(*d*) All cash flows will have the same estimated values in every life cycle.

6.35 When comparing five alternatives that have different lives by the AW method, you must:

(*a*) Find the AW of each over the life of the longest-lived alternative.
(*b*) Find the AW of each over the life of the shortest-lived alternative.
(*c*) Find the AW of each over the LCM of all of the alternatives.
(*d*) Find the AW of each alternative over its life without considering the life of the other alternatives.

6.36 The annual worth of an alternative can be calculated from the alternative's:

(*a*) Present worth by multiplying by (*A*/*P*,*i*,*n*)
(*b*) Future worth by multiplying by (*F*/*A*,*i*,*n*)
(*c*) Either (*a*) or (*b*)
(*d*) Neither (*a*) nor (*b*)

6.37 The alternatives shown are to be compared on the basis of annual worth. At an interest rate of 10% per year, the values of *n* that you could use in the (*A*/*P*,*i*,*n*) factors to make a correct comparison by the annual worth method are:

	A	B
First cost, $	−50,000	−90,000
Annual cost, $ per year	−10,000	−4,000
Salvage value, $	13,000	15,000
Life, years	3	6

(*a*) $n = 3$ years for A and 3 years for B
(*b*) $n = 3$ years for A and 6 years for B
(*c*) Either (*a*) or (*b*)
(*d*) Neither (*a*) nor (*b*)

tonozdayim.com/@Zedeleyici31

6.38 The alternatives shown are to be compared on the basis of a perpetual (i.e., forever) equivalent annual worth. At an interest rate of 10% per year, the equation that represents the perpetual AW of X1 is:

	X1	Y1
First cost, $	−50,000	−90,000
Annual cost, $ per year	−10,000	−4,000
Salvage value, $	13,000	15,000
Life, years	3	6

(*a*) $AW_{X1} = -50{,}000(0.10) - 10{,}000 + 13{,}000(0.10)$

(*b*) $AW_{X1} = -50{,}000(0.10) - 10{,}000 + 13{,}000(A/F,10\%,3)$

(*c*) $AW_{X1} = -50{,}000(0.10) - 10{,}000 - 37{,}000(P/F,10\%,3)(0.10) + 13{,}000(0.10)$

(*d*) $AW_{X1} = -50{,}000(A/P,10\%,3) - 10{,}000 + 13{,}000(A/F,10\%,3)$

6.39 To get the AW of a cash flow of $10,000 that occurs every 10 years forever, with the first one occurring 10 years from now, you should:

(*a*) Multiply $10,000 by (*A/P,i,*10).
(*b*) Multiply $10,000 by (*A/F,i,*10).
(*c*) Multiply $10,000 by *i*.
(*d*) Multiply $10,000 by (*A/F,i,n*) and then multiply by *i*.

Problems 6.40 through 6.43 refer to the following estimates.

The alternatives are mutually exclusive and the MARR is 6% per year.

	Vendor 1	Vendor 2	Vendor 3
First cost, $	−200,000	−550,000	−1,000,000
Annual cost, $ per year	−50,000	−20,000	−10,000
Revenue, $ per year	120,000	120,000	110,000
Salvage value, $	25,000	0	500,000
Life, years	10	15	∞

6.40 The annual worth of vendor 2 cash flow estimates is closest to:

(*a*) $−63,370
(*b*) $43,370
(*c*) $−43,370
(*d*) $63,370

6.41 Of the following three relations, the correct one or ones to calculate the annual worth of vendor 1 cash flow estimates is (*note*: all dollar values are in thousands):

Relation 1: $AW_1 = -200(A/P,6\%,10) + 70 + 25(A/F,6\%,10)$

Relation 2: $AW_1 = [-200 - 50(P/A,6\%,10) + 120(P/A,6\%,10) + 25(P/F,6\%,10)](A/P,6\%,10)$

Relation 3: $AW_1 = -200(F/P,6\%,10) + 25 + (-50 + 120)(A/P,6\%,10)$

(*a*) 1 and 3
(*b*) Only 1
(*c*) 1 and 2
(*d*) Only 3

6.42 The AW values for the alternatives are listed below. The vendor or vendors that should be recommended is:

$AW_1 = \$44{,}723$ $AW_2 = \$43{,}370$
$AW_3 = \$40{,}000$

(*a*) 1 and 2
(*b*) 3
(*c*) 2
(*d*) 1

6.43 The capital recovery amount for vendor 3 is:

(*a*) $40,000 per year
(*b*) $60,000 per year
(*c*) $43,370 per year
(*d*) $100,000 per year

6.44 If a revenue alternative has a negative AW value and it was correctly calculated, it means the following:

(*a*) The equivalent annual worth of revenues does not exceed that of the costs.
(*b*) The estimates are wrong somewhere.
(*c*) A minus or plus sign of a cash flow was entered incorrectly into the PMT spreadsheet function.
(*d*) The alternative should have a longer life so revenues will exceed costs.

6.45 Estimates for one of two process upgrades are as follows: first cost of $40,000, annual cost of $5000 per year, market value that decreases by $2000 per year to the salvage value of $20,000 after the expected life of 10 years. If a 4-year study period is used for AW analysis at 15% per year, the correct AW value is closest to:

(*a*) $−15,000
(*b*) $−11,900
(*c*) $−7600
(*d*) $−12,600

6.46 The perpetual annual worth of investing $50,000 now and $20,000 per year starting in year 16 and continuing forever at 12% per year is closest to:

(*a*) $−4200
(*b*) $−8650
(*c*) $−9655
(*d*) $−10,655

tonozdayim.com/@Zedeleyici31

6.47 All the following statements about the capital recovery amount for an alternative are false *except:*

(*a*) Annual revenue can be no more than this amount, if the alternative is selected.

(*b*) A monetary estimate of new capital funds required each year for the life of the alternative.

(*c*) An amount of revenue required to recover the first cost plus a stated return over the life of the alternative.

(*d*) Does not consider the salvage value, since it is returned at the end of the alternative's life.

CASE STUDY

THE CHANGING SCENE OF AN ANNUAL WORTH ANALYSIS

Background and Information

Harry, owner of an automobile battery distributorship in Atlanta, Georgia, performed an economic analysis 3 years ago when he decided to place surge protectors in-line for all his major pieces of testing equipment. The estimates used and the annual worth analysis at MARR = 15% are summarized below. Two different manufacturers' protectors were compared.

	PowrUp	Lloyd's
Cost and installation, $	−26,000	−36,000
Annual maintenance cost, $ per year	−800	−300
Salvage value, $	2,000	3,000
Equipment repair savings, $	25,000	35,000
Useful life, years	6	10

The spreadsheet in Figure 6–9 is the one Harry used to make the decision. Lloyd's was the clear choice due to its substantially larger AW value. The Lloyd's protectors were installed.

During a quick review this last year (year 3 of operation), it was obvious that the maintenance costs and repair savings have not followed (and will not follow) the estimates made 3 years ago. In fact, the maintenance contract cost (which includes quarterly inspection) is going from $300 to $1200 per year next year and will then increase 10% per year for the next 10 years. Also, the repair savings for the last 3 years were $35,000, $32,000, and $28,000, as best as Harry can determine. He believes savings will decrease by $2000 per year hereafter. Finally, these 3-year-old protectors are worth nothing on the market now, so the salvage in 7 years is zero, not $3000.

Case Study Exercises

1. Plot a graph of the newly estimated maintenance costs and repair savings projections, assuming the protectors last for 7 more years.
2. With these new estimates, what is the recalculated AW for the Lloyd's protectors? Use the old first cost and maintenance cost estimates for the first 3 years. If these estimates had been made 3 years ago, would Lloyd's still have been the economic choice?
3. How has the capital recovery amount changed for the Lloyd's protectors with these new estimates?

	A	B	C	D	E	F	G
1	MARR =	15%					
2							
3			PowrUp			Lloyd's	
4		Investment	Annual	Repair	Investment	Annual	Repair
5	Year	and salvage	maintenance	savings	and salvage	maintenance	savings
6	0	-26,000	0	0	-36,000	0	0
7	1	0	-800	25,000	0	-300	35,000
8	2	0	-800	25,000	0	-300	35,000
9	3	0	-800	25,000	0	-300	35,000
10	4	0	-800	25,000	0	-300	35,000
11	5	0	-800	25,000	0	-300	35,000
12	6	2,000	-800	25,000	0	-300	35,000
13	7				0	-300	35,000
14	8				0	-300	35,000
15	9				0	-300	35,000
16	10				3,000	-300	35,000
17	AW element	-6,642	-800	25,000	-7,025	-300	35,000
18	**Total AW**			**$ 17,558**			**$ 27,675**

Figure 6–9
Annual worth analysis of surge protector alternatives, case study.

tonozdayim.com/@Zedeleyici31

CHAPTER SUMMARY

The rate of return of a cash flow series is determined by setting a PW-based or AW-based relation equal to zero and solving for the value of i^*. The ROR is a term used and understood by almost everybody. Most people, however, can have considerable difficulty in calculating a rate of return correctly for anything other than a conventional cash flow series. For some types of series, more than one ROR possibility exists. The maximum number of i^* values is equal to the number of changes in the sign of the net cash flow series (Descartes' rule of signs). Also, a single positive rate can be found if the cumulative net cash flow series starts negatively and has only one sign change (Norstrom's criterion).

When multiple i^* values are indicated, either of the two techniques covered in this chapter can be applied to find a single, reliable rate for the nonconventional net cash flow series. In the case of the ROIC technique, additional information is necessary about the *investment rate* that excess project funds will realize, while the modified ROR technique requires this same information, plus the *borrowing rate* for the organization considering the project. Usually, the investment rate is set equal to the MARR, and the borrowing rate takes on the historical WACC rate. Each technique will result in slightly different rates, but they are reliable for making the economic decision, whereas the multiple rates are often not useful to decision making.

If an exact ROR is not necessary, it is strongly recommended that the PW or AW method at the MARR be used to decide upon economic justification.

PROBLEMS

Understanding ROR

7.1 Under what circumstances would the rate of return be (*a*) −100%, and (*b*) infinite?

7.2 A shrewd investor loaned $1,000,000 to a start-up company at 10% per year interest for 3 years, but the terms of the agreement were such that interest would be charged on the principal rather than on the unpaid balance. How much extra interest did the company pay?

7.3 What is the *nominal* rate of return per year on an investment that increases in value by 8% every 3 months?

7.4 Assume you borrow $50,000 at 10% per year interest and you agree to repay the loan in five equal annual payments. What is the amount of the unrecovered balance immediately after you make the third payment?

7.5 International Potash got a $50 million loan amortized over a 10-year period at 10% per year interest. The loan agreement stipulates that the loan will be repaid in 10 equal annual payments with interest charged on the principal amount of the loan (not on the unrecovered balance).
(*a*) What is the amount of each payment?
(*b*) What is the total amount of interest paid? How does the total interest paid compare with the principal of the loan?

Determination of ROR

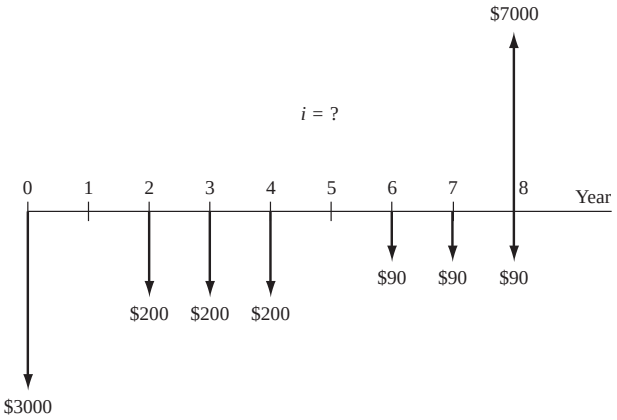
7.6 In 2010, the city of Houston, Texas, collected $24,112,054 in fines from motorists because of traffic violations caught by red-light cameras. The cost of operating the system was $8,432,372. The net profit, that is, profit after operating costs, is split equally (that is, 50% each) between the city and the operator of the camera system. What will be the rate of return over a 3-year period to the contractor that paid for, installed, and operates the system, if its initial cost was $9,000,000 and the profit for each of the 3 years is the same as it was in 2010?

7.7 P&G sold its prescription drug business to Warner-Chilcott, Ltd. for $3.1 billion. If income from product sales is $2 billion per year and net profit is 20% of sales, what rate of return will the company make over a 10-year planning horizon?

7.8 Water damage from a major flood in a Midwestern city resulted in damages estimated at $108 million. As a result of the claimant payouts, insurance companies raised homeowners' insurance rates by an average of $59 per year for each of the 160,000 households in the affected city. If a 20-year study period is considered, what was the rate of return on the $108 million paid by the insurance companies?

tonozdayim.com/@Zedeleyici31

7.9 Determine the rate of return for the cash flows shown in the diagram. (If requested by your instructor, show both hand and spreadsheet solutions.)



7.10 The Office of Naval Research sponsors a contest for college students to build underwater robots that can perform a series of tasks without human intervention. The University of Florida, with its SubjuGator robot, won the $7000 first prize (and serious bragging rights) over 21 other universities. If the team spent $2000 for parts (at time 0) and the project took 2 years, what annual rate of return did the team make?

7.11 For the cash flows shown, determine the rate of return.

Year	0	1	2	3	4	5
Expense, $	−17,000	−2,500	−2,500	−2,500	−2,500	−2,500
Revenue, $	0	5,000	6,000	7,000	8,000	12,000

7.12 In an effort to avoid foreclosure proceedings on struggling mortgage customers, Bank of America proposed an allowance that a jobless customer make no payment on their mortgage for up to 9 months. If the customer did not find a job within that time period, they would have to sign over their house to the bank. The bank would give them $2000 for moving expenses.

Assume John and his family had a mortgage payment of $2900 per month and he was not able to find a job within the 9-month period. If the bank saved $40,000 in foreclosure costs, what rate of return per month did the bank make on the allowance? Assume the first payment that was skipped was due at the end of month 1 and the $40,000 foreclosure savings and $2000 moving expense occurred at the end of the 9-month forbearance period.

7.13 The Closing the Gaps initiative by the Texas Higher Education Coordinating Board established the goal of increasing the number of students in higher education in Texas from 1,064,247 in 2000 to 1,694,247 in 2015. If the increase were to occur uniformly, what rate of increase would be required each year to meet the goal?

7.14 U.S. Census Bureau statistics show that the annual earnings for persons with a high school diploma are $35,220 versus $57,925 for someone with a bachelor's degree. If the cost of attending college is assumed to be $30,000 per year for 4 years and the forgone earnings during those years are assumed to be $35,220 per year, what rate of return does earning a bachelor's degree represent? Use a 35-year study period. (*Hint:* The investment in years 1 through 4 is the cost of college plus the foregone earnings, and the income in years 5 through 35 is the difference in income between a high school diploma and a bachelor's degree.)

7.15 The Ester Municipal Water Utility issued 20-year bonds in the amount of $53 million for several high-priority flood control improvement projects. The bonds carried a 5.38% dividend rate with the dividend payable annually. The U.S. economy was in a recession at that time, so as part of the federal stimulus program, the Utility gets a 35% reimbursement on the dividend it pays.

(*a*) What is the effective dividend rate that the Utility is paying on the bonds?

(*b*) What is the total dollar amount the Utility will *save* in dividends over the life of the bonds?

(*c*) What is the future worth in year 20 of the dividend savings, if the interest rate is 6% per year?

7.16 A contract between BF Goodrich and the Steelworkers Union of America called for the company to spend $100 million in capital investment to keep the facilities competitive. The contract also required the company to provide buyout packages for 400 workers. If the average buyout package is $100,000 and the company is able to reduce costs by $20 million per year, what rate of return will the company make over a 10-year period? Assume all of the company's expenditures occur at time 0 and the savings begin 1 year later.

7.17 Rubber sidewalks made from ground up tires are said to be environmentally friendly and easier on people's knees. Rubbersidewalks, Inc. of Gardena, California, manufactures the small rubberized squares that are being installed where tree roots, freezing weather, and snow removal have required sidewalk replacement or major repairs every 3 years. The District of Columbia spent $60,000 for a rubber sidewalk to replace broken concrete in a residential neighborhood lined with towering willow oaks. If a concrete sidewalk costs $28,000 and

tonozdayim.com/@Zedeleyici31

lasts only 3 years versus a 9-year life for the rubber sidewalks, what rate of return does this represent?

7.18 Efficient light jets (ELJs) are smaller aircraft that may revolutionize the way people travel by plane. They cost between $1.5 and $3 million, seat 5 to 7 people, and can fly up to 1100 miles at cruising speeds approaching 425 mph. Eclipse Aerospace was founded in 2009, and its sole business is making ELJs. The company invested $500 million (time 0) and began taking orders 2 years later. If the company accepted orders for 2500 planes and received 10% down (in year 2) on planes having an average cost of $1.8 million, what rate of return will the company make over a 10-year planning period? Assume 500 of the planes are delivered each year in years 6 through 10 and that the company's M&O costs average $10 million per year in years 1 through 10. (If requested by your instructor, show both hand and spreadsheet solutions.)

7.19 Betson Enterprises distributes and markets the Big Buck video game which allows players to "hunt" for elk, antelope, moose, and bucks without shivering outside in the cold. E-sports entertainment in New York City purchased five machines for $6000 each and took in an average of $600 total per week in sales. What rate of return does this represent (*a*) per week and (*b*) per year (nominal)? Use a 3-year study period with 52 weeks per year.

7.20 A 473-foot, 7000-ton World War II troop carrier (once commissioned as the *USS Excambion*) was sunk in the Gulf of Mexico to serve as an underwater habitat and diving destination. The project took 10 years of planning and cost $4 million. Assume the $4 million was expended equally in years 1 through 10. What rate of return does the venture represent, if increased fishing and recreation activities are valued at $270,000 per year beginning in year 11 and they continue in perpetuity? (If assigned by your instructor, show both hand and spreadsheet solutions.)

Multiple ROR Values

7.21 What is meant by a *nonconventional* cash flow series?

7.22 Explain at least three types of projects in which large net cash flow changes may cause sign changes during the life of the project, thus indicating the possible presence of multiple ROR values.

7.23 Explain a situation with which you are personally familiar for which the net cash flows have changed signs in a fashion similar to those in Figure 7–5.

7.24 According to Descartes' rule of signs, what is the maximum number of real-number values that will balance a rate of return equation?

7.25 According to Descartes' rule of signs, how many possible i^* values are there for net cash flows that have the following signs?
(*a*) + − + + + − +
(*b*) − − − + + + + +
(*c*) + + + + − − − + − − − + − + − + − − −

7.26 According to Norstrom's criterion, there are two requirements regarding the cumulative cash flows that must be satisfied to ensure that there is only one positive root in a rate of return equation. What are they?

7.27 According to Descartes' rule of signs, how many possible i^* values are there for the cash flows shown?

Year	1	2	3	4	5	6
Net Cash Flow, $	+4100	−2000	−7000	+12,000	−700	+800

7.28 According to Descartes' rule of signs, how many i^* values are possible for the cash flows shown?

Year	1	2	3	4
Revenue, $	25,000	13,000	4,000	70,000
Costs, $	−30,000	−7,000	−6,000	−12,000

7.29 According to Descartes' rule *and* Norstrom's criterion, how many i^* values are possible for the cash flow (CF) sequence shown?

Year	1	2	3	4	5
Net Cash Flow, $	+16,000	−32,000	−25,000	+50,000	−8,000
Cumulative CF, $	+16,000	−16,000	−41,000	+9,000	+1,000

7.30 For the cash flows shown, determine the sum of the cumulative cash flows.

Year	0	1	2	3	4
Revenue, $		25,000	15,000	4,000	18,000
Costs, $	−6,000	−30,000	−7,000	−6,000	−12,000

7.31 Stan-Rite Corp of Manitowoc, Wisconsin, is a B to B company that manufactures many types of industrial products, including portable measuring arms with absolute encoders, designed to perform 3D inspections of industrial parts. If the company's cash flow (in millions) for one of its product divisions is as shown on the next page, determine (*a*) the number of possible i^* values and (*b*) all rate of return values between 0% and 100%.

tonozdayim.com/@Zedeleyici31

Year	Expenses	Revenues
0	$−30	$ 0
1	−20	18
2	−25	19
3	−15	36
4	−22	52
5	−20	38
6	−30	70

7.32 Julie received a $50 bill for her birthday at the end of January. At the end of February, she spent this $50 and an additional $150 to buy clothes. Her parents then gave her $50 and $125 at the end of March and April, respectively, as she prepared to go to summer school and needed the clothes. Her conclusion was that over the 4 months, she had received $25 more than she spent. Determine if Julie has a multiple rate of return situation for these cash flows. If so, determine the multiple rates and comment on their validity. The cash flow values are as follows:

Month	Jan (0)	Feb (1)	Mar (2)	Apr (3)
Cash Flow, $	50	−200	50	125

7.33 Veggie Burger Boy sells franchises to individuals who want to start small in the sandwiches-for-vegeterians business and grow in net cash flow over the years. A franchisee in Mississippi provided the $5000 up-front money, but did very poorly the first year. He was allowed to borrow at the end of his first year from the corporation's capital incentive fund with a promise to repay the loan in addition to the annual share that the corporation contractually receives from annual sales. The net cash flows from the corporation's perspective are shown below.

Year	0	1	2	3	4	5	6
NCF, $	5000	−10,100	500	2000	2000	2000	2000

The corporate chief financial officer (CFO) has some questions concerning this NCF series. Help her by doing the following, using a spreadsheet.

(*a*) Plot the PW versus *i* graph and estimate the rate of return for this franchise.

(*b*) Use the IRR function on a spreadsheet to find the corresponding return.

(*c*) Basing your conclusions on Descartes' and Norstrom's rules, provide the CFO with some advice on what ROR value is the most reliable for this franchise over the 6-year period. The normal corporate MARR used for franchisee evaluation is 30% per year.

7.34 In 2011, Vaught Industries closed its plant in Marionsville following labor, environmental, and safety problems. The plant was built in 2005 based on an older technology to produce meat products. It had positive NCF until 2010 and discontinued operation in 2011 due to labor and safety problems. In 2012, prior to the sale of the facility and property, Vaught spent $1 million to make the site environmentally acceptable to a potential buyer. The net cash flows in $100,000 over the years are listed below. Use a spreadsheet to do the following.

(*a*) Check for multiple rates of return.

(*b*) Find all rates that are real numbers between −25% and +50%, and calculate the PW value for interest rates in this range.

(*c*) Indicate which is the best and correct *i** value to use in a PW analysis.

Year	2005	2006	2007	2008	2009	2010	2011	2012
NCF, $	−25	+10	+10	+15	+15	−5	−6	−10

7.35 Five years ago, VistaCare spent $5 million to develop and introduce a new service in home health care for people who require frequent blood dialysis treatments. The service was not well received after the first year and was removed from the market. When reintroduced 4 years after its initial launch, it was much more profitable. Now, in year 5, VistaCare has spent a large sum on research to broaden the application of this service. Use the NCF series below to plot the PW versus *i* graph and estimate the ROR over the 5 years. NCF values are in $1 million units.

Year	0	1	2	3	4	5
Net Cash Flow, $	−5000	5000	0	0	15,000	−15,000

Removing Multiple *i** Values

7.36 In calculating the external rate of return by the modified rate of return approach, it is necessary to use two different rates of return, the investment rate i_i and the borrowing rate i_b. When is each used?

7.37 In the modified rate of return approach for determining a single interest rate from net cash flows, state which interest rate is usually higher, the investment rate i_i or the borrowing rate i_b. State why.

7.38 Use the modified rate of return approach with an investment rate of 18% per year and a borrowing rate of 10% to find the external rate of return for the following cash flows.

Year	0	1	2	3
Net Cash Flow, $	+16,000	−32,000	−25,000	+70,000

7.39 Harley worked for many years to save enough money to start his own residential landscape design business. The cash flows shown are those he recorded for the first 6 years as his own boss. Find the external rate of

tonozdayim.com/@Zedeleyici31

return using the modified rate of return approach, an investment rate of 15% per year, and a borrowing rate of 8%. (After using the procedure, use the MIRR function to confirm your answer.)

Year	0	1	2	3	4	5	6
NCF, $	−9000	+4100	−2000	−7000	+12,000	+700	+800

7.40 Samara, an engineer working for GE, invested her bonus money each year in company stock. Her bonus has been $8000 each year for the past 6 years (i.e., at the end of years 1 to 6). At the end of year 7, she sold the stock for $52,000 to buy a condo; she purchased no stock that year. In years 8 to 10, she again invested the $8000 bonus. Samara sold all of the remaining stock for $28,000 immediately after the investment at the end of year 10.

(*a*) Determine the number of possible rate of return values in the net cash flow series using the two sign tests.

(*b*) Determine the external rate of return by hand, using the modified rate of return approach with an investment rate of 12% per year and a borrowing rate of 8%.

(*c*) Find the external rate of return by spreadsheet using the ROIC approach with an investment rate of 12% per year.

(*d*) Enter the cash flows into a spreadsheet, and use the IRR function to find the *i** value. You should get the same value as the ROIC in part (*c*). Explain why this is so, given that the investment rate is 12% per year. (*Hint:* Look carefully at the column labeled "Future worth, F, $" when you solved part (*c*) using the spreadsheet.)

7.41 Swagelok Co. of Solon, Ohio, makes variable area flowmeters (VAFs) that measure liquid and gas flow rates by means of a tapered tube and float. If tooling and setup costs were $400,000 in year 0 and an additional $190,000 in year 3, determine the external rate of return using the modified rate of return approach. The revenue was $160,000 per year in years 1 through 10. Assume the company's MARR is 20% per year and its cost of capital is 9% per year.

7.42 A company that makes clutch disks for race cars has the cash flows shown for one department.

Year	Cash Flow, $1000
0	−65
1	30
2	84
3	−10
4	−12

(*a*) Determine the number of positive roots to the rate of return relation.

(*b*) Calculate the internal rate of return.

(*c*) Calculate the external rate of return using the return on invested capital (ROIC) approach with an investment rate of 15% per year. (As assigned by your instructor, solve by hand and/or spreadsheet.)

7.43 For the cash flow series below, calculate the external rate of return, using the return on invested capital approach with an investment rate of 14% per year.

Year	Cash Flow, $
0	3000
1	−2000
2	1000
3	−6000
4	3800

7.44 Five years ago, a company made a $500,000 investment in a new high-temperature material. The product did poorly after only 1 year on the market. However, with a new name and advertising campaign 4 years later it did much better. New development funds have been expended this year (year 5) at a cost of $1.5 million. Determine the external rate of return using the ROIC approach and an investment rate of 15% per year. The *i** rate is 44.1% per year.

Year	Cash Flow, $
0	−500,000
1	400,000
2	0
3	0
4	2,000,000
5	−1,500,000

Bonds

7.45 What is the bond coupon rate on a $25,000 mortgage bond that has semiannual interest payments of $1250 and a 20-year maturity date?

7.46 An equipment trust bond with a face value of $10,000 has a bond coupon rate of 8% per year, payable quarterly. What are the amount and frequency of the dividend payments?

7.47 What is the face value of a municipal bond that matures in 20 years and has a bond coupon rate of 6% per year with semiannual payments of $900?

7.48 What is the present worth of a $50,000 debenture bond that has a bond coupon rate of 8% per year, payable quarterly? The bond matures in 15 years. The interest rate in the marketplace is 6% per year, compounded quarterly.

tonozdayim.com/@Zedeleyici31

7.49 Best Buy issued collateral bonds *4 years ago* that have a face value of $20,000 each and a coupon rate of 8% per year, payable semiannually. If the bond maturity date is 20 years *from the date they were issued* and the interest rate in the marketplace is now 12% per year, compounded semiannually, what is the present worth (now) of one bond?

7.50 In 2011, El Paso Water Utilities (EPWU) issued bonds worth $9.125 million to improve the Van Buren dam in central El Paso and to finance three other drainage projects. The bonds were purchased by the Texas Water Development Board under the federal stimulus program wherein EPWU did not have to pay any dividend on the bonds. If the bond dividend rate would have been 4% per year, payable quarterly, with a bond maturity date 18 years after issuance, what is the present worth of the dividend savings to EPWU rate payers? Assume the market interest rate is 6% per year.

7.51 A recently issued industrial bond with a face value of $10,000 has a coupon rate of 8% per year, payable annually. The bond matures 20 years from now. Jeremy is interested in buying one bond. If he pays $10,000 for the bond and plans to hold it to maturity, what rate of return per year will he realize?

7.52 Due to a significant troop buildup at the local military base, a school district issued $10,000,000 in bonds to build new schools. The bond coupon rate is 6% per year, payable semiannually, with a maturity date of 20 years. If an investor is able to purchase one of the bonds that has a face value of $5000 for $4800, what rate of return per 6 months will the investor realize? Assume the bond is kept to maturity.

7.53 As the name implies, a zero-coupon bond pays no dividend, only the face value when it matures. If a zero coupon bond that has a face value of $10,000 and a maturity date of 15 years is for sale for $2000, what rate of return will the purchaser make, provided the bond is held to maturity?

7.54 To provide infrastructure in the outlying areas of Morgantown, West Virginia, the city council issued 30-year bonds with a face value of $25 million. The bond coupon rate was set at 5% per year, payable semiannually. Because the market interest rate increased immediately before the bonds were sold, the city received only $23.5 million from the bond sale. What was the semiannual interest rate when the bonds were sold?

7.55 An investor who purchased a $10,000 mortgage bond today paid only $6000 for it. The bond coupon rate is 8% per year, payable quarterly, and the maturity date is 18 years from the year of issuance. Because the bond is in default, it will pay no dividend for the next 2 years. If the bond dividend is in fact paid for the following 5 years (after the 2 years) and the investor then sells the bond for $7000, what rate of return will be realized (*a*) per quarter and (*b*) per year (nominal)?

7.56 Five years ago, GSI, an oil services company headquartered in Texas, issued $10 million worth of 12% 30-year bonds with the dividend payable quarterly. The bonds have a call date of this year if GSI decides to take advantage of it. The interest rate in the marketplace decreased enough that the company is considering calling the bonds since the coupon rate is relatively high. If the company buys the bonds back now for $11 million, determine the rate of return that the company will make (*a*) per quarter and (*b*) per year (nominal). (*Hint:* The "call" option means the following: By spending $11 million now, the company will not have to make the quarterly bond dividend payments or pay the face value of the bonds when they come due 25 years from now.)

7.57 Four years ago, Chevron issued $5 million worth of debenture bonds with a coupon rate of 10% per year, payable semiannually. Market interest rates dropped, and the company called the bonds (i.e., paid them off in advance) at a 10% premium on the face value. Therefore, it cost the corporation $5.5 million to retire the bonds. What semiannual rate of return did an investor make who purchased a $5000 bond 4 years ago and held it until it was called 4 years later?

ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

7.58 All of the following mean the same as *rate of return* except:
(*a*) Internal rate of return
(*b*) Time for return of capital
(*c*) Interest rate
(*d*) Return on investment

7.59 The numerical value of i in a rate of return equation can range from:
(*a*) 0% to 100%
(*b*) 0 to ∞
(*c*) −100% to +100%
(*d*) −100% to ∞

tonozdayim.com/@Zedeleyici31

7.60 The internal rate of return on an investment refers to the interest rate earned on the:
(*a*) Initial investment
(*b*) Unrecovered balance of the investment
(*c*) Money recovered from an investment
(*d*) Income from an investment

7.61 A conventional (or simple) cash flow series is one wherein:
(*a*) The algebraic signs on the net cash flows change only once.
(*b*) The interest rate you get is a simple interest rate.
(*c*) The total of the net cash flows is equal to 0.
(*d*) The total of the cumulative cash flows is equal to 0.

7.62 According to Descartes' rule of signs, for a net cash flow sequence of $--++-+$, the number of possible i values is:
(*a*) 2
(*b*) 3
(*c*) 4
(*d*) 5

7.63 According to Norstrom's criterion, the one statement below that is correct is:
(*a*) The cumulative cash flow must start out positively.
(*b*) The cumulative cash flow must start out negatively.
(*c*) The cumulative cash flow must equal 0.
(*d*) The net cash flow must start out positively.

7.64 According to Descartes' rule *and* Norstrom's criterion, the number of positive i^* values for the following cash flow sequence is:

Year	1	2	3	4
Revenue, $	25,000	15,000	4,000	18,000
Cost, $	30,000	7,000	6,000	12,000

(*a*) 1
(*b*) 2
(*c*) 3
(*d*) 4

7.65 For the net cash flows and cumulative cash flows shown, the value of x is:

Year	1	2	3	4	5
NCF, $	+13,000	−29,000	−25,000	x	−8000
Cumulative NCF, $	+13,000	−16,000	−41,000	+9000	+1000

(*a*) $7000
(*b*) $16,000
(*c*) $36,000
(*d*) $50,000

7.66 A company that uses a minimum attractive rate of return of 10% per year is evaluating new processes to improve operational efficiency. The estimates associated with candidate processes are shown.

	Alternative I	Alternative J
First cost, $	−40,000	−50,000
Annual cost, $ per year	−15,000	−12,000
Salvage value, $	5,000	5,000
Life, years	3	6

The statement that is most correct is:
(*a*) The alternatives are revenue alternatives.
(*b*) The alternatives are cost alternatives.
(*c*) The alternatives are revenue alternatives and DN is an option.
(*d*) The alternatives are cost alternatives and DN is an option.

7.67 Scientific Instruments, Inc. uses a MARR of 8% per year. The company is evaluating a new process to reduce water effluents from its manufacturing processes. The estimate associated with the process follows. In evaluating the process on the basis of a rate of return analysis, the correct equation to use is:

	New Process
First cost, $	−40,000
NCF, $ per year	13,000
Salvage value, $	5,000
Life, years	3

(*a*) $0 = -40{,}000 + 13{,}000(P/A,i,3) + 5000(P/F,i,3)$
(*b*) $0 = -40{,}000(A/P,i,3) + 13{,}000 + 5000(A/F,i,3)$
(*c*) $0 = -40{,}000(F/P,i,3) + 13{,}000(F/A,i,3) + 5000$
(*d*) Any of the above

7.68 When one is using the modified ROR method to remove multiple ROR values, an additional estimate needed besides the cash flows and their timings is:
(*a*) The ROIC value
(*b*) External rate of return
(*c*) Investment rate
(*d*) Internal rate of return

7.69 For the following cash flows, the modified rate of return method uses a borrowing rate of 10%, and an investment rate is 12% per year. The correct computation for the present worth in year 0 is:

Year	1	2	3	4	5
NCF, $	−10,000	0	0	−19,000	+25,000

(*a*) $-10{,}000 - 19{,}000(P/F,12\%,4)$
(*b*) $-10{,}000 - 19{,}000(P/F,12\%,4) + 25{,}000(P/F,10\%,5)$

tonozdayim.com/@Zedeleyici31

(*c*) 25,000(P/F,10%,5)
(*d*) $-10{,}000 - 19{,}000(P/F,10\%,4)$

7.70 The return on invested capital (ROIC) method removes multiple ROR values from a cash flow sequence. If the future worth computation in year t is $F_t < 0$, the ROIC rate i'' is used. The interpretation of $F_t < 0$ most closely means:
(*a*) The net balance of project cash flows in year t is negative.
(*b*) The resulting external rate of return will be positive.
(*c*) The net balance of project cash flows is positive in year t.
(*d*) The sequence has nonremovable negative ROR values.

7.71 The meaning of *return on invested capital* for a corporation is best stated as:
(*a*) A rate-of-return measure that equates the internal and external ROR
(*b*) A measure of how effectively the corporation uses capital funds invested in it
(*c*) The value at which borrowing ROR and investing ROR are equal
(*d*) The external rate of return value is based on total capital invested

7.72 A corporate $10,000 bond has a coupon rate of 8% per year, payable semiannually. The bond matures 20 years from now. At an interest rate of 6% per year, compounded semiannually, the amount and frequency of the bond dividend payments are:
(*a*) $600 every 6 months
(*b*) $800 every 6 months
(*c*) $300 every 6 months
(*d*) $400 every 6 months

7.73 A $20,000 mortgage bond that is due in 1 year pays interest of $500 every 3 months. The bond's coupon rate is:
(*a*) 2.5% per year, payable quarterly
(*b*) 5% per year, payable quarterly
(*c*) 5% per year, payable semiannually
(*d*) 10% per year, payable quarterly

7.74 A $10,000 municipal bond due in 10 years pays interest of $400 every 6 months. If an investor purchases the bond now for $9000 and holds it to maturity, the rate of return received can be determined by the following equation:
(*a*) $0 = -9000 + 400(P/A,i,10) + 10{,}000(P/F,i,10)$
(*b*) $0 = -9000 + 400(P/A,i,20) + 10{,}000(P/F,i,20)$
(*c*) $0 = -10{,}000 + 400(P/A,i,20) + 10{,}000(P/F,i,20)$
(*d*) $0 = -9000 + 800(P/A,i,10) + 10{,}000(P/F,i,10)$

7.75 A debenture bond issued 3 years ago has a face value of $5000, a coupon rate of 4% per year, payable semiannually, and a maturity date of 20 years *from the date it was issued*. The bond is for sale now for $4500. If the interest rate in the marketplace is compounded quarterly, the value of n that must be used in the P/A factor to calculate the rate of return for the bond is:
(*a*) 34
(*b*) 40
(*c*) 68
(*d*) 80

CASE STUDY

DEVELOPING AND SELLING AN INNOVATIVE IDEA

Background

Three engineers who worked for Mitchell Engineering, a company specializing in public housing development, went to lunch together several times a week. Over time they decided to work on solar energy production ideas. After a lot of weekend time over several years, they had designed and developed a prototype of a low-cost, scalable solar energy plant for use in multifamily dwellings on the low end and medium-sized manufacturing facilities on the upper end. For residential applications, the collector could be mounted along side a TV dish and be programmed to track the sun. The generator and additional equipment are installed in a closet-sized area in an apartment or on a floor for multiple-apartment supply. The system serves as a supplement to the electricity provided by the local power company. After some 6 months of testing, it was agreed that the system was ready to market and reliably state that an electricity bill in high-rises could be reduced by approximately 40% per month. This was great news for low-income dwellers on government subsidy that are required to pay their own utility bills.

Information

With a hefty bank loan and $200,000 of their own capital, they were able to install demonstration sites in three cities in the sunbelt. Net cash flow after all expenses, loan repayment, and taxes for the first 4 years was acceptable; $55,000 at the

tonozdayim.com/@Zedeleyici31

PROBLEMS

Understanding Incremental ROR

8.1 In a tabulation of cash flow, the column entitled "Rate of return on the incremental cash flow" represents the rate of return on what?

8.2 If the rate of return on the incremental cash flow between two alternatives is less than the minimum attractive rate of return, which alternative should be selected, if any?

8.3 An engineer is comparing three projects by the incremental ROR method. There are revenue and cost cash flow estimates. He used the IRR function of Excel to determine the ROR values for each project. The first one is 3.5% above the MARR, the second is 1.2% below the MARR, and the third is 2.4% above the MARR. Which alternatives, if any, must he include in the incremental ROR analysis?

8.4 The rates of return on alternatives X and Y are 15% and 12%, respectively. Alternative Y requires a larger investment than alternative X.
(*a*) What is known about the rate of return on the increment of investment between the two alternatives?
(*b*) If the MARR is 12%, which alternative should be selected and why?

8.5 Victoria is comparing two mutually exclusive alternatives, A and B. The overall ROR on alternative A is greater than the MARR, and the overall ROR on alternative B, which requires the larger investment, is exactly equal to the MARR.
(*a*) What is known about the ROR on the increment between A and B?
(*b*) Which alternative should be selected?

8.6 A food processing company is considering two types of moisture analyzers. Only one can be selected. The company expects an infrared model to yield a rate of return of 27% per year. A more expensive microwave model will yield a rate of return of 22% per year. If the company's MARR is 19% per year, can you determine which model should be purchased solely on the basis of the overall rate of return information provided? Why or why not?

8.7 If $80,000 is invested at 30% and another $50,000 is invested at 20% per year, what is the overall rate of return on the entire $130,000?

8.8 A total of $100,000 was invested in two different projects identified as Z1 and Z2. If the overall rate of return on the $100,000 was 30% and the rate of return on the $30,000 invested in Z1 was 15%, what was the rate of return on Z2?

8.9 Tuggle, Inc., which manufactures rigid shaft couplings, has $600,000 to invest. The company is considering three different projects that will yield the following rates of return.

Project X	$i_X = 24\%$
Project Y	$i_Y = 18\%$
Project Z	$i_Z = 30\%$

The initial investment required for each project is $100,000, $300,000, and $200,000, respectively. If Tuggle's MARR is 15% per year and it invests in all three projects, what rate of return will the company make?

8.10 Two options are available for setting up a wireless meter scanner and controller. A simple setup is good for 2 years and has an initial cost of $12,000, no salvage value, and an operating cost of $27,000 per year. A more permanent system has a higher first cost of $73,000, but it has an estimated life of 6 years and a salvage value of $15,000. It costs only $14,000 per year to operate and maintain. If the two options are compared using an incremental rate of return, what are the incremental cash flows in (*a*) year 0 and (*b*) year 2?

8.11 Prepare a tabulation of incremental cash flows for the two machine alternatives below.

	Machine X	Machine Y
First cost, $	−35,000	−90,000
Annual operating cost, $ per year	−31,600	−19,400
Salvage value, $	0	8,000
Life, years	2	4

8.12 For the alternatives shown, determine the sum of the incremental cash flows for Q – P.

	Alternative P	Alternative Q
First cost, $	−50,000	−85,000
Annual operating cost, $ per year	−8,600	−2,000
Annual revenue, $ per year	22,000	45,000
Salvage value, $	3,000	8,000
Life, years	3	6

8.13 The tabulation of the incremental cash flows between alternatives A and B is shown on the next page. Alternative A has a 3-year life and alternative B a 6-year life. If neither alternative has a salvage value, what is (*a*) the first cost of alternative A and (*b*) the first cost of alternative B?

tonozdayim.com/@Zedeleyici31

Year	Incremental Cash Flow (B − A), $
0	–20,000
1	5,000
2	5,000
3	12,000
4	5,000
5	5,000
6	5,000

8.14 Standby power for pumps at water distribution booster stations can be provided by either gasoline- or diesel-powered engines. The costs for the gasoline engines are as follows:

	Gasoline
First cost, $	−150,000
Annual M&O, $ per year	−41,000
Salvage value, $	23,000
Life, years	15

The incremental PW cash flow equation associated with (diesel – gasoline) is

$$0 = -40{,}000 + 11{,}000(P/A,i,15) + 16{,}000(P/F,i,15)$$

Determine the following:
(*a*) First cost of the diesel engines
(*b*) Annual M&O cost of the diesel engines
(*c*) Salvage value of the diesel engines

8.15 Several high-value parts for NASA's reusable space exploration vehicle can be either anodized or powder-coated. Some of the costs for each process are shown below:

	Anodize	Powder Coat
First cost, $	?	−65,000
Annual cost, $ per year	−21,000	?
Resale value, $	?	6,000
Life, years	3	3

The incremental AW cash flow equation associated with (powder coat – anodize) is

$$0 = -14{,}000(A/P,i,3) + 5000 + 2000(A/F,i,3)$$

What is (*a*) the first cost for anodizing, (*b*) the annual cost for powder coating, and (*c*) the resale (salvage) value of the anodized parts?

Incremental ROR Comparison (Two Alternatives)

8.16 Specialty Gases & Chemicals manufactures nitrogen trifluoride, a highly specialized gas used as an industrial cleansing agent for flat panels installed in laptop computers, televisions, and desktop monitors. The incremental cash flow associated with two alternatives for chemical storage and handling systems (identified as P3 and X3) has been calculated in $1000 units. Determine (*a*) the rate of return on the incremental cash flows and (*b*) which one should be selected if the company's MARR is 25% per year. Alternative X3 requires the larger initial investment.

Year	Incremental Cash Flow (X3 − P3), $1000
0	$−4600
1–9	1100
10	2000

8.17 As groundwater wells age, they sometimes begin to pump sand (and they become known as "sanders"), and this can cause damage to downstream desalting equipment. This situation can be dealt with by drilling a new well at a cost of $1,000,000 or by installing a tank and self-cleaning screen ahead of the desalting equipment. The tank and screen will cost $230,000 to install and $61,000 per year to operate and maintain. A new well will have a pump that is more efficient than the old one, and it will require almost no maintenance, so its operating cost will be only $18,000 per year. If the salvage values are estimated at 10% of the first cost, use a present worth relation to (*a*) calculate the incremental rate of return and (*b*) determine which alternative is better at a MARR of 6% per year over a 20-year study period.

8.18 Konica Minolta plans to sell a copier that prints documents on both sides simultaneously, cutting in half the time it takes to complete big commercial jobs. The costs associated with producing chemically-treated vinyl rollers and fiber-impregnated rubber rollers are shown below. Determine which of the two types should be selected by calculating the rate of return on the incremental investment. Assume the company's MARR is 21% per year. (Solve by hand and/or spreadsheet, as instructed.)

	Treated	Impregnated
First cost, $	−50,000	−95,000
Annual cost, $ per year	−100,000	−85,000
Salvage value, $	5,000	11,000
Life, years	3	6

8.19 The Texas Department of Transportation (TxDOT) is considering two designs for crash barriers along a reconstructed portion of I-10. Design 2B will cost $3 million to install and $135,000 per year to maintain. Design 4R will cost $3.7 million to install and $70,000 per year to maintain. Calculate the rate of return and determine which design is preferred if TxDOT uses a MARR of 6% per year and a 20-year project period.

tonozdayim.com/@Zedeleyici31

8.20 Chem-Tex Chemical is considering two additives for improving the dry-weather stability of its low-cost acrylic paint. Additive A has a first cost of $110,000 and an annual operating cost of $60,000. Additive B has a first cost of $175,000 and an annual operating cost of $35,000. If the company uses a 3-year recovery period for paint products and a MARR of 20% per year, which process is economically favored? Use an incremental ROR analysis.

8.21 The manager of Liquid Sleeve, Inc., a company that makes a sealing solution for machine shaft surfaces that have been compromised by abrasion, high pressures, or inadequate lubrication, is considering adding metal-based nanoparticles of either type Al or Fe to its solution to increase the product's performance at high temperatures. The costs associated with each are shown below. The company's MARR is 20% per year. Do the following using a PW-based rate of return analysis and a spreadsheet:

(*a*) Determine which nanoparticle type the company should select using the Δi^* value.

(*b*) On the same graph, plot the PW versus different i values for each alternative. Indicate the breakeven i^* value and the MARR value on the plot.

(*c*) Use the plot of PW versus Δi values to select the better alternative with MARR = 20% per year. Is the answer the same as in part (*a*)?

	Type Fe	Type Al
First cost, $	−150,000	−280,000
Annual operating cost, $ per year	−92,000	−74,000
Salvage value, $	30,000	70,000
Life, years	2	4

8.22 A chemical company is considering two processes for isolating DNA material. The incremental cash flows between the two alternatives, J and S, have an incremental rate of return that is less than 40%, which is the MARR of the company. However, the company CEO prefers the more expensive process S. She believes the company can implement cost controls to reduce the annual cost of the more expensive process. By how much would she have to reduce the annual operating cost of alternative S (in $ per year) for it to have an incremental rate of return of exactly 40%?

Year	Incremental Cash Flow (S − J), $
0	−900,000
1	400,000
2	400,000
3	400,000

8.23 The incremental cash flows for two alternative electrode setups are shown. The MARR is 12% per year, and alternative Dryloc requires a larger initial investment compared to NPT.

(*a*) Determine which should be selected using an AW-based rate of return analysis.

(*b*) Use a graph of incremental values to determine the largest MARR value that will justify the NPT alternative.

Year	Incremental Cash Flow (Dryloc − NPT), $
0	−56,000
1−8	+8,900
9	+12,000

8.24 Hewett Electronics manufactures amplified pressure transducers. It must decide between two machines for a finishing operation. Select one for them on the basis of AW-based rate of return analysis. The company's MARR is 18% per year.

	Variable Speed	Dual Speed
First cost, $	−270,000	−245,000
Annual operating cost, $ per year	−135,000	−139,000
Salvage value, $	75,000	35,000
Life, years	6	6

8.25 A manufacturer of hydraulic equipment is trying to determine whether it should use monoflange double block and bleed (DBB) valves or a multi-valve system (MVS) for chemical injection. The costs are shown below. Use an AW-based rate of return analysis and a MARR of 18% per year to determine the better of the two options.

	DBB	MVS
First cost, $	−40,000	−71,000
Annual cost, $ per year	−60,000	−65,000
Salvage value, $	0	18,000
Life, years	2	4

8.26 Poly-Chem Plastics is considering two types of injection molding machines—hydraulic and electric. The hydraulic press (HP) will have a first cost of $600,000, annual costs of $200,000, and a salvage value of $70,000 after 5 years. Electric machine technology (EMT) will have a first cost of $800,000, annual costs of $150,000, and a salvage value of $130,000 after 5 years.

(*a*) Use an AW-based rate of return equation to determine the ROR on the increment of investment between the two.

tonozdayim.com/@Zedeleyici31

(*b*) Determine which machine the company should select, if the MARR = 16% per year.

(*c*) Plot the AW versus *i* graph for each alternative's cash flows, and utilize it to determine the largest MARR that will justify the EMT extra investment of $200,000.

8.27 Last week Eduardo calculated the overall project ROR values for two alternatives A and B using the estimates below. He calculated $i_A^* = 34.2\%$ and $i_B^* = 31.2\%$ and recommended acceptance of A since its rate of return exceeded the established MARR of 30% by a greater amount than project B. Yesterday, the general manager of the company announced a major capital investment program, which includes a large drop in the MARR from 30% to 20% per year. Do the following to help Eduardo better understand the rate of return method and what this reduction in MARR means.

(*a*) Explain the error that Eduardo made in performing the rate of return analysis.

(*b*) Perform the correct analysis using each MARR value.

(*c*) Illustrate the ranking inconsistency problem using the two MARR values, and determine the maximum MARR that will justify alternative B.

	Alternative A	Alternative B
First cost, $	−40,000	−85,000
Annual operating cost, $ per year	−5,500	−15,000
Annual revenue, $ per year	22,000	45,000
Salvage value, $	0	20,000
Life, years	6	6
*i**, %	34.2	29.2

Multiple Alternative Comparison

8.28 Four mutually exclusive revenue alternatives are under consideration to automate a baking and packaging process at Able Bakery Products. The alternatives are ranked in order of increasing initial investment and compared by incremental rate of return analysis. The rate of return on each increment of investment was less than the MARR. Which alternative should be selected?

8.29 A WiMAX wireless network integrated with a satellite network can provide connectivity to any location within 10 km of the base station. The number of sectors per base station can be varied to increase the bandwidth. An independent cable operator is considering three bandwidth alternatives. Assume a life of 20 years and a MARR of 10% per year to determine which alternative is best using an incremental rate of return analysis.

Bandwidth, Mbps	First Cost, $1000	Operating Cost, $1000 per Year	Annual Income, $1000 per Year
44	–40,000	–2000	+5000
55	–46,000	–1000	+5000
88	–61,000	–500	+8000

8.30 Xerox's iGenX high-speed commercial printers cost $1.5 billion to develop. The machines cost $500,000 to $750,000 depending on what options the client selects. Spectrum Imaging Systems is considering the purchase of a new printer based on recent contracts it received for printing weekly magazine and mail-out advertising materials. The operating costs and revenues generated are related to a large extent to the speed and other capabilities of the copier. Spectrum is considering the four machines shown below. The company uses a 3-year planning period and a MARR of 15% per year. Determine which copier the company should acquire on the basis of an incremental rate of return analysis.

Copier	Initial Investment, $	Operating Cost, $ per Year	Annual Revenue, $ per Year	Salvage Value, $
iGen-1	–500,000	–350,000	+450,000	+70,000
iGen-2	–600,000	–300,000	+460,000	+85,000
iGen-3	–650,000	–275,000	+480,000	+95,000
iGen-4	–750,000	–200,000	+510,000	+120,000

8.31 Ashley Foods, Inc. has determined that any one of five machines can be used in one phase of its chili canning operation. The costs of the machines are estimated below, and all machines are estimated to have a 4-year useful life. If the minimum attractive rate of return is 20% per year, determine which machine should be selected on the basis of a rate of return analysis.

Machine	First Cost, $	Annual Operating Cost, $ per Year
1	−31,000	−16,000
2	−29,000	−19,300
3	−34,500	−17,000
4	−49,000	−12,200
5	−41,000	−15,500

8.32 Five revenue projects are under consideration by General Dynamics for improving material flow through an assembly line. The initial cost in

tonozdayim.com/@Zedeleyici31

$1000 and the life of each project are as follows (revenue estimates are not shown):

	Project				
	A	B	C	D	E
Initial cost, $1000	−700	−2300	−900	−300	−1600
Life, years	5	8	5	5	6

An engineer made the comparisons shown below. From the calculations, determine which project, if any, should be undertaken if the company's MARR is (*a*) 11.5% per year and (*b*) 13.5% per year. If other calculations are necessary to make a decision, state which ones.

Comparison	Incremental Rate of Return, %
B vs DN	13%
A vs B	19%
D vs DN	11%
E vs B	15%
E vs D	24%
E vs A	21%
C vs DN	7%
C vs A	19%
E vs DN	12%
A vs DN	10%
E vs C	33%
D vs C	33%
D vs B	29%

8.33 The five alternatives shown here are being evaluated by the rate of return method.

Alternative	Initial Investment, $	ROR versus DN, %	Incremental Rate of Return, %				
			A	B	C	D	E
A	–25,000	9.6	—	27.3	9.4	35.3	25.0
B	–35,000	15.1		—	0	38.5	24.4
C	–40,000	13.4			—	46.5	27.3
D	–60,000	25.4				—	6.8
E	–75,000	20.2					—

(*a*) If the alternatives are *mutually exclusive* and the MARR is 26% per year, which alternative should be selected?

(*b*) If the alternatives are *mutually exclusive* and the MARR is 15% per year, which alternative should be selected?

(*c*) If the alternatives are *independent* and the MARR is 15% per year, which alternative(s) should be selected?

8.34 Five mutually exclusive revenue alternatives that have *infinite lives* are under consideration for increasing productivity in a manufacturing operation. The initial costs and cash flows of each project are shown. If the MARR is 14.9% per year, which alternative should be selected?

	Alternative				
	A	B	C	D	E
Initial cost, $	−7,000	−23,000	−9,000	−3,000	−16,000
Cash flow, $ per year	1,000	3,500	1,400	500	2,200
Rate of return (vs DN), %	14.3	15.2	15.6	16.7	13.8

8.35 The plant manager at Automaton Robotics is looking at the summarized incremental rate of return information shown below for five mutually exclusive alternatives, one of which must be chosen. The table includes the overall ROR and the incremental comparison of alternatives. Which alternative is best if the minimum attractive rate of return is (*a*) 15% per year and (*b*) 12% per year?

Alternative	First Cost, $	Overall ROR, %	Incremental Rate of Return, %				
			A	B	C	D	E
A	−80,000	14	—	12	11	17	24
B	−60,000	16	12	—	14	23	21
C	−40,000	17	11	14	—	35	29
D	−30,000	12	17	23	35	—	17
E	−20,000	8	24	21	29	17	—

8.36 Only one of four different machines can be purchased for Glass Act Products. An engineer performed the following analysis to select the best machine, all of which have a 10-year life. Which machine, if any, should the company select at a MARR of 22% per year?

	Machine			
	1	2	3	4
Initial cost, $	−44,000	−60,000	−72,000	−98,000
Annual cost, $ per year	−70,000	−64,000	−61,000	−58,000
Annual savings, $ per year	+80,000	+80,000	+80,000	+82,000
Overall ROR, %	18.6	23.4	23.1	20.8
Machines compared		2 to 1	3 to 2	4 to 3
Incremental investment, $		−16,000	−12,000	−26,000
Incremental cash flow, $ per year		+6,000	+3,000	+5,000
ROR on increment, %		35.7	21.4	14.1

8.37 The U.S. Bureau of Reclamation is considering five national park projects shown below, all of which can be considered to last indefinitely. At a MARR of 7.5% per year, determine which should be selected, if they are (*a*) independent and (*b*) mutually exclusive.

Project ID	First Cost, $1000	Annual Income, $1000	Rate of Return, %
A	−20,000	+2000	10.0
B	−10,000	+1300	13.0
C	−15,000	+1000	6.6
D	−70,000	+4000	5.7
E	−50,000	+2600	5.2

tonozdayim.com/@Zedeleyici31

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
(*b*) Select the alternative whose *incremental* ROR is the highest
(*c*) Select the alternative with ROR $\geq$ MARR that has the lowest initial investment cost
(*d*) Select the alternative with the largest initial investment that has been incrementally justified

8.40 When comparing independent projects by the ROR method, you should:
(*a*) Find the ROR of each project and pick the ones with the highest ROR
(*b*) Select all projects that have an overall ROR $\geq$ MARR
(*c*) Select the project with an overall ROR $\geq$ MARR that involves the lowest initial investment cost
(*d*) Select the project with the largest initial investment that has been incrementally justified

8.41 Of the following scenarios, alternative Y requires a higher initial investment than alternative X, and the MARR is 20% per year. The only scenario that requires an incremental investment analysis to select an alternative is that:
(*a*) X has an overall ROR of 22% per year, and Y has an overall ROR of 24% per year
(*b*) X has an overall ROR of 19% per year, and Y has an overall ROR of 23% per year
(*c*) X has an overall ROR of 18% per year, and Y has an overall ROR of 19% per year
(*d*) X has an overall ROR of 28% per year, and Y has an overall ROR of 26% per year

8.42 Alternatives whose cash flows (excluding the salvage value) are all negative are called:
(*a*) Revenue alternatives
(*b*) Nonconventional alternatives
(*c*) Cost alternatives
(*d*) Independent alternatives

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

8.44 Helical Systems, Inc. uses a minimum attractive rate of return of 8% per year, compounded annually. The company is evaluating two new processes for improving the efficiency of its manufacturing operation. The cash flow estimates associated with each process are shown below. A correct equation to use for an incremental rate of return analysis is:

	Process I	Process J
First cost, $	−40,000	−50,000
Annual cost, $ per year	−15,000	−12,000
Salvage value, $	5,000	6,000
Life, years	3	3

(*a*) $0 = -10{,}000 + 3000(P/A,\Delta i^*,3) + 1000(P/F,\Delta i^*,3)$
(*b*) $0 = -40{,}000(A/P,\Delta i^*,3) - 15{,}000 + 5000(A/F,\Delta i^*,3)$
(*c*) $0 = -50{,}000(A/P,\Delta i^*,3) - 12{,}000 + 6000(A/F,\Delta i^*,3)$
(*d*) $0 = -10{,}000 - 3000(P/A,\Delta i^*,3) + 1000(P/F,\Delta i^*,3)$

8.45 For the four independent projects shown, the one or ones to select using a MARR of 14% per year are:

Project	Rate of Return, % per Year
A	14
B	12
C	15
D	10

(*a*) Only C
(*b*) Only A and C
(*c*) Only A
(*d*) Can't tell; need to conduct incremental analysis

tonozdayim.com/@Zedeleyici31

Problems 8.46 through 8.48 are based on the following information.

Five alternatives are being evaluated by the incremental rate of return method.

Alternative	Initial Investment, $	Overall ROR versus DN, %	Incremental Rate of Return, % A	B	C	D	E
A	−25,000	9.6	—	27.3	9.4	35.3	25.0
B	−35,000	15.1		—	0	38.5	24.4
C	−40,000	13.4			—	46.5	27.3
D	−60,000	25.4				—	6.8
E	−75,000	20.2					—

8.46 If the projects are mutually exclusive and the minimum attractive rate of return is 14% per year, the best alternative is:
(*a*) B (*b*) C (*c*) D (*d*) E

8.47 If the projects are mutually exclusive and the MARR is 20% per year, the best alternative is:
(*a*) B
(*b*) C
(*c*) D
(*d*) E

8.48 If the projects are independent, instead of mutually exclusive, the one or ones to select at an MARR of 18% per year are:
(*a*) B and C
(*b*) B, D, and E
(*c*) D and E
(*d*) B, C, and E

CASE STUDY

ROR ANALYSIS WITH ESTIMATED LIVES THAT VARY

Background

Make-to-Specs is a software system under development by ABC Corporation. It will be able to translate digital versions of three-dimensional computer models, containing a wide variety of part shapes with machined and highly finished (ultra-smooth) surfaces. The product of the system is the numerically controlled (NC) machine code for the part's manufacturing. Additionally, Make-to-Specs will build the code for superfine finishing of surfaces with continuous control of the finishing machines.

Information

There are two alternative computers that can provide the server function for the software interfaces and shared database updates on the manufacturing floor while Make-to-Specs is operating in parallel mode. The server first cost and estimated contribution to annual net cash flow are summarized below.

	Server 1	Server 2
First cost, $	100,000	200,000
Net cash flow, $/year	35,000	50,000 year 1, plus 5000 per year for years 2, 3, and 4 (gradient) 70,000 maximum for years 5 on, even if the server is replaced
Life, years	3 or 4	5 or 8

The life estimates were developed by two different individuals: a design engineer and a manufacturing manager. They have asked that, at this stage of the project, all analyses be performed using both life estimates for each system.

Case Study Exercises

Use spreadsheet analysis to determine the following:

1. If the MARR = 12%, which server should be selected? Use the PW or AW method to make the selection.
2. Use incremental ROR analysis to decide between the servers at MARR = 12%.
3. Use any method of economic analysis to display on the spreadsheet the value of the incremental ROR between server 2 with a life estimate of 5 years and a life estimate of 8 years.

tonozdayim.com/@Zedeleyici31

PROBLEMS

Working with MARR

10.1 List at least three factors that affect the MARR, and discuss how each one affects it.

10.2 State whether each of the following involves debt financing or equity financing.
(*a*) $10,000 taken from one partner's savings account to pay for equipment repair
(*b*) Issuance of preferred stock worth $1.3 million
(*c*) Short-term loan of $75,000 from a local bank
(*d*) Issuance of $3 million worth of 20-year bonds
(*e*) Del Engineering buyback of $8 million of its own stock using internal funds

10.3 Helical Products, Inc. uses an after-tax MARR of 12% per year. If the company's effective tax rate (federal, state, and local taxes) is 40%, determine the company's before-tax MARR.

10.4 The owner of a small pipeline construction company is trying to figure out how much he should bid in his attempt to win his first "big" contract. He estimates that his cost to complete the project will be $7.2 million. He wants to bid an amount that will give him an after-tax rate of return of 15% per year if he gets the job, but he doesn't know how much he should bid on a before-tax basis. He told you that his effective state tax rate is 7% and his effective federal tax rate is 22%.
(*a*) The expression for determining the overall effective tax rate is

state rate + (1 − state rate)(federal rate)

What should his before-tax MARR be in order for him to make an after-tax MARR of 15% per year?
(*b*) How much should he bid on the job?

10.5 A group of private equity investors provided $16 million to a start-up company involved in making high-technology detection systems for drugs and other types of contraband. Immediately after the investment was made, another investment opportunity came up for which the investors didn't have enough capital. That project would have yielded an estimated rate of return of 29% per year before taxes. If the group's effective tax rate is 32%, what after-tax rate of return would the forgone project have yielded?

10.6 Five projects were ranked in decreasing order by two measures—rate of return (ROR) and present worth (PW)—to determine which ones should be funded, with the total initial investment not to exceed $18 million. Use the results below to determine the opportunity cost for each measure.

				Ranking by ROR		Ranking by PW	
Project	ROR, %	PW at 15%, $1000	Initial Investment, $1000	Project	Cumulative Investment, $1000	Project	Cumulative Investment, $1000
A	44.5	7,138	8,000	A	8,000	A	8,000
B	12.8	−1,162	15,000	E	13,000	C	16,000
C	20.4	1,051	8,000	C	21,000	E	21,000
D	9.6	−863	8,000	B	36,000	D	29,000
E	26.0	936	5,000	D	44,000	B	44,000

10.7 Tom, the owner of Burger Palace, determined that his weighted average cost of capital is 8%. He expects a return of 4% per year on all of his investments. A proposal presented by the owner of the Dairy Choice next door seems quite risky to Tom, but is an intriguing partnership opportunity. Tom has determined that the proposal's "risk factor" will require an additional 3% per year return for him to accept it.
(*a*) Use the recommended approach to determine the MARR that Tom should use, and explain how the 3% risk factor is compensated for in this MARR.
(*b*) Determine the effective MARR for his business if Tom turns down the proposal.

D-E Mix and WACC

10.8 Electrical generators produce not only electricity, but also heat from conductor resistance and from friction losses in bearings. A company that manufactures generator coolers for nuclear and gas turbine power plants undertook a plant expansion through financing that had a debt-equity mix of 45–55. If $18 million came from mortgages and bond sales, what was the total amount of the financing?

10.9 Determine the debt-to-equity mix when Applied Technology bought out Southwest Semiconductor using financing as follows: $12 million from mortgages, $5 million from retained earnings, $10 million from cash on hand, and $20 million from bonds.

10.10 Business and engineering seniors are comparing methods of financing their college education during their senior year. The business student has $30,000 in student loans that come due at graduation. Interest is an effective 4% per year. The engineering senior owes $50,000, 50% from his parents with no interest due and 50% from a

tonozdayim.com/@Zedeleyici31

credit union loan. This latter amount is also due at graduation with an effective rate of 7% per year.

(*a*) What is the D-E mix for each student?

(*b*) If their grandparents pay the loans in full at graduation, what are the amounts on the checks they write for each graduate?

(*c*) When grandparents pay the full amount at graduation, what percent of the principal does the interest represent?

10.11 Two public corporations, First Engineering and Midwest Development, each show capitalization of $175 million in their annual reports. The balance sheet for First Engineering indicates a total debt of $87 million, and that of Midwest Development indicates a net worth of $62 million. Determine the D-E mix for each company.

10.12 Forest Products, Inc. invested $50 million. The company's overall D-E mix is 60–40.What is the return on the company's equity, if the net income is $5 million on a revenue base of $6 million?

10.13 Determine the weighted average cost of capital for a company that manufactures miniature triaxial accelerometers for space-restricted applications. The financing profile, with interest rates, is as follows: $3 million in stock sales at 15% per year, $4 million in bonds at 9%, and $6 million in retained earnings at 7% per year.

10.14 Growth Transgenics Enterprises (GTE) is contemplating the purchase of its rival. One of GTE's genetics engineers got interested in the financing strategy of the buyout. He learned there are two plans being considered. Plan 1 requires 50% equity funds from GTE's retained earnings that currently earn 9% per year, with the balance borrowed externally at 6%, based on the company's excellent stock rating. Plan 2 requires only 20% equity funds with the balance borrowed at a higher rate of 8% per year.

(*a*) Which plan has the lower average cost of capital?

(*b*) If GTE's owners decide that the current corporate WACC of 8.2% will not be exceeded, what is the maximum cost of debt capital allowed for each plan? Are these rates higher or lower than the current estimates?

10.15 Midac Corporation wants to arrange for $50 million in capital to finance the manufacturing of a new consumer product. The current plan is 60% equity capital and 40% debt financing. Calculate the WACC for the following scenario:

Equity capital: 60%, or $35 million, via common stock sales for 40% of this amount that will pay dividends at a rate of 5% per year, and the remaining 60% from retained earnings, which currently earn 9% per year.

Debt capital: 40%, or $15 million, obtained through two sources—bank loans for $10 million borrowed at 8% per year, and the remainder in convertible bonds at an estimated 10% per year bond dividend rate.

10.16 A public corporation in which you own common stock reported a WACC of 11.1% for the year in its report to stockholders. The common stock that you own has averaged a total return of 7% per year over the last 3 years. The annual report also mentions that projects within the corporation are 75% funded by its own capital. Estimate the company's cost of debt capital.

10.17 BASF will invest $14 million this year to upgrade its ethylene glycol processes. This chemical is used to produce polyester resins to manufacture products varying from construction materials to aircraft, and from luggage to home appliances. Equity capital costs 14.5% per year and will supply 65% of the capital funds. Debt capital costs 10% per year before taxes. The effective tax rate for BASF is 36%.

(*a*) Determine the amount of annual revenue after taxes that is consumed in covering the interest on the project's initial cost.

(*b*) If the corporation does not want to use 65% of its own funds, the financing plan may include 75% debt capital. Determine the amount of annual revenue needed to cover the interest with this plan, and explain the effect it may have on the corporation's ability to borrow in the future.

10.18 A couple planning for their child's college education can fund part of or all the expected $100,000 tuition cost from their own funds (through an education IRA) or borrow all or part of it. The average return for their own funds is 7% per year, but the loan is expected to have a higher interest rate as the loan amount increases. Use a spreadsheet to generate a plot of the WACC curve with the estimated loan interest rates below and determine the best D-E mix for the couple.

Loan Amount, $	Interest Rate, % per year
10,000	5.0
30,000	6.0
50,000	8.0
60,000	9.0
75,000	11.0
100,000	13.0

tonozdayim.com/@Zedeleyici31

10.19 Over the last few years, Carol's Fashion Store, a statewide franchise, has experienced the D-E mixes and costs of debt and equity capital on several projects summarized below.
(*a*) Plot debt, equity, and weighted average cost of capital.
(*b*) Determine what mix of debt and equity capital provided the lowest WACC.

	Debt capital		Equity capital	
Project	Percent	Rate	Percent	Rate
A	100%	14.5%		
B	70	13.0	30%	7.8%
C	65	12.0	35	7.8
D	50	11.5	50	7.9
E	35	9.9	65	9.8
F	20	12.4	80	12.5
G			100	12.5

10.20 For Problem 10.19, use a spreadsheet to (*a*) determine the best D-E mix and (*b*) determine the best D-E mix if the cost of debt capital increases by 10% per year, for example, 13.0% increases to 14.3%.

Cost of Debt Capital

10.21 The cash flow plan associated with a debt financing transaction allowed a company to receive $2,800,000 now in lieu of future interest payments of $196,000 per year for 10 years plus a lump sum of $2,800,000 in year 10. If the company's effective tax rate is 33%, determine the company's cost of debt capital (*a*) before taxes and (*b*) after taxes.

10.22 A company that makes several different types of skateboards, Jennings Outdoors, incurred interest expenses of $1,200,000 per year from various types of debt financing. The company borrowed $19,000,000 in year 0 and repaid the principal of the loans in year 15 in a lump-sum payment of $20,000,000. If the company's effective tax rate is 29%, what was the company's cost of debt capital (*a*) before taxes and (*b*) after taxes?

10.23 Molex Inc., a manufacturer of cable assemblies for polycrystalline photovoltaic solar modules, requires $3.1 million in debt capital. The company plans to sell 15-year bonds that carry a dividend of 6% per year, payable semiannually. Molex has an effective tax rate of 32% per year. Determine (*a*) the nominal annual after-tax cost of debt capital and (*b*) the effective annual after-tax cost of debt capital.

10.24 Tri-States Gas Producers expects to borrow $800,000 for field engineering improvements. Two methods of debt financing are possible—borrow it all from a bank or issue debenture bonds. The company will pay an effective 8% per year to the bank for 8 years. The principal on the loan will be reduced uniformly over the 8 years, with the remainder of each annual payment going toward interest. The bond issue will be for 800 10-year bonds of $1000 each that require a 6% per year dividend payment.
(*a*) Which method of financing is cheaper after an effective tax rate of 40% is considered?
(*b*) Which is the cheaper method using a before-tax analysis?

10.25 The Sullivan Family Partnership plans to purchase a refurbished condo in their hometown for investment purposes. The negotiated $200,000 purchase price will be financed with 20% of savings (retained earnings) which consistently makes 6.5% per year after all relevant income taxes are paid. Eighty percent will be borrowed at a before-tax rate of 9% per year for 15 years with the principal repaid in equal annual installments. If the effective tax rate is 22% per year, based only on these data, answer the following.
(*a*) What is the partnership's annual loan payment for each of the 15 years?
(*b*) What is the net present worth difference between the $200,000 now and the PW of the cost of the 80–20 D-E mix series of cash flows necessary to finance the purchase? What does this PW value mean?
(*c*) What is the after-tax WACC for this purchase?

Cost of Equity Capital

10.26 Determine the cost of equity capital to Hy-Lok USA if the company sells 500,000 shares of its preferred stock at a 5% discount from its price of $130. The stock carries a $10 per year dividend.

10.27 The initial public offering price for the common stock of SW Refining is $23 per share, and it will pay a first-year dividend of $0.92 per share. If the appreciation rate in dividends is anticipated to be 3.2% per year, determine the cost of equity capital for the stock offering.

10.28 The cost of debt capital is lower after taxes than before taxes. The cost of equity capital is more difficult to estimate using the dividend method or the CAPM model, for example, yet the after-tax and before-tax cost of equity capital is the same. Why are the after-tax rates not the same for both types of financing?

10.29 H2W Technologies is considering raising capital to expand its offerings of 2-phase and 4-phase

tonozdayim.com/@Zedeleyici31

linear stepper motors. The beta value for its stock is 1.41. Use the capital asset pricing model and a 3.8% premium above the risk-free return to determine the cost of equity capital if the risk-free return is 3.2%.

10.30 Management at Hirschman Engineering has asked you to determine the cost of equity capital based on the company's common stock. The company wants you to use two methods: the dividend method and the CAPM. Last year, the first year for dividends, the stock paid $0.75 per share on the average of $11.50 on the New York Stock Exchange. Management hopes to grow the dividend rate at 3% per year. Hirschman Engineering stock has a volatility that is higher than the norm at 1.3. If safe investments are returning 5.5% and the 3% growth on common stocks is also the premium above the risk-free investments that Hirschman Engineering plans to pay, calculate the cost of equity capital using the two methods.

10.31 Common stocks issued by Meggitt Sensing Systems paid stockholders $0.93 per share on an average price of $18.80 last year. The company expects to grow the dividend rate at a maximum of 1.5% per year. The stock volatility is 1.19, and other stocks in the same industry are paying an average of 4.95% per year dividend. U.S Treasury bills are returning 4.5%. Determine the company's cost of equity capital last year using (*a*) the dividend method and (*b*) the CAPM.

10.32 Last year a Japanese engineering materials corporation, Yamachi Inc., purchased some U.S. Treasury bonds that return an average of 4% per year. Now, Euro bonds are being purchased with a realized average return of 3.9% per year. The volatility factor of Yamachi stock last year was 1.10 and has increased this year to 1.18. Other publicly traded stocks in this same business are paying an average of 5.1% dividends per year. Determine the cost of equity capital for each year, and explain why the increase or decrease seems to have occurred.

10.33 The engineering manager at FXO Plastics wants to complete an alternative evaluation study. She asked the finance manager for the corporate MARR. The finance manager gave her some data on the project and stated that all projects must clear their average (pooled) cost by at least 4%.

Funds Source	Amount, $	Average Cost, %
Retained earnings	4,000,000	7.4
Stock sales	6,000,000	4.8
Long-term loans	5,000,000	9.8

(*a*) Use the data to determine the minimum MARR.

(*b*) The study is after taxes and part (*a*) provided the before-tax MARR. Determine the correct MARR to use if the tax rate was 32% last year and the finance manager meant that the 4% above the cost is for after-tax evaluations.

Different D-E Mixes

10.34 Why is it financially unhealthy for an individual to maintain a large percentage of debt financing over a long time, that is, to be highly leveraged?

10.35 In a leveraged buyout of one company by another, the purchasing company usually obtains borrowed money and inserts as little of its own equity as possible into the purchase. Explain some circumstances under which such a buyout may put the purchasing company at economic risk.

10.36 Grainger and Company has an opportunity to invest $500,000 in a new line of direct-drive rotary screw compressors. Financing will be equally split between common stock ($250,000) and a loan with an 8% after-tax interest rate. The estimated annual NCF after taxes is $48,000 for the next 7 years. The effective tax rate is 50%. Grainger uses the capital asset pricing model for evaluation of its common stock. Recent analysis shows that it has a volatility rating of 0.95 and is paying a premium of 5% above a safe return on its common stock. Nationally, the safest investment is currently paying 3% per year. Is the investment financially attractive if Grainger uses as the MARR its (*a*) equity cost of capital and (*b*) WACC?

10.37 Fairmont Industries primarily relies on 100% equity financing to fund projects. A good opportunity is available that will require $250,000 in capital. The Fairmont owner can supply the money from personal investments that currently earn an average of 7.5% per year. The annual net cash flow from the project is estimated at $30,000 for the next 15 years. Alternatively, 60% of the required amount can be borrowed for 15 years at 7% per year. If the MARR is the WACC, determine which plan, if either, should be undertaken. This is a before-tax analysis.

10.38 Omega Engineering Inc. has an opportunity to invest $10,000,000 in a new engineering remote control system for offshore drilling platforms. Financing will be split between common stock sales ($5,000,000) and a loan with an 8% per year interest rate. Omega's share of the annual net cash flow is estimated to be $1.35 million for each of the next 5 years. Omega is about to initiate CAPM as

tonozdayim.com/@Zedeleyici31

its common stock evaluation model. Recent analysis shows that it has a volatility rating of 1.22 and is paying a premium of 5% on its common stock dividend. The U.S. Treasury bills are currently paying 4% per year. Is the venture financially attractive if the MARR equals (*a*) the cost of equity capital and (*b*) the WACC?

10.39 A new annular die process is to be installed for extruding pipes, tubes, and tubular films. The phase I installed price for the dies and machinery is $2,000,000. The manufacturer has not decided how to finance the system. The WACC over the last 5 years has averaged 10% per year.

(*a*) Two financing alternatives have been defined. The first requires an investment of 40% equity funds at 9% and a loan for the balance at an interest rate of 10% per year. The second alternative requires only 25% equity funds and the balance borrowed at 10.5% per year. Which approach will result in the smaller average cost of capital?

(*b*) Yesterday, the corporate finance committee decided that the WACC for all new projects must not exceed the 5-year historical average of 10% per year. With this restriction, what is the maximum loan interest rate that can be incurred for each of the financing alternatives?

10.40 Shadowland, a manufacturer of air-freightable pet crates, has identified two projects that, though having a relatively high risk, are expected to move the company into new revenue markets. Utilize a spreadsheet solution to (*a*) select any combination of the projects if the MARR is equal to the after-tax WACC and (*b*) determine if the same projects should be selected if the risk factors are enough to require an additional 2% per year for the investment to be made.

Project	Initial Investment, $	After-Tax Cash Flow, $/Year	Life, Years
Wildlife (W)	−250,000	48,000	10
Reptiles (R)	−125,000	30,000	5

Financing will be developed using a D-E mix of 60–40 with equity funds costing 7.5% per year. Debt financing will be developed from $10,000, 5% per year, paid quarterly, 10-year bonds. The effective tax rate is 30% per year.

10.41 Two friends each invested $20,000 of their own (equity) funds. Stan, being more conservative, purchased utility and manufacturing corporation stocks. Theresa, being a risk taker, *leveraged* the $20,000 and purchased a $100,000 condo for rental property. Considering no taxes, dividends, or revenues, analyze these two purchases by doing the following for one year after the funds were invested.

(*a*) Determine the year-end values of their equity funds if there was a 10% *increase* in the value of the stocks and the condo.

(*b*) Determine the year-end values of their equity funds if there was a 10% *decrease* in the value of the stocks and the condo.

(*c*) Use your results to explain why *leverage* can be financially risky.

Multiple, Noneconomic Attributes

10.42 In multiple attribute analysis, if three different alternatives are to be evaluated on the basis of eight attributes that are considered of equal importance, what is the weight of each attribute?

10.43 A consulting engineer asked a company manager to assign importance values (0 to 100) to five attributes that will be included in an alternative evaluation process. Determine the weight of each attribute using the importance scores.

Attribute	Importance Score
1. Safety	60
2. Cost	40
3. Impact	80
4. Environmental	30
5. Acceptability	20

10.44 Ten attributes were rank-ordered in terms of increasing importance and were identified as A, B, C, . . . , and J. Determine the weight of (*a*) attribute C and (*b*) attribute J.

10.45 A team of three people submitted the following statements about the attributes to be used in a weighted attribute evaluation. Use the statements to determine the normalized weights if assigned scores are between 0 and 100.

Attribute	Comment
1. Flexibility (F)	The most important factor
2. Safety (S)	70% as important as uptime
3. Uptime (U)	One-half as important as flexibility
4. Rate of return (R)	Twice as important as safety

10.46 Different types and capacities of crawler hoes are being considered for use in a major excavation on a pipe-laying project. Several supervisors who served on similar projects in the past have identified some of the attributes and their view of relative importance. For the information that follows, determine the weighted rank order, using a 0-to-10 scale and the normalized weights.

tonozdayim.com/@Zedeleyici31

Attribute	Comment
1. Truck versus hoe height	90% as important as trenching speed
2. Type of topsoil	Only 10% of most important attribute
3. Type of subsoil	30% as important as trenching speed
4. Hoe cycle time	Twice as important as type of subsoil
5. Hoe trenching speed	Most important attribute
6. Pipe laying speed	80% as important as hoe cycle time

10.47 John, who works at Swatch, has decided to use the weighted attribute method to compare three systems for manufacturing a watchband. The vice president and her assistant VP have evaluated each of three attributes in terms of importance to them, and John has placed an evaluation from 0 to 100 on each alternative for the three attributes. John's *ratings* for each alternative are as follows:

	Alternative		
Attribute	1	2	3
Economic return > MARR	50	70	100
High throughput	100	60	30
Low scrap rate	100	40	50

Use the *weights* below to evaluate the alternatives. Are the results the same for both persons' weights? Why?

Importance Score	VP	Assistant VP
Economic return > MARR	20	100
High throughput	80	80
Low scrap rate	100	20

10.48 The Athlete's Shop has evaluated two proposals for weight lifting and exercise equipment. A present worth analysis at $i = 15\%$ per year of estimated revenues and costs resulted in $PW_A = \$440{,}000$ and $PW_B = \$390{,}000$. In addition to this economic measure, three more attributes were independently assigned a relative importance score from 0 to 100 by the shop manager and the lead trainer.

	Importance Score	
Attribute	Manager	Trainer
Economics	80	80
Durability	35	80
Flexibility	30	100
Maintainability	20	50

Separately, you have used the four attributes to rate the two equipment proposals on a scale of 0 to 1.0 as shown in the following table. The economic attribute was rated using the PW values.

Attribute	Proposal A	Proposal B
Economics	1.00	0.90
Durability	0.35	1.00
Flexibility	1.00	0.90
Maintainability	0.25	1.00

Select the better proposal using each of the following methods.
(*a*) Present worth
(*b*) Weighted evaluations of the shop manager
(*c*) Weighted evaluations of the lead trainer

ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

10.49 The term *opportunity cost* refers to:
(*a*) The first cost of an alternative that has been accepted for funding
(*b*) The total cost of an alternative that has been accepted for funding
(*c*) The rate of return or profit available on the next-best alternative that had to be forgone due to lack of capital funds
(*d*) The cost of an alternative that was not recognized as an alternative that actually represented a good opportunity

10.50 The cost of capital is established on the basis of:
(*a*) The cost of debt financing
(*b*) The weighted average of debt and equity financing
(*c*) The cost of equity financing
(*d*) The cost of debt financing plus the expected inflation rate

10.51 All of the following are examples of debt capital except:
(*a*) Retained earnings
(*b*) Long-term bonds
(*c*) Loan from a local bank
(*d*) Purchase of equipment using a credit card

10.52 All of the following are examples of equity capital except:
(*a*) Sale of preferred stock
(*b*) Long-term bonds
(*c*) Company cash on hand
(*d*) Use of retained earnings

tonozdayim.com/@Zedeleyici31

10.53 If a public utility expands its capacity to generate electricity by obtaining $41 million from retained earnings and $30 million from municipal bond sales, the utilities' debt-to-equity mix is closest to:
(*a*) 58% debt and 42% equity
(*b*) 73% debt and 27% equity
(*c*) 27% debt and 73% equity
(*d*) 42% debt and 58% equity

10.54 Gentech, Inc. financed a new product as follows: $5 million in stock sales at 13.7% per year, $2 million in retained earnings at 8.9% per year, and $3 million through convertible bonds at 7.8% per year. The company's WACC is closest to:
(*a*) 9% per year
(*b*) 10% per year
(*c*) 11% per year
(*d*) 12% per year

10.55 If the after-tax rate of return for a cash flow series is 11.2% and the corporate effective tax rate is 39%, the approximated before-tax rate of return is closest to:
(*a*) 6.8%
(*b*) 5.4%
(*c*) 18.4%
(*d*) 28.7%

10.56 Medzyme Pharmaceuticals has maintained a 50-50 D-E mix for capital investments. Equity capital has cost 11%; however, debt capital that historically cost 9% has now increased by 20% per year. If Medzyme does not want to exceed its historical weighted average cost of capital (WACC), and it is forced to go to a D-E mix of 75–25, the maximum acceptable cost of equity capital is closest to:
(*a*) 7.6%
(*b*) 9.2%
(*c*) 9.8%
(*d*) 10.9%

10.57 The importance values (0 to 100) for five attributes are shown below. The weight to assign to attribute 1 is:
(*a*) 0.16
(*b*) 0.20
(*c*) 0.22
(*d*) 0.25

Attribute	Importance Score
1	55
2	45
3	85
4	30
5	60

10.58 For eight attributes rank-ordered in terms of increasing importance, the weighting of the sixth attribute is closest to:
(*a*) 0.17
(*b*) 0.14
(*c*) 0.08
(*d*) 0.03

CASE STUDY

WHICH IS BETTER—DEBT OR EQUITY FINANCING?

Background

Pizza Hut Corporation has decided to enter the catering business in three states within its Southeastern U.S. Division, using the name Pizza Hut At-Your-Place. To deliver the meals and serving personnel, it is about to purchase 200 vans with custom interiors for a total of $1.5 million. Each van is expected to be used for 10 years and have a $1000 salvage value.

A feasibility study completed last year indicated that the At-Your-Place business venture could realize an estimated annual net cash flow of $300,000 before taxes in the three states. After-tax considerations would have to take into account the effective tax rate of 35% paid by Pizza Hut.

An engineer with Pizza Hut's Distribution Division has worked with the corporate finance office to determine how to best develop the $1.5 million capital needed for the purchase of vans. There are two viable financing plans.

Information

Plan A is debt financing for 50% of the capital ($750,000) with the 8% per year compound interest loan repaid over 10 years with uniform year-end payments. (A simplifying assumption that $75,000 of the principal is repaid with each annual payment can be made.)

Plan B is 100% equity capital raised from the sale of $15 per share common stock. The financial manager informed the engineer that stock is paying $0.50 per share in dividends and that this dividend rate has been increasing at an average of 5% each year. This dividend pattern is expected to continue, based on the current financial environment.

Case Study Exercises

1. What values of MARR should the engineer use to determine the better financing plan?

tonozdayim.com/@Zedeleyici31

for each year of ownership can be made, these year-by-year (marginal) costs help determine the best challenger.

The economic service life (ESL) analysis is designed to determine the best challenger's years of service and the resulting lowest total AW of costs. The resulting n_C and AW_C values are used in the replacement study. The same analysis can be performed for the ESL of the defender.

Replacement studies in which no study period (planning horizon) is specified utilize the annual worth method of comparing two unequal-life alternatives. The better AW value determines how long the defender is retained before replacement.

When a study period is specified for the replacement study, it is vital that the market value and cost estimates for the defender be as accurate as possible. When the defender's remaining life is shorter than the study period, it is critical that the cost for continuing service be estimated carefully. All the viable options for using the defender and challenger are enumerated, and their AW equivalent cash flows are determined. For each option, the PW or AW value is used to select the best option. This option determines how long the defender is retained before replacement.

PROBLEMS

Foundations of Replacement

11.1 In a replacement study, what is meant by "taking the nonowner's viewpoint"?

11.2 An asset that was purchased 3 years ago for $100,000 is becoming obsolete faster than expected. The company thought the asset would last 5 years and that its book value would decrease by $20,000 each year and, therefore, be worthless at the end of year 5. In considering a more versatile, more reliable high-tech replacement, the company discovered that the presently owned asset has a market value of only $15,000. If the replacement is purchased immediately at a first cost of $75,000 and if it will have a lower annual worth, what is the amount of the sunk cost? Assume the company's MARR is 15% per year.

11.3 As a muscle car aficionado, a friend of yours likes to restore cars of the 60s and 70s and sell them for a profit. He started his latest project (a 1965 Shelby GT350) four months ago and has a total of $126,000 invested so far. Another opportunity has come up (a 1969 Dodge Charger) that he is thinking of buying because he believes he could sell it for a profit of $60,000 after it is completely restored. To do so, however, he would have to sell the unfinished Shelby first. He thought that the completely restored Shelby would be worth $195,000, resulting in a tidy profit of $22,000, but in its half-restored condition, the most he could get now is $115,000. In discussing the situation with you, he stated that if he could sell the Shelby now and buy the Charger at a reduced price, he would make up for the money he will lose in selling the Shelby at a lower-than-desired price.
(*a*) What is wrong with this thinking?
(*b*) What is his sunk cost in the Shelby?

11.4 In conducting a replacement study wherein the planning horizon is unspecified, list three assumptions that are inherent in an annual worth analysis of the defender and challenger.

11.5 A civil engineer who owns his own design/build/operate company purchased a small crane 3 years ago at a cost of $60,000. At that time, it was expected to be used for 10 years and then traded in for its salvage value of $10,000. Due to increased construction activities, the company would prefer to trade for a new, larger crane now that will cost $80,000. The company estimates that the old crane can be used, if necessary, for another 3 years, at which time it would have a $23,000 estimated market value. Its current market value is estimated to be $39,000, and if it is used for another 3 years, it will have M&O costs (exclusive of operator costs) of $17,000 per year. Determine the values of *P*, *n*, *S*, and AOC that should be used for the existing crane in a replacement analysis.

11.6 Equipment that was purchased by Newport Corporation for making pneumatic vibration isolators cost $90,000 two years ago. It has a market value that can be described by the relation $90,000 − 8000*k*, where *k* is the years from time of purchase. Experience with this type of equipment has shown that the operating cost for the first 4 years is $65,000 per year, after which it increases by $6300 per year. The asset's salvage value was originally estimated to be $7000 after a predicted 10-year useful life. Determine the values of *P*, *S*, and AOC if a replacement study is done (*a*) now and (*b*) 1 year from now.

11.7 A piece of equipment that was purchased 2 years ago by Toshiba Imaging for $50,000 was expected to have a useful life of 5 years with a $5000 salvage

tonozdayim.com/@Zedeleyici31

value. Its performance was less than expected, and it was upgraded for $20,000 one year ago. Increased demand now requires that the equipment be upgraded again for another $17,000 so that it can be used for 3 more years. If upgraded, its annual operating cost will be $27,000 and it will have a $12,000 salvage after 3 years. Alternatively, it can be replaced with new equipment priced at $65,000 with operating costs of $14,000 per year and a salvage value of $23,000 after 6 years. If replaced now, the existing equipment will be sold for $7000. Determine the values of P, S, AOC, and n for the defender in a replacement study.

Economic Service Life

11.8 For equipment that has a first cost of $10,000 and the estimated operating costs and year-end salvage values shown below, determine the economic service life at $i = 10\%$ per year.

Year	Operating Cost, $ per Year	Salvage Value, $
1	−1000	7000
2	−1200	5000
3	−1300	4500
4	−2000	3000
5	−3000	2000

11.9 To improve package tracking at a UPS transfer facility, conveyor equipment was upgraded with RFID sensors at a cost of $345,000. The operating cost is expected to be $148,000 per year for the first 3 years and $210,000 for the next 3 years. The salvage value of the equipment is expected to be $140,000 for the first 3 years, but due to obsolescence, it won't have a significant value after that. At an interest rate of 10% per year, determine

(*a*) The economic service life of the equipment and associated annual worth

(*b*) The percentage increase in the AW of cost if the equipment is retained 2 years longer than the ESL

11.10 Economic service life calculations for an asset are shown below. If an interest rate of 10% per year was used in making the calculations, determine the values of P and S that were used in calculating the AW for year 3.

Years Retained	AW of First Cost, $	AW of Operating Cost, $ per Year	AW of Salvage Value, $
1	−51,700	−15,000	35,000
2	−27,091	−17,000	13,810
3	−18,899	−19,000	6,648
4	−14,827	−21,000	4,309
5	−12,398	−23,000	2,457

11.11 The initial cost of a bridge that is expected to be in place forever is $70 million. Maintenance can be done at 1-, 2-, 3-, or 4-year intervals, but the longer the interval between servicing, the higher the cost. The costs of servicing are estimated at $83,000, $91,000, $125,000, and $183,000 for intervals of 1 through 4 years, respectively. What interval should be scheduled for maintenance to minimize the overall equivalent annual cost? The interest rate is 8% per year.

11.12 A construction company bought a 180,000 metric ton earth sifter at a cost of $65,000. The company expects to keep the equipment a maximum of 7 years. The operating cost is expected to follow the series described by $40{,}000 + 10{,}000k$, where k is the number of years since it was purchased ($k = 1, 2, \ldots, 7$). The salvage value is estimated to be $30,000 for years 1 and 2 and $20,000 for years 3 through 7. At an interest rate of 10% per year, determine the economic service life and the associated equivalent annual cost of the sifter.

11.13 An engineer determined the ESL of a new $80,000 piece of equipment and recorded the calculations shown below. [Note that the numbers are annual worth values associated with various years of retention; that is, if the equipment is kept for, say, 3 years, the AW (years 1 through 3) of the first cost is $32,169, the AW of the operating cost is $51,000, and the AW of the salvage value is $6042.] The engineer forgot to enter the AW of the salvage value for 2 years of retention. From the information available, determine the following:

(*a*) The interest rate used in the ESL calculations.

(*b*) The salvage value after 2 years, if the total AW of the equipment in year 2 was $78,762. Use the interest rate determined in part (*a*).

Years Retained	AW of First Cost, $	AW of Operating Cost, $	AW of Salvage Value, $
1	−88,000	−45,000	50,000
2	−46,095	−46,000	?
3	−32,169	−51,000	6,042

11.14 A large, standby electricity generator in a hospital operating room has a first cost of $70,000 and may be used for a maximum of 6 years. Its salvage value, which decreases by 15% per year, is described by the equation $S = 70{,}000(1 - 0.15)^n$, where n is the number of years after purchase. The operating cost of the generator will be constant at $75,000 per year. At an interest rate of 12% per year, what are the economic service life and the associated AW value?

tonozdayim.com/@Zedeleyici31

11.15 A piece of equipment has a first cost of \$150,000, a maximum useful life of 7 years, and a market (salvage) value described by the relation $S = 120{,}000 - 20{,}000k$, where k is the number of years since it was purchased. The salvage value cannot go below zero. The AOC series is estimated using $AOC = 60{,}000 + 10{,}000k$. The interest rate is 15% per year. Determine the economic service life (*a*) by hand solution, using regular AW computations, and (*b*) by spreadsheet, using annual marginal cost estimates.

11.16 Determine the economic service life and corresponding AW value for a machine that has the following cash flow estimates. Use an interest rate of 14% per year and hand solution.

Year	Salvage Value, \$	Operating Cost, \$ per Year
0	100,000	—
1	75,000	–28,000
2	60,000	–31,000
3	50,000	–34,000
4	40,000	–34,000
5	25,000	–34,000
6	15,000	–45,000
7	0	–49,000

11.17 Use the annual marginal costs to find the economic service life for Problem 11.16 on a spreadsheet. Assume the salvage values are the best estimates of future market value. Develop an Excel chart of annual marginal costs (MC) and AW of MC over 7 years.

11.18 **Keep or Replace the Kiln Case** PE

In Example 11.3, the market value (salvage value) series of the proposed \$38 million replacement kiln (GH) dropped to \$25 million in only 1 year and then retained 75% of the previous year's market value through the remainder of its 12-year expected life. Based on the experience with the current kiln, and the higher-temperature capability of the replacement, the new kiln is actually expected to retain only 50% of the previous year's value starting in year 5. Additionally, the heating element replacement in year 6 will probably cost \$4 million, not \$2 million. And finally, the maintenance costs will be considerably higher as the kiln ages. Starting in year 5, the AOC is expected to increase by 25% per year, not 10% as predicted earlier. The Manager of Critical Equipment is now very concerned that the ESL will be significantly decreased from the 12 years calculated earlier (Example 11.3).

(*a*) Determine the new ESL and associated AW value.

(*b*) In percentage changes, estimate how much these new cost estimates may affect the minimum-cost life and AW of cost estimate.

Replacement Study

11.19 In a one-year-later analysis, what action should be taken if (*a*) all estimates are still current and the year is n_D, (*b*) all estimates are still current and the year is not n_D, and (*c*) the estimates have changed?

11.20 Based on company records of similar equipment, a consulting aerospace engineer at Aerospatiale estimated AW values for a presently owned, highly accurate steel rivet inserter.

If Retained This Number of Years	AW Value, \$ per Year
1	−62,000
2	−51,000
3	−49,000
4	−53,000
5	−70,000

A challenger has ESL = 2 years and AW_C = \$−48,000 per year. (*a*) If the consultant must recommend a replace/retain decision today, should the company keep the defender or purchase the challenger? Why? The MARR is 15% per year. (*b*) When should the next replacement evaluation take place?

11.21 In planning a plant expansion, MedImmune has an economic decision to make—upgrade the existing controlled-environment rooms or purchase new ones. The presently owned ones were purchased 4 years ago for \$250,000. They have a current "quick sale" value of \$20,000, but for an investment of \$100,000 now, they would be adequate for another 4 years, after which they would be sold for \$40,000. Alternatively, new controlled-environment rooms could be purchased at a cost of \$270,000. They are expected to have a 10-year life with a \$50,000 salvage value at that time. Determine whether the company should upgrade or replace. Use a MARR of 20% per year.

11.22 Three years ago, Witt Gas Controls purchased equipment for \$80,000 that was expected to have a useful life of 5 years with a \$9000 salvage value. Increased demand necessitated an upgrade costing \$30,000 one year ago. Technology changes now require that the equipment be upgraded again for another \$25,000 so that it can be used for 3 more years. Its annual operating cost will be \$47,000, and it will have a \$22,000 salvage after 3 years. Alternatively, it can be replaced with new equipment that will cost \$68,000 with operating costs of \$35,000 per year and a salvage value of \$21,000 after 3 years. If replaced now, the existing equipment will be sold for \$9000. Calculate the annual worth of the defender at an interest rate of 10% per year.

tonozdayim.com/@Zedeleyici31

11.23 A recent environmental engineering graduate is trying to decide whether he should keep his presently owned car or purchase a more environmentally friendly hybrid. A new car will cost $26,000 and have annual operation and maintenance costs of $1200 per year with an $8000 salvage value in 5 years (which is its estimated economic service life).

The presently owned car has a resale value *now* of $5000; one year from now it will be $3000, two years from now $2500, and 3 years from now $2200. Its operating cost is expected to be $1900 this year, with costs increasing by $200 per year. The presently owned car will definitely not be kept longer than 3 more years. Assuming used cars like the one presently owned *will always* be available, should the presently owned car be sold now, 1 year from now, 2 years from now, or 3 years from now? Use annual worth calculations at $i = 10\%$ per year and show your work.

11.24 A pulp and paper company is evaluating whether it should retain the current bleaching process that uses chlorine dioxide or replace it with a proprietary "oxypure" process. The relevant information for each process is shown. Use an interest rate of 15% per year to perform the replacement study.

	Current Process	Oxypure Process
Original cost 6 years ago, $	−450,000	—
Investment cost now, $	—	−700,000
Current market value, $	25,000	—
Annual operating cost, $/year	−180,000	−70,000
Salvage value, $	0	50,000
Remaining life, years	5	10

11.25 A machine that is critical to the Phelps-Dodge copper refining operation was purchased 7 years ago for $160,000. Last year a replacement study was performed with the decision to retain it for 3 more years. The situation has changed. The equipment is estimated to have a value of $8000 if "scavenged" for parts now or anytime in the future. If kept in service, it can be minimally upgraded at a cost of $43,000, which will make it usable for up to 2 more years. Its operating cost is expected to be $22,000 the first year and $25,000 the second year. Alternatively, the company can purchase a new system that will have an equivalent annual worth of $−47,063 per year over its ESL. The company uses a MARR of 10% per year. Calculate the relevant annual worth values, and determine when the company should replace the machine.

11.26 A crushing machine that is a basic component of a metal recycling operation is wearing out faster than expected. The machine was purchased 2 years ago for $400,000. At that time, the buyer thought the machine would serve its needs for at least 5 years, at which time the machine would be sold to a smaller independent recycler for $80,000. Now, however, the company thinks the market value of the diminished machine is only $50,000. If it is kept, the machine's operating cost will be $37,000 per year for the next 2 years, after which it will be scrapped for $1000. If it is kept for only 1 year, the market value is estimated to be $10,000. Alternatively, the company can outsource the process now for a fixed cost of $56,000 per year. At an interest rate of 10% per year, should the company continue with the current machine or outsource the process?

11.27 The data associated with operating and maintaining an asset are shown below. The company manager has already decided to keep the machine for 1 more year (i.e., until the end of year 1), but you have been asked to determine the cost of keeping it 1 more year after that. At an interest rate of 10% per year, estimate the AW of keeping the machine from year 1 to year 2.

Year	Market Value, $	Operating Cost, $ per Year
0	30,000	−15,000
1	25,000	−15,000
2	14,000	−15,000
3	10,000	−15,000

11.28 A machine that cost $120,000 three years ago can be sold now for $54,000. Its market value for the next 2 years is expected to be $40,000 and $20,000 one year and 2 years from now, respectively. Its operating cost was $18,000 for the first 3 years of its life, but the M&O cost is expected to be $23,000 for the next 2 years. A new improved machine that can be purchased for $138,000 will have an economic life of 5 years, an operating cost of $9000 per year, and a salvage value of $32,000 after 5 years. At an interest rate of 10% per year, determine if the presently owned machine should be replaced now, 1 year from now, or 2 years from now.

11.29 The projected market value and M&O costs associated with a presently owned machine are shown (next page). An outside vendor of services has offered to provide the service of the existing machine at a fixed price per year. If the presently owned machine is replaced now, the cost of the fixed-price contract will be $33,000 for each of the next 3 years. If the presently owned machine is

tonozdayim.com/@Zedeleyici31

replaced next year or the year after that, the contract price will be $35,000 per year. Determine if and when the defender should be replaced with the outside vendor using an interest rate of 10% per year. Assume used equipment similar to the defender will always be available.

Year	Market Value, $	M&O Cost, $ per Year
0	30,000	—
1	25,000	−24,000
2	14,000	−25,000
3	10,000	−26,000
4	8,000	—

11.30 BioHealth, a biodevice systems leasing company, is considering a new equipment purchase to replace a currently owned asset that was purchased 2 years ago for $250,000. It is appraised at a current market value of only $50,000. An upgrade is possible for $200,000 now that would be adequate for another 3 years of lease rights, after which the entire system could be sold on the international circuit for an estimated $40,000. The challenger, which can be purchased for $300,000, has an expected life of 10 years and a $50,000 salvage value. Determine whether the company should upgrade or replace at a MARR of 12% per year. Assume the AOC estimates are the same for both alternatives.

11.31 For the estimates in Problem 11.30, use a spreadsheet-based analysis to determine the first cost for the augmentation of the current system that will make the defender and challenger break even. Is this a maximum or minimum for the upgrade, if the current system is to be retained?

11.32 Herald Richter and Associates, 5 years ago, purchased for $45,000 a microwave signal graphical plotter for corrosion detection in concrete structures. It is expected to have the market values and annual operating costs shown below for its remaining useful life of up to 3 years. It could be traded now at an appraised market value of $8000.

Year	Market Value at End of Year, $	AOC, $ per Year
1	6000	–50,000
2	4000	–53,000
3	1000	–60,000

A replacement plotter with new Internet-based, digital technology costing $125,000 has an estimated $10,000 salvage value after its 5-year life and an AOC of $31,000 per year. At an interest rate of 15% per year, determine how many more years Richter should retain the present plotter. Solve (*a*) by hand and (*b*) by using a spreadsheet.

11.33 In the opportunity cost approach to replacement analysis, what does the *opportunity* refer to?

11.34 State what is meant by the *cash flow approach* to replacement analysis, and list two reasons why it is not a good idea to use this method.

Replacement Study over a Specified Study Period

11.35 ABB Communications is considering replacing equipment that had a first cost of $300,000 five years ago. The company CEO wants to know if the equipment should be replaced now or at any other time over the next 3 years to minimize the cost of producing miniature background suppression sensors. Since the present equipment or the proposed equipment can be used for any or all of the 3-year period, one of the company's industrial engineers produced AW cost information for the defender and challenger as shown below. The values represent the annual costs of the respective equipment if used for the indicated number of years. Determine when the defender should be replaced to minimize the cost to ABB for the 3-year study period using an interest rate of 10% per year.

Number of Years Kept	AW If Kept Stated Number of Years, $ per Year	
	Defender	Challenger
1	−22,000	−29,000
2	−24,000	−26,000
3	−27,000	−25,000

11.36 The table below shows present worth calculations of the costs associated with using a presently owned machine (defender) and a possible replacement (challenger) for different numbers of years. Determine when the defender should be replaced using an interest rate of 10% per year and a 5-year study period. Show solutions (*a*) by hand and (*b*) by spreadsheet.

Number of Years Kept/Used	PW If Kept/Used Stated Number of Years, $	
	Defender	Challenger
1	−36,000	−89,000
2	−75,000	−96,000
3	−125,000	−102,000
4	−166,000	−113,000
5	−217,000	−149,000

11.37 Nano Technologies intends to use the newest and finest equipment in its labs. Accordingly, a senior engineer has recommended that a 2-year-old piece

tonozdayim.com/@Zedeleyici31

of precision measurement equipment be replaced immediately. This engineer believes it can be shown that the proposed equipment is economically advantageous at a 10% per year return and a planning horizon of 3 years.

(*a*) Perform the replacement analysis using the annual worth method for a specified 3-year study period.

(*b*) Determine the challenger's capital recovery amount for the 3-year study period and the expected full life. Comment on the effect made by the 3-year study period.

	Current	Proposed
Original purchase price, $	−30,000	−40,000
Current market value, $	17,000	—
Remaining life, years	5	15
Estimated value in 3 years, $	9,000	20,000
Salvage value after 15 years, $	—	5,000
Annual operating cost, $ per year	−8,000	−3,000

11.38 An industrial engineer at a fiber-optic manufacturing company is considering two robots to reduce costs in a production line. Robot X will have a first cost of $82,000, an annual maintenance and operation (M&O) cost of $30,000, and salvage values of $50,000, $42,000, and $35,000 after 1, 2, and 3 years, respectively. Robot Y will have a first cost of $97,000, an annual M&O cost of $27,000, and salvage values of $60,000, $51,000, and $42,000 after 1, 2, and 3 years, respectively. Which robot should be selected if a 2-year study period is specified at an interest rate of 15% per year and replacement after 1 year is not an option?

11.39 A 3-year-old machine purchased for $140,000 is not able to meet today's market demands. The machine can be upgraded now for $70,000 or sold to a subcontracting company for $40,000. The current machine will have an annual operating cost of $85,000 per year and a $30,000 salvage value in 3 years. If upgraded, the presently owned machine will be retained for only 3 more years, then replaced with a machine to be used in the manufacture of several other product lines. The replacement machine, which will serve the company now and for at least 8 years, will cost $220,000. Its salvage value will be $50,000 for years 1 through 4; $20,000 after 5 years; and $10,000 thereafter. It will have an estimated operating cost of $65,000 per year. You want to perform an economic analysis at 15% per year using a 3-year planning horizon.

(*a*) Should the company replace the presently owned machine now, or do it 3 years from now?

(*b*) Compare the capital recovery requirements for the replacement machine (challenger) over the study period and an expected life of 8 years.

11.40 Two processes can be used for producing a polymer that reduces friction loss in engines. Process K, which is currently in place, has a market value of $165,000 now, an operating cost of $69,000 per year, and a salvage value of $50,000 after 1 more year and $40,000 after its maximum 2-year remaining life. Process L, the challenger, will have a first cost of $230,000, an operating cost of $65,000 per year, and salvage values of $100,000 after 1 year, $70,000 after 2 years, $45,000 after 3 years, and $26,000 after its maximum expected 4-year life. The company's MARR is 12% per year. You have been asked to determine which process to select when (*a*) a 2-year study period is used and (*b*) a 3-year study period is used.

11.41 Keep or Replace the Kiln Case



In Example 11.8, the in-place kiln and replacement kiln (GH) were evaluated using a fixed study period of 6 years. This is a significantly shortened period compared to the expected 12-year life of the challenger. Use the best estimates available throughout this case to determine the impact on the capital recovery amount for the GH kiln of shortening the evaluation time from 12 to 6 years.

11.42 Nabisco Bakers currently employs staff to operate the equipment used to sterilize much of the mixing, baking, and packaging facilities in a large cookie and cracker manufacturing plant in Iowa. The plant manager, who is dedicated to cutting costs but not sacrificing quality and hygiene, has the projected data shown in the table below if the current system were retained for up to its maximum expected life of 5 years. A contract company has proposed a turnkey sanitation system for $5.0 million per year if Nabisco signs on for 4 to 10 years, and $5.5 million per year for a shorter number of years.

Years Retained	AW, $ per Year	Close-Down Expense, $
0	—	−3,000,000
1	−2,300,000	−2,500,000
2	−2,300,000	−2,000,000
3	−3,000,000	−1,000,000
4	−3,000,000	−1,000,000
5	−3,500,000	−500,000

(*a*) At a MARR = 8% per year, perform a replacement study for the plant manager with a fixed study period of 5 years, when it is anticipated that the plant will be shut down due to the age of the facility and projected technological obsolescence. As you perform the study, take into account that regardless of the number of years that the current sanitation system is retained, a one-time close-down

tonozdayim.com/@Zedeleyici31

cost will be incurred for personnel and equipment during the last year of operation. (*Hint:* Calculate AW values for all combinations of defender/challenger options.)

(*b*) What is the percentage change in the AW amount each year for the 5-year period? If the decision to retain the current sanitation system for all 5 years is made, what is the economic disadvantage in AW compared to that of the most economic retention period?

Replacement Value

11.43 In 2008, Amphenol Industrial purchased a new quality inspection system for $550,000. The estimated salvage value was $50,000 after 8 years. Currently the expected remaining life is 3 years with an AOC of $27,000 per year and an estimated salvage value of $30,000. The new president has recommended early replacement of the system with one that costs $400,000 and has a 5-year economic service life, a $45,000 salvage value, and an estimated AOC of $50,000 per year. If the MARR for the corporation is 12% per year, find the minimum trade-in value now necessary to make the president's replacement economically advantageous.

11.44 A CNC milling machine purchased by Proto Tool and Die 10 years ago for $75,000 can be used for 3 more years. Estimates are an annual operating cost of $63,000 and a salvage value of $25,000. A challenger will cost $130,000 with an economic life of 6 years and an operating cost of $32,000 per year. Its salvage value will be $45,000. On the basis of these estimates, what market value for the existing asset will render the challenger equally attractive? Use an interest rate of 12% per year.

11.45 Hydrochloric acid, which fumes at room temperatures, creates a very corrosive work environment, causing steel tools to rust and equipment to fail prematurely. A distillation system purchased 4 years ago for $80,000 can be used for only 2 more years, at which time it will be scrapped with no value. Its operating cost is $75,000 per year. A more corrosion-resistant challenger will cost $220,000 with an operating cost of $49,000 per year. It is expected to have a $30,000 salvage value after its 6-year ESL. At an interest rate of 10% per year, what minimum replacement value now for the present system will render the challenger attractive?

11.46 Engine oil purifier machines can effectively remove acid, pitch, particles, water, and gas from used oil. Purifier A was purchased 5 years ago for $90,000. Its operating cost is higher than expected, so if it is not replaced now, it will likely be used for only 3 more years. Its operating cost this year will be $140,000, increasing by $2000 per year through the end of its useful life, at which time it will be donated for its recyclable scrap value. A more efficient challenger, purifier B, will cost $150,000 with a $50,000 salvage value after its 8-year ESL. Its operating cost is expected to be $82,000 for year 1, increasing by $500 per year thereafter. What is the market value for A that will make the two purifiers equally attractive at an interest rate of 12% per year?

ADDITIONAL PROBLEMS AND FE EXAM REVIEW QUESTIONS

11.47 In conducting a replacement study, all of the following are correct viewpoints for the analyst except:
(*a*) Consultant's
(*b*) Owner's
(*c*) Outsider's
(*d*) Nonowner's

11.48 A sunk cost is the difference between:
(*a*) The first cost and the salvage value
(*b*) The market value and the salvage value
(*c*) The first cost and the market value
(*d*) The book value and the market value

11.49 A truck was purchased 3 years ago for $45,000 and can be sold today for $24,000. The operating costs are $9000 per year, and it is expected to last 4 more years with a $5000 salvage value. A new truck, which will perform that same service, can be purchased for $50,000, and it will have a life of 10 years with operating costs of $28,000 per year and a $10,000 salvage value. The value that should be used as *P* for the presently owned vehicle in a replacement study is:
(*a*) $45,000
(*b*) $5000
(*c*) $50,000
(*d*) $24,000

11.50 The economic service life of an asset with the PW and AW values on the next page is:
(*a*) 1 year
(*b*) 2 years
(*c*) 3 years
(*d*) 4 years

tonozdayim.com/@Zedeleyici31

Years *n*	Present Worth If Kept *n* Years, $	Annual Worth If Kept *n* Years, $/Year
1	−15,455	−17,000
2	−28,646	−16,286
3	−45,019	−18,102
4	−57,655	−18,188
5	−72,867	−19,222

11.51 In looking for ways to cut costs and increase profit (to make the company's stock go up), one of the company's industrial engineers (IEs) determined that the equivalent annual worth of an existing machine over its remaining useful life of 3 years will be $–70,000 per year. The IE also determined that a replacement with more advanced features will have an AW of $–80,000 per year if it is kept for 2 years or less, $–75,000 if it is kept between 3 and 4 years, and $–65,000 if it is kept for 5 to 10 years. If the engineer uses a 3-year study period and an interest rate of 15% per year, she should recommend that the existing machine be:

(*a*) Replaced now
(*b*) Replaced 1 year from now
(*c*) Replaced 2 years from now
(*d*) Not replaced

11.52 The equivalent annual worth of an existing machine at American Semiconductor is estimated to be $–70,000 per year over its remaining useful life of 3 years. It can be replaced now or later with a machine that will have an AW of $–90,000 per year if it is kept for 2 years or less, –$65,000 if it is kept between 3 and 5 years, and $–110,000 if it is kept for 6 to 8 years. The company wants an analysis of what it should do for a 3-year study period at an interest rate of 15% per year. The replacement must be made now or 3 years from now, according to the department supervisor. You should recommend that the existing machine be replaced:

(*a*) Now
(*b*) 1 year from now
(*c*) 2 years from now
(*d*) Can't tell; must find AW of different retention combinations for the two machines

11.53 The cost characteristics of a CO testing machine at Dytran Instruments are shown below. The cost of a new tester is $100,000. The equation for determining the AW of keeping the tester for 2 years is:

(*a*) $AW = -100{,}000(A/P,i,8) - [42{,}000(P/F,i,1) + 47{,}000(P/F,i,2)](A/P,i,8) + 40{,}000(A/F,i,8)$
(*b*) $AW = -100{,}000(A/P,i,2) - [42{,}000(P/F,i,1) + 47{,}000(P/F,i,2)](A/P,i,2) + 40{,}000(A/F,i,2)$
(*c*) $AW = -100{,}000(A/P,i,2) - 47{,}000 + 40{,}000(A/F,i,2)$
(*d*) $AW = -100{,}000(A/P,i,2) - 42{,}000 + 40{,}000(A/F,i,2)$

Machine Age, Years	M&O Costs, $ per Year	Salvage Value at End of Year, $
1	−42,000	60,000
2	−47,000	40,000
3	−49,000	31,000
4	−50,000	24,000
5	−52,000	15,000
6	−54,000	10,000
7	−63,000	10,000
8	−67,000	10,000

11.54 An engineer with Haliburton calculated the AW values shown for a presently owned machine by using estimates he obtained from the vendor and company records.

Retention Period, Years	AW Value, $ per Year
1	−92,000
2	−81,000
3	−87,000
4	−89,000
5	−95,000

A challenger has an economic service life of 7 years with an AW of $–86,000 per year. Assume that used machines like the one presently owned will always be available and that the MARR is 12% per year. If all future costs remain as estimated for the analysis, the company should purchase the challenger:

(*a*) Now
(*b*) After 2 years
(*c*) After 3 years
(*d*) Never

11.55 The annual worth values for a defender, which can be replaced with a similar used asset, and a challenger are estimated. The defender should be replaced:

(*a*) Now
(*b*) 1 year from now
(*c*) 2 years from now
(*d*) 3 years from now

Number of Years Retained	AW Value, $ per Year	
	Defender	Challenger
1	−14,000	−21,000
2	−13,700	−18,000
3	−16,900	−13,100
4	−17,000	−15,600
5	−18,000	−17,500

tonozdayim.com/@Zedeleyici31