PREFACE

The Instructor's Manual consists of solutions to the problems posed at the end of each chapter. These files are organized by chapter and are available in .pdf format. Microsoft Excel files have also been included for selected problems and can be found in the same directory as the chapter files.

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Solutions to Chapter 1 Problems

1-1 Total profit in 2009 = 100,000,000 × \$0.10 = \$10,000,000. This is an attractive project despite the low profit on each computer − the huge market potential makes it an attractive undertaking.

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1-2 The economic aspects of an engineering project are of equal importance to its physical aspects. It is very important to the engineering profession and the public that the designs for products, structures, systems, and services result in economic consequences acceptable to the user(s). Otherwise, the basic social needs (or wants) will not be satisfied.

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1-3 Some non-monetary factors (attributes) that might be important are:

- Safety
- Reliability (from the viewpoint of user service)
- Quality in terms of consumer expectations
- Aesthetics (how it looks, and so on)
- Patent considerations

1-4 At first glance, Tyler's options seem to be: (1) immediately pay \$803 to the owner of the other person's car or (2) submit a claim to the insurance company. If Tyler keeps his Nissan for five more years (an assumption), the cost of option 2 is (\$803 − \$500) + \$60 × 5 years = \$603. This amount is less than paying \$803 out-of-pocket, so Tyler probably should have submitted an insurance claim. But if his premiums go higher and higher each subsequent year (another assumption!), Tyler ought to pursue option 1.

What we don't know in this problem is the age and condition of the other person's car. If we assume it's a clunker, another option for Tyler is to offer to buy the other person's car and fix it himself and then sell it over the internet. Or Tyler could donate the unrepaired (or repaired) car to his favorite charity.

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1-5 **(a)** 15,000 miles per year / 25 mpg = 600 gallons per year of E20
Savings = 600 gallons per year ($3.00 − $2.55) = $270 per year

(b) Gasoline saved = 0.20 (600 gal/yr)(1,000,000 people) = 120 million gallons per year

1-6 A potential alternative, in order to be selected as a feasible alternative for *detailed* analysis, must be considered capable of achieving the outcomes for the project based on preliminary analysis. The planned outcomes for a project are the goals, objectives, performance criteria, and other results that have been established.

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1-7 Uncertainty refers to the variation of actual values that will occur in the future from the estimated values developed at the time of the study associated with a project. Engineering economic analysis is prospective in that it deals with the analysis of the estimated future consequences of alternative courses of action. Thus, uncertainty is inherently involved. Some causes of uncertainty are:

- Rapid changes in the demand for products and services.
- Inflation and price changes.
- Changes in technology.
- Competition in the world marketplace.
- Changes in regulatory requirements.
- Lack of an adequate costing base (data) for a new project.

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1-8 Increased lifetime earnings of a college graduate = $1,200,000(0.75) = $900,000

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1-9 Strategy 1: Change oil every 3,000 miles. Cost = (15,000/3,000)($30) = $150 / year
Strategy 2: Change oil every 5,000 miles. Cost = (15,000/5,000)($30) = $90 / year

Savings = $60 per year

1-10 **(a)** Assume that the MTBF and the average cost per repair are known or can be developed from historical data for the existing equipment. Then, if no changes were made in the replacement item that affects the average cost per repair the impact of the improvement in the MTBF can be estimated in the monetary unit (e.g. dollars) directly based on the 40% change in the MTBF only. Specifically, the maintenance cost under these circumstances would be estimated to be 40% less.

(b) Estimating the economic consequences of this improvement in the product will take close cooperation between engineering design, marketing, purchasing, production and other functions within the organization. The impact of these changes can be developed by estimating the increase in production cost, deciding upon any changes in product prices, estimating changes in sales (revenues) that will result from the improved product, and then estimating the change in the net income of the organization.

(c) This situation deals with two basic tasks. These tasks are developing feasible alternatives for improved discharge levels that the company believes will maintain a "good neighbor" policy and estimating the costs associated with each alternative. Once these tasks are completed, a typical decision situation exists and the monetary consequences will be defined by the alternative selected.

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1-11 The relationship between engineering economic analysis and engineering design is characterized by its integrated nature. As indicated in Figure 1-1, each of the first six activities of the analysis procedure has information transfer with one or two of the six activities in the design process. Information from the design process activities is used in doing the steps of the analysis procedure, particularly for procedure Steps 1 and 2. Similarly, the economic results of the procedure Steps 3, 4 and 5 are an integral part of the design process Activity 4. Likewise, the preferred alternative based on the economic aspects of the situation (Activity 6) is critical to the selection and specification of the preferred design alternative (Activity 5). Iteration within the analysis procedure steps occurs in conjunction with any iteration in the design process activities.

1-12 **(a)** Problem: To find the least expensive method for setting up capacity to produce drill bits.

(b) Assumptions: The revenue per unit will be the same for either machine; startup costs are negligible; breakdowns are not frequent; previous employee's data are correct; drill bits are manufactured the same way regardless of the alternative chosen; in-house technicians can modify the old machine so its life span will match that of the new machine; neither machine has any resale value; there is no union to lobby for in-house work; etc.

(c) Alternatives: (1) Modify the old machine for producing the new drill bit (using in-house technicians); (2) Buy a new machine for $450,000; (3) Get McDonald Inc. to modify the machine; (4) Outsource the work to another company.

(d) Criterion: Least cost in dollars for the anticipated production runs, given that quality and delivery time are essentially unaffected (i.e., not compromised).

(e) Risks: The old machine could be less reliable than a new one; the old machine could cause environmental hazards; fixing the old machine in-house could prove to be unsatisfactory; the old machine could be less safe than a new one; etc.

(f) Non-monetary Considerations: Safety; environmental concerns; quality/reliability differences; "flexibility" of a new machine; job security for in-house work; image to outside companies by having a new technology (machine); etc.

(g) Post Audit: Did either machine (or outsourcing) fail to deliver high quality product on time? Were maintenance costs of the machines acceptable? Did the total production costs allow an acceptable profit to be made?

1-13 **(a)** Problem A: Subject to time, grade point average and energy that Mary is willing/able to exert, Problem A might be "How can Mary survive the senior year and graduate during the coming year (earn a college degree)?"

Problem B: Subject to knowledge of the job market, mobility and professional ambition, Mary's Problem B could be "How can I use my brother's entry-level job as a spring board into a higher-paying position with a career advancement opportunity (maybe no college degree)?"

(b) Problem A - Some feasible solutions for Problem A would include:

(1) Get a loan from her brother and take fewer courses per term, possibly graduating in the summer.

(2) Quit partying and devote her extra time and limited funds to the task of graduating in the spring term (maybe Mary could get a scholarship to help with tuition, room and board).

Problem B - Some feasible solutions for Problem B would include:

(1) Work for her brother and take over the company to enable him to start another entrepreneurial venture.

(2) Work part-time for her brother and continue to take courses over the next couple of years in order to graduate.

(3) Work for her brother for one or two semesters to build up funds for her senior year. While interviewing, bring up the real life working experience and request a higher starting salary.

1-14 A Typical Discussion/Solution:

(a) One problem involves how to satisfy the hunger of three students -- assume a piping hot delicious pizza will satisfy this need. (Another problem is to learn enough about Engineering Economy to pass -- or better yet earn an "A" or a "B" -- on the final examination and ace the course. Maybe a pizza will solve this problem too?) Let's use "hunger satisfaction with a pizza" as the problem/need definition.

(b) *Principle 1 - Develop the Alternatives*

i) Alternative A is to order a pizza from "Pick-Up Sticks"
ii) Alternative B is to order a pizza from "Fred's"

Other options probably exist but we'll stick to these two alternatives

Principle 2 - Focus on the Differences
Difference in delivery time could be an issue. A perceived difference in the quality of the ingredients used to make the pizza could be another factor to consider. We'll concentrate our attention on cost differences in part (c) to follow.

Principle 3 - Use a Consistent Viewpoint
Consider your problem from the perspective of three customers wanting to get a good deal. Does it make sense to buy a pizza having a crust that your dog enjoys, or ordering a pizza from a shop that employs only college students? Use the customer's point of view in this situation rather than that of the owner of the pizza shop or the driver of the delivery vehicle.

Principle 4 - Use a Common Unit of Measure
Most people use "dollars" as one of the most important measures for examining differences between alternatives. In deciding which pizza to order, we'll use a cost-based metric in part (c).

Principle 5 - Consider All Relevant Criteria
Factors other than cost may affect the decision about which pizza to order. For example, variety and quality of toppings and delivery time may be extremely important to your choice. Dynamics of group decision making may also introduce various "political" considerations into the final selection (can you name a couple?)

Principle 6 - Make Uncertainty Explicit
The variability in quality of the pizza, its delivery time and even its price should be carefully examined in making your selection. (Advertised prices are often valid under special conditions -- call first to check on this!)

Principle 7 - Revisit Your Decision
After you've consumed your pizza and returned to studying for the final exam, were you pleased with the taste of the toppings? On the downside, was the crust like cardboard? You'll keep these sorts of things in mind (good and bad) when you order your next pizza!

1-14 ***continued***

(c) Finally some numbers to crunch -- don't forget to list any key assumptions that underpin your analysis to minimize the cost per unit volume (Principles 1, 2, 3, 4 and 6 are integral to this comparison)

Assumptions: (i) weight is directly proportional to volume (to avoid a "meringue" pizza with lots of fluff but meager substance), (ii) you and your study companions will eat the entire pizza (avoids variable amounts of discarded leftovers and hence difficult-to-predict cost of cubic inch consumed) and (iii) data provided in the Example Problem are accurate (the numbers have been confirmed by phone calls).

Analysis:

<u>Alternative A "Pick-Up-Sticks"</u>
Volume = 20″ x 20″ x 1 ¼″ = 500 in.^{3}
Total Cost = \$15 (1.05) + \$1.50 = \$17.25
Cost per in.^{3} = \$0.035

<u>Alternative B "Fred's"</u>
Volume = (3.1416)(10″)^2 (1.75″) = 550 in.^{3}
Total Cost = \$17.25 (1.05) = \$18.11
Cost per in.^{3} = \$0.033

Therefore, order the pizza from "Fred's" to minimize total cost per cubic inch.

(d) Typical other criteria you and your friends could consider are: (i) cost per square inch of pizza (select "Pick-Up-Sticks"), (ii) minimize total cost regardless of area or volume (select "Pick-Up-Sticks"), and (iii) "Fred's" can deliver in 30 minutes but "Pick-Up-Sticks" cannot deliver for one hour because one of their ovens is not working properly (select "Fred's").

1-15 Definition of Need

Some homeowners need to determine (confirm) whether a storm door could fix their problem. If yes, install a storm door. If it will not basically solve the problem, proceed with the problem formulation activity.

Problem Formulation

The homeowner's problem seems to be one of heat loss and/or aesthetic appearance of their house. Hence, one problem formulation could be:

> "To find different alternatives to prevent heat loss from the house."

Alternatives

- Caulking of windows
- Weather stripping
- Better heating equipment
- Install a storm door
- More insulation in the walls, ceiling, etc. of the house
- Various combinations of the above

1-16 *STEP 1—Define the Problem*: Your basic problem is that you need transportation. Further evaluation leads to the elimination of walking, riding a bicycle, and taking a bus as feasible alternatives.

STEP 2—Develop Your Alternatives (Principle 1 is used here.): Your problem has been reduced to either replacing or repairing your automobile. The alternatives would appear to be

1. Sell the wrecked car for $2,000 to the wholesaler and spend this money, the $1,000 insurance check, and all of your $7,000 savings account on a newer car. The total amount paid out of your savings account is $7,000, and the car will have 28,000 miles of prior use.
2. Spend the $1,000 insurance check and $1,000 of savings to fix the car. The total amount paid out of your savings is $1,000, and the car will have 58,000 miles of prior use.
3. Spend the $1,000 insurance check and $1,000 of your savings to fix the car and then sell the car for $4,500. Spend the $4,500 plus $5,500 of additional savings to buy the newer car. The total amount paid out of savings is $6,500, and the car will have 28,000 miles.
4. Give the car to a part-time mechanic, who will repair it for $1,100 ($1,000 insurance and $100 of your savings), but will take an additional month of repair time. You will also have to rent a car for that time at $400/month (paid out of savings). The total amount paid out of savings is $500, and the car will have 58,000 miles on the odometer.
5. Same as Alternative 4, but you then sell the car for $4,500 and use this money plus $5,500 of additional savings to buy the newer car. The total amount paid out of savings is $6,000, and the newer car will have 28,000 miles of prior use.

ASSUMPTIONS:

1. The less reliable repair shop in Alternatives 4 and 5 will not take longer than one extra month to repair the car.
2. Each car will perform at a satisfactory operating condition (as it was originally intended) and will provide the same total mileage before being sold or salvaged.
3. Interest earned on money remaining in savings is negligible.

STEP 3—Estimate the Cash Flows for Each Alternative (Principle 2 should be adhered to in this step.)

1. Alternative 1 varies from all others because the car is not to be repaired at all but merely sold. This eliminates the benefit of the $500 increase in the value of the car when it is repaired and then sold. Also this alternative leaves no money in your savings account. There is a cash flow of −$8,000 to gain a newer car valued at $10,000.
2. Alternative 2 varies from Alternative 1 because it allows the old car to be repaired. Alternative 2 differs from Alternatives 4 and 5 because it utilizes a more expensive ($500 more) and less risky repair facility. It also varies from Alternatives 3 and 5 because the car will be kept. The cash flow is −$2,000 and the repaired car can be sold for $4,500.
3. Alternative 3 gains an additional $500 by repairing the car and selling it to buy the same car as in Alternative 1. The cash flow is −$7,500 to gain the newer car valued at $10,000.
4. Alternative 4 uses the same idea as Alternative 2, but involves a less expensive repair shop. The repair shop is more risky in the quality of its end product, but will only cost $1,100 in repairs and $400 in an additional month's rental of a car. The cash flow is −$1,500 to keep the older car valued at $4,500.
5. Alternative 5 is the same as Alternative 4, but gains an additional $500 by selling the repaired car and purchasing a newer car as in Alternatives 1 and 3. The cash flow is −$7,000 to obtain the newer car valued at $10,000.

1-16 ***continued***

STEP 4—Select a Criterion: It is very important to use a consistent viewpoint (Principle 3) and a common unit of measure (Principle 4) in performing this step. The viewpoint in this situation is yours (the owner of the wrecked car).

The value of the car to the owner is its market value (i.e., $10,000 for the newer car and $4,500 for the repaired car). Hence, the dollar is used as the consistent value against which everything is measured. This reduces all decisions to a quantitative level, which can then be reviewed later with qualitative factors that may carry their own dollar value (e.g., how much is low mileage or a reliable repair shop worth?).

STEP 5—Analyze and Compare the Alternatives: Make sure you consider all relevant criteria (Principle 5).

1. Alternative 1 is eliminated, because Alternative 3 gains the same end result and would also provide the car owner with $500 more cash. This is experienced with no change in the risk to the owner. (Car value = $10,000, savings = 0, total worth = $10,000.)
2. Alternative 2 is a good alternative to consider, because it spends the least amount of cash, leaving $6,000 in the bank. Alternative 2 provides the same end result as Alternative 4, but costs $500 more to repair. Therefore, Alternative 2 is eliminated. (Car value = $4,500, savings = $6,000, total worth = $10,500.)
3. Alternative 3 is eliminated, because Alternative 5 also repairs the car but at a lower out-of-savings cost ($500 difference), and both Alternatives 3 and 5 have the same end result of buying the newer car. (Car value = $10,000, savings = $500, total worth = $10,500.)
4. Alternative 4 is a good alternative, because it saves $500 by using a cheaper repair facility, provided that the risk of a poor repair job is judged to be small. (Car value = $4,500, savings = $6,500, total worth = $11,000.)
5. Alternative 5 repairs the car at a lower cost ($500 cheaper) and eliminates the risk of breakdown by selling the car to someone else at an additional $500 gain. (Car value = $10,000, savings = $1,000, total worth = $11,000.)

STEP 6—Select the Best Alternative: When performing this step of the procedure, you should make uncertainty explicit (Principle 6). Among the uncertainties that can be found in this problem, the following are the most relevant to the decision. If the original car is repaired and kept, there is a possibility that it would have a higher frequency of breakdowns (based on personal experience). If a cheaper repair facility is used, the chance of a later breakdown is even greater (based on personal experience). Buying a newer car will use up most of your savings. Also, the newer car purchased may be too expensive, based on the additional price paid (which is at least $6,000/30,000 miles = 20 cents per mile). Finally, the newer car may also have been in an accident and could have a worse repair history than the presently owned car.

Based on the information in all previous steps, *Alternative 5* was actually chosen.

STEP 7—Monitor the Performance of Your Choice

This step goes hand-in-hand with Principle 7 (revisit your decisions). The newer car turned out after being "test driven" for 20,000 miles to be a real beauty. Mileage was great, and no repairs were needed. The systematic process of identifying and analyzing alternative solutions to this problem really paid off!

1-17 Imprudent use of electronic mail, for example, can involve legal issues, confidential financial data, trade secrets, regulatory issues, public relations goofs, etc. These matters are difficult to "dollarize" but add to the $30,000 annual savings cited in the problem. Surfing the web inappropriately can lead to legal prosecution for pornography violations.

1-18 **(a)** Value of metal in collection = (5,000/130 lb)(0.95)($3.50/lb)
+ (5,000/130 lb)(0.05)($1.00/lb) = $129.81

Each penny is worth about 2.6 cents for its metal content. The numismatic value of each coin is most likely much greater. Note: It is illegal to melt down coins.

(b) This answer is left to the individual student. In general, the cost of purchases would go up slightly. The inflation rate would be adversely affected if all purchases were rounded up to the nearest nickel. Additional note: The cost of producing a nickel is almost 10 cents. Maybe the U.S. government should get out of the business of minting coins and turn over the minting operation to privately-owned subcontractors.

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Solutions to Chapter 2 Problems

2-1 Fixed Cost Elements:

- Executive salaries and the related cost of benefits
- Salaries and other expenses associated with operating a legal department
- Operation and maintenance (O&M) expenses for physical facilities (buildings, parking lots, landscaping, etc.)
- Insurance, property taxes, and any license fees
- Other administrative expenses (personnel not directly related to production; copying, duplicating, and graphics support; light vehicle fleet; etc.)
- Interest cost on borrowed capital

Variable Cost Elements:

- Direct labor
- Materials used in the product or service
- Electricity, lubricating and cutting oil, and so on for equipment used to produce a product or deliver a service
- Replacement parts and other maintenance expenses for jigs and fixtures
- Maintenance material and replacement parts for equipment used to produce a product or deliver a service
- The portion of the costs for a support activity (to production or service delivery) that varies with quantity of output (e.g., for central compressed air support: electricity, replacement parts, and other O&M expenses)

2-2

	Fixed	Variable
Raw Materials		X
Direct Labor		X
Supplies		X
Utilities*	X	X
Property Taxes	X	
Administrative Salaries	X	
Payroll Taxes	X	X
Insurance-Building and Equipment	X	
Clerical Salaries	X	
Sales Commissions		X
Rent	X	
Interest on Borrowed Money	X	

* Classification is situation dependent

2-3 (a) $$\# \text{ cows} = \frac{1{,}000{,}000 \text{ miles/year}}{(365 \text{ days/year})(15 \text{ miles/day})} = 182.6 \text{ or } 183 \text{ cows}$$

annual cost = (1,000,000 miles/year)($5 / 60 miles) = $83,333 per year

(b) $$\text{Annual cost of gasoline} = \frac{1{,}000{,}000 \text{ miles/year}}{30 \text{ miles/gallon}}(\$3/\text{gallon}) = \$100{,}000 \text{ per year}$$

It would cost $16,667 more per year to fuel the fleet of cars with gasoline.

2-4

Cost	Site A	Site B
Rent Hauling	= \$5,000 (4)(200,000)(\$1.50) = \$1,200,000	= \$100,000 (3)(200,000)(\$1.50) = \$900,000
Total	\$1,205,000	\$1,000,000

Note that the revenue of \$8.00/yd^3 is independent of the site selected. Thus, we can maximize profit by minimizing total cost. The solid waste site should be located in Site B.

2-5 Stan's asking price of $4,000 is probably too high because the new transmission adds little value to the N.A.D.A. estimate of the car's worth. (Low mileage is a typical consideration that may inflate the N.A.D.A. estimate.) If Stan can get $3,000 for his car, he should accept this offer. Then the $4,000 - $3,000 = $1,000 "loss" on his car is a sunk cost.

2-6 The $97 you spent on a passport is a sunk cost because you cannot get your money back. If you decide to take a trip out of the U.S. at a later date, the passport's cost becomes part of the fixed cost of making the trip (just as the cost of new luggage would be).

2-7 If the value of the re-machining option ($60,000) is reasonably certain, this option should be chosen. Even if the re-machined parts can be sold for only $45,001, this option is attractive. If management is highly risk adverse (they can tolerate little or no risk), the second-hand market is the way to proceed to guarantee $15,000 on the transaction.

2-8 The certainty of making \$200,000 - \$120,000 = \$80,000 net income is not particularly good. If your friend keeps her present job, she is turning away from a risky \$80,000 gain. This "opportunity cost" of \$80,000 balanced in favor of a sure \$60,000 would indicate your friend is risk averse and does not want to work hard as an independent consultant to make an extra \$20,000 next year.

2-9 **(a)** If you purchase a new car, you are turning away from a risky 20% per year return. If you are a risk taker, your opportunity cost is 20%, otherwise; it is 6% per year.

(b) When you invest in the high tech company's common stock, the next best return you've given up is 6% per year. This is your opportunity cost in situation (b).

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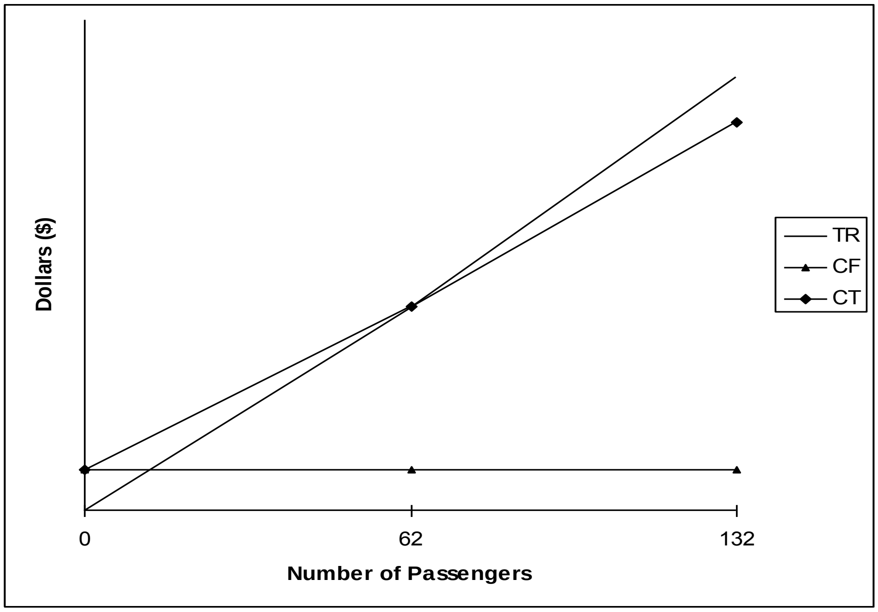
2-10 **(a)** The life cycle cost concept encompasses a time horizon for a product, structure, system, or service from the initial needs assessment to final phaseout and disposal activities. Definition of requirements; conceptual design, advanced development, and prototype testing; detailed design and resource acquisition for production or construction; actual production or construction; and operation and customer use, and maintenance and support are other primary activities involved during the life cycle.

(b) The acquisition phase includes the definitions of requirements as well as the conceptual and detailed design activities. It is during these activities that the future costs to produce (or construct), operate, and maintain a product, structure, system, or service are predetermined. Since these future costs (during the operation phase) are 80-90 percent of the life cycle costs, the greatest potential for lowering life cycle costs is during the acquisition phase (in the definition of requirements and design activities).

2-11 (a)



(b) Fixed costs that could change the BE point from 62 passengers to a lower number include: reduced aircraft insurance costs (by re-negotiating premiums with the existing insurance company or a new company), lower administrative expenses in the front office, increased health insurance costs for the employees (i.e. lowering the cost of the premiums to the airline company) by raising the deductibles on the group policy.

(c) Variable costs that could be reduced to lower the BE point include: no more meals on flights, less external air circulated throughout the cabin, fewer flight attendants. Note: One big cost is fuel, which is fixed for a given flight but variable with air speed. The captain can fly the aircraft at a lower speed to save fuel.

2-12 **(a)** $p = 150 - 0.02D$; $C_F = \$42,000$; $c_V = \$53$/circuit board

$$D^* = \frac{a - c_v}{2b} = \frac{150 - 53}{2(0.02)} = \underline{2,425 \text{ circuit boards/month}}$$

(b) Profit (loss) = Total Revenue - Total Cost

$= 150D - 0.02D^2 - (42,000 + 53D)$

$= 150(2,425) - 0.02(2,425)^2 - 42,000 - 53(2,425)$

$= \underline{\$\ 75,612.50\text{/month}}$ (maximum profit)

(c) Breakeven occurs when profit = 0.

Profit $= 0 = -0.02D^2 + 97D - 42,000$

$= D^2 - 4,850D + 2,100,000$

$$D' = \frac{4,850 \pm \sqrt{(4,850)^2 - 4(2,100,000)}}{2}$$

$D'_1 = 480.6 \approx 481$ circuit boards / month

$D'_2 = 4,369.4 \approx 4,369$ circuit boards / month

(d) The range of profitable demand is 481 to 4,369 circuit boards per month.

2-13 **(a)** Total Revenue = p D = (180 – 5D) D = 180D – $5D^2$
Total Cost = (40D) D = $40D^2$
Total Profit = $-5D^2 + 180D - 40D^2$

$$\frac{d(\text{Profit})}{d\text{D}} = -10\text{D} + 180 - 80\text{D} = 0;\ 90\text{D} = 180;\ \text{D}^* = 2 \text{ units/week}$$

$$\frac{d^2(\text{Profit})}{d\text{D}^2} = -90 < 0 \ \therefore \ \text{maximum profit}$$

(b) Total Profit = $-5(2^2) + 180(2) - 40(2^2)$
= -20 + 360 – 160 = \$180 / week

2-14 **(a)** $p = 600 - 0.05D$; $C_F = \$900{,}000$/month; $c_v = \$131.50$ per unit

The unit demand, D, is one thousand board feet.

$$D^* = \frac{a - c_v}{2b} = \frac{600 - 131.50}{2(0.05)} = \underline{4{,}685 \text{ units/month}} \qquad \text{(Eqn. 2-10)}$$

Profit (loss) = $600D - 0.05D^2 - (900{,}000 + 131.50D)$

$= [600(4{,}685) - 0.05(4{,}685)^2] - [\$900{,}000 + \$131.50(4{,}685)]$

$= \$197{,}461.25$ / month (maximum profit)

(b) $$D' = \frac{468.5 \pm \sqrt{(468.5)^2 - 4(0.05)(9{,}000{,}000)}}{2(0.05)}$$

$$D_1' = \frac{468.5 - 198.73}{0.1} = 2{,}698 \text{ units/month}$$

$$D_2' = \frac{468.5 + 198.73}{0.1} = 6{,}672 \text{ units/month}$$

Range of profitable demand is <u>2,698 units to 6,672 units</u> per month.

2-15 **(a)** $\text{Profit} = \left[38 + \frac{2700}{D} - \frac{5000}{D^2}\right]D - 1000 - 40D$

$= 38D + 2700 - \frac{5000}{D} - 1000 - 40D$

$\text{Profit} = -2D - \frac{5000}{D} + 1700$

$\frac{d(\text{Profit})}{dD} = -2 + \frac{5000}{D^2} = 0$

or, $D^2 = \frac{5000}{2} = 2500$ and $D^* =$ <u>50 units per month</u>

(b) $\frac{d^2(\text{Profit})}{dD^2} = \frac{-10{,}000}{D^3} < 0 \text{ for } D > 1$

Therefore, <u>D^* = 50 is a point of maximum profit</u>.

2-16 Profit = Total revenue - Total cost

$= (15X - 0.2X^2) - (12 + 0.3X + 0.27X^2)$

$= 14.7X - 0.47X^2 - 12$

$$\frac{d\text{Profit}}{dX} = 0 = 14.7 - 0.94X$$

X = <u>15.64 megawatts</u>

Note: $\frac{d^2\text{Profit}}{dX^2} = -0.94$ thus, X = 15.64 megawatts maximizes profit

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2-17 Breakeven point in units of production:

C_F = \$100,000/yr; C_V = \$140,000/yr (70% of capacity)
Sales = \$280,000/yr (70% of capacity); p = \$40/unit
Annual Sales (units) = \$280,000/\$40 = 7,000 units/yr (70% capacity)

c_v = \$140,000/7,000 = \$20/unit

$$D' = \frac{C_F}{p - c_v} = \frac{\$100{,}000}{(\$40 - \$20)} = \underline{5{,}000 \text{ units/yr}}$$

or in terms of capacity, we have: 7,000units/0.7 = x units/1.0

Thus, x (100% capacity) = 7,000/0.7 = 10,000 units/yr

$$D' (\% \text{ of capacity}) = \frac{\$5{,}000}{(10{,}000} = \underline{0.5 \text{ or } 50\% \text{ of capacity}}$$

2-18 C_F = \$504,000 per month; c_v = \$166 per unit; p = \$328 per unit

$$D' = \frac{C_F}{p - c_v} = \frac{\$504{,}000}{(\$328 - \$166)/\text{unit}} = \underline{3{,}112 \text{ pumps per month}}$$

Reduced Costs: C_F at (-18%) = \$504,000 (1 - 0.18) = \$413,280

c_v at (- 6%) = \$166 (1 - 0.06) = \$156.04

$$D' = \frac{\$413{,}280}{(\$328 - \$156.04)/\text{unit}} = \underline{2{,}404 \text{ pumps per month}} \qquad \text{(Eqn. 2-13)}$$

$$\frac{3{,}112 - 2{,}404}{3{,}112} = 0.2275, \text{ or a 22.75\% reduction in the breakeven point.}$$

2-19 **(a)** BE = \$1,000,000 / (\$29.95 – \$20.00) = 100,503 customers per month

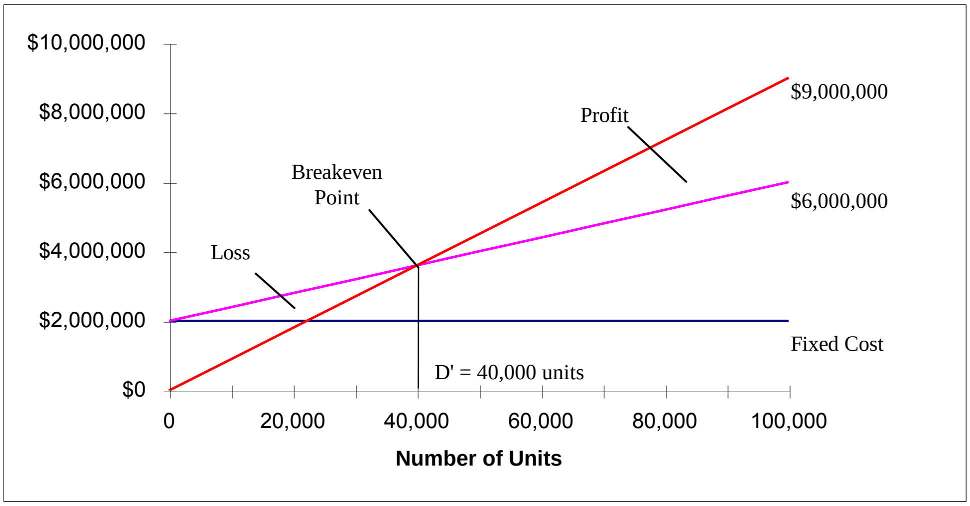
(b) New BE point = \$1,000,000 / (\$39.95 – \$25.00) = 66,890 per month

(c) For 75,000 subscribers per month, profit equals

75,000 (\$39.95 – \$25.00) – \$1,000,000 = \$121,250 per month

This improves on the monthly loss experienced in part (a).

2-20 **(a)** $D' = \dfrac{C_F}{p - c_v} = \dfrac{\$2{,}000{,}000}{(\$90 - \$40)\,/\,\text{unit}} = \underline{40{,}000 \text{ units per year}}$



(b) Profit (Loss) = Total Revenue - Total Cost

(90% Capacity) = 90,000 ($90) - [$2,000,000 + 90,000 ($40)]

= $<u>2,500,000</u> per year

(100% Capacity) = [90,000($90) + 10,000($70)] - [$2,000,000 + 100,000($40)]

= $<u>2,800,000</u> per year

2-21 Annual savings are at least equal to ($60/lb)(600 lb) = $36,000. So the company can spend no more than $36,000 (conservative) and still be economical. Other factors include ease of maintenance / cleaning, passenger comfort and aesthetic appeal of the improvements. Yes, this proposal appears to have merit so it should be supported.

2-22 Jerry's logic is correct if the AC system does not degrade in the next ten years (very unlikely). Because the leak will probably get worse, two or more refrigerant re-charges per year may soon become necessary. Jerry's strategy could be to continue re-charging his AC system until two re-charges are required in a single year. Then he should consider repairing the evaporator (and possibly other faulty parts of his system).

2-23 Over 81,000 miles, the gasoline-only car will consume 2,700 gallons of fuel. The flex-fueled car will use 3,000 gallons of E85. So we have

$$(3{,}000 \text{ gallons})(X) + \$1{,}000 = (2{,}700 \text{ gallons})(\$2.89/\text{gal})$$

and

$$X = \$2.268 \text{ per gallon}$$

This is 21.5% less expensive than gasoline. Can our farmers pull it off – maybe with government subsidies?

2-24 **(a)** Total Annual Cost (TAC) = Fixed cost + Cost of Heat Loss = 450X + 50 + $\frac{4.80}{X^{1/2}}$

$$\frac{d(\text{TAC})}{d\text{X}} = 0 = 450 - \frac{2.40}{X^{3/2}}$$

$$X^{3/2} = \frac{2.40}{450} = 0.00533$$

X^* = <u>0.0305 meters</u>

(b) $$\frac{d^2(\text{TAC})}{d\text{X}^2} = \frac{3.6}{X^{5/2}} > 0 \qquad \text{for } X > 0.$$

Since the second derivative is positive, X^* = 0.0305 meters is a minimum cost thickness.

(c) The cost of the extra insulation (a directly varying cost) is being traded-off against the value of reduction in lost heat (an indirectly varying cost).

2-25 Let X = number of weeks to delay harvesting
and R = total revenue as a function of X

$$R = (1{,}000 \text{ bushels} + 1{,}000 \text{ bushels} \cdot X)(\$3.00/\text{bushel} - \$0.50/\text{bushel} \cdot X)$$

$$R = \$3{,}000 + \$2{,}500X - \$500X^2$$

$$\frac{dR}{dX} = 2{,}500 - 1{,}000X = 0$$

So $X^* = 2.5$ weeks

$$\frac{d^2R}{dX^2} = -1{,}000 \text{ so, we have a stationary point, } X^*, \text{ that is a maximum.}$$

Maximum revenue = $\$3{,}000 + \$2{,}500(2.5) - 500(2.5)^2$ = <u>$6,125</u>

2-26

$$C_T = C_o + C_c = knv^2 + \frac{\$1,500n}{v}$$

$$\frac{dC_T}{dv} = 0 = 2kv - \frac{1,500}{v^2} = kv^3 - 750$$

$$v = \sqrt[3]{\frac{750}{k}}$$

To find k, we know that

$$\frac{C_o}{n} = \$100\text{/mile at v = 12 miles/hr}$$

$$\frac{C_o}{n} = kv^2 = k(12)^2 = 100$$

and

$$k = 100/144 = 0.6944$$

so, $v = \sqrt[3]{\frac{750}{0.6944}} = 10.25 \text{ miles/hr}.$

The ship should be operated at an average velocity of 10.25 mph to minimize the total cost of operation and perishable cargo.

Note: The second derivative of the cost model with respect to velocity is:

$$\frac{d^2C_T}{dv^2} = 1.388n + 3,000\frac{n}{v^3}$$

The value of the second derivative will be greater than 0 for n > 0 and v > 0. Thus we have found a minimum cost velocity.

2-27

	R11	R19	R30	R38
A. Investment cost	\$1,800	\$2,700	\$3,900	\$4,800
B. Annual Heating Load (10^6 Btu/yr)	74	69.8	67.2	66.2
C. Cost of heat loss/yr	\$1,609.50	\$1,518.15	\$1,461.60	\$1,439.85
D. Cost of heat loss over 25 years	\$40,238	\$37,954	\$36,540	\$35,996
E. Total Life Cycle Cost = A + D	\$42,038	\$40,654	\$40,440	\$40,796

R30 is the most economical insulation thickness.

2-28 Solve for k: $C_0/n = kv$ v in miles/hr

$$\frac{1\,\text{gallon}}{18\,\text{miles}} = 1/18 \text{ miles/gal} = k \cdot 70 \text{ miles/hr}; \; k = 1/1260 \text{ hr-gal/mi}^2$$

$$k = 0.000794 \text{ hr-gal/mi}^2$$

$C_G = 0.000794$ hr-gal/mi$^2 \cdot n \cdot v \cdot \$3.00$/gal

$C_{FSS} = n \cdot \$5$/hr $\cdot\, 1/v$

Find C_T

$C_T = \$0.002382$ hr/mi$^2 \cdot v$ mi/hr + \$5/hr $\cdot\, v^{-1}$ hr/mil (\$/mile)

$$\frac{dC_T}{dv} = 0.002382 - 5v^{-2} = 0; \quad 0.002382\, v^2 = 5; \quad v^2 = 2099; \quad v^* = 45.8 \text{ mi/hr}$$

Check $\frac{d^2C_T}{dv^2} = 10v^{-3}$ which is positive for v > 0, so total cost is minimized.

2-29 **(a)** $\dfrac{dC}{d\lambda} = -\dfrac{C_I}{\lambda^2} + C_R t = 0$

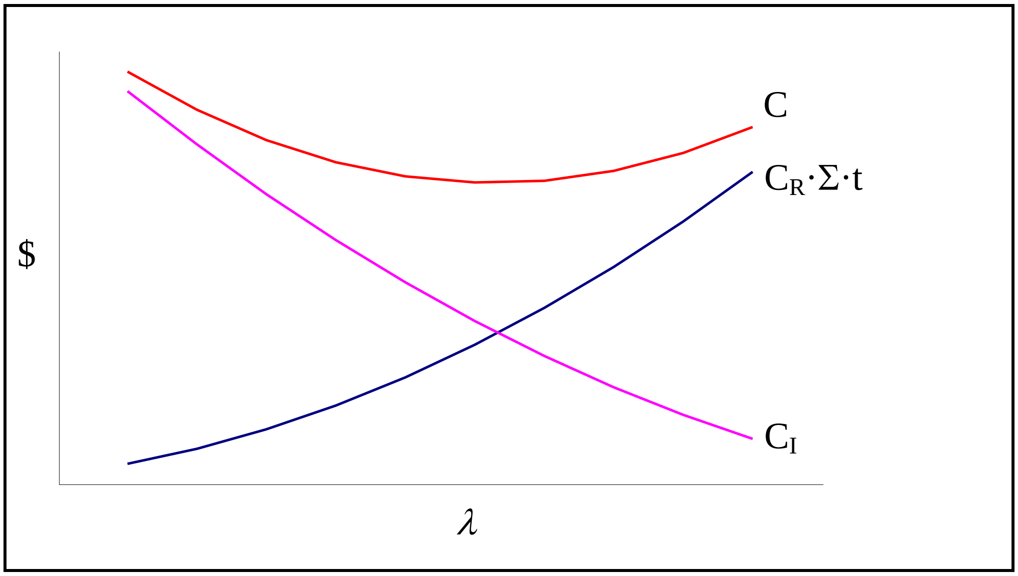
or, $\lambda^2 = C_I/C_R t$

and, $\lambda^* = (C_I/C_R t)^{1/2}$; we are only interested in the positive root.

(b) $\dfrac{d^2C}{d\lambda^2} = \dfrac{2C_I}{\lambda^3} > 0$ for $\lambda > 0$

Therefore, λ^* results in a minimum life-cycle cost value.

(c) Investment cost versus total repair cost



2-30 $\left(\frac{100{,}000}{22\text{ mpg}} - \frac{100{,}000}{28\text{ mpg}}\right)$ (\$3.00/gallon) = \$2,922

Total extra amount = \$2,500 + \$2,922 = <u>\$5,422</u>

Assume the time value of money can be ignored and that comfort and aesthetics are comparable for the two cars.

2-31 **(a)** With Dynolube you will average (20 mpg)(1.01) = 20.2 miles per gallon (a 1% improvement). Over 50,000 miles of driving, you will save

$$\frac{50{,}000\text{ miles}}{20\text{ mpg}} - \frac{50{,}000\text{ miles}}{20.2\text{ mpg}} = 24.75\text{ gallons of gasoline.}$$

This will save (24.75 gallons)($3.00 per gallon) = $74.25.

(b) Yes, the Dynolube is an economically sound choice.

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2-32 The cost of tires containing compressed air is (\$200 / 50,000 miles) = \$0.004 per mile. Similarly, the cost of tires filled with 100% nitrogen is (\$220 / 62,500 miles) = \$0.00352 per mile. On the face of it, this appears to be a good deal if the claims are all true (a big assumption). But recall that air is 78% nitrogen, so this whole thing may be a gimmick to take advantage of a gullible public. At 200,000 miles of driving, one original set of tires and three replacements would be needed for compressed-air tires. One original set and two replacements (close enough) would be required for the 100% nitrogen-filled tires. What other assumptions are being made?

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2-33

Cost Factor	Brass-Copper Alloy	Plastic Molding
Casting / pc	(25 lb)($3.35/lb) = $83.75	(20 lb)($7.40/lb) = $148.00
Machining /pc	$ 6.00	0.00
Weight Penalty / pc	(25 lb - 20 lb)($6/lb) = $30.00	0.00
Total Cost /pc	$119.75	$148.00

The Brass-Copper alloy should be selected to save $148.00 - $119.75 = $28.25 over the life cycle of each radiator.

2-34 **(a)** Machine A

Non-defective units/day = (100 units/hr)(7 hrs/day)(1 - 0.25)(1 - 0.03)
$\approx$ 509 units/day

Note: 3 months = (52 weeks/year)/4 = 13 weeks

Non-defective units/3-months = (13 weeks)(5 days/week)(509 units/day)
= 33,085 units (> 30,000 required)

Machine B

Non-defective units/day = (130 units/hr)(6 hrs/day)(1 - 0.25)(1 - 0.10)
$\approx$ 526 units/day

Non-defective units/3-months = (13 weeks)(5 days/week)(526 units/day)
= 34,190 units (> 30,000 required)

Either machine will produce the required 30,000 non-defective units/3-months

(b) Strategy: Select the machine that minimizes costs per non-defective unit since revenue for 30,000 units over 3-months is not affected by the choice of the machine (Rule 2). Also assume capacity reductions affect material costs but not labor costs.

Machine A

Total cost/day = (100 units/hr)(7 hrs/day)(1 - 0.25)($6/unit)
+ ($15/hr + $5/hr)(7 hrs/day)
= $3,290/day

Cost/non-defective unit = ($3,290/day)/(509 non-defective units/day)
= $6.46/unit

Machine B

Total cost/day = (130 units/hr)(6 hrs/day)(1 - 0.25)($6/unit)
+ ($15/hr + $5/hr)(6 hrs/day)
= $3,630/day

Cost/non-defective unit = ($3,630/day)/(526 non-defective units/day)
= $6.90/unit

Select Machine A.

2-35 Strategy: Select the design which minimizes total cost for 125,000 units/year (Rule 2). Ignore the sunk costs because they do not affect the analysis of future costs.

(a) Design A

Total cost/125,000 units = (16 hrs/1,000 units)($18.60/hr)(125,000)
+ (4.5 hrs/1,000 units)($16.90/hr)(125,000)
= $46,706.25, or $0.37365/unit

Design B

Total cost/125,000 units = (7 hrs/1,000 units)($18.60/hr)(125,000)
+ (12 hrs/1,000 units)($16.90/hr)(125,000)
= $41,625, or $0.333/unit

Select Design B

(b) Savings of Design B over Design A are:

Annual savings (125,000 units) = $46,706.25 - $41,625 = $5081.25

Or, savings/unit = $0.37365 - $0.333 = $0.04065/unit.

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2-36 Profit per day = Revenue per day – Cost per day

= (Production rate)(Production time)($30/part)[1-(% rejected+% tested)/100]

– (Production rate)(Production time)($4/part) – (Production time)($40/hr)

Process 1: Profit per day = (35 parts/hr)(4 hrs/day)($30/part)(1-0.2) –

(35 parts/hr)(4 hrs/day)($4/part) – (4 hrs/day)($40/hr)

= $2640/day

Process 2: Profit per day = (15 parts/hr)(7 hrs/day)($30/part) (1-0.09) –

(15 parts/hr)(7 hrs/day)($4/part) – (7 hrs/day)($40/hr)

= $2155.60/day

Process 1 should be chosen to maximize profit per day.

2-37 At 70 mph your car gets 0.8 (30 mpg) = 24 mpg and at 80 mph it gets 0.6(30 mpg) = 18 mpg. The extra cost of fuel at 80 mph is:

(400 miles/18mpg – 400 miles/24 mpg)($3.00 per gallon) = $16.67

The reduced time to make the trip at 80 mph is about 45 minutes. Is this a good tradeoff in your opinion? What other factors are involved?

2-38 **(a)** Assume a fixed-size production run which is identical for both speeds. Revenue is therefore the same for both speeds. Also assume the decision will be made on economic grounds alone (quality considerations, for example, are not a factor).

Speed A: Cycle Time = 15 hrs. + 1.5 hrs. = 16.5
Tool Cost $1,000/20 = $50 per cycle
Sharpening Cost = $25 per cycle
Tool-Setter $18/hr (1.5 hr./cycle) = $27 per cycle
Operator 16.5 hrs/cycle ($15/hr) = $247.50 per cycle
Variable OH 16.5 hrs/cycle ($25/hr) = $412.50 per cycle

Total Cost per Cycle = $762

$$\text{Cost per Piece} = \frac{\$762/\text{cycle}}{(15\text{ hrs/cycle})(400\text{ pc/hr})}$$

Cost per Piece = $0.127

Speed B: Cycle Time = 10 hrs. + 1.5 hrs. = 11.5
Tool Cost $1,000/20 = $50 per cycle
Sharpening Cost = $25 per cycle
Tool-Setter $18/hr (1.5 hr./cycle) = $27 per cycle
Operator 11.5 hrs/cycle ($15/hr) = $172.50 per cycle
Variable OH 11.5 hrs/cycle ($25/hr) = $287.50 per cycle

Total Cost per Cycle = $562

$$\text{Cost per Piece} = \frac{\$562/\text{cycle}}{(10\text{ hrs/cycle})(540\text{ pc/hr})}$$

Cost per Piece = $0.104 Therefore, select Speed B.

(b) Extra tooling and operating expenses are traded off for extra output (production).

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2-39 Relevant costs: tool cost, grinding cost, tool setter, overhead
Criterion: Minimum cost per piece
Assumption: All output can be used

Cycle = Production time + Tool changing time

Speed A: Cycle = 15 hours + 1.5 hour = 16.5 hours
Number of cycles = 20

Tool cost	= \$500/20 cycles	= \$ 25 / cycle
Grinding	= \$25/cycle	= \$ 25 / cycle
Tool Setter	= (\$8/hr)(1.5 hrs/cycle)	= \$ 12 / cycle
Overhead	= (\$3.75/hr)(16.5 hrs/cycle)	= \$ 61.88 / cycle
		\$123.88 / cycle

$$\text{Cost / piece} = \frac{\$123.88\text{ / cycle}}{(15\text{ hrs/cycle})(400\text{ pc/hr})} = \$0.0206\text{ / piece}$$

Speed B: Cycle = 12 hours + 1.5 hour = 13.5 hours
Number of cycles = 20

Tool cost	= \$500/20 cycles	= \$ 25 / cycle
Grinding	= \$25/cycle	= \$ 25 / cycle
Tool Setter	= (\$8/hr)(1.5 hrs/cycle)	= \$ 12 / cycle
Overhead	= (\$3.75/hr)(13.5 hrs/cycle)	= \$ 50.63 / cycle
		\$ 112.63 / cycle

$$\text{Cost / piece} = \frac{\$112.63\text{ / cycle}}{(12\text{ hrs/cycle})(480\text{ pc/hr})} = \$0.0196\text{ / piece}$$

Speed C: Cycle = 10 hours + 1.5 hour = 11.5 hours
Number of cycles = 20

Tool cost	= \$500/20 cycles	= \$ 25 / cycle
Grinding	= \$25/cycle	= \$ 25 / cycle
Tool Setter	= (\$8/hr)(1.5 hrs/cycle)	= \$ 12 / cycle
Overhead	= (\$3.75/hr)(11.5 hrs/cycle)	= \$ 43.13 / cycle
		\$ 105.13 / cycle

$$\text{Cost / piece} = \frac{\$105.13\text{ / cycle}}{(10\text{ hrs/cycle})(540\text{ pc/hr})} = \$0.0195\text{ / piece}$$

Assuming all else equal (quality, etc.) choose speed C to minimize cost/piece.

2-40 Option A (Purchase):

C_T = (10,000 items)($8.50/item) = $85,000

Option B (Manufacture):

Direct Materials	=	$5.00/item
Direct Labor	=	$1.50/item
Overhead	=	$3.00/item
		$9.50/item

C_T = (10,000 items)($9.50/item) = $95,000

Choose Option A (Purchase Item).

2-41 Assume you cannot stand the anxiety associated with the chance of running out of gasoline if you elect to return the car with no gas in it. Therefore, suppose you leave three gallons in the tank as “insurance” that a tow-truck will not be needed should you run out of gas in an unfamiliar city. The cost (i.e., the security blanket) will be ($2.70 + $0.30 = $3.00) x 3 gallons = $9.00. If you bring back the car with a full tank of gasoline, the extra cost will be $0.30 x the capacity, in gallons, of the tank. Assuming a 15-gallon tank, this option will cost you $4.50. Hence, you will save $9.00 – $4.50 = $4.50 by bringing back the car with a full tank of gasoline.

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2-42 Assumptions: You can sell all the metal that is recovered

Method 1:	Recovered ore	= (0.62)(100,000 tons)	= 62,000 tons
	Removal cost	= (62,000 tons)($23/ton)	= $1,426,000
	Processing cost	= (62,000 tons)($40/ton)	= $2,480,000
	Recovered metal	= (300 lbs/ton)(62,000 tons)	= 18,600,000 lbs
	Revenues	= (18,600,000 lbs)($0.8 / lb)	= $14,880,000

Profit = Revenues - Cost = $14,880,000 - ($1,426,000 + $2,480,000)
= $10,974,000

Method 2:	Recovered ore	= (0.5)(100,000 tons)	= 50,000 tons
	Removal cost	= (50,000 tons)($15/ton)	= $750,000
	Processing cost	= (50,000 tons)($40/ton)	= $2,000,000
	Recovered metal	= (300 lbs/ton)(50,000 tons)	= 15,000,000 lbs
	Revenues	= (15,000,000 lbs)($0.8 / lb)	= $12,000,000

Profit = Revenues - Cost = $12,000,000 - ($750,000 + $2,000,000)
= $9,250,000

Select Method 1 (62% recovered) to maximize total profit from the mine.

2-43 Profit/oz. (Method A) = \$350/oz. - (\$220/t-water)/(0.9 oz./t-water)(0.85)
= \$62.42/oz.

Profit/oz. (Method B) = \$350/oz. - (\$160/t-water)/(0.9 oz./t-water)(0.65)
= \$76.50/oz.

Select <u>Method B</u>

2-44	**(a)** False;	**(d)** False;	**(g)** False;	**(j)** False;	**(m)** True;	**(p)** False;	**(s)** False
	(b) False;	**(e)** True;	**(h)** True;	**(k)** True;	**(n)** True;	**(q)** True;	
	(c) True;	**(f)** True;	**(i)** True;	**(l)** False;	**(o)** True;	**(r)** True;	

2-45 **(a)** $$\text{Loss} = \frac{(1{,}750{,}000\ \text{Btu})\left(\dfrac{\text{lb coal}}{12{,}000\ \text{Btu}}\right)}{0.30} = 486\ \text{lbs of coal}$$

(b) 486 pounds of coal produces (486)(1.83) = 889 pounds of CO_2 in a year.

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2-46 **(a)** Let X = breakeven point in miles
Fuel cost (car dealer option) = (\$2.00/gal)(1 gal/20 miles) = \$0.10/mile
Motor Pool Cost = Car Dealer Cost

$$(\$0.36/\text{mi})\text{X} = (6\text{ days})(\$30/\text{day}) + (\$0.20/\text{mi} + \$0.10/\text{mi})\text{X}$$

$$\$0.36\text{X} = 180 + \$0.30\text{X} \qquad \text{and} \qquad \text{X} = \underline{3{,}000 \text{ miles}}$$

(b) 6 days (100 miles/day) = 600 free miles
If the total driving distance is less than 600 miles, then the breakeven point equation is given by:

(\$0.36/mi)X = (6 days)(\$30 /day) + (\$0.10/mi)X
X = 692.3 miles > 600 miles

This is outside of the range [0, 600], thus renting from State Tech Motor Pool is best for distances less than 600 miles.

If driving more than 600 miles, then the breakeven point can be determined using the following equation:

(\$0.36/mi)X = (6 days)(\$30 /day) + (\$0.20/mi)(X - 600 mi) + (\$0.10/mi)X

X = <u>1,000 miles</u>   The true breakeven point is 1000 miles.

(c) The car dealer was correct in stating that there is a breakeven point at 750 miles. If driving less than 900 miles, the breakeven point is:

(\$0.34/mi)X = (6 days)(\$30 /day) + (\$0.10/mi)X
X = 750 miles < 900 miles

However, if driving more than 900 miles, there is another breakeven point.

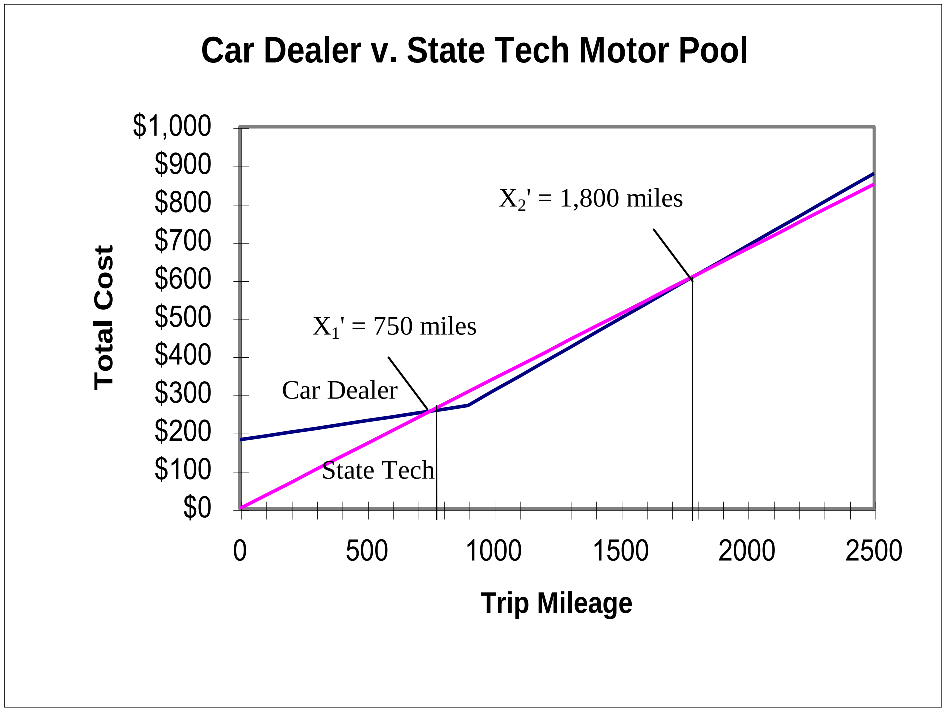
(\$0.34/mi)X = (6 days)(\$30/day) + (\$0.28/mi)(X-900 mi) + (\$0.10/mi)X

X = 1800 miles > 900 miles

The car dealer is correct, but only if the group travels in the range between 750 miles and 1,800 miles. Since the group is traveling more than 1,800 miles, it is better for them to rent from State Tech Motor Pool.

This problem is unique in that there are two breakeven points. The following graph shows the two points.

2-46 ***continued***



2-47 This problem is location specific. We'll assume the problem setting is in Tennessee. The eight years ($2,400 / $300) to recover the initial investment in the stove is expensive (i.e. excessive) by traditional measures. But the annual cost savings could increase due to inflation. Taking pride in being "green" is one factor that may affect the homeowner's decision to purchase a corn-burning stove.

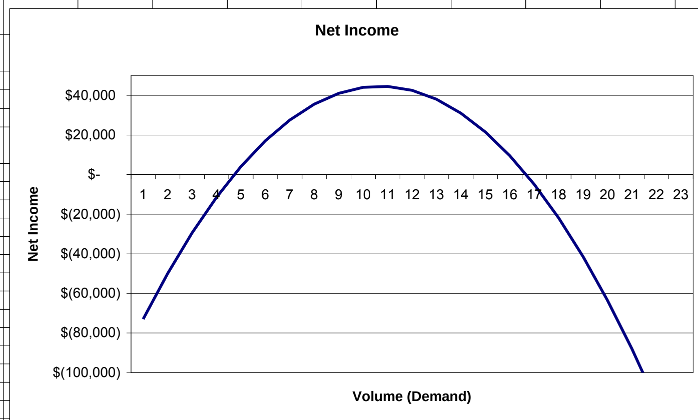
Solutions to Spreadsheet Exercises

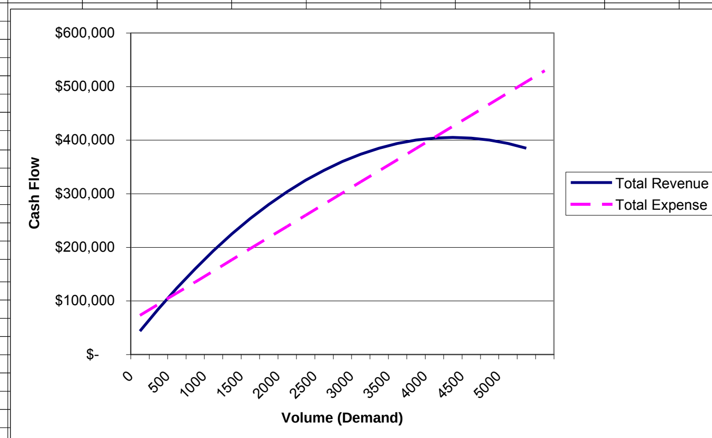
2-48

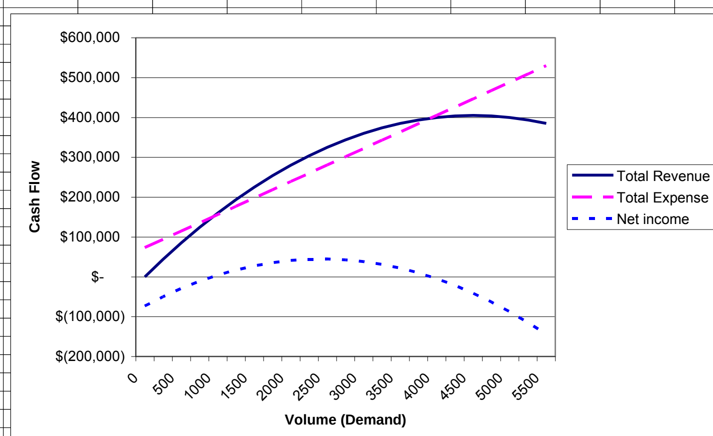
	A	B	C	D	E
1	Fixed cost/ mo. =	$ 73,000		Demand Start point (D) =	0
2	Variable cost/unit =	$ 83		Demand Increment =	250
3	a =	$ 180			
4	b =	$ 0.02			
5					
6	Monthly Demand	Price per Unit	Total Revenue	Total Expense	Net income
7	0	$ 180	$ -	$ 73,000	$ (73,000)
8	250	$ 175	$ 43,750	$ 93,750	$ (50,000)
9	500	$ 170	$ 85,000	$ 114,500	$ (29,500)
10	750	$ 165	$ 123,750	$ 135,250	$ (11,500)
11	1000	$ 160	$ 160,000	$ 156,000	$ 4,000
12	1250	$ 155	$ 193,750	$ 176,750	$ 17,000
13	1500	$ 150	$ 225,000	$ 197,500	$ 27,500
14	1750	$ 145	$ 253,750	$ 218,250	$ 35,500
15	2000	$ 140	$ 280,000	$ 239,000	$ 41,000
16	2250	$ 135	$ 303,750	$ 259,750	$ 44,000
17	2500	$ 130	$ 325,000	$ 280,500	$ 44,500
18	2750	$ 125	$ 343,750	$ 301,250	$ 42,500
19	3000	$ 120	$ 360,000	$ 322,000	$ 38,000
20	3250	$ 115	$ 373,750	$ 342,750	$ 31,000
21	3500	$ 110	$ 385,000	$ 363,500	$ 21,500
22	3750	$ 105	$ 393,750	$ 384,250	$ 9,500
23	4000	$ 100	$ 400,000	$ 405,000	$ (5,000)
24	4250	$ 95	$ 403,750	$ 425,750	$ (22,000)
25	4500	$ 90	$ 405,000	$ 446,500	$ (41,500)
26	4750	$ 85	$ 403,750	$ 467,250	$ (63,500)
27	5000	$ 80	$ 400,000	$ 488,000	$ (88,000)
28	5250	$ 75	$ 393,750	$ 508,750	$ (115,000)
29	5500	$ 70	$ 385,000	$ 529,500	$ (144,500)

Summary of impact of changes in cost components on optimum demand and profitable range of demand.

Percent Change				
C_F	c_v	D*	D_1'	D_2'
-10%	-10%	2,633	724	4541
0%	-10%	2,633	824	4443
10%	-10%	2,633	928	4339
-10%	0%	2,425	816	4036
0%	0%	2,425	932	3918
10%	0%	2,425	1060	3790
-10%	10%	2,218	940	3495
0%	10%	2,218	1092	3343
10%	10%	2,218	1268	3167







Reducing fixed costs has no impact on the optimum demand value, but does broaden the profitable range of demand. Reducing variable costs increase the optimum demand value as well as the range of profitable demand.

2-49

Value Increase =	$ 0.10	Speed =	**5,000**	**6,000**
New Blade	$ 45.00	Sharpen Interval =	2.0	1.5
Sharpening Cost	$ 10.00	bd-ft/hr =	1,000	1,200
Change Over (hrs.)	0.25			
Blade Life (cycles)	8			
Shift Length (hrs.)	8	bd.-ft. required =	unlimited	

Speed	**5,000**	**6,000**
Output/cycle	2,000	1,800
Number of cycles	3.56	4.57
Resharpening Cost =	$ 35.56	$ 45.71
Blade Cost =	$ 20.00	$ 25.71

Speed	**5,000**	**6,000**
Value Added	$ 711.11	$ 822.86
Total Expense	$ 55.56	$ 71.43
Net Profit/day	$ 655.56	$ 751.43

The new blade is not a good deal. The 10% reduction in the cost of the blade does not compensate for the 20% reduction in blade life.

2-50

Value Increase =	$ 0.10		Speed =	**5,000**	**6,000**
New Blade	$ 50.00		Sharpen Interval =	2.0	1.5
Sharpening Cost	$ 10.00		bd-ft/hr =	1,000	1,200
Change Over (hrs.)	0.25				
Blade Life (cycles)	10				
Shift Length (hrs.)	8		bd.-ft. required =	100,000	

Speed	**5,000**	**6,000**
Output/cycle	2,000	1,800
Number of cycles	50.00	55.56
Resharpening Cost =	$ 500.00	$ 555.56
Blade Cost =	$ 250.00	$ 277.78

Speed	**5,000**	**6,000**
Total Expense	$ 750.00	$ 833.33
Cost per bd-ft	$ 0.0075	$ 0.0083

Operating the planer at 6,000 ft/min reduces the life of the blade, resulting in higher overall resharpening cost and blade cost, regardless of the job size. If these are the only factors considered, it will always be more economical to operate at 5,000 ft/min for a limited job size.

The benefit of operating at 6,000 ft/min is a reduction in the <u>time</u> required to complete the job. If the assumption that the operator is idle during any time savings is relaxed, we would see that it is more economical to operate at 6,000 ft/min.

2-51 New annual heating load = (230 days)(72 °F – 46 °F) = 5,980 degree days. Now, 136.7×10^6 Btu are lost with no insulation. The following U-factors were used in determining the new heating load for the various insulation thicknesses.

	U-factor	Heating Load
R11	0.2940	101.3×10^6 Btu
R19	0.2773	95.5×10^6 Btu
R30	0.2670	92×10^6 Btu
R38	0.2630	90.6×10^6 Btu

	\$/kWhr	\$/10^6 Btu
Energy Cost	\$0.086	\$25.20

	R11	R19	R30	R38
Investment Cost	\$ 900	\$ 1,350	\$ 1,950	\$ 2,400
Annual Heating Load (10^6 Btu)	101.3	95.5	92	90.6
Cost of Heat Loss/yr	\$2,553	\$2,406	\$2,318	\$2,283
Cost of Heat Loss over 25 years	\$63,814	\$60,160	\$57,955	\$57,073
Total Life Cycle Cost	\$64,714	\$61,510	\$59,905	\$59,473

Solutions to Case Study Exercises

2-52 In this problem we observe that "an ounce of prevention is worth a pound of cure." The ounce of prevention is the total annual cost of daylight use of headlights, and the pound of cure is postponement of an auto accident because of continuous use of headlights. Clearly, we desire to postpone an accident forever for a very small cost.

The key factors in the case study are the cost of an auto accident and the frequency of an auto accident. By avoiding an accident, a driver "saves" its cost. In postponing an accident for as long as possible, the "annual cost" of an accident is reduced, which is a good thing. So as the cost of an accident increases, for example, a driver can afford to spend more money each year to prevent it from happening through continuous use of headlights. Similarly, as the acceptable frequency of an accident is lowered, the total annual cost of prevention (daytime use of headlights) can also decrease, perhaps by purchasing less expensive headlights or driving less mileage each year.

Based on the assumptions given in the case study, the cost of fuel has a modest impact on the cost of continuous use of headlights. The same can be said for fuel efficiency. If a vehicle gets only 15 miles to the gallon of fuel, the total annual cost would increase by about 65%. This would then reduce the acceptable value of an accident to "at least one accident being avoided during the next 16 years." To increase this value to a more acceptable level, we would need to reduce the cost of fuel, for instance. Many other scenarios can be developed.

2-53 Suppose my local car dealer tells me that it costs no more than \$0.03 per gallon of fuel to drive with my headlights on all the time. For the case study, this amounts to (500 gallons of fuel per year) x \$0.03 per gallon = \$15 per year. So the cost effectiveness of continuous use of headlights is roughly six times better than for the situation in the case study.

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Solutions to FE Practice Problems

2-54 $p = 400 - D^2$

$TR = p \cdot D = (400 - D^2)\, D = 400D - D^3$

$TC = \$1125 + \$100 \cdot D$

Total Profit / month = $TR - TC = 400D - D^3 - \$1125 - \$100D$

$= -D^3 + 300D - 1125$

$\dfrac{d\text{TP}}{dD} = -3D^2 + 300 = 0 \;\rightarrow\; D^2 = 100 \;\rightarrow\; D^* = \underline{10 \text{ units}}$

$\dfrac{d^2\text{TP}}{dD^2} = -6D$; at $D = D^*$, $\dfrac{d^2\text{TP}}{dD^2} = -60$

Negative, therefore maximizes profit.

<u>Select (a)</u>

2-55 $-D^3 + 300D - 1125 = 0$ for breakeven

At <u>D = 15 units;</u> $-15^3 + 300(15) - 1125 = 0$

<u>Select (b)</u>

2-56 C_F = \$100,000 + \$20,000 = \$120,000 per year
C_V = \$15 + \$10 = \$25 per unit
p = \$40 per unit

$$D' = \frac{C_F}{p - c_v} = \frac{\$120{,}000}{(\$40 - \$25)} = \underline{8{,}000 \text{ units/yr}}$$

Select (c)

2-57 Profit = $pD - (C_F + C_V D)$

At D = 10,000 units/yr,

Profit/yr = (40)(10,000) – [120,000 + (25)(10,000)] = $\underline{\$30,000}$

Select (e)

2-58 Profit = $pD - (C_F + C_V D)$

$60{,}000 = 35D - (120{,}000 + 25D)$

$180{,}000 = 10D$; D = <u>18,000 units/yr</u>

<u>Select (d)</u>

2-59

Castings produced/hr.	100	200	300	400	500
Total revenue/hr. Total cost/hr.	\$2,000 1,000	\$3,400 2,600	\$4,800 3,200	\$6,000 3,900	\$7,250 4,700
Profit/hr.	\$1,000	\$ 800	\$1,600	\$2,100	\$2,550*

Therefore, produce <u>500</u> castings per hour. <u>Select (e)</u>

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2-60 Savings in first year = (7,900,000 chips) (0.01 min/chip) (1 hr/60 min) ($8/hr + 5.50/hr) = $17,775

<u>Select (d)</u>

Solutions to Problems in Appendix

2-A-1 **(a)** Details of transactions

(a) Smith invested $35,000 cash to start the business.
(b) Purchased $350 of office supplies on account.
(c) Paid $30,000 to acquire land as a future building site.
(d) Earned service revenue and received cash of $1,900.
(e) Paid $100 on account.
(f) Paid for a personal vacation, which is not a transaction of the business.
(g) Paid cash expenses for rent, $400, and utilities, $100.
(h) Sold office supplies for cost of $150.
(i) Withdrew $1,200 cash for personal use.

Analysis of Transactions:

	ASSETS						LIABILITIES		OWNER'S EQUITY	Type of Owner's Equity Transaction
	Cash	+	Office Supplies	+	Land		Payable	+	Capital	
(a)	+35,000								+35,000	Owner investment
(b)			+ 350				+ 350			
(c)	−30,000				+30,000					
(d)	+ 1,900								+1,900	Service revenue
(e)	− 100					=	− 100			
(f)	Not a									
(g)	− 400								−400	Rent expense
	− 100								−100	Utilities expense
(h)	+ 150		− 150							
(i)	− 1,200								−1,200	Owner withdrawal
Bal.	5,250		200		30,000		250		35,200	
			35,450					35,450		

(b) Financial Statements of Campus Apartments Locators

Income Statement
Month Ended July 31, 2007

Revenue:		
Service revenue ……………………………………………………….		$1,900
Expenses:		
Rent expense …………………………………………………………	$400	
Utilities expense ……………………………………………………	100	
Total expenses ……………………………………………………...		500
Net income ……………………………………………………………………		$1,400

2-A-1 *continued*

Statement of Owner's Equity
Month Ended July 31, 2007

Jill Smith, capital, July 1, 2007 ………………………………………………		$ 0
Add:	Investment by owner …………………………………………………	35,000
	Net income for the month ……………………………………………	1,400
		36,400
Less:	Withdrawals by owner ……………………………………………….	(1,200)
Jill Smith, capital, July 31, 2007 …………………………………………….		$35,200

Balance Sheet
July 31,2007

Assets		Liabilities	
Cash ……………………….	$5,250	Accounts payable ………..………..	$ 250
Office supplies ……………	200		
Land ………………………	30,000	Owner's Equity	
		Jill Smith, capital …………………….	35,200
Total assets ……………….	35,450	Total liabilities and owner's equity …………………..	$35,450

Req. 1

Peavy Design

Analysis of Transactions

	ASSETS				= LIABILITIES +	OWNER'S EQUITY	
DATE	CASH +	ACCOUNTS RECEIVABLE +	SUPPLIES +	LAND =	ACCOUNTS PAYABLE +	DANIEL PEAVY, CAPITAL	TYPE OF OWNER'S EQUITY TRANSACTION
Bal.	1,720	3,240		24,100	5,400	23,660	
a)	12,000					12,000	Owner investment
Bal.	13,720	3,240		24,100	5,400	35,660	
b)	(5,400)				(5,400)		
Bal.	8,320	3,240		24,100	-0-	35,660	
c)	1,100					1,100	Service revenue
Bal.	9,420	3,240		24,100		36,760	
d)	750	(750)					
Bal.	10,170	2,490		24,100		36,760	
e)			720		720		
Bal.	10,170	2,490	720	24,100	720	36,760	
f)		5,000				5,000	Service revenue
Bal.	10,170	7,490	720	24,100	720	41,760	
g)	1,700					1,700	Owner investment
Bal.	11,870	7,490	720	24,100	720	43,460	
h)	(1,200)					(1,200)	Rent expense
	(660)					(660)	Advertising expense
Bal.	10,010	7,490	720	24,100	720	41,600	
i)	80		(80)				
Bal.	10,090	7,490	640	24,100	720	41,600	
j)	(4,000)					(4,000)	Owner withdrawal
Bal.	6,090	7,490	640	24,100	720	37,600	

$\underbrace{6{,}090 + 7{,}490 + 640 + 24{,}100}_{38,320}$ $\qquad$ $\underbrace{720 + 37{,}600}_{38,320}$

Req. 2

Peavy Design		
Income Statement		
Month Ended May 31, 20X5		
Revenues:		
Service revenue ($1,100 + $5,000)		$6,100
Expenses:		
Rent expense	$1,200	
Advertising expense	660	
Total expenses		1,860
Net income		$4,240

Req. 3

Peavy Design	
Statement of Owner's Equity	
Month Ended May 31, 20X5	
Daniel Peavy, capital, April 30, 20X5	$23,660
Add: Investments by owner ($12,000 + $1,700)	13,700
Net income for the month	4,240
	41,600
Less: Withdrawals by owner	(4,000)
Daniel Peavy, capital, May 31, 20X5	$37,600

Req. 4

Peavy Design			
Balance Sheet			
May 31, 20X5			
ASSETS		LIABILITIES	
Cash	$ 6,090	Accounts payable	$ 720
Accounts receivable	7,490		
Supplies	640	OWNER'S EQUITY	
Land	24,100	Daniel Peavy, capital	37,600
		Total liabilities and	
Total assets	$38,320	owner's equity	$38,320

2-A-3 1. Overhead

Compensation for non-chargeable time, 0.15 x \$3,600,000	\$ 540,000
Other costs	1,449,000

(a) Total overhead	\$1,989,000
(b) Direct labor, 0.85 x \$3,600,000	\$3,060,000

Overhead application rate, (a) ÷ (b)	65%

2. Hourly rate:

\$60,000 ÷ (48 x 40) = \$60,000 ÷ 1,920	\$31.25

Many students will forget that “his work there” includes an overhead application:

Direct labor, 10 x \$31.25	\$312.50
Applied overhead, \$312.50 x 0.65	203.13

Total costs applied	\$515.63

We point out that direct-labor time on a job is usually compiled for all classes of engineers and then applied at their different compensation rates. Overhead is usually not applied on the piecemeal basis demonstrated here. Instead, it is applied in one step after all the labor costs of the job have been accumulated.

Solutions To Chapter 3 Problems

3-1 Left as an individual exercise by each student. One possible solution:

At a typical household, the cost of washing and drying a 12 pound load of laundry would include: water ($0.40), detergent ($0.25), washing machine – dryer equipment ($1.50), electric power ($0.75), and floor space ($0.10). This totals $3.00 for a load of laundry.

Ask your students to fine tune these numbers. Also ask them to comment on the statement that "your time is worth nothing unless you have an opportunity to use your time elsewhere" while your washer and dryer are busy. Why not add $5 for your labor?

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3-2 A representative cost and revenue structure for construction, 10-years of ownership and use, and the sale of a home is:

Cost or Revenue Category	Typical Cost and Revenue Elements
Captial Investment	Real estate (lot) cost; architect/engineering fees; construction costs (labor,material, other); working capital (tools, initial operating supplies, etc.); landscaping costs.
Annual Operating and Maintenance Costs	Utilities (electricity, water, gas, telephone, garbage); cable TV; painting (interior and exterior); yard upkeep (labor and materials); routine maintenance (furnace, air conditioner, hot water heater, etc.); insurance; taxes.
Major Repair or Replacement Costs	Roof; furnace; air conditioner; plumbing fixtures; garage door opener; driveway and sidewalks; patio; and so on.
Real Estate Fees	Acquisition; selling.
Asset Sales	Sale of home (year 10).

3-3 Left as an individual exercise by each student. One possible solution:

The cost of an oil and filter change would be approximately: five quarts of oil ($5.50), oil filter ($4.75), labor ($4.00), and building / equipment ($3.00). This totals $17.75. The actual cost of an oil and filter change is around $20, which leaves a profit of $2.25 for the service station owner. This is a markup of 12.7% by the station. The station will make even more money when you need new wiper blades, a replacement tail-light, new fan belts, and so on. The $20 oil change turns into a $75 visit fairly quickly. Does this sound familiar?

Ask the students to supply other items to the "shopping list" of add-ons above.

3-4 **(a)** (62 million tons per year) (0.05) = 3.1 million tons of greenhouse gas per year

$$\frac{\$1.2\text{ billion}}{3.1\text{ million tons per year}} = \$387.10\text{ per ton}$$

(b) (3 billion tons per year) (0.03) = 90 million tons per year

$$\frac{\$1.2\text{ billion}}{3.1\text{ million tons/year}} = \frac{\$X\text{ billion}}{90\text{ million tons}}$$

$$X = \$34.84\text{ billion}$$

3-5 (24,000 ft^2)(60,000 Btu/ft^2) = 1,440 million Btu during the heating season. This is 1,440 thousand cubic feet of natural gas, and the cost would be (1,440,000 ft^3)(\$9/1000 ft^3) = \$12,960 for the heating season.

Side note: The building uses 0.3 million kWhr of electricity × \$0.10 per kWhr = \$30,000 to cool the area. The total bill will be about \$43,000. The owner must take this into account when she decides on a price to charge per square foot of leased space.

3-6 **(a)** Standard electric bill = (400 kWhr)(12 months/year)($0.10/kWhr) = $480 per year.
Green power bill = (12 months/year)($4/month) = $48 per year.
Total electric bill = $528 per year.

(b) $528 / 4,800 kWhr = $0.11 per kWhr (a 10% increase due to green power usage)

(c) The technology used to capture energy from solar, wind power and methane is more expensive than traditional power generation methods (coal, natural gas, and so on).

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3-7 **(a)** Relatively easy to estimate. Contact a real estate firm specializing in commercial property.

(b) Accurate construction cost estimate can be obtained by soliciting bids from local construction contractors engaged in this type of construction.

(c) Working capital costs can be reasonably estimated by carefully planning and identifying the specific needs, and then contacting equipment distributors and other suppliers; estimating local labor rates and company staffing; establishing essential inventory levels; and so on.

(d) Total capital investment can be reasonably estimated from a, b, and c plus the cost of other fixed assets such as major equipment, plus the cost of any consulting or engineering services.

(e) It is not easy to estimate total annual labor and material costs due to the initial uncertainty of sales demand for the product. However, these costs can be controlled since they occur over time and the expenditure can be matched to the demand.

(f) First year revenues for a new product are difficult to estimate. A marketing consultant could be helpful.

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3-8 $C_{2009} = C_{2004}\left(\frac{\bar{I}_{2009}}{\bar{I}_{2004}}\right) \qquad = \$200{,}000\left(\frac{293}{223}\right) = \underline{\$262{,}780.27}$

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3-9 $$\bar{I}_{2008} = \frac{0.70\left(\frac{62}{41}\right)+0.05\left(\frac{57}{38}\right)+0.25\left(\frac{53}{33}\right)}{0.70+0.05+0.25}\times 100 = 153.5$$

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3-10 **(a)** $\bar{I}_{2008} = 0.30(200) + 0.20(175) + 0.50(162) = \underline{176}$

(b) $\bar{I}_{2004} = 0.30(160) + 0.20(145) + 0.50(135) = \underline{144.5}$

$$C_{2008} = \$650{,}000\left(\frac{176}{144.5}\right) = \underline{\$791{,}696}$$

3-11 Let C_A = cost of new boiler, $S_A = 1.42X$

C_B = cost of old boiler, today $S_B = X$

$$C_B = \$181{,}000\left(\frac{221}{162}\right) = \$246{,}920$$

$$C_A = \$246{,}920\left(\frac{1.42X}{X}\right)^{0.8} = \$326{,}879$$

Total cost with options = \$326,879 + \$28,000 = <u>\$354,879</u>

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3-12 The average compound rate of growth is 2.4% per year.

$C_{2008} = C_{2006}[(1+0.24)^2]$ or C_{2008} = \$10.2(1.0486) = \$10.7 million

3-13 **(a)** $C_{now}(80\text{-kW}) = \$160{,}000\left(\frac{194}{187}\right) = \$165{,}989$

$C_{now}(120\text{-kW}) = \$165{,}989\left(\frac{120}{80}\right)^{0.6} = \$211{,}707$

Total Cost = \$211,707 + \$18,000 = <u>\$229,707</u>

(b) $C_{now}(40\text{-kW}) = \$165{,}989\left(\frac{40}{80}\right)^{0.6} = \$109{,}512$

Total Cost = \$109,512 + \$18,000 = <u>\$127,512</u>

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3-14 1 mile = 5,280 feet; 25 miles = 132,000 feet; 50 yards = 150 feet. A light pole is to be installed every 50 yards or every 150 feet. Thus, 132,000 feet/150 feet = 880 light poles need to be installed.

Cost of installing light poles = 880($2,500) = $2,200,000

Total cost = $15,000/mile(25 miles) + $2,200,000 = <u>$2,575,000</u>

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3-15 Material: $(7{,}500\ \text{ft}^2)(\$8.50/\text{lb})(15\ \text{lb/ft}) + (7{,}500\ \text{ft})(\$10/\text{ft}) = \$1{,}031{,}250$
Design and labor: $16,000 + $180,000 = $196,000
Total cost = $1,227,250

3-16 Cost in 10 years = $\left(\frac{2{,}400}{2{,}000}\right)$(400 lbs)(\$3.50/lb)$(1.045)^{10}$ = \$2,609

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3-17 K = 126 hours; s = 0.95 (95% learning curve); n = (log 0.95)/(log 2) = -0.074

(a) $Z_8 = 126(8)^{-0.074}$ = <u>108 hours</u>;

$Z_{50} = 126(50)^{-0.074}$ = <u>94.3 hours</u>

(b) $C_5 = T_5/5$; $T_5 = 126 \sum_{u=1}^{5} u^{-0.074}$ = 587.4 hrs; C_5 = 587.4 / 5 = <u>117.5 hrs</u>

3-18 $K = 1.15X$; $s = 0.90$ (90% learning curve); $n = (\log 0.90)/(\log 2) = -0.152$

$$Z_{30} = 1.15X(30)^{-0.152} = 0.686X$$

After 30 months, a (1 - 0.686) = 31.4% reduction in overhead costs is expected (with respect to the present cost of $X).

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3-19 $Z_3 = 846.2 = K(3)^n$ and $Z_5 = 783.0 = K(5)^n$. So $(846.2/783.0) = (3/5)^n$ and $1.0807 = (0.6)^n$. Furthermore, $\log(1.0807) = n \log(0.6)$. Finally, we get

$$n = \frac{0.03371}{-0.22185} = -0.152.$$

This is a 90% learning curve.

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3-20 Material Costs: $I_{1999} = 200$ $I_{2006} = 289$ $X = 0.65$
$S_{1999} = 800$ $S_{2006} = 1000$
$C_{1999} = \$25{,}000$

$$C_{2006} = \$25{,}000\left(\frac{289}{200}\right)\left(\frac{1000}{800}\right)^{0.65} = \$41{,}764$$

Manufacturing Costs: $s = 0.88$ $K = \$12{,}000$

$$Z_{50} = \$12{,}000\ (50)^{\log(0.88)/\log(2)} = \$5{,}832$$

Total Cost = (\$41,764 + \$5,832)(100) = \$4,759,600

3-21 The following table facilitates the intermediate calculations needed to compute the values of b_0 and b_1 using Equations (3-8) and (3-9).

I	x_i	y_i	x_i^2	$x_i y_i$
1	14,500	800,000	210,250,000	11,600,000,000
2	15,000	825,000	225,000,000	12,375,000,000
3	17,000	875,000	289,000,000	14,875,000,000
4	18,500	972,000	342,250,000	17,982,000,000
5	20,400	1,074,000	416,160,000	21,909,600,000
6	21,000	1,250,000	441,000,000	26,250,000,000
7	25,000	1,307,000	625,000,000	32,675,000,000
8	26,750	1,534,000	715,562,500	41,034,500,000
9	28,000	1,475,500	784,000,000	41,314,000,000
10	30,000	1,525,000	900,000,000	45,750,000,000
Totals	216,150	11,637,500	4,948,222,500	265,765,100,000

$$b_1 = \frac{(10)(265{,}765{,}100{,}000) - (216{,}150)(11{,}637{,}500)}{(10)(4{,}948{,}222{,}500) - (216{,}150)^2} = 51.5$$

$$b_0 = \frac{11{,}637{,}500 - (51.5)(216{,}150)}{10} = 50{,}631$$

(a) The resulting CER relating supermarket building cost to building area (x) is:

<u>Cost = 50,631 + 51.5x</u>

So the estimated cost for the 23,000 ft^2 store is:

Cost = \$50,631 + (\$51.5/ft^2)(23,000 ft^2) = <u>\$1,235,131</u>

(b) The CER developed in part (a) relates the cost of building a supermarket to its planned area using the following equation:

Cost = 50,631 + 51.5x

Using this equation, we can predict the cost of the ten buildings given their areas.

i	x_i	y_i	$Cost_i$	$(y_i - Cost_i)^2$	$(x_i - \bar{x})(y_i - \bar{y})$	$(x_i - \bar{x})^2$	$(y_i - \bar{y})^2$
1	14,500	800,000	797,345	7,048,179	2,588,081,250	50,623,225	132,314,062,500
2	15,000	825,000	823,094	3,633,147	2,240,831,250	43,758,225	114,751,562,500
3	17,000	875,000	926,089	2,610,081,256	1,332,581,250	21,298,225	83,376,562,500
4	18,500	972,000	1,003,335	981,896,725	597,301,250	9,703,225	36,768,062,500
5	20,400	1,074,000	1,101,181	738,780,429	109,046,250	1,476,225	8,055,062,500
6	21,000	1,250,000	1,132,079	13,905,356,010	-53,043,750	378,225	7,439,062,500
7	25,000	1,307,000	1,338,069	965,288,881	484,901,250	11,458,225	20,520,562,500
8	26,750	1,534,000	1,428,190	11,195,807,942	1,901,233,750	26,368,225	137,085,062,500
9	28,000	1,475,500	1,492,562	291,099,988	1,990,523,750	40,768,225	97,188,062,500
10	30,000	1,525,000	1,595,557	4,978,246,304	3,029,081,250	70,308,225	130,501,562,500
Totals	216,150	11,637,500	11,637,500	35,677,238,861	14,220,537,500	276,140,250	767,999,625,000

$$\bar{x} = \frac{1}{10}(216{,}150) = 21{,}615 \qquad \bar{y} = \frac{1}{10}(11{,}637{,}500) = 1{,}163{,}750$$

Using Equations (3-10) and (3-11), we can compute the standard error and correlation coefficient for the CER.

$$SE = \sqrt{\frac{35{,}677{,}238{,}861}{10}} = \underline{59{,}730}$$

$$R = \frac{14{,}220{,}537{,}500}{\sqrt{(276{,}140{,}250)(767{,}999{,}625{,}000)}} = \underline{0.9765}$$

3-22 x_i = weight of order (lbs)
y_i = packaging and processing costs ($)

(a) $y = b_0 + b_1x$

$\sum x_i = 2530 \quad \bar{x} = 253 \qquad \sum x_i^2 = 658{,}900$

$\sum y_i = 1024 \quad \bar{y} = 102.4 \qquad \sum y_i^2 = 106{,}348$

$\sum x_i y_i = 264{,}320$

$$b_1 = \frac{264{,}320 - (253)(1024)}{658{,}900 - (253)(2530)} = 0.279$$

$b_0 = 102.4 - (0.279)(253) = 31.813; \qquad y = \underline{31.813 + 0.279x}$

(b) $R = \dfrac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}$

$S_{xy} = 264{,}320 - (2530)(1024)/10 = 5{,}248$

$S_{xx} = 658{,}900 - (2530)^2/10 = 18{,}810$

$S_{yy} = 106{,}348 - (1024)^2/10 = 1{,}490.4$

$$R = \frac{5248}{\sqrt{(18{,}810)(1490.4)}} = \underline{0.99}$$

(c) $y = 31.813 + (0.279)(250) = \underline{\$101.56}$

3-23 Using the spreadsheet template of Figure 3-8, the total manufacturing cost and unit selling price are estimated to be $221.43 and $248.00, respectively.

	Unit Estimate		Factor Estimate		Direct	Row
MANUFACTURING COST ELEMENTS	Units	Cost/Unit	Factor	of Row	Estimate	Total
A: Factory Labor	4.20	$ 11.15				$ 46.83
B: Planning Labor						
C: Quality Control						-
D: TOTAL LABOR						46.83
E: Factory Overhead			150%	A		70.25
F: General & Admin. Expense						-
G: Production Material					$ 26.20	26.20
H: Outside Manufacture					74.87	74.87
I: SUBTOTAL						218.15
J: Packing Costs			7%	A		3.28
K: TOTAL DIRECT CHARGE						221.43
L: Other Direct Charge						-
M: Facility Rental						-
N: TOTAL MANUFACTURING COST						221.43
O: Quantity (lot size)						1.00
P: MANUFACTURING COST / UNIT						221.43
Q: Profit/Fee			12%	P		26.57
R: UNIT SELLING PRICE						$ 248.00

* 1 unit = 1 lot of 100 wire cutters

3-24 The estimate of direct labor hours is based on the time to produce the 50th unit.

K = 1.76 hours
s = 0.8 (80% learning curve)
n = (log 0.80)/(log 2) = -0.322
$Z_{50} = 1.76(50)^{-0.322} = 0.5$ hours

Factory Labor	= (\$15/hr)(0.5 hr/widget)	= \$7.50 / widget
Production Material	= \$375 / 100 widgets	= \$3.75 / widget
Factory Overhead	= (1.25)(\$7.50 / widget)	= \$9.375 / widget
Packing Costs	= (0.75)(\$7.50 / widget)	= \$5.625 / widget
Total Manufacturing Cost		= \$26.25 / widget
Desired Profit	= (0.20)(\$26.25 / widget)	= \$5.25 / widget
Unit Selling Price		= \$31.50 / widget

3-25 K = 5.26 hours
s = 0.85 (85% learning curve)
n = (log 0.85)/(log 2) = -0.2345
$Z_{20} = (5.26)(20)^{-0.2345} = 2.61$ hours

Direct labor = ($15/hour)(2.61 hours/unit)	= $39.15/unit
Factory overhead = (1.2)($39.15/unit)	= $46.98/unit
Production material	= $300/unit
Packing costs = (0.2)($39.15/unit)	= $ 7.83/unit
Total manufacturing cost	= $393.96/unit

(a) Maximum profit that company can have to remain competitive = $420 - $393.96 = $26.04/unit. Profit margin = $26.04/$393.96 = 0.0661 = 6.61%

(b) At 15% profit margin, the target cost is given by (Eq. 3-13):

TC = $420/(1.15) = $365.22/unit

Hence, the target cost cannot be achieved.

Two possible ways to achieve target cost:
(1) Reduce profit margin to less than or equal to 6.61%
(2) Try to obtain production material at a lower cost. Since the TMC exceeds TC by ($393.96 - $365.22) = $28.74/unit, therefore, the material cost should be reduced by at least $28.74/unit.

3-26 Profit = Revenue – Cost

$25,000 = ($20.00/unit)(x) – [($21.00/unit)(.2 hours/unit)(x) + ($4.00/unit)(x) + (1.2)($21.00/unit)(.2 hours/unit)(x) + ($1.20/unit)(x)]

$25,000 = 5.56x; x = <u>4,497 units</u>

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3-27 $\$127(1.19)^5 = \$303$ per square foot in five years. The total estimated cost in five years is (320,000 ft^2)($\$303/ft^2$) = \$96,960,000. It's a good idea to build this facility today and then, if needed, add on the additional space five years later.

3-28 The amount of the FICO score affected is (0.35)(720) = 252. If this drops by 10%, the payment history score will be (0.90)(252) = 227 and the overall FICO score will be 695. This lower value could adversely affect the interest rate you'll be quoted on your next loan.

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3-29 Boiler Cost = \$300,000 $\left(\frac{10mW}{6mW}\right)^{0.8}$ = \$451,440

Generator Cost = \$400,000 $\left(\frac{9mW}{6mW}\right)^{0.6}$ = \$510,170

Tank Cost = \$106,000 $\left(\frac{91{,}500gal}{80{,}000gal}\right)^{0.66}$ = \$115,826

Total Cost = (2)(\$451,440) + (2)(\$510,170) + \$115,826 + \$200,000 = <u>\$2,239,046</u>

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3-30 $Y_3 = 846.2 = Y_1(3)^n$

$Y_5 = 783.0 = Y_1(5)^n$

$\frac{846.2}{783.0} = (3/5)^n$ or $1.0807 = (0.6)^n$

$\log 1.0807 = n \log (0.6)$

$\frac{0.03371}{-0.22185} = n$, thus $n = -0.415$

and $n = \log s/\log 2$, where s = learning curve as decimal

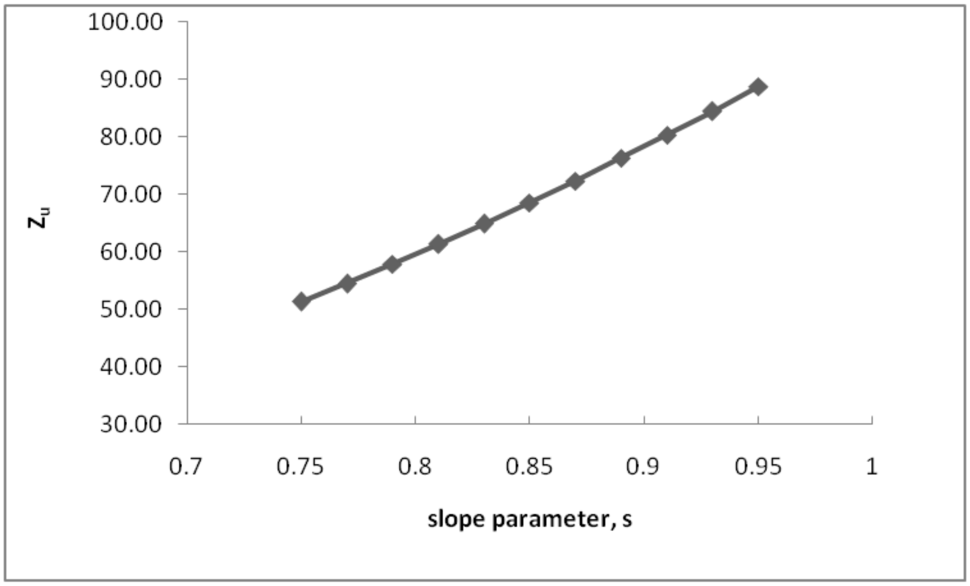
$-0.152 = \log s/0.30103$

$-0.04576 = \log s$, $s =$ <u>0.9 (90% learning curve)</u>

Solutions to Spreadsheet Exercises

3-31 See P3-31.xls.

K	100
u	5
s	Z_u
0.75	51.27
0.77	54.51
0.79	57.85
0.81	61.31
0.83	64.88
0.85	68.57
0.87	72.37
0.89	76.29
0.91	80.33
0.93	84.49
0.95	88.77



3-32 See P3-32.xls.

(a) Based on the constant reduction rate of 8% each time the number of homes constructed doubles, a 92% leanring curve applies to the situation. The cumulative average material cost per square foot for the first five homes is $24.12.

(b) The estimated material cost per square foot for the 16th home is $19.34.

S	0.92		
K	$27		
	Material	Cumulative	Cumulative
Home	Cost per ft^2	Sum	Average
1	$ 27.00	$ 27.00	$ 27.00
2	$ 24.84	$ 51.84	$ 25.92
3	$ 23.66	$ 75.50	$ 25.17
4	$ 22.85	$ 98.35	$ 24.59
5	$ 22.25	$ 120.60	$ 24.12
6	$ 21.76	$ 142.36	$ 23.73
7	$ 21.37	$ 163.73	$ 23.39
8	$ 21.02	$ 184.75	$ 23.09
9	$ 20.73	$ 205.48	$ 22.83
10	$ 20.47	$ 225.95	$ 22.59
11	$ 20.23	$ 246.18	$ 22.38
12	$ 20.02	$ 266.21	$ 22.18
13	$ 19.83	$ 286.04	$ 22.00
14	$ 19.66	$ 305.69	$ 21.84
15	$ 19.49	$ 325.19	$ 21.68
16	$ 19.34	$ 344.53	$ 21.53

3-33

	A	B	C	D	E	F	G	H	I	J	K
1	Spacecraft	Weight	Cost								
2	0	100	$ 600								
3	1	400	$ 278								
4	2	530	$ 414								
5	3	750	$ 557								
6	4	900	$ 689								
7	5	1,130	$ 740								
8	6	1,200	$ 851								
9											
10	SUMMARY OUTPUT										
11											
12	Regression Sta										
13	Multiple R										
14	R Square										
15	Adjusted R Square										
16	Standard Error										
17	Observations										
18											
19	ANOVA										
20					*F*	*Significance F*					
21	Regression			212	4.9646179	0.076342997					
22	Residual			729							
23	Total	6	229930.8571								
24											
25		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*		
26	Intercept	341.9170907	125.2152843	2.73063383	0.0412491	20.04148132	663.7927001	20.04148132	663.7927001		
27	Weight	0.346423227	0.155476261	2.22814225	0.076343	-0.053240574	0.746087027	-0.053240574	0.746087027		
28											
29											
30											
31	RESIDUAL OUTPUT										
32											
33	*Observation*	*Predicted Cost*	*Residuals*								
34	1	376.5594133	223.4405867								
35	2	480.4863813	-202.4863813								
36	3	525.5214008	-111.5214008								
37	4	601.7345106	-44.73451063								
38	5	653.6979946	35.30200539								
39	6	733.3753367	6.624663274								
40	7	757.6249626	93.37503741								
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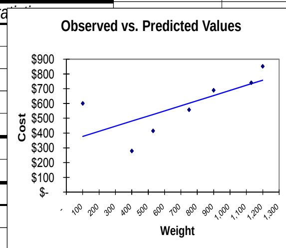

3-34

Column A		Column B		Column C		Column D	Column E
		Unit Estimate		Factor Estimate		Direct	Row
MANUFACTURING COST ELEMENTS		Units	Cost/Unit	Factor	of Row	Estimate	Total
A:	Factory Labor	36.48	$ 10.54				$ 384.50
B:	Planning Labor			12%	A		46.14
C:	Quality Control			11%	A		42.29
D:	TOTAL LABOR						472.93
E:	Factory Overhead			105%	D		496.58
F:	General & Admin. Expense			15%	D		70.94
G:	Production Material					$ 110.23	110.23
H:	Outside Manufacture					28.00	28.00
I:	SUBTOTAL						1,178.69
J:	Packing Costs			5%	I		58.93
K:	TOTAL DIRECT CHARGE						1,237.62
L:	Other Direct Charge			1%	K		12.38
M:	Facility Rental						-
N:	TOTAL MANUFACTURING COST						1,250.00
O:	Quantity (lot size)						50
P:	MANUFACTURING COST / UNIT						25.00
	Competitor's Selling Price	$ 27.50					
	Desired Return on Sales	10%					
	Target Cost	$ 25.00					

Solutions to Case Study Exercises

3-35 Other cost factors include maintenance, packaging, supervision, materials, among others. Also, the case solution presents a before-tax economic analysis.

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3-36 Left as an exercise for the student. However, by observation, it appears that the factory overhead and factory labor are good candidates since they comprise the largest percentage contributions to the per unit demanufacuring cost.

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3-37 A 50% increase in labor costs equates to a factor of 15%; a 90% increase in Transportation equates to a factor of 38%. The corresponding demnaufacturing cost per unit is \$5.19. The per unit cost of using the outside contractor (i.e., the target cost) is \$11.70. Should the proposed demanufacturing method be adopted, the revised per unit cost savings is \$6.51 for a 55.6% reduction over the per unit cost for the outside contractor.

		Unit Elements		Factor Estimates		Row
	DE-MANUFACTURING COST ELEMENTS	Units	Cost/Unit	Factor	of Row	Total
A:	Factory Labor	24.5 hrs	\$ 12.00/hr			\$ 294.00
B:	Quality Costs - Training			15%	A	\$ 44.10
C:	TOTAL LABOR					\$ 338.10
D:	Factory Overhead - Set up Costs			150%	C	\$ 507.15
E:	Transportation Cost			38%	C	\$ 192.72
F:	TOTAL DIRECT CHARGE					\$ 699.87
G:	Facitily Rental					-
H:	TOTAL DE-MANUFACTURING COST					\$ 1,037.97
I:	Quantity - Lot Size					200
J:	De-manufacturing Cost/Unit					\$ 5.19
	Outside Cost/Unit - Target Cost	\$ 11.70				

Solutions to FE Practice Problems

3-38 K = 460 hours; s = 0.92 (91% learning curve); n = (log 0.92)/(log 2) = -0.120

$C_{30} = T_{30}/30$; $T_{30} = 460 \sum_{u=1}^{30} u^{-0.120} = 10,419.63$ hrs;

$C_{30} = 10,419.63 / 30 = 347.3211$

Select (d)

3-39 $-1{,}500 + 800 + (.07-.05)(1.85)(10)x = 0$

$-700 + 0.60x = 0$

$x = 700/0.60 = 1{,}167$ miles/year

<u>Select (a)</u>

3-40 $AC_{current}$ = \$4,000
Proposed: N = 13 years, SV = 11% of first cost

$$\$4,000 = I\,(A/P,12\%,13) - (0.11)I\,(A/F,12\%,13)$$
$$\$4,000 = I(0.1557) - (0.003927)I$$
$$\$4,000 = I\,(0.1517)$$

I = \$26,358

<u>Select (c)</u>

3-41 Let X = average time spent supervising the average employee. Then the time spent supervising employee A = 2X and the time spent supervising employee B = 0.5X. The total time units spent by the supervisor is then 2X + 0.5X + (8)X = 10.5X. The monthly cost of the supervisor is \$3,800 and can be allocated among the employees in the following manner:

$$\$3{,}800/10.5X = \$361.90 \;/\; X \text{ time units.}$$

Employee A (when compared to employee B) costs (2X – 0.5X)(\$361.90/X) = \$542.85 more for the same units of production. If employee B is compensated accordingly, the monthly salary for employee B should be \$3,000 + \$542.85 = \$3,542.85.

<u>Select (a)</u>

3-42 Type X filter: cost = \$5, changed every 7,000 miles along with 5 quarts oil
between each oil change 1 quart of oil must be added after each 1,000 miles

Type Y filter: cost = ?, changed every 5,000 miles along with 5 quarts of oil
no additional oil between filter changes

oil = \$1.08 / quart

Common multiple = 35,000 miles

For filter X = 5 oil changes: 5(\$5 + 5(\$1.08) + 6(\$1.08)) = (5)\$16.88 = \$84.40
For filter Y = 7 oil changes: $7C_Y$ + 7(5)(\$1.08) = 7X + \$37.8

$$\$84.40 = 7C_Y + \$37.8$$
$$\$46.60 = 7C_Y$$

$$C_Y = \$6.66$$

<u>Select (d)</u>

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Solutions to Chapter 4 Problems

4-1 $\underline{I} = P(N)(i) = \$10{,}000\ (4.25\text{ yrs.})\ (0.10/\text{yr}) = \$\underline{4{,}250}$

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4-2 $\underline{I}$ = (\$200)(1% /month)(6 months) = \$12

Total owed = \$200 + \$12 = \$212

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4-3 $\underline{I}$ = \$1,000 (2.5 yrs.) (0.08) = \$200; F = P + $\underline{I}$ = \$1,000 + \$200 = \$<u>1,200</u>

4-4 Simple interest earned = 5(i)P

Compound interest earned = $P(1 + i)^5 - P$

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4-5

Year	Amount Owed at Beginning of Year	Interest Accrued for Year	Total Amount Owed at End of Year	Principal Payment	Total End of Year Payment
1	$2,000	$ 200	$2,200	$ 0	$ 200
2	2,000	200	2,200	0	200
3	2,000	200	2,200	0	200
4	2,000	200	2,200	1,000	1,200
5	1,000	100	1,100	0	100
6	1,000	100	1,100	0	100
7	1,000	100	1,100	0	100
8	1,000	100	1,100	1,000	1,100
	Total Interest =	$ 1,200			

$200 in interest is payable each year for the first four years. $100 in interest is payable each year for the second four years. The total interest paid over the eight year period is $1,200.

4-6

Month	Amount Owed at BOM	Interest Accrued for Month	Total Amount Owed at End of Month	Principal Payment	Total EOM Payment
1	$17,000	$ 170	$17,170	$ 0	$ 170
2	17,000	170	17,170	8,500	8,670
3	8,500	85	8,585	0	85
4	8,500	85	8,585	8,500	8,585
	Total Interest =	$510			

Total interest paid over the four month loan period = $510.

4-7 **(a)** EOY 1 principal = \$3,880 − \$800 = \$3,080

EOY 3 interest = [\$10,000 − \$3,080 − \$3,326.40](0.08) = \$287.49

EOY 3 principal = \$3,880 − \$287.49 = \$3,592.51

(b) Beginning of year 3 principal = \$10,000 − \$3,080 − \$3,326.40 = \$3,593.60

4-8 F = \$10,000 (F/P, 6%, 5) = \$10,000 (1.3382) = \$<u>13,382</u>

4-9 F = \$400 (F/P, 9%, 40) = \$400 (31.4094) = \$12,563.76

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4-10 Consumer Loan: F = $5,000 (F/P, 12%, 5) = $5,000 (1.7623) = $8,811.50
Interest = $8,811.50 − $5,000 = $3,811.50

PLUS Loan: F = $5,000 (F/P, 8.5%, 5) = $5,000 $(1.085)^5$ = $7,518.28
Interest = $2,518.28

Difference = $3,811.50 − $2,518.28 = $1,293.22

Chandra will save money by following the advice of her father.

4-11 F = \$25,000 (F/P, 10%, 25) = \$25,000 (10.8347) = \$270,867.50

4-12 $P = \$18,000\ (P/F, 7\%, 15) = \$18,000\ (0.3624) = \$6,523.20$

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4-13 P = \$10,000 (P/F, 5%, 10) = \$10,000 (0.7835) = \$7,835

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4-14 $N = 2005 - 1981 = 24$ years

$P = \$67 \, (P/F, 3.2\%, 24) = \$67 \, (1.032)^{-24} = \$31.46$

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4-15 $\$50 = \$25\ (F/P, 10\%, N)$

$2 = (1.10)^N$

$\log(2) = N \log(1.1)$

$$N = \frac{\log(2)}{\log(1.1)}$$

N = <u>7.27 years</u>

4-16 Solution by Rule of 72: $N \approx \frac{72}{10} = 7.2$ years.

Compare to the exact solution:

$\$10,000 = \$5,000\ (F/P, 10\%, N) = \$5,000\ (1 + 0.10)^N$

$2 = 1.1^N$; $\ln(2) = N \ln(1.1)$; and N = <u>7.2725 years</u>

4-17 $\$4,000 = \$1,000 (F/P, 15\%, N)$

$4 = (1.15)^N$

$N = \log(4)/\log(1.15) = 9.9$ or $N = 10$ years

Alternative solution: $4 = (F/P, 15\%, N)$ and from Table C-15, the value of N is 10.

4-18 $\$1,000,000 = \$10,000\ (F/P, 10\%, N)$

$100 = (F/P, 10\%, N) = (1.10)^N$

$N = \log(100)/\log(1.1) = 48.3$ or 49 years

4-19 The \$1,000 originally invested dollars doubles nine times in 36 years, so the student will gain (\$1,000)(2^9) − \$1,000 = \$511,000 in 36 years.

An alternate approach is to solve 2 = (F/P, i′, 4) for i′ = 18.921%. Then

F = \$1,000 (F/P, 18.921%, 36) = \$512,000.

Thus, the gain is \$512,000 − \$1,000 = \$511,000.

4-20 $N = 2007 – 1885 = 122$ years

$0.41 = 0.02\ (1 + i)^{122}$

$i = \sqrt[122]{0.41/0.02} - 1 = 0.025$ or 2.5% per year

4-21 **(a)** $N = 2007 - 1982 = 25$ years

$\$100{,}000 = \$25{,}000\,(1 + i)^{25}$

$i = \sqrt[25]{4} - 1 = 0.057$ or 5.7% per year.

So Barney and Lynne did not really do that well at all!

(b) $\$100{,}000 = \$1{,}000\,(F/P, i', 25)$

$(F/A, i', 25) = 100$

$i' = 10.1\%$ per year

In this situation they did pretty well on their mutual fund investment.

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4-22 $\$102,000 = \$9,000 (F/P, i'\%, 36)$ or $i' = 6.98\%$. This is more than double the Consumer Price index.

4-23 **(a)** $5,290 = $827 (F/P, i%, 23) i = 8.4% per year

(b) $5,290 = $2,018 (F/P, i%, 12) i = 8.36% per year

(c) 1982−2005: $198.1 = 96.5\,(1+i)^{23}$ i = 3.18% per year
1993−2005: $198.1 = 144.5\,(1+i)^{12}$ i = 2.66% per year

The cost of tuition and fees has risen 2.6 times faster than the CPI for the 1982−2005 time period. Over the 1993−2005 period, they have risen more than three times as fast.

4-24 $15 = $6 (F/P, i%, 6); i = 16.5% per year. This is more than five times the annual inflation rate! Turn down the thermostat on your gas furnace.

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4-25 F = \$1,000 (F/A, 5%, 15) = \$1,000 (21.5786) = \$21,578.60

4-26 $F = \$100\ (F/A,\ 30\%,25) = \$100\left[\frac{(1.3)^{25}-1}{0.30}\right] = \$234{,}880$

4-27 0.01 ($20,000) = $200 per year will be placed in the savings account. This will accumulate to F = $200 (F/A, 5%,15) = $200 (21.5786) = $4,315.72

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4-28 F = \$730 (F/A, 7%, 35) = \$730 (138.2369) = \$100,913. Of this amount, \$730 × 35 = \$25,550 is money you paid in and \$75,363 is accumulated interest.

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4-29 **(a)** F = \$848 (F/A, 10%, 45) = \$848 (718.9048) = \$609,631. Liam's friend has exaggerated the truth because the claim is too high.

(b) Liam is trading off the answer in part (a) against the likelihood that he will survive to age 65. If Liam's health is good, he may choose to gamble and go ahead with the mutual fund.

(c) Answer left to the student.

4-30 The reduction in management fees between an actively – managed fund and an index fund is 0.005 ($100,000) = $500 per year. The compound worth of this difference in 0 years is F = $500 (F/A, 8%, 20) = $22,881. This is 22.88% of the original investment of $100,000. So the difference in sales commissions does add up to a large number. We assume that both types of accounts grow in value at the same rate. Try to minimize commisions!

4-31 **(a)** P = \$10,000 (P/A, 2%, 12) = \$10,000 (10.5753) = \$105,573

(b) P = \$10,000 + \$10,000 (P/A, 2%, 11) = \$107,868

(c) The present equivalent in part (b) is higher because the cash flows are not as far into the future, so less discounting occurs.

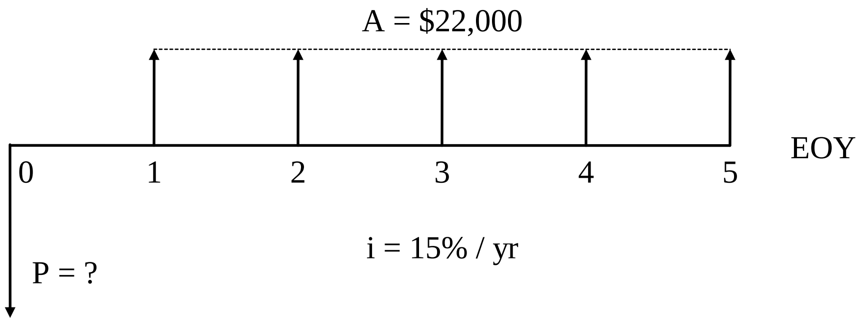
4-32 $P = \$2{,}500\ (P/A,\ 5\%,\ 4) = \$2{,}500\ (3.5460) = \$\underline{8{,}865}$

4-33 The carbon fiber automobile would average around 39 miles per gallon of gasoline. The dollar savings in fuel per year is

$$A = \left[\frac{117{,}000/6}{30} - \frac{117{,}000/6}{39}\right](\$3.00) = \$450$$

The extra sticker price that can be afforded is \$450 (P/A, 20%, 6) = \$1,496. This is not a whole lot of room to wiggle compared to the sticker price of the conventional car. So the cost of manufacturing carbon fiber automobiles must be made much more competitive against conventional ferrous−aluminum car bodies and parts.

4-34



P = $22,000 (P/A, 15%, 5) = $22,000 (3.3522) = $<u>73,748.40</u>

The company can justify spending up to $73,748.40 for this piece of equipment.

4-35 P = \$100,000 (P/A, 8%, 20) = \$100,000 (9.8181) = \$981,810. Gerard will get \$1,018,190 less than the stated \$2,000,000 jackpot if he elects this option. Clearly, Gerard should take the \$1,000,000 now (assuming income tax considerations are ignored). Gerard – this is still a lot of money so we don't feel too sorry for you.

4-36 $P \le \$350\,(P/A, 8\%, 18) \le 350\,(9.3719) \le \$\underline{3{,}280.16}$

Thus, the homeowner can afford to spend no more than \$3,280.16 for the thermal windows.

4-37 P = \$100,000 (P/A, 15%, 10) = \$100,000 (5.0188) = \$501,880

4-38 A = \$150,000 (A/F, 9%, 20) = \$150,000 (0.0195) = \$<u>2,925</u>

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4-39 $N = 12 \times 25 = 300$ months

$$A = \$500{,}000\ (A/F,\ 0.5\%,\ 300) = \$500{,}000\left[\frac{0.005}{(1.005)^{300}-1}\right] = \$720 \text{ per month}$$

4-40 **(a)** N = \$1 million per year / \$0.005 per cup = 200,000,000 cups per year

(b) $N = \dfrac{\$5 \text{ million } (A/F, 15\%, 5)}{\$0.005 \text{ per cup}}$ = 148,300,000 cups per year

(c) The compounding of interest.

4-41 $(A/P, i\%, N) = \dfrac{i(1+i)^N}{(1+i)^N - 1} = \dfrac{i}{1 - 1/(1+i)^N} = \dfrac{i}{1 - (P/F, i\%, N)}$

4-42 A = \$10,000,000 (A/P, 15%, 4) = \$10,000,000 (0.3503) = \$3,503,000

4-43 Fuel savings over eight years = $\frac{100{,}000 \text{ miles}}{26 \text{ miles/gallon}} - \frac{100{,}000 \text{ miles}}{28 \text{ miles/gallon}} \cong 275$ gallons, which is about 34.4 gallons per year. Let X represent the cost of gasoline ($/gal).

$$\$800 = (34.4 \text{ gal/yr})(X/\text{gal})(P/A, 10\%, 8)$$

$$\frac{\$800}{(34.4 \text{ gal})(5.3349)} = X, \text{ or } X = \$4.36/\text{gal}$$

If the actual cost of gasoline is less than $4.36 per gallon, the CVT is not a good deal.

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4-44 A = \$10,000,000 (A/P, 7%, 6) = \$10,000,000 (0.2098) = \$2,098,000 per year

Total interest paid = \$2,098,000 (6) − \$10,000,000 = \$2,588,000

4-45 $A = \$500{,}000\ (A/P, 15\%, 6) = \$500{,}000\ (0.2642) = \$132{,}100$

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4-46 With traditional financing, the monthly payment will be A = \$84,000 (A/P, ¾%, 60) = \$1,747.20. The monthly payment with the 0% financing plan would be \$84,000/60 = \$1,400 per month. Total savings = (\$1,747.20 − \$1,400)(60) = \$20,832. Thus the claim is true.

4-47 \$35 million + \$39 million = \$35 million (F/P, i, 40)

$(1 + i)^{40} = 74/3$

i = 1.89% per year

4-48 40A − \$35 million = \$39 million, thus A = \$1,850,000.

We also know that A = \$35 million (A/P, i%, 40). We can guess various interest rates and compare the resulting value of A to \$1,850,000. For example, at i = 4%, A = \$1,767,500. At i = 5%, A = \$2,040,500. By linear interpolation, i ≈ 4.3% per year.

4-49 **(a)** P = A (P/A, i%, N); \$1,000 = \$200(P/A, 12%,N); (P/A, 12%, N) = 5.0000

By looking at the 12% interest table in Appendix C under the P/A column, <u>N ≈ 8 years</u>.

(b) P = A (P/A, i%, N); \$1,000 = \$200 (P/A, i%,10); (P/A, i%, 10) = 5.0000

(P/A, 15%, 10) = 5.0188 and (P/A, 18%, 10) = 4.4941, thus 15% < i < 18%

$$\text{By using linear interpolation - } \frac{18\% - 15\%}{5.0188 - 4.4941} = \frac{i\% - 15\%}{5.0188 - 5.00}$$

$\therefore$ <u>i = 15.11%</u>

(c) P = A (P/A, i%, N) = \$200 (P/A, 12%, 5) = 200 (3.6048) = \$<u>720.96</u>

(d) A = P (A/P, i%, N) = \$1,000 (A/P, 12%, 5) = \$1,000 (0.2774) = \$<u>277.40</u>

4-50 $100,000 = $1,000,000 (A/P, 6%, N), so (A/P, 6%, N) = 0.10.

From Table C-9, $13 \leq N \leq 14$.

If i = 8%, Table C-11 gives us $16 \leq N \leq 17$.

4-51 \$3,500 = \$100 (P/A, 1.75%, N), so by trial and error, or exact numerical solution, we find that N = 55 months to repay the credit card value. Note: (P/A, 1.75%, 55) = 35.1345

4-52 $100,000 = $10,000 (A/P, 5%, N), so (A/P, 5%, N) = 0.10.

From Table C-8, $12 \leq N \leq 13$.

4-53 F_6 = \$2,000 (F/A, 5%, 6) = \$2,000 (6.8019) =\$13,603.80

and

$F_{10} = F_6$ (F/P, 5%, 4) = \$13,603.80 (1.2155) = \$<u>16,535.42</u>

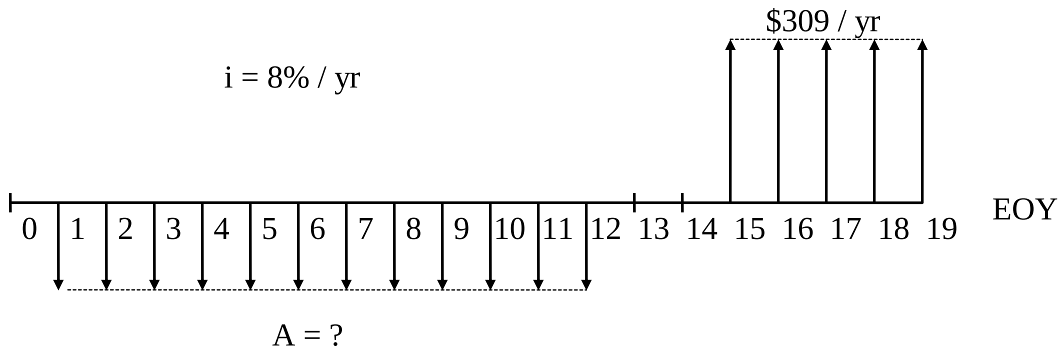
4-54 F_{12} = \$24,000 (F/P, ½%, 12)
= \$24,000 (1.0617)
= \$25,480.80

and

A = F_{12} (A/P, ½%, 36)
= \$25,480.80 (0.0304)
= \$<u>774.62 per month</u>

4-55 F = \$3,000 (F/A, 10%, 8)(F/P, 10%, 33) = \$3,000(11.4359)(23.2252) = \$796,803. This sounds too good to be true, but it really is true! The stock market is one place where a return of 10% might be earned over the span of time in this problem.

4-56



P_{12} (of deposits) = A (F/A, 8%,12), and P_{13} = P_{12} (F/P, 8%, 1)
P_{13}' (of withdrawals) = \$309 (P/A, 8%, 5)

By letting P_{13} = P_{13}', we have

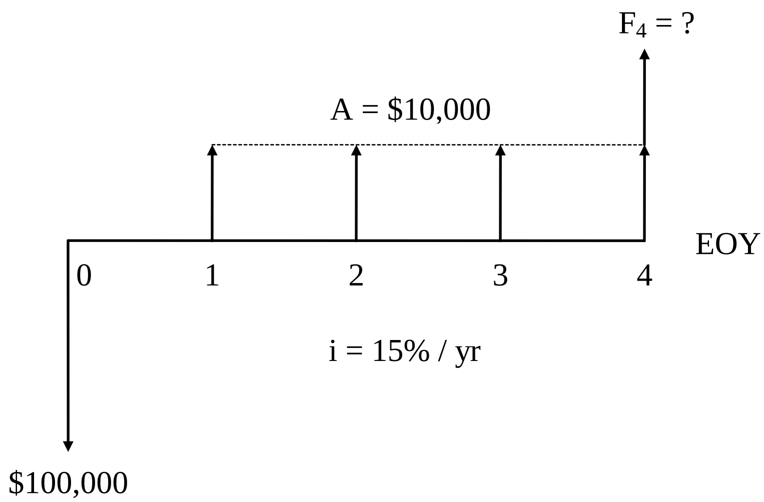
[A (F/A, 8%,12)](F/P, 8%, 1) = \$309 (P/A, 8%, 5)
[A(18.9771)] (1.08) = \$309 (3.9927)
A = \$<u>60.20</u>

4-57 This is a deferred annuity, the time periods are months, and i = 3/4 % per month:

P_{71} = \$500 (P/A, 3/4%, 60) = \$500 (48.1733) = \$24,086.65

P_0 = \$24,086.65 (P/F, 3/4% ,71) = 24,086.65 (0.58836) = \$<u>14,171.62</u>

4-58



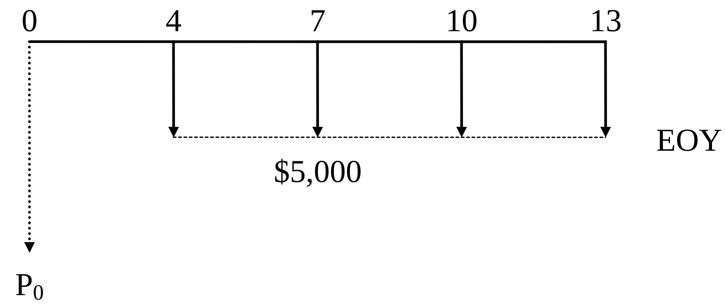
$$\text{Equivalent receipts} = \text{Equivalent expenditures}$$

$$F_4 + \$10{,}000\,(F/A, 15\%, 4) = \$100{,}000\,(F/P, 15\%, 4)$$

so,

$$F_4 = \$100{,}000\,(F/P, 15\%, 4) - \$10{,}000\,(F/A, 15\%, 4)$$
$$= \$100{,}000\,(1.7490) - \$10{,}000\,(4.9934)$$
$$= \$174{,}900 - \$49{,}934 = \$\underline{124{,}966}$$

4-59 **(a)**



(b) P_0 = \$5,000 [(P/F, 12%, 4) + (P/F, 12%, 7) + (P/F, 12%, 10) + (P/F, 12%, 13]
P_0 = \$5,000 (1.639) = \$8,195

(c) A = \$8,195 (F/P, 12%, 4)(A/P, 12%, 9) = \$2,420

4-60 $P_0 = -\$1,000\ (P/A, 10\%, 5) - \$10,000\ (P/F, 10\%, 15) - \$10,000\ (P/F, 10\%, 30)$

$= -\$1,000\ (3.7908) - \$10,000\ (0.2394) - \$10,000\ (0.0573)$

$= -\$6,757.80$

$A = -\$6,757.80\ (A/P, 10\%, 50) = -\$6,757.80\ (0.1009) = -\$\underline{681.86}$

4-61 **(a)** F_{65} = \$2,000 (F/A, 6%, 40) = \$2,000 (154.762) = \$309,524

(b) A_{66-85} = \$309,524 (A/P, 6%, 20) = \$309,524 (0.0872) = \$26,990 per year or about \$2,249 per month.

4-62 Using time = 0 as the reference point, set $P_0(LHS) = P_0(RHS)$:

$$\begin{aligned}
\$2{,}000(P/F,8\%,2) + \$5{,}000(P/F,8\%,6) &= Z(P/F,8\%,4) - 2Z(P/F,8\%,5) + 3Z(P/F,8\%,6) \\
\$2{,}000(0.8573) + \$5{,}000(0.6302) &= Z(0.7350) - 2Z(0.6806) + 3Z(0.6302) \\
\$4{,}865.6 &= 1.2644\ Z \\
Z &= \$\underline{3{,}848.15}
\end{aligned}$$

4-63 **(a)** Cost in 10 years = $75,000 (F/P, 10%, 10) = $75,000 (2.5937) = $194,528

A = $194,528 (A/F, 6%, 10) = $194,528 (0.0759) = $14,765

(b) Because $150,000 is less than $194,528, this is a good deal (the college's cost increases are less than 10% per year).

4-64 A_1 = [\$10,000(F/P,9%,4) − \$5,000](A/F,9%,4)

= [\$10,000(1.4116) − \$5,000](0.2187)

= <u>\$1993.67</u>

A_2 = \$5,000(A/P,9%,4) = \$5,000(0.3087) = <u>\$1543.50</u>

4-65 New tires every two years (EOY 2, 4, 6, 8, 10).

P = \$400 (A/F, 12%, 2)(P/A, 12%, 10) = \$400 (0.4717)(5.6502) = \$1,066

Another approach would be to discount each of the five cash flows individually using the appropriate (P/F) factors.

This value of \$1,066 is most likely an upper bound on what the deal is worth to you.

4-66 $F_5 = \$100\ (F/A, 8\%, 4)\ (F/P, 8\%, 1) + \$100\ (P/A, 8\%, 2)$

$= 100\ (4.5061)(1.08) + 100\ (1.7833) = \$\underline{664.99}$

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4-67 Value of debt in eight years = \$10,000 (F/A, 15%, 8) = \$10,000 (13.7268) = \$137,268

Annual payment = \$137,268 (A/P, 15%, 10) = \$137,268 (0.1993) = \$27,358

The moral is to avoid debt if at all possible. Otherwise, minimize it by reducing the amount borrowed, the obligation period, and/or the interest rate. It is assumed in this problem that the interest rate remains constant at 15% per year over the next 18 years.

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4-68 Using time = 0 as the reference point, set $P_0(LHS) = P_0(RHS)$

$$\$1{,}000(P/F,12\%,1) + \$1{,}000(P/F,12\%,3) - \$1{,}000(P/F,12\%,5) = W + W(P/F,12\%,7)$$

$$\$1{,}000(0.8929) + \$1{,}000(0.7118) - \$1{,}000(0.5674) = W + W(0.4523)$$

$$\$1{,}037.30 = 1.4523\ W$$

$$W = \underline{\$714.25}$$

4-69 **(a)** Monthly payment = \$30,000 (A/P, ¾%, 48) = \$30,000 (0.0249) = \$747.
Amount owed after 24^{th} payment = \$747 (P/A, ¾%, 24) = \$747 (21.8891) = \$16,351.

(b) Not counting the \$5,000 down payment, your friend is "upside down" by \$1,351. This happens when she owes more on the car than it is worth in the marketplace. Nothing much can be done about this situation except to keep the car longer and hope the vehicle remains in good working order. Or if the mileage is low and the car is in very good condition, perhaps it is worth more than \$15,000 and she should consider selling it.

4-70 $P_0 = -\$100{,}000 - \$10{,}000\,(P/A, 15\%, 10) - \$30{,}000\,(P/F, 15\%, 5)$

$= -\$100{,}000 - \$10{,}000\,(5.0188) - \$30{,}000\,(0.4972)$

$= \underline{-\$165{,}104}$

4-71 Profit = (\$0.08/gal)(20,000 gal/mo) = \$1,600 per month.

\$30,000 = \$1,600 (P/A, 1%, N), so (P/A, 1%, N) = 18.75

From Table C-4, N = 21 months.

4-72 Equivalent cash inflows = Equivalent cash outflows

Using time 0 as the equivalence point and N = total life of the system:

$$\$2{,}000(P/F,18\%,1) + \$4{,}000(P/F,18\%,2) + \$5{,}000(P/A,18\%,N-2)(P/F,18\%,2) = \$20{,}000$$

$$\$2{,}000(0.8475) + \$4{,}000(0.7182) + \$5{,}000(P/A, 18\%, N-2)(0.7182) = \$20{,}000$$

$$\$5{,}000\ (P/A,18\%,N-2)(0.7182) = \$15432.20$$

$$(P/A, 18\%, N-2) = 4.297$$

From Table C-17, (P/A,18%,8) = 4.078 and (P/A,18%,9) = 4.303

Thus, (N−2) = 9 and N = 11 years . Note that if the system lasts for only 10 years, the present equivalent of the cash inflows < present equivalent of the cash outflows.

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4-73 Left side:

P_L = 10 (P/F, 15%, 1) + H (P/A, 15%, 16−4) (P/F, 15%, 4) +
1.7H (P/A, 15%, 6) (P/F, 15%, 7)
= −10 (0.8696) + H(5.4206) (0.5718) + 1.7H (3.7845) (0.3759)
= 5.5182H – 8.696

Right side:

$P_R = -P_0 + 2P_0$ (P/F, 15%, 10) $= -P_0 + 2P_0$ (0.2472) $= -0.5056\ P_0$

set $P_R = P_L$: $-0.5056\ P_0 = 5.5182H - 8.696$

$P_0 = \underline{17.199 - 10.91H}$

4-74 A = \$500 + \$100(A/G,8%,20) = \$500 + \$100(7.0369) = <u>\$1,203.69</u>

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4-75 $P_0(\text{rental income}) = \$1{,}300(P/A,9\%,15) - \$50(P/G,9\%,15)$

$= \$1{,}300(8.0607) - \$50(43.807)$

$= \underline{\$8{,}288.56}$

The present equivalent of the rental income is greater than the present equivalent of the $8,000 investment, so the rental property appears to be a good investment.

4-76 P_0 (loan amount) = P_0 (loan repayment)

$10,000 = Z(P/G,7%,8)(P/F,7%,2)

$10,000 = Z(18.825)(0.8734)

$10,000 = 16.4417 Z

Z = $<u>608.21</u>

4-77 **(a)** F = \$600 (P/G, i%, 6)(F/P i%, 6) = \$10,000

If i = 7%, F = \$9,884.81 < \$10,000, ∴ i > 7%
If i = 8%, F= \$10,019.37 > \$10,000, ∴ i < 8%

Thus, 7% < i < 8%. Using linear interpolation,

$$\frac{i\% - 7\%}{\$10{,}000 - \$9{,}884.81} = \frac{8\% - 7\%}{\$10{,}019.37 - \$9{,}884.81}$$

i = <u>7.86%</u>

(b) F = \$600 (P/G, 5%, N) (F/P, 5%, N) = \$10,000

If N = 6, F = \$9,622.99 < \$10,000, ∴ N > 6
If N = 7, F= \$13,704.03 > \$10,000, ∴ N < 7

Thus, 6 < N < 7. Using linear interpolation,

$$\frac{N - 6}{\$10{,}000 - \$9{,}622.99} = \frac{7 - 6}{\$13{,}704.03 - \$9{,}622.99}$$

N = <u>6.1</u> periods. If an integer value of N is desired, choose N = 7 periods.

(c) F = \$1,000(P/G,10%,12)(F/P,10%,12)
= \$1,000(29.901)(3.1384) = \$<u>93,841.30</u>

(d) $$G = F(P/F,10\%,6)\frac{1}{(P/G,10\%,6)} = \$8{,}000(0.5645)\frac{1}{9.684} = \underline{\$466.34}$$

4-78 **(a)** $\$2,000 = \$100\ (P/A, 0.5\%, 12) + G\ (P/G, 0.5\%, 12)$
$= \$100\ (11.6189) + G\ (63.214)$

G = $13.26 per month beginning at the end of month 2

(b) $A = \$2,000\ (A/P, 0.5\%, 12) = \$2,000\ (0.0861) = \$172.20$

(c) $G = \dfrac{\$2,000 - \$150(11.6189)}{63.214} = \$4.07$ per month beginning at end of month 2.

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4-79 Using time 1 as the reference point, set $P_1(LHS) = P_1(RHS)$

$$
\begin{aligned}
K(P/A,12\%,2)\ (P/F,12\%,2) &= \$100(P/A,12\%,6) + \$110(P/G,12\%,6) \\
K(1.6901)\ (0.7972) &= \$100(4.1114) + \$110(8.93) \\
1.3473\ K &= \$1{,}393.44 \\
K &= \$\underline{1{,}034.25}
\end{aligned}
$$

4-80 F = \$1,000 (F/A, 8%, 4) (F/P, 8%, 1) − \$200 (P/G, 8%, 4) (F/P, 8%, 5)

= \$1,000 (4.5061) (1.08) − \$200 (4.65) (1.4693) = \$<u>3,500.14</u>

4-81 A $= [\$2,000\ (P/A,8\%,4) + \$400\ (P/G,8\%,4)]\ (P/F,8\%,2)\ (A/F,8\%,11)$

$= [\$2,000\ (3.3121) + \$400\ (4.650)]\ (0.8573)\ (0.0601) = \$\underline{437.14}$

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4-82 Savings in heat loss: $\$3{,}000(0.8) = \$2{,}400$ next year

Savings will increase by: $\$200(0.8) = \$160$ each year (gradient)

$$
\begin{aligned}
P_0(\text{savings}) &= \$2{,}400(P/A,10\%,15) + \$160\ (P/G,10\%,15) \\
&= \$2{,}400\ (7.6061) + 160\ (40.15) \\
&= \$\underline{24{,}678.64}
\end{aligned}
$$

The present equivalent value of the savings is greater than the installation cost of \$18,000. Therefore recommend installing the insulation.

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4-83 Using time 1 as the equivalence point:

$$- R\,(P/G,15\%,N-1) = -27R\,(P/F,15\%,3) + 27R\,(P/F,15\%,9)$$

$$- R\,(P/G,15\%,N-1) = -27R\,(0.6575) + 27R\,(0.2843)$$

$$(P/G,15\%,N-1) = 10.0764$$

From Table C-15, $(P/G,15\%,7) = 10.192$, thus $N - 1 = 7$ and N = 8 years.

4-84 The present equivalent of energy savings can be determined with Equation (4-30):

$$P = \$18{,}000\,\frac{1-(P/F,15\%,10)(F/P,12\%,10)}{0.15-0.12} = \$18{,}000(0.2322)/0.03 = \$139{,}320.$$

Therefore, the investment in the insulation is justified by a wide margin.

4-85 Note N = 6

$$P_0 = -\frac{\$175{,}000[1-(P/F{,}18\%{,}5)(F/P{,}8\%{,}6)]}{0.18-0.08}$$

$$= \frac{\$175{,}000[1-(0.3704)(1.58690]}{0.10}$$

$$= \$721{,}371$$

You can afford to spend as much as $\underline{721,371}$ for a higher quality heat exchanger.

4-86 $P_{S1} = \$1{,}000 + \dfrac{\$1{,}000(1.05)[1-(P/F,10\%,5)(F/P,5\%,5)]}{0.10-0.05} = \$5{,}358.45$

$P_{S2} = \dfrac{\$2{,}000[1-(P/F,10\%,5)(1-0.06)^5]}{0.10+0.06} = \$6{,}804$

Choose S2.

4-87 $P = \dfrac{\$500[1 - (P/F,12\%,15)(F/P,6\%,15)]}{0.12 - 0.06}$

$= \$\underline{4,684.51}$

4-88 $P_{Gas} = \dfrac{\$8,800[1-(P/F,18\%,15)(F/P,10\%,15)]}{0.18-0.10} = \$71,632$

$P_{Maint.} = \dfrac{\$345(1.15)[1-(P/F,18\%,15)(F/P,15\%,15)]}{0.18-0.15} = \$4,239$

A = (\$71,632 + \$4,239)(A/P, 18%, 15) = \$14,901

4-89 $\$1{,}304.35\,(1+\bar{f})^{10} = \$5{,}276.82$; Solving yields $\bar{f} = 15\%$

$$P_{-1} = \frac{\$1{,}304.35[1-(P/F,20\%,11)(F/P,15\%,11)]}{0.20-0.15}$$

$$= \frac{\$1{,}304.35[1-(0.1346)(4.6524)]}{0.05}$$

$$= \$9{,}750.98$$

$\therefore\ P_0 = \$9{,}750.98\,(F/P,20\%,1) = \$9{,}750.98\,(1.20) = \$11{,}701.18$

$\therefore\ A = \$11{,}701.18\,(A/P,20\%,10) = \$11{,}701.18\,(0.2385) = \$\underline{2{,}790.73}$

4-90 $F = \dfrac{\$2{,}200[1-(P/F, 7\%, 40)(F/P, 3\%, 40)]}{0.07-0.03}(F/P, 7\%, 40) = \$644{,}128$

4-91 **(a)** $P_0 = \dfrac{\$10{,}000[1-(P/F,12\%,8)(F/P,7\%,8)]}{0.12-0.07}$

$$= \frac{\$10{,}000[1-(0.4039)(1.7182)]}{0.05}$$

$$= \$\underline{61{,}204}$$

We can justify spending up to $61,204 for the device

(b) Using the result of part (a):

A = $61,204 (A/P, 12%, 8) = $61,204 (0.2013) = $<u>12,320</u>

4-92 $P = \$1{,}000\,(P/A, 12\%, 15) + \dfrac{\$300[1-(P/F,12\%,10)(F/P,6\%,10)]}{0.12-0.06} = \$8{,}012$

4-93 **(a)** $P_0 = \dfrac{\$5{,}000[1-(P/F, 8\%, 8)(F/P, 6\%, 8)]}{0.08-0.06} = \$34{,}717$

(b) $P_0' = \$4{,}000\ (P/A, 8\%, 8) + G\ (P/G, 8\%, 8)$

(c) Set $P_0 = P_0'$ and solve for G = \$658.80.

4-94 $F = \$2{,}000\ (F/A, 4\%, 5)(F/P, 4\%, 1)(F/P, 6\%, 4) = \$14{,}223$

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4-95 F = [$1,000 (F/P, 10%, 1)(F/P, 12%, 1) + $1,000](F/P, 12%, 1)(F/P, 14%, 1) = $2,850

4-96 F = \$10,000 (F/P, 14%, 1) (F/P, 12%, 1)(F/P, 10%,2)(F/P,12%,1)
= \$10,000 (1.14) (1.12)(1.21)(1.12) = \$<u>17,303.19</u>

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4-97 P = \$1,000 (P/F, 8%, 1) + \$2,000 (P/F, 10%, 1)(P/F, 8%, 1)

+ \$1,000 (P/F, 6%, 1)(P/F, 8%, 1)(P/F, 10%, 1)(P/F, 8%, 1)

+ \$2,000 (P/F, 6%, 3)(P/F, 8%, 1)(P/F, 10%, 1)(P/F, 8%, 1)

= \$1,000 (0.9259) + \$2,000 (0.9091)(0.9259)

+ \$1,000 (0.9434)(0.9259)(0.9091)(0.9259)

+ \$2,000 (0.8396)(0.9259)(0.9091)(0.9259)

= \$<u>4,653.33</u>

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4-98 $A_{Card\ 1}$ = \$4,500 (A/P, 21/12 %, 120) = \$89.97
$A_{Card\ 2}$ = \$5,700 (A/P, 2%, 120) = \$125.67
$A_{Card\ 3}$ = \$3,200 (A/P, 1.5%, 120) = \$57.66
$A_{Consolidated}$ = \$13,400 (A/P, 16.5/12 %, 120) = \$228.66

Mary's current monthly payments total \$273.30. The consolidated payment represents a (\$273.30 − \$228.66)/\$273.30 × 100% = 16.3%. So while consolidating the credit cards will benefit Mary, the company has overstated the amount of this savings.

4-99 **(a)** r = 10%, M = 2/yr ; i = $\left[1+\frac{r}{M}\right]^{M} - 1 = \left[1+\frac{0.1}{2}\right]^{2} - 1 = 0.1025 = \underline{10.25\%}$

(b) r = 10%, M = 4/yr ; i = $\left[1+\frac{r}{M}\right]^{M} - 1 = \left[1+\frac{0.1}{4}\right]^{4} - 1 = 0.1038 = \underline{10.38\%}$

(c) r = 10%, M = 52/yr ; i = $\left[1+\frac{r}{M}\right]^{M} - 1 = \left[1+\frac{0.1}{52}\right]^{52} - 1 = 0.1051 = \underline{10.51\%}$

4-100 $[1 + 0.05875/X]^X - 1 = 0.0604$ $\quad$ $X = 12$ (monthly compounding)

4-101 i / 6 months = 8% / 2 = 4%; N = 5 years = 10 6−month periods

A = \$3,000 (A/F, 4%,10) = \$3,000 (0.0833) = \$249.99

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4-102 (a) For a 30−year loan:

A = \$300,000 (A/P, 0.5%, 360) = \$300,000 (0.0060) = \$1,800 per month

For a 50 year loan:

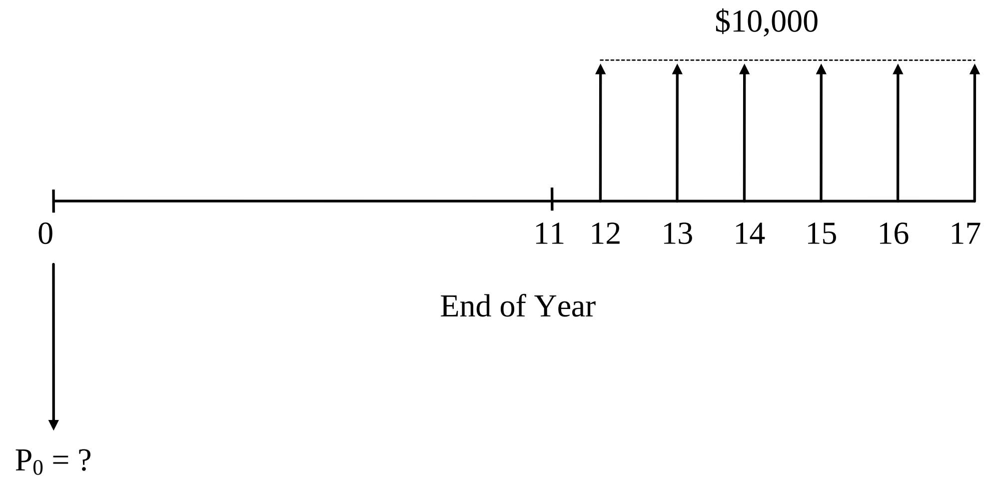
A = \$300,000 (A/P, 0.5%, 600) = \$300,000 (0.0053) = \$1,590 per month

The difference is \$210 per month.

(b) 30−year: Total interest paid = \$1,800 (360) − \$300,000 = \$348,000
50−year: Total interest paid = \$1,590 (600) − \$300,000 = \$654,000

Difference = \$306,000

4-103 $r = 12\%$; $M = 12$; $i\,/\,yr = (1 + \frac{0.12}{12})^{12} - 1 = 0.1268$ or 12.68%



$P_0 = \$10{,}000(P/A,12.68\%,6)(P/F,12.68\%,11)$

$= \$10{,}000\ (4.034)(0.2689) = \$\underline{10{,}847.43}$

4-104 A = $50,000,000 (A/F, 2%, 80) = $50,000,000 (0.0052) = $260,000 per quarter

4-105 i / qtr = 12% / 4 = 3%; N = 10 years = 40 quarters

F = \$7,500 (F/P,3%,40) = \$7,500 (3.2620) = \$<u>24,465</u>

OR

r = 12%, M =4, $i_{eff/yr} = \left(1+\dfrac{0.12}{4}\right)^4 - 1$ = 0.1255 or 12.55%

F = \$7,500 (F/P,12.55%,10) = \$7,500 (3.2620) = \$<u>24,465</u>

4-106 Monthly interest = 2.4% / 12 = 0.2% per month. The present equivalent of payments is

$$P = \$1,238 + \$249\ (P/A, 0.2\%, 39) = \$1,238 + \$249\ (37.4818) = \$10,571$$

The difference is \$3,429 against the MSRP, so this 24.5% discount is very good for the buyer.

4-107 **(a)** A = \$10,000 (A/P, 1% per month, 36 months)
= \$10,000 (0.0332) = \$<u>332</u>

(b) 0 = \$9,800 − \$332 (P/A, i' per month, 36 months)
By trial and error, i' = 1.115% per month so the true APR is
12 (1.115%) = <u>13.38% per year</u>

4-108 **(a)** F = \$200 (F/A, 0.5%, 360) = \$200 (1004.52) = \$200,904.

The \$200 (360) = \$72,000 paid into the account grows to \$200,904 through compounding over 30 years (360 months).

(b) F in today's spending power = \$200,904 (P/F, 2%, 30) = \$200,904 (0.5521) = \$110,919. Thus, the spending power equivalent is about half the amount saved in part (a). Now you can see why it is important for the Federal Reserve Board to keep a modest inflation rate (2−3% per year) in the economy.

4-109 **(a)** A = \$20,000 (A/P, 0.75%, 36) = \$20,000 (0.0318) = \$636
Interest = \$636 (36) − \$20,000 = \$2,896

A = \$20,000 (A/P, 0.75%, 72) = \$20,000 (0.0180) = \$360
Interest = \$360 (72) − \$20,000 = \$5,920

Difference = \$3,024

(b) You would be willing to pay this extra interest if either you can't afford the \$636 payment or if you can invest at > 0.75% per month.

4-110 Number of monthly deposits = (5 years)(12 months/yr) = 60

$400,000 = $200,000(F/P, i' / month, 60) + $676(F/A, i' / month, 60)

Try i' / month = 0.75%: $400,000 > $364,126.69, $\therefore$ i' / month > 0.75%
Try i' / month = 1%: $400,000 < $418,548.72, $\therefore$ i' / month < 1%

Using linear interpolation:

$$\frac{i'/\text{month} - 0.75\%}{\$400{,}000 - \$364{,}126.69} = \frac{1\% - 0.75\%}{\$418{,}548.72 - \$364{,}126.69}; \qquad i' / \text{month} = 0.9148\%$$

Therefore, i' / year = $(1.009148)^{12} - 1 = 0.1155$ or 11.55% per year

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4-111 **(a)** $\$1,100 = \$19.80 (P/A, 1.5\%, N)$, so $(P/A, 1.5\%, N) = 55.5556$

This can be solved by trial and error or using Excel.

N = NPER (0.015, 19.8, −1100) = 120

(b) N = NPER (0.015, 29.8, −1100) = 54

(c) Difference = $19.80 (120) − $29.80 (54) = $766.80

4-112 $0.35 = e^r - 1 \quad e^r = 1.35 \qquad r = \ln(1.35) \quad \underline{r} = 30\%$

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4-113 $i = e^{0.11333} - 1 = 0.12$ or 12% per year

4-114 $i = e^{0.06} - 1 = 0.0618$ or 6.18% per year

4-115 **(a)** $A = \$8{,}000(A/F,\underline{8}\%,10) = \dfrac{\$8{,}000}{(F/A,\underline{8}\%,10)} = \dfrac{\$8{,}000}{14.7147} = \underline{\$543.67}$

(b) $P = \$1{,}000(P/A,\underline{8}\%,12) = \$1{,}000(7.4094) = \underline{\$7{,}409.40}$

(c) $r = 8\%/2\% = \underline{4}\%$

$$F = \$243(F/A,\underline{4}\%,12) = \$243\left[\frac{e^{(0.04)(12)}-1}{e^{0.04}-1}\right] = \$243(15.0959) = \underline{\$3{,}668.30}$$

(d) $F = \$1{,}000(F/P,\underline{8}\%,9) = \$1{,}000(2.0544) = \underline{\$2{,}054.40}$

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4-116 Set Equivalent cash outflows = Equivalent cash inflows

Using time 9 as the equivalence point,

$$Z\,(F/P,\underline{20}\%,9) = \$500(F/A,\underline{20}\%,5) + Z\,(F/P,\underline{20}\%,6)$$
$$6.0496\,Z = \$500(7.7609) + 3.3201\,Z$$
$$2.7295\,Z = \$3{,}880.45$$
$$Z = \underline{\$1{,}421.67}$$

4-117 $i = e^{0.072} - 1 = 0.0747$ or 7.47% per year

$F = \$5,000\ e^{0.072(2)} = \$5,774.42$

4-118 F_{18} = \$10,000 (F/P,8%,18) = \$10,000 (4.2207) = \$42,207

4-119 $\underline{r}$ = 10% / 2 = $\underline{5}$% every six months, compounded continuously

$$A = \$18{,}000(A/P,\ \underline{5}\%,24) = \frac{\$18{,}000}{(P/A,\underline{5}\%,24)} = \frac{\$18{,}000}{13.6296} = \underline{\$1{,}320.66}$$

4-120 P = \$3,500 (P/A,<u>10</u>%,5) = \$3,500 (3.7412) = \$<u>13,094.20</u>

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4-121 $\$16,000 = \$7,000\ (F/P, r\%, 9)$

$\$16,000 = \$7,000\ e^{9r}$; $2.2857 = e^{9r}$; $9r = \ln(2.2857) = 0.8267$

$r = 0.0919$ or 9.19%

4-122 r = 10% per year, compounded continuously

(a) F = \$2000 (F/A,10%,30] = \$2000 (181.472) = \$362,944

(b) $A = \$362,944(A/P,\underline{10}\%,10) = \dfrac{\$362,944}{(P/A,\underline{10}\%,10)} = \dfrac{\$362,944}{6.0104} = \underline{\$60,386}$

4-123 **(a)** False; **(b)** False; **(c)** False; **(d)** True; **(e)** False; **(f)** True; **(g)** False; **(h)** False; **(i)** False

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4-124 **(a)** True; $i/yr = e^r - 1 = e^{0.1} - 1 = 0.1052$ or $10.52\% > r = 10\%$

(b) True; In fact, more than half of the principal is still owed after the tenth monthly payment is made.

$r = \underline{10}\% / 12 = \underline{0.833}\%$ per month compounded continuously.

$$P_0 = \$185(P/A,\underline{0.833}\%,24) = \$185\left(\frac{e^{0.00833(24)} - 1}{e^{0.00833(24)}(e^{0.00833} - 1)}\right)$$

$$= \$185(21.6627) = \$4{,}008$$

Amount still owed immediately following tenth payment $= \$185(P/A,\underline{0.833}\%,10) = \$185(13.1595) = \$2{,}435$

$$\frac{\$2{,}435}{\$4{,}008} * 100 = 61\%$$ of principal is still owed after tenth payment.

(c) False; $r = 8\%$, $M = 2$, $i/yr = \left[1 + \frac{0.08}{2}\right]^2 - 1 = 0.0816 = 8.16\%$

$F = P(F/P, i\%, N)$

$\$1{,}791 \stackrel{?}{=} \$900\ (F/P,8.16\%,10)$

$\$1{,}791 \stackrel{?}{=} \$900\ (1.0816)^{10}$

$\$1{,}791 \neq \$1{,}972$

(d) False; $$(P/A, i\%, N) = \sum_{k=1}^{N}(P/F,\ i\%, k) \neq \frac{N}{1+i}$$

(e) Part i) $(P/A,i\%,N)\ \underline{(F/P,i\%,N)} = (F/A,i\%,N)$

Note: $$\frac{(F/A,i\%,N)}{(P/A,i\%,N)} = (F/A,i\%,N)(A/P,i\%,N) = \left[\frac{(1+i)^N - 1}{i}\right]\left[\frac{i\,(1+i)^N}{(1+i)^N - 1}\right]$$

$$= (1+i)^N = (F/P,i\%,N)$$

Part ii) $(A/G,i\%,N)(P/A,i\%,N) = \underline{(P/G,i\%,N)}$

Note: $$(A/G,i\%,N)(P/A,i\%,N) = \left[\frac{1}{i} - \frac{N}{(1+i)^N - 1}\right]\left[\frac{(1+i)^N - 1}{i(1+i)^N}\right]$$

$$= \frac{1}{i}\left[\frac{(1+i)^N - 1}{i(1+i)^N} - \frac{N}{(1+i)^N}\right]$$

$$= (P/G,i\%,N)$$

4-125 F = \$10,000 (F/P, 11%, 25) = \$10,000 (13.5855) = \$135,855

F (in today's dollars) = \$135,855 (P/F, 3%, 25) = \$135,855 (0.4776) = \$64,884

4-126 (a) Javier's monthly mortgage payment is

$$\$100{,}000\ (A/P,\ 0.5\%,\ 360) = \$100{,}000\ (0.0060) = \$600$$

After adding the additional \$400 for property taxes and insurance, the total condo payment is \$1,000 per month.

(b) This is an open−ended exercise for students to have fun with. Utilities could easily be in the \$300−\$500 per month ballpark. Condo homeowner association fees might be another \$100−\$200 per month. Other miscellaneous expenses could bring Javier's total monthly expenses to \$1,500−\$1,700. This is a fairly expensive undertaking for Javier!

(c) The monthly interest rate is 5.8% / 12 = 0.4833%. Javier's monthly mortgage payment will be \$100,000 (0.0083) = \$830. The savings in interest paid on the mortgage between the answers in parts (a) and (c) is enormous (\$66,600).

4-127 If the rate of return on your invstment is about 14% per year, set up cash flow diagrams for starting to save at age 20 (first deposit at age 21), age 25 and age 30 to determine that

A = 0.0007F for 40 years of saving
2A = 0.0014F for 35 years of saving
4A = 0.0028F for 30 years of saving.

Here F = $1,000,000 and the coefficient of F is the appropriate (A/F, i%, N) factor. The big assumption is whether you can earn 14% per year on your investments. If not, the above statement is not true. That it is true for i = 14% is a real eye–opener for most students. Moral: start saving early!

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4-128 Let's start (guess) that three points (\$3,000) are paid up front on a loan over 15 (12) = 180 months. The loan amount will be \$103,000(A/P, 0.5%, 180) = \$103,000(0.0084) = \$865.20 per month. The true interest rate per month on the loan is found as follows: \$100,000 = \$865.20(P/A, i%, 180), or i = 0.5325% per month. The effective interest rate per year is $(1 + 0.005325)^{12} - 1 = 0.0658$ or 6.58% per year. Thus, three points are being charged (lucky starting guess).

Solutions to Spreadsheet Exercises

4-129 See P4-129.xls.

Credit Card Balance:	$17,000
Credit Card APR:	12%

Plan 1: Pay interest due at end of each month and principal at the end of fourth month.

	1	$17,000	$170	$17,170	$0	$170
	2	$17,000	$170	$17,170	$0	$170
	3	$17,000	$170	$17,170	$0	$170
	4	$17,000	$170	$17,170	$17,000	$17,170
$-mo. =		$68,000	$680	= total interest		

Plan 2: Pay off the debt in four equal end-of-month installments (principal and interest).

	1	$17,000	$170	$17,170	$4,187	$4,357
	2	$12,813	$128	$12,941	$4,229	$4,357
	3	$8,585	$86	$8,670	$4,271	$4,357
	4	$4,314	$43	$4,357	$4,314	$4,357
$-mo. =		$42,711	$427	= total interest		

Plan 3: Pay principal and interest in one payment at end of fourth month.

	1	$17,000	$170	$17,170	$0	$0
	2	$17,170	$172	$17,342	$0	$0
	3	$17,342	$173	$17,515	$0	$0
	4	$17,515	$175	$17,690	$0	$17,690
$-mo. =		$69,027	$690	= total interest		

4-130

EOY	Cash Flow
0	$ (15,000)
1	$ 2,000
2	$ 2,500
3	$ 3,000
4	$ 3,500
5	$ 4,000
6	$ 4,000
7	$ 4,000
8	$ 4,000
P	$ 2,189
A	$ 410
F	$ 4,692

Notice that a cell is not designated for the interest rate. Therefore, the interest rate must be entered specifically in the NPV, PMT, and FV financial functions. The following entries in the designated cells will yield the results for P, A, and F:

B11 = NPV (0.1, B3:B10) + B2 P = $2,189.02
B12 = PMT (0.1, A10, −B11) or = PMT (0.1, 8, −B11) A = $410.32
B13 = FV (0.1, A10, −B12) or = FV (0.1, 9, −B12) F = $4,692.38

4-131

i / yr =	25%
f =	20%
A_1 =	$ 1,000
N =	10

EOY	
1	$ 1,000
2	$ 1,200
3	$ 1,440
4	$ 1,728
5	$ 2,074
6	$ 2,488
7	$ 2,986
8	$ 3,583
9	$ 4,300
10	$ 5,160
P =	$ 6,703
A =	$ 1,877
F =	$ 62,430

4-132 See P4-132.xls.

Note: This spreadsheet assumes monthly compounding.

Loan Amount	$25,000
# of Payments	60

APR	Payment
0%	$416.67
1%	$427.34
2%	$438.19
3%	$449.22
4%	$460.41
5%	$471.78
6%	$483.32
7%	$495.03
8%	$506.91
9%	$518.96
10%	$531.18
11%	$543.56
12%	$556.11

Solutions to Case Study Exercises

4-133 Amount set aside each month = \$311.40
Interest rate = 3%/12 = ¼% per month
First payment occurs at the end of the first month of year 6
Amount available at end of 10−year time frame:

$$F = \$311.40\ (F/A,\ ¼\%,\ 60) = \$311.40\ (64.6467) = \underline{\$20{,}130.98}$$

4-134 Assume the utility cost remains at \$150 per month.

Assume a property tax and insurance rate equal to 25% of the principal and interest (P&I) payment.

Total Monthly Payment = \$800 = 1.25 (P&I)
P&I = \$640

Assume a 30−year mortgage at 6% compounded monthly.

Mortgage amount = \$640 (P/A, ½%, 360) = \$640 (166.7916) = \$106,747

Maximum purchase price = \$106,747 + \$40,000 = <u>\$146,747</u>

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4-135 A = \$320; i = 10%/12 = 0.833% per month; N = 120 months

F = \$320 (F/A, 0.833%, 120) = \$320 (204.7981) = <u>\$65,535.39</u>

Solutions to FE Practice Problems

4-136 $\underline{I} = (P)(N)(i) = \$3,000\ (7)\ (0.06) = \$1,260$
$F = P + \underline{I} = \$3,000 + \$1,260 = \$4,260$

<u>Select (e)</u>

4-137 $P = \$100,000\ (P/F, 10\%, 25)$
$= \$100,000\ (0.0923) = \$9,230$

<u>Select (b)</u>

4-138 $F = \$2{,}000\ (F/A,2\%,30) = \$2{,}000\ (40.5681)$
$= \$81{,}136$

<u>Select (d)</u>

4-139 i / mo. = 0.5%, N = 30 x 12 = 360 months

P = \$1,500 (P/A, 0.5%, 360)

$$= \$1,500 \left[\frac{(1.005)^{360} - 1}{(0.005)(1.005)^{360}} \right]$$

= \$1,500 (166.7916) = \$250,187

<u>Select (c)</u>

4-140 $A = \$8,000; G = \$7,000$

$A_{total} = \$8,000 + \$7,000 (A/G, 12\%, 5)$

$= \$8,000 + \$7,000 (1.7746) = \$20,422$

Select (a)

4-141 \$9,982 = \$2,500 (P/A, i', 5)

3.9928 = (P/A, i', 5); i' = 8% / yr

\$9,982 = G (P/G. 8%, 5)

\$9,982 = G (7.372)

G = \$1,354

<u>Select (d)</u>

4-142 5 years x 12 month/year = 60 months; i/mo. = 9%/12 = 3/4%

A = \$15,000 (A/P, 3/4%, 60) = \$15,000 (0.0208) = \$312

Select (c)

4-143 $i_{monthly} = \frac{6.00\% \text{ / year}}{12 \text{ months / year}} = 1/2\% \text{ / month}$

A = \$100,000 (A/F, 1/2%, 60) = 100,000 (0.0143) = \$<u>1,430</u>

<u>Select (d)</u>

4-144 A = \$20,000 (A/P,1%,60) = \$444

P (of remaining 40 payments) = \$444 (P/A,1%,40) or P = \$14,579

<u>Select (c)</u>

4-145 i / mo. = 12%/12 = 1% per month; N = 4 x 12 = 48 months

A = $5,000 (A/P, 1% per month, 48 months)

= $5,000 (0.0263) = $131.50

<u>Select (a)</u>

4-146 $0.192 = e^r - 1$

$r = \ln(1.192) = 17.56\%$

<u>Select (c)</u>

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4-147 $r = 12\%$

$i = e^{0.12} - 1 = 0.1275$ or 12.75% compounded annually

<u>Select (c)</u>

4-148 $F = \$7{,}000\ (F/P, \underline{12\%}, 3) = \$7{,}000\ e^{(0.12)(3)}$
$= \$7{,}000e^{0.36}$
$= \$7{,}000\ (1.4333) = \$10{,}033$

<u>Select (c)</u>

Solutions to Chapter 5 Problems

5-1 No. A higher MARR reduces the present worth of future cash inflows created by savings (reductions) in annual operating costs. The initial investment (at time 0) is unaffected, so higher MARRs reduce the price that a company should be willing to pay for this equipment.

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5-2 **(a)** PW (12%) = − \$640,000 + \$180,000 (P/A,12%,8) − \$42,000 (P/A,12%,8)
+ \$4,000 (P/G, 12%,6)(P/F,12%,2) + \$20,000 (P/F,12%,8)
= − \$640,000 + \$180,000 (4.9676) − \$42,000 (4.9676)
+ \$4,000 (8.930)(0.7972) + \$20,000 (0.4039)
= \$<u>82,082.78</u>

(b) Based on PW, the proposal is acceptable.

5-3 Bonus = \$12.5 million (P/A, 20%, 3)(0.001) = \$26,331. This is a very nice bonus for Josh's contribution to the company. (The international passengers did not balk at this idea because flights have been packed to capacity for the past year.)

5-4 $PW(12\%) = -\$13{,}000 + \$3{,}000\ (P/F,12\%,15) - \$100\ (P/A,12\%,15)$

$$- \$200\ (P/F,12\%,5) - \$550\ (P/F,12\%,10)$$

$$= -\$13{,}000 + \$3{,}000(0.1827) - \$100(6.8109) - \$200(0.5674)$$

$$- \$550(0.3220)$$

$$= -\$\underline{13{,}423.57}$$

5-5 Amount to deposit now = \$20,000 + \$250 (P/A, 0.5%, 360) = \$20,000 + \$250(166.7916)
= \$61,698

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5-6 Demand charge / year = $\dfrac{(\$90\,/\,\text{kW/yr})(100\,\text{hp})(0.746\,\text{kW/hp})}{0.9}$ = \$7,640 / year

Energy charge / year = $\dfrac{(\$0.08\,/\,\text{kWh})(100\,\text{hp})(0.746\,\text{kW/hp})(8{,}760\,\text{hr/yr})}{0.9}$ = \$58,089 / year

Total annual cost of operation = \$65,549

PW(15%) = −\$3,500 − \$65,549 (P/A, 15%, 10) = −\$332,477.

Notice that the annual cost of operating the motor is almost 19 times the initial investment costs of the motor!

5-7 PW(18%) = −\$84,000 + \$18,000 (P/A, 18%, 6) = −\$21,043.

Since PW < 0, this is not an acceptable investment.

5-8 The weekly interest rate equals 6.5% / 52, or 0.125% per week. The present worth of an indefinitely long payout period is \$5,000 / 0.00125 = \$4,000,000.

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5-9 Assume miles driven each year is roughly constant at 12,000. A four-speed transmission car will consume 400 gallons of gasoline each year, and the fuel cost is $1,200 per year. The annual savings due to a six-speed transmission is 0.04 ($1,200) = $48. Over a ten year life, the present worth of savings will be $48 (P/A, 6%, 10) = $353. This is how much extra the motorist should be willing to pay for a six-speed transmission.

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5-10 Desired yield per year = 10%

$$V_N = \$1,000\ (P/F,\ 10\%,\ 10) + 0.14\ (\$1,000)\ (P/A,10\%,10)$$
$$= \$1,000\ (0.3855) + \$140\ (6.1446) = \$\underline{1,245.74}$$

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5-11 V_N = \$10,000 (P/F, 1.75%, 120) + \$150 (P/A, 1.75%, 120)
= \$10,000 (0.1247) + \$150 (50.0171)
= \$8,750

The worth of Jim's bonds had dropped by \$1,250 because of the increase in the marketplace interest rates for long-term debt. With bonds, as the interest rate in the economy goes up, the value of the bond decreases and vice versa.

5-12 Desired yield per quarter = 12%/4 = 3%; N = 4(10) = 40 quarters

V_N = \$10,000 (P/F,3%,40) + 0.02 (\$10,000) (P/A,3%,40)

= \$10,000 (0.3066) + \$200 (23.1148)

= \$<u>7,688.96</u>

5-13 True interest rate in the IRR associated with the equation PW(i') = 0.

$$(\$1{,}000{,}000 – \$50{,}000) – \$40{,}000\ (P/A,i',15\%) - \$70{,}256\ (P/A,i',15) – \$1{,}000{,}000\ (P/F,i',15) = 0$$

$$\$950{,}000 - \$110{,}526\ (P/A,i',15\%) - \$1{,}000{,}000\ (P/F,i',15) = 0$$

at 10%: $\$950{,}000 - \$110256\ (7.6061) - \$1{,}000{,}000\ (0.2394) = -\$128{,}018$
at 12%: $\$950{,}000 - \$110{,}256\ (6.8109) - \$1{,}000{,}000\ (0.1827) = +\$16{,}357$

By interpolation, <u>i' = 11.773%</u>

5-14 Purchase price of the bonds = \$9,780
Annual interest paid by the government = (0.05)(\$10,000) = \$500
Redemption value in 10 years = \$10,000

Yield on the bonds is found by finding i′ that satisfies the following equation:

$$0 = -\$9{,}780 + \$500\,(P/A, i', 10) + \$10{,}000\,(P/F, i', 10)$$

$$i' = 5.29\% \text{ per year (the yield)}$$

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5-15 Interest payments from bond = \$100,000 (0.0725) = \$7,250 every six months

$P_0 = 0 = -\$100,000 + \$7,250\ [P/A,i'\%,10(2)] + \$110,000\ [P/F,i'\%,10(2)]$

$PW(7\%) = \$5,230.50 \quad > 0, \therefore i'\% > 7\%$
$PW(8\%) = -\$5,223.78 < 0, \therefore i'\% < 8\%$

Linear interpolation between 7% and 8% yields: i'% = 7.5% per six months.

5-16 **(a)** $$CW(10\%) = \frac{\$1{,}500}{0.10} + \left[\frac{\$10{,}000\,(A/F,10\%,4)}{0.10}\right](P/F,10\%,1) = \$\underline{34{,}591}$$

(b) Find the value for N for which (A/P,10%,N) = 0.10
From Table C-13, N = 80 years

5-17 AW = −\$20,000,000 (A/P, 8%, 40) − \$600,000 = −\$2,278,000

CW = −\$2,278,000 / 0.08 = −\$28,475,000

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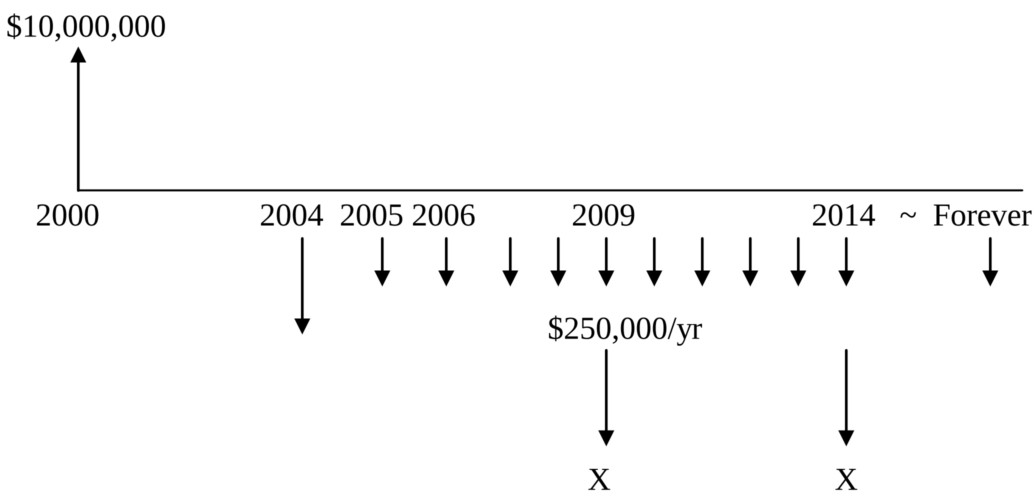
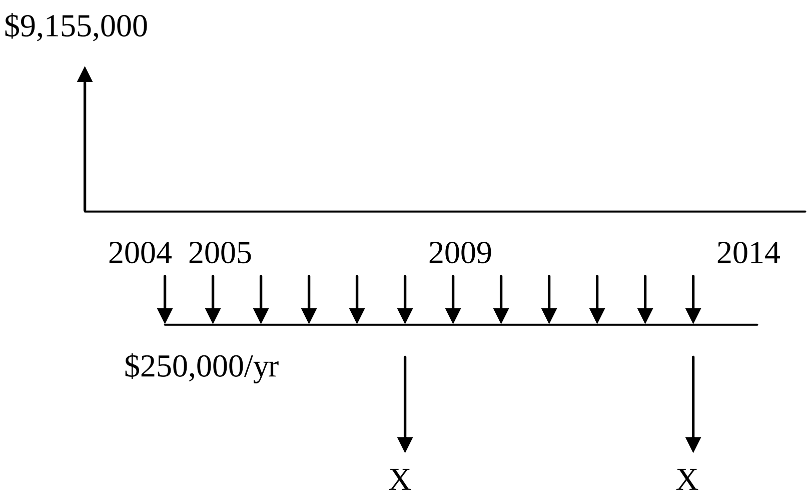
5-18



Amount at July 2004:

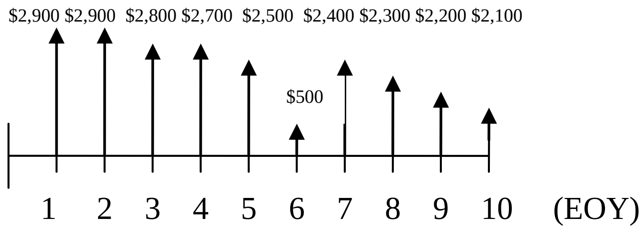
$$\$100{,}000(1.05)^4 - \$3{,}000{,}000 = \$12{,}155{,}000 - \$3{,}000{,}000 = \$9{,}155{,}000$$



$$\$9{,}155{,}000 = \$250{,}000(P/A,5\%,\infty) + X(A/F,5\%,5)(P/A,5\%,\infty)$$
$$= \$250{,}000\,(20) + 0.181X\,(20)$$

or $\underline{X = \$1{,}147{,}790 \text{ every 5 years}}$

5-19



Let A = \$2,900, G = −\$100 (delayed 1 year)
F_6 = −\$2,000

P_0 = \$2,900 (P/A,6\$,10) – 100(P/G,6%,9)(P/F,6%,1) − \$2,000(P/F,6%,6)
= \$2,900 (7.3601) − \$100 (24.5768) (0.9434) − \$2,000 (0.7050)
= \$17,615.71

FW_{10} = \$17,615.71(F/P, 6%, 10) = \$17,615.71(1.7908) = \$31,546.21

5-20 Tax savings per year = (0.034)($50,000) = $1,700

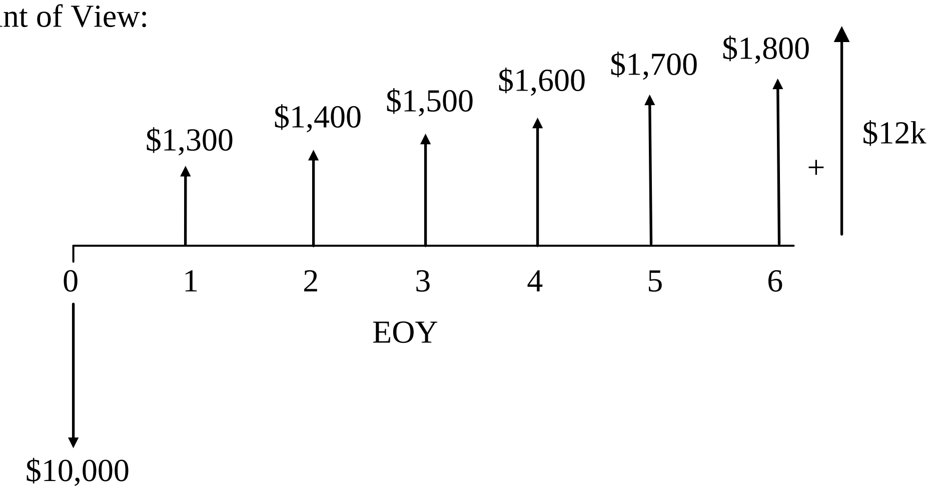
FW = $1,700 (F/A, 12%, 10) = $1,700 (17.5487) = $29,833

5-21 $FW(15\%) = -\$10{,}000\,(F/P,15\%,5) + (\$8{,}000 - \$4000)(F/A,15\%,5) - \$1{,}000$

$= -\$10{,}000\,(2.0114) + \$4000(6.7424) - \$1{,}000$

$= \$\underline{5{,}855.60}$

5-22 Your Point of View:



(R−E) = $1,300 (yr. 1)

= $1,300 + (k−1)($100) for $1 \le k \le 6$

FW(15%) = −$10,000(F/P, 15%, 6) + $1,300 (F/A, 15%, 6)
+ $100 (P/G, 15%, 6)(F/P, 15%, 6) + $12,000
= −$10,000(2.3131) + $1,300(8.7537) + $100(7.937)(2.3131) + $12,000
= $2,085.72 > 0; the investment appears to be a good one if the risk is low.

5-23 Opportunity Cost = Investment at BOY x (P/F, 15%, 1) = BOY (0.15)

Capital Recovery Amount = Opportunity Cost + Loss in Value During Year

Year	Investment at Beginning of Year	Opportunity Cost of Interest (i = 15%)	Loss in Value During Year	Capital Recovery Amount
1	\$10,000	\$10,000 (0.15) = **1,500**	\$3,000	1,500 + 3,000 = **4,500**
2	10,000−3000 = **7,000**	7,000 (0.15) = **1,050**	2,000	1,050 + 2,000 = **3,050**
3	7,000 − 2,000 = **5,000**	5,000 (0.15) = **750**	2,000	750 + 2,000 = **2,750**
4	5,000 − 2,000 = **3,000**	3,000 (0.15) = **450**	**1,000**	450 + 1,000 = **1,450**

P_0 = \$4,500 (P/F,15%,1) + \$3,050 (P/F,15%,2) + \$2,750 (P/F,15%,3)
+\$1,450 (P/F, 15%, 4)
= \$4,500 (0.8696) + \$3,050 (0.7561) + \$2,750 (0.6575) + \$1,450 (0.5718)
= \$ 8,856.54

A = \$8,856.54 (A/P,15%,4) = \$8,856.49 (0.3503) = \$<u>3,102.45</u>

This same value can be obtained and confirmed with Equation (5-5):

CR(i%) = I (A/P, i%, N) − S (A/F, i%, N)
= \$10,000 (A/P,15%,4) − \$2,000 (A/F,15%,4)
= \$10,000 (0.3503) − \$2,000 (0.2003)
= \$<u>3,102.12</u>

Note: The Annual Worth from the table and the CR amount from Equation (5-5) are the same.

5-24

Year	Investment at Beginning of Year	Opportunity Cost of Interest (i = 15%)	Loss in Value During Year	Capital Recovery Amount
1	$1,000	$50	$250 − $50 = <u>$200</u>	$250
2	1,000 − 200 = <u>800</u>	800(0.05) = <u>40</u>	200	240
3	600	30	200	230
4	600 − 200 = <u>400</u>	20	400 − 300 = <u>100</u>	20 + 100 = <u>120</u>

(a) Loss in Value = Capital Recovery Amount − Opportunity Cost

(b) Investment at BOY_2 = Investment at BOY_1 − Loss in Value during Year 1

(c) Opportunity Cost = Investment at BOY * (0.05)

(d) Investment at BOY_4 = Investment at BOY_3 − Loss in Value during Year 3

(e) Loss in Value during year 4 = Investment at BOY_4 − Salvage Value at EOY_4

(f) Capital Recovery Amount = Opportunity Cost + Loss in Value during Year

5-25 $AW(20\%) = -\$50{,}000\ (A/P, 20\%, 5) + \$20{,}000 - \$5{,}000 = -\$1{,}720 < 0$.

Not a good investment.

5-26 $AW(18\%) = -\$15{,}000(A/P, 18\%, 2) + \$10{,}000 - \$3{,}000 + \$10{,}000(A/F, 18\%, 2) = \$2{,}006.50 > 0$.

A good investment.

5-27 Capital Investment = −\$300,000 − \$600,000 − \$250,000 − \$100,000 = −\$1,250,000

Revenue = \$750,000 per year

Market Value = \$400,000 + \$350,000 + \$50,000 = \$800,000

Expenses = −\$475,000 per year

$$\begin{aligned} AW(15\%) &= \$750{,}000 - \$475{,}000 - \$1{,}250{,}000(A/P, 15\%, 10) + \$900{,}000(A/F, 15\%, 10) \\ &= \$275{,}000 - \$1{,}250{,}000(0.1993) + \$900{,}000(0.0493) \\ &= \underline{\$70{,}245} > 0 \end{aligned}$$

Therefore, they should invest in the new product line (Note: all of the \$100,000 working capital recovered at the end of year 10).

5-28 **(a)** Initial investment = \$54,000 (one-time cost)
Operating expenses = \$450 + \$7.50(3,000) = \$22,950 per year (recurring expense)
Disposal = \$8,000 (one-time cost)

AW(15%) = −\$54,000(A/P, 15%, 8) − \$22,950 − \$8,000(A/F, 15%, 8) = −\$35,570

(b) Fuel related cost = (\$22,500 / \$35,570) × 100% = 63.3% of the total.

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5-29 Investment cost of new buses = 35 ($40,000 − $5,000) = $1,225,000

Annual fuel + maintenance = $144,000 − $10,000 = $134,000

EUAC(6%) = $1,225,000(A/P, 6%, 15) + $134,000 = $260,175

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5-30 F_{14} = A(F/A,4%,17) = 23.6975A
F_{11} = 23.6975A (P/F,4%,3) = 21.067A

so then

21.067A = \$32,500(P/F,4%,1)+ \$34,125(P/F,4%,2) + \$35,750 (P/F,4%,3)

and A = <u>\$4,490/year</u>

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5-31 The incremental investment is (0.08)($250,000) = $20,000. The equivalent annual savings (A) is then $20,000(A/P, 10%, 30) = $2,122 to justify the extra investment. If this savings represents 15% of the total annual heating and cooling expense, the total annual expenditure would have to be $14,147. This is high in most parts of the U.S., so green homes are difficult to justify on economic grounds alone. Can you list some non-economic considerations that may bear on the decision to build a green home?

5-32 Let X = units produced per year. Then the breakeven equation becomes:

$$AW(15\%) = -\$500{,}000(A/P, 15\%, 5) - \$35{,}000 + X(\$50 - \$7.50) = 0$$

Solving yields X = 4,333 units per year.

5-33 Monthly gasoline savings = 10 gallons x \$2.75 per gallon = \$27.50 per month.

\$1,200 = \$27.50 per month × (P/A, 0.5% per month, N months)
(P/A, 0.5%, N) = 43.64

From Table C-2, 48 < N < 60

Interpolating yields N = 50 months.

Using Excel, NPER(0.005, 27.5, −1200) = 49.35

5-34 **(a)** $AW = 0 = -\$10{,}000{,}000(A/P, i', 4) + \$2{,}800{,}000 + \$5{,}000{,}000(A/F, i', 4)$

Solving yields $i' = 18.5\%$

(b) Yes, IRR (18.5%) > MARR (15%). The plant should be built.

5-35 $PW_{cost} = PW_{benefit}$

$\$17,000 = (0.8)\ (\$4,000)\ (P/A,i\%,10) + (0.8)(\$300)(P/G,i\%,10)$

i = <u>14%</u>

5-36 $PW = 0 = -\$200,000 + (\$100,000 - \$64,000)(P/A, i', 10)$

$i' = 12.4\% >$ MARR; project is justified

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5-37 Prepay amount = \$12.95 × 12 months = \$155.40

$\$155.40 = \$12.95 + \$12.95(P/A, i', 12)$

$i' = 1.365\%$ per month

$i_{eff} = (1.0365)^{12} - 1 = 0.1767$ or 17.67% per year.

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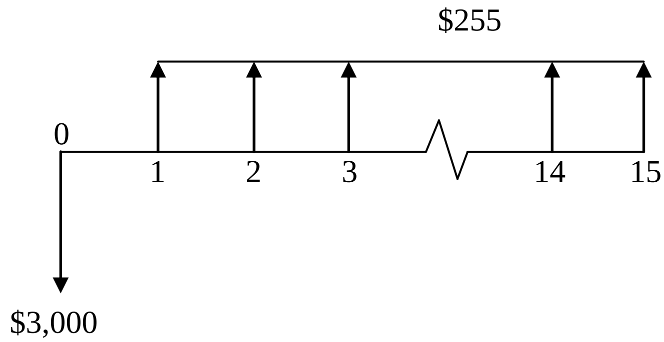
5-38



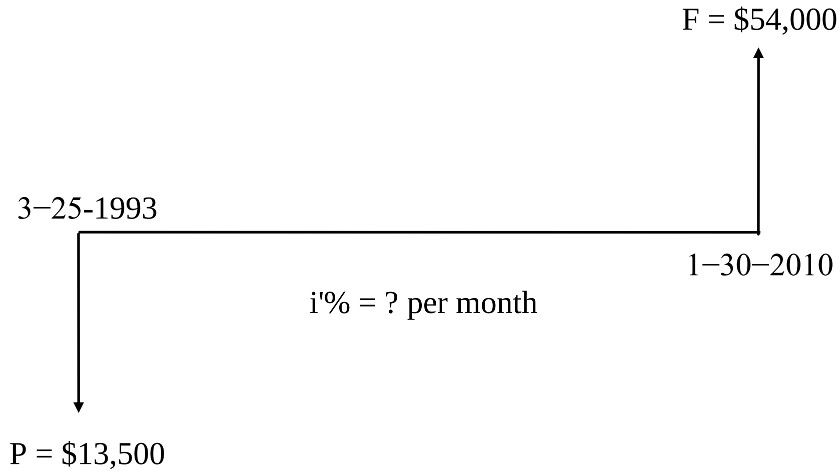
$\$3{,}000 = \$255\,(P/A, i', 15)$
$i' = 3.2\%$ per month
$r = 12 \times 3.2\% = 38.4\%$ compounded monthly (APR)
$i_{eff} = (1.032)^{12} - 1 = 0.459$ or 45.9% per year

5-39 Letting A = \$200 per month, we solve for the unknown interest rate (IRR) as follows:

$$4\,[\ \$200(120)\ ] = \$200\ (F/A,\ i' \text{ per month, } 120 \text{ months})$$
$$480 = [(1 + i')^{120} - 1] / i'$$

Solving this we find that i' = 1.98% per month. The annual effective IRR is $(1.0198)^{12} - 1 = 0.2653$. Thus, IRR = 26.53% per year – not a bad return!

5-40 The following cash flow diagram summarizes the known information in this problem.



The value of N is the number of time periods separating P and F. If monthly compounding is assumed, N equals (9 months in 1993) + (192 months from 1994 through 2009) + (1 month in 2010) = 202 months (to the nearest integer). Therefore, we can determine the unknown interest rate using:

$$F = P\,(1+ i'\%)^N;\ \$54{,}000 = \$13{,}500\,(1+ i'\%)^{202}$$

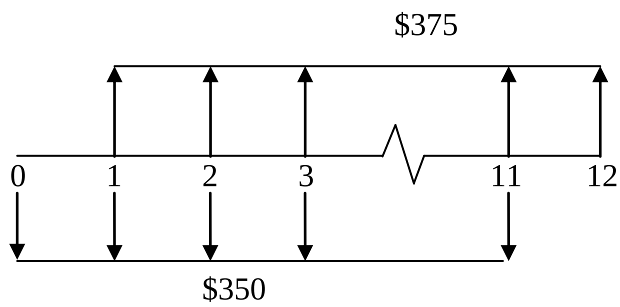
Using logarithms, i'% per month = 0.69%.

The nominal rate of interest = (12)(0.69%) = 8.28% per year and the effective annual interest rate = $[(1.0069)^{12} - 1](100\%)$ = <u>8.6% per year</u>.

5-41 $0 = -\$20,000(F/P, i', 9) - \$16,000(F/P, i', 4) + \$60,000$

Solving yields $i' = 7.57\%$ per year. This was a fairly good investment.

5-42



The CFD is from the lender's viewpoint. Equating outflows to inflows:

$$\$350 + \$350(P/A, i', 11) = \$375(P/A, i', 12)$$
$$i' = 7.14\% \text{ per month}$$

The effective annual interest rate is $(1.0714)^{12} - 1 = 1.288$ (128.8%). Jess's wife is correct, and in fact, the U.S. military is moving to correct predatory lending practices near its installations.

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5-43 \$10,000 = \$200 (F/A,i,45) (F/P,i,3) or i per month is approximately equal to 0.4165% which equates to i per year of $(1.004165)^{12} - 1 = 0.0511$ (5.11% per year). This is a conservative investment when Stan makes the assumption that the investment firm will pay him \$10,000 when he leaves the service at the end of 4 years (i.e., there is little risk involved). Stan should probably take this opportunity to invest money while he is in the service. It beats U.S. savnings bonds which pay about 4% per year.

5-44 PW(i'%) of outflows = PW(i'%) of inflows

\$308.57 (P/A,i'%,35) = \$7,800

(P/A,i'%,35) = 25.2779

(P/A,1%,35) = 29.4085 and (P/A,2%,35) = 24.9986, Therefore, 1% < i'% < 2%.

Linear interpolation yields: i'% = 1.9% per month

A.P.R. = (1.9% per month)(12 months/year) = <u>22.8% compounded monthly</u>

5-45 General Equation:

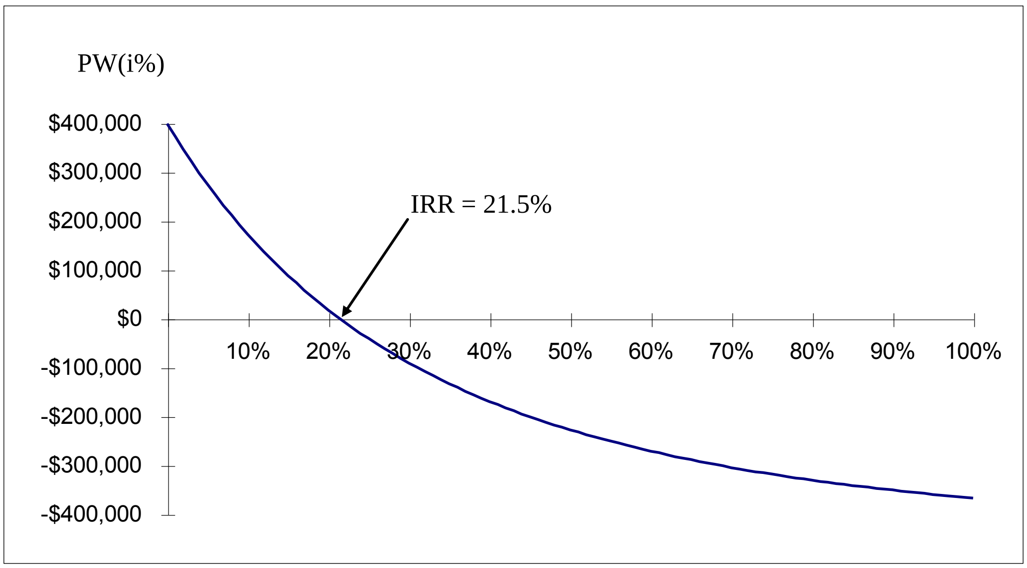
$$PW(i'\%) = 0 = -\$450{,}000 - \$42{,}500(P/F,i'\%,1) + \$92{,}800(P/F,i'\%,2)$$
$$+ \$386{,}000(P/F, i'\%, 3) + \$614{,}600(P/F, i'\%, 4)$$
$$- \$202{,}200(P/F, i'\%, 5)$$

$PW(20\%) = \$17{,}561 > 0, \therefore i'\% > 20\%$

$PW(25\%) = -\$41{,}497 < 0, \therefore i'\% < 25\%$

Linear interpolation between 20% and 25% yields: i'% = 21.5% > 10%, so the new product line appears to be profitable.

However, due to the multiple sign changes in the cash flow pattern, the possibility of multiple IRRs exists. The following graph of PW versus i indicates that multiple IRRs do not exist for this problem.



5-46 **(a)** $PW(i'\%) = 0 = -\$23{,}000 - \$1{,}200\,(P/A,i'\%,4) - \$8{,}000\,(P/F,i'\%,4)$
$+ \$5{,}500\,(P/A,i'\%,11)(P/F,i'\%,4) + \$33{,}000\,(P/F,i'\%,15)$

By linear interpolation, i'% = IRR = <u>10</u>%

(b) $FW(12\%) = -\$23{,}000(F/P,12\%,15) - \$1{,}200(F/A,12\%,4)(F/P,12\%,11)$
$- \$8{,}000(F/P,12\%,11) + \$5{,}500\,(F/A,12\%,11) + \$33{,}000$
$= -\$23{,}000(5.4736) - \$1{,}200(4.7793)(3.4785) - \$8{,}000(3.4785)$
$+ \$5{,}500\,(20.6546) + \$33{,}000$
$= -\$\underline{27{,}070.25}$

(c) $\left|-\$23{,}000 - \$1{,}200(P/A,12\%,4) - \$8{,}000(P/F,12\%,4)\right|\,(F/P,i'\%,15)$
$= \$5{,}500(F/A,12\%,11) + \$33{,}000$

$[\$23{,}000 + \$1{,}200(3.0373) + \$8{,}000(0.6355)]\,(F/P,i'\%,15)$
$= \$5{,}500(20.6546) + \$33{,}000$

$\$31{,}728.76\,(1 + i')^{15} = \$146{,}600.30$

$i' = ERR = \underline{0.1074 \text{ or } 10.74\%}$

5-47 IRR method:

$$PW(i'\%) = 0 = \$500{,}000(P/F,i'\%,1) + \$300{,}000(P/F,i'\%,2)$$
$$+ [\$100{,}000 + \$100{,}000(P/A,i'\%,7) + \$50{,}000(P/G,i'\%,7)](P/F,i'\%,3)$$
$$- \$2{,}500{,}000\ (P/F,i'\%,4)$$

i'%	Present Worth
1	$103,331.55
2	63,694.68
3	30,228.14
4	2,175.18
5	−21,130.28

i'%	Present Worth
30	−$12,186.78
31	−5,479.09
32	1,182.76

There are two internal rates of return: 4.9% and 31.2% per year.

ERR Method:

$$\left|-\$2{,}400{,}000\right|(P/F,8\%,4)(F/P,i'\%,10) = \$500{,}000(F/P,8\%,9)$$
$$+\$300{,}000(F/P,8\%,8)$$
$$+ \$100{,}000(F/P,8\%,7)$$
$$+ \$150{,}000(P/A,8\%,6)(F/P,8\%,6)$$
$$+ \$50{,}000(P/G,8\%,6)(F/P,8\%,6)$$

After solving, the external rate of return is 7.6% per year.

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5-48 The general equation to find the internal rate of return is:

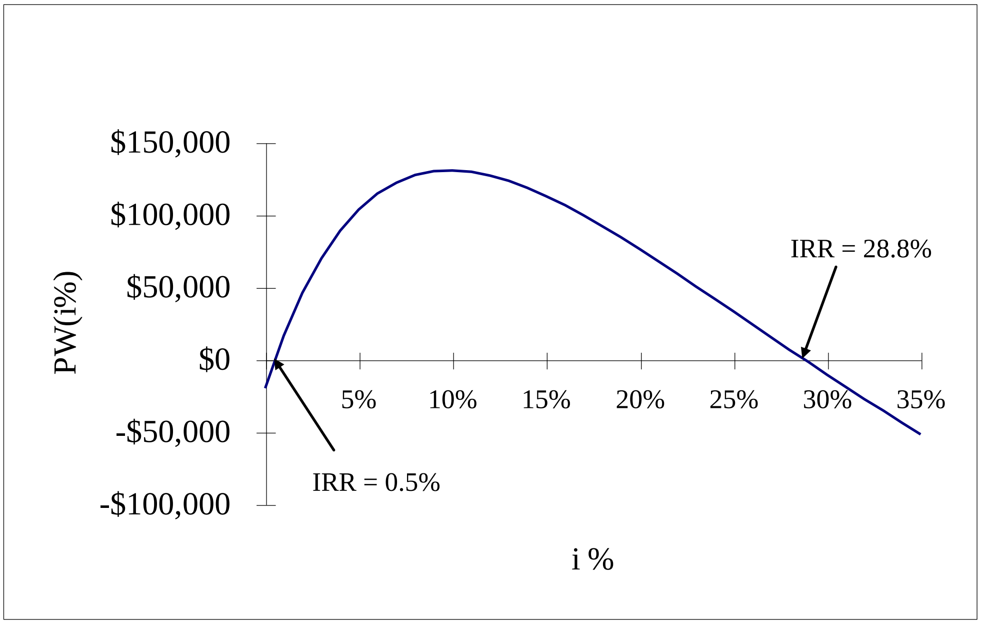
PW(i'%)= 0 = −\$520,000 + \$200,000 (P/A, i'%, 10) − \$1,500,000 (P/F, i'%, 10)

(a)

i'%	PW(i'%)
0	− \$ 20,000
0.5	0
1	10,250
4	89,000
10	131,000

i'%	PW(i'%)
15	\$113,000
20	76,000
25	33,000
30	− 10,350
40	− 89,100

i'% = 1/2% and 28.8% per year.



(b) Assume ε = 20% per year.

$\left|-\$520{,}000-\$1{,}500{,}000(P/F,20\%,10)\right|(F/P,i'\%,10)=\$200{,}000(F/A,20\%,10)$

$[\$520{,}000 + \$1{,}500{,}000(0.1615)](F/P,i'\%,10) = \$200{,}000(25.9587)$

$\$762{,}250\ (1+i')^{10} = \$5{,}191{,}740$ $\quad$ i' = 0.2115 or <u>21.15%</u>

ERR > 20%, therefore the project is economically acceptable.

5-49 To determine the simple payback period, compute the net cash flow (inflow less outflow) for each year and then determine the cumulative balance over time until a positive balance is obtained.

EOY, *k*	Cumulative Net Cash Flow (Balance)
0	−\$10,000
1	−\$14,000
2	−\$11,000
3	−\$8,000
4	−\$5,000
5	−\$2,000
6	+\$1,000

The payback period, to the nearest year, is six years. Notice that the cash flows occurring after the payback period are ignored. This project's liquidity is not very attractive, but its profitability may be acceptable. Ask your student's to compute the PW of this proposed investment when the MARR = 10% per year to see if it is profitable.

5-50 **(a)** Average electrical output per year = 285 MW (0.75) = 213.75 MW. This translates into 8,760 hours per year × 213,750 kW = 1.842.45 × 10^6 kWh per year of output. Thus, the annual profit will be \$55,273,500 when the profit of a kiloWatt hour is \$0.03. The simple payback period (once the plant is operating) is \$570,000,000 / \$55,273,500 = 10.3 years (round it up to 11 years since we are using the end of year cash flow convention). This is not a liquid investment and should be considered "high risk".

(b) The IRR is determined from the following equation (all figures in \$ millions):

$$0 = -\$285 - \$285(P/F, i', 1) + \$55.2735(P/A, i', 20)(P/F, i', 1)$$

Solving yields i′ = 6.8% per year. This is typically not an acceptable IRR to most utilities. This investment does not look attractive.

5-51 **(a)** $0 = -\$4,900 + \$1,875(P/A, i', 5)$; $i' = 26.4\%$

(b) $\theta = \$4,900 / \$1,875 = 3$ years (to the integer year)

(c) The IRR will signal an acceptable (profitable) project if the MARR is less than 26.4% and the value of θ may indicate a poor project in terms of liquidity.

(d) $1/\theta = 33.3\%$. This is the payback rate of return, and it over-estimates the actual IRR.

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5-52 **(a)** Savings = 15,000 kWh (\$0.09/kWh) = \$1,350 per year. The net annual savings will be \$1,350 − \$300 = \$1,050. For a simple payback period of two years, the hospital can afford to invest 2 × \$1,050 = \$2,100 in the project.

(b) AW(15%) = −\$2,100(A/P, 15%, 6) + \$1,050 = \$495, which indicates a favorable project.

5-53 PW(i'%) = 0 = −\$100,000 + \$20,000 (P/A,i'%,5) + \$10,000 (P/G,i'%,5) + \$10,000 (P/F,i'%,5)

PW(20%) = \$12,891 > 0, ∴ i'% > 20%
PW(25%) = −\$897 < 0, ∴ i'% < 25%

By linear interpolation, i'% = IRR = 24.7%

EOY	Cumulative Cash Flow
1	−\$100,000 + \$20,000 = −\$80,000 < 0
2	−80,000 + 30,000 = −50,000 < 0
3	−50,000 + 40,000 = −10,000 < 0
4	−10,000 + 50,000 = 40,000 > 0

∴ θ = 4 years

Although this project is profitable (IRR > MARR), it is not acceptable since θ = 4 years is greater than the maximum allowable simple payback period of 3 years.

5-54 Examine the PW(8%) at the end of year 4:

$$PW(8\%) = -\$300{,}000 - \$50{,}000(P/A, 8\%, 4) + \$100{,}000(P/G, 8\%, 4) = -\$605$$

This project does not meet the stated acceptability criterion for liquidity ($\theta' > 4$).

5-55 **(a)** FW(18%) = \$84,028 $\geq$ 0, so the profitability is acceptable.

(b) IRR = 38.4% $\geq$ 18%, so the investment is a profitable one.

(c) θ' = 4 years, so the liquidity is marginal at best.

5-56 **(a)** Annual Savings = \$2.5 billion

Affordable amount: PW = \$2.5 billion (P/A, 7%, 40) = \$33.33 billion

(b) θ = \$25 billion / \$2.5 billion = 10 years

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5-57 Find the IRR:

$$0 = -\$200,000(P/A, i', 3) + \$50,000(P/F, i', 4) + \$250,000(P/A, i', 5)(P/F, i', 4)$$

By trial and error, $i' = 17.65\%$, which is greater than the MARR. As a matter of interest, the PW(15%) = \$51,094. But the simple payback period is seven years, so the gamble in this firm is probably too great for a risk intolerant investor (like most of us).

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5-58 **(a)** Set AW(8%) = 0 and solve for S, the salvage value.

$0 = -\$2{,}000(A/P, 10\%, 8) + \$350 + S\,(A/F, 10\%, 8)$; $S = \$283.75$

(b) Set PW(i′) = 0 (or AW or FW) and solve for i′.

$0 = -\$2{,}000 + \$350(P/A, i', 8)$; $i' = 8.15\%$ per year

5-59 Because the face value (what a bond is worth at maturity) of a bond and its interest payout are fixed, the trading price of a bond will increase as interest rates go down. This is because people are willing to pay more money for a bond to obtain the fixed interest rate in a declining interest rate market. For instance, if the bond pays 8% per year, people will pay more for the bond when interest rates in the economy drop from, for example, 6% to 5% per year.

5-60 **(a)** In all three cases, IRR = 15.3%. This is true for EOY 0 as a reference point in time, and also for EOY 4 as a reference point in time.

(b) $PW_1(10\%) = \$137.24$ at EOY 0

$PW_2(10\%) = \$137.24$ at EOY 4
$PW_2(10\%) = \$93.73$ at EOY 0

$PW_3(10\%) = \$686.18$ at EOY 4
$PW_3(10\%) = \$468.67$ at EOY 0

Select (3) to maximize PW(10%). However, the PW(IRR=15.3%) would be zero for all three situations.

5-61 **(a)** Loan repayment amount = \$30 million (A/P, 6%, 40) = \$1.995 million per year.
Recurring expenses = \$4,000 (300) = \$1.2 million per year
Total annual expenses = \$1.995 million + \$1.2 million = \$3.195 million per year
Revenue = \$12,000 (300)(0.80) = \$2.88 million per year
Annual Profit (loss) = \$2.88 million − \$3.195 million = −\$0.315 million per year

(b) Revenue = \$12,000 (300)(0.95) = \$3.42 million per year
Annual Profit (loss) = \$3.42 million − \$3.195 million = +\$0.225 million per year

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5-62 We can solve for N using trial and error. If we guess N = 53 months, we'll find that economic equivalence is established with the following relationship:

$$\$50,000 = \$1,040(P/A, ¾\%, 53) + \$1,040(P/F, ¾\%, 1) + \$1,040(P/F, ¾\%, 13) + \$1,040(P/F, ¾\%, 25) + \$1,040(P/F, ¾\%, 37) + \$1,040(P/F, ¾\%, 49)$$

So N = 53 months. This means that five extra payments will reduce the loan period from 60 months to 53 months. This is a net savings of two payments ($2,080) over the loan's duration. If Javier can earn more than ¾% per month on his money, he should not make extra payments on this loan.

5-63 **(a)** AW(15%) = −\$710,000(A/P, 15%, 5) + \$198,000 + \$100,000(A/F, 15%, 5)
= \$1,828 per year.

Yes, it is a good investment opportunity

(b) IRR: 0 = −\$710,000(A/P, i′, 5) + \$198,000 + \$100,000(A/F, i′, 5)
i′ = 15.3%

θ = 4 years

θ' = 5 years

(c) Other factors include sales price of reworked units, life of the machine, the company’s reputation, and demand for the product.

Solutions to Spreadsheet Exercises

5-64

Desired Ending Balance	$ 250,000
Current Age	25
Age at Retirement	60

		Interest Rate per Year		
		4%	8%	12%
N	5	$ 4,458	$ 2,207	$ 1,036
	10	$ 6,003	$ 3,420	$ 1,875
	15	$ 8,395	$ 5,463	$ 3,470
	20	$ 12,485	$ 9,207	$ 6,706

The formula used in cell C7 is:

=−PMT(C$6,$D$3−$D$2−$B7,,D1)

Note that this uses the *fv* parameter of the PMT function instead of the *pv* parameter. The formula in cell C7 was copied over the range C7:E10.

The trend in the table shows that as the interest rate increases, less has to be saved each year. Also, the longer Jane delays the start of her annual savings, the larger the annual deposit will have to be.

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5-65 $0.1 P = P (A/P,8\%,N)$ so $N \approx 21$ years

A payout duration table can be constructed for selected payout percentages and compound interest rates as follows:

Payout/Yr (% of principal)		Interest Rate/Year 4%	6%	8%	10%
	10%	13.0*	15.7	20.9	never
	20%	5.7	6.1	6.6	7.3
	30%	3.7	3.8	4.0	4.3

* Note: Table entries are years.

5-66

MARR =		20%
Reinvestment rate =		20%
Capital Investment =	$	25,000
Market Value =	$	5,000
Useful Life =	$	5
Annual Savings =	$	8,000
Annual Expense =	$	–

EOY		Cash Flow	EOY		Cash Flow
0	$	(25,000)	0	$	(25,000)
1	$	8,000	1	$	8,000
2	$	8,000	2	$	8,000
3	$	8,000	3	$	8,000
4	$	8,000	4	$	8,000
5	$	8,000	5	$	13,000
5	$	5,000			

Present Value =	$	934.28
Annual Worth =	$	312.41
Future Worth =	$	2,324.80
Internal Rate of Return =		21.58%
External Rate of Return =		20.88%

The following table displays the results of different MARRs on the profitability measures.

	MARR = 18%	MARR = 22%
Present Worth	$ 2,202.91	$(240.89)
Annual Worth	$ 704.44	$ (84.12)
Future Worth	$ 5,039.73	$(651.04)
IRR	21.58%	21.58%
ERR	20.88%	20.88%

The original recommendation is unchanged for a MARR = 18%. However, the recommendation does change for MARR = 22% (which is greater than the IRR of the project's cash flows).
Note that the ERR is unaffected by changes in the MARR. This is because 1) the reinvestment rate was assumed to remain at 20%, and 2) there is only a single net cash outflow occurring at t=0.

5-67 See P5-67.xls.

EOY	Labor savings	Operating expenses	Net savings
0			
1	$ 15,000.00	$ (3,500.00)	$ 11,500.00
2	$ 16,050.00	$ (3,750.00)	$ 12,300.00
3	$ 17,173.50	$ (4,000.00)	$ 13,173.50
4	$ 18,375.65	$ (4,250.00)	$ 14,125.65
5	$ 19,661.94	$ (4,500.00)	$ 15,161.94
6	$ 21,038.28	$ (4,750.00)	$ 16,288.28
7	$ 22,510.96	$ (5,000.00)	$ 17,510.96
8	$ 24,086.72	$ (5,250.00)	$ 18,836.72
9	$ 25,772.79	$ (5,500.00)	$ 20,272.79
10	$ 27,576.89	$ (5,750.00)	$ 21,826.89
		PW	$ 93,560.18

The hospital can afford to pay $93,560 for this device.

5-68 See P5-68.xls.

Given:	Loan Amount	$30,000,000
	Interest Rate	6%
	Repayment Periods	40
	Annual Expenses (per apartment)	$4,000
	Number of units	300
Inputs:	Annual Rental Fee	$12,000
	Occupancy Rate	89%
Intermediate Calculations:		
	Annual Loan Payment	$1,993,846
Results:	Annual Profit (Loss)	$0

The Goal Seek function was used to find the breakeven occupancy rate of 89%.

Solutions to Case Study Exercises

5-69 Average number of wafers per week:

(10 wafers/hr)(168 hr/wk)(0.90) = 1,512

Added profit per month:

(1,512 wafers/wk)(4.333 wk/month)($150/wafer) = $982,724

PW(1%) = −$250,000 − $25,000(P/A, 1%, 60) + $982,724(P/A, 1%, 60) = $42,804,482

The increase in CVD utilization serves to make the project even more attractive.

5-70 Average number of wafers per week:

(15 wafers/hr)(168 hr/wk)(0.80) = 2,016

New breakeven point:

$$X = \frac{\$1,373,875}{(2,016)(4.333)(44.955)} = \$3.50 / \text{wafer}$$

\$3.50/\$100 = 0.035 extra microprocessors per wafer.

The retrofitted CVD tool would significantly reduce the breakeven point.

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5-71 Average number of wafers per week:

(10 wafers/hr)(150 hr/wk)(0.90) = 1,350

Added profit per month:

(1,350 wafers/wk)(4.333 wk/month)($150/wafer) = $877,433

PW(1%) = −$250,000 − $25,000(P/A, 1%, 60) + $877,433(P/A, 1%, 60)
= $38,071,126

New breakeven point:

$$X = \frac{\$1,373,875}{(1,350)(4.333)(44.955)} = \$5.225 / \text{wafer}$$

$5.225/$100 = 0.05225 extra microprocessors per wafer.

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Solutions to FE Practice Problems

5-72 The remaining loan principal immediately after the 240th payment of \$200 is:

$$\$200(P/A, 7\%/12, 120) = \$200(86.1264) = \$17{,}225$$

The IRR on this investment can be dtermined by solving for i′ in this equation:

$$0 = -\$20{,}000 - \$200(P/A, i', 240) + [\$100{,}000 - \$17{,}225](P/F, i', 240)$$

By trial and error we find that i′ is about 0.128% per month. This corresponds to an effective annual interest rate of $(1.00128)^{12} - 1 = 0.015$ (1.5%)

Select (d)

5-73 i / mo. = 9%/12 = ¾% per month; N = 4 x 12 = 48 months

$$A = \$8{,}000\ (A/P,\ ¾\%\ \text{per month},\ 48\ \text{months})$$
$$= \$8{,}000\ (.0249) = \$199.20$$

<u>Select (d)</u>

5-74

EOY	Cumulative PW (i = 12%)
0	−\$300,000
1	−\$300,000 + \$111,837.50(P/F,12%,1) = −\$200,140.30
2	−200,140.30 + \$111,837.50(P/F,12%,2) = −\$110,983.45
3	−\$110,983.45 + \$111,837.50(P/F,12%,3) = −\$31,377.52
4	−\$31,377.52 + \$111,837.50(P/F,12%,4) = \$39,695.21 > 0
	$\therefore$ Ø' = 4

<u>Select (a)</u>

5-75 $\$14,316 = X(A/P,8\%,\infty)$

$\$14,316 = X\,(0.08)$

$X = \$178,950$

<u>Select (a)</u>

5-76 Find i% such that PW(i%) = 0

$0 = -\$3{,}345 + \$1{,}100(P/A,i'\%,4)$
PW(10%) = \$141.89 tells us that i'% > 10%
PW (12%) = −\$3.97 tells us that i'% < 12% (but close!)

$\therefore$ IRR = 11.95%

Select (b)

5-77 $V_N = C(P/F,i\%,N) + rZ(P/A,i\%,N) = \$981$
N = 8 periods
r = 10% per period   ($1,000/$100 = 10%)

C = Z = $1,000

$981= $1,000(P/F,i%,8) + (.10)($1,000)(P/A,i%,8)
$981 = $1,000(P/F,i%,8) + $100(P/A,i%,8)

Try i = 10%; $466.50 + $533.49 = $999.99
Try i = 12%; $403.90 + $496.76 = $900.66

By observation, i% is > 10% but very close to 10%

∴ rate of return = 10.35%

<u>Select (c)</u>

5-78 AW = −\$5,123 + \$1,100 (P/A,10%,20)
(P/A,10%,20) = 4.6573

Using the interest tables, (P/A,10%,6) = 4.3553 and (P/A,10%,7) = 4.8684.
Thus, $6 < N < 7$. Using linear interpolation we find that $N \approx 6.5$.
$\therefore \quad N = \theta' = 7$

<u>Select (a)</u>

5-79 AW = (\$5,000 + \$500 (A/G.1%24))*(F/P,1%,12)
= (\$5,000 + \$500*11.02337)*1.0100*12.6825
= \$134,649

<u>Select (e)</u>

5-80 i = 12%

$\bar{f}$ = 5%

$$\text{PW}(12\%) = \$9{,}000 + \frac{\$7000[1-(\text{P/F},12\%,6)(\text{F/P},5\%,6)]}{0.12-0.05}$$

$$= \$9{,}000 + \frac{\$7000[1-(0.5066)(1.3401)]}{0.07}$$

$$= \$41{,}110.53$$

$$\text{AW}(12\%) = \$41{,}110.53\,(\text{A/P},12\%,6) = \$41{,}110.53(0.2432)$$

$$= \$9{,}998.08$$

<u>Select (c)</u>

5-81 P = \$8,000 (P/A,12%,4)(P/F,12%,16)
= \$8,000 (3.0373) (0.1631) = \$3,963.07

Select (d)

5-82 $P = \$386(P/A, 1\%, 38)(P/F, 1\%, 1) = \$12{,}033$

<u>Select (b)</u>

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Solutions to Problems in Appendix

5-A-1 [\$50 + \$360(P/F, 8%, 2)](F/P, ERR, 3) = \$235(F/P, 8%, 2) + \$180

$\$358.63\,(1 + \text{ERR})^3 = \$454.10$

ERR = 8.19% per year

A maximum of three IRR values are suggested by Descartes' rule of signs.

5-A-2 [\$5,000 + \$1,000(P/F, 12%, 2)](F/P, ERR, 3) = \$6,000(F/P, 12%, 2) + \$4,000

$\$5,797.20\ (1 + \text{ERR})^3 = \$11,526.40$

ERR = 25.75% per year.

Nordstrom's criterion indicates that a unique IRR exists since there is only one sign change in the cumulative cash flow. A plot of PW v. *i* confirms a single IRR value of 45%.

5-A-3 Descartes' rule allows for the possiblity of two IRRs. A plot of PW v. *i* confirms this (26.73% and 37.12%). The ERR metric is a more useful measure in this situation.

[\$1,810(P/F, 10%, 4)](F/P, ERR, 10) = \$120(F/P, 10%, 10) + \$90(F/P, 10%, 9) + … + \$100

$\$1,236.23\ (1 + \text{ERR})^{10} = \$3,624.30$

ERR = 11.36% per year

Solutions to Chapter 6 Problems

6-1 **(a)** Acceptable alternatives are those having a PW(15%) ≥ 0.

Alt I: PW (15%) = −\$100,000 + \$15,200(P/A, 15%, 12) + \$10,000(P/F, 15%, 12)
= −\$15,738

Alt II: PW(15%) = −\$152,000 + \$31,900 (P/A, 15%,12)
= \$20,917

Alt III: PW(15%) = −\$184,000 + \$35,900(P/A, 15%, 12) + \$15,000(P/F, 15%, 12)
= \$13,403

Alt IV: PW(15%) = −\$220,000 + \$41,500(P/A, 15%, 12) + \$20,000(P/F, 15%, 12)
= \$8,693

Alternative I is economically infeasible, and Alternative II should be selected because it has the highest positive PW value.

(b) If total investment capital is limited to \$200,000, Alternative II should be selected since it is within the budget and is also economically feasible.

(c) Rule 1; the net annual revenues are present and vary among the alternatives.

6-2 Present Worth Method, MARR = 12% per year

PW_{D1} (12%) = −$600,000 − $780,000(P/A,12%,10) = −$5,007,156
PW_{D2} (12%) = −$760,000 − $728,000(P/A,12%,10) = −$4,873,346
PW_{D3} (12%) = −$1,240,000 − $630,000(P/A,12%,10) = −$4,799,626
PW_{D4} (12%) = −$1,600,000 − $574,000(P/A,12%,10) = −$4,843,215

Select Design D3 to minimize the present worth of costs.

Future Worth Method, MARR = 12% per year

FW_{D1} (12%) = −$600,000(F/P, 12%,10) − $780,000(F/A,12%,10) = −$15,551,446
FW_{D2} (12%) = −$760,000 (F/P,12%,10) − $728,000(F/A,12%,10) = −$15,135,862
FW_{D3} (12%) = −$1,240,000 (F/P,12%,10) − $630,000(F/A,12%,10) = −$14,906,873
FW_{D4} (12%) = −$1,600,000 (F/P,12%,10) – $574,000(F/A,12%,10) = −$15,042,234

Select Design D3 to minimize the future worth of costs.

Annual Worth Method, MARR = 12% per year

AW_{D1} (12%) = −$600,000 (A/P,12%,10) – $780,000 = −$886,200
AW_{D2} (12%) = −$760,000 (A/P,12%,10) – $728,000 = −$862,520
AW_{D3} (12%) = −$1,240,000 (A/P,12%,10) – $630,000 = −$849,480
AW_{D4} (12%) = −$1,600,000 (A/P,12%,10) – $574,000 = −$857,200

Select Design D3 to minimize the annual worth of costs.

6-3 1 inch of insulation:

Investment cost = (1,000 feet)($0.60 per foot) = $600
Annual cost of heat lost = ($2 per ft per yr)(1,000 feet)(1 – 0.88) = $240 per year
AW(6%) = −$600(A/P, 6%, 10) − $240 = −$321.54

2 inches of insulation:

Investment cost = (1,000 feet)($1.10 per foot) = $1,100
Annual cost of heat lost = ($2 per ft per yr)(1,000 feet)(1 – 0.92) = $160 per year
AW(6%) = −$1,100(A/P, 6%, 10) − $160 = −$309.49

Two inches of insulation should be recommended.

6-4 Assume all units are produced and sold each year.

$$AW_A(20\%) = -\$30{,}000\ (A/P,20\%,10) + 15{,}000\ (\$3.10 - \$1.00) - \$15{,}000 + \$10{,}000\ (A/F,20\%,10)$$
$$= \$9{,}730$$

$$AW_B(20\%) = -\$6{,}000\ (A/P,20\%,10) + 20{,}000\ (\$4.40 - \$1.40) - \$30{,}000 + \$10{,}000\ (A/F,20\%,10)$$
$$= \$16{,}075$$

$$AW_C(20\%) = -\$40{,}000\ (A/P,20\%,10) + 18{,}000\ (\$3.70 - \$0.90) - \$25{,}000 + \$10{,}000\ (A/F,20\%,10)$$
$$= \$16{,}245$$

Select Design C to minimize the annual worth.

6-5 FW Method:

$FW_A = -\$170,000\ (F/P,10\%,10) + (\$114,000 - \$70,000)\ (F/A,10\%,10) = \$260,317$

$FW_B = -\$330,000\ (F/P,10\%,10) + (\$147,000 - \$79,000)\ (F/A,10\%,10) = \$227,822$

$FW_C = -\$300,000\ (F/P,10\%,10) + (\$130,000 - 64,000)\ (F/A,10\%,10) = \$273,758$

Choose C

PW Method:

$PW_A = -\$170,000 + (\$114,000 - \$70,000)\ (P/A,10\%,10) = \$100,362$

$PW_B = -\$330,000 + (\$147,000 - \$79,000)\ (P/A,10\%,10) = \$87,833$

$PW_C = -\$300,000 + (\$130,000 - \$64,000)\ (P/A,10\%,10) = \$105,544$

Choose C

AW Method:

$AW_A = -\$170,000\ (A/P,10\%,10) + \$114,000 - \$70,000 = \$16,341$

$AW_B = -\$330,000\ (A/P,10\%,10) + \$147,000 - \$79,000 = \$14,309$

$AW_C = -\$300,000\ (A/P,10\%,10) + \$130,000 - \$64,000 = \$17,190$

Choose C

6-6 Wet Tower, Mechanical Draft

$$\begin{aligned}
AW(12\%) &= -\$3{,}000{,}000\ (A/P,12\%,30) \\
&\quad - 40\left(\frac{200hp}{0.9}\right)\left(\frac{0.746kw}{hp}\right)(8{,}760\text{ hr/yr})\ (\$0.022/\text{kWh}) \\
&\quad - 40\left(\frac{150hp}{0.9}\right)\left(\frac{0.746kw}{hp}\right)(8{,}760\text{ hr/yr})\ (\$0.022/\text{kWh}) - \$150{,}000 \\
&= -\$372{,}300 - \$1{,}277{,}948 - \$479{,}230 - \$150{,}000 \\
&= -\$2{,}229{,}478/\text{yr.}
\end{aligned}$$

Wet Tower, Natural Draft

$$\begin{aligned}
AW(12\%) &= -\$8{,}700{,}00(A/P,12\%,30) \\
&\quad - 20\left(\frac{150hp}{0.9}\right)\left(\frac{0.746kw}{hp}\right)(8{,}760\text{ hr/yr})\ (\$0.022/\text{kWh}) \\
&\quad - \$1{,}076{,}670 - \$479{,}230 = -\underline{\$1{,}558{,}900/\text{yr.}}
\end{aligned}$$

Dry Tower, Mechanical Draft

$$\begin{aligned}
AW(12\%) &= -\$5{,}100{,}000(A/P,12\%,30) - \$1{,}277{,}948/2 \\
&\quad - 40\left(\frac{100hp}{0.9}\right)\left(\frac{0.746kw}{hp}\right)(8{,}760\text{ hr/yr})\ (\$0.022/\text{kWh}) - \$170{,}000 \\
&= -\$2{,}080{,}858/\text{yr.}
\end{aligned}$$

Dry Tower, Natural Draft

$$\begin{aligned}
AW(12\%) &= -\$9{,}000{,}000(A/P,12\%,30) - \$638{,}974 - \$120{,}000 \\
&= -\$1{,}875{,}874/\text{yr.}
\end{aligned}$$

The wet cooling tower with natural draft heat removal from the condenser water is the most economical (i.e., least costly) alternative.

Non−economic factors include operating considerations and licensing the plant in a given location with its unique environmental characteristics.

6-7 $PW_A(20\%) = -\$28,000 + (\$23,000 - \$15,000)(P/A,20\%,10) + \$6,000(P/F,20\%,10)$
$= \$6,509$

$PW_B(20\%) = -\$55,000 + (\$28,000 - \$13,000)(P/A,20\%,10) + \$8,000(P/F,20\%,10)$
$= \$\underline{9,180}$

$PW_C(20\%) = -\$40,000 + (\$32,000 - \$22,000)(P/A,20\%,10) + \$10,000(P/F,20\%,10)$
$= \$3,540$

Select Alternative B to maximize present worth.

Note: If you were to pick the alternative with the highest total IRR, you would have incorrectly selected Alternative A.

6-8 Assume zero salvage value for both alternatives.

A: Incandescent lighting system

10 kW (8,760 hr/yr) = 87,600 kWh/yr.($0.045/kWh) = $3,942/yr.

B: Fluorescent lighting system

4.5 kW (8,760 hr/yr) = 39,420 kWh/yr.($0.045/kWh) = $1,773/yr.

Net $PW_A(15\%) = -\$3{,}942(P/A,15\%,5) = \underline{-\$13{,}214.20}$
Net $PW_B(15\%) = -\$11{,}000 - \$1{,}773(P/A,15\%,5) = -\$16{,}943.45$

Therefore, keep existing incadescent lighting system.

6-9 $FW_A(10\%) = -\$780,000(F/P,10\%,10) + \$138,060(F/A,10\%,10) = \$177,231$

$FW_B(10\%) = -\$1,840,000(F/P,10\%,10) + \$311,000(F/A,10\%,10) = \$\underline{184,123}$

Select <u>Alternative B</u> to maximize future worth.

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6-10 Let's use the EUAC method.

$EUAC_A(8\%) = \$30,000(A/P, 8\%, 20) + X + \$7,500 = \$10,557 + X$

$EUAC_B(8\%) = \$55,000(A/P, 8\%, 20) + X = \$5,604.50 + X$

$EUAC_C(8\%) = \$180,000(A/P, 8\%, 20) + X - \$1,500 = \$16,842 + X$

Because X is equal for all fuel types, select B as the most economical.

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6-11 Capacity (units/year)

A1: (7,400 units/month)(12 months/year)[1 + 4(0.007)] = 91,286 units/year

A2: 7,400(12)[1 + (6.5)(0.007)] = 92,840 units/year

Therefore, either alternative will produce the maximum 91,000 units per year that are estimated to be sold.

Alternative A1

$$\begin{aligned} AW(18\%) &= -\$260{,}000\ (A/P,18\%,5) - \$9{,}400 + (91{,}000 - 88{,}800)(\$48.20) \\ &= \$13{,}492 \end{aligned}$$

Alternative A2

$$\begin{aligned} AW(18\%) &= -\$505{,}000\ (A/P,18\%,5) + \$6{,}200 + (91{,}000 - 88{,}800)(\$48.20) \\ &= -\$49{,}259 \end{aligned}$$

Yes (the project should be implemented); select A1; because it maximizes the AW value [and A2 is not economically justified at (demand) = 91,000 units/year].

6-12 Design A: All components have a 20 year life.

Capital Investment

Concrete pavement: (\$90/ft)(5,280 ft/mi)	= \$475,200 /mile
Paved ditches: 2×(\$3/ft)(5,280 ft/mi)	= \$31,680 /mile
Box culverts: (3 culverts/mile)(\$9,000/culvert)	= \$27,000 /mile
Total Capital Investment	= \$533,880 /mile

Maintenance

Annual maintenance: \$1,800 /mile

Periodic cleaning of culverts*:

(3 culverts/mile)(\$450/culvert) = \$1,350 /mile every 5 years

$AW_A(6\%) = -\$533,880(A/P,6\%,20) - \$1,800 - \$1,350(A/F,6\%,5)^* = -\$48,594$ /mile

$PW_A(6\%) = -\$533,880 - [\$1,800 + \$1,350(A/F,6\%,5)](P/A,6\%,20) = -\$557,273$ /mile

* assumes a cleaning also occurs at the end of year 20.

Design B: All components have a 10 year life.

Capital Investment (Year 0)

Bituminous pavement: (\$45/ft)(5,280 ft/mi)	= \$237,600 /mile
Sodded ditches: 2×(\$1.50/ft)(5,280 ft/mi)	= \$15,840 /mile
Pipe culverts: (3 culverts/mile)(\$2,250/culvert)	= \$6,750 /mile
Total	= \$260,190 /mile

Capital Investment (EOY 10)

Bituminous pavement: (\$45/ft)(5,280 ft/mi)	= \$237,600 /mile
Sodded ditches: 2×(\$1.50/ft)(5,280 ft/mi)	= \$15,840 /mile
Replacement culverts:	
(3 culverts/mile)(\$2,400/culvert)	= \$7,200 /mile
Total	= \$260,640 /mile

Maintenance

Annual pavement maintenance:	= \$2,700 /mile
Annual cleaning of culverts:	
(3 culverts/mile)(\$225/culvert)	= \$675 /mile
Annual ditch maintenance:	
2×(\$1.50/ft)(5280 ft/mi)	= \$15,840 /mile
Total	= \$19,215 /mile

$AW_B(6\%) = -[\$260,190 + \$260,640(P/F,6\%,10)](A/P,6\%,20) - \$19,215 = -\$54,595$ /mile

$PW_B(6\%) = -\$260,190 - \$260,640(P/F,6\%,10) - \$19,215(P/A,6\%,20) = -\$626,126$ /mile

Select Design A (concrete pavement) to minimize costs.

6-13 Method: Incremental PW

Order alternatives by increasing capital investment: ER3, ER1, ER2.

Is ER3 an acceptable base alternative?

$PW_{ER3}(12\%) = -\$81{,}200 + \$19{,}750(P/A,12\%,6) = \$0.15 \approx 0.$
Since PW(MARR=12%) ≥ 0, ER3 is an acceptable base alternative.

Analyze Δ (ER1 − ER3)

$$
\begin{aligned}
PW_{\Delta}(12\%) &= -(\$98{,}600 - \$81{,}200) + \frac{\$25{,}800[1-(P/F,12\%,6)(F/P,6\%,6)]}{0.12-0.06} \\
&= -\$17{,}400 + \frac{\$25{,}800(0.2814)}{0.06} - \$19{,}750(4.1114) \\
&= \$22{,}402 > 0
\end{aligned}
$$

The additional capital investment earns more than the MARR. Therefore, design ER1 is preferred to design ER3.

Analyze Δ (ER2 − ER1)

$$
\begin{aligned}
PW_{\Delta}(12\%) &= -(\$115{,}000 - \$98{,}600) + \$29{,}000(P/A,12\%,6) + \$150(P/G,12\%,6) \\
&\quad - \frac{\$25{,}800[1-(P/F,12\%,6)(F/P,6\%,6)]}{0.12-0.06} \\
&= -\$16{,}400 + \$29{,}000(4.1114) + \$150(8.93) - \frac{\$25{,}800(0.2814)}{0.06} \\
&= -\$16{,}832 < 0
\end{aligned}
$$

The additional capital investment required by design ER2 has a negative PW (earns less than the MARR). Therefore, design ER1 is preferred to design ER2.

Decision: Recommend Design ER1

6-14 **(a)** $AW_1(12\%) = -\$2{,}500(A/P,12\%,5) + \$750 + \$2{,}000\ (A/F,12\%,5)$
$= -\$2{,}500(0.2774) + \$750 + \$2{,}000(0.1574)$
$= \$\underline{371.30}$

(b) $AW_2(12\%) = -\$4{,}000\ (A/P,12\%,5) + \$1{,}200 + \$2{,}000\ (A/F,12\%,5)$
$= \$\underline{405.20}$

(c) $AW_\Delta(12\%) = [-\$4{,}000 - (-\$2{,}500)](A/P,12\%,5) + (\$1{,}200 - \$750)$
$+ (\$2{,}000 - \$2{,}000)(A/F,12\%,5)$
$= \$33.90$

(d) Alternative 2 should be selected. In parts (a) and (b), Alternative 2 was shown to have the largest AW. In part (c), the annual worth of the incremental investment needed for Alternative 2 was shown to be positive meaning that it earns more than the required 12% per year.

6-15 **(a)** $PW_1(10\%) = \$2,745$; $PW_2(10\%) = \$,2566$; $PW_3(10\%) = \$2,429$

(b) $IRR_1 = 25\%$; $IRR_2 = 26.5\%$; $IRR_3 = 22.2\%$

(c) Select Project 1 to maximize profitability.

(d) This is because the IRR method assumes reinvestment of cash flows at the IRR whereas the PW method assumes reinvestment at the MARR.

6-16 **(a)** Cost of electricity for the 90% efficient motor:
[30 hp/0.90](0.746 kW/hp)($0.10/kWh)(4,000 hr/yr) = $9,946.67 per year

Cost of electricity of the 93% efficient motor:
[30 hp/0.93](0.746 kW/hp)($0.10/kWh)(4,000 hr/yr) = $9,625.81 per year

$PW_{90\%}(15\%) = -\$2,200 - \$9,946.67(P/A, 15\%, 8) = -\$46,834$

$PW_{93\%}(15\%) = -\$3,200 - \$9,625.81(P/A, 15\%, 8) = -\$46,394$

The 93% efficient motor is the better choice. Notice that energy expense dominates the analysis. For instance, the 93% efficient motor has a PW of energy expense that is $43,194 / $3,200, or over 13 times its purchase price. Generally speaking, the potential for savings is enourmous for high efficiency motors and pumps.

(b) $9,946.67 − $9,625.81 = $320.86 per year savings

PW(15%) of savings = $320.86(P/A, 15%, 8) = $1,440, which exceeds the extra investment cost of $1,000, so the more efficienct motor is preferred. Thus, the PW of the incremental investment is $440.

6-17 Cost of electricity of the 90% efficient motor = \$9,946.67 (0.60) = \$5,968 per year
Cost of electricity of the 93% efficient motor = \$9,625.81 (0.60) = \$5,775 per year

$PW_{90\%}(15\%) = -\$2{,}200 - \$5{,}968(P/A, 15\%, 8) = -\$28{,}980$
$PW_{93\%}(15\%) = -\$3{,}200 - \$5{,}775(P/A, 15\%, 8) = -\$29{,}114$

In this case, the 90% efficient motor should be selected by a slim margin.

6-18 **(a)** $PW_A(15\%) = -\$179,645$
$PW_B(15\%) = -\$189,593$
$PW_C(15\%) = -\$177,958$, so the rank order is C > A > B (C is the best).

(b) The extra investment of $42,000 in Equipment C [i.e. $\Delta(C-B)$] will produce savings of $16,000 per year for years one through five. Thus, the breakeven interest rate can be determined as follows: $0 = -\$42,000 + \$16,000(P/A, i', 5)$, or $i' = 26.19\%$. If the MARR is greater than 26.19%, select Equipment B; otherwise select Equipment C.

6-19 **(a)** $PW_X(15\%) = \$21,493$
$PW_Y(15\%) = \$35,291$. Recommend Alternative Y.

(b) IRR on the incremental cash flow (−\$50,000 in year one, −\$51,000 in year two, and \$145,760 in year 3) is 27.19%. This favors Y when the MARR is 15%.

(c) If the MARR is 27.5%, $PW_X = -\$464$ and $PW_Y = -\$727$. Choose X if one alternative must be selected.

(d) The simple payback period for Alt. X is 2 years; for Alt. Y it is 3 years.

(e) Based on the answer to parts (a) and (b), Alternative Y should be recommended.

6-20 **(a)** $0 = -\$51{,}000 + \$25{,}000(P/F, i', 2) + \$50{,}000(P/F, i', 3)$ $\quad i'_N = 15.7\%$

(b) If the MARR = 8%, select N since $i'_{(N-M)} = 8.7\% > \text{MARR}$.

(c) If the MARR = 15%, select M since $i'_{(N-M)} = 8.7\% < \text{MARR}$.

6-21 **(a)** \$50,000 / \$20,000 per year = 2.5 years, so $\theta = 3$ years. This is marginally acceptable.

(b) Try N = 3: PW(20%) = −\$50,000 + \$20,000(P/A, 20%, 3) = − \$4,336
Try N = 4: PW(20%) = −\$50,000 + \$20,000(P/A, 20%, 4) = +\$7,100, so $\theta' = 4$ years. Again, this is marginal.

(c) 0 = −\$50,000 + \$20,000(P/A, i′, 5) + \$5,000(P/F, i′, 5), or i′ = 30% per year. This exceeds the MARR, so the investment is a profitable one.

6-22 List the alternatives in increasing order of initial cost: DN, B, D, A, C.

In general, we have P = A (P/A, i′, 80) which becomes i′ = A / P when the MARR is 12% and N = 80 years, where i′ is the IRR of the project or the incremental cash flows. The incremental comparisons follow:

Δ(B−DN) = 8/52 = 0.154 (15.4%), so select B.
Δ(D−B) = 1/3 = 0.333 (33.3%), so select D.
Δ(A−D) = 1/7 = 0.143 (14.3%), so select A.
Δ(C−A) = 10/88 = 0.114 (11.4%), so keep A.

Therefore, we recommend Alternative A even though it does not have the largest IRR or the largest ΔIRR.

6-23 Examine Δ(New Baghouse – New ESP):

Incremental investment = \$147,500
Incremental annual expenses = \$42,000 per year for 10 years

Therefore, by inspection, the extra investment required by the new baghouse is producing extra annual expenses, so the new ESP should be recommended.

Doublecheck: PW(15%) for the new baghouse = −\$1,719,671
PW(15%) for the new ESP = −\$1,359,876

The economic advantage of the ESP may not be sufficient enough to overcome its inability to meet certain design specifications under varying operating conditions.

6-24 Initially, choose FMC unless the incremental savings in annual expenses for the Deere ($5,000) outweigh the incremental investment cost ($40,000).

$0 = -\$40{,}000 + \$5{,}000(P/A, i', 12) + \$60{,}000(P/F, i', 12)$ and $i' = 14.3\%$. This is greater than the MARR = 12%, so the Deere combine should be purchased.

A confirmation of the correct choice is provided below through PW analysis.

$PW_{Deere}(12\%) = -\$240{,}000 - \$5{,}000(P/A, 12\%, 12) + \$80{,}000(P/F, 12\%, 12) = -\$250{,}436$
$PW_{FMC}(12\%) = -\$200{,}000 - \$10{,}000(P/A, 12\%, 12) + \$20{,}000(P/F, 12\%, 12) = -\$256{,}810$

The farmer should select the Deere machine.

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6-25 Rank order: C → A → B

C → A: $0 = -\$200{,}000 + \$58{,}060(P/A, i', 10)$, so $i' = 26.2\% > 10\%$, so choose A.

A → B: $0 = -\$1{,}100{,}000 + \$178{,}130(P/A, i', 10)$, so $i' = 9.88\% < 10\%$, so keep A.

Recommend Alternative A.

6-26 Rank alternatives by increasing capital investment: A,B,C,D and E. Since the ERR on Equipment A > MARR, it is an acceptable base alternative. Therefore, ERR_Δ on $\Delta(B-A)$ must be examined.

<u>$\Delta(B-A)$</u>

$(\$50,000 - \$38,000)(F/P, i'_\Delta, 10) = (\$14,100 - \$11,000)(F/A, 18\%, 10)$

$i'_\Delta = 19.8\% >$ MARR, therefore select B.

<u>$\Delta(C-B)$</u>

$\$5,000\ (F/P, i'_\Delta, 10) = \$2,200(F/A, 18\%, 10)$

$i'_\Delta = 26.3\% >$ MARR, therefore select C.

<u>$\Delta(D-C)$</u>

$\$5,000\ (F/P, i'_\Delta, 10) = \$500(F/A, 18\%, 10)$

$i'_\Delta = 8.9\% <$ MARR, therefore keep C.

<u>$\Delta(E-C)$</u>

$\$15,000\ (F/P, i'_\Delta, 10) = \$2,900(F/A, 18\%, 10)$

$i'_\Delta = 16.4\% <$ MARR, therefore keep C as best.

Answer: <u>Select C.</u>

6-27 Rank order: D1 → D2 → D3 → D4

D1 → D2: $160,000(1 + i')^{10}$ = $42,000(F/A, 12%, 10) i' = 19%, select D2
D2 → D3: $480,000(1 + i')^{10}$ = $98,000(F/A, 12%, 10) i' = 11.5%, keep D2
D2 → D4: $840,000(1 + i')^{10}$ = $204,000(F/A, 12%, 10) i' = 15.6%, select D4

Recommend D4.

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6-28 **(a)** Use AW to deal with different useful lives

$$AW_x(5\%) = -\$6,000(A/P,5\%,12) - \$2,500 = -\$3,176.80$$

$$AW_y(5\%) = -\$14,000(A/P,5\%,18) + \$2,800(A/F,5\%,18) - \$2,400 = -\$3,497.60$$

Select Alternative X (could also calculate PW over 36 years and compare)

(b) $PW_x(5\%) = -\$6,000 - \$2,500(P/A,5\%,12) - \$8,000(P/A,5\%,6)(P/F,5\%,12)$
$= -\$50,767.45$

$PW_y(5\%) = -\$3,497.60(P/A,5\%,18) = -\$40,885.54$

Select Alternative Y (could also calculate AW over 18 years and compare)

6-29 **(a)** Assume repeatability so that AWs can be directly compared (over a 15−year study period).

$$AW_A(8\%) = -\$1{,}200(A/P,8\%,3) - \$160 - \frac{60hp}{0.90}(0.746 \text{ kW/hp})(800 \text{ hrs/yr.})(\$0.07/\text{kWh})$$
$$= -\$3{,}410.67$$

$$AW_B(8\%) = -\$1{,}000(A/P,8\%,5) - \$100 - \frac{60hp}{0.80}(0.746 \text{ kW/hp})(800 \text{ hrs/yr.})(\$0.07/\text{kWh})$$
$$= -\$3{,}483.70$$

By a slim margin, select Motor A

(b) Increased capital investment of Motor A (relative to Motor B) is being traded off for improved electrical efficiency and lower annual energy expenses.

6-30 Skyline: $CW(10\%) = -\$500{,}000 - \$30{,}000/0.10 + \$10{,}000(P/A, 10\%, 20)$
$- \$200{,}000(A/F, 10\%, 20)/0.10$
$= -\$749{,}864$

Prairie View: $CW(10\%) = -\$700{,}000 - \$300{,}000(P/F, 10\%, 30) - \$10{,}000/0.10$
$= -\$817{,}190$

The Skyline proposal is less expensive over an indefinitely long study period and would be the recommended choice based on economics alone.

6-31 Number of machines needed:

D1: $\dfrac{3{,}450}{2{,}000(0.8)(0.9)} = 2.40$ (3 machines)

D2: $\dfrac{2{,}350}{2{,}000(0.75)(0.8)} = 1.96$ (2 machines)

Annual equivalent cost of ownership:

D1: \$16,000(3)(A/P,15%,6) − \$3,000(3)(A/F,15%,6) = \$11,653.80
D2: \$24,000(2)(A/P,15%,8) − \$4,000(2)(A/F,15%,8) = \$10,116.00

Annual operating expenses (assume repeatability):

D1: \$5,000(3) = \$15,000
D2: \$7,500(2) = \$15,000

Total equivalent annual cost:

D1: \$11,653.60 + \$15,000 = \$26,653.80
D2: \$10,116.00 + \$15,000 = \$25,116.00

Select Machine D2 to minimize total equivalent annual cost.

6-32 **(a)** $PW_A(15\%) = -\$272,000 - \$28,800(P/A,15\%,9) + \$25,000(P/F,15\%,6)$
$- \$66,000(P/A,15\%,3)(P/F,15\%,6)$
$= -\$463,758$

$PW_B(15\%) = -\$346,000 - \$19,300(P/A,15\%,9) + \$40,000(P/F,15\%,9)$
$= -\$\underline{426,720}$

Select B to minimize equivalent cost.

(b) Alternative A is the base alternative because it requires the least capital investment.

Year	Δ (B − A) cash flow	
0	−\$346,000 − (−\$272,000)	= −\$74,000
1 − 5	− 19,300 − (−\$28,800)	= 9,500
6	− 19,300 − (−\$28,800 + \$25,000)	= − 15,500
7 − 8	− 19,300 − (−\$94,800)	= 75,500
9	− 19,300 + \$40,000 − (−\$94,800)	= 115,500

$PW_\Delta(i'_\Delta\%) = 0 = -\$74,000 + \$9,500(P/A, i'_\Delta\%,5) - \$15,500(P/F, i'_\Delta\%,6)$
$+ \$75,500(P/A, i'_\Delta\%,2)(P/F, i'_\Delta\%,6) + \$115,500(P/F, i'_\Delta\%,9)$

By trial and error, $i'_\Delta\% = 22.5\% >$ MARR. Therefore the incremental investment is justified and Alternative B should be selected. Note that there are multiple sign changes. It is possible that there are multiple IRR_Δs.

(c) Again, Alternative A would be the base alternative. Using the incremental cash flows computed in part (b), the ERR_Δ is found by solving the following equation:

$\left|-\$74,000 - \$15,500(P/F,15\%,6)\right| (F/P, i'_\Delta\%,9)$
$= \$9,500(F/A,15\%,5)(F/P,15\%,4) + \$75,500(F/A,15\%,3) + \$40,000$

$\$80,701(1 + i'_\Delta)^9 = \$404,202$

$ERR_\Delta = 19.9\% >$ MARR. Therefore, select Alternative B

(d) $PW_L(15\%) = -\$94,800\ (P/A,15\%,9)$
$= -\$452,348$

Thus, leasing crane A is <u>not</u> preferred to the selected alternative (B), but would be preferred to the purchase of crane A.

6-33 $CW_A(10\%) = \dfrac{[-\$50{,}000(A/P,10\%,25) + \$5{,}000(A/F,10\%,25) - \$1{,}200]}{0.10}$

$= -\$66{,}590$

$CW_B(10\%) = \dfrac{-\$90{,}000(A/P,10\%,50) - \$5{,}000(P/A,10\%,15)(A/P,10\%,50) - \$1{,}000}{0.10}$

$= -\$139{,}183$

Select Plan A to minimize costs.

6-34 **(a)** $PW_1(8\%) = -\$100{,}000 - \$80{,}000(P/F, 8\%, 5) + \$20{,}000(P/F, 8\%, 10)$
$+ \$28{,}000(P/A, 8\%, 10)$
$= \$42{,}699$

$PW_2(8\%) = -\$150{,}000 + \$30{,}000(P/A, 8\%, 10) = \$51{,}303$

Therefore, select alternative 2 to maximize profitability.

(b) $PW_1(15\%) = \$5{,}694$ $PW_2(15\%) = \$564$

If the MARR is changed to 15% per year, alternative 1 becomes the better choice. The principal assumption in parts (a) and (b) is the repeatability of cash flows for alternative 1.

6-35 Assume a common 40 yr. life and use the AW method (PW could be used if 2 life cycles of Boiler A are explicitly considered over a 40 year study period.)

$$AW_A(10\%) = -\$50{,}000(A/P,10\%,20) + \$10{,}000(A/F,10\%,20) - \$9{,}000 = -\$14{,}704$$

$$AW_B(10\%) = -\$120{,}000(A/P,10\%,40) + \$20{,}000(A/F,10\%,40) - \$3{,}000 - \$300(A/G,10\%,40) = -\$17{,}962$$

or $PW_A(10\%) = -\$143{,}735$ over 40 years; $PW_B(10\%) - -\$175{,}580$ over 40 years.

6-36 Assume repeatability.

$$AW_A(20\%) = -\$2{,}000(A/P,20\%,5) + (\$3{,}200 - \$2{,}100) + \$100(A/F,20\%,5)$$
$$= \$444.64$$
$$AW_B(20\%) = -\$4{,}200(A/P,20\%,10) + (\$6{,}000 - \$4{,}000) + \$420(A/F,20\%,10)$$
$$= \$1{,}014.47$$
$$AW_C(20\%) = -\$7{,}000(A/P,20\%,10) + (\$8{,}000 - \$5{,}100) + \$600(A/F,20\%,10)$$
$$= \$\underline{1{,}253.60}$$

Select <u>Alternative C</u> to maximize annual worth

6-37 $CW_{D1}(10\%) = \dfrac{[-\$50{,}000(A/P,10\%,20) + \$10{,}000(A/F,10\%,20) - \$9{,}000]}{0.10}$

$= \underline{-\$147{,}000}$

$CW_{D2}(10\%) = \dfrac{[-\$120{,}000(A/P,10\%,50) + \$20{,}000(A/F,10\%,50) - \$5{,}000]}{0.10}$

$= -\$170{,}900$

Select Design D1 to minimize costs.

6-38 $AW_{2\text{ cm}}(15\%) = -\$20{,}000(A/P, 15\%, 4) + \$5{,}000 = -\$2{,}006$ per year
$AW_{5\text{ cm}}(15\%) = -\$40{,}000(A/P, 15\%, 6) + \$7{,}500 = -\$3{,}068$ per year

Therefore, the 2 cm thickness should be recommended.

6-39 $CR_{5\ cm}(15\%) = \$40{,}000(A/P, 15\%, 6) = \$10{,}568$
$MV_{5\ cm}$ after four years = $\$10{,}568(P/A, 15\%, 2) = \$17{,}180$

$AW_{5\ cm}(15\%) = -\$40{,}000(A/P, 15\%, 4) + \$7{,}500 + \$17{,}180(A/F, 15\%, 4) = -\$3{,}071$

Still recommend 2 cm thickness.

6-40 Assume repeatability.

(a) Machine A:

CR cost/yr = \$35,000(A/P,10%,10) − \$3,500(A/F,10%,10) = \$5,475.05
Maint. Cost/yr = \$1,000

CR and maintenance cost/part = $\dfrac{\$5{,}475.05 + \$1{,}000}{10{,}000\, parts}$ = \$0.6475

Labor cost/part = $\dfrac{\$16/hr}{3\, parts/hr}$ = \$5.3333

Total cost/part (to nearest cent) = \$5.98

Machine B:

CR cost/yr = \$150,000(A/P,10%,8) − \$15,000(A/F,10%,8) = \$26,799
Maint. Cost/yr = \$3,000

CR and maintenance cost/part = $\dfrac{\$26{,}799 + \$3{,}000}{10{,}000\, parts}$ = \$2.98

Labor cost/part = $\dfrac{\$20/hr}{6\, parts/hr}$ = \$3.33

Total cost/part (to nearest cent) = \$6.31

Select Machine A to minimize total cost per part.

(b) Machine A:

Labor cost/part = $\dfrac{\$8/hr}{3\, parts/hr.}$ = \$2.67

(other costs remain unchanged)
Total cost/part (to nearest cent) = \$3.31

Machine B:

Labor cost/part = $\dfrac{\$10/hr}{6\, parts/hr.}$ = \$1.67

(other costs remain unchanged)
Total cost/part (to nearest cent) = \$4.65

Select Machine A to minimize total cost per part.

6-41 **(a)** Assume repeatability.

$AW_A = -\$20{,}000(A/P,20\%,5) - \$5{,}500 + \$1{,}000(A/F,20\%,5) = -\$12{,}053.60$
$AW_B = -\$38{,}000(A/P,20\%,10) - \$4{,}000 + \$4{,}200(A/F,20\%,10) = -\$12{,}901.30$

<u>Select A</u>

(b) $AW_A(20\%) = -\$12{,}053.60$
$AW_B(20\%) = -\$38{,}000(A/P,20\%,5) - \$4{,}000 + \$15{,}000(A/F,20\%,5)$
$= -\$14{,}691.20$
<u>Select A</u>

6-42 Trail on Flat Terrain:

Paving cost = ($\$3/m^2$)(2 m)(14,000 m) = \$84,000
Site preparation = (0.2)(\$84,000) = \$16,800
Annual Maintenance = (0.05)(\$84,000) = \$4,200

CW = −\$16,800 −\$84,000 − \$4,200/0.06 = −\$170,800

Trail on Hilly Terrain:

Paving cost = ($\$3/m^2$)(2 m)(12,000 m) = \$72,000
Site preparation = (0.2)(\$72,000) = \$14,400
Annual Maintenance = (0.08)(\$72,000) = \$5,760

CW = −\$14,400 −\$72,000 − \$5,760/0.06 = −\$182,400

Recommend the trail on flat terrain.

6-43 Compare the annual worths of the two infinite series:

$AW_A(10\%) = \$1,000 + [\$500/0.10](P/F, 10\%, 10)(A/P, 10\%, \infty) = \$1,192.75$

$AW_B(10\%) = \$1,200 + [\$100/0.10](P/F, 10\%, 10)(A/P, 10\%, \infty) = \$1,238.55$

Select Trust B.

6-44 **(a)** How many machines will be needed?

6,150/(3,000*0.85*0.95) = 2.54 (3 lathes of type L1

Or

4,400/(3,000*0.90*0.90) = 1.81 (2 lathes of type L2)

(b) The annual cost of ownership, based on capital investment, is

$18,000*3*(A/P,18%,7) = $14,169.60 for lathe L1

and

$25,000*2*(A/P,18%,11) = $10,740.00 for L2.

Repeatability is assumed.

(c) Since the workers are paid for idle time we cannot make any reductions in annual expenses. Thus, annual expenses for 3 L1is 3*$5,000 = $15,000/yr. For 2 L2s, the annual expense equals 2*$9,500 = $19,000/yr.

(d) The total equivalent annual cost for the two options equals: $14,169.60 + $15,000 = $29,169.60 for lathe L1 and $10,740.00 + $19,000 = $29,740.00 for lathe L2. Hence, <u>lathe L1</u> is the preferred choice to minimize equivalent annual choice.

6-45 **(a)** Repeatability assumption

$AW_{E1}(15\%) = -\$14{,}000\,(A/P,15\%,5) - \$14{,}000 + \$8{,}000\,(A/F,15\%,5)$
$= -\$\underline{16{,}990}$
$AW_{E2}(15\%) = -\$65{,}000(A/P,15\%,20) - \$9{,}000 + \$13{,}000\,(A/F,15\%,20)$
$= -\$19{,}260$

Select Alternative E1 to minimize costs.

(b) Coterminated assumption (5−year study period)

$AW_{E1}(15\%) = -\$\underline{16{,}990}$; unchanged from Part (a)

Imputed market value (MV_5) for Alternative E2:

$MV_5 = [\$65{,}000(A/P,15\%,20) - \$13{,}000\,(A/F,15\%,20)](P/A,15\%,15)$
$+ \$13{,}000\,(P/F,15\%,15) = \$61{,}590$

$AW_{E2}(15\%) = -\$65{,}000(A/P,15\%,5) - \$9{,}000 + \$61{,}590(A/F,15\%,5)$
$= -\$19{,}256$ (slight difference from Part (a) is due to rounding)

Select Alternative E1 to minimize costs. The reason AW_{E2} in Part b is the same as in Part a is the annual expenses are the same over the 20−year period in Part a as they are over the 5−year period in Part b.

6-46 Assume a 24-year study period. Alternative 1 (no auxiliary equipment) has a negative cash flow of \$30,000 now and another \$30,000 at EOY 12. Alternative 2 (auxiliary equipment) has a negative cash flow of (\$30,000 + Aux\$) now and positive savings of \$400 at EOYs 1−24. So we can equate PW(6%) of Alt. 1 to PW(6%) of Alt. 2 and solve for Aux\$.

$$-\$30{,}000 - \$30{,}000(P/F, 6\%, 12) = -(\$30{,}000 + \text{Aux\$}) + \$400(P/A, 6\%, 24)$$

$$\text{Aux\$} = \$19{,}925$$

The managers of the plan can afford to spend up to \$19,925 for the auxiliary equipment.

6-47 $CW_L(15\%) = \dfrac{[-\$274{,}000(A/P,15\%,83) - \$10{,}000 - \$50{,}000(A/F,15\%,6)]}{0.15}$

$= -\$\underline{378{,}733}$

$CW_H(15\%) = \dfrac{[-\$326{,}000(A/P,15\%,92) - \$8{,}000 - \$42{,}000(A/F,15\%,7)]}{0.15}$

$= -\$404{,}645$

Select Bridge Design L to minimize cost.

6-48 Alternative E1

$$PW_{E1}(15\%) = -\$210,000 - \$31,000\,(P/A,15\%,6) - \$2,000\,(P/G,15\%,6) + \$21,000\,(P/F,15\%,6)$$
$$= -\$334,118$$

Alternative E2

Calculate an imputed MV at EOY 6:

$$\text{Capital Recovery Amount} = -\$264,000\,(A/P,15\%,10) + \$38,000\,(A/F,15\%,10)$$
$$= -\$50,742$$

$$MV_6 = |-\$50,742|\,(P/A,15\%,4) + \$38,000\,(P/F,15\%,4) = \$166,597$$

$$i_{CR} = \frac{0.15 - 0.057}{1.057} = 0.088 \text{ or, } 8.8\%; \quad (P/A,8.8\%,6) = \frac{(1.088)^6 - 1}{0.088(1.088)^6} = 4.5128$$

$$PW_{E2}(15\%) = -\$264,000 - \frac{\$19,000}{1.057}(P/A,8.8\%,6) + \$166,597\,(P/F,15\%,6)$$
$$= \underline{-\$273,100}$$

Select Alternative E2.

6-49 Assume repeatability.

$AW_A(10\%) = -\$30{,}000(A/P, 10\%, 5) - \$450 - \$6{,}000 = -\$14{,}364$
$AW_B(10\%) = -\$38{,}000(A/P, 10\%, 4) - \$600 - \$4{,}000 = -\$16{,}589$

Recommend Proposal A, assuming a proposal must be chosen.

6-50 **(a)** $PW_A(8\%) = [-\$250 + \$40.69(P/A, 8\%, 10)][1 + (P/F, 8\%, 10)] = \$33.70$
$PW_B(8\%) = -\$375 + \$44.05(P/A, 8\%, 20) = \$57.49$
$PW_C(8\%) = [-\$500(A/P, 8\%, 5) + \$131.90](P/A, 8\%, 20)] = \$65.29$

Select C to maximize PW over a common 20-year study period.

(b) $PW_A(8\%) = -\$250 + \$40.69(P/A, 8\%, 10) = \$23.03$
$PW_B(8\%) = -\$375 + \$44.05(P/A, 8\%, 20) = \$57.49$
$PW_C(8\%) = -\$500 + \$131.90(P/A, 8\%, 5) = \$26.64$

Select B to maximize PW over a common 20-year study period with reinvestment in alternatives A and C occurring at 8% per year (instead of at 10% per year as in Part a). Notice that we continue to analyze MEAs over a common 20-year period.

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6-51 Assume repeatability

$$CW_{S1}(10\%) = \frac{-\$72{,}000(A/P,10\%,9) - \$2{,}200 - \$300(A/G,10\%,9) + \$8{,}400(A/F,10\%,9)}{0.10}$$

$$= -\$150{,}927$$

For Alternative S2, the PW of the annual expenses over a single life are:

$$PW(10\%) = \frac{\$2{,}100[1-(P/F,10\%,12)(F/P,5\%,12)]}{0.10-0.05}$$

$$= \$17{,}969$$

$$CW_{S2}(10\%) = \frac{-\$90{,}000(A/P,10\%,12) - \$17{,}969(A/P,10\%,12) + \$13{,}000(A/F,10\%,12)}{0.10}$$

$$= -\$152{,}414$$

Alternative S1 is preferred to minimize costs.

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6-52 Rank order: DN → III → II → I

DN → III: IRR = 22.9% (given) > 10%; select III

III → II: $0 = -\$10{,}000 + \$400(P/A, i', 20) + \$20{,}000(P/F, i', 10)$
$i' = 11.3\% > 10\%$; select II

II → I: $0 = -\$10{,}000 + \$750(P/A, i', 20)$
$i' = 4\% < 10\%$; keep II

Invest in alternative II.

6-53 Assume repeatabillity. Use method described in Section 6.5.1.

Rank order: DN,Alt. 1, Alt. 3, Alt. 2

IRR on $\Delta(1-\text{DN})$ = 33% > 20%, so select Alt. 1

IRR on $\Delta(3-1)$: set $AW_1(i') = AW_3(i')$ and solve for i′

$$-\$30{,}000(A/P, i',5) + \$12{,}000 + \$10{,}000(A/F, i',5)$$
$$= -\$40{,}000(A/P, i',6) + \$13{,}000 + \$10{,}000(A/F, i',6)$$

$i' \approx \frac{1}{2}\% \ll 20\%$, so select Alt. 1

IRR on $\Delta(2-1)$: set $AW_1(i') = AW_2(i')$ and solve for i′

$$-\$30{,}000(A/P, i',5) + \$12{,}000 + \$10{,}000(A/F, i',5)$$
$$= -\$60{,}000(A/P, i',5) + \$23{,}500 + \$10{,}000(A/F, i',5)$$

$i' \approx 26.5\% > 20\%$, so select <u>Alternative 2</u>

6-54 $\$95{,}000(F/P, i', 20) = \$12{,}500(F/A, 10\%, 20) + \$5{,}000(F/P, 10\%, 10)$

$i' = 10.7\% > \text{MARR}$

Since the ERR of the incremental investment required for Alternative A is greater than the MARR, Alternative A is preferred.

6-55 Assume repeatability. Rank order: DN, Komatsu, Caterpillar, Deere

IRR on Δ(Komatsu – DN) = 27.2% > 15%, so select Komatsu.

IRR on Δ(Caterpillar – Komatsu): Set $AW_K(i') - AW_C(i')$ and solve for i′

$-\$17{,}000\,(A/P, i',5) + \$6{,}200 + \$3{,}500\,(A/F, i',5) = -\$22{,}000\,(A/P, i',4) + \$7{,}000 + \$4{,}000\,(A/F, i',4)$

At i′ = 0%, $AW_C(0\%) - AW_K(0\%) = -\$1{,}000$

Therefore, i′ < 0% << 15%, so select Komatsu.

IRR on Δ(Deere – Komatsu): Set $AW_K(i') - AW_D(i')$ and solve for i′

$-\$17{,}000\,(A/P, i',5) + \$6{,}200 + \$3{,}500\,(A/F, i',5) = -\$26{,}200\,(A/P, i',10) + \$7{,}500 + \$5{,}000\,(A/F, i',10)$

i′ ≈ 25.1% > 15%, so select <u>Deere</u>.

6-56 Rank order: Gravity-fed, Vacuum

The IRR of the Gravity-fed exceeds 15%, so it is acceptable. We must next consider the incremental difference, Δ(V-l – G-f) as follows: $0 = -\$13{,}400 + \$24{,}500(P/F, i', 5)$. The IRR on this increment is 12.8%, so we reject Vacuum-led and stick with Gravity-fed as our choice.

6-57 Assume repeatability. Let:

N_A = life of blower costing \$42,000
N_B = life of the more efficient blower
H = hours of operation per year
C = cost of electricity per kilowatt−hour
X = cost of the more efficient blower

$$\text{Operation Cost of A} = OC_A = \frac{90\text{ hp }(0.746\text{ kW / hp})(H\text{ hrs / yr})(C\text{ \$ / kW - hr})}{0.72}$$

$AW_A(20\%) = -\$42{,}000\ (A/P,20\%,N_A) - (OC_A)$

$$\text{Operation Cost of B} = OC_B = \frac{90\text{ hp }(0.746\text{ kW / hp})(H\text{ hrs / yr})(C\text{ \$ / kW - hr})}{0.81}$$

$AW_B(20\%) = -\ X\ (A/P,20\%,N_B) - (OC_B)$

Set $AW_A(20\%) = AW_B(20\%)$ and solve for X.

$$\$42{,}000\ (A/P,20\%,N_A) - X\ (A/P,20\%,\ N_B) = OC_B - OC_A$$

6-58 The \$284,000 is irrelevant (it's a sunk cost). There are two alternatives:

a. Abandon the project. The PW of this alternative is \$20,000.
b. Continue. The PW of this alternative is the sum of two parts:
   (1) Development: (−320,000)(P/F,7%,1) = −\$299,065
   (2) Fees: (24,000)(1/.07) = \$342,857

   The sum of these is \$43,792.

Unless the fee estimate is very far off, it is <u>better to continue</u>.

6-59 Compare future worths of the two alternatives at the end of year 5:

$$FW_1(10\%) = -\$80{,}000(F/P,10\%,5) + \$20{,}000(F/A,10\%,5) + \$4{,}000(F/P,10\%,1) + \$6{,}000 = \$\underline{3{,}662}$$
$$FW_2(10\%) = -\$80{,}000(F/P,10\%,3) + \$33{,}000(F/A,10\%,3) = \$2{,}750$$

Select <u>Alternative 1</u> to maximize the future worth measure of profitability.

<u>Note</u>: We could have computed the present worth at 10% of $\Delta(1-2)$. The PW on the difference is \$562, so again Alternative 1 would be recommended.

6-60 Amy's future worth: F = \$10,000(F/A, 8%, 10)(F/P, 8%, 23) = \$850,581
Frank's future worth: F′ = \$10,000(F/A, 8%, 23) = \$608,933

Amy will have moremoney saved than Frank will have when they are both 60 years old (almost 40% more than Frank!). This occurs even though Amy invested \$100,000 and Frank socked away an amazing \$230,000! The moral is to start saving early in life and let the magic of compound interest work on your behalf.

6-61 15,000/5,000 = 3 oil changes / year × \$30 / oil change = \$90
15,000/3,000 = 5 oil changes / year × \$30 / oil change = \$150

PW(savings) = \$60(P/A, 10%, 6) = \$261

6-62 **(a)** F = \$10,000 with interest-only being repaid each month.

(b) F = \$5,000(F/P, 0.75%, 48) + \$5,000(F/P, 0.75%, 24) = \$13,139 with no interest repaid while in school.

(c) Monthly payment (interest repaid each month) = \$10,000(A/P, 0.75%, 60) = \$208
Monthly payment with no interest repaid = \$13,139(A/P, 0.75%, 60) = \$273.29

(d) Total interest (interest paid while in school) = \$37.50(48) + \$37.50(24)
+ \$208(60) − \$10,000 = \$5,180

Total interest (with no interest paid while in school) = \$273.29(60) − \$10,000
= \$6,397

Therefore the difference is \$1,217 more interest if Sara does not repay any interest while she is in school. This is 23.5% higher than the \$5,180 Sara repays when interest-only is paid while she is attending college.

6-63 A = \$200,000(A/P, 7%/12, 360) = \$1,330.60 per month with 7% APR.
A = \$200,000(A/P, 8%/12, 360) = \$1,467.53 per month with 8% APR.

This represents a (\$136.93/\$1,330.60) × 100% = 10.3% increase in monthly payment, so the realtor's claim is not correct. Maybe his claim is based on the (1% / 7%) × 100% = 14.3% increase in the APR itself.

6-64 Bond: FW = \$10,000 with certainty (IRR = 5.922%)
CD: FW = \$7,500(F/P, 6.25%, 5) = \$7,500(1.3541) = \$10,155.80 (IRR = 6.25%)

The CD is better, assuming comparable risk in both investments.

6-65 The incremental amount that you have available to invest now on the certificate of deposit is $3,800 (if you pay $4,200 now and invest the remainder). It can grow to $3,800 (1.03) = $3,914 by January 1. It will not cover the $4,200 due at that time, so the discounted plan should be chosen.

6-66 Electrical demand / year (incandescent bulbs) = 1,000 Watts × 3,000 hours = 3,000 kWh
Annual energy cost (incandescent bulbs) = 3,000 kWh × \$0.10/kWh = \$300
Annual purchase cost of incandescent bulbs = 10 × \$0.75 = \$7.50
Annual CO_2 penalty for incandescent bulbs = (150 lb/bulb)(10 bulbs)(\$0.02/lb) = \$30

Total annual expenses = \$300 + \$7.5 + 30 = \$337.50

PW(costs of incandescent) = \$500 + \$337.50(P/A, 8%, 10) = \$2,765

Now the maximum affordable cost (X) for the CFB fixtures and bulbs is as follows:

Annual energy cost (CFB) = \$300 (1 – 0.7) = \$90

10X + \$90(P/A, 8%, 10) = \$2,765

So, X = \$216 (which includes the CFB fixture and a CFB bulb that will last 10 years). If a CFB bulb costs \$5, this leaves \$211 for the purchase of each CFB fixture. Because CFB fixtures generally cost less than \$211, it is economical for Bob and Sally to install fluorescent lighting in their new home. Ask your students to list non-monetary advantages and disadvantages of fluorescent and incandescent lighting. Is their choice the same based on economics alone?

6-67 Design 1 $PW_1 = -\$100,000 + \$20,000\,(P/A,10\%,10) = \$22,891.34$

Design 2 $PW_2 = -\$160,000 + \$27,000\,(P/A,10\%,10) + \$20,000\,(P/F,10\%,10)$
$= \$13,614.18$

Design 3 $PW_3 = -\$200,000 + \$28,000\,(P/A,10\%,10) + \$40,000\,(P/F,10\%,10)$
$= -\$12,530.39$

Design 4 $PW_4 = -\$260,000 + \$45,500\,(P/A,10\%,10) + \$10,000\,(P/F,10\%,10)$
$= \$\underline{23,433.23}$

Select <u>Design 4</u> by slim margin.

$IRR_1 \approx 15.1\%$, $IRR_2 \approx 12\%$, $IRR_3 < 10\%$, $IRR_4 \approx 12\%$;
<u>Moral</u>: Do not select Design 1 to maximize IRR!

Solutions to Spreadsheet Exercises

6-68 (a)

MARR =		15%			Annual Output Capacity			120,000
Useful Life =		5			Selling price =		$	0.375
Expenses		**P1**		**P2**		**P3**		**P4**
Capital Investment	$	24,000	$	30,400	$	49,600	$	52,000
Power	$	2,720	$	2,720	$	4,800	$	5,040
Labor	$	26,400	$	24,000	$	16,800	$	14,800
Maintenance	$	1,600	$	1,800	$	2,600	$	2,000
Tax & Insurance	$	480	$	608	$	992	$	1,040
Reject Rate		8.4%		0.3%		2.6%		5.6%
Revenue	$	41,220	$	44,865	$	43,830	$	42,480

EOY		**P1**		**P2**		**P3**		**P4**
0	$	(24,000)	$	(30,400)	$	(49,600)	$	(52,000)
1	$	10,020	$	15,737	$	18,638	$	19,600
2	$	10,020	$	15,737	$	18,638	$	19,600
3	$	10,020	$	15,737	$	18,638	$	19,600
4	$	10,020	$	15,737	$	18,638	$	19,600
5	$	10,020	$	15,737	$	18,638	$	19,600

PW =	$	9,589	$	22,353	$	12,877	$	13,702
AW =	$	2,860	$	6,668	$	3,842	$	4,088
FW =	$	19,286	$	44,960	$	25,901	$	27,560

For a MARR = 15% per year, P2 is still the recommended alternative.
The overall ranking of the alternatives remains P2 > P4 > P3 > P1.

6-68 (b)

MARR =	10%		Annual Output Capacity	120,000	
Useful Life =	5		Selling price =	$ 0.500	

Expenses	**P1**	**P2**	**P3**	**P4**
Capital Investment	$ 24,000	$ 30,400	$ 49,600	$ 52,000
Power	$ 2,720	$ 2,720	$ 4,800	$ 5,040
Labor	$ 26,400	$ 24,000	$ 16,800	$ 14,800
Maintenance	$ 1,600	$ 1,800	$ 2,600	$ 2,000
Tax & Insurance	$ 480	$ 608	$ 992	$ 1,040
Reject Rate	8.4%	0.3%	2.6%	5.6%
Revenue	$ 54,960	$ 59,820	$ 58,440	$ 56,640

EOY	**P1**	**P2**	**P3**	**P4**
0	$ (24,000)	$ (30,400)	$ (49,600)	$ (52,000)
1	$ 23,760	$ 30,692	$ 33,248	$ 33,760
2	$ 23,760	$ 30,692	$ 33,248	$ 33,760
3	$ 23,760	$ 30,692	$ 33,248	$ 33,760
4	$ 23,760	$ 30,692	$ 33,248	$ 33,760
5	$ 23,760	$ 30,692	$ 33,248	$ 33,760

PW =	$ 66,069	$ 85,947	$ 76,436	$ 75,977
AW =	$ 17,429	$ 22,673	$ 20,164	$ 20,043
FW =	$ 106,405	$ 138,418	$ 123,101	$ 122,362

For a selling price of $0.50, P2 is still the recommended alternative.

However, the overall ranking of the alternatives is now P2 > P3 > P4 > P1.

6-68 (c)

MARR =	10%		Annual Output Capacity		120,000
Useful Life =	5		Selling price =	$	0.375
			Scrap Price =	$	0.100

Expenses	**P1**	**P2**	**P3**	**P4**
Capital Investment	$ 24,000	$ 30,400	$ 49,600	$ 52,000
Power	$ 2,720	$ 2,720	$ 4,800	$ 5,040
Labor	$ 26,400	$ 24,000	$ 16,800	$ 14,800
Maintenance	$ 1,600	$ 1,800	$ 2,600	$ 2,000
Tax & Insurance	$ 480	$ 608	$ 992	$ 1,040
Reject Rate	8.4%	0.3%	2.6%	5.6%
Revenue	$ 42,228	$ 44,901	$ 44,142	$ 43,152

EOY	**P1**	**P2**	**P3**	**P4**
0	$ (24,000)	$ (30,400)	$ (49,600)	$ (52,000)
1	$ 11,028	$ 15,773	$ 18,950	$ 20,272
2	$ 11,028	$ 15,773	$ 18,950	$ 20,272
3	$ 11,028	$ 15,773	$ 18,950	$ 20,272
4	$ 11,028	$ 15,773	$ 18,950	$ 20,272
5	$ 11,028	$ 15,773	$ 18,950	$ 20,272

PW =	$ 17,805	$ 29,392	$ 22,235	$ 24,847
AW =	$ 4,697	$ 7,754	$ 5,866	$ 6,555
FW =	$ 28,675	$ 47,336	$ 35,810	$ 40,016

Including a scrap price of $0.10, P2 is still the recommended alternative.
The overall ranking of the alternatives remains P2 > P4 > P3 > P1.

6-68 (d)

MARR =		15%			Annual Output Capacity			120,000
Useful Life =		5			Selling price =		$	0.375
					Scrap Price =		$	0.100
Expenses		**P1**		**P2**		**P3**		**P4**
Capital Investment	$	24,000	$	30,400	$	49,600	$	52,000
Power	$	2,720	$	2,720	$	4,800	$	5,040
Labor	$	26,400	$	24,000	$	16,800	$	14,800
Maintenance	$	1,600	$	1,800	$	2,600	$	2,000
Tax & Insurance	$	480	$	608	$	992	$	1,040
Reject Rate		8.4%		0.3%		2.6%		5.6%
Revenue	$	42,228	$	44,901	$	44,142	$	43,152

EOY		**P1**		**P2**		**P3**		**P4**
0	$	(24,000)	$	(30,400)	$	(49,600)	$	(52,000)
1	$	11,028	$	15,773	$	18,950	$	20,272
2	$	11,028	$	15,773	$	18,950	$	20,272
3	$	11,028	$	15,773	$	18,950	$	20,272
4	$	11,028	$	15,773	$	18,950	$	20,272
5	$	11,028	$	15,773	$	18,950	$	20,272

PW =	$	12,968	$	22,474	$	13,923	$	15,955
AW =	$	3,868	$	6,704	$	4,154	$	4,760
FW =	$	26,082	$	45,202	$	28,005	$	32,091

When all changes occur simultaneously, P2 is still the recommended alternative. The overall ranking of the alternatives remains P2 > P4 > P3 > P1.

6-69 See P6-69.xls

Investment Amount		$4,000				
Interest Rate		5%				
Class A:				Class B:		
		Account Value				Account Value
	Fee	at EOY			Fee	at EOY
0	5%	$ 3,800.00		0	0	$ 4,000.00
1	0.61%	$ 3,966.82		1	2.35%	$ 4,106.00
2	0.61%	$ 4,140.96		2	0.34%	$ 4,297.34
3	0.61%	$ 4,322.75		3	1.37%	$ 4,453.33
4	0.61%	$ 4,512.52		4	1.37%	$ 4,614.99
5	0.61%	$ 4,710.62		5	1.37%	$ 4,782.51
6	0.61%	$ 4,917.42		6	1.37%	$ 4,956.12
7	0.61%	$ 5,133.29		7	1.37%	$ 5,136.03
8	0.61%	$ 5,358.64		8	1.37%	$ 5,322.46
9	0.61%	$ 5,593.89		9	1.37%	$ 5,515.67
10	0.61%	$ 5,839.46		10	1.37%	$ 5,715.89

It takes eight years for the Class A account to be preferred to the Class B account.

6-70 (a)

MARR	20%	

	SP240	HEPS9
Capital investment	$ 33,200	$ 47,600
Annual energy expense	$ 2,165	$ 1,720
Annual maintenance:		
Starting year	1	4
First year	$ 1,100	$ 500
Increase per year	$ 500	$ 100
Useful life (years)	5	9
Market Value	$ −	$ 5,000

EOY	SP240	HEPS9
4	$ (4,765)	$ (2,220)
5	$ (5,265)	$ (2,320)
6		$ (2,420)
7		$ (2,520)
8		$ (2,620)
9		$ 2,280
AW(20%)	$ (15,187)	$ (13,621)

6-70 (b)

MARR	20%	

	SP240	HEPS9
Capital investment	$ 28,519	$ 47,600
Annual energy expense	$ 2,165	$ 1,720
Annual maintenance:		
Starting year	1	4
First year	$ 1,100	$ 500
Increase per year	$ 500	$ 100
Useful life (years)	5	9
Market Value	$ –	$ 5,000

EOY	SP240	HEPS9	
0	$ (28,519)	$ (47,600)	
1	$ (3,265)	$ (1,720)	
2	$ (3,765)	$ (1,720)	
3	$ (4,265)	$ (1,720)	
4	$ (4,765)	$ (2,220)	
5	$ (5,265)	$ (2,320)	
6		$ (2,420)	
7		$ (2,520)	
8		$ (2,620)	
9		$ 2,280	
			Difference
AW(20%)	$ (13,621)	$ (13,621)	$ –

If the capital investment for SP240 was $28,519, we would be indifferent as to which pump was implemented.

6-71 See P6-71.xls.

	A	B	C
Investment cost	$28,000	$55,000	$40,000
Annual expenses	$15,000	$13,000	$22,000
Annual revenues	$23,000	$28,000	$32,000
Market value	$6,000	$8,000	$10,000
Useful life	10 years	10 years	10 years

MARR 20%

	A - DN	C - A	B-A
0	($28,000)	($12,000)	($27,000)
1	$8,000	$2,000	$7,000
2	$8,000	$2,000	$7,000
3	$8,000	$2,000	$7,000
4	$8,000	$2,000	$7,000
5	$8,000	$2,000	$7,000
6	$8,000	$2,000	$7,000
7	$8,000	$2,000	$7,000
8	$8,000	$2,000	$7,000
9	$8,000	$2,000	$7,000
10	$14,000	$6,000	$9,000
IRR	26.4%	13.1%	22.8%
Good?	Yes	No	Yes

Invest in alternative B.

Solutions to Case Study Exercises

6-72 Other factors that could be included are distribution costs to grocers, storage costs at grocery stores and projected revenues in the likely event that half gallons are sold for less than twice the price of a quart, and quarts are sold for less than twice the price of a pint. Such non−proportional pricing is common for consumer food products.

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6-73 If landfill costs double, the recommendation for the assumptions given in the case study will be to "produce ice cream and yogurt in half−gallon containers."

6-74 At your grocery store you will probably discover that the profit associated with a smaller container of ice cream is greater than that of a larger container. For a fixed amount of consumption (e.g. 20,000,000 gallons per year), it is likely that packaging in pint containers is the way to go. Ned and Larry's Ice Cream Company apparently already knows this to be true.

Solutions to FE Practice Problems

6-75 Set $PW_{\text{all now}}(i') = PW_{\text{3 checks}}(i')$ and solve for i'
$\$125{,}000 = \$50{,}000 + \$50{,}000\,(P/A,i',2)$
$(P/A,i',2) = 1.5$; $i' \approx 21.6\%$

Select (c)

If the MARR > 21.6%, select $125,000 now; if MARR < 21.6%, select $50,000 at time 0, 1, and 2.

If MARR = 21.6%, Bill would be indifferent.

6-76 Savings per plan = \$40,000 − \$30,000 = \$10,000 / year
Let X = number of planes operated per year.

$$\$500,000 = \$10,000\,(X)\,(P/A,10\%,15) + \$100,000\,(P/F,10\%,15)$$

$$X = \frac{\$500,000 - \$100,000(0.2394)}{\$10,000(7.6061)}$$

X = 6.26 or 7 planes per year

<u>Select (a)</u>

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6-77 $PW_B(15\%) = -\$16{,}000 + \$5{,}500\,(P/A,15\%,3) + \$6{,}150\,(P/F,15\%,3) = \$601$

<u>Select (b)</u> − Alternative A to maximize PW

6-78 $FW_C(12\%) = -\$13,000\ (F/P,12\%,10) - \$500\ (F/A,12\%,10) + \$1,750 = -\$47,400$

<u>Select (c)</u> – Alternative C to minimize costs.

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6-79 $AW_A(12\%) = -\$12{,}000(A/P, 12\%, 4) + \$4{,}000 + \$3{,}000(A/F, 12\%, 4) = \$677$
$AW_B(12\%) = -\$15{,}800(A/P, 12\%, 4) + \$5{,}200 + \$3{,}500(A/F, 12\%, 4) = \$730$
$AW_C(12\%) = -\$8{,}000(A/P, 12\%, 4) + \$3{,}000 + \$1{,}500(A/F, 12\%, 4) = \$680$

Select (b)

6-80 IRR on $\Delta(B - C)$:

$$0 = -\$3{,}000 + (\$460 - \$100)(P/A,i',6) + \$3{,}350(P/F,i',6)$$

$$i' = 13.4\% > 10\%$$

<u>Select (c)</u> – Alternative B

6-81 $\Delta PW_{W \rightarrow X}(15\%) = -\$550 + \$15\ (P/A,15\%,8) + \$200\ (P/F,15\%,8)$
$= -\$417.31 < 0$

<u>Select (a)</u> – Alternative W

6-82 Rank Order: DN→D→C→A→E→B

Assuming the MARR ≤ 42.5%, Alternative D is the base alternative. The first Comparison to be made based on the tank ordering would be D→C.

<u>Select (e)</u>

6-83 $PW_{A\to B}(15\%) = [-\$90{,}000 - (-\$60{,}000)] + (\$12{,}000 - \$20{,}000)\ (P/A,15\%,10)$
$+ (\$15{,}000 - \$10{,}000)\ (P/F,15\%,10)$
$= -\$68{,}914$

<u>Select (a)</u>

6-84 $PW_A(i') = 0 = -\$60{,}000 + \$20{,}000\,(P/A,i',10)$

$i' = 31.5\%$

Select (a)

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6-85 Eliminate Alt. B and Alt. E (IRR < 15%)

$PW_A(15\%) = -\$60{,}000 + \$20{,}000\ (P/A,15\%,10) + \$10{,}000\ (P/F,15\%,10)$
$= \$42{,}848$

$PW_C(15\%) = -\$40{,}000 + \$13{,}000\ (P/A,15\%,10) + \$10{,}000\ (P/F,15\%,10)$
$= \$27{,}716$

$PW_D(15\%) = -\$30{,}000 + \$13{,}000\ (P/A,15\%,10) + \$10{,}000\ (P/F,15\%,10)$
$= \$37{,}716$

Select (b) – Alternative A to maximize PW.

6-86 $AW_X(10\%) = -\$500,000(A/P, 10\%, 5) + \$131,900 = 0$
$AW_Y(10\%) = -\$250,000(A/P, 10\%, 10) + \$40,690 = \$15$
$AW_Z(10\%) = -\$400,000(A/P, 10\%, 20) + \$44,050 = -\$2,950$

<u>Select (b)</u>

Solutions to Chapter 7 Problems

7-1 The actual magnitude of depreciation cannot be determined until the asset is retired from service (it is always paid or committed in advance). Also, throughout the life of the asset we can only estimate what the annual or periodic depreciation cost is. Another difference is that relatively little can be done to control depreciation cost once an asset has been acquired, except through maintenance expenditures. Usually much can be done to control the ordinary out-of–pocket expenses such as labor and material.

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7-2 To be considered depreciable, a property must be:

1) used in a business to produce income;
2) have a determinable life of greater than one year; and
3) lose value through wearing out, becoming obsolete, etc.

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7-3 Personal property is generally any property that can be moved from one location to another, such as equipment or furniture. Real property is land and anything erected or growing on it.

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7-4 The cost basis is usually the purchase price of the property, plus any sales taxes, transportation costs, and the cost of installation or improving the property to make it fit for intended use. Salvage value is not considered, nor is the cost of the land the property is on.

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7-5 Under MACRS, the ADS might be preferred to the GDS in several cases. If profits are expected to be relatively low in the near future, but were going to increase to a fairly constant level after that, the ADS would be a way to "save up" depreciation for when it is needed later. In essence, income taxes would be deferred until a later time when the firm is financially more able to pay them.

7-6 Basis = \$120,000

(a) d_2 = (\$120,000 − \$10,000)/10 = \$<u>11,000</u>

(b) BV_1 = \$120,000 − \$11,000 = \$<u>109,000</u>

(c) BV_{10} = \$120,000 − \$11,000(10) = \$<u>10,000</u>

7-7 $B = \$160,000 + \$15,000 + \$15,000 = \$190,000$

(a) $d_k = d_3 = (\$190,000 - \$40,000)/5 = \$30,000$
$BV_3 = \$190,000 – (3)(\$30,000) = \$100,000$

(b) $BV_2 = \$190,000 – (2)(\$30,000) = \$130,000$
R = 2/3 for the double declining balance method
$BV_4 = \$130,000(1 – 2/3)^2 = \$14,444.44$

7-8 Basis = \$60,000 and SV_N = \$12,000. Find d_3 and BV_5.

(a) $d_3 = d_k = \dfrac{B - SV_N}{N} = \dfrac{\$60,000 - \$12,000}{14} = \$\underline{3,428.57}$

$BV_5 = \$60,000 - (5)(\$3,428.57) = \$\underline{42,857.15}$

(b)

Year, k	(1) Beginning of Year BV[a]	(2) Depreciation Method: 200% Declining Balance Method[b]	(3) Depreciation Method: Straight−Line Method[c]	(4) Depreciation Amount Selected[d]
1	\$ 60,000.00	\$8,571.43	\$3,428.57	\$8,571.43
2	51,428.57	7,346.94	3,032.97	7,346.94
3	44,081.63	6,297.38	2,673.47	6,297.38
4	37,784.25	5,397.75	2,344.02	5,397.75
5	32,386.50	4,626.64	2,038.65	4,626.64

[a] Column 1 for year k − column 4 for year k = the entry in column 1 for year k+1
[b] Column 1 x (2 / 14)
[c] Column 1 minus estimated SV_N divided by remaining years from the beginning of the current year through the fourteenth year.
[d] Select the larger amount of column 2 or column 3.

From the above table,

$d_3 = \$\underline{6,297.38}$ and $BV_5 = \$32,386.50 - \$4,626.64 = \$\underline{27,759.86}$

(c) From Table 7-2, the GDS recovery period is 7 years.

$d_3 = \$60,000\ (0.1749) = \$\underline{10,494}$

$BV_5 = \$60,000 - \$60,000\ (0.1429 + 0.2449 + 0.1749 + 0.1249 + 0.0893)$
$= \$\underline{13,386}$

(d) From Table 7-2, the ADS recovery period is 14 years.

$d_1 = d_{15} = (0.5)\left(\dfrac{\$60,000}{14}\right) = \$2,142.86$

$d_2 = d_3 = \cdots = d_{14} = \left(\dfrac{\$60,000}{14}\right) = \$\underline{4,285.71}$

$BV_5 = \$60,000 - [\$2,142.86 + 4(\$4,285.71)] = \$\underline{40,714.30}$

7-9 **(a)** $d_2 = \frac{2}{7}\left[\left(\frac{5}{7}\right)(\$35{,}000)\right] = \$\underline{7{,}142.86}$

(b) GDS recovery period = 5 years (from Table 7-4)

$d_2 = 0.32\ (\$35{,}000) = \$\underline{11{,}200}$

(c) Assuming the ADS recovery period is 7 years (that is, equal to the class life):

$d_2 = \frac{1}{7}(\$35{,}000) = \underline{\$5{,}000}$

7-10 From Table 7-2, the GDS recovery period is seven years. The MACRS depreciation deductions from Table 7-3 are the following: $100,000(0.1429) = $14,290 in 2007; $24,490 in 2008; $17,490 in 2009; $12,490 in 2010; $8,930 in 2011; $8,920 in 2012; $8,930 in 2013; and $4,460 in 2014. Notice that salvage value is ignored by MACRS.

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7-11 From Table 7-2, the GDS recovery period is 3 years.

(a) Basis = \$195,000
d^*_3 = \$195,000 (0.3333 + 0.4445 + 0.1481) = \$<u>180,550.50</u>

(b) d_4 = 0.0741 (\$195,000) = \$<u>14,449.50</u>

(c) BV_2 = \$195,000 (1 − 0.3333 − 0.4445) = \$<u>43,329</u>

7-12 A general purpose truck has a GDS recovery period of five years, so MACRS depreciation in year five is \$100,000(0.1152) = \$11,520. Straight-line depreciation in year five would be (\$100,000 − \$8,000)/8 = \$11,500. The difference in depriciation amounts is \$20.

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7-13 **(a)** From Table 7-2, the GDS recovery period is 5 years and the ADS recovery period is 6 years**.**

GDS depreciation deductions:

d_1 = 0.2000 ($300,000) = $60,000	d_4 = 0.1152 ($300,000) = $34,560
d_2 = 0.3200 ($300,000) = $96,000	d_5 = 0.1152 ($300,000) = $34,560
d_3 = 0.1920 ($300,000) = $57,600	d_6 = 0.0576 ($300,000) = $17,280

ADS depreciation deductions**:**

$$d_1 = d_7 = (0.5)\left(\frac{\$300{,}000}{6}\right) = \$25{,}000$$

$$d_2 = d_3 = \cdots = d_6 = \frac{\$300{,}000}{6} = \$50{,}000$$

(b) Assume calculation of PW at time of purchase and the depreciation deduction is taken at the end of the year.

PW_{GDS} = $60,000 (P/F,12%,1) + $96,000(P/F,12%,2) + $57,600(P/F,12%,3)
+ $34,560(P/F, 12%,4) + $34,560(P/F,12%,5) + $17,280(P/F,12%,6)
= $<u>221,431.15</u>

PW_{ADS} = $25,000 (P/F,12%,1) + $50,000 (P/A,12%,5)(P/F,12%,1)
+ $25,000(P/F,12%,7)
= $<u>194,566.30</u>

Difference = PW_{Δ} = $221,431.15 − $194,566.30 = $<u>26,864.85</u>

7-14 From Table 7-4, the GDS recovery period is 5 years.
Cost basis = \$99,500 + \$15,000 trade in = \$114,500

(a) d_3 = 0.192 (\$114,500) = \$<u>21,984</u>

(b) BV_4 = \$114,500 − \$114,500 (0.2 + 0.32 + 0.192 +0.1152) = \$<u>19,786</u>

(c) R = 2/9.5 = 0.2105
d_4^* = \$114,500 [1 − (1 − 0.2105)^4] = \$<u>70,015</u>

7-15 **(a)** Cost basis = \$1,500,000 + \$35,000 + \$50,000 = \$1,585,000

(b) From Table 7-2, the class life is 10 years.

(c) The GDS recovery period is seven years. Thus, the MACRS depreciation in year five is \$1,585,000(0.0893) = \$141,540.50.

(d) Remember that only half the normal depreciation amount can be claimed in the year an asset is disposed of. BV_6 = (1 – 0.8215)(\$1,585,000) = \$282,922.50. The depreciation recaptured is $MV_6 - BV_6$ = \$360,000 − \$282,922.50 = \$77,077.50.

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7-16 Depreciation per unit of production = $\frac{\$25{,}000 - \$5{,}000}{100{,}000 \text{ units}}$ = \$0.20/unit

d_4 = (10,000 units) (\$0.2/unit) = \$<u>2,000</u>

BV_4 = \$25,000 − (60,000 units + 10,000 units)(\$0.20/unit) = \$<u>11,000</u>

7-17 Total units of production over the five year life = 100,000 cubic yards

d_3 = (36,000/100,000)($60,000 − $10,000) = $18,000

BV_2 = $60,000 – ($d_1$ + d_2) = $60,000 – [(0.16)($50,000) + (0.24)($50,000)]
= $60,000 – ($8,000 + $12,000)
= $40,000

7-18 **(a)** Income taxes = \$50,000 (0.15) + \$25,000 (0.25) + \$15,000 (0.34) = \$18,850

(b) Depreciation + Expenses = \$220,000 − \$90,000 = \$130,000

7-19 t = state + local + federal (1 – state – local)

$$
\begin{aligned}
t &= \text{state} + \text{local} + \text{federal}\,(1 - \text{state} - \text{local}) \\
&= \text{federal} + (1 - \text{federal})(\text{state}) + (1 - \text{federal})(\text{local}) \\
&= 0.35 + 0.65(0.06) + 0.65(0.01) \\
&= 0.3955 \text{ (round it to 40\%)}
\end{aligned}
$$

7-20 $t = 0.06 + 0.34(1 - 0.06) = 0.3796$, or 37.96%;
$t = 0.12 + 0.34(1 - 0.12) = 0.4192$, or 41.92%

7-21 $t = 0.5 + (1 - 0.5)(0.39) = 0.4205$ (effective income tax rate)

After-tax MARR $= 0.18(1 - 0.4205) = 0.1043$ (10.43%)

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7-22 BV_3 = \$125,000 – (3)(\$125,000/5) = \$50,000

(a) Gain on disposal = \$70,000 − \$50,000 = \$20,000
Tax liability on gain = 0.4(\$20,000) = \$8,000
Net cash inflow = \$70,000 − \$8,000 = \$62,000

(b) Loss on disposal = \$50,000 − \$20,000 = \$30,000
Tax credit from loss = 0.4(\$30,000) = \$12,000
Net cash inflow = \$30,000 + \$12,000 = \$42,000

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7-23 **(a)** $\text{Before-tax MARR} = \dfrac{\text{After - tax MARR}}{1 - t} = \dfrac{0.15}{1 - 0.40} = 0.25$, or 25%

(b)

Year	Depreciation	Year	Depreciation
1	$12,861	5	$8,037
2	22,041	6	8,028
3	15,741	7	8,037
4	11,241	8	4,014

(c) $BV_8 = 0$, therefore TI_8 = $10,000 (Property having a 7-year recovery period is fully depreciated after N+1=8 years.)

(d)

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF	PW (15%)
0	−$90,000	---	---	---	−$90,000	−$90,000
1	15,000	$12,861	$2,139	−$856	14,144	12,299
2	15,000	22,041	−7,041	2,816	17,816	13,472
3	15,000	15,741	−741	296	15,296	10,058
4	15,000	11,241	3,759	−1,504	13,496	7,717
5	15,000	8,037	6,963	−2,785	12,215	6,073
6	15,000	8,028	6,972	−2,789	12,211	5,279
7	15,000	8,037	6,963	−2,785	12,215	4,592
8	15,000	4,014	10,986	−4,394	10,606	3,467
8	10,000	---	10,000	−4,000	6,000	1,961
					PW(15%) =	−$25,082

(e) No, reject the project because PW(ATCF) < 0 at MARR = 15%.

7-24

EOY	(A) BTCF	(B) Depr.	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−\$10M	---	---	---	− \$10M
1	\$4M	\$2.5M	\$1.5M	−\$0.6M	\$3.4M
2	\$4M	\$2.5M	\$1.5M	−\$0.6M	\$3.4M
3	\$4M	\$2.5M	\$1.5M	−\$0.6M	\$3.4M
4a	\$4M	\$2.5M	\$1.5M	−\$0.6M	\$3.4M
4b	0		0	0	

M ≡ millions of dollars

PW(15%) = −\$10M + \$3.4M (P/A,i%,4) = −\$.293M
IRR: 0 = −\$10M + \$3.4M (P/A,i%,4); i' = 13.54%
Because PW(10%) < 0 and IRR < 15%, this project should <u>not</u> be recommended.

7-25

EOY	(A) BTCF	(B) Depr.	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$15,000	---	---	---	− $15,000
1	7,000	$3,000	$4,000	−$1,600	5,400
2a	7,000	2,400	4,600	−1,840	5,160
2b	10,000		400	−160	9,840

d_2 = $15,000(0.32)(0.5) = $2,400
BV_2 = $15,000 − $3,000 − $2,400 = $9,600
MV_2 = $15,000 − $2,500(2) = $10,000

PW(15%) = −$15,000 + $5,400(P/F, 15%, 1) + ($5,160 + $9,840)(P/F, 15%, 2) = $1,037.81

AW(15%) = $1,037.81(A/P, 15%, 2) = $638.36 ≥ 0, so the investment is a profitable one.

7-26 (a)

EOY	BTCF	d	TI	T(40%)	ATCF
0	−$200,000				−$200,000
1	36,000	$20,000	$16,000	−$6,400	29,600

The IRR is found as follows: 0 = −$200,000 + $29,000(P/A, i′, 10). Solving yields i′ = 7.85%. Because this after-tax IRR is less than 8%, the robot should not be acquired.

(b)

EOY	BTCF	d	TI	T(40%)	ATCF
0	−200,000				−200,000
1	36,000	28,580	7,420	−2968	33,032
2	36,000	48,980	−12,980	5192	41,192
3	36,000	34,980	1,020	−408	35,592
4	36,000	24,980	11,020	−4408	31,592
5	36,000	17,860	18,140	−7256	28,744
6	36,000	17,840	18,160	−7264	28,736
7	36,000	17,860	18,140	−7256	28,744
8	36,000	8,920	27,080	−10832	25,168
9	36,000		36,000	−14400	21,600
10	36,000		36,000	−14400	21,600
				PW(8%)	$ 6,226.76
				IRR	8.76%

7-27 The sales revenue is \$40 per ticket x 60,000 tickets per year = \$2,400,000 per year and the investment in working capital is (1/12)(\$2,400,000) = \$200,000. The the total investment is \$800,000 = \$200,000 = \$1,000,000 and depreciation is \$800,000 / 4 = \$200,000 per year. Total annual operating costs are \$24 (60,000 tickets) + \$400,000 = \$1,840,000.

EOY	(A) BTCF	(B) Depr.	(C) = (A) − (B) TI	(D) = −t (C) T (50%)	(E) = (A) + (D) ATCF
0	−\$1,000,000	---	---	---	−\$1,000,000
1	\$560,000	\$200,000	\$360,000	−\$122,400	\$437,600
2	\$560,000	\$200,000	\$360,000	−\$122,400	\$437,600
3	\$560,000	\$200,000	\$360,000	−\$122,400	\$437,600
4a	\$560,000	\$200,000	\$360,000	−\$122,400	\$437,600
4b	\$200,000	——	——	——	\$200,000

PW(15%) = −\$1,000,000 + \$437,600 (P/A,15%,4) + \$200,000 (P/F,15%,4)
= \$363,690 >> 0; <u>the investment should be made</u>.

7-28 $d = (\$84,000 – 0)/6 = \$14,000$

EOY	BTCF	d	TI	T(40%)	ATCF
0	−$84,000				−$84,000
1	18,000	$14,000	$4,000	−$1,600	16,400

PW(12%) = −$84,000 + $16,400(P/A, 12%, 6) = −$16,573

The IRR is found by solving 0 = −$84,000 + $16,400(P/A, i′, 6) for i′ = 4.72%. The new truck is not a good investment. It fails to earn the required 12% per year after taxes (PW < 0). This is confirmed by an after-tax IRR = 4.72% < MARR.

7-29

EOY	BTCF	d	TI	T	ATCF
0	−$200,000				−$200,000
1	−65,000	$40,000	−$105,000	$42,000	−23,000
2	−65,000	64,000	−129,000	51,600	−13,400
3a	−65,000	19,200	−84,200	33,680	−31,320
3b	70,000		−6,800	2,720	72,720

$$\begin{aligned}\text{EUAC}(12\%) &= [\$200{,}000 + \$23{,}000(P/F, 12\%, 1) + \$13{,}400(P/F, 12\%, 2) \\ &\quad + (\$31{,}320 - \$72{,}720)(P/F, 12\%, 3)](A/P, 12\%, 3) \\ &= \$83{,}989\end{aligned}$$

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7-30

	(A)	(B)	(C) = (A) − (B)	(D) = −t (C)	(E) = (A) + (D)
EOY	BTCF	Depr*	TI	T (50%)	ATCF
0	−\$160,000	---	---	---	−\$160,000
1	\$35,000	\$26,000	\$9,000	−\$4,500	\$30,500
2	\$35,000	\$41,600	−\$6,600	\$3,300	\$38,300
3	\$35,000	\$24,960	\$10,040	−\$5,020	\$29,980
4	\$35,000	\$14,976	\$20,024	−\$10,012	\$24,988
5	\$35,000	\$7,488	\$27,512	−\$13,756	\$21,244
5	\$30,000**	---	0−\$14,976***	\$7,488	\$37,488

*d = \$130,000 · $r_k(p)$ (see Table 7-3)
**Assume land recovered at original cost of \$30,000
***MV – BV; Market Value of equipment (purchased) is negligible at the end of year 5.
Assume 1/2 year on year 5 depreciation (recapture = \$14,976)

PW(5%) = −\$160,000 + \$30,500(P/F,5%,1) + \$38,300(P/F,5%,2) + \$29,980(P/F,5%,3)
+ \$24,988(P/F5%,4) + (\$21,244+\$37,488)(P/F,5%,5)
= −\$160,000 + \$30,500(0.9524) + \$38,300(0.9070) + \$29,980(0.8638)
+ \$24,988(0.8227) + \$58,732(0.7835)
= −\$3,742.83

<u>PW($MARR_{AT}$) < 0, not a profitable investment</u>

7-31

EOY	BTCF	Depreciation	Taxable Income	Income Tax	ATCF
0	−\$P	---	---	---	−\$P
1-5	\$15,000	\$P/5	\$15,000 − \$P/5	−\$6,000 + 0.08P	\$9,000 + \$0.08P

$P \leq \$9{,}000(P/A, 12\%, 5) + 0.08P(P/A, 12\%, 5)$
$P \leq \$32{,}443.20 + 0.2884P$
$P \leq \$45{,}592$ for the proposed system.

7-32 X = annual production level

EOY	BTCF	d	Taxable Income	Income Tax	ATCF
0	−\$500,000	---	---	---	−\$500,000
1-5	−35,000 + 42.5X	\$100,000	−\$135,000 + \$42.5X	\$54,000 – \$17X	19,000 + 25.5X

AW = 0 = −\$500,000(A/P, 10%, 5) +\$19,000 + \$25.5X

X = 4,427.40 or 4,428 units per year must be produced (and sold) for this project to be economically viable.

7-33

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$50,000	---	---	---	−$50,000
1	14,000	$10,000	$4,000	−$1,600	12,400
2	14,000	10,000	4,000	−1,600	12,400
3	14,000	10,000	4,000	−1,600	12,400
4	14,000	10,000	4,000	−1,600	12,400
5	14,000	10,000	4,000	−1,600	12,400
6	14,000	0	14,000	−5,600	8,400
.	14,000	0	14,000	−5,600	8,400
.	14,000	0	14,000	−5,600	8,400
N	14,000	0	14,000	−5,600	8,400

Let X = N − 5 years. Set PW(10%) = 0 and solve for X:

$$0 = -\$50{,}000 + \$12{,}400(P/A,10\%,5) + \$8{,}400(P/A,10\%,X)(P/F,10\%,5)$$
$$(P/A,10\%,X) = 0.5741$$

X ≈ 1 year. Thus, N = 5 + X = <u>6 years</u>

7-34 After-tax MARR = 7.2% per year.

EOY	BTCF	d	TI	T	ATCF
0	-$12,000				-$12,000
1	4,000	4,000	$0	$0	4,000
2	4,000	5,334	-1,334	534	4,534
3	4,000	1,777	2,223	-889	3,111
4	4,000	889	3,111	-1,244	2,756
4	3,000	---	3,000	-1,200	1,800
				A: PW	$ 1,651

EOY	BTCF	d	TI	T	ATCF
0	-$15,800				-$15,800
1	5,200	$5,266	-$66	$26	5,226
2	5,200	7,023	-1,823	729	5,929
3	5,200	2,340	2,860	-1,144	4,056
4	5,200	1,171	4,029	-1,612	3,588
4	3,500	---	3,500	-1,400	2,100
				B: PW	$ 1,835

EOY	BTCF	d	TI	T	ATCF
0	-$8,000				-$8,000
1	3,000	$2,666	$334	-$133	2,867
2	3,000	3,556	-556	222	3,222
3	3,000	1,185	1,815	-726	2,274
4	3,000	593	2,407	-963	2,037
4	1,500	---	1,500	-600	900
				C: PW	$ 1,548

Choose alternative B to maximize after-tax PW. Alternative B was also chosen when a before-tax analysis was done in Problem 6-79.

7-35 $t = s + f(1 - s) = 0.04 + 0.34(1 - 0.04) = 0.3664$, or 36.64%

EOY	(A) Investment	(B) Revenues	(C) Expenses	(D)=(A)+(B)+(C) BTCF	(E) Depr[a]
0	−$1,000,000	---	---	− $1,000,000	---
1		X	$636,000	X − 636,000	$139,986
2		X	674,160	X − 674,160	186,690
3		X	714,610	X − 714,610	31,101[b]
3	280,000[c]	---	---	280,000	---
3	580,000[d]	---	---	580,000	---

[a] Cost basis for depreciation calculations = $420,000
[b] Only a half-year of depreciation is allowable
[c] Market value of depreciable investment
[d] Assumed value of non−depreciable investment (land and working capital)

EOY	(F)=(D)−(E) TI	(G)= −t (F) T(36.64%)	(H)=(D)+(G) ATCF
0	---	0	−$1,000,000
1	X − 775,986	−0.3664X + 284,321	0.6336X − 351,679
2	X − 860,850	−0.3664X + 315,415	0.6336X − 358,745
3	X − 745,711	−0.3664X + 273,229	0.6336X − 441,381
3	217,777[e]	−79,793	200,207
3	---	---	580,000

[e] $MV - BV_3 = \$280,000 - \$62,223 = \$217,777$

$$PW(10\%) = 0 = -\$1,000,000 + (0.6336\,X)(P/A,10\%,3) - \$351,679(P/F,10\%,1)$$

$$- \$358,745(P/F,10\%,2) - \$441,381(P/F,10\%,3) + \$780,207(P/F,10\%,3)$$

$$X = \frac{\$1,361,618}{(2.4869)(0.6336)} = \underline{\$864,135 / \text{year}}$$

7-36 Assume repeatability.

Alternative A: Plastic
d = ($5000−$1000)/5 = $800

EOY	(A) BTCF	(B) Depr.	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$5,000	---	---	---	− $5,000
1−5	−$300	$800	−$1,100	$440	$140
5	0	---	−$1,000	$400	$400

$AW_A(12\%) = -\$5{,}000(A/P,12\%,5) + \$140 + \$400(A/F,12\%,5) = -\$1{,}184$

Alternative B: Copper
d = ($10,000 − $5,000)/10 = $500

EOY	(A) BTCF	(B) Depr.	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$10,000	---	---	---	− $10,000
1−10	−$100	$500	−$600	$240	$140
10	0	---	−$5,000	$2,000	$2,000

$AW_B(12\%) = -\$10{,}000(A/P,12\%,10) + \$140 + \$2{,}000(A/F,12\%,5) = -\$1{,}516$

Select Alternative A: Plastic.

7-37

EOY	BTCF	d	TI	T	ATCF
0	-$1,140,000				-$1,140,000.0
1	-115,500	$162,906	-$278,406	$111,362.4	-4,137.6
2	-115,500	279,186	-394,686	157,874.4	42,374.4
3	-115,500	199,386	-314,886	125,954.4	10,454.4
4	-115,500	142,386	-257,886	103,154.4	-12,345.6
5	-115,500	101,802	-217,302	86,920.8	-28,579.2
6	-115,500	101,688	-217,188	86,875.2	-28,624.8
7	-115,500	101,802	-217,302	86,920.8	-28,579.2
8	-115,500	50,844	-166,344	66,537.6	-48,962.4
9	-115,500		-115,500	46,200.0	-69,300.0
10	-115,500		-115,500	46,200.0	-69,300.0
				PW(9%)	-$1,255,661

EOY	BTCF	d	TI	T	ATCF
0	-$992,500				-$992,500.0
1	-73,200	$141,828	-$215,028	$86,011.3	12,811.3
2	-73,200	243,063	-316,263	126,505.3	53,305.3
3	-73,200	173,588	-246,788	98,715.3	25,515.3
4	-73,200	123,963	-197,163	78,865.3	5,665.3
5	-73,200	88,630	-161,830	64,732.1	-8,467.9
6	-73,200	88,531	-161,731	64,692.4	-8,507.6
7	-73,200	88,630	-161,830	64,732.1	-8,467.9
8	-73,200	44,266	-117,466	46,986.2	-26,213.8
9	-73,200		-73,200	29,280.0	-43,920.0
10	-73,200		-73,200	29,280.0	-43,920.0
				PW(9%)	-$983,060

Select new ESP to maximize after-tax present worth.

7-38 Assume repeatability**.**

Purchase Option: From Table 7-2, the ADS recovery period is 6 years (asset class 36.0). Applying the half year convention, depreciation deductions can be claimed over a 7-year period.

$d_1 = d_7 = (0.5)(\$30{,}000/6) = \$2{,}500$
$d_2 = d_3 = ... = d_6 = (\$30{,}000/6) = \$5{,}000$

EOY	(A) BTCF	(B) Depr.	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$30,000	---	---	---	− $30,000
1	0	$2,500	−$2,500	$1,000	1,000
2	0	5,000	− 5,000	2,000	2,000
3	0	5,000	− 5,000	2,000	2,000
4	− 10,000	5,000	−15,000	6,000	− 4,000 = − 10,000 + 6,000
5	0	5,000	− 5,000	2,000	2,000
6	0	5,000	− 5,000	2,000	2,000
7	0	2,500	− 2,500	1,000	1,000
8	0	---	0	0	0

$$\text{PW}(12\%) = -\$30{,}000 + \$1{,}000(P/A,12\%,7) + \$1{,}000(P/A,12\%,5)(P/F,12\%,1) - \$6{,}000(P/F,12\%,4)$$
$$= -\$26{,}030.47$$
$$\text{AW}(12\%) = -\$26{,}030.47\ (A/P,12\%,8) = -\$5{,}240$$

Leasing Option

$$\text{ATCF} = -(1 - 0.40)(\text{Leasing Cost}) = \text{AW}(12\%)$$

For the leasing option to be more economical than the purchase option,

$$-(0.6)\ (\text{Leasing Cost}) < -\$5{,}240$$

$$\text{Leasing Cost} < \$8{,}733$$

If Leasing Cost < $8,733 per year, lease the tanks; otherwise, purchase the tanks.

7-39 Assume repeatability.

Fixture X

EOY	(A) BTCF	(B) Depr.	(C) = (A) − (B) TI	(D) = −t (C) T (50%)	(E) = (A) + (D) ATCF
0	−$30,000	---	---	---	− $30,000
1−5	−$3,000	$6,000	−$9,000	$4,500	$1,500
6	−$3,000	0	−$3,000	$1,500	−$1,500
6*	$6,000	---	$6,000**	−$3,000	$3,000

*Market Value **Depreciation Recapture

$AW_X(8\%) = \underline{-\$4,989}$

Fixture Y

EOY	(A) BTCF	(B) Depr.	(C) = (A) − (B) TI	(D) = −t (C) T (50%)	(E) = (A) + (D) ATCF
0	−$40,000	---	---	---	− $40,000
1	−$2,500	$8,000	−$10,500	$5,250	$2,750
2	−$2,500	$12,800	−$15,300	$7,650	$5,150
3	−$2,500	$7,680	−$10,180	$5,090	$2,590
4	−$2,500	$4,608	−$7,108	$3,554	$1,054
5	−$2,500	$4,608	−$7,108	$3,554	$1,054
6	−$2,500	$2,304	−$4,804	$2,402	−$98
7	−$2,500	0	−$2,500	$1,250	−$1,250
8	−$2,500	0	−$2,500	$1,250	−$1,250
8	$4,000*	---	$4,000	−$2,000	$2,000

* Market Value

$AW_B(8\%) = -\$5,199$

Select Fixture X.

7-40 Pump A:

EOY	BTCF	d	TI	T(40%)	ATCF
0	-$2,000				-$2,000
1	-400	$400	-$800	$320	-80
2	-400	400	-800	320	-80
3	-400	400	-800	320	-80
4	-400	400	-800	320	-80
5	-400	400	-800	320	-80
5	400		400	-160	240
				PW_A(10%)	-$2,154

Pump B:

EOY	BTCF	d	TI	T(40%)	ATCF
0	-$1,000				-$1,000.00
1	-800	$333.30	-$1,133.35	$453.34	-346.71
2	-800	444.50	-1,244.55	497.82	-302.23
3	-800	148.10	-948.15	379.26	-420.79
4	-800	74.10	-874.15	349.66	-450.39
5	-800	---	-800.05	320.02	-480.03
5	200		200	-80	120.00
				PW_B(10%)	-$2,412

Incremental Analysis (A – B):

EOY	ΔATCF
0	-$1,000.00
1	266.71
2	222.23
3	340.79
4	370.39
5	520.03
IRR	18.4%

The incremental investment is justified, select Pump A.

7-41 Machine A:

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$20,000	---	---	---	−$20,000
1−12	$12,000	$1,333.33	$10,666.67	−$4,266.67	$7,733.33
12	$4,000	---	0	0	$4,000

$$AW = -\$20{,}000\overset{0.1468}{(A/P,10\%,12)} + \$7733.33 + \$4{,}000\overset{0.0468}{(A/F,10\%,12)} = \$4{,}984.53$$

Machine B:

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$30,000	---	---	---	−$30,000
1−8	$18,000	$3,750	$14,250	−$5,700	$12,300

$$AW = -\$30{,}000\overset{0.1874}{(A/P,10\%,8)} + \$12{,}300 = \$6{,}678$$

7-42 Assume repeatability and compare AW over useful life.

Design A:

EOY	BTCF	d	TI	T(40%)	ATCF
0	-$1,000,000				-$1,000,000
1	200,000	$200,000	$0	$0	200,000
2	200,000	320,000	-120,000	48,000	248,000
3	200,000	192,000	8,000	-3,200	196,800
4	200,000	115,200	84,800	-33,920	166,080
5	200,000	115,200	84,800	-33,920	166,080
6	200,000	57,600	142,400	-56,960	143,040
7a	200,000		200,000	-80,000	120,000
7b	1,000,000		1,000,000	-400,000	600,000
				PW(10%)	$ 201,409
				AW(10%)	$ 41,371

Design B:

EOY	BTCF	d	TI	T(40%)	ATCF
0	-$2,000,000				-$2,000,000
1	400,000	$400,000	$0	$0	400,000
2	400,000	640,000	-240,000	96,000	496,000
3	400,000	384,000	16,000	-6,400	393,600
4	400,000	230,400	169,600	-67,840	332,160
5	400,000	230,400	169,600	-67,840	332,160
6	400,000	115,200	284,800	-113,920	286,080
6	1,100,000		1,100,000	-440,000	660,000
				PW(10%)	$ 36,424
				AW(10%)	$ 8,363

Select Design A to maximize after-tax AW.

7-43 **(a)** Straight−line depreciation:

Method I

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$10,000	---	---	---	−$10,000
1−5	$14,150	$1,800	−$15,950	$6,380	−$7,770
5	$1,000	---	0	0	$1,000

$PW_0(12\%) = -\$10,000 - \$7,770(P/A,12\%,5) + \$1,000(P/F,12\%,5) = -\$37,441,68$

To have a basis for computation, assume that Method I is duplicated for years 6−10. Transform the additional $PW_5(12\%) = -\$37,449.68$ to the present and get:

$$PW(12\%) = PW_0(12\%) + (P/F,12\%,5)PW_5(12\%) = -\$58,867.10$$

Method II

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$40,000	---	---	---	−$40,000
1−10	−$7,000	$3,500	−$10,500	$4,200	−$2,800
10	$5,000	---	0	0	$5,000

$$PW(12\%) = -\$40,000 - \$2,800(P/A,12\%,10) + \$5,000(P/F,12\%,10) = -\$54,210.76$$

Thus, Method II is the better alternative.

(b) MACRS depreciation:

Method I

Assume that MV_5 is $1,000. The MACRS property class is 5 years. This means that the tax−life is 6 years which is greater than the useful life of 5 years.

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$10,000	---	---	---	−$10,000
1	−$14,150	$2,000	−$16,150	$6,460	−$7,690
2	−$14,150	$3,200	−$17,350	$6,940	−$7,210
3	−$14,150	$1,920	−$16,070	$6,428	−$7,722
4	−$14,150	$1,152	−$15,302	$6,120.80	−$8,029.20
5	−$14,150	$1,152	−$15,302	$6,120.80	−$8,029.20
5	$1,000	---	$1,000	−$400	$600
6	0	$576	−$576	$230.40	$230.40

7-43 (b) *continued*

PW (12%) = −$37,311.71
PW(12%) over 10 years = −$37,311[1+(P/F,12%,5)] = −$58,482

To get a figure for comparison, convert PW(12%) to annual worth over the useful life of 5 years:

AW(12%) = −$37,311.71(A/P,12%,5) = −$10,350.63

With straight line depreciation the annual worth is AW_{SL}(12%) = −$37,441.68(A/P,12%,5) = $10,368.69. We note that the annual worths are basically the same. This is due to the fact that, whatever depreciation method we use, the depreciation deductions are small relative to the annual expenses.

<u>Method II</u>
The MACRS class life is 7 years. Assume that MV_5 is $5,000

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$40,000	---	---	---	−$40,000
1	− $7,000	$5,716	−$12,716	$5,086.40	−$1,913.60
2	− $7,000	$9,796	−$16,796	$6,718.40	−$281.60
3	− $7,000	$6,996	−$13,996	$5,598.40	−$1,401.60
4	− $7,000	$4,996	−$11,996	$4,798.40	−$2,201.60
5	− $7,000	$3,572	−$10,572	$4,228.80	−$2,771.20
6	$7,000	$3,568	−$10,568	$4,227.20	−$2,772.80
7	$7,000	$3,572	−$10,572	$4,228.80	−$2,771.20
8	$7,000	$1,784	−$8,784	$3,513.60	−$3,486.40
9	$7,000	0	−$7,000	$2,800	−$4,200
10	$7,000	0	−$7,000	$2,800	−$4,200
10	$5,000	---	$5,000	−$2,000	$3,000

PW(12%) = −$51,869.57

AW over the useful life of 10 years: AW(12%) −$51,869.67(A/P,12%,10) = −$9,180.11

Thus, <u>Method II</u> is chosen also in this case.

AW_{SL}(12%) = −$54,210.76(A/P,12%,10) = −$9,594.45

We notice a more significant difference in this case. Here, the timing of the depreciation deductions is of greater importance.

7-44 Freezer 1:

EOY	BTCF	d	TI	T(40%)	ATCF	Total ATCF
0	-11,000				-11,000	-11,000
1	3,000	3,000	0	0	3,000	3,000
2	3,000	3,000	0	0	3,000	3,000
3	3,000	3,000	0	0	3,000	3,000
4	3,000		3,000	-1,200	1,800	1,800
5a	3,000	---	3,000	-1,200	1,800	3,800
5b	2,000	---	0	0	2,000	
					PW(12%)	-$494.35

Freezer 2:

EOY	BTCF	d	TI	T(40%)	ATCF	Total ATCF
0	-33,000				-33,000.00	-33,000.00
1	9,000	10,998.90	-1,998.90	799.56	9,799.56	9,799.56
2	9,000	14,668.50	-5,668.50	2,267.40	11,267.40	11,267.40
3	9,000	4,887.30	4,112.70	-1,645.08	7,354.92	7,354.92
4	9,000	2,445.30	6,554.70	-2,621.88	6,378.12	6,378.12
5a	9,000	---	9,000	-3600	5,400.00	6,600.00
5b	2,000	---	2,000	-800.00	1,200.00	
					PW(12%)	-$2,234.58

Hence, if one freezer must be seleccted, it should be Freezer 1.

7-45 Manufacturing designed for varying degrees of automation:

(A)

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$10,000	---	---	---	−$10,000
1−5	−$9,500	$2,000	−$11,500	$4,600	−$4,900

Straight Line Depreciation: ($10,000−0)/5 = $2,000

(B)

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$14,000	---	---	---	−$14,000
1−5	−$8,300	$2,800	−$11,100	$4,440	−$3,860

Depreciation: ($14,000−0)/5 = $2,800

(C)

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$20,000	---	---	---	−$20,000
1−5	−$6,000	$4,000	−$10,000	$4,000	−$2,000

Depreciation: ($20,000−0)/5 = $4,000

(D)

EOY	(A) BTCF	(B) Depr	(C) = (A) − (B) TI	(D) = −t (C) T (40%)	(E) = (A) + (D) ATCF
0	−$30,000	---	---	---	−$30,000
1−5	−$4,500	$6,000	−$10,500	$4,200	−$300

Depreciation: ($30,000−0)/5 = $6,000

AW_A = −$10,000(A/P,15%,5) − $4,900 = −$7,883
AW_B = −$14,000(A/P,15%,5) − $3,860 = −$8,036.20
AW_C = −$20,000(A/P,15%,5) − $2,000 = −$7,966
AW_D= −$30,000(A/P,15%,5) − $300 = −$9,249

Select to automate to Degree A.

7-46 Use a study period of 3 years

Quotation I

EOY	BTCF Capital	BTCF Operating	Depr. Fact.	Depr.	Book Value	Gain (Loss) On Disp.	Δ in Ord. Inc	Δ Cash Flow for IT (Cap)	Δ Cash Flow for IT (Oper)	ATCF
0	$(180,000)				$180,000					$(180,000)
1	---	$(28,000)	0.2000	$(36,000)	$144,000		$(64,000)		$ 25,600	$ (2,400)
2	---	$(28,000)	0.3200	$(57,600)	$ 86,400		$(85,600)		$ 34,240	$ 6,240
3	$50,000	$(28,000)	0.0960	$(17,280)	$ 69,120	$ (19,120)	$(45,280)	$ 7,648	$ 18,112	$ 47,760

PW of ATCF, Quotation I: $(143,174)
IT = Income Taxes

Quotation II

EOY	BTCF Capital	BTCF Operating	Depr. Fact.	Depr.	Book Value	Gain (Loss) On Disp.	Δ in Ord. Inc	Δ Cash Flow for IT (Cap)	Δ Cash Flow for IT (Oper)	ATCF
0	$(200,000)				$200,000					$(200,000)
1	---	$(17,000)	0.2000	$(40,000)	$160,000		$(57,000)		$ 22,800	$ 5,800
2	---	$(17,000)	0.3200	$(64,000)	$ 96,000		$(81,000)		$ 32,400	$ 15,400
3	$60,000	$(17,000)	0.0960	$(19,200)	$ 76,800	$ (16,800)	$(36,200)	$ 6,720	$ 14,480	$ 64,200

PW of ATCF, Quotation II: $(136,848)
IT = Income Taxes

Accept Quotation II.

7-47 Depreciation schedule (MACRS 5-year property class). The cost basis (B) is assumed to be $345,000.

Year	BV_{k-1}	r_k	d_k	BV_k
1	$345,000	0.2000	$ 69,000	$276,000
2	276,000	0.3200	110,400	165,600
3	165,600	0.1920	66,240	99,360
4	99,360	0.1152	39,744	59,616
5	59,616	0.1152	39,744	19,872
6	19,872	0.0576	19,872	0

(a) Economic Value Added (EVA):

EOY	BTCF	Depr	TI	−t = −0.5 T(50%)	NOPAT
1	$112,000[a]	$ 69,000	$ 43,000	− $21,500	$21,500
2		110,400	1,600	− 800	800
3		66,240	45,760	− 22,880	22,880
4		39,744	72,256	− 36,128	36,128
5		39,744	72,256	− 36,128	36,128
6	112,000	19,872	92,128	− 46,064	46,064
6	120,000[b]		120,000[c]	− 60,000	60,000

[a] $BTCF_k$ = $120,000 − $8,000 = $112,000
[b] MV_6 = $120,000
[c] Gain on disposal = $MV_6 - BV_6$ = $120,000 − 0 = $120,000

EOY	EVA	PW(10%)
1	$ 21,500 − 0.10 ($345,000) = − $13,000	− $11,818
2	800 − 0.10 (276,000) = − 26,800	− 22,148
3	22,880 − 0.10 (165,600) = 6,320	4,748
4	36,128 − 0.10 (99,360) = 26,192	17,888
5	36,128 − 0.10 (59,616) = 30,166	18,730
6	46,064 − 0.10 (19,872) = 44,077	24,880
6	60,000	33,870
		Total: $66,150

The present equivalent of the EVA = $66,150.

7-47 (b) After−tax cash flow (ATCF):

EOY	BTCF	T(50%)	ATCF	PW(10%)
0	−$345,000	0	−$345,000	−$345,000
1	112,000	− $21,500	90,500	82,274
2		− 800	111,200	91,896
3		− 22,880	89,120	66,957
4		− 36,128	75,872	51,822
5		− 36,128	75,872	47,109
6	112,000	− 46,064	65,936	37,222
6	120,000	− 60,000	60,000	33,870
				Total: $66,150

Yes; the PW(10%) of the ATCF (<u>$66,150</u>) is the same as the present equivalent of the annual EVA amounts.

7-48 Beginning-of-year book values:

Year	BV_{k-1}	d_k	BV_k
1	$ 180,000	$ 36,000	$ 144,000
2	144,000	57,600	86,400
3	86,400	34,560	51,840
4	51,840	20,736	31,104
5	31,104	20,736	10,368
6	10,368	10,368	0

EOY	NOPAT[a]	(0.10) BV_{k-1}	EVA[b]
1	0	$ 18,000	− $ 18,000
2	− $ 13,392	14,400	− 27,720
3	893	8,640	− 7,747
4	9,464	5,184	4,280
5	9,464	3,110	6,354
6	15,892	1,037	14,855
7	22,320	0	22,320
8	22,320	0	22,320
9	22,320	0	22,320
10	22,320	0	22,320
10	18,600	---	18,600

[a] From Table 7-6: Column (C) algebraically added to Column (D).

[b] Equation 7-22: $EVA_k = NOPAT_k - i \bullet BV_{k-1}$

$$\begin{aligned} PW(10\%) &= -\$18{,}000\,(P/F,10\%,1) - \cdots + \$14{,}855\,(P/F,10\%,6) \\ &\quad + \$22{,}320\,(P/A,10\%,4)\,(P/F,10\%,6) + \$18{,}600\,(P/F,10\%,10) \\ &= \underline{\$17{,}208} \end{aligned}$$

7-49 Depreciation schedule (3-year property class). The cost basis (B) is assumed to be \$84,000.

Year	BV_{k-1}	r_k	d_k	BV_k
1	\$ 84,000	0.3333	\$ 28,000	\$ 56,000
2	56,000	0.4445	37,338	18,662
3	18,662	0.1481	12,440	6,222
4	6,222	0.0741	6,222	0

After−tax cash flow (ATCF):

EOY	BTCF	Depr	TI	− t = − 0.5 T (50%)	ATCF
0	− \$ 84,000	0	0	0	− \$ 84,000
1	40,000	\$ 28,000	\$ 12,000	− \$ 6,000	34,000
2	40,000	37,338	2,662	− 1,331	38,669
3	40,000	12,440	27,560	− 13,780	26,220
4	40,000	6,222	33,778	− 16,889	23,111

PW(12%) = −\$84,000 + \$34,000 (P/F,12%,1) + ⋯ + \$23,111 (P/F,12%,4)
= \$10,535
AW(12%) = \$10,535 (A/P,12%,4) = <u>\$3,468</u>

Economic Value Added (EVA):

EOY	NOPAT[a]	(0.12) BV_{k-1}	EVA[b]
1	\$ 6,000	\$ 10,080	− \$ 4,080
2	1,331	6,720	− 5,389
3	13,780	2,239	11,541
4	16,889	747	16,142

[a] From ATCF analysis above: $NOPAT_k = (TI)_k - [T(50\%)]_k$
[b] Equation 7-22: $EVA_k = NOPAT_k - i \bullet BV_{k-1}$

PW(12%) = − \$4,080 (P/F,12%,1) − ⋯ + \$16,142 (P/F,12%,4)
= \$10,535
AW(12%)[*] = \$10,535 (A/P,12%,4) = <u>\$3,468</u>

[*] Annual equivalent EVA.

7-50 Leasing Option: PW(10%) = −$166,036; AW(10%) = −$43,800

EOY	BTCF (A)	Depr	Interest	Principal Payment (B)	TI	Taxes Payable (40%) (C)	ATCF (A) + (B) + (C)
0	−$75,000	−−			−−	−−	−$75,000
0	−$55,000	0	0	0	−$55,000	$22,000	−$33,000
1	−$55,000	0	0	0	−$55,000	$22,000	−$33,000
2	−$55,000	0	0	0	−$55,000	$22,000	−$33,000
3	−$55,000	0	0	0	−$55,000	$22,000	−$33,000
4	−$55,000	0	0	0	−$55,000	$22,000	−$33,000
5	+$75,000						$75,000

Purchasing Option: PW(10%) = −$191,197; AW(10%) = −$50,438

EOY	BTCF (A)	Depr	Interest	Principal Payment (B)	TI	Taxes Payable (40%) (C)	ATCF (A) + (B) + (C)
0	−$350,000	−−		$350,000	−−	−−	$0
1	−$20,000	$116,655	−$28,000	−$107,800	−$164,655	$65,862	−$89,938
2	−$20,000	$155,575	−$19,376	−$116,424	−$194,951	$77,980	−$77,820
3	−$20,000	$51,835	−$10,062	−$125,738	−$81,897	$32,759	−$123,041
4	−$20,000	$25,935	0	0	−$45,935	$18,374	−$1,626
5a	−$20,000	0	0	0	−$20,000	$8,000	−$12,000
5b	+$150,000	−−	−−	−−	+$150,000	−$60,000	+$90,000

Payment = −$350,000 (A/P,8%,3) = −$135,800

Select the lease.

7-51 F = \$200(F/A, 2/3%, 360)(1 – 0.28) = \$200(1,490.3716)(0.72) = \$214,614

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7-52 $F = \$5{,}000(1 - 0.28)(F/P, 8\%, 30) = \$36{,}226$

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7-53 $PW(i) = 0 = -\$9{,}000 + (\$10{,}000)(0.10/2)(1-0.28)(P/A,i\%,15)$
$+ [\$10{,}000 - (\$10{,}000 - \$9{,}000)(0.28)](P/F,i\%,15)$
$= -\$9{,}000 + \$360(P/A,i\%,15) + \$9{,}720(P/F,i\%,15)$

i%	PW(i)
4%	\$400.14
i%	0
5%	−\$587.99

$i\% = 4.4\%/6$ months, $r = 8.8\%/\text{year}$, $i_{eff.} = 8.99\%/\text{year}$

7-54 529 Plan: $F = \$10{,}000(F/A, 8\%, 10) = \$144{,}866$
Roth Plan: $F = \$10{,}000(1 – 0.28)(F/A, 8\%, 10) = \$104{,}304$ (not quite enough)

Thus, the 529 plan accumulates 38.9% more in future worth compared to the Roth IRA. It's a much better deal if the parents can meet the withdrawal restrictions placed on the 529 fund.

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7-55 **(a)** Roth IRA: F = \$1,440(F/A, 8%, 30) = \$163,128
Tax-deductible IRA: F = \$2,000(F/A, 8%, 30)(1 – 0.28) = \$163,128

Both plans are equivalent when the income tax rate is constant at 28% (a big assumption).

(b) Roth IRA: F = 163, 128
Tax-deductible IRA: F = \$2,000(F/A, 8%, 30)(1 – 0.30) = \$158,596

For this assumption, the Roth IRA is better. In reality, the income tax rate will vary year-by-year, so it's virtually impossible to get an "actual" comparison between the two plans. The ROTH IRA has more flexibility regarding how it can be cashed out over multiple years after the retiree reaches age 70.5.

7-56 Left to student.

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Solutions to Spreadsheet Exercises

7-57

MARR	10%
Cost Basis	$500,000
Useful Life	10
Market Value	$ 20,000
DB Rate	200%
MACRS Recovery Period	7

EOY	SL Method	DB Method	MACRS Method
1	$ 48,000	$100,000	$ 71,429
2	$ 48,000	$ 80,000	$122,449
3	$ 48,000	$ 64,000	$ 87,464
4	$ 48,000	$ 51,200	$ 62,474
5	$ 48,000	$ 40,960	$ 44,624
6	$ 48,000	$ 32,768	$ 44,624
7	$ 48,000	$ 26,214	$ 44,624
8	$ 48,000	$ 20,972	$ 22,312
9	$ 48,000	$ 16,777	
10	$ 48,000	$ 13,422	
PW(10%)	$294,939	$319,534	$360,721

The MACRS method results in the largest PW of the depreciation deductions.

7-58 (a)

After-tax MARR =	15%	Capital Investment =	$ 10,000,000
effective tax rate =	40.00%	Market Value =	$ -
		Annual Savings =	$ 4,000,000
		Useful Life =	4

EOY	BTCF	Depreciation Deduction	Taxable Income	Cash Flow for Income Taxes	ATCF	Adjusted ATCF
0	$(10,000,000)				$ (10,000,000)	$(10,000,000)
1	$ 4,000,000	$ 2,500,000	$ 1,500,000	$ (600,000)	$ 3,400,000	$ 3,400,000
2	$ 4,000,000	$ 2,500,000	$ 1,500,000	$ (600,000)	$ 3,400,000	$ 3,400,000
3	$ 4,000,000	$ 2,500,000	$ 1,500,000	$ (600,000)	$ 3,400,000	$ 3,400,000
4	$ 4,000,000	$ 2,500,000	$ 1,500,000	$ (600,000)	$ 3,400,000	$ 3,400,000
4	$ -		$ -	$ -	$ -	
					PW =	(293,073.57)
					IRR =	13.54%

(b)

After-tax MARR =	15%	Capital Investment =	$ 10,000,000
effective tax rate =	40.00%	Market Value =	$ 1,024,000
		Annual Savings =	$ 4,000,000
		Useful Life =	4

EOY	BTCF	Depreciation Deduction	Taxable Income	Cash Flow for Income Taxes	ATCF	Adjusted ATCF
0	$(10,000,000)				$ (10,000,000)	$(10,000,000)
1	$ 4,000,000	$ 2,244,000	$ 1,756,000	$ (702,400)	$ 3,297,600	$ 3,297,600
2	$ 4,000,000	$ 2,244,000	$ 1,756,000	$ (702,400)	$ 3,297,600	$ 3,297,600
3	$ 4,000,000	$ 2,244,000	$ 1,756,000	$ (702,400)	$ 3,297,600	$ 3,297,600
4	$ 4,000,000	$ 2,244,000	$ 1,756,000	$ (702,400)	$ 3,297,600	$ 4,321,600
4	$ 1,024,000		$ -	$ -	$ 1,024,000	
					PW =	51.97
					IRR =	15.00%

If a market value of at least $1,024,000 could be expected at the end of year 4, this investment would be acceptable.

7-59 See P7-59.xls.

Table Entries are Before-tax Rate of Returns on taxable bonds.

		Federal Income Tax Rate		
		15%	28%	35%
After-Tax Rate of Return on Municipal Bonds	4%	4.71%	5.56%	6.15%
	5%	5.88%	6.94%	7.69%
	6%	7.06%	8.33%	9.23%

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7-60 See P7-60.xls.

Natural Gas-Fired Plant			
			Units
Investment	$1.12 billion	$ 1,120,000,000	$
Capacity Factor	80%	80%	
Max Capacity	800 MW	800000	kW
Efficiency	40%	40%	
Annual o&M	$0.01 / kWhr	$0.01	$/kWhr
Cost of gas	$8.00 per million Btu	$ 0.000008	$/Btu
CO2 tax	$15 / MT CO2	$ 15.00	$ / MT CO2
CO2 emitted	55 MT CO2 / billion Btu	0.000000055	MT CO2/Btu
Conversion	1 kWhr = 3413 Btu	3413	Btu/kWhr
	Annual Output	640000	kW
	Hours per Year	8760	Hr
	Annual Output	5606400000	kWhr
	Annual O&M	$ 56,064,000	
	Annual Cost of Gas	$ 382,692,864	
	Annual CO2 Tax	$ 39,465,202	
	Total Annual Cost	$ 478,222,066	
	Annual CO2 emitted	2631013.44	
		1195.9152	MT

Coal-Fired Plant			
			Units
Investment	$1.12 billion	$ 1,120,000,000	$
Capacity Factor	80%	80%	
Max Capacity	800 MW	800000	kW
Efficiency	35%	35%	
Annual o&M	$0.02 / kWhr	$0.02	$/kWhr
Cost of coal	$3.50 / million Btu	$ 0.0000035	$/Btu
CO2 tax	$15 / MT CO2	$ 15.00	$ / MT CO2
CO2 emitted	90 MT CO2 / billion Btu	0.00000009	MT CO2/Btu
Conversion	1 kWhr = 3413 Btu	3413	Btu/kWhr
	Annual Output	640000	kW
	Hours per Year	8760	hr
	Annual Output	5,606,400,000.00	kWhr
	Annual O&M	$ 112,128,000	
	Annual Cost of Gas	$ 191,346,432	
	Annual CO2 Tax	$ 73,805,052	
	Total Annual Cost	$ 377,279,484	
	Annual CO2 emitted	4920336.823	
		2236.516738	MT

After-tax Analysis:

BTCF	D	TI	T	ATCF	ATCF + CR
Natural Gas:					
$(478,222,066)	$37,333,333	$(515,555,399)	$206,222,160	$(271,999,906)	$(390,808,664)
Coal:					
$(377,279,484)	$37,333,333	$(414,612,818)	$165,845,127	$(211,434,357)	$(330,243,115)

AT cost of electricity		
Natural Gas:	$	(0.07)
Coal:	$	(0.06)

Solutions to FE Practice Problems

7-61 d_3 = \$150,000(0.1749) = \$26,235

Select (a)

7-62 $BV_2 = \$150{,}000(1 - 0.1429 - 0.2449) = \$91{,}830$

Select (c)

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7-63 d_4 = \$150,000(0.1249)(0.5) = \$9,367.5

Select (b)

7-64 $d_k = (\$550,000 - \$25,000)/10 = \$52,500$

<u>Select (c)</u>

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7-65 BV_{10} = \$550,000 – (10)(\$52,500) = \$25,000

<u>Select (b)</u>

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7-66 $d_k = (\$550{,}000 - \$25{,}000)/10 = \$52{,}500$

$BV_{10} = \$550{,}000 - (10)(\$52{,}500) = \$25{,}000$

$MV_{10} - BV_{10} = \$35{,}000 - \$25{,}000 = \$10{,}000$

<u>Select (d)</u>

7-67 From Table 7-2, the GDS recovery period is 10 years (asset class 13.3).

Select (d)

7-68 From Table 7-2, the GDS recovery period for woord products equipment (Asset Class 24.4) is 7 years.

Select (b)

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7-69 Cost Basis = \$100,000 + \$10,000 = \$110,000

$$d_k = \frac{\$110{,}000 - \$5{,}000}{10} = \$10{,}500$$

<u>Select (a)</u>

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7-70 BV_{10} = \$110,000 – (10)(\$10,500) = \$5,000

Select (c)

7-71 d_6 = \$110,000 (0.0892) = \$9,812

Select (a)

7-72 Using the half year convention:

$d_5^* = \$110,000\ [0.1429 + 0.2449 + 0.1749 + 0.0893(0.5)]$
$= \$80,547.50$

$BV_5 = \$110,000 - \$80,547.50 = \$29.452.50$

<u>Select (a)</u>

7-73 $BV_4 = \$16{,}000(1 - 2/8)^4 = \$5{,}062.50$

<u>Select (d)</u>

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7-74 $d_k = \dfrac{\$12,000 - \$2,000}{8} = \$1,250$

<u>Select (d)</u>

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7-75 $d_A^* = \$12,000\ (0.1429 + 0.2449 + 0.1749 + 0.1249) = \$8,251.20$

$BV_4 = \$12,000 - \$8,251.20 = \$3,748.80$

<u>Select (a)</u>

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7-76 t = 0.05 + 0.35(0.95) = 38.25%

Select (c)

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7-77 Using Equation (7-15):

$0.40 = 0.20 + \text{federal rate } (1 - 0.20)$

$\text{federal rate} = 0.25 \text{ or } 25\%$

<u>Select (b)</u>

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7-78 After-tax MARR = (1 − 0.4)(18%) = 10.8%

<u>Select (c)</u>

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7-79 $ATCF_k$ = (\$110,000 − \$65,000) – 0.40(\$110,000 − \$65,000 − \$25,000) = \$37,000

Select (e)

7-80 BTCF5 = (R−E) + MV = [$40,000 + $30,000] + $40,000 = $110,000

Select (e)

7-81 TI_3 = \$70,000 − \$135,000(0.1481) = \$41,120

<u>Select (d)</u>

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7-82 After Tax MARR = (1−0.40)(20%) = 12%

PW(12%) = $70,000(1−0.40)(P/A,12%,5)
= $42,000(3.6048) = $151,402

Select (c)

7-83 $BV_3 = \$195{,}000 - \$195{,}000(0.3333 + 0.4445 + \frac{0.1481}{2}) = \$28{,}889$

Deprecitaion Recapture = $50,000 − $28,889 = $21,111

Taxes = 0.40($21,111) = $8,444

<u>Select (a)</u>

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Solutions to Chapter 8 Problems

8-1 With no inflation in the U.S. economy, the GDP will grow at 3% per year. Inflation will add to the real rate of growth, so the actual GDP will exceed 3% per year by about the value of the inflation rate.

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8-2 $A = \$1,000$; $N = 10$

(a) $f = 6\%$ per year; $i_r = 4\%$ per year

In Part (a), the \$1,000 is an A\$ uniform cash flow (annuity)

$i_m = 0.04 + 0.06 + (0.04)(0.06) = 0.1024$, or 10.24% per year

$PW(i_m) = \$1,000\,(P/A,10.24\%,10) = \$1,000(6.0817) = \$\underline{6,082}$

(b) In Part (b), the \$1,000 is a R\$ uniform cash flow (annuity) because the A\$ cash flow is \$1,000 $(1.06)^k$ where $1 \le k \le 10$; i.e.,

$$(R\$)_k = (A\$)_k \left(\frac{1}{1+f}\right)^{k-b} = \$1,000\,(1.06)^k \left(\frac{1}{1+0.06}\right)^{k-0} = \$1,000;\ 1 \le k \le 10$$

$PW(i_r) = \$1,000\,(P/A,4\%,10) = \$\underline{8,111}$

8-3 f = 4% per year; N = ? (when does $1 equal $0.50 in today's purchasing power)

From Equation 8-1, with k = 0, we have

$$(R\$)_N = \$0.50 = (\$1)\left(\frac{1}{(1.04)^N}\right)$$

$$(1.04)^N = 2$$

$$N\,(\ln(1.04)) = \ln(2)$$

$$N = \frac{\ln(2)}{\ln(1.04)} \cong 18 \text{ years}$$

In 18 years, the dollar's purchasing power will be one–half of what it is now if the general price inflation rate is 4% per year.

8-4 In ten years a service/commodity that increases at the 4% general inflation rate will cost (F/P, 4%, 10) = 1.4802 times its current cost. But health care costs will increase to (F/P, 12%, 10) = 3.1058 times their current value. The ratio of 3.1058 to 1.4802 is 2.10, which means that health care will cost 210% more than an inflation-indexed service/commodity in ten years.

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8-5 Situation **a**: FW_5 (A$) = $2,500 (F/P, 8%, 5) = $2,500 (1.4693) = $3,673

Situation **b**: FW_5 (A$) = $4,000 (given)

Choose situation **b**. (Note: The general inflation rate, 5%, is a distractor not needed in the solution.)

8-6 $f = 6\%$ per year; $i_r = 9\%$ per year; $b = 0$

Alternative A: Estimates are in actual dollars, so the combined (market) interest rate must be used to compute the present worth (PW).

$$i_m = i_r + f + (i_r)(f) = 0.09 + 0.06 + (0.09)(0.06) = 0.1554 \text{ or } 15.54\% \text{ per year}$$

$$\begin{aligned}
\text{PW}(15.54\%) &= -\$120{,}000(P/F,15.54\%,1) - \$132{,}000(P/F,15.54\%,2) \\
&\qquad - \$148{,}000(P/F,15.54\%,3) - \$160{,}000(P/F,15.54\%,4) \\
&= -\$120{,}000(0.8655) - \$132{,}000(0.7491) - \$148{,}000(0.6483) \\
&\qquad - \$160{,}000(0.5611) \\
&= -\$388{,}466
\end{aligned}$$

Alternative B: Estimates are in real dollars, so the real interest rate must be used to compute the present worth (PW).

$$\begin{aligned}
\text{PW}(9\%) &= -\$100{,}000(P/A,9\%,4) - \$10{,}000(P/G,9\%,4) \\
&= -\$100{,}000(3.2397) - \$10{,}000(4.511) \\
&= -\$369{,}080
\end{aligned}$$

Alternative B has the least negative equivalent worth in the base time period (a PW value in this case since $b = 0$).

8-7 **(a)** $6.58 = $50(P/F, i', 50), or $i' = -3.97\%$ (annual average loss in purchasing power)

(b) $1,952 = $50(F/P, i^*, 50), or $i^* = 7.6\%$ (which is the market interest rate). The real rate earned on the investment in stocks is $(7.6\% - 3.97\%)/1.0397 = 3.5\%$.

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8-8 Alternative | Present Worth of Costs

Alternative	Present Worth of Costs	
I	\$10,000	= \$10,000
II	\$7,000 + \$5,000(P/F,8%,6)	= \$10,151
III	\$5,000 + \$5,000(P/F,8%,3) + \$5,000(P/F,8%,6)	= \$12,120

Therefore, Alternative I is most economical with respect to the objective of minimizing equivalent cost.

8-9 The engineer's salary has increased by 6.47%, 7.18%, and 6.96% in years 2, 3, and 4, respectively. These are annual rates of change. By using Equation 8-1, but with each year's general price inflation <u>taken into account separately</u>, the R$ equivalents in year 0 dollars are calculated as follows.

EOY	Salary (R$ in Year 0)	
1	$34,000 (P/F,7.1%,1)	= $ 31,746
2	$36,200 (P/F,7.1%,1)(P/F,5.4%,1)	= 32,069
3	$38,800 (P/F,7.1%,1)(P/F,5.4%,1)(P/F,8.9%,1)	= 31,564
4	$41,500 (P/F,7.1%,1)(P/F,5.4%,1)(P/F,8.9%,1)(P/F,11.2%,1)	= 30,361

8-10 Tennessee index-adjusted salary = (95/132) × \$70,000 = \$50,379 per year
Tennessee actual salary = (1.00 = 0.11) × \$70,000 = \$62,300 per year
"Savings" = \$62,300 − \$50,379 = \$11,921 per year
FW(10%) = \$11,921(F/A, 10%, 5) = \$72,779. Paul is not penalized at all!

8-11 $R\$_{10}^{(0)} = \$400M(1.75) = \$700M$

$A\$_{10} = \$920M = \$700M(1+f)^{10}$

$$1.314 = (1+f)^{10}$$

$$f = \sqrt[10]{1.314} - 1 = 0.0277 \text{ or } 2.77\%$$

8-12 After-tax nominal return per year = 6% (1 – 0.33) = 4%
Approximate real return per year = 4% − 3% = 1% each year.
F (in today's purchasing power) = \$100,000(F/P, 1%, 10) = \$110,460

8-13 F = \$100,000(F/P, 10%, 10) = \$259,370 Taxable Earnings = \$159,370
After-tax F = \$159,370(1 – 0.33) + \$100,000 = \$206,778
F (in today's purchasing power) = \$206,778 (P/F, 3%, 10) = \$153,864

Your younger brother is ahead by about \$43,400 with his concern over performance (total return) rather than risk avoidance (safety).

8-14 Unit cost (8 years ago) = $\$89 / ft^2$ $\quad S_B = 80{,}000\ ft^2$
$X = 0.92$ $\quad S_A = 125{,}000\ ft^2$
$e_C = 5.4\%$ per year $\quad i_m = MARR_c = 12\%$ per year
$e_{AE} = 5.66\%$ per year $\quad f = 7.69\%$ per year

(a) Using the power sizing technique (exponential cost estimating model) from Section 3.4.1, with an adjustment for the price increase in construction costs, we have:

$$C_A = C_B\left(\frac{S_A}{S_B}\right)^X (1 + e_C)^8$$

$$= (\$89/ft^2)(80{,}000\ ft^2)\left(\frac{125{,}000}{80{,}000}\right)^{0.92}(1.054)^8$$

$$= \$16{,}350{,}060$$

Total Capital Investment = \$16,350,060 (1 + 0.05 + 0.042 + 0.08 + 0.31)
= \$<u>24,230,790</u>

(b) Note: The building is <u>not</u> being sold at the end of the 10 years. Therefore, working capital is not considered to be recovered at that time.

$$PW(12\%) = -\$24{,}230{,}790 - (\$5)(125{,}000\ ft^2)\frac{[1-(P/F,12\%,10)(F/P,5.66\%,10)]}{0.12-0.0566}$$

$$= -\$24{,}230{,}790 - \frac{625{,}000(0.4416)}{0.0634}$$

$$= \underline{-\$28{,}584{,}102}$$

(c) $i_r = \dfrac{0.12 - 0.0769}{1.0769} = 0.04$ or 4% per year

Assuming the base year to be the present (b = 0), we have:

AW(4%) = −\$28,584,102 (A/P,4%,10) = <u>−\$3,524,420</u>

8-15 **(a)** $10,000(6.07) = $60,700

(b) $R\$_{20}$ = $60,700(P/F, 6%, 20) = $18,926.50

(c) $\$10,000(1 + i_r)^{20} = \$18,926.50$
$i_r = 3.24\%$

(d) $P_2 = \$10,000(1 - 0.18)(1 - 0.33) = \$5,658$
$\$5,658(1 + i_m)^{18} = \$60,700$
$i_m = 14.1\%$

8-16 In this problem, b = 2009 (i.e., the purchasing power of a real dollar is defined by the fiscal year 2009 dollar), and f = 5.6% per year.

For years 2007 and 2008, more 2009 dollars are required than the actual dollar amounts spent in those two years. This is because the 2009 dollar has less purchasing power than actual dollars in 2007 and 2008. Also, the entries in Column 4 indicate that in real dollars, the annual budget amounts decrease between 2008 and 2011. This contrasts with the actual dollar amounts in Column 2 which increase during this period. This difference reflects that the actual dollar amounts after 2008 increase at an annual rate less than the general price inflation rate and purchasing power is decreasing each year.

(1) Fiscal Year	(2) Budget Amount (A$)	(3) (P/F,f %, k−b) $[1/(1.056)^{k-b}]$	(4) Estimate (R$), b=2009
2007	$1,615,000	1.1151	$1,800,887
2008	1,728,000	1.0560	1,824,768
2009	1,780,000	1.0000	1,780,000
2010	1,858,300	0.9470	1,759,810
2011	1,912,200	0.8968	1,714,861

8-17 In 10 years, the investor will receive the original $10,000 plus interest that has accumulated at 10% per year, in actual dollars. Therefore, the market rate of return (IRR_c) is 10%.

Then, based on Equation 8-5, the real rate of return (IRR_r) is:

$$i_r' = \frac{i_c - f}{1 + f} = 0.0185\text{, or } 1.85\% \text{ per year}$$

8-18 **(a)** Lump sum interest in 2010 = (\$2.4 billion/5)(F/A, 10%, 5) – 2.4 billion
= \$530,448,000

(b) $C_{2005} = (\$2.4 \text{ billion}) \left(\dfrac{200{,}000}{150{,}000}\right)^{0.91} = \$3.12 \text{ billion}$

(c) C_{2015} = (\$3.12 billion)(F/P, 9.2%, 10) = \$7.52 billion

8-19 **(a)** $R\$_{28} = \$690(P/F, 3.2\%, 28) = \$285.64$

(b) $\$850 = \$690(1.032)^N$; N = 6.62 years

(c) $\$285.56 = \$850(1 + i_r)^{28}$; $i_r = -3.82\%$
This was not a good investment to have mad in January of 1980.

8-20 **(a)** Cost in year 2020 = \$15,000 (F/P,6%,15) = \$35,949

Cost in year 2021 = \$38,106

Cost in year 2022 = \$40,392

Cost in year 2023 = \$42,816

Total (un−discounted dollars) = \$157,263

(b) Because $i_m = \bar{f}$, P_{2020} = 4(\$35,949) = \$143,796

so A = \$143,796 (A/P,0.5%,156 months)

= \$143,796 (0.00925)

= \$1,330 per month

8-21 **(a)** R\$ = \$7.50$(1.018)^{22}$ = \$11.10 per thousand cubic feet

(b) A\$ = \$7.50$(1.032)^{22}$ = \$22.20 per thousand cubic feet

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8-22 **(a)** From Equation (8-1), we see that real dollars as of year k = 0 (today) is $1,107,706(P/F, 3%, 60) = $187,978 which is still a tidy sum of purchasing power.

(b) When f = 2% per year, we have $R\$_0$ = $1,107,706(P/F, 2%, 60) = $337,629. The impact of inflation is clear when you compare the results of Parts (a) and (b).

8-23 **(a)** Cost in 10 years = $(\$3.75/\text{lb})(400\text{ lb})\left(\dfrac{2{,}400\text{ ft}^2}{2{,}200\text{ ft}^2}\right)(1.085)^{10} = \$3{,}700$

(b) Left to student.

8-24 You've got to be kidding! You have foregone 10% per year earnings on your money to save 5% per year on postage stamps? Give me a break. The U.S. Postal Service might just get away with this ruse. Only time will tell.

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8-25 Based on Equation (4-28), we have

$$\text{PW} = \$2.5 \text{ billion } \frac{[1-(0.0668)(3.2620)]}{0.07-0.03} = \$48.88 \text{ billion and AW} = \$3.67 \text{ billion.}$$

With inflation considered in this problem, the taxpayers can afford to increase the subsidy for the F-T technology.

8-26 $\$20,000 = \$10,000(F/P,i_m,11)$ or $i_m = 0.065$ (6.5%) per year.
$i_r = (i_m - f)/(1+f) = (0.065 - 0.03)/(1.03) = 0.03398$ or 3.4% per year.

This is a failrly good return in real terms. Historically, real returns have been in the 2−3% per year ball park.

8-27 MARR = i_m = 25% per year; Assume f = 8% per year; Let k = 0

Note that the estimated cash flows are in R$ except for the contract maintenance agreement ($3,000 / year). However, the PW of $3,000 per year at i_m = 25% per year is equal to the PW of the R$ equivalent at i_r. Therefore, the PW of the cash flows as a function of N is:

$$PW = -\$50,000 + \$18,000\,(P/A, i_r, N) - \$3,000\,(P/A, 25\%, N)$$

and,

$$i_r = \frac{0.25 - 0.08}{1.08} = 0.1574$$

or 15.74% per year

By trial and error we have:

N	PW
3	−$15,257
4	−6,455
5	1,230

The life of the computer system must be at least 5 years for it to be economically justified.

8-28 Device A:

EOY	BTCF	d	TI	T(50%)	ATCF
0	-$100,000				-$100,000
1	-5,000	$20,000	-$25,000	$12,500	7,500
2	-5,500	32,000	-37,500	18,750	13,250
3	-6,050	19,200	-25,250	12,625	6,575
4	-6,655	11,520	-18,175	9,088	2,433
5	-7,321	11,520	-18,841	9,420	2,100
6	-8,053	5,760	-13,813	6,906	-1,146
				PW(8%)	-$73,982

Device B:

EOY	BTCF	d	TI	T(50%)	ATCF
0	-$150,000				-$150,000
1	-3,000	$30,000	-$33,000	$16,500	13,500
2	-3,300	48,000	-51,300	25,650	22,350
3	-3,630	28,800	-32,430	16,215	12,585
4	-3,993	17,280	-21,273	10,637	6,644
5	-4,392	17,280	-21,672	10,836	6,444
6	-4,832	8,640	-13,472	6,736	1,904
				PW(8%)	-$97,879

Device A should be selected to maximize after-tax present worth.

8-29 $\frac{\$20(F/P, 22.5\%, N)}{\$10(F/P, 13.1\%, N)} > 5$. One approach would be to find the minimum value of N by trial and error.

At N = 12 years, the cost of an RA dose is $228.38 and the cost of a diabetes inhaler use is $43.81. The ratio of RA to diabetes is 5.21, so N = 12 years wil "git 'er done."

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8-30 Option 1: Software with 3 year upgrade agreement.

Year	(A) BTCF (A$)	(B) Depreci− ation	Taxable Income: C=A+B	Cash Flow for Income Taxes D = −t(C)	ATCF (A$) A+D
0	−$X	–––	–––	–––	−$X
1	0	$X/3	−$X/3	$0.1133X	$0.1133X
2	0	$X/3	−$X/3	$0.1133X	$0.1133X
3	0	$X/3	−$X/3	$0.1133X	$0.1133X

$PW_1(20\%) = -\$X + \$0.1133X(P/A,20\%,3)$

Year	(A) BTCF (A$)	(B) Depreci− ation	Taxable Income: C=A+B	Cash Flow for Income Taxes D = −t(C)	ATCF (A) A+D
1	−$20,000	–––	− $20,000	$6,800	−$13,200
2	− 22,000	–––	− 22,000	7,480	− 14,520
3	− 24,200	–––	− 24,200	8,228	− 15,972

$$PW_2(20\%) = -\$13{,}200(P/F,20\%,1) - \$14{,}520(P/F,20\%,2) - \$15{,}972(P/F,20\%,3)$$
$$= -\$30{,}326$$

Set $PW_1 = PW_2$ and solve for X.

$$-\$X + \$0.1133X(P/A,20\%,3) = -\$30{,}326$$

$$-\$0.761X = -\$30{,}326$$

$$X = \$39{,}836$$

Therefore, $39,836 could be spent for software with a 3 year upgrade agreement (i.e., Option 1).

8-31 $1 / 0.55 pound = $1.82 per pound
$1.82 per pound / 1.4 euro per pound = $1.30 per euro, or 1 U.S. dollor will buy 0.77 euro.

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8-32 In 2005 there was parity between the U.S. dollar and the Real. But in 2010 one Real is worth $0.50 U.S., so the investment is now worth $50 million and the bank has suffered a major loss. Conventional wisdom would be to cut the losses instead of chasing bad money with good money (i.e. sell out).

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8-33 **(a)** In two years: $\$1\ (1.026)^2 = 6.4X$
or, $\$1 = 6.4X / (1.026)^2 = 6.08$ units of X.

(b) In three years: $\$1 = (6.4X)\ (1.026)^3$
$= 6.91$ units of X.

8-34 **(a)** The value of 0.5 pound Sterling is 90 cents, so 5 cents can be saved on each item purchased in U.S. dollars.

(b) 100,000 items × \$0.05 = \$5,000 can be saved by purchasing in the U.S.

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8-35 i_{US} = 26% per year

(a) f_e = 8% per year

i_{fm} = 0.26 + 0.08 + (0.26)(0.08) = 0.3608, or 36.08% per year

(IRR on project in Country A currency)

(b) f_e = −6% per year

i_{fm} = 0.26 + (− 0.06) + (0.26)(− 0.06) = 0.1844, or 18.44% per year

(IRR on project in Country B currency)

8-36 Left to student.

8-37 (a)

EOY	NCF (T−marks)	Exchange Rate (T−marks/$)	NCF ($)	PW(18%)
0	−$3,600,000	20.000	−$180,000	− $180,000
1	450,000	22.400	20,089	17,025
2	1,500,000	25.088	59,790	42,941
3	1,500,000	28.099	53,383	32,489
4	1,500,000	31.470	47,664	24,585
5	1,500,000	35.247	42,557	18,602
6	1,500,000	39.476	37,998	14,074
7	1,500,000	44.214	33,926	10,649
			PW (18%) =	− $19,635

Project is not economically acceptable.

(b) IRR_{fc} in terms of T−marks:

$$PW(i'\%) = -3{,}600{,}000 + 450{,}000\,(P/F, i'\%, 1) + 1{,}500{,}000\,(P/A, i'\%, 6)\,(P/F, i'\%, 1)$$

By linear interpolation, $i'\% = IRR_{fc} = 0.2798$, or 28.0% per year.

(c) From Equation 8-7, we have:

$$(IRR)_{US} = \frac{IRR_{fc} - f_e}{1 + f_e} = \frac{0.28 - 0.12}{1.12} = 0.1429, \text{ or } 14.29\% < 18\%$$

Note: This confirms our recommendation in part (a).

8-38 100 euros × \$1.24 = \$124. The cost in U.S. dollars is \$124 + \$40 = \$164. Sanjay may think he is paying too much for the jewelry, but he goes ahead with the purchase anyway. He could have converted his 100 euros into U.S. dollars, but there is a 7.5 euro commission on the transaction. Or he could have kept his 100 euros for the next trip he makes to Europe and simply charge the purchase to his credit card.

8-39 i_{fm} = 20% per year; f_e = −2.2% per year

Current exchange rate = \$1 per 92 Z−Krons

$$i_{US} = \frac{0.20 - (-0.022)}{1 - 0.022} = 22.7\%$$

PW(22.7%) = −\$168,000,000 − \$32,000,000(P/F,22.7%,1)
+ \$69,000,000(P/A,22.7%,10)
= −\$168,000,000 − \$32,000,000(0.8150) + \$69,000,000(3.8357)
= \$70,583,300 > 0

Yes, this project will meet the company's economic decision criteria.

8-40 (a)

Year	(A) BTCF (R$)	(B) Adjustment $(1.10)^{\text{Year}}$	(C) BTCF (A$)	(D) Lease Payment (A$)	(E) Taxable Income: (C) – (D)	(F) Cash Flow for Income Taxes −t(E)	(G) ATCF (A$) C−D+F
1	− $4,000	1.100	−$4,400	$80,000	−$84,000	$33,760	−$50,640
2	− 4,000	1.210	− 4,840	60,000	− 64,840	25,936	− 38,904
3	− 4,000	1.331	− 5,324	50,000	− 55,324	22,130	− 33,194
4	− 4,000	1.464	− 5,856	50,000	− 55,856	22,342	− 33,514
5	− 4,000	1.611	− 6,442	50,000	− 56,442	22,577	− 33,865
6	− 4,000	1.772	− 7,086	50,000	− 57,086	22,834	−34,252

(b) $i_m = (1.05)(1.09524) - 1 = 0.15 = \underline{15\% \text{ per year}}$

$$PW = -\$50{,}640(P/F,15\%,1) - \$38{,}904(P/F,15\%,2) - \$33{,}194(P/F,15\%,3) - \$33{,}514(P/F,15\%,4) - \$33{,}865(P/F,15\%,5) - \$34{,}252(P/F,15\%,6)$$
$$= -\$146{,}084$$

$$EUAC = \$146{,}084(A/P,15\%,6) = \$38{,}595$$

8-41 Demand = 500 million BTU/year; Efficiency = 80%, N = 12 years

f = 10% per year; b = 0
MARR = i_m = 18% per year

$$\text{Annual gas demand} = \left(\frac{500 \text{ million Btu}}{0.8}\right)\left(\frac{1{,}000 \text{ ft}^3 \text{ of gas}}{\text{million Btu}}\right) = 625{,}000 \text{ ft}^3 \text{ of gas}$$

$$A_1 = \frac{\$7.50(1.1)}{1000\,\text{ft}^3} = \frac{\$8.25}{1000\,\text{ft}^3}$$

$$\begin{aligned}
PW(18\%) &= -(625{,}000 \text{ ft}^3)\left(\frac{\$8.25}{1000\,\text{ft}^3}\right)\frac{[1-(P/F,18\%,12)(F/P,10\%,12)]}{0.18-0.10} \\
&= -(625{,}000 \text{ ft}^3)\left(\frac{\$8.25}{1000\,\text{ft}^3}\right)(7.1176) \\
&= \underline{-\$36{,}700}
\end{aligned}$$

8-42 **(a)** Cost of compressor replacement at EOY 8 (A$) = $\$500(1 + 0.06)^8 = \$797$

Annual maintenance expense: A_1(A$) = $100 (1.06) = $106

Annual electricity expense: A_1(A$) = $680(1.10) = $748

$$PW(15\%) = -\$2{,}500 - \$797\,(P/F,15\%,8)$$

$$-\$106\,\frac{[1-(P/F,15\%,15)(F/P,6\%,15)]}{0.15-0.06}$$

$$-\$748\,\frac{[1-(P/F,15\%,15)(F/P,10\%,15)]}{0.15-0.10}$$

$$= \$2{,}500 - \$797\,(0.3269) - \frac{\$106(0.70546)}{0.09} - \frac{\$748(0.48662)}{0.05}$$

$$= -\$10{,}871$$

A$: AW(15%) = −$10.871(A/P,15%,15) = <u>−$1,859</u>

(b) $i_r = \dfrac{0.15-0.06}{1.06} = 0.085$ or 8.5% per year

= −$10,871 (0.1204) = <u>−$1,309</u>

8-43 d_k = ($150,000−0)/3 = $50,000

Year	(A) Revenues(A$)	(B) Expenses (A$)	(C) BTCF (A$) A+B	(D) Depreci−ation	(E) Taxable Income: C−D	(F) Cash Flow for Income Taxes −t(E)	(G) ATCF (A$) C+F
0		−$150,000	−$150,000	–––	–––	–––	−$150,000
1	$84,000	−21,800	62,200	$50,000	$12,200	−$6,100	56,100
2	88,200	−23,762	64,438	50,000	14,438	−7,219	57,219
3	92,610	−25,900	66,709	50,000	16,709	−8,355	58,354

For discounting purposes, i_m = 26% would be used since the ATCFs are expressed in actual dollars.

8-44 Annual revenues in year k (A$) = $\$360,000(1.025)^k$
Annual expenses in year k (A$) = $-\$239,000(1.056)^k$

(a) The values in the following table are expressed in A$.

EOY	Annual Revenues	Annual Expenses	BTCF	Depr	TI	T(39%)	ATCF (A$)
0			−$220,000	–––	–––	–––	−$220,000
1	$369,000	− $252,384	116,616	$44,000	$72,616	− $28,320	88,296
2	378,225	− 266,518	111,707	70,400	41,307	− 16,110	95,597
3	387,681	− 281,442	106,239	42,240	63,999	− 24,960	81,279
4	397,373	− 297,203	100,170	25,344	74,826	− 29,182	70,988
5	407,307	− 313,847	93,460	25,344	68,116	− 26,565	66,895
6	417,490	− 331,422	86,068	12,672	73,396	− 28,624	57,444
6			40,000	–––	40,000	− 15,600	24,400

$$PW(10\%) = \sum_{k=0}^{6} ATCF_k\ (P/F,10\%,k) = \$136,557$$

Total investment that can be afforded (including new equipment) =

$136,557 + $220,000 = <u>$356,557</u>

(b) $ATCF_k$ (R$) = $ATCF_k$ (A$)(P/F,4.9%,k)

Year, k	$ATCF_k$ (A$)	(P/F,4.9%,k)	$ATCF_k$ (R$)
0	− $220,000	1.0000	− $220,000
1	88,296	0.9533	84,173
2	95,597	0.9088	86,879
3	81,279	0.8663	70,412
4	70,988	0.8258	58,622
5	66,895	0.7873	52,666
6	57,444	0.7505	43,112
6	24,400	0.7505	18,312

8-45 Purchase (A$ Analysis):

EOY	Investment / Market Value	Oper., Ins. & Other Expenses (O,I,OE)	Maintenance Expense	BTCF
0	− $600,000			− $600,000
1		− $27,560[b]	− $34,880[c]	− 62,440
2		− 29,214	− 38,019	− 67,233
3		− 30,966	− 41,441	− 72,407
4		− 32,824	− 45,171	− 77,995
5		− 34,794	− 49,236	− 84,030
6		− 36,881	− 53,667	− 90,549
6	101,355[a]			101,355

EOY	BTCF	Depr[d]	TI	T(34%)	ATCF (A$)
0	− $600,000				− $600,000
1	− 62,440	$120,000	− $182,440	$62,030	− 410
2	− 67,233	192,000	− 259,233	88,139	20,906
3	− 72,407	115,200	− 187,607	63,786	− 8,621
4	− 77,995	69,120	− 147,115	50,019	− 27,976
5	− 84,030	69,120	− 153,150	52,071	− 31,959
6	− 90,549	34,560	− 125,108	42,537	− 48,012
6	101,355		101,355	− 34,461	66,894

Notes:

[a] $(MV)_6 = \$90,000\,(1.02)^6 = \$101,355$
[b] $(O,I,OE)_k = \$26,000\,(1.06)^k$
[c] $(Maint)_k = \$32,000\,(1.09)^k$
[d] Cost Basis = $600,000

$i_m = 0.13208 + 0.06 + (0.13208)(0.06) = 0.20$, or 20% per year

$$FW_6\,(A\$) = \sum_{k=0}^{6} ATCF_k\,(F/P, 20\%, 6-k) = -\$1,823,920$$

8-45 ***continued***

Lease (A$ Analysis):

EOY	Leasing Costs	Oper., Ins. & Other Expenses	Maint. Expense	BTCF
1	− $300,000	− $27,560	− $34,880	− $362,440
2	− 200,000	− 29,214	− 38,019	− 267,233
3	− 200,000	− 30,966	− 41,441	− 272,407
4	− 200,000	− 32,824	− 45,171	− 277,995
5	− 200,000	− 34,794	− 49,236	− 284,030
6	− 200,000	− 36,881	− 53,667	− 290,549

EOY	BTCF	Depr	TI	T(34%)	ATCF (A$)
1	− $362,440	0	− $362,440	$123,230	− $239,210
2	− 267,233	0	− 267,233	90,859	− 176,374
3	− 272,407	0	− 272,407	92,618	− 179,789
4	− 277,995	0	− 277,995	94,518	− 183,477
5	− 284,030	0	− 284,030	96,570	− 187,460
6	− 290,549	0	− 290,549	98,787	− 191,762

$$FW_6\,(A\$) = \sum_{k=0}^{6} ATCF_k\,(F/P, 20\%, 6-k) = -\$1{,}952{,}551$$

Therefore choose Purchase Alternative due to smaller FW of costs.

8-46 Assuming that EOY 1 cost for purchased components is \$85,000,000

EOY	Cash Flow (w)	Cash Flow (w/o)
0	−20,000,000	0
1	−85,000,000	−85,000,000
2	−80,750,000	−85,000,000
3	−76,712,500	−85,000,000
4	−72,876,875	−85,000,000
5	−69,233,031	−85,000,000
PW	−300,467,957	−306,405,977

i(r) = 0.178947368
(P/A,i(r),5) = 3.134641881
PW(w) = −20,000,000 – (85,000,000/(1−.05))[P/A,((0.12+0.05)/(1−0.05)),5]
= −300,467,957.81

PW(w/o) = −85,000,000(P/A,12%,5) = −306,405,977.20
PW(Difference) = \$5,938,019.39
AW(Difference) = \$1,647,264.37

Assuming that EOY 1 cost for purchased components is \$85,000,000 (1−0.05)

EOY	Cash Flow (w)	Cash Flow (w/o)
0	−20,000,000.00	0.00
1	−80,750,000.00	−85,000,000.00
2	−76,712,500.00	−85,000,000.00
3	−72,876,875.00	−85,000,000.00
4	−69,233,031.25	−85,000,000.00
5	−65,771,379.69	−85,000,000.00
PW	−286,444,559.92	−306,405,977.20

i(r) = 0.178947368
(P/A,i(r),5) = 3.134641881
PW(w) = −20,000,000 – 85,000,000[P/A,((0.12+0.05)/(1−0.05)),5]
= −286,444,559.92

PW(w/o) = −85,000,000(P/A,12%,5) = −306,405,977.20
PW(Difference) = \$19,961,417.28
AW(Difference) = \$5,537,491.42

8-47 Left to student.

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8-48 This is intended to be a tailor-made exercise (at the discretion of the instructor).

Assumptions:

- Salary and fringe benefits for the new analyst will be \$28,000 (1.3) = \$36,400 in year 1 purchasing power. This increases 6% per year thereafter.
- Staff retirements occur at the end of the year. Therefore, there are no realized savings in year 1. Savings of \$16,200 in year 2, \$32,400 in year 3, and \$48,600 each year thereafter are expressed in real purchasing power keyed to year 0.
- First−year savings on purchases are 3% of \$1,000,000 (1.10) = \$33,000 and this increases by 10% per year thereafter.
- Contingency costs will not be considered as cash flows until they are spent (we assume they won't be spent).
- The effective income tax rate is = 38%.
- There is no market value at the end of the 6−year project life.

EOY	Capital Investment	Service Contract	New Analyst	Manpower Savings	Savings on Purchases	Total BTCF
0	− \$80,000					−\$80,000
1		− \$6,000	−\$36,400	\$ 0	\$33,000	− 9,400
2		− 6,000	− 38,584	18,202	36,300	9,918
3		− 6,000	− 40,899	38,588	39,930	31,619
4		− 6,000	− 43,353	61,356	43,923	55,926
5		− 6,000	− 45,954	65,037	48,315	61,398
6		− 6,000	− 48,711	68,940	53,147	67,376

EOY	BTCF	Depr.	TI	T(38%)	ATCF (A\$)
0	−\$80,000	–––	–––	–––	−\$80,000
1	−9,400	\$16,000	−\$25,400	\$9,652	252
2	9,918	25,600	−15,682	5,959	15,877
3	31,619	15,360	16,259	−6,178	25,441
4	55,926	9,216	46,710	−17,750	38,176
5	61,398	9,216	52,182	−19,829	41,569
6	67,376	4,608	62,768	−23,852	43,524

$$\text{PW}(15\%) = \sum_{k=0}^{6} \text{ATCF}_k\,(\text{P/F}, 15\%, \text{k}) = \$10{,}263$$

In view of MARR of 15%, this investment should be undertaken. The instructor may wish to ask the class to explore various "what if" questions involving changes in the assumptions listed above. For example, how much change would occur in the PW value if we assume staff retirements occur at the beginning of the year?)

Solutions to Spreadsheet Exercises

8-49 See P8-49.xls.

Typical solution for (*) is (P/F, 4%, 10) = 0.6756, so 32.44% of purchasing power has been lost due to inflation. This rounds to −32%.

Erosion of Money's Purchasing Power

		(years)		
		10	15	25
Inflation	2%	-18%	-26%	-39%
Rate	3%	-26%	-36%	-52%
	4%	-32%*	-44%	-62%

8-50 See P8-50.xls.

Starting Salary =	$ 60,000	% Salary to Save Annually	8.64%
Annual Salary Increase =	8.00%		864
Savings Interest Rate =	7.50%		
Average Inflation Rate =	3.75%		
Desired amount in 2027 (R$) =	$ 500,000		

Desired Amount in 2027 (A$) = $1,508,736

Year	Salary (A$)	Savings (A$)	Bank Balance (A$)
1997	$ 60,000	$ 5,184	$ 5,184
1998	$ 64,800	$ 5,599	$ 11,172
1999	$ 69,984	$ 6,047	$ 18,056
2000	$ 75,583	$ 6,530	$ 25,941
2001	$ 81,629	$ 7,053	$ 34,939
2002	$ 88,160	$ 7,617	$ 45,176
2003	$ 95,212	$ 8,226	$ 56,791
2004	$ 102,829	$ 8,884	$ 69,935
2005	$ 111,056	$ 9,595	$ 84,775
2006	$ 119,940	$ 10,363	$ 101,496
2007	$ 129,535	$ 11,192	$ 120,300
2008	$ 139,898	$ 12,087	$ 141,410
2009	$ 151,090	$ 13,054	$ 165,070
2010	$ 163,177	$ 14,099	$ 191,548
2011	$ 176,232	$ 15,226	$ 221,141
2012	$ 190,330	$ 16,445	$ 254,171
2013	$ 205,557	$ 17,760	$ 290,994
2014	$ 222,001	$ 19,181	$ 331,999
2015	$ 239,761	$ 20,715	$ 377,615
2016	$ 258,942	$ 22,373	$ 428,308
2017	$ 279,657	$ 24,162	$ 484,594
2018	$ 302,030	$ 26,095	$ 547,034
2019	$ 326,192	$ 28,183	$ 616,244
2020	$ 352,288	$ 30,438	$ 692,900
2021	$ 380,471	$ 32,873	$ 777,741
2022	$ 410,909	$ 35,502	$ 871,574
2023	$ 443,781	$ 38,343	$ 975,284
2024	$ 479,284	$ 41,410	$ 1,089,841
2025	$ 517,626	$ 44,723	$ 1,216,302
2026	$ 559,036	$ 48,301	$ 1,355,825
2027	$ 603,759	$ 52,165	$ 1,509,677

Difference between Desired and Actual = $ 941

8-51 $f = 4.5\%$ per year; i_m (after−tax) = 12% per year; $t = 40\%$; $b = 0$
increase rate = 6 % per year (applies to annual expenses, replacement costs, and market value)
Analysis period = 20 years; Useful life = 10 years
MACRS (GDS) 5−year property class

Capital investment (and cost basis, B) = −\$260,000
Market value (at end of year 10) in year 0 dollars = \$50,000

Annual expenses (in year 0 dollars) = −\$6,000
Annual property tax = 4% of capital investment (does not inflate)
Assume like replacement at end of year 10.

EOY	Annual Expenses	Property Taxes	BTCF	Depr.	TI	T(40%)	ATCF (A\$)	ATCF* (R\$)
0			-\$260,000				-\$260,000	-\$260,000
1	-\$6,360	-\$10,400	-16,760	52,000	-68,760	27,504	10,744	10,281
2	-6,742	-10,400	-17,142	83,200	-100,342	40,137	22,995	21,057
3	-7,146	-10,400	-17,546	49,920	-67,466	26,986	9,440	8,272
4	-7,575	-10,400	-17,975	29,952	-47,927	19,171	1,196	1,003
5	-8,029	-10,400	-18,429	29,952	-48,381	19,352	923	741
6	-8,511	-10,400	-18,911	14,976	-33,887	13,555	-5,356	-4,113
7	-9,022	-10,400	-19,422	0	-19,422	7,769	-11,653	-8,563
8	-9,563	-10,400	-19,963	0	-19,963	7,985	-11,978	-8,423
9	-10,137	-10,400	-20,537	0	-20,537	8,215	-12,322	-8,292
10	-10,745	-10,400	-21,145	0	-21,145	8,458	-12,687	-8,170
10			89,542		89,542	-35,817	53,725	34,595
10			-465,620				-465,620	-299,826
11	-11,390	-18,625	-30,015	93,124	-123,139	49,256	19,241	11,856
12	-12,073	-18,625	-30,698	148,998	-179,696	71,878	41,180	24,282
13	-12,798	-18,625	-31,423	89,399	-120,822	48,329	16,906	9,540
14	-13,565	-18,625	-32,190	53,639	-85,829	34,332	2,142	1,157
15	-14,379	-18,625	-33,004	53,639	-86,643	34,657	1,653	854
16	-15,242	-18,625	-33,867	26,820	-60,687	24,275	-9,592	-4,743
17	-16,157	-18,625	-34,782	0	-34,782	13,913	-20,869	-9,875
18	-17,126	-18,625	-35,751	0	-35,751	14,300	-21,451	-9,713
19	-18,154	-18,625	-36,779	0	-36,779	14,712	-22,067	-9,562
20	-19,243	-18,625	-37,868	0	-37,868	15,147	-22,721	-9,421
20			160,357		160,357	-64,143	96,214	39,894

* $ATCF(R\$) = ATCF(A\$) \times 1/(1.045)^k$

$$i_r = \frac{0.12 - 0.045}{1.045} = 0.0718 \text{ or } 7.18\% \text{ per year}$$

$$PW = \sum_{k=0}^{20} ATCF_k\ (A\$)\ (P/F, 12\%, k) = \sum_{k=0}^{20} ATCF_k\ (R\$)\ (P/F, 7.18\%, k) = -\$359{,}665$$

Solutions to Case Study Exercises

8-52 PW(maintenance costs) $= \dfrac{A_1[1-(P/F,8\%,5)(F/P,4\%,5)]}{0.08-0.04}$

$= A_1(4.29785)$

where A_1 = \$1,000 for the induction motor and A_1 = \$1,250 for the synchronous motor.

PW(electricity costs) $= \dfrac{A_1[1-(P/F,8\%,5)(F/P,5\%,5)]}{0.08-0.05}$

$= A_1(4.37834)$

where A_1 = \$50,552 for the induction motor and A_1 = \$55,950 for the synchronous motor.

PW_{TC}(induction motor) = \$17,640 + \$1,000(4.29785) + \$50,552(4.37834)
= \$17,640 + \$4,298 + \$221,334
= \$243,272

PW_{TC}(synchronous motor) = \$24,500 + \$1,250(4.29785) + \$55,950(4.37834)
= \$24,500 + \$5,372 + \$244,968
= \$274,840

PW_{TC}(A) = (3)(\$243,272) + [\$17,640 + \$4,298 + (350/400)(\$221,334)]
= \$945,421

PW_{TC}(B) = (3)(\$274,840) + [\$24,500 + \$5,372 + (50/500)(\$244,968)]
= \$878,889

PW_{TC}(C) = (3)(\$243,272) + [\$24,500 + \$5,372 + (350/500)(\$244,968)]
= \$931,166

PW_{TC}(D) = (3)(\$274,840) + [\$17,640 + \$4,298 + (50/400)(\$221,334)]
= \$874,125

Option (D) has the lowest present worth of total costs. Thus, the recommendation is still to power the assembly line using three 500 hp synchronous motors operated at a power factor of 1.0 and one 400 hp induction motor.

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8-53 PW(electricity costs) $= \dfrac{A_1[1-(P/F,8\%,8)(F/P,6\%,8)]}{0.08-0.06}$

$= A_1(6.9435)$

where A_1 = \$50,552 for the induction motor and A_1 = \$55,950 for the synchronous motor.

$$
\begin{aligned}
PW_{TC}(\text{induction motor}) &= \$17{,}640 + \$1{,}000(6.5136) + \$50{,}552(6.9435) \\
&= \$17{,}640 + \$6{,}514 + \$351{,}008 \\
&= \$375{,}162
\end{aligned}
$$

$$
\begin{aligned}
PW_{TC}(\text{synchronous motor}) &= \$24{,}500 + \$1{,}250(6.5136) + \$55{,}950(6.9435) \\
&= \$24{,}500 + \$8{,}142 + \$388{,}489 \\
&= \$421{,}131
\end{aligned}
$$

$$
\begin{aligned}
PW_{TC}(A) &= (3)(\$375{,}162) + [\$17{,}640 + \$6{,}514 + (350/400)(\$351{,}008)] \\
&= \$1{,}456{,}772
\end{aligned}
$$

$$
\begin{aligned}
PW_{TC}(B) &= (3)(\$421{,}131) + [\$24{,}500 + \$8{,}142 + (50/500)(\$388{,}489)] \\
&= \$1{,}334{,}884
\end{aligned}
$$

$$
\begin{aligned}
PW_{TC}(C) &= (3)(\$375{,}162) + [\$24{,}500 + \$8{,}142 + (350/500)(\$388{,}489)] \\
&= \$1{,}430{,}070
\end{aligned}
$$

$$
\begin{aligned}
PW_{TC}(D) &= (3)(\$421{,}131) + [\$17{,}640 + \$6{,}514 + (50/400)(\$351{,}008)] \\
&= \$1{,}331{,}423
\end{aligned}
$$

Option (D) has the lowest present worth of total costs. Thus, the recommendation is still to power the assembly line using three 500 hp synchronous motors operated at a power factor of 1.0 and one 400 hp induction motor.

8-54 The following four options will be considered:

(A) Four induction motors (three at 400 hp, one at 100 hp)
(B) Three synchronous motors (two at 500 hp, one at 300 hp)
(C) Three induction motors at 400 hp plus one synchronous motor at 100 hp
(D) Two synchronous motors at 500 hp plus one induction motor at 300 hp.

$$PW_{TC}(A) = (3)(\$364{,}045) + [\$17{,}640 + \$6{,}514 + (100/400)(\$339{,}891)] = \$1{,}201{,}262$$

$$PW_{TC}(B) = (2)(\$408{,}827) + [\$24{,}500 + \$8{,}142 + (300/500)(\$376{,}185)] = \$1{,}076{,}007$$

$$PW_{TC}(C) = (3)(\$364{,}045) + [\$24{,}500 + \$8{,}142 + (100/500)(\$376{,}185)] = \$1{,}200{,}014$$

$$PW_{TC}(D) = (2)(\$408{,}827) + [\$17{,}640 + \$6{,}514 + (300/400)(\$339{,}891)] = \$1{,}096{,}726$$

Option (B) has the lowest present worth of total costs. Thus, the recommendation is to power the assembly line using three 500 hp synchronous motors: two operated at 500 hp and one at 300 hp.

Solutions to FE Practice Problems

8-55 Expected cost of Machine in 2004 = $\$2,550(1.07)^4 = \$3,342.53$

True percentage increzse in cost = $\dfrac{\$3,930 - \$3.342.53}{\$3,343.53}$ x 100% = 17.58%

<u>Select (d)</u>

8-56 $i_r = 0.07$; $f = 0.09$
$i_m = 0.07 + 0.09 + (0.07)(0.09) = 0.1663$

Select (a)

8-57 By using Equation (8-1), we have R\$ = \$1(P/F, 2.4%, 44) = \$0.3522.

Select (b)

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8-58 A$ Analysis: $i_m - 0.098 + 0.02 + (0.098)(0.02) = 0.12$ or 12%

$PW_A(12\%) = -\$27{,}000 + \$4{,}000(P/A,12\%,5) = -\$2{,}581$
$PW_B(12\%) = -\$19{,}000 + \$5{,}000(P/A,12\%,5) = -\$976$

Neither alternative is acceptable.

<u>Select (c)</u>

8-59 A_1 = \$25,000 (1.04) = \$26,000

$$\text{PW} = \frac{\$26{,}000\left[1-(P/F,7\%,\infty)(F/P,4\%,\infty)\right]}{0.07-0.04}$$

$$= \frac{\$26{,}000}{0.03}\left[1-\underbrace{\frac{(1.04)^{\infty}}{(1.07)^{\infty}}}_{\to\, 0}\right]$$

= \$866,667

<u>Select (a)</u>

8-60 ($1.60 Canadian/Euro)($0.75 US/$1.00 Canadian) = $1.20 US/Euro

Select (c)

8-61 \$1 U.S. = 0.75 Euro
\$67 U.S. = 67 (0.75) = 50.25 Euro

<u>Select (b)</u>

Solutions to Chapter 9 Problems

9-1 Defender (old lift truck):

Using the outsider viewpoint, the investment value of the old lift truck is its current market value.

Defender: PW(20%) = –\$7,000 – \$8,000(P/A, 20%, 5) = –\$30,925
Challenger: PW(20%) = –\$22,000 – \$5,100(P/A, 20%, 5) + \$9,000(P/F, 20%, 5)
= –\$33,635

<u>Keep the old lift truck</u> ($PW_{Defender} > PW_{Challenger}$).

9-2 Stan's estimates of next year's expenses are accurate for insurance and finance charges but inaccurate for other types of expenses. So the \$9,200 − \$8,700 difference associated with purchasing a newer model truck must be judged carefully. The \$500 difference (an its uncertainty) is probably more than offset by the added reliability of a newer truck and the peace of mind it affords. Thus, Stan should sell his old fuel−inefficient van and purchase the newer truck. Other considerations should include the safety of a newer vehicle − Stan fears that the van will breakdown on the interstate and cause a major accident.

9-3 Old Crane (Defender):

Using the outsider viewpoint, the investment value of the defender is its current market value plus the cost of the overhaul required to keep it in service.

Capital investment = \$8,000 + \$4,000 = \$12,000
Annual O&M costs = \$3,000
Market value (EOY 10) = \$0

AW(10%) = –\$12,000(A/P, 10%,10) – \$3,000 = –\$4,952

New Crane (Challenger):

Capital investment = \$18,000
Annual O&M costs = \$1,000
Market value (EOY 10) = \$4,000

AW(10%) = –\$18,000(A/P, 10%, 10) – \$1,000 + \$4,000(A/F, 10%, 10) = –\$3,678

Replace the old crane ($AW_{Challenger} > AW_{Defender}$).

9-4 **(a)**

EOY k	BOY Amount	Deprec.	Interest	C_k Oper. Exp.	Total Cost For Year k (with Obsol.)	Average Cost
1	$80,000	$80,000	0	$10,000	$94,000	$94,000
2	0	0	0	16,000	20,000	57,000
3	0	0	0	22,000	26,000	46,667
4	0	0	0	28,000	32,000	43,000
5	0	0	0	34,000	38,000	42,000
6	0	0	0	40,000	44,000	42,333

The economic life is 5 years.

(b)

EOY k	BOY Amount	Deprec.	Interest	C_k Oper. Exp.	Total Cost For Year k (no Obsol.)	Average Cost
1	$80,000	$80,000	0	$10,000	$90,000	$90,000
2	0	0	0	16,000	16,000	53,000
3	0	0	0	22,000	22,000	42,667
4	0	0	0	28,000	28,000	39,000
5	0	0	0	34,000	34,000	38,000
6	0	0	0	40,000	40,000	38,333

The economic life is 5 years. This is the same answer as for Part (a), so a constant expense over time can be ignored in calculating economic life.

9-5 For N = 1, EUAC = $13,200
For N = 2, EUAC = $ 6,914
For N = 3, EUAC = $ 4,825
For N = 4, EUAC = $ 4,217
For N = 5, EUAC = $ 3,854
For N = 6, EUAC = $ 3,937

For higher years, the EUAC increases, so N* = 5 years for the challenger.

9-6

EOY	EUAC
1	\$62,000
2	\$55,950 = \$80,000(A/P, 15%, 2) − \$50,000(A/F, 15%,2) + \$30,000
3	\$54,960 = \$80,000(A/P, 15%, 2) − \$50,000(A/F, 15%,2) + [\$30,000(P/A, 15%, 2) + \$35,000(P/F, 15%, 3)](A/P, 15%, 3)
4	\$56,170
5	\$56,920

9-7 **Challenger** **Defender**

EOY	**Market Value**	**O&M**	**Market Value**	**O&M**
0	\$42,500	––	\$25,000	––
1	\$31,00	\$10,000	\$17,000	\$14,000
2	\$25,000	\$12,500	––	––

Challenger

Year	**Market Value**	**Loss in Value**	**Cost of Capital**	**O&M**	**Marginal Cost**	**EUAC**
0	\$42,500.00	––	––	––	––	––
1	\$31,000.00	\$11,500.00	\$6,375.00	\$10,000.00	\$27,875.00	\$27,875.00
2	\$25,000.00	\$6,000.00	\$4,650.00	\$12,500.00	\$23,150.00	\$25,677.33

Defender

Year	**Market Value**	**Loss in Value**	**Cost of Capital**	**O&M**	**Marginal Cost**	**EUAC**
0	\$25,000.00	––	––	––	––	––
1	\$17,000.00	\$8,000.00	\$3,750.00	\$14,000.00	\$25,750.00	Not necessary to calculate EUAC!

Min(EUAC) of Challenger < Marginal Cost of keeping Defender for 1 additional year; therefore, Replace Immediately

9-8 Challenger

EOY	MV@EOY	Loss in Value	Cost of Capital	O&M	Marginal Cost	EUAC
0	$50,000.00	––	––	––	---	––
1	$40,000.00	$10,000.00	$5,000.00	$13,000.00	$28,000.00	$28,000.00
2	$32,000.00	$8,000.00	$4,000.00	$15,500.00	$27,500.00	$27,761.90
3	$24,000.00	$8,000.00	$3,200.00	$18,000.00	$29,200.00	$28,196.37
4	$16,000.00	$8,000.00	$2,400.00	$20,500.00	$30,900.00	$28,778.93

Defender

EOY	MV@EOY	Loss in Value	Cost of Capital	O&M	Marginal Cost	EUAC
0	$35,000.00	––	––	––	---	––
1	$25,000.00	$10,000.00	$3,500.00	$18,500.00	$32,000.00	
2	$21,000.00	$4,000.00	$2,500.00	$21,000.00	$27,500.00	***$29,857.14***
3	$17,000.00	$4,000.00	$2,100.00	$23,500.00	$29,600.00	
4	$13,000.00	$4,000.00	$1,700.00	$26,000.00	$31,700	

The minimum EUAC of the Challenger is less than the marginal cost of keeping the Defender for one more year. Therefore, the Defender should be replaced immediately.

9-9 Present Machine (Defender)

Year	Capital Recovery Amount	Expenses for Year	Total	EUAC
1	\$4,000(0.15)+(4,000−3,000) = \$1,600	\$20,000	\$21,600	\$21,600*
2	\$3,000(0.15)+(3,000−2,500) = \$950	\$25,000	\$25,950	\$23,622
3	\$2,500(0.15)+(2,500−2,000) = \$875	\$30,000	\$30,875	\$25,713

* The economic life of the "defender" is 1 year, and the EUAC during this year is \$21,600.

Improved Machine (Challenger)

Useful life is 12 years; Find EUAC(15%) over this period of time.

EUAC(15%) = \$30,000(A/P,15%,12) − \$2,000(A/F,15%,12) + \$16,000 = \$21,466

Because \$21,466 is less than \$21,600, the new improved machine should replace the present machine immediately.

9-10 The repeatability assumption and the AW method (over one useful life cycle) are used in the comparison of the two robots. The use of repeatability as a simplified modeling approach can be supported in this case.

The estimated annual expenses for the defender are a geometric cash flow sequence (Chapter 4). The negative estimated market value (−$1,500) indicates an expected net cost for the disposal of the asset at the end of six years.

$$\begin{aligned}
\mathrm{AW_D}(25\%) &= -(\$38{,}200 + \$2{,}000)(\mathrm{A/P},25\%,6) \\
&\quad - \frac{\$1{,}400[1-(\mathrm{P/F},25\%,6)(\mathrm{F/P},8\%,6)]}{0.25-0.08}(\mathrm{A/P},25\%,6) \\
&= -\$15{,}383
\end{aligned}$$

and, for the challenger, the AW over its useful life is

$$\begin{aligned}
AW_C(25\%) &= -(\$51{,}000 + \$5{,}500)(A/P,25\%,10) \\
&\quad -[\$1{,}000(P/A,25\%,10) + \$150(P/G,25\%,10)](A/P,25\%,10) \\
&\quad + \$7{,}000(A/F,25\%,10) \\
&= -\$17{,}035
\end{aligned}$$

<u>The defender should be retained</u> because the AW over its useful life has the least negative value (−$15,382).

9-11 The overpass can be reinforced to extend its life for 5 years and then be replaced by a new concrete overpass. An alternative is to build the new concrete overpass immediately. Coterminate the study period at 40 years.

Cash Flow Analysis:

EOY	Reinforce Now, Replace Later	Replace with New Overpass Now	Δ(Replace Now − Reinforce)
0	− $36,000[a]	− $140,000	− $104,000
1	0	3,200[b]	3,200
2	0	3,200	3,200
3	0	3,200	3,200
4	0	3,200	3,200
5	0	3,200	3,200
5	− $124,000[c]	0	124,000
6 → 40	0	0	0[d]

[a] −$22,000 (reinforcement) − $14,000 (MV of scrap foregone) = −$36,000

[b] Savings in annual expenses

[c] $16,000(scrap value) − $140,000(investment in new overpass) = −$124,000

[d] The same overpass is in place during years 6 − 40, thus there is no difference in the annual expenses.

$$PW_{\Delta}(10\%) = -\$104,000 + \$3,200(P/A,10\%,5) + \$124,000(P/F,10\%,5)$$
$$= -\$14,880 < 0$$

It is more economical to reinforce the existing bridge and delay its replacement.

9-12 **(a)** 3,600 gallons of gasoline will be required to drive the car averaging 27.5 mpg, and 2,750 gallons will be required at 36 mpg. The fuel savings will be 850 gallons over the life of the car. At $3 per gallon, this amounts to a savings of $2,550 over 99,000 miles of driving. The carbon dioxide emissions "saved" = (0.1 lb/mi)(99,000 mi) = 9,900 lb of CO_2.

(b) CO_2 penalty for defender = $0.02(9,900) = $198. This places an extra burden on the defender.

9-13 Defender:

Annual Expenses = \$300,000 + \$250,000 + \$500,000(0.04) + \$8,000 = \$578,000

$\text{EUAC}_D(10\%)$ = \$150,000(A/P, 10%, 8) − \$50,000(A/F, 10%, 8) + \$578,000 = \$601,740

Challenger:

$\text{EUAC}_C(10\%)$ = \$250,000 + \$100,000 + \$100,000 = \$450,000

Decision: Sell the defender and lease a new machine to minimize EUAC.

9-14 Defender: Assume that MV = 0 five years from now.

EUAC = \$6,000(A/P, 15%, 5) + \$900 +\$100(A/G, 15%, 5) = \$2,862

Challenger:

EUAC = \$11,000(A/P, 15%, 5) − \$3,000(A/F, 15%, 5) + \$150 = \$2,986

Keep the existing machine.

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9-15 Abandonment Interval:

Keep for N = 1 year:

PW (10%) = −\$7,500 + (\$6,200 + \$2,000)(P/F,10%,1) = −\$45

Keep for N = 2 years:

PW (10%) = −\$7,500 + \$2,000(P/A,10%,2) + \$5,200(P/F,10%,2) = \$268

Keep for N = 3 years:

PW (10%) = −\$7,500 + \$2,000(P/A,10%,3) + \$4,000(P/F,10%,3) = \$479

Keep for N = 4 years:

PW (10%) = −\$7,500 + \$2,000(P/A,10%,4) + \$2,200(P/F,10%,4) = \$342

Keep for N = 5 years:

PW (10%) = −\$7,500 + \$2,000(P/A,10%,5) = \$82

PW (10%) is a maximum at 3 years. Therefore, the centrifuge should be retained for three years before abandonment.

9-16

EOY, k	Market Value	Loss in Value	Cost of Capital	Annual Expenses	Approximate After−Tax Total (Marginal) Cost[a]
0	$8,000	---	---	---	---
1	4,700	$3,300	$560	$3,000	$4,116
2	3,200	1,500	329	3,000	2,897
3	2,200	1,000	224	3,500	2,834
4	1,450	750	154	4,000	2,942
5	950	500	102	4,500	3,061
6	600	350	67	5,250	3,400
7	300	300	42	6,250	3,955
8	0	300	21	7,750	4,843

EOY, k	MACRS BV	Interest on Tax Credit[b]	Adjusted After−Tax Total (Marginal) Cost[c]	PW(7%)	EUAC
0	$8,000	---	---	---	---
1	6,400	$224	$4,340	$4,056	$4,340
2	3,840	179	3,076	2,687	3,729
3	2,304	108	2,942	2,402	3,485
4	1,382	65	3,007	2,294	3,377
5	461	39	3,100	2,210	3,329*
6	0	13	3,413	2,274	3,341
7	0	0	3,955	2,463	3,412
8	0	0	4,843	2,819	3,552

[a] Approx. After−Tax Total Cost = (0.6)(Loss in Value + Cost of Capital + Annual Expenses)

[b] Interest on tax credit = (0.07) (0.4) BV_{k-1}

[c] Adj. After−Tax Total Cost = Approx. After−Tax Total Cost + Interest on tax credit

* The economic life of this equipment is <u>5 years</u>.

9-17 BV_0 = \$62,000(1 – 0.2 – 0.32 – 0.192 – 0.1152) = \$10,714
MV_0 = \$12,000
Expense for year 0 repair work = \$4,000
Using the format presented in Figure 9-5 with an additional row entry for the repair expense:

EOY	BTCF	Depr	TI	T (39%)	ATCF
0	−\$12,000	---	−(\$12,000 – \$10,714) = –\$1,286	\$ 520	–\$11,498
0	− 4,000	---	− \$4,000	1,560	–2,440
				Total	–\$13,938

<u>The total after−tax investment in the defender is \$13,938</u>. This value includes the opportunity foregone by not selling the current asset for \$12,000 (modified by the tax consequence of the income taxes that *won't* be paid on the gain of \$12,000 – \$10,714 = \$1,286) as well as the after−tax expense of the required repair work.

9-18 **(a)**

Year, k	Defender EUAC through year k	Challenger EUAC through year k
1	$15,702*	$20,866
2	16,627	20,458
3	17,932	20,037*
4	---	21,503
5	---	21,612

* The economic life of the defender is 1 year. The economic life of the challenger is 3 years.

(b)

Year	Defender Marginal Cost for Year
1	$15,702
2	17,662
3	21,038

Based on this analysis, the defender should be kept for two years before being replaced by the challenger. Although the economic life of the defender is 1 year, the marginal cost of keeping the defender for the second year is less than the minimum EUAC of the challenger.

(c) Assumptions: Infinite analysis period with repetitive cycles of replacement with challenger (every three years) starting at the end of the second year.

9-19 Keep the Defender:

EOY	BTCF	Depr	TI	T (40%)	ATCF
0	−\$57,000	---	−\$27,000[a]	\$10,800	−\$46,200
1→5	−27,000	6,000	−33,000	13,200	−13,800
5	21,656[b]	---	21,656	−8,662	12,994

[a] Gain on disposal = \$57,000 − \$30,000 = \$27,000 (if sold now).
[b] MV_5 = \$18,500$(1.032)^5$ = \$21,656

Replace with Challenger:

EOY	BTCF	Depr	TI	T (40%)	ATCF
0	0	---	---	---	0
1−5	−\$36,500	0	−\$36,500	\$14,600	−\$21,900

EOY	Incremental Cash Flows Δ (Def. – Chal.)
0	− \$46,200
1−5	8,100
5	12,994

To find the incremental IRR, solve

$$AW(i') = 0 = -\$46{,}200(A/P, i', 5) + \$8{,}100 + \$12{,}994(A/F, i', 5)$$

for i′ = 4.36%. This is less than the after-tax MARR of 9%, so the challenger should be accepted.

9-20 (a) Keep the Defender:

EOY	BTCF	Depr	TI	T (40%)	ATCF
0	−$14,000	---	−$4,000[a]	$1,600	−$12,400
1→6	0	0	0	0	0
6	0	---	−10,000[b]	$4,000	4,000

[a] Gain on disposal = $14,000 − $10,000 = $4,000 (if sold now).
[b] Loss on disposal for defender when sold 6 years from now.

Replace with Challenger:

EOY	BTCF	Depr	TI	T (40%)	ATCF
0	−$80,000	---	---	---	−$80,000
1	7,000	$ 16,000	−$ 9,000	$ 3,600	10,600
2	10,500	25,600	− 15,100	6,040	16,540
3	11,000	15,360	− 4,360	1,744	12,744
4	11,500	9,216	2,284	− 914	10,586
5	12,000	9,216	2,784	− 1,114	10,886
6	12,500	4,608	7,892	− 3,157	9,343
6	20,000	---	20,000	− 8,000	12,000

EOY	Incremental Cash Flows Δ (Challenger − Defender)
0	− $67,600
1	10,600
2	16,540
3	12,744
4	10,586
5	10,886
6	9,343
6	8,000

(b) ERR Analysis (ε =12%)

$$\$67{,}600\ (F/P,\ i'_{\Delta}\%,6) = \sum_{k=1}^{6} \Delta\ ATCF_k\ (F/P,12\%,6-k)$$

$$\$67{,}600(1+ i'_{\Delta})^6 = \$105{,}425$$

$$i'_{\Delta}\% = ERR_{\Delta} = 7.7\%$$

Since ERR_{Δ} < MARR, the defender should not be replaced with the challenger.

9-21 Assume study period = 10 years.

Keep Pumping Station (defender)

EOY	BTCF	Depr	TI	T (50%)	ATCF
0	− $75,000	---	---	---	−$75,000
1−10	− 7,500	$3,000	− 10,500	5,250	−2,250
10	+ 30,000	---	− 15,000	7,500	37,500

BV_{15} = \$90,000 – 15(\$3,000) = \$45,000

$EUAC_D$(5%) = \$75,000(A/P, 5%, 10) − \$37,500(A/F, 5%, 10) + \$2,250 = \$8,981

Sell Pumping Station (challenger)

EOY	BTCF	Depr	TI	T (50%)	ATCF
1−10	−$10,000	---	−$10,000	+$5,000	−$5,000

$EUAC_C$(5%) = \$5,000

Decision: Sell the pumping station (\$5,000 < \$8,981).

9-22 Assume study period = 6 years.

Keep the Defender: Assume MV = 0 at end of study period.

EOY	BTCF	Depr	TI	T (40%)	ATCF
0	− $130,000[a]	0	−$90,000[b]	$36,000	−$94,000
1	− 1,800	$4,000	− 5,800	2,320	520
2−5	− 1,800	8,000	− 9,800	3,920	2,120
6	− 1,800	4,000	− 5,800	2,320	520

[a] Total investment = $90,000 (MV if sold now) + $40,000 (cost of moving) = $130,000

[b] The entire $90,000 (gain on disposal) would have been taxable if the defender was sold, since the current BV of the conveyor system is zero.

$$\begin{aligned} PW(10\%) &= -\$94{,}000 + \$520(P/A,10\%,6) + \$1{,}600(P/A,10\%,4)(P/F,10\%,1) \\ &= \underline{-\$87{,}124} \end{aligned}$$

Replace with Challenger:

EOY	BTCF	Depr	TI	T (40%)	ATCF
0	−$120,000	---	---	---	−$120,000
1	3,610[a]	$ 24,000	−$20,390	$ 8,156	11,766
2	3,992	38,400	− 34,408	13,763	17,755
3	4,396	23,040	− 18,644	7,458	11,854
4	4,825	13,824	− 8,999	3,600	8,425
5	5,279	13,824	− 8,545	3,418	8,697
6	5,761	6,912	− 1,151	460	6,221
6	71,643[b]	---	71,643	− 28,657	42,986

[a] $BTCF_k = \$6{,}000(1.06)^k - \$2{,}750$

[b] $MV_6 = (0.5)(\$120{,}000)(1.03)^6 = \$71{,}643$. Note that the entire MV amount is taxable since $BV_6 = 0$.

$$PW(10\%) = \sum_{k=0}^{6} ATCF_k\,(P/F,10\%,k) = -\$46{,}793$$

Therefore, replace the defender now with the challenger.

9-23 Keep the Defender:

EOY	BTCF	Depr	TI	T (40%)	ATCF
0	−$57,000	---	− $30,000[a]	$12,000	−$45,000
1–4	− 27,000	$6,000	− 33,000	13,200	− 13,800
5	− 27,000	3,000	− 30,000	12,000	− 15,000
5	21,656[b]	---	21,656	− 8,662	12,994

[a] Gain (if sold) = $57,000 − $27,000 = $30,000

[b] Market value = $18,500(1.032)^5 = $21,656

Replace with Challenger:

EOY	BTCF	Depr	TI	T (40%)	ATCF
1–5	−$36,500	0	−$36,500	14,600	− 21,900

Incremental Analysis Δ(Defender − Challenger):

Capital Investment: −$45,000

Annual Expenses:

Years 1–4 −$13,800 − (−$21,900)= $ 8,100 (Savings)

Year 5 −$15,000 − (−$21,900)= $ 6,900 (Savings)

Market Value (ATCF): $12,994 − $0 = $12,994

PW(i'%) = 0 = −$45,000 + $8,100(P/A, i'%, 4) + ($6,900 + $12,994)(P/F,i'%,5)

By trial and error, i'% = 4.5% < MARR.

Therefore, lease the challenger.

9-24 Keep diesel-electric unit:

EOY	BTCF	Depr	TI	T (50%)	ATCF
0	− $35,000	---	− $10,000[a]	$5,000	−$30,000
1−5	− 19,000	$5,000	− 24,000	12,000	− 7,000

AW(15%) = −$30,000(A/P, 15%, 5) − $7,000 = −$15,949

[a] MV – BV = $35,000 − $25,000 = $10,000, which is shown as an opportunity cost.

Buy power from a utility:

EOY	BTCF	Depr	TI	T (50%)	ATCF
1−5	−$30,000	---	−$30,000	+$15,000	−$15,000

AW(15%) = −$15,000

Therefore, the company should consider buying power from the soutside source and selling the diesel-electric unit now.

9-25 Use the capitalized worth method and the repeatability assumption due to the indefinitely long study period. Note that all market values are completely offset by the removal costs.

Alternative a: Do not relocate existing transformers

Site A: Property tax for existing transformers (years 1 − 10)

$$= -(\$2{,}100 + \$475)(0.02) = -\$51.50$$

Capital investment for replacement transformers (EOY 10 and every 30 years thereafter)

$$= -\$900 - \$340 = -\$1{,}240$$

Property tax for replacment transformers (years 11 − ∞)

$$= -(\$900 + \$340)(0.02) = -\$24.80$$

Site B: Capital investment for new transformers (EOY 0 and every 30 years thereafter)

$$= -\$2{,}100 - \$475 = -\$2{,}575$$

Property tax for new transformers (years 1 − ∞) = $-\$2{,}575(0.02) = -\$51.50$

$$CW_a(8\%) = -\$51.50(P/A,8\%,10) - \left[\frac{\$1{,}240(A/P,8\%,30) + \$24.80}{0.08}\right](P/F,8\%,10)$$
$$- \left[\frac{\$2{,}575(A/P,8\%,30) + \$51.50}{0.08}\right]$$
$$= -\$4{,}629$$

Alternative b: Relocate existing transformers

Cost to remove existing transformers from site A and reinstall at site B (EOY 0)

$$= -\$110 - \$475 = -\$585$$

Site A: Capital investment for replacing transformers (EOY 0 and every 30 years thereafter)

$$= -\$900 - \$340 = -\$1{,}240$$

Property tax for new transformers (years 1 − ∞)

$$= -\$1{,}240(0.02) = -\$24.80$$

Site B: Property tax for relocated transformers (years 1 − 10)

$$= -(\$2{,}100 + \$475)(0.02) = -\$51.50$$

Capital investment for replacement transformers (EOY 10 and every 30 years thereafter)

$$= -\$2{,}100 - \$475 = -\$2{,}575$$

Property tax for replacement transformers (years 11 − ∞)

$$= -\$2{,}575(0.02) = -\$51.50$$

$$CW_b(8\%) = -\$585 - \left[\frac{\$1{,}240(A/P,8\%,30) + \$24.80}{0.08}\right] - \$51.50(P/A,8\%,10)$$

$$- \left[\frac{\$2{,}575(A/P,8\%,30) + \$51.50}{0.08}\right](P/F,8\%,10)$$

$$= -\$4{,}239$$

It is more economical to relocate the existing transformers (Alternative b).

9-26 (a)

EOY	MV	Loss in Value	Cost of Capital	O&M	Marginal Cost (M.C.)	EUAC
0	$70,000.00					
1	$56,000.00	$14,000.00	$7,000.00	$5,500.00	$26,500.00	$26,500.00
2	$44,000.00	$12,000.00	$5,600.00	$6,800.00	$24,400.00	$25,500.00
3	$34,000.00	$10,000.00	$4,400.00	$7,400.00	$21,800.00	$24,382,18
4	$22,000.00	$12,000.00	$3,400.00	$9,700.00	$25,100.00	$24,536.85

Economic Life = 3 years

(b)

EOY	BTCF	Depr	TI	Taxes Payable	ATCF
0	−$40,000.00		−$28,768.00	$11,507.20	−$28,492.80
0	−$12,000.00		0.00	0.00	−$12,000.00
1	−$8,500.00	−$11,488.00	−$19,988.00	$7,995.20	−$504.80
2	−$10,500.00	−$7,744.00	−$18,244.00	$7,297.60	−$3,202.40
3	−$14,000.00	−$4,000.00	−$18,000.00	$7,200.00	−$6,800.00
4	−$16,000.00	0.00	−$16,000.00	$6,400.00	−$9,600.00

BV(now) = $11,232.00; MV(now) = $40,000.00; MV(now) – BV(now) = $28,768.00

Solutions to Spreadsheet Exercises

9-27 **(a)**

	A	B	C	D	E	F	G	H	I
1	MARR =	7.73%							
2									
3	EOY	End of Year MV	CR Amount	Annual Expense	PW of Annual Exp.	EUAC of Ann. Exp.	Cumulative EUAC		
4	0	$ 20,000							
5	1	$ 15,000	$ 6,546	$ 2,000	$ 1,856	$ 2,000	$ 8,546		
6	2	$ 11,250	$ 5,758	$ 3,000	$ 2,585	$ 2,481	$ 8,240	<- Min EUAC	
7	3	$ 8,500	$ 5,098	$ 4,620	$ 3,695	$ 3,142	$ 8,240		
8	4	$ 6,500	$ 4,554	$ 8,000	$ 5,939	$ 4,224	$ 8,778		
9	5	$ 4,750	$ 4,159	$ 12,000	$ 8,270	$ 5,557	$ 9,716		
10									
11									

(b)

	A	B	C	D	E	F	G	H	I
1	MARR =	38.15%							
2									
3	EOY	End of Year MV	CR Amount	Annual Expense	PW of Annual Exp.	EUAC of Ann. Exp.	Cumulative EUAC		
4	0	$ 20,000							
5	1	$ 15,000	$ 12,630	$ 2,000	$ 1,448	$ 2,000	$ 14,630		
6	2	$ 11,250	$ 11,304	$ 3,000	$ 1,572	$ 2,420	$ 13,724		
7	3	$ 8,500	$ 10,311	$ 4,620	$ 1,752	$ 2,933	$ 13,243		
8	4	$ 6,500	$ 9,579	$ 8,000	$ 2,196	$ 3,664	$ 13,243	<- Min EUAC	
9	5	$ 4,750	$ 9,073	$ 12,000	$ 2,385	$ 4,453	$ 13,526		
10									
11									

9-28 See P9-28.xls.

MARR	15%				
Defender:					
Percent Change in Annual Expenses =				-0.7%	
			CR		
EOY k	MV	Expenses	Amount	Total	$EUAC_k$
0	4,000				
1	3,000	19,860	1,600	21,460	$21,460.00
2	2,500	24,825	950	25,775	$23,466.98
3	2,000	29,790	875	30,665	$25,539.84

Challenger:			
Investment	$30,000	EUAC	$21,465.46
Annual Expenses	$16,000		
Economic Life	12		
MV after 12 years	$2,000		

If the annual expenses of the defender were to lower by 0.7%, the replacement would be delayed by at least one year.

Solutions to Case Study Exercises

9-29 The defender would be the preferred alternative for annual lease rates greater than $51,818.

Effective Tax Rate =	40%	Operating hours/yr =	260
After Tax MARR =	12%	Study period =	10
Useful Life =	15	Annual Expense Rate of Increase / yr. =	4%
O & M Expenses / hr. =	$ 85		
Annual Expense: other =	$ 2,400		
Fixed Lease Rate =	$ 51,818	NOTE: All estimates expressed in year 0 dollars	

Year	Lease	Annual Expenses	Taxable Income	Cash Flow for Income Taxes	ATCF	Adjusted ATCF
0	$ (10,000)				$ (10,000)	$ (10,000)
1	$ (51,818)	$ (25,480)	$ (77,298)	$ 30,919	$ (46,379)	$ (46,379)
2	$ (51,818)	$ (26,499)	$ (78,317)	$ 31,327	$ (46,990)	$ (46,990)
3	$ (51,818)	$ (27,559)	$ (79,377)	$ 31,751	$ (47,626)	$ (47,626)
4	$ (51,818)	$ (28,662)	$ (80,479)	$ 32,192	$ (48,288)	$ (48,288)
5	$ (51,818)	$ (29,808)	$ (81,626)	$ 32,650	$ (48,976)	$ (48,976)
6	$ (51,818)	$ (31,000)	$ (82,818)	$ 33,127	$ (49,691)	$ (49,691)
7	$ (51,818)	$ (32,240)	$ (84,058)	$ 33,623	$ (50,435)	$ (50,435)
8	$ (51,818)	$ (33,530)	$ (85,348)	$ 34,139	$ (51,209)	$ (51,209)
9	$ (51,818)	$ (34,871)	$ (86,689)	$ 34,676	$ (52,013)	$ (52,013)
10	$ (51,818)	$ (36,266)	$ (88,084)	$ 35,234	$ (52,850)	$ (42,850)
10	$ 10,000				$ 10,000	

PW =	$ (282,472)

9-30 A study period of five years still favors the challenger.

			80 kW	40 kW
Effective Tax Rate =	40%			
After tax MARR =	12%	Capital Investment	$ 90,000	$ 140,000
Class Life =	7	Annual O & M Expenses / hr.	$ 80	$ 35
DB Rate =	200%	Other Annual Expenses	$ 3,200	$ 1,000
80 kW Cost Basis =	$ 210,000	Depreciation year at study start	5	0
Annual Expense Rate of Increase / yr. =	4%	MV at end of life	$ 30,000	$ 38,000
MV Rate of increase / yr.=	2%			
Operating Hours / yr. =	260	NOTE: All estimates expressed in year 0 dollars		

Year	BTCF	80 kW d(k)	40 kW d(k)	Taxable Income	Cash Flow for Income Taxes	ATCF	Adjusted ATCF
0	$ (230,000)			$ (43,145)	$ 17,258	$ (212,742)	$ (212,742)
1	$ (35,464)	$ 18,742	$ 20,000	$ (74,206)	$ 29,682	$ (5,782)	$ (5,782)
2	$ (36,883)	$ 18,742	$ 34,286	$ (89,910)	$ 35,964	$ (918)	$ (918)
3	$ (38,358)	$ 9,371	$ 24,490	$ (72,219)	$ 28,888	$ (9,470)	$ (9,470)
4	$ (39,892)		$ 17,493	$ (57,385)	$ 22,954	$ (16,938)	$ (16,938)
5	$ (41,488)		$ 12,495	$ (53,983)	$ 21,593	$ (19,895)	$ 37,646
5	$ 75,077			$ 43,841	$ (17,536)	$ 57,541	

PW = $ (214,780)

	80 kW	40 kW
Year 5 BV	$ -	$ 31,237

9-31 The defender would be preferred to the new challenger; however, the original challenger is still the preferred alternative.

			40 kW (per unit)	Total
Effective Tax Rate =	40%			
After tax MARR =	12%	Capital Investment	$ 120,000	$ 360,000
Class Life =	7	Annual O & M Expenses / hr.	$ 35	$ 105
DB Rate =	200%	Other Annual Expenses	$ 1,000	$ 3,000
Annual Expense Rate of Increase / yr. =	4%	MV at end of life	$ 38,000	$ 114,000
MV Rate of increase / yr.=	2%			
Operating Hours / yr. =	260	NOTE: All estimates expressed in year 0 dollars		

Year	BTCF	Three 40 kW d(k)	Taxable Income	Cash Flow for Income Taxes	ATCF	Adjusted ATCF
0	$ (360,000)			$ -	$ (360,000)	$ (360,000)
1	$ (31,512)	$ 51,429	$ (82,941)	$ 33,176	$ 1,664	$ 1,664
2	$ (32,772)	$ 88,163	$ (120,936)	$ 48,374	$ 15,602	$ 15,602
3	$ (34,083)	$ 62,974	$ (97,057)	$ 38,823	$ 4,739	$ 4,739
4	$ (35,447)	$ 44,981	$ (80,428)	$ 32,171	$ (3,276)	$ (3,276)
5	$ (36,865)	$ 32,129	$ (68,994)	$ 27,598	$ (9,267)	$ (9,267)
6	$ (38,339)	$ 32,129	$ (70,469)	$ 28,187	$ (10,152)	$ (10,152)
7	$ (39,873)	$ 32,129	$ (72,002)	$ 28,801	$ (11,072)	$ (11,072)
8	$ (41,468)	$ 16,065	$ (57,532)	$ 23,013	$ (18,455)	$ (18,455)
9	$ (43,126)		$ (43,126)	$ 17,251	$ (25,876)	$ (25,876)
10	$ (44,851)		$ (44,851)	$ 17,941	$ (26,911)	$ 56,468
10	$ 138,965		$ 138,965	$ (55,586)	$ 83,379	

PW =	$ (358,798)

Solutions to FE Practice Problems

9-32 Machine A (Defender):

$PW_A(12\%) = -\$10{,}400 - \$2{,}000\ (P/A,12\%,5) + \$2{,}000\ (P/F,12\%,5) = -\$16{,}475$

Machine B (Challenger):

$PW_B(12\%) = -\$14{,}000 = \$1{,}400\ (P/A,12\%,5) + \$1{,}400\ (P/F,12\%,5) = -\$18{,}252$

Continue with Machine A.

<u>Select (a)</u>

9-33 Let X = repair cost for existing machine (defender)

$PW_D(12\%) = -\$15,000 - X$

$PW_C(12\%) = -\$44,000 + \$6,000\ (P/A,12\%,5) = -\$22,371$

Set $PW_D 12\%) = PW_C(12\%)$ and solve for X.

$-\$15,000 - X = -\$22,271; \quad X = \$7,371$

<u>Select (c)</u>

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9-34 $EUAC_A(12\%) = \$7{,}000\ (A/P,12\%,7) + \$1{,}000 - \$1{,}000\ (A/F,12\%,7)$
$= \$2{,}435$

<u>Select (e)</u>

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9-35 $EUAC_B(12\%) = \$50,000\ A/P,12\%,10) + \$600 - \$5,000\ (A/F,12\%,10)$
$= \$9,165$

<u>Select (d)</u>

9-36 If sold:

	BTCF	d	TI	T
0	\$40,000	0	\$40,500 − \$34,500 = \$6,000	(−0.29)(6,000) = −\$1,740

ATCF

\$40,500 − \$1,740 = \$38,760

Select (c)

Solutions to Chapter 10 Problems

10-1 $$\text{B/C} = \frac{\$460{,}000}{\$3{,}000{,}000(\text{A/P},10\%,\infty)+\$57{,}000} = \frac{\$460{,}000}{\$357{,}000} = 1.29 > 1$$

Because the B-C ratio is greater than one, the project is economically attractive.

10-2 Incremental investment = \$250,000(0.08) = \$20,000

AW = \$20,000(A/P, 10%, 30) = \$2,122

For B/C $\geq$ 1, the annual savings in heating and cooling expense needs to be greater than or equal to \$2,122. If this savings represents 15% of the total annual expense, the total annual expenditure would have to be in the neighborhood of \$2,122/0.15 = \$14,147 (compare this with \$3,000). This is quite high in most parts of the United States, so green homes without subsidies are difficult to justify on economic grounds alone.

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10-3 **(a)** Sum of benefits minus dis−benefits = \$650,000 per year
B/C Ratio = \$650,000 / (0.08 x \$7,000,000) = 1.16
Thus plan is acceptable because B/C > 1.0

(b) B/C Ratio = \$650,000 / (A/P,10%,20)(\$7,000,000) = 0.79
This plan is no longer acceptable to the town.

10-4 Conventional B/C = $\dfrac{(300{,}000)(\$0.10)(P/A, 15\%, 6)}{\$120{,}000 - \$8{,}000(P/F, 15\%, 6)} = \dfrac{\$113{,}535}{\$116{,}542} < 1$

The project is not acceptable.

10-5 The present worth of benefits (savings) is

$$\text{PW}(18\%) = \$30{,}000(1.04)\frac{[1-(\text{P/F},18\%,6)(\text{F/P},4\%,6)]}{0.18-0.04} = \$118{,}410$$

The present worth of cost is \$120,000. The ratio of benefits to cost is 0.99, so the project is still unacceptable.

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10-6 **(a)** AW (benefits) = (2.05 − 0.15)($1,000,000) + (3.35 − 0.35)($750,000) = $4,150,000
AW (costs) = $45,000,000 (A/P, 8%, 50) − $85,000 = $3,591,500

$$\text{B/C} = \frac{\$4{,}150{,}000}{\$3{,}591{,}500} = 1.16 > 1$$

Recommend constructing the tunnel.

(b) Let X = value of life saved

$$\text{B/C} = 1.0 = \frac{(2.05 - 0.15)(X) + (3.35 - 0.35)(\$750{,}000)}{\$3{,}591{,}500}$$

1.9(X) = $1,341,500

X = $706,053

10-7 PW (benefits) = $\frac{\$2{,}500{,}000[1-(P/F,10\%,30)(F/P,2.25\%,30)]}{0.10-0.0225}$

= \$2,5000,000(11.4619)

= \$28,654,750

PW (costs) = \$17,500,000* + \$325,000(P/A,10%,30)

+ \$1,250,000(A/F,10%,5)(P/A,10%,25)

= \$22,422,258

B/C = $\frac{\$28{,}654{,}750}{\$22{,}422{,}258}$ = 1.28 > 1

Therefore, the toll bridge should be constructed.

* The above analysis assumes that the initial surfacing of the bridge is included in the \$17,500,000. Even if this assumption is relaxed, the toll bridge should be constructed.

$$\text{B/C} = \frac{\$28{,}654{,}750}{\$22{,}422{,}258+\$1{,}250{,}000} = 1.21 > 1$$

10-8 Assumption: Initial investment includes initial surfacing of the bridge.

(a) PW (Benefits) = $\dfrac{\$3{,}000{,}000}{0.10} = \$30{,}000{,}000$

$$\text{PW (Costs)} = \$22{,}500{,}000 + \frac{\$250{,}000 + \$1{,}000{,}000\,(\text{A / F},10\%,7) \ + \$1{,}750{,}000\,(\text{A / F},10\%,20)}{0.1}$$

$$= \$26{,}360{,}250$$

CW (10%) = PW (benefits) − PW (costs) = \$30,000,000 − \$26,360,250 = <u>\$3,639,750</u>

(b) B/C = $\dfrac{\$30{,}000{,}000}{\$26{,}360{,}250} = 1.14$

(c) Assume repeatability for the initial design

$$\Delta B/\Delta C = \frac{\$30{,}000{,}000\,(\text{A / P}, 10\%, \infty) - \$28{,}652{,}800\,(\text{A / P}, 10\%, 30)}{\$26{,}360{,}250\,(\text{A / P}, 10\%, \infty) - \$22{,}422{,}258(\text{A / P}, 10\%, 30)} = \frac{-\$40{,}062}{\$257{,}023} = -0.16 < 1$$

<u>The initial design (described in Problem 10-15) should be selected</u>.

10-9 **(a)** Figures are in thousands.

Project	Annual Benefits	Annual Costs	B/C ratio
A	$1,800	$2,000	0.90
B	5,600	4,200	1.33
C	8,400	6,800	1.24
D	2,600	2,800	0.93
E	6,600	5,400	1.22

Projects B,C and E are acceptable. Recall that these projects are independent,

(b) The best project is B, followed closely by C and E. (The instructor might suggest that students rework this problem assuming the projects are mutually exclusive. An incremental analysis then leads to the conclusion that Project C should be chosen.)

(c) When considerable judgement regarding the value of intangible factors is present, project B should be selected because it allows for a greater degree of error in benefits estimation.

10-10 **(a)**

Plan	PW of Costs	PW of Benefits	B/C ratio
A	$123,000	$139,000	1.13
B	135,000	150,000	1.11
C	99,000	114000	1.15

From the above analysis, all three plans (A, B, and C) should be selected.

(b) Reclassifying 10% of costs as disbenefits in the numerator of the B/C ratio produces these results:

Plan	PW of Costs	PW of Benefits	B/C ratio	% change
A	$110,700	$126,700	1.14	+0.9
B	121,500	136,500	1.12	+0.9
C	89,100	104,100	1.17	+1.7

(c) A constant amount subtracted from the denominator and numerator of the B/C ratio does not appreciably affect the recomputed ratio.

10-11 After ordering according to increasing costs, B➔E➔A➔C➔D

Alternative or Investment Considered	B/C Ratio	Justified?
B	$\frac{\$810}{\$900} = 0.9\ (<1)$	No
E	$\frac{\$1{,}140}{\$990} = 1.15\ (>1)$	Yes
Δ(A−E)	$\frac{\$1{,}110 - \$1{,}140}{\$1{,}050 - \$990} = -0.5\ (<0)$	No
Δ(C−E)	$\frac{\$1{,}390 - \$1{,}140}{\$1{,}230 - \$990} = 1.0471 (>0)$	Yes
Δ(D−C)	$\frac{\$1{,}500 - \$1{,}390}{\$1{,}350 - \$1{,}230} = 0.917\ (<0)$	No

Therefore, Alternative C should be adopted.

10-12 DN → A: $B/C = \dfrac{\$80{,}000(P/A, 10\%, 4) - \$10{,}000(P/G, 10\%, 4)}{\$160{,}000} = \dfrac{\$209{,}812}{\$160{,}000} = 1.31 > 1$, so select system A vs. DN.

A → C: $\dfrac{\Delta B}{\Delta C} = \dfrac{-\$10{,}000(P/A, 10\%, 4) + \$10{,}000(P/G, 10\%, 4)}{\$40{,}000} = \dfrac{\$12{,}081}{\$40{,}000} = 0.3$. The incremental B-C ratio is less than one, so keep system A.

A → B: $\dfrac{\Delta B}{\Delta C} = \dfrac{\$40{,}000(P/A, 10\%, 4) - \$10{,}000(P/G, 10\%, 4)}{\$85{,}000} = \dfrac{\$83{,}016}{\$85{,}000} = 0.98 < 1$. Therefore system A is the best choice.

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10-13 The conventional B/C ratio for Alternative A is:

$$\frac{\$1{,}000{,}000+\$500{,}000}{\$20{,}000{,}000(A/P,5\%,50)\ +\ \$200{,}000}=\frac{\$1{,}500{,}000}{\$1{,}296{,}000}=1.16$$

The conventional B/C ratio for Alternative B is:

$$\frac{\$800{,}000+\$1{,}300{,}000}{\$30{,}000{,}000(A/P,5\%,50)\ +\ \$100{,}000}=\frac{\$2{,}100{,}000}{\$1{,}744{,}000}=1.20$$

Both alternatives are acceptable. An incremental analysis is required to determine which alternative should be chosen.

Incremental Analysis: Δ(B−A)

Δ Capital investment = $10,000,000
Δ Annual O & M costs = $1,000,000
Δ Annual power sales = −$200,000
Δ Other annual benefits = $800,000

$$\Delta B/\Delta C = \frac{\$800{,}000-\$200{,}000}{\$10{,}000{,}000(A/P,5\%,50)-\$100{,}000}=\frac{\$600{,}000}{\$448{,}000}=1.34>1$$

Select <u>Alternative B</u>.

10-14 **(a)** System 2 is inferior to both System 1 and System 3, so it can be dropped from consideration.

System	1	3	4	5
B-C ratio	8.0	3.5	1.6	2.0

System 1 has the largest B-C ratio, but it would not be selected for this reason. We must examine the incremental B-C ratios for the four systems. Notice that the systems are rank ordered from low PW of costs to high PW of costs. System 1 is an acceptable alternative to use to start the incremental comparisons.

(b) B-C ratios for: $\Delta(3 - 1)$ = \$6,000/\$3,000 = 2.00. Select 3, drop 1.
$\Delta(4 - 3)$ = \$2,000/\$6,000 = 0.33. Keep 3, drop 4.
$\Delta(5 - 3)$ = \$10,000/\$8,000 = 1.25. Select System 5.

System 3 has the highest incremental B-C ratio, but it wouldn't be chosen for that reason.

(c) The last increment with a B-C ratio greater than or equal to one was System 5. This is the best alternative.

10-15 From Example 10-7:

$PW_{(\text{Benefits,A})}$ = \$21,316,851
$PW_{(\text{Benefits,B})}$ = \$22,457,055
$PW_{(\text{Benefits,C})}$ = \$24,787,036

PW(Costs,A) = \$8,500,000 + \$750,000(P/A,10%,50) = \$15,936,100
PW(Costs,B) = \$10,000,000 + \$725,000(P/A,10%,50) = \$17,188,230
PW(Costs,C) = \$12,000,000 + \$700,000(P/A,10%,50) = \$18,940,360

Rank order: DN → A→ B→ C

$$\text{B−C(A)} = \frac{\$21{,}316{,}851}{\$15{,}936{,}100} = 1.3376 > 1.0$$

Therefore, Project A is acceptable.

$$\frac{\Delta B}{\Delta C}(\text{B−A}) = \frac{\$22{,}457{,}055 - \$21{,}316{,}851}{\$17{,}188{,}230 - \$15{,}936{,}100} = 0.9106 < 1.0$$

Increment required for Project B is not acceptable.

$$\frac{\Delta B}{\Delta C}(\text{C−A}) = \frac{\$24{,}787{,}036 - \$21{,}316{,}851}{\$18{,}940{,}360 - \$15{,}936{,}100} = 1.1551 > 1.0$$

Increment required for Project C is acceptable. Recommend Project C.

Note that MV = \$0 had little impact on the values of the B−C ratios. This is due to the length of the study period.

10-16

Alternative	Total Equivalent Annual Cost	Annual Benefits	B/C Ratio
No Control	$100,000	$ 0	0.00
Levees	110,000	112,000	1.02
Small Dam	105,000	110,000	1.05

(a) Maximum benefit − choose levees.

(b) Minimum cost − choose no flood control.

(c) Maximum (B/C) − choose the small dam.

(d) Largest investment having incremental B/C ratio larger than 1:
Rank alternatives by increasing total annual cost:
No Control, Small Dam, Levees

Δ (Small Dam − No Control): $\Delta B/\Delta C = \dfrac{\$110{,}000}{\$5{,}000} = 22 > 1$

Select the small dam over no control.

Δ (Levees − Small Dam): $\Delta B/\Delta C = \dfrac{\$2{,}000}{\$5{,}000} = 0.4 < 1$

Choose the small dam.

(e) Largest B/C ratio − choose the small dam (which is coincidentally the correct choice). The correct choice based on incremental analysis would be to select the small dam as seen in part (d).

10-17 B → D: $\Delta B/\Delta C$ = \$1,000/[\$3,000(0.12)] = 2.78 > 1, so choose D.

D → A: $\Delta B/\Delta C$ = \$1,000/[\$7,000(0.12)] = 1.19 > 1, so choose A.

A → C: $\Delta B/\Delta C$ = \$10,000/[\$88,000(0.12)] = 0.95 < 1, so keep A.

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10-18 **(a)** Figures are in thousands. Option A has lowest equivalent annual cost, followed by (in order of annual cost) B, C, and D.

Options	Annual Benefits	Annual Costs	ΔB/ΔC Ratio	Choice
A	$650	$301.6	2.16	A
Δ (B − A)	162	101.4	1.60	B
Δ (C − B)	228	288.6	0.79	B
Δ (D − B)	332	481.0	0.69	B

Therefore, from the incremental analysis, option B should be chosen.

(b) Figures are in thousands.

Options	Annual Benefits	Annual Costs	ΔB/ΔC Ratio	Choice
A	$598	$249.6	2.40	A
Δ (B − A)	110	49.4	2.23	B
Δ (C − B)	176	236.6	0.74	B
Δ (D − B)	254	403.0	0.63	B

Again, option B is best choice.

10-19

Route*	Construction Cost	Annual Maint. Cost	Total Annual Benefits	Total PW Costs	Total PW Benefits	B/C Ratio
A	$185,000	$2,000	$8,500	$209,467	$103,985	0.50
B	220,000	3,000	15,000	256,701	183,503	0.71
C	290,000	4,000	20,800	338,934	254,457	0.75

*Assume that a roadway must be constructed.

Sample calculation for A:

Total PW Cost = $185,000 + $2,000 (P/A, 8%, 50) = $209,467

Total PW Benefits = $8,500 (P/A, 8%, 50) = $103,985

B/C Ratio = $103,985 / $209,467 = 0.50

Comparison of routes	$\Delta B/\Delta C$	Decision
Δ (B − A)	1.68	Select Alternative B
Δ (C − B)	0.86	Keep Alternative B

From an incremental analysis, route B is the "least objectionable" alternative. If B is chosen, it simply means that the state will be receiving less than an 8% return on its capital. If another alternative could be identified that had a B/C ratio greater than or equal to one, it should be recommended.

10-20 **(a)** DN → B: $13,000(P/A, 8%, 10)/$50,000 = 1.74; choose B.
B → C: $2,300(P/A, 8%, 10)/$15,000 = 1.03; choose C.
C → A: $700(P/A, 8%, 10)/$10,000 = 0.47; keep C.

(b) DN → B: $18,000/[$50,000(A/P, 8%, 10) + $5,000] = 1.44; choose B.
B → C: $2,000/[$15,000(A/P, 8%, 10) − $300] = 1.03; choose C.
C → A: 0 / difference in costs = 0; keep C.

(c) Although the incremental B-C values are not identical, the recommendation should be the same.

10-21

Annual Benefits	I. Improve Channel	II. Dam	III. Dam and Channel
Flood reduction	$200,000	$550,000	$650,000
Irrigation	---	175,000	175,000
Recreation	---	45,000	45,000
Total Benefits	$200,000	$770,000	$870,000

Annual Costs	I. Improve Channel	II. Dam	III. Dam and Channel
CR Amount	$293,750	$850,000	$1,143,750
O&M	80,000	50,000	130,000
Total Costs	$373,750	$900,000	$1,273,750
Benefit − Cost Ratio	0.54	0.86	0.68

Although all three values are less than one, assume that one of the alternatives has to be chosen (i.e. doing nothing is not an acceptable alternative).

Incremental Analysis: I, II, III (ordered by increasing capital recovery amount)

<u>Δ (II − I)</u>

$\Delta B/\Delta C = \dfrac{\$570{,}000}{\$526{,}250} = 1.08 > 1$, Select II.

$\Delta B/\Delta C = \dfrac{\$100{,}000}{\$373{,}750} = 0.27 < 1$, Keep II.

If one option must be selected, <u>recommend building the dam (II)</u>.

10-22 **(a)** The port manager's analysis is in error due to failure to consider the time value of money. Whether or not capital would have to be borrowed, it has earning power which must be considered. He also does not consider the cost of capital relative to the recovery of invested capital.

(b) Assuming capital to be worth 5%, and that piers will be needed indefinitely:

AW_{old} (5%) = − \$40,000 (A/P, 5%, 40) − \$27,000 = −\$29,332
AW_{new} (5%) = − \$600,000 (A/P, 5%, 50) − \$2,000 = − \$34,880

<u>It is more economical to retain the steel pier</u>.

10-23 One must be chosen (DN not an option). Choose Gravity-fed unless $\Delta B/\Delta C \geq 1$.

$$\Delta B/\Delta C = \frac{\$24{,}000(P/F, 15\%, 5)}{\$37{,}900 - \$24{,}500} = \frac{\$12{,}181}{\$13{,}400} < 1.$$ Stay with Gravity-fed.

Although annual benefits are the same, not having to re-invest in five year is an added benefit of the Vacuum-led.

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10-24 Construct Levee:

AW (benefits) = \$1,500,000
AW (costs) = \$25,000,000 (A/P,8%,25) + \$725,000 = \$3,067,500

Dredge Channel:

AW (benefits) = \$0
AW (costs) = \$15,000,000 (A/P,8%,25) + \$375,000 = \$1,780,500

<u>Δ (Levee − Channel)</u>

$$\Delta B/\Delta C = \frac{\$1{,}500{,}000 - \$0}{\$3{,}067{,}500 - \$1{,}780{,}500} = 1.17 > 1$$

<u>Construct the levee</u>.

10-25 Design A:

$$CW(\text{benefits}) = \frac{\$2{,}150{,}000}{0.1} = \$21{,}500{,}000$$

$$CW(\text{costs}) = \$17{,}000{,}000 + \frac{\$12{,}000(P/A,10\%,34)(A/P,10\%,35)}{0.1}$$

$$+ \frac{\$40{,}000(A/F,10\%,7)}{0.1} + \frac{\$3{,}000{,}000(A/F,10\%,35)}{0.1}$$

$$= \$17{,}272{,}729$$

Design B:

$$CW(\text{benefits}) = \frac{\$1{,}900{,}000}{0.1} = \$19{,}000{,}000$$

$$CW(\text{costs}) = \$14{,}000{,}000 + \frac{\$17{,}500(P/A,10\%,24)(A/P,10\%,25)}{0.1}$$

$$+ \frac{\$40{,}000(A/F,10\%,5)}{0.1} + \frac{\$3{,}500{,}000(A/F,10\%,25)}{0.1}$$

$$= \$14{,}595{,}790$$

Design C:

$$CW(\text{benefits}) = \frac{\$1{,}750{,}000}{0.1} = \$17{,}500{,}000$$

$$CW(\text{costs}) = \$12{,}500{,}000 + \frac{\$20{,}000(P/A,10\%,24)(A/P,10\%,25)}{0.1}$$

$$+ \frac{\$40{,}000(A/F,10\%,5)}{0.1} + \frac{\$3{,}750{,}000(A/F,10\%,25)}{0.1}$$

$$= \$13{,}146{,}043$$

Order alternative designs by increasing investment: C, B, A.

	C	Δ (B − C)	Δ (A − B)
Δ CW (benefits)	\$17,500,000	\$1,500,000	\$2,500,000
Δ CW (costs)	13,146,043	1,449,747	2,676,939
ΔB/ΔC	1.33	1.03	0.93
Increment justified?	Yes	Yes	No
Current best design	C	B	B

Decision: Select Design B.

10-26 $AW_B(12\%) = \$20,000$
$AW_C(12\%) = \$50,000\ (A/P,12\%,6) + \$6,000 = \$18,160$

$$B\text{−}C\ \text{Ratio} = \frac{\$20,000}{\$18,160} = 1.1$$

<u>Select (d)</u>

10-27 Truck X is acceptable (results of Problem 10-22). Check B−C ratio of incremental investment required for Truck Y.

$\Delta\, AW_B(12\%) = \$22{,}000 - \$20{,}000 = \$2{,}000$

$\Delta\, AW_C(12\%) = \$64{,}000 - \$50{,}000)\ (A/P,12\%,6) + (\$5{,}000 - \$6{,}000)$

$= \$2{,}405$

$$\Delta\, B\text{−}C = \frac{\$2{,}000}{\$2{,}405} = 0.83 < 1$$

<u>Select (b)</u>

Incremental investment required by Truck Y is not justified. Purchase Truck X.

10-28 For B−C to equal 1, $AW_B(12\%) = AW_C(12\%)$

$AW_B(12\%) = \$600,000\ (F/P,12\%,2.5)\ (A/F,12\%,5)$
$= \$126,776$

$PW_B(12\%) = \$126,776\ (P/A,12\%,15) = \$843,026$

<u>Select (c)</u>

10-29 $PW_B(12\%) = \$24,000\ (P/A,12\%,14)(P/F,12\%,2)$
$= \$126,816$

$PW_C(12\%) = \$60,000 + \$5,000\ (P/A,12\%,16) = \$94,870$

$$\text{Conventional B−C} = \frac{\$126,816}{\$94,870} = 1.337$$

<u>Select (b)</u>

10-30 $PW_{B-O\&M}(12\%) = \$24,000\ (P/A,12\%,14)\ (P/F,12\%,2) - \$5,000\ (P/A,12\%,16)$
$= \$91,946$

$PW_C(12\%) = \$60,000$

$$\text{Modified B}-\text{C} = \frac{\$91,946}{\$60,000} = 1.53$$

<u>Select (a)</u>

Solutions to Chapter 11 Problems

11-1 Letting X denote the annual sales of the product, the annual worth for the venture can be determined as follows:

$$\begin{aligned} AW(15\%) &= -\$200{,}000(A/P, 15\%, 5) - \$50{,}000 - 0.1(\$25)X + \$12.50X \\ &= -\$109{,}660 + \$10X \end{aligned}$$

From this equation, we find that X = 10,996 units per year. If it is believed that at least 10,966 units can be sold each year, the venture appears to be economically worthwhile. Even though the firm does not know with certainty how many units of the new device will be sold annually, the information provided by the breakeven analysis will assist management in deciding whether or not to undertake the venture.

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11-2 The unknown is now the mileage driven each year (instead of fuel cost).

$$EUAC_H = \$30{,}000(A/P, 3\%, 5) + (\$3.50/\text{gal})(X \text{ mi/yr})/(30 \text{ mpg})$$

$$EUAC_G = \$28{,}000(A/P, 3\%, 5) + (\$3.50/\text{gal})(X \text{ mi/yr})/(25 \text{ mpg})$$

Setting $EUAC_H = EUAC_G$, we find the breakeven mileage to be X = 30,300 miles per year.

11-3 The annual operating expenses of long-haul tractors equipped with the various deflectors are calculated as a function of mileage dirven per year, X:

Windshear: [(X mi/yr)(0.92)(0.2 gal/mi)($3.00/gal)] = $0.552X / yr
Blowby: [(X mi/yr)(0.96)(0.2 gal/mi)($3.00/gal)] = $0.576X / yr
Air-vantage: [(X mi/yr)(0.90)(0.2 gal/mi)($3.00/gal)] = $0.540X / yr

EUAC can now be written in terms of X.

$$EUAC_W = \$1{,}000(A/P, 10\%, 10) + \$10 + \$0.552X = \$172.70 + \$0.552X$$
$$EUAC_B = \$400(A/P, 10\%, 10) + \$5 + \$0.576X = \$70.08 + \$0.576X$$
$$EUAC_A = \$1{,}200(A/P, 10\%, 5) + \$5 + \$0.540X = \$321.56 + \$0.540X$$

The breakeven values can be computed between each pair of deflectors by equating their EUAC equations and solving for X.

Windshear and Blowby: X = 4,276 miles per year
Blowby and Air-vantage: X = 6,986 miles per year
Air-vantage and Windshear: X = 12,405 miles per year

The range over which each deflector is preferred is:

$X \leq 4{,}276$		Select Blowby
$4{,}276 \leq X \leq 12{,}405$		Select Windshear
$12{,}405 \leq X$		Select Air-vantage

11-4 The break-even deferment period, T′, is determined as follows:

Provide now: PW(costs) = \$1,400,000 + \$850,000(P/F, 10%, T′)
No Provision: PW(costs) = \$1,250,000 + \$1,150,000(P/F, 10%, T′)

If the difference between the two alternatives is examined, it can be seen that \$150,000 now is being traded off against \$300,000 at a later date. The question is, what "later date" constitutes the break-even point? By equating the PW(costs) and solving, we have 0.5 = (P/F, 10%, T′) and T′ = log(2)/log(1.1) = 7.27. Or, from Appendix C, we see that T′ is approximately seven years. Thus, if the additional space will be required in less than seven years, it would be more economical to make immediate provision in the foundation and structural details. If the addition would not likely be needed until after seven years, greater economy would be achieved by making no such provision in the first structure.

11-5 **(a)** $AW_1(15\%) = -\$4,500\,(A/P, 15\%, 8) + \$1,600 - \$400 + \$800\,(A/F, 15\%, 8)$
$= -\$4,500(0.2229) + \$1,200 + \$800\,(0.0729)$
$= \$255$

$AW_2(15\%) = -\$6,000(A/P, 15\%,10) + \$1,850 - \$500 + \$1,200(A/F,15\%,10)$
$= -\$6,000(0.1993) + \$1,350 + \$1,200\,(0.0493)$
$= \$213$

Therefore, the initial decision is to select Alternative 1. To determine the capital investment of Alternative 2 (I_2) so that the initial decision would be reversed, equate the AWs:

$$AW_1(15\%) = AW_2(15\%)$$

$\$255 = -I_2\,(A/P, 15\%, 10) + \$1,350 + \$1,200\,(A/F, 15\%, 10)$
$\$255 = -I_2\,(0.1993) + \$1,350 + \$1,200\,(0.0493)$
$I_2 = \$5,791$

The capital investment of Alternative 2 would have to be $5,791 or less for the initial decision to be reversed.

(b) Set $AW_1(15\%) = AW_2(15\%)$ and solve for N assuming market values remain constant.

$-\$4,500\,(A/P,15\%,N) + \$1,200 + \$800\,(A/F,15\%,N) = \$213$
$-\$4,500\,(A/P, 15\%, N) + \$986.64 + \$800\,(A/F, 15\%, N) = 0$

By trial and error, N = <u>7.3 years</u>.

11-6 **(a)** Let X = operating hours per year

$$EUAC_A(12\%) = \$2,410(A/P, 12\%, 8) - \$80(A/F, 12\%, 8) + (15\text{ hp})(0.746\text{ kW/hp})(\$0.06/\text{kWh})(X)/(0.6)$$
$$= \$478.63 + \$1.119X$$

$$EUAC_B(12\%) = \$4,820(A/P, 12\%, 8) + (10\text{ hp})(0.746\text{ kW/hp})(\$0.06/\text{kWh})(X)/(0.75)$$
$$= \$970.27 + \$0.5968X$$

Setting $EUAC_A = EUAC_B$ we find X = 941 hours per year. At annual operating hours greater than 941 (including 2,000), we prefer the more efficient pump, Pump B. This is confirmed by calculating the EUAC with X = 2,000.

$EUAC_A(12\%) = \$2,716$ $\quad\quad$ $EUAC_B(12\%) = \$2,164$

(b) Let η_A = breakeven efficiency of pump A at 2,000 operating hours per year. We already know that $EUAC_B(12\%) = \$2,164$ at 2,000 hours per year.

$$EUAC_A(12\%) = \$2,164 = \$2,410(A/P, 12\%, 8) - \$80(A/F, 12\%,8) + (15\text{ hp})(0.746\text{ kW/hp})(\$0.06/\text{kWh})(X)/\eta_A$$

Solving, we get $\eta_A = 79.67\%$

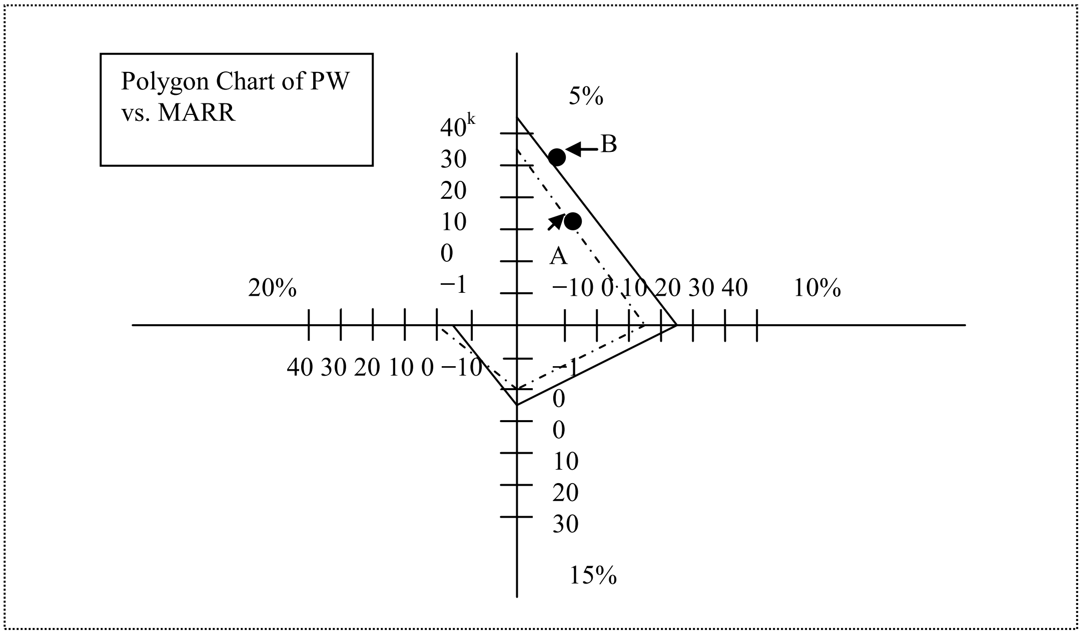
11-7 Assume repeatability. Set $AW_A(10\%) = AW_B(10\%)$ and solve for breakeven value of X.

$AW_A(10\%) = -\$5{,}000\ (A/P,10\%,5) + \$1{,}500 + \$1{,}900\ (A/F,10\%,5) = \$492{,}22$

$AW_B(10\%) = -X((A/P,10\%,7) + \$1{,}400 + \$4{,}00\ (A/F,10\%,7)$
$= -0.2054X + \$1{,}821.60$

$\$492.22 = -0.2054X + \$1{,}821.60$
$X = (\$1{,}821.60 - \$492.22) / (0.2054) = \$6{,}472.15$
At $X = 0$, $AW_B(10\%) = \$1{,}821.60 > \$492.22$, so Alt. B is preferred.
At $X = \$6{,}500$, $AW_B(10\%) = \$486.50 < \$492.22$, so Alt. A is preferred.

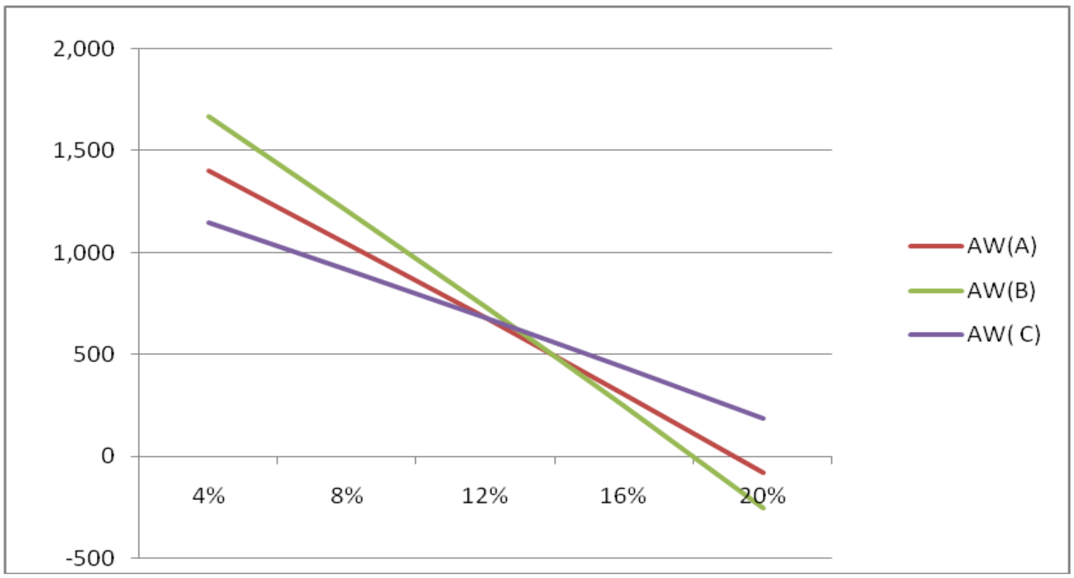
Select Alt. B for $0 \leq X \leq \$6{,}472.15$



11-8

Alternative	A	B	C
Investment Capital	12,000	15,800	8,000
Annual Savings	4,000	5,200	3,000
MV (after 4 years)	3,000	3,500	1,500

MARR	AW(A)	AW(B)	AW(C)
4%	1,401	1,671	1,149
8%	1,043	1,206	918
12%	677	730	680
16%	304	244	437
20%	-77	-251	189



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11-9 After−tax, A$ Analysis: Let X = annual before−tax revenue requirement.

EOY	Investment	Annual Revenue	Annual Expenses	BTCF (A$)
0	−$1,166,000[1]			−$1,166,000
1		X	−$519,750[3]	−519,750+X
2		X	− 545,738	−545,738+X
3		X	− 573,024	−573,024+X
4		X	− 601,676	−601,676+X
4	441,741[2]			441,741

[1] Capital Investment = (55 trucks)($21,000/truck) = $1,166,000
[2] Market Value = MV_4 = 0.35($1,166,000)$(1.02)^4$ = $441,741
[3] Annual Expenses in year k = (55 trucks)(20,000 mi/truck)($0.45/mi)$(1.05)^k$
= $495,000$(1.05)^k$

EOY	BTCF (A$)	Depr.	TI	T(38%)	ATCF (A$)
0	− $1,166,000	---	---	---	− $1,166,000
1	−519,750 + X	$388,628	− 908,378 + X	345,184−0.38X	−174,566+0.62X
2	−545,738 + X	518,287	−1,064,025 + X	404,330−0.38X	−141,408+0.62X
3	−573,024 + X	172,685	− 745,709 + X	283,369−0.38X	−289,655+0.62X
4	−601,676 + X	86,401	− 688,077 + X	261,469−0.38X	−340,207+0.62X
4	441,741	---	441,741	−167,862	273,879

PW(15%) = 0 = − $1,166,000 − $174,566(P/F,15%,1) − $141,408 (P/F,15%,2)
− $289,655(P/F,15%,3) − $340,207(P/F,15%,4)
+ $273,879(P/F,15%,4) + 0.62X(P/A,15%,4)
0 = − $1,653,096 + 1.77X

Thus, X = $1,653,096/1.77 = $933,953 in annual revenues per year.

Breakeven Point Interpretation: The equivalent uniform annual revenue of $933,953 per year is the breakeven point between signing the contract (and purchasing the trucks, etc.), and not signing the contract (and making no change in current operations).

11-10 **(a)** Annual Revenues = (150 rooms)(0.6)$\left(\dfrac{\$45}{\text{room - day}}\right)\left(\dfrac{365\text{ days}}{\text{year}}\right)$ = \$1,478,250

AW(10%) = \$1,478,250 − \$125,000 − \$5,000,000(A/P,10%,15)
+ (0.2)(\$5,000,000)(A/F,10%,15) − \$1,875,000 (A/P,10%,5)
= \$232,625 > 0

Yes, the project is economically feasible.

(b) <u>Sensitivity with respect to Decision Reversal</u>

Capital Investment: \$232,625* − \$5,000,000(A/P,10%,15)X = 0
X = 0.3538 or <u>35.38%</u>

* Market value is assumed to remain constant at \$1,000,000.

Occupancy Rate: \$232,625 + 45(150)(365)(0.6)X = 0
X = −0.1574 or <u>−15.74%</u>

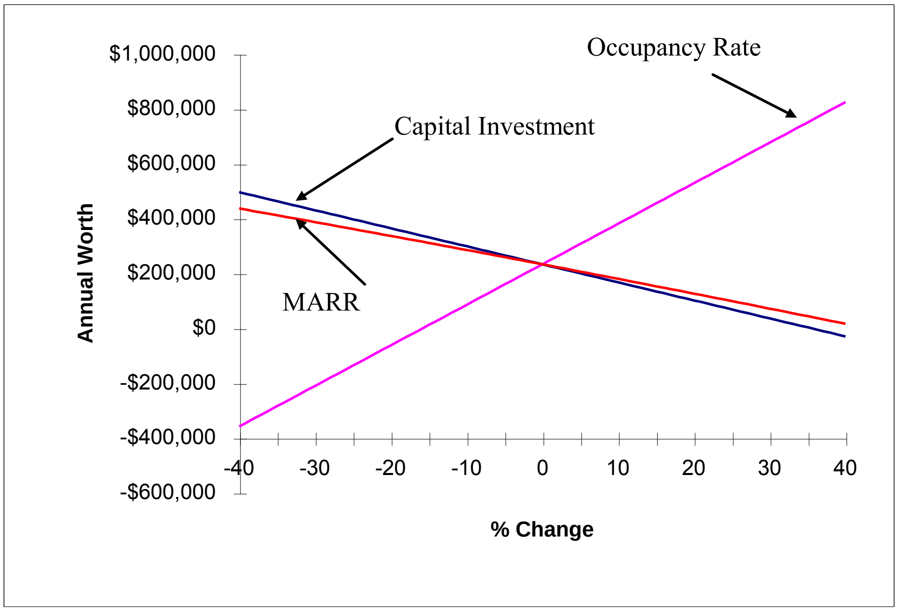
MARR: (find the IRR and calculate % change)
By trial and error, IRR = 14.3%.
Therefore, the MARR must increase by 14.3/10 − 1 = <u>43 %</u>

The decision is most sensitive to changes in occupancy rate (requires the smallest percent change to reverse the decision).

(c) Annual worth is a linear function with respect to capital investment and occupancy rate − we can construct the plot using points from parts (a) and (b). Annual worth is non−linear with respect to the MARR, therefore additional data points are necessary.

i	% change	AW
6%	−40%	\$557,200
8%	−20%	378,559
10%	0	232,625
12%	20%	112,679
14%	40%	12,808

11-10 (c) *continued*



11-11 **(a)** Let X = hours per day for new system.

$EUAC_{New}$ = \$150,000(A/P, 1%, 60) − \$50,000(A/F, 1%, 60) + (\$40/hr)(X)(20 days/mo)

$EUAC_{Used}$ = \$75,000(A/P, 1%, 60) − \$20,000(A/F, 1%, 60)
+ (\$40/hr)(8 hr/day)(20 day/mo)

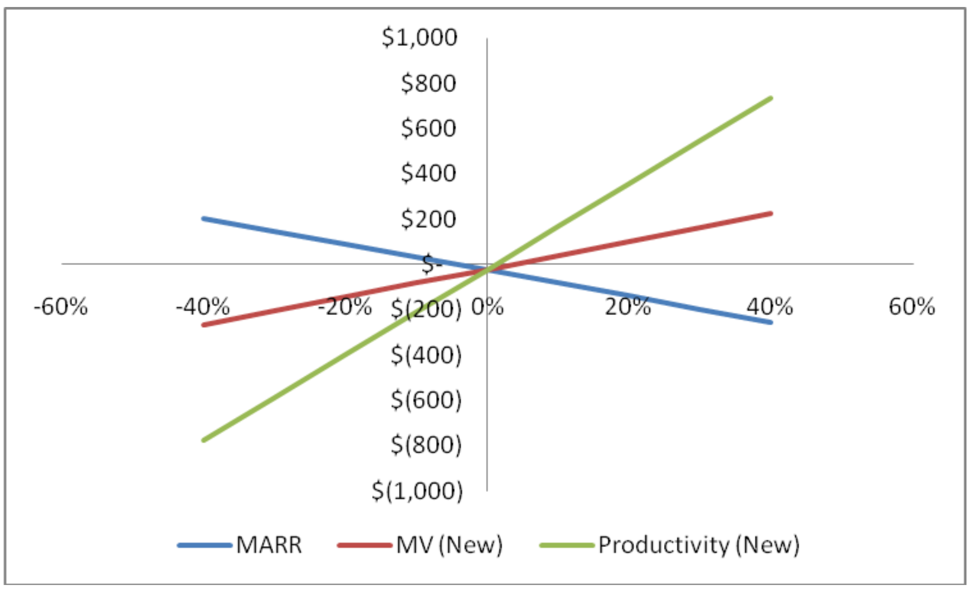
Set $EUAC_{New}$ = $EUAC_{Used}$ and solve for X = 6.38 hours per day. This corresponds to an [(8 – 6.38)/8] × 100% = 20.3% reduction in labor hours.

(b) If the new system is expected to reduce labor hours by only 20%, the used system would be recommended. This conclusion is confirmed by computing the PW of the incremental investment (\$75,000) required the new system, PW_{Δ} = −\$946. But the margin of victory for the used system is small, and management may elect to go ahead and purchase the new system because of intangible factors such as reliability and prestige value of having the latest technology.

11-12

Most Likely Estimates			
		New	Used
Capital Investment		$150,000	$75,000
Market Value		$50,000	$20,000
Annual Labor Cost		$5,120	$6,400
MARR (per month)	1.00%		

		Incremental AW	
% Change	MARR	MV (New)	Productivity (New)
-40%	$ 205	$ (266)	$ (778)
-30%	$ 149	$ (205)	$ (589)
-20%	$ 93	$ (143)	$ (399)
-10%	$ 36	$ (82)	$ (210)
0%	$ (21)	$ (21)	$ (21)
10%	$ (79)	$ 40	$ 168
20%	$ (136)	$ 101	$ 357
30%	$ (195)	$ 163	$ 547
40%	$ (254)	$ 224	$ 736



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11-13 The entries in the following table are AW values and were generated using the following equation:

$$AW(6\%) = -\$30{,}000{,}000(A/P, 6\%, 40) - 300(\$4{,}000) + \text{occupancy rate} \times \text{rental fee} \times 300$$

	Occupancy Rate					
Rental Fee	75%	80%	85%	90%	95%	100%
$6,000	($1,843,846)	($1,753,846)	($1,663,846)	($1,573,846)	($1,483,846)	($1,393,846)
$7,000	($1,618,846)	($1,513,846)	($1,408,846)	($1,303,846)	($1,198,846)	($1,093,846)
$8,000	($1,393,846)	($1,273,846)	($1,153,846)	($1,033,846)	($913,846)	($793,846)
$9,000	($1,168,846)	($1,033,846)	($898,846)	($763,846)	($628,846)	($493,846)
$10,000	($943,846)	($793,846)	($643,846)	($493,846)	($343,846)	($193,846)
$11,000	($718,846)	($553,846)	($388,846)	($223,846)	($58,846)	$106,154
$12,000	($493,846)	($313,846)	($133,846)	$46,154	$226,154	$406,154
$13,000	($268,846)	($73,846)	$121,154	$316,154	$511,154	$706,154
$14,000	($43,846)	$166,154	$376,154	$586,154	$796,154	$1,006,154
$15,000	$181,154	$406,154	$631,154	$856,154	$1,081,154	$1,306,154
$16,000	$406,154	$646,154	$886,154	$1,126,154	$1,366,154	$1,606,154
$17,000	$631,154	$886,154	$1,141,154	$1,396,154	$1,651,154	$1,906,154
$18,000	$856,154	$1,126,154	$1,396,154	$1,666,154	$1,936,154	$2,206,154

11-14 **(a)** Analysis at most likely estimates:

PW(15%) = −\$30,000 + (\$20,000 = \$5,000) (P/A,15%,5) + \$1,000 (P/F,15%,5)
= \$20,780.20

<u>Sensitivity to changes in capital investment</u>:

+5%: PW(15%) = −\$30,000(1.05) _ (\$20,000 − \$5,000)(P/A,15%,5) +
\$1,000(P/F,15%,5) = −\$19,280.20

−5%: PW*15%) = −\$30,000(0.95) + (\$20,000 − \$5,000)(P/A,15%,5) +
\$1,000(P/F,15%,5) = \$22,280.20

Breakeven percent change:

PW(15%) = 0 = −\$30,000(1 + x%) + (\$20,000 − \$5,000)(P/A,15%,5) +
\$1,000(P/F,15%,5)
x = 0.693 or +69.3% increase in capital investment cost

<u>Sensitivy to changes in annual expenses</u>:

+10%: PW(15%) = −\$30,000 + [\$20,000 − \$5,000(1.1)](P/A,15%,5) +
\$1,000(P/F,15%,5) = \$19,104.10

−10%: PW(15%) = −\$30,000 + [\$20,000 − \$5,000)(0.9)](P/A,15%,5) +
\$1,000(P/F,15%,5) = \$22,456.30

Breakeven percent change:

PW(15%) = 0 = −\$30,000 + [\$20,000 − \$5,000(1 + x%)](P/A,15%,5) +
\$1,000(P/F,15%,5)
x = 1.24 or +124% increase in annual expenses

<u>Sensitivity to changes in annual revenue</u>:

+20%: PW(15%) = −\$30,000 + [\$20,000(1.2) − \$5,000](P/A,15%,5) + \$1,000(P/F,15%,5)
= \$34,189

−20%: PW(15%) = −\$30,000 + [\$20,000(0.8) − \$5,000](P/A,15%,5) + \$1,000(P/F,15%,5)
= \$7,371.40

Breakeven percent change:

PW(15%) = 0 = −\$30,000 + [\$20,000(1 + x%) = \$5,000](P/A,15%,5) + \$1,000(P/F,15%,5)
x = −0.31 or – 31% (decrease in annual revenues)

11-14 (a) *continued*

Sensitivity to changes in market value:

+20%: PW(15%) = −\$30,000 + (\$20,000 − \$5,000)(P/A,15%,5) + \$1,000(1.2)(P/F,15%,5)
= \$20,879.64

−20%: PW(15%) = −\$30,000 + (\$20,000 − \$5,000)(P/A,15%,5) + \$1,000(0.8)(P/F,15%,5)
= \$20,680.76

Breakeven percent change:

PW(15%) = 0 = −\$30,000 + (\$20,000 − \$5,000)(P/A,15%,5) +
\$1,000(1 + x%)(P/F,15%,5)
X = −41.79 or −417.9% (decrease in market value)

Sensitivity to changes in useful life:

At +20%, n = 6
PW(15%) = −\$30,000 + (\$20,000 − \$5,000)(P/A,15%,6) + \$1,000(P/F,15%,6)
= \$27,199.80

At −20%, n = 4
PW(15%) = −\$30,000 + (\$20,000 − \$5,000)(P/A,15%,4) + \$1,000(P/F,15%,4)
= \$13,396.80

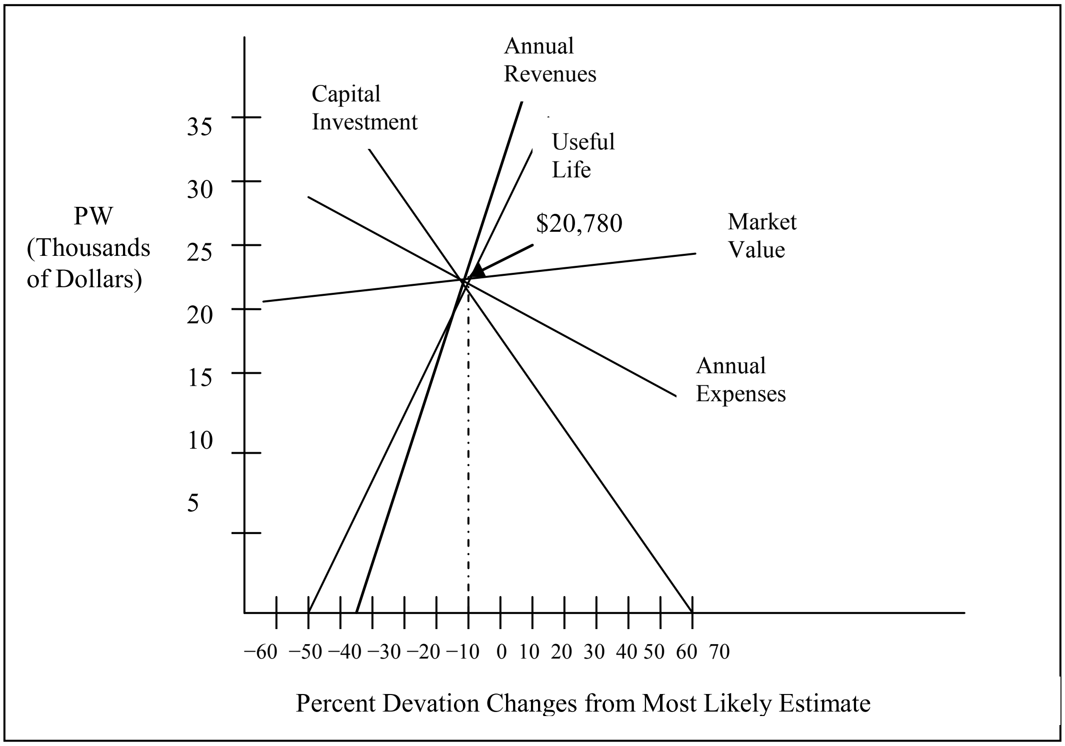
Breakeven percent change:

At n = 3 (−40%):
PW(15%) = −\$30,000 + (\$20,000 − \$5,000)(P/A,15%,3) + \$1,000(P/F,15%,3)
= \$4,905.50

At n =2 (−60%):
PW(15%) = −\$30,000 + (\$20,000 − \$5,000)(P/A,15%,2) + \$1,000(P/F,15%,2)
= −\$4,858.40
Breakeven life ≈ 2.5years, a −50% change

11-14 (a) *continued*

Recommendation: Proceed with the project. PW is positive for values of factors (changed individually) within stated accuracy ranges. However, if all factors are at their worst values, PW(15%) = −\$1,065 [capital investment at +5%, annual expenses at +10%, annual revenues, market value, and useful life at −20%].



(b) Factors can be ranked base on the breakeven percent change.

Highest need	Annual Revenues	−31%
	Useful Life	−50%
	Capital Investment	+69.3%
	Annual Expense	+124%
Lowest need	Market Value	−418%

11-15 Repair cost = \$5,000:

$PW(i'\%) = 0 = -\$10{,}000 + \$4{,}000(P/A,i'\%,5) - \$5{,}000(P/F,i'\%,3)$

By trial and error, IRR = 15.5%

Repair cost = \$7,000:

$PW(i'\%) = 0 = -\$10{,}000 + \$4{,}000(P/A,i'\%,5) - \$7{,}000(P/F,i'\%,3)$

By trial and error, IRR = 9.6%

Repair cost = \$3,000

$PW(i'\%) = 0 = -\$10{,}000 + \$4{,}000(P/A,i'\%,5) - \$3{,}000(P/F,i'\%,3)$

By trial and error, IRR = 21%

The sensitivity analysis indicates that if the repairs at the end of year 3 cost \$5,000 or less, it will be economical to invest in the machine. However, if the repairs cost \$7,000, the IRR of the purchase is less than the MARR.

A follow−up analysis would be to determine the maximum repair cost that would still result in the desired return of 10%. Let R = repair cost at the end of year 3.

$$PW(10\%) = 0 = -\$10{,}000 + \$4{,}000(P/A,10\%,5) - R\,(P/F,10\%,3)$$

$$0.7513(R) = \$4{,}163.20$$
$$R = \$\underline{6{,}872}$$

As long as the repair cost at the end of year 3 does not exceed \$6,872 (which represents a 37.44% increase over the estimated cost of \$5,000), the IRR of the purchase will be ≥ 10%.

11-16 Let x = amount of rebate. Then the purchase price with 2.9% financing is \$30,000 and the purchase price with the 8.9% financing is \$30,000 – x. We want to find the value of x such that the monthly payment is the same. Using Excel we can easily find the monthly payment of the 2.9% plan: PMT(0.029/12, 48, −30,000) = \$662.70. Then

$$30{,}000 - x = \text{PV}(0.089/12, 48, -662.70) = \$26{,}681.53$$

and x = \$3,318.47. If you are offered a rebate less than this amount then you should take the 2.9% financing offer.

11-17 1) Assume salvage value for each system = 0
2) The difference in user cost will be projected as a savings for system #2.
Savings = $0.02/vehicle
3) There are approximately 8,760 hours/year

System 1: AW method
CR = $32,000(A/P,10%,10) = $5,206.40
Annual Maintenance = $75

$$\text{Operation Cost} = \frac{(28\text{ kW})(8{,}760\text{ hr/yr})(\$0.08/\text{kWh})}{0.78} = \$25{,}157 \text{ per year}$$

$AC_{\#1}$ = $5,206.40 + $75 + $25,157 = $30,438.40

System #2:
CR = $45,000(A/P,10%,15) = $5,917.50
Annual Maintenance = $100

$$\text{Operation Cost} = \frac{(34\text{ kW})(8{,}760\text{ hr/yr})(\$0.08/\text{kWh})}{0.90} = \$26{,}475$$

Let N = # vehicles using intersection
Savings per vehicle = ($0.24 − $0.22) N = $0.02 N

$AC_{\#2}$ = $5,917.50 + $100 + $26,475 – 0.2N = $32,492.50 − $0.02N

For Breakeven point:
$30,438.40 = $32,492.50 − $0.02N and N = 102,705 cars per year

For ADT = Average Daily Traffic

$$N = \frac{102{,}705}{365} = 282 \text{ vehicles/day (rounded to next highest integer)}$$

11-18 Let X = annual Btu requirement (in 10^3 Btu)

AW_{oil} (10%) = −\$80,000(A/P,10%,20) + \$4,000 − (\$2.20/140)(X)
= −\$5,400 − \$0.0157X

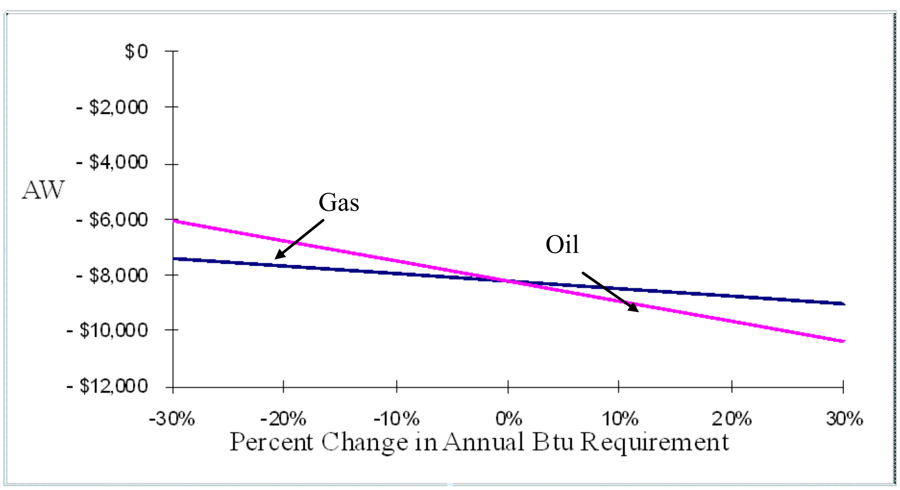
AW_{gas} (10%) = −\$60,000(A/P,10%,20) + \$6,000 − (\$0.04/1)(X)
= −\$1,050 − \$0.04X

To find breakeven value of X, set AW_{oil} (10%) = AW_{gas} (10%) and solve for X.

−\$5,400 − \$0.0157X = −\$1,050 − \$0.04X
X = 179,012 or 179,012,000 Btu per year

Now let's examine the sensitivity of the decision to changes in the annual Btu requirement. The following table and graph indicate that the conversion to natural gas is preferred if the annual Btu requirement is less than the breakeven point, else the conversion to oil is preferred.

	Annual Worth	
% change in X	Oil	Gas
−30	−\$7,430	−\$6,125
−20	−7,720	−6,850
−10	−8,010	−7,575
0	−8,300	−8,300
10	−8,590	−9,025
20	−8,880	−9,750
30	−9,170	−10,475



11-19 (a) AW(optimistic) = − \$90,000(A/P,10%,12) + \$35,000 + \$30,000(A/F,10%,12)
= \$23,192

AW(most likely) = −\$100,000(A/P,10%,10) + \$30,000 + \$20,000(A/F,10%,10)
= \$14,984

AW(pessimistic) = −\$120,000(A/P,10%,6) + \$20,000
= −\$7,552

(b)

		Net Annual Cash Flow		
		O	M	P
Useful Life	O	\$21,256	\$16,256	\$6,256
	M	19,984	14,984	4,984
	P	14,632	9,632	− 368

11-20 Build 4−lane bridge now:

PW(12%) = −$350,000

Build two−lane bridge now:

Optimistic: widen bridge to four lanes in 7 years

PW(12%) = −$200,000 − [$200,000 + (7)($25,000)](P/F,12%,7) = −$369,613

Most Likely: widen bridge to four lanes in 5 years

PW(12%) = −$200,000 − [$200,000 + (5)($25,000)](P/F,12%,5) = −$384,405

Pessimistic: widen bridge to four lanes in 4 years

PW(12%) = −$200,000 − [$200,000 + (4)($25,000)](P/F,12%,4) = −$390,650

Recommend building the 4−lane bridge now. In this problem, there is no difficulty in interpreting the results since building the 4−lane bridge now is preferred to a delay in widening the bridge for 7 years (optimistic estimate).

The advantage of pessimistic, most likely, and optimistic estimates is that the uncertainty involved is made explicit. Therefore, the information should be more useful in decision−making. However, when mixed results are obtained, significant judgement is required in reaching a decision. Mixed results would occur in this problem, for example, if the PW of a 7−year delay in widening the bridge were less than $350,000.

11-21 Let X = miles driven per year.

$EUAC_{Dart}$ = \$13,000(A/P, 10%, 5) + (X/100 mpg)(\$8/gal)

$EUAC_{Other}$ = \$10,000(A/P, 10%, 5) + (X/50 mpg)(\$8/gal)

Setting $EUAC_{Dart} = EUAC_{Other}$, we can solve for X = 9,892.5 miles per year. If you are planning on driving 10,000 miles or more per year, the Dart is the most economical vehicle.

11-22 (a) Alternative A:

EOY	BTCF	Depr	TI	T(40%)	ATCF
0	- $108,000,000	---	---	---	- $108,000,000
1	- 3,460,000	$5,400,000	- $8,860,000	$3,544,000	84,000
2	- 3,460,000	10,260,000	- 13,720,000	5,488,000	2,028,000
3	- 3,460,000	9,234,000	- 12,694,000	5,077,600	1,617,600
4	- 3,460,000	8,316,000	- 11,776,000	4,710,400	1,250,400
5	- 3,460,000	7,484,400	- 10,944,400	4,377,760	917,760
6	- 3,460,000	6,728,400	- 10,188,400	4,075,360	615,360
7	- 3,460,000	6,372,000	- 9,832,000	3,932,800	472,800
8	- 3,460,000	6,372,000	- 9,832,000	3,932,800	472,800
9	- 3,460,000	6,382,800	- 9,842,800	3,937,120	477,120
10	- 3,460,000	6,372,000	- 9,832,000	3,932,800	472,800
11	- 3,460,000	6,382,800	- 9,842,800	3,937,120	477,120
12	- 3,460,000	6,372,000	- 9,832,000	3,932,800	472,800
13	- 3,460,000	6,382,800	- 9,842,800	3,937,120	477,120
14	- 3,460,000	6,372,000	- 9,832,000	3,932,800	472,800
15	- 3,460,000	6,382,800	- 9,842,800	3,937,120	477,120
16	- 3,460,000	3,186,000	- 6,646,000	2,658,400	- 801,600
17	- 3,460,000	0	- 3,460,000	1,384,000	- 2,076,000
18	- 3,460,000	0	- 3,460,000	1,384,000	- 2,076,000
19	- 3,460,000	0	- 3,460,000	1,384,000	- 2,076,000
20	- 3,460,000	0	- 3,460,000	1,384,000	- 2,076,000
20	43,200,000	---	43,200,000	- 17,280,000	25,920,000

$$PW(10\%) = \sum_{k=0}^{20} ATCF_k\,(P/F,10\%,k) = -\$99,472,154$$

11-22 (a) ***continued***

<u>Alternative B</u>: Compute ATCFs for current estimate of capital investment.

Using the ATCFs shown in the following table:

$$PW(10\%) = \sum_{k=0}^{20} ATCF_k\,(P/F,10\%,k) = -\$79{,}065{,}532$$

ATCFs for Alternative B given original capital investment amount:

EOY	BTCF	Depr	TI	T(40%)	ATCF
0	- $17,000,000	---	---	---	- $17,000,000
1	- 12,400,000	$ 850,000	- $13,250,000	$5,300,000	- 7,100,000
2	- 12,400,000	1,615,000	- 14,015,000	5,606,000	- 6,794,000
3	- 12,400,000	1,453,500	- 13,853,500	5,541,400	- 6,858,600
4	- 12,400,000	1,309,000	- 13,709,000	5,483,600	- 6,916,400
5	- 15,400,000	1,178,100	- 16,578,100	6,631,240	- 8,768,760
6	- 12,400,000	1,059,100	- 13,459,100	5,383,640	- 7,016,360
7	- 12,400,000	1,003,000	- 13,403,000	5,361,200	- 7,038,800
8	- 12,400,000	1,003,000	- 13,403,000	5,361,200	- 7,038,800
9	- 12,400,000	1,004,700	- 13,404,700	5,361,880	- 7,038,120
10	- 15,400,000	1,003,000	- 16,403,000	6,561,200	- 8,838,800
11	- 12,400,000	1,004,700	- 13,404,700	5,361,880	- 7,038,120
12	- 12,400,000	1,003,000	- 13,403,000	5,361,200	- 7,038,800
13	- 12,400,000	1,004,700	- 13,404,700	5,361,880	- 7,038,120
14	- 12,400,000	1,003,000	- 13,403,000	5,361,200	- 7,038,800
15	- 15,400,000	1,004,700	- 16,404,700	6,561,880	- 8,838,120
16	- 12,400,000	501,500	- 12,901,500	5,160,600	- 7,239,400
17	- 12,400,000	0	- 12,400,000	4,960,000	- 7,440,000
18	- 12,400,000	0	- 12,400,000	4,960,000	- 7,440,000
19	- 12,400,000	0	- 12,400,000	4,960,000	- 7,440,000
20	- 12,400,000	0	- 12,400,000	4,960,000	- 7,440,000
20	0	---	0	0	0

11-22 (a) ***continued***

Alternative B (revised to include extra investment permissible to breakeven)

EOY	BTCF	Depr	TI	T(40%)	ATCF
0	- $42,731,490	---	---	---	- $42,731,490
1	- 12,400,000	$2,136,574	- $14,536,574	$5,814,630	- 6,585,370
2	- 12,400,000	4,059,492	- 16,459,492	6,583,797	- 5,816,203
3	- 12,400,000	3,653,542	- 16,053,542	6,421,417	- 5,978,583
4	- 12,400,000	3,290,325	- 15,690,325	6,276,130	- 6,123,870
5	- 15,400,000	2,961,292	- 18,361,292	7,344,517	- 8,055,483
6	- 12,400,000	2,662,172	- 15,062,172	6,024,869	- 6,375,131
7	- 12,400,000	2,521,158	- 14,921,158	5,968,463	- 6,431,537
8	- 12,400,000	2,521,158	- 14,921,158	5,968,463	- 6,431,537
9	- 12,400,000	2,525,431	- 14,925,431	5,970,172	- 6,429,828
10	- 15,400,000	2,521,158	- 17,921,158	7,168,463	- 8,231,537
11	- 12,400,000	2,525,431	- 14,925,431	5,970,172	- 6,429,828
12	- 12,400,000	2,521,158	- 14,921,158	5,968,463	- 6,431,537
13	- 12,400,000	2,525,431	- 14,925,431	5,970,172	- 6,429,828
14	- 12,400,000	2,521,158	- 14,921,158	5,968,463	- 6,431,537
15	- 15,400,000	2,525,431	- 17,925,431	7,170,172	- 8,229,828
16	- 12,400,000	1,260,579	- 13,660,579	5,464,232	- 6,935,768
17	- 12,400,000	0	- 12,400,000	4,960,000	- 7,440,000
18	- 12,400,000	0	- 12,400,000	4,960,000	- 7,440,000
19	- 12,400,000	0	- 12,400,000	4,960,000	- 7,440,000
20	- 12,400,000	0	- 12,400,000	4,960,000	- 7,440,000
20	0	---	0	0	0

The above solution for Alternative B is the result of a trial and error procedure for obtaining identical present worths of ATCFs.

Extra Capital = $42,731,490 − $17,000,000 = $25,731,490

This solution takes into account depreciation credits arising from the extra capital that can be invested in Alternative B to breakeven with Alternative A.

11-22 (b) Coterminate both alternatives at the end of year 10.

Alternative A:

EOY	BTCF	Depr	TI	T(40%)	ATCF
0	- $108,000,000	---	---	---	- $108,000,000
1	- 3,460,000	$5,400,000	- $8,860,000	$3,544,000	84,000
2	- 3,460,000	10,260,000	- 13,720,000	5,488,000	2,028,000
3	- 3,460,000	9,234,000	- 12,694,000	5,077,600	1,617,600
4	- 3,460,000	8,316,000	- 11,776,000	4,710,400	1,250,400
5	- 3,460,000	7,484,400	- 10,944,400	4,377,760	917,760
6	- 3,460,000	6,728,400	- 10,188,400	4,075,360	615,360
7	- 3,460,000	6,372,000	- 9,832,000	3,932,800	472,800
8	- 3,460,000	6,372,000	- 9,832,000	3,932,800	472,800
9	- 3,460,000	6,382,800	- 9,842,800	3,937,120	477,120
10	- 3,460,000	3,186,000	- 6,646,000	2,658,400	- 801,600
10	43,200,000	---	4,935,600	- 1,974,240	41,225,760

*MV_{10} = \$43,200,000; BV_{10} = \$38,264,400

$$PW(10\%) = \sum_{k=0}^{10} ATCF_k\,(P/F,10\%,k) = -\$87,010,230$$

Alternative B:

EOY	BTCF	Depr	TI	T(40%)	ATCF
0	- $17,000,000	---	---	---	- $17,000,000
1	- 12,400,000	$850,000	- $13,250,000	$5,300,000	- 7,100,000
2	- 12,400,000	1,615,000	- 14,015,000	5,606,000	- 6,794,000
3	- 12,400,000	1,453,500	- 13,853,500	5,541,400	- 6,858,600
4	- 12,400,000	1,309,000	- 13,709,000	5,483,600	- 6,916,400
5	- 15,400,000	1,178,100	- 16,578,100	6,631,240	- 8,768,760
6	- 12,400,000	1,059,100	- 13,459,100	5,383,640	- 7,016,360
7	- 12,400,000	1,003,000	- 13,403,000	5,361,200	- 7,038,800
8	- 12,400,000	1,003,000	- 13,403,000	5,361,200	- 7,038,800
9	- 12,400,000	1,004,700	- 13,404,700	5,361,880	- 7,038,120
10	- 15,400,000	501,500	- 15,901,500	6,360,600	- 9,039,400
10	0	---	- 6,023,100	2,409,240	2,409,240

*MV_{10} = 0; BV_{10} = \$6,023,100

$$PW(10\%) = \sum_{k=0}^{10} ATCF_k\,(P/F,10\%,k) = -\$60,788,379$$

11-22 (b) ***continued***

If the study period is reduced to 10 years, Alternative B would still be recommended.

Sensitivity of Alternative B to cotermination at EOY 10:

$$\left(\frac{-\$79{,}065{,}532+\$60{,}788{,}379}{-\$79{,}065{,}532}\right)\times 100\% = \text{ 23.1\% less expensive.}$$

(c) If our annual operating expenses of Alternative B double, the extra present worth of cost in part (a) equals:

$$(-\$2.1 \text{ million})(1 - 0.4) \bullet (P/A, 10\%, 20) = -\$10{,}727{,}090.$$

This makes the total present worth of Alternative B equal to:

$$-\$79{,}065{,}532 - \$10{,}727{,}090 = -\$89{,}792{,}622.$$

Because −$89,792,622 > −$99,472,154, the initial decision to adopt Alternative B is not reversed.

EOY	BTCF	Depr	TI	T (40%)	ATCF
0	- $17,000,000	---	---	---	- $17,000,000
1	- 14,500,000	$ 850,000	- $15,350,000	$6,140,000	- 8,360,000
2	- 14,500,000	1,615,000	- 16,115,000	6,446,000	- 8,054,000
3	- 14,500,000	1,453,500	- 15,953,500	6,381,400	- 8,118,600
4	- 14,500,000	1,309,000	- 15,809,000	6,323,600	- 8,176,400
5	- 17,500,000	1,178,100	- 18,678,100	7,471,240	- 10,028,760
6	- 14,500,000	1,059,100	- 15,559,100	6,223,640	- 8,276,360
7	- 14,500,000	1,003,000	- 15,503,000	6,201,200	- 8,298,800
8	- 14,500,000	1,003,000	- 15,503,000	6,201,200	- 8,298,800
9	- 14,500,000	1,004,700	- 15,504,700	6,201,880	- 8,298,120
10	- 17,500,000	1,003,000	- 18,503,000	7,401,200	- 10,098,800
11	- 14,500,000	1,004,700	- 15,504,700	6,201,880	- 8,298,120
12	- 14,500,000	1,003,000	- 15,503,000	6,201,200	- 8,298,800
13	- 14,500,000	1,004,700	- 15,504,700	6,201,880	- 8,298,120
14	- 14,500,000	1,003,000	- 15,503,000	6,201,200	- 8,298,800
15	- 17,500,000	1,004,700	- 18,504,700	7,401,880	- 10,098,120
16	- 14,500,000	501,500	- 15,001,500	6,000,600	- 8,499,400
17	- 14,500,000	0	- 14,500,000	5,800,000	- 8,700,000
18	- 14,500,000	0	- 14,500,000	5,800,000	- 8,700,000
19	- 14,500,000	0	- 14,500,000	5,800,000	- 8,700,000
20	- 14,500,000	0	- 14,500,000	5,800,000	- 8,700,000
20	0	---	0	0	0

Solutions to Spreadsheet Exercises

11-23 Left as an individual exercise. See F11-6.xls.

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11-24 See P11-24.xls

Single Factor Change:					Fuel Economy of Gas Engine (mpg)			
					24	25	26	27
Extra Cost		$1,200		12%	$287.41	$262.60	$239.69	$218.49
$ / gal		$3.00	MARR	13%	$279.12	$254.31	$231.41	$210.20
Miles/yr		20,000		14%	$270.76	$245.95	$223.05	$201.84
				15%	$262.32	$237.51	$214.61	$193.40
Fuel Economy (mpg):								
Gas engine		25						
% Improvement		33%						
Diesel engine		33.25						
MARR		14%						
AW(fuel savings)	$	595.49						
Net AW	$	245.95						

11-25 See P11-25.xls.

MARR	20%	Useful Life	20
Installation Expense ($/in.)	150	Operating Hours per Year	8,760
Annual Tax and Insurance Rate	5%	Cost of Heat Loss ($/Btu)	0.00004

Insulation Thickness (in.)	Heat Loss (Btu/hr)	Installation Expense	Annual Taxes and Insurance	Cost of Heat Removal ($/yr.)	Equiv. Uniform Annual Cost
3	4,400	450	22.5	1541.76	$1,656.67
4	3,400	600	30.0	1191.36	$1,344.57
5	2,800	750	37.5	981.12	$1,172.64
6	2,400	900	45.0	840.96	$1,070.78
7	2,000	1050	52.5	700.80	$968.92
8	1,800	1200	60.0	630.72	$937.15

Change in Cost of Heat Loss	Equivalent Uniform Annual Cost					
	3	4	5	6	7	8
-50%	$885.79	$748.89	$682.08	$650.30	$618.52	$621.79
-40%	$1,039.97	$868.03	$780.19	$734.40	$688.60	$684.86
-30%	$1,194.14	$987.17	$878.30	$818.49	$758.68	$747.93
-20%	$1,348.32	$1,106.30	$976.41	$902.59	$828.76	$811.00
-10%	$1,502.49	$1,225.44	$1,074.53	$986.68	$898.84	$874.08
0%	$1,656.67	$1,344.57	$1,172.64	$1,070.78	$968.92	$937.15
10%	$1,810.85	$1,463.71	$1,270.75	$1,154.88	$1,039.00	$1,000.22
20%	$1,965.02	$1,582.85	$1,368.86	$1,238.97	$1,109.08	$1,063.29
30%	$2,119.20	$1,701.98	$1,466.97	$1,323.07	$1,179.16	$1,126.36
40%	$2,273.37	$1,821.12	$1,565.09	$1,407.16	$1,249.24	$1,189.44
50%	$2,427.55	$1,940.25	$1,663.20	$1,491.26	$1,319.32	$1,252.51

11-25 *continued*

MARR	20%		Useful Life	20
Installation Expense ($/in.)	$ 150		Operating Hours per Yr.	8,760
Annual Tax and Insurance Rate	5%		Cost of Heat Loss ($/Btu)	$ 0.00002

Insulation Thickness (in.)	Heat Loss (Btu/hr)	Installation Expense	Annual Taxes and Insurance	Cost of Heat Removal ($/yr)	Equivalent Annual Worth
3	4,400	$ (450)	$ (22.50)	$ (770.88)	$ (885.79)
4	3,400	$ (600)	$ (30.00)	$ (595.68)	$ (748.89)
5	2,800	$ (750)	$ (37.50)	$ (490.56)	$ (682.08)
6	2,400	$ (900)	$ (45.00)	$ (420.48)	$ (650.30)
7	2,000	$ (1,050)	$ (52.50)	$ (350.40)	$ (618.52)
8	1,800	$ (1,200)	$ (60.00)	$ (315.36)	$ (621.79)

	Equivalent Annual Worth					
	3	4	5	6	7	8
-50%	$ (500.35)	$ (451.05)	$ (436.80)	$ (440.06)	$ (443.32)	$ (464.11)
-40%	$ (577.44)	$ (510.62)	$ (485.85)	$ (482.11)	$ (478.36)	$ (495.64)
-30%	$ (654.53)	$ (570.19)	$ (534.91)	$ (524.16)	$ (513.40)	$ (527.18)
-20%	$ (731.61)	$ (629.76)	$ (583.97)	$ (566.20)	$ (548.44)	$ (558.72)
-10%	$ (808.70)	$ (689.33)	$ (633.02)	$ (608.25)	$ (583.48)	$ (590.25)
0%	$ (885.79)	$ (748.89)	$ (682.08)	$ (650.30)	$ (618.52)	$ (621.79)
10%	$ (962.88)	$ (808.46)	$ (731.13)	$ (692.35)	$ (653.56)	$ (653.32)
20%	$ (1,039.97)	$ (868.03)	$ (780.19)	$ (734.40)	$ (688.60)	$ (684.86)
30%	$ (1,117.05)	$ (927.60)	$ (829.25)	$ (776.44)	$ (723.64)	$ (716.40)
40%	$ (1,194.14)	$ (987.17)	$ (878.30)	$ (818.49)	$ (758.68)	$ (747.93)
50%	$ (1,271.23)	$ (1,046.73)	$ (927.36)	$ (860.54)	$ (793.72)	$ (779.47)

11-26 See P11-26.xls.

	O	ML	P
Capital Investment	$90,000	$100,000	$120,000
Useful Life (years)	12	10	6
Market Value	$30,000	$20,000	$0
Net annual cash flow	$35,000	$30,000	$20,000
MARR	11%	11%	11%
Annual Worth	$22,458	$14,216	-$8,365

		Net Annual Cash Flow		
		O	ML	P
Useful Life		$35,000	$30,000	$20,000
O	12	$20,478	$15,478	$5,478
ML	10	$19,216	$14,216	$4,216
P	6	$13,890	$8,890	($1,110)

11-27 See P11-27.xls.

Most Likely Estimates:	
Investment	$10,000,000
Market Value	$5,000,000
Annual Savings	$2,800,000
MARR	15%
Present Worth	$852,706

% Change	Inv.	MV	Ann. Sav.
-40%	$4,852,706	($290,801)	($2,344,870)
-30%	$3,852,706	($4,924)	($1,545,476)
-20%	$2,852,706	$280,952	($746,082)
-10%	$1,852,706	$566,829	$53,312
0%	$852,706	$852,706	$852,706
10%	($147,294)	$1,138,582	$1,652,100
20%	($1,147,294)	$1,424,459	$2,451,494
30%	($2,147,294)	$1,710,336	$3,250,887
40%	($3,147,294)	$1,996,212	$4,050,281

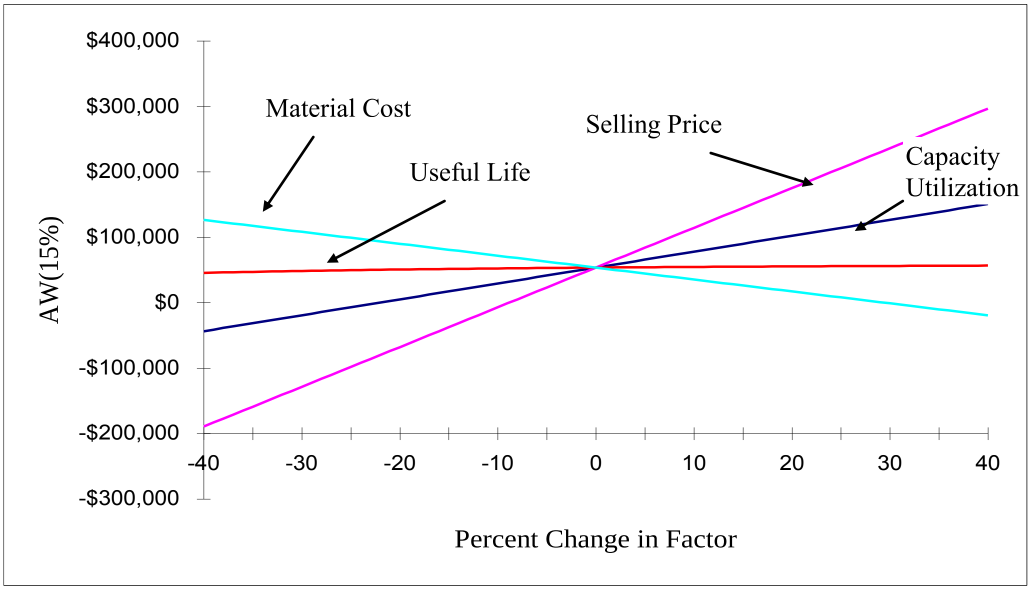
Breakeven Points:

Investment	**$10,852,706**
Market Value	$5,000,000
Annual Savings	$2,800,000
MARR	15%
Present Worth	$0.00

Investment	$10,000,000
Market Value	**$3,508,613**
Annual Savings	$2,800,000
MARR	15%
Present Worth	$0

Investment	$10,000,000
Market Value	$5,000,000
Annual Savings	**$2,501,327**
MARR	15%
Present Worth	$0

11-28 The following sensitivity graph was created using the results from the case study:



Raw Material Costs: Assume, because of competition, that only 50% of any material cost increase (above $27/yd^3) can be recovered through an increase in the selling price ($45/yd^3). The resulting AW(15%) values with 10, 20, and 30% material cost increases are:

	Percent Increase in Material Cost (M)		
	10	20	30
AW(15%)	$35,397	$17,172	− $1,053

11-29 The three most sensitive factors are: capacity utilization (U), selling price (S), and material costs (M). Two approaches are used in this solution. The <u>first</u> involves a modified O − ML − P approach to develop scenarios. The <u>second</u> uses selected changes in the three factors, in combination, for the development of scenarios.

<u>Modified O − ML − P scenarios</u>

Factor	Estimated Value		
	O*	ML*	P
Selling Price (S)	$45	$45	$40.50 (−10%)
Capacity Utilization (U)	90%	75%	50%
Material Costs (M)	$27	$27	$35.10 (+30%)

* For S and M the optimistic and most likely estimates are the same. The three factors have $2 \times 2 \times 3 = 12$ combinations or scenarios.

$$\begin{aligned} \text{AW}(15\%) = {} & \$72(250)(\text{U})\left(\text{S} + \frac{\text{M} - 27}{2}\right) && \text{Annual Revenue} \\ & - \$72(250)(\text{U})(\text{M}) && \text{Material costs} \\ & - \$9{,}143(1 + \text{U}) && \text{O\&M expenses} \\ & - \$182{,}521 && \text{Other expenses} \\ = {} & \$18{,}000(\text{U})\left[\left(\text{S} + \frac{\text{M} - 27}{2}\right) - \text{M}\right] - \$9{,}143(\text{U}) - \$182{,}521 \end{aligned}$$

* Assumes that 50% of any material cost increase above $\$27/\text{yd}^3$ can be recovered through an <u>increase</u> in the selling price ($\$45/\text{yd}^3$ or $\$40.50/\text{yd}^3$).

Capacity Utilization (U)	Selling Price (S): O, ML: $45		Selling Price (S): P: $40.50	
	Material Cost (M): O, ML: $27	P: $35.10	O, ML: $27	P: $35.10
O: 90%	$101*	$35	$28	− $38
ML: 75%	54	− 1	− 7	− 62
P: 50%	− 25	− 62	− 66	− 102

* AW(15%) of scenario (in thousands) based on calculation above.

This modified O − ML − P analysis highlights the importance of U > 75% and material costs (M) remaining close to $\$27/\text{yd}^3$. The project results are sensitive to combinations of changes in these factors.

<u>Other Selected Scenarios</u>

Factor	Percent Deviation for Combination:		
	A	B	C
Capacity Utilization	−10%	−15%	−25%
Material Cost	+10%	+10%	+ 5%
Selling Price	0%	+ 3%	0%
AW(15%)	−$2,800	$2,850	−$18,940

These additional scenarios further emphasize the sensitivity of the project to the combined effect of modest changes in the three factors.

Solutions to FE Practice Problems

11-30 Existing Bridge:

$$PW_E(12\%) = -\$1,6000,000 - \$20,000(P/A,12\%,20) - \$70,000[(P/F,12\%,5) + (P/F,12\%,10) + (P/F,12\%,15)] = -\$1,824,435$$

New Bridge:

$$PW_N(12\%) = -X - [\$24,000 + (5)(\$10,000)](P/A,12\%,20) + (\$0.25)(4000,000)(P/A,12\%,20)$$
$$= -X + \$194,204$$

Set PWE(12%) = PWN(12%) and solve for X.

$$-\$1,824,435 = -X + \$194,204$$
$$X = \$2,018,639$$

Select (b)

11-31 X = average number of vehicles per day

$$AW(12\%) = 0 = -\$117{,}000/\text{mile}(A/P,12\%,25) - \frac{(0.03)(\$117{,}000)}{mile}$$

$$+ (X \text{ vehicles/day})(365 \text{ days/yr})(\$1{,}200/\text{accident})\left(\frac{1{,}250-710 accidents}{1{,}000{,}000 vehicle-miles}\right)$$

X = 77.91 vehicles/day

<u>Select (a)</u>

11-32 $AW(12\%) = -\$8{,}000(A/P,12\%,7) + X(\$0.50 - \$0.26) - \$2{,}000 = 0$

$X = 15{,}637$

Select (e)

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11-33 $AW(12\%) = -\$16,000(A/P.12\%,7) + X(\$0.50 - \$0.16) - \$4,000 = 0$

$X = 22,076$

Select (c)

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11-34 $AW_A(12\%) - \$8,000(A/P,12\%,7) + 35,000(\$0.50 - \$0.26) - \$2,000 = \$4,647$

$AW_B(12\%) = -\$16,000(A/F,12\%,7) + 35,000(\$0.50 - \$0.16) - \$4,000 = \$4,394$

<u>Select (b)</u> – Install Machine A

11-35 False

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11-36 False

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11-37 False

11-38 True

11-39 False

Solutions to Chapter 12 Problems

12-1 $\text{EUAC}_{\text{nothing}} = (0.01)(\$1{,}000{,}000) = \$10{,}000$

$$\text{EUAC}_{\text{culvert}} = \left(\$50{,}000 + \frac{\$2{,}000\left[1-(\text{P/F}, 7\%, 20)(\text{F/P}, 5\%, 20)\right]}{0.07-0.05}\right)(\text{A/P}, 7\%, 20) = \$7{,}688$$

The EUAC of building the culvert is less than the EUAC of a mudslide (with no culvert). Building the culvert is economical.

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12-2 Build the 4−lane bridge now:

PW = −$3,500,000

Build 2−lane bridge now, add two lanes later:

Year of Expansion k	PW of Expansion Expenses
3	− [$2,000,000 + (3)($250,000)](P/F,12%,3) = −$1,957,450
4	− [$2,000,000 + (4)($250,000)](P/F,12%,4) = −$1,906,500
5	− [$2,000,000 + (5)($250,000)](P/F,12%,5) = −$1,844,050
6	− [$2,000,000 + (6)($250,000)](P/F,12%,6) = −$1,773,100

E(PW) = − $2,000,000 − $1,957,450(0.1) − $1,906,500(0.2) − $1,844,050(0.3)
− $1,773,100(0.4)
= −$3,839,500

Decision: The four−lane bridge should be built now.

12-3 Set E(PW) of the difference between the two alternatives equal to zero and use a trial and error procedure to solve for the interest rate.

$$E(PW)_{\Delta} = 0 = -\$3{,}500{,}000 + \$2{,}000{,}000$$

$$+ \sum_{N=3}^{6} \left[\$2{,}000{,}000 + \$250{,}000(N)\right](P/F, i_{\Delta}', N)\ Pr(N)$$

I	$E(PW)_{\Delta}$
12%	\$339,500
15	113,875
18	−78,368

An interest rate of i = 15% <u>will not</u> reverse the initial decision to build the four−lane bridge now. The two−lane bridge would be preferred for interest rates greater than:

$$i = 0.15 + 0.03\left(\frac{113{,}875}{192{,}243}\right) = 0.1678 \text{ or } 16.78\%.$$

Engineering Economy, Fourteenth Edition, by Sullivan, Wicks, and Koelling. ISBN 0-13-614297-4.

12-4 **(a)** 260,000 ft^3 per day × \$8 per thousand ft^3 = \$2,080 per day (revenue)
Profit per year = (365 days/yr)(\$2,080 / day)(0.9) = \$683,280
E(PW) = \$683,280(P/A, 15%, 10) − \$250,000 = \$92,925 ≥ 0, a good investment.

(b) E(PW) = \$683,289(P/A, 15%, 7)(0.1) − \$250,000 = \$34,272 (still okay)

(c) Left to instructor.

12-5 $E(X) = 0(0.5) + 1(0.45) + 2(0.30) + 3(0.30) = 1.65$

$E(S) = 5(0.40) + 6(0.20) + 8(0.40) = 6.4$

$E(P) = E(X) \cdot E(S) = (1.65) \cdot (6.4) = \underline{10.56}$

$V(X) = (0)^2(0.05) + (1)^2(0.45) + (2)^2(0.3) – (1.65)^2$

$V(X) = 0.7275$

$V(S) = 25(0.40) + 36(0.20) + 64(0.40) – (6.4)^2 = 1.84$

$V(X \cdot S) = (E(x))^2V(S) + (E(S)^2)V(X) + V(X)\cdot V(S)$

$V(X \cdot S) = (1.65)^2 1.84 + (6.4)^2(0.7275) + (0.7275)(1.84)$

$V(X \cdot S) = V(P) = \underline{36.146}$

$\sigma_p = 6.012$

12-6

Hurricane Category	Annual Cost of Financing the Rebuild (A)	Expected Annual Property Damage (B)	Expected Total Annual Cost (A) + (B)
5	$5,082,000	$ 500,000	$ 5,582,000
4	$3,630,000	$ 1,000,000	$ 4,630,000
3	$2,541,000	$ 3,000,000	$ 5,541,000
2	$1,452,000	$ 5,000,000	$ 6,452,000
1	$ 726,000	$10,000,000	$10,726,000

(A) = Capital Investment × (A/P, 6%, 30)
(B) = $100,000,000 × Probablility of storm exceeding levee height

Therefore, protect the city from a category 4 hurricane.

12-7 Expected equivalent annual costs <u>given</u> that one main power failure occurs and the backup generator is needed:

Alternative	Capital Recovery Amount*	Annual O&M Expenses	Annual Cost of Backup Failure	Total Annual Cost
R	−$30,032	−$5,000	−($400,000)(0.04) = −$16,000	−$51,03
S	−26,092	−7,000	−($400,000)(0.05) = −20,000	−53,092
T	−32,435	−4,000	−($400,000)(0.02) = −8,000	−44,435

*From Chapter 5, CR(10%) = −(Capital Invest.)(A/P,10%,10) + (MV)(A/F,10%,10)

To minimize total annual cost, recommend <u>Alternative T</u>.

If two main power failures occur per year, the expected equivalent costs become:

<u>Alternative R</u>

Pr{0 failures} = (0.96)(0.96) = 0.9216
Pr{1 failure } = 2(0.96)(0.04) = 0.0768
Pr{2 failures} = (0.04)(0.04) = <u>0.0016</u>
1.0000

Annual cost of Backup Failure = −$400,000(0.0768) + 2(−$400,000)(0.0016)
= −$32,000

<u>Alternative S</u>

Pr{0 failures} = (0.95)(0.95) = 0.9025
Pr{1 failure } = 2(0.95)(0.05) = 0.0950
Pr{2 failures} = (0.05)(0.05) = <u>0.0025</u>
1.0000

Annual cost of Backup Failure = −$400,000(0.0950) + 2(−$400,000)(0.0025)
= −$40,000

<u>Alternative T</u>

Pr{0 failures} = (0.98)(0.98) = 0.9604
Pr{1 failure } = 2(0.98)(0.02) = 0.0392
Pr{2 failures} = (0.02)(0.02) = <u>0.0004</u>
1.0000

Annual cost of Backup Failure = −$400,000(0.0392) + 2(−$400,000)(0.0004)
= −$16,000

12-7 ***continued***

Alternative	Capital Recovery Amount*	Annual O&M Expenses	Annual Cost of Backup Failure *	Total Annual Cost
R	−$30,032	−$5,000	−$32,000	−$67,032
S	−26,092	−7,000	− 40,000	−73,092
T	−32,435	−4,000	−16,000	−52,435

* Note for each alternative, the annual cost of "failure" given 2 occurences per year is twice the cost given 1 occurrence per year. A logical result.

Again, Alternative T is selected. This answer should be obvious since Alternative T is the most reliable alternative.

12-8

Skiing Days	Annual Revenues	Annual Expenses	Net Annual Receipts (NAR)
80	(500)(80)($10) = $400,000	−$1,500(80) = −$120,000	$280,000
100	$400,000 + (400)(20)($10) = $480,000	−$1,500(100) = −$150,000	$330,000
120	$480,000 + (300)(20)($10) = $540,000	−$1,500(120) = −$180,000	$360,000

E(NAR) = $280,000 (0.60) + $330,000 (0.3) + $360,000 (0.10) = $303,000

i = 25% /yr.; N = 5 yr.; Project cost = $900,000

E(PW) = −$900,000 + $303,000 (P/A, 25%, 5) = −$<u>85,142</u> < 0

Do not build the lift.

12-9 Capital Investment = \$900,000; Annual O&M expenses = \$1,500 per day

Total Days Per Year	No. of People/Day First 80	Next 20	Next 20	Demand (X) Person−Days Per Year	p(X)
80	500	−	−	40,000	0.6
100	500	400	−	48,000	0.3
120	500	400	300	54,000	0.1

Annual Revenue (R) = \$10 (Person−Days/Year)

<u>80−Day Season (40,000 Person−Days)</u>

EOY	BTCF	Depr.	TI	T(40%)	ATCF
0	-\$900,000	---	---	---	-\$900,000
1	280,000	\$ 64,286	\$215,714	-\$86,286	193,714
2	280,000	128,571	151,429	-60,571	219,429
3	280,000	128,571	151,429	-60,571	219,429
4	280,000	128,571	151,429	-60,571	219,429
5	280,000	128,571	151,429	-60,571	219,429
6	280,000	128,571	151,429	-60,571	219,429
7	280,000	128,571	151,429	-60,571	219,429
8	280,000	64,286	215,714	-86,286	193,714

$PW_{80}(15\%)$ = −\$900,000+[\$193,714 + \$219,429 (P/A,15% 6)](P/F,15% 1)
+ \$193,714 (P/F,15%, 8)
= \$53,920

<u>100−Day Season (48,000 Person−Days)</u>

EOY	BTCF	Depr.	TI	T(40%)	ATCF
0	-\$900,000	---	---	---	-\$900,000
1	330,000	\$ 64,286	\$265,714	-\$106,286	223,714
2	330,000	128,571	201,429	-80,571	249,429
3	330,000	128,571	201,429	-80,571	249,429
4	330,000	128,571	201,429	-80,571	249,429
5	330,000	128,571	201,429	-80,571	249,429
6	330,000	128,571	201,429	-80,571	249,429
7	330,000	128,571	201,429	-80,571	249,429
8	330,000	64,286	265,714	-106,286	223,714

$PW_{100}(15\%)$ = −\$900,000+[\$223,714 + \$249,429(P/A, 15%, 6)](P/F, 15%, 1)
+\$223,714 (P/F, 15%, 8)
= \$188,545

12-9 ***continued***

120−Day Season (54,000 Person−Days)

EOY	BTCF	Depr.	TI	T(40%)	ATCF
0	-$900,000	---	---	---	-$900,000
1	360,000	$ 64,286	$295,714	-$118,286	241,714
2	360,000	128,571	231,429	-92,571	267,429
3	360,000	128,571	231,429	-92,571	267,429
4	360,000	128,571	231,429	-92,571	267,429
5	360,000	128,571	231,429	-92,571	267,429
6	360,000	128,571	231,429	-92,571	267,429
7	360,000	128,571	231,429	-92,571	267,429
8	360,000	64,286	295,714	-118,286	241,714

$$\begin{aligned} PW_{120}(15\%) &= -\$900{,}000+[\$241{,}714 + \$267{,}429(P/A,15\%, 6)](P/F,15,\% \ 1) \\ &\quad +\$241{,}714(P/F,15\%, 8) \\ &= \$269{,}320 \end{aligned}$$

Days of Skiing (X)	p(X)	PW(ATCF)	E[PW(X)]	$[PW(X)]^2$	$p(X)[PW(X)]^2$
80	0.6	53,920	32,352	2,907,366,400	1,744,419,840
100	0.3	188,545	56,564	35,549,217,025	10,664,765,108
120	0.1	269,320	26,932	72,533,262,400	7,253,326,240
		E(PW) =	$115,848	$E[(PW)^2]$ =	19,662,511,188 $(\$)^2$

E(PW) $= \Sigma$ [p(X) PW(ATCF)] = $<u>115,848</u>

V(PW) $= \Sigma \{p(X)\,[PW(X)]^2\} - [E(PW)]^2 = 19{,}662{,}511{,}188 - (115{,}848)^2$

$= \underline{6{,}241{,}752{,}084}\ (\$)^2$

SD(PW) $= [V(PW)]^{1/2} = \$\underline{79{,}005}$

Recommend that the lift be installed since E(PW) = $115,848 > 0 and one SD ($79,005) is only 68% of E(PW).

12-10 <u>Depreciation</u>

$$\text{SL amount} = \frac{0.8(\$100{,}000)}{4} = \$20{,}000$$

ADS: $d_1 = d_5 = \$20{,}000/2 = \$10{,}000$
$d_2 = d_3 = d_4 = \$20{,}000$

<u>After−tax analysis</u>

Let ${}^{\$}A_{1,L}$ = cost savings in first year (before−taxes) for performance level L.

$$\begin{aligned} PW_{AT}(12\%) &= -\$100{,}000 + (0.4)(0.2)(\$100{,}000) \\ &\quad + (1-0.4)\frac{\$A_{1,L}[1-(P/F,12\%,5)(F/P,6\%,5)]}{0.12-0.06} \\ &\quad + 0.4(\$20{,}000)(P/A,12\%,3)(P/F,12\%,1) \\ &\quad + 0.4(\$10{,}000)[(P/F,12\%,1) + (P/F,12\%,5)] \\ &= -\$92{,}000 + 2.407({}^{\$}A_{1,L}) + \$17{,}157 + \$5{,}841 \\ &= 2.407({}^{\$}A_{1,L}) - \$69{,}002, \quad L = 1, 2, 3, 4 \end{aligned}$$

Performance Level (L)	p(L)	$PW_{AT}(12\%)$	$E(PW_{AT})$
1	0.15	− $14,854	− $2,227
2	0.25	15,243	3,811
3	0.35	37,387	13,085
4	0.25	74,937	18,734
			Total: $33,403

$E(PW_{AT})$ = <u>$33,403</u>; implement the project.

12-11 **(a)** PW(N) = −\$418,000 + \$148,000 (P/A, 15%, N)

N	PW(N)	p(N)	PW(N) • p(N)	In Millions $[PW(N)]^2$	In Millions $[PW(N)]^2 \cdot p(N)$
3	−\$80,086	0.1	−\$8,009	6,413.77	641.38
4	4,540	0.1	454	20.61	2.06
5	78,126	0.2	15,625	6,103.67	1,220.73
6	142,106	0.3	42,632	20,194.12	6,058.24
7	197,739	0.2	39,548	39,100.71	7,820.14
8	246,120	0.1	24,612	60,575.05	6,057.57
		E(PW) = \$114,862		$E[(PW)^2] = 21{,}800.06\times10^6(\$)^2$	

$V(PW) = 21{,}800.06\times10^6 - (114{,}862)^2 = \underline{8{,}606.78\times10^6}\ (\$)^2$

$SD(PW) = (8{,}606.78\times10^6)^{1/2} = \$\underline{92{,}773}$

(b) Pr{PW < 0} = 0.1 (From work table above)

Recommend purchase of equipment: E(PW) = \$114, 862 is favorable; SD(PW) = \$92,773 is less than the E(PW); and Pr{PW<0} = 0.1 is low.

12-12 (a)

j	EOY Net Cash Flow			PW(j)
	0	1	2	
1	−\$29,000	\$6,000	\$17,500	−\$10,551
2	−29,000	6,000	19,000	−9,417
3	−29,000	6,000	23,000	−6,392
4	−29,000	12,000	20,000	−3,443
5	−29,000	12,000	24,600	35
6	−29,000	12,000	28,000	2,606
7	−29,000	19,000	22,400	4,459
8	−29,000	19,000	27,500	8,315
9	−29,000	19,000	31,000	10,962

j	PW(j)	p(j)	PW(j) • p(j)	In Millions $[PW(j)]^2$	In Millions $[PW(j)]^2$ • p(j)
1	−\$10,551	0.02	−\$211	111.32	2.23
2	−9,417	0.04	−377	88.67	3.55
3	−6,392	0.14	−895	40.86	5.72
4	−3,443	0.12	−413	11.85	1.42
5	35	0.30	11	–	–
6	2,606	0.18	469	6.79	1.22
7	4,459	0.06	268	19.88	1.19
8	8,315	0.08	665	69.14	5.53
9	10,962	0.06	658	120.15	7.21
		E(PW) = \$175		$E[(PW)^2] = 28.07 \times 10^6$ (\$)^2	

V(PW) $= 28.07 \times 10^6 - (175)^2 = \underline{28.04} \times 10^6$ (\$)^2

SD(PW) = $(28.04 \times 10^6)^{1/2}$ = \$<u>5,295</u>

(b) Pr{PW > 0} = 0.30 + 0.18 +0.06 + 0.08 + 0.06 = <u>0.68</u>

12-13 (a) i_m = MARR = 15%; General inflation rate (f) = 4%
Increase rate for annual revenues = 6.48%

$$PW(N) = -\$100,000 + \frac{\$40,000[1-(P/F,15\%,N)(F/P,6.48\%,N)]}{0.15-0.0648}$$

N	PW(N)	p(N)	PW(N) • p(N)	In Millions $[PW(N)]^2$	$[PW(N)]^2$ • p(N)
1	−$65,218	0.03	−$1,957	$4,253.39	127.60
2	−33,012	0.10	−3,301	1,089.79	108.98
3	−3,192	0.30	−958	10.19	3.06
4	24,418	0.30	7,325	596.24	178.87
5	49,983	0.17	8,497	2,498.30	424.71
6	73,654	0.10	7,365	5,424.91	542.49
		E(PW)=$16,971		$E[(PW)^2] = 1,385.71 \times 10^6$ ($)^2	

$V(PW) = 1,385.71 \times 10^6 - (16,971)^2 = \underline{1,097.7 \times 10^6}$ ($)^2
$SD(PW) = (1,097.7 \times 10^6)^{1/2} = \$\underline{33,131}$

(b) Pr(PW > 0} = 0.30 + 0.17 + 0.10 = $\underline{0.57}$

(c) $i_r = \dfrac{0.15-0.04}{1.04} = 0.10577$ or 10.577%

$$E(AW)_{R\$} = \sum_{N=1}^{6} PW(N)(A/P,10.577\%,N)\,p(N) = \$\underline{1,866}$$

The project appears questionable. The E(PW) is positive but the SD(PW) is approximately two times the expected value. Also the Pr{PW > 0} = 0.57 is only somewhat attractive.

12-14 Notice that the probable extra capital investment for project B is a negative consideration to the selection of this project. But let's examine the expected value and variance of cash inflows for both projects to see if they might compensate for the higher capital investment for project B. The expected cash inflow for project A is $1,840 per year, while the expected cash inflow for project B is $1,670. The variance of project A is 86,400 $\$^2$ and the variance of project B is 1,374,100 $\$^2$, so project A has a greater expected value of cash inflows and smaller variance of cash inflows than project B. Project A appears to be the clear choice (it probably has a lower capital investment too). Note that in this problem, risk and reward do not travel in the same direction. As the risk (variance) of project B goes up, its reward (expected annual cash flow becomes lower.

12-15 From the normal probability tables (App. E):

$$1.28 = \frac{X - \mu}{\sigma} = \frac{30{,}000 - 25{,}000}{\sigma} = \frac{5{,}000}{\sigma}$$

so $\sigma - 3{,}906.25$ pounds per hour and the

variance = $\sigma^2 = 15.26 \text{ x } 10^6$ (lbs/hr)^2

12-16 Normally distributed random variable: E(X) = \$175, V(X) = 25 (\$)^2

$\Pr\{X \geq 171\} = ?$ $\qquad Z = \dfrac{X - \mu}{\sigma} = \dfrac{171 - 175}{\sqrt{25}} = -0.8$

$\Pr\{X \geq 171\} = \Pr\{Z \geq -0.8\} = 1 - \Pr\{Z \leq -0.8\} = 1 - 0.2119 = \underline{0.7881}$

12-17 **(a)**

k	$E(X_k)$	C_k	$E(F_k)$	(P/F,15%,k)	$PW[E(F_k)]$
0	−\$41,167	1	−\$41,167	1.0000	−\$41,167
1	− 2,208	2	− 4,416	0.8696	− 3,840
2	10,600	1	10,600	0.7561	8,015
3	6,067	4	24,268	0.6575	15,956
4	4,817	5	24,085	0.5718	13,772
5	17,333	1	17,333	0.4972	8,618

k	$V(X_k)$	$[C_k(P/F)]^2$	$V[PW(F_k)]$
0	1,361,111	1.0000	1,361,111
1	11,736	3.0248	35,499
2	71,111	0.5717	40,653
3	17,778	6.9169	122,969
4	6,944	18.1739	56,759
5	90,000	0.2472	22,249

$$E(PW) = \sum_{k=0}^{5} PW[E(F_k)] = \$\underline{1,354}$$

$$V(PW) = \sum_{k=0}^{5} V[PW(F_k)] = \underline{1,639,240\ (\$)^2}$$

(b) Assumption: The PW of the net cash flow is a normally distributed random variable with $\mu = E(PW)$ and $\sigma^2 = V(PW)$.

$$\Pr\{PW \geq 0\} = 1 - \Pr\{PW \leq 0\} = 1 - \Pr\left\{Z \leq \frac{0 - \$1,354}{\sqrt{1,639,240}}\right\}$$

$$= 1 - \Pr\{Z \leq -1.06\}$$

$$= 1 - 0.1446$$

$$= \underline{0.8554}$$

(c) Yes; if PW (at i = MARR) > 0 then the IRR > MARR. Therefore, it is correct to conclude that $\Pr\{IRR \geq MARR\} = \Pr\{PW \geq 0\}$.

12-18 Notice that these are cost alternatives.

$E[PW_A(15\%)] = -[13{,}000 + 5{,}000\,(P/A,15\%,8) - 2{,}000\,(P/F,15\%,8)] = -\$34{,}783$

$$V[PW_A(15\%)] = \frac{(500)^2(P/A,15\%,16)}{2.15} + (800)^2\,(P/F,15\%,16) = 770{,}746\ \$^2$$

$E[PW_B(15\%)] = -[7{,}500\,(P/A,15\%,8)] = -\$33{,}655$

$$V[PW_B(15\%)] = \frac{(750)^2(P/A,15\%,16)}{2.15} = 1{,}557{,}794\ \$^2$$

Now let $Y = PW_A - PW_B$ (i.e., $B \rightarrow A$) and find $\Pr(Y > 0)$.

$E(Y) = E(PW_A) - E(PW_B) = -1{,}128$

$V(Y) = V(PW_A) + V(PW_B) = 2{,}318{,}540$

$$\Pr(Y \geq 0) = \Pr\left(S \geq \frac{0-(-1{,}128)}{\sqrt{2{,}318{,}540}}\right)$$

$$= \Pr(S \geq 0.741) = \Pr(S \leq -0.741) \cong 0.23$$

12-19

EOY	E(B – A)	V (B + A)
0	−\$4,000	$(500)^2 = 250{,}000$
1	\$500	$(300)^2 + (600)^2 = 450{,}000$
2	−\$1,500	$(300)^2 + (600)^2 = 450{,}000$
3	\$500	$(300)^2 + (800)^2 = 730{,}000$
4	−\$1,500	$(300)^2 + (800)^2 = 730{,}000$

At i = 15%

E[PW(B – A)] = −4,000 + 500 (P/F,15%,1) – 1,500 (P/F,15%,2) + 500 (P/F,15%,3)
−1,500 (P/F,15%,4) = <u>−\$5,228</u>

V[PW(B − A)] = 250,000 + 450,00 (P/F,15%,2) + 450,000 (P/F,15%,4)
+ 730,000 (P/F,15%,6) + 730,000 (P/F,15%,8) = 1,401,791

$\sigma\,(PW_{A\rightarrow B})$ = \$<u>1,183.97</u>

12-20 (a)

Random Number	**Life** $[3 + \frac{RN}{100}(5-3)]$	**Nearest Whole Number**	**Investment −$120,000(A/P,15%.N)**	**Salvage SV(A/F,15%,N)**	**Equivalent AW**
13	3.26	3	−$52,560	5,184	−$47,376
51	4.02	4	−$42.036	2,404	−$39,632
35	3.7	4	−$42,036	2.404	−$39,632
90	4.8	5	−$35,796	890	−$34,906
					−$161,546
				μ =	−$40,387

(b) $$\text{Variance} = \frac{(-\$47{,}376-\mu)^2+(-\$39{,}632-\mu)^2+(-\$39{,}632-\mu)^2+(-\$34{,}906-\mu)^2}{3}$$

with $\mu = -\$40{,}387$

12-21 Monte Carlo Simulation for the Proposed Project

Random Normal Deviate RND	Investment 200,000 + RND * 10,000 P	Three Random Numbers RN	Project Life, N = 5+ RN/999(15−5) N	N to Nearest Integer N	One Random Number R	Annual Receiptss A	AW [(P−MV)(A/P,10%,N) + MV(10%)+A] AW
1.102	**211,020**	**131**	**6.311311**	**6**	**4**	**16,000**	**−34,450.192**
0.148	**201,480**	**513**	**10.13514**	**10**	**5**	**16,000**	**−187,80.796**
2.372	**223,720**	**350**	**8.503504**	**9**	**4**	**16,000**	**−24,837.792**
−0.145	**198,550**	**904**	**14.04905**	**14**	**7**	**16,000**	**−12,943.235**
0.104	**201,040**	**440**	**9.404404**	**9**	**9**	**22,000**	**−14,900.544**
1.419	**214,190**	**107**	**6.071071**	**6**	**4**	**16,000**	**−35,178.024**
0.069	**200,690**	**507**	**10.07508**	**10**	**5**	**16,000**	**−18,652.263**
0.797	**207,970**	**782**	**12.82783**	**13**	**6**	**16,000**	**−15,282.176**
−0.393	**196,070**	**258**	**7.582583**	**8**	**8**	**22,000**	**−16,743.518**
−0.874	**191,260**	**504**	**10.04505**	**10**	**3**	**16,000**	**−17,118.002**
						SUM	**−208,886.54**

The estimate of AW based on ten repititions of the experiment is <u>−$208,886.54</u>.

An estimate of the standard deviation of AW can be found by:

$$\sigma[AW] = \frac{\sqrt{\sum_{i=1}^{K}(AW_i - E[W])^2}}{\sqrt{K-1}}$$

σ = 7,992.784

Due to reasons of space only 10 of the simulation trials are presented here. It can be noticed that these estimates are within the range of the real value and will get even closer with more trials.

12-22 Although the present worth of Alternative 2 is higher than the present worth of Alternative 1, it may be wise to select Alternative 1 since the probability of present worth being greater than zero for Alternative 1 is greater and there is less variability in present worth for Alternative 1.

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12-23 PW for each success category

$$\text{PW(A)} = -\$280{,}000 + \$200{,}000\,\overset{P/A,15\%,6}{(\;3.7845\;)} = \$476{,}900$$
$$\text{PW(B)} = -\$280{,}000 + \$100{,}000\,(\;3.7845\;) = \$98{,}450$$
$$\text{PW(C)} = -\$280{,}000 + \$20{,}000\,(\;3.7845\;) = -\$204{,}310$$

E(PW) based on prior probabilities

$$\text{E(PW)} = 0.35(\$476{,}900) + 0.35(\$98{,}450) + 0.30(-\$204{,}310) = \$140{,}080$$

Joint and marginal probabilities

Success Category	Joint Probabilities		Marginal p(S)
	Good (G)	Quite Poor (P)	
A	0.3150	0.0350	0.35
B	0.0875	0.2625	0.35
C	0.0150	0.2850	0.30
Marginal Test Outcome	0.4175	0.5825	1.0

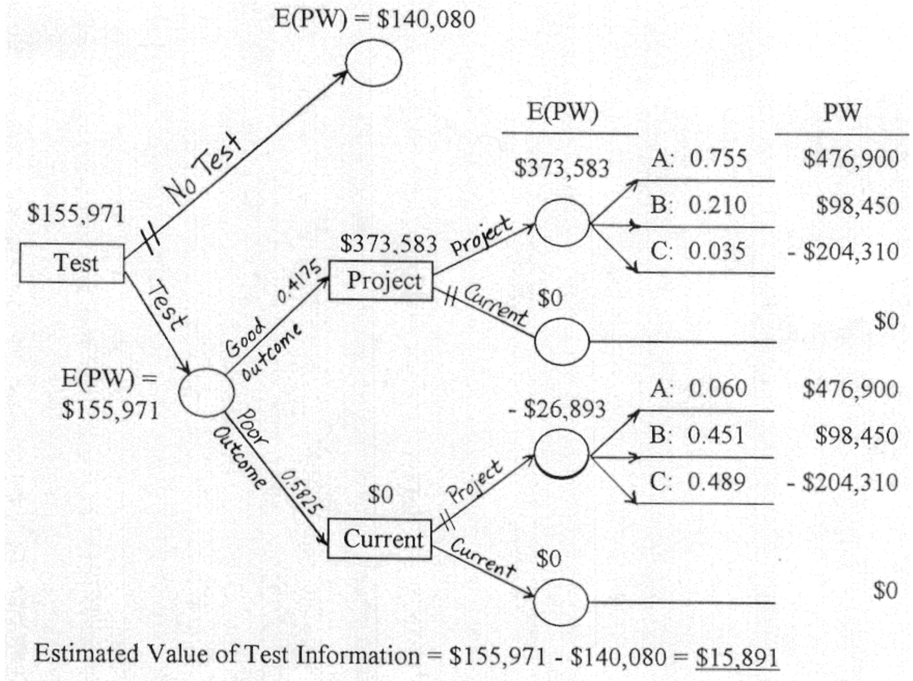
$p(A,G) = p(G/A) \cdot p(A) = 0.90(0.35) = 0.3150$
$p(A,P) = p(P/A) \cdot p(A) = 0.10(0.35) = 0.0350$
$p(B,G) = p(G/B) \cdot p(B) = 0.25(0.35) = 0.0875$
$p(B,P) = p(P/B) \cdot p(B) = 0.75(0.35) = 0.2625$
$p(C,G) = p(G/C) \cdot p(C) = 0.05(0.30) = 0.0150$
$p(C,P) = p(P/C) \cdot p(C) = 0.95(0.30) = 0.2850$

Revised probabilities

Given Test Outcome	Revised p(S)			sum
	A	B	C	
Good (G)	0.755	0.210	0.035	1.0
Quite Poor (P)	0.060	0.451	0.489	1.0

E(PW) = $140,080

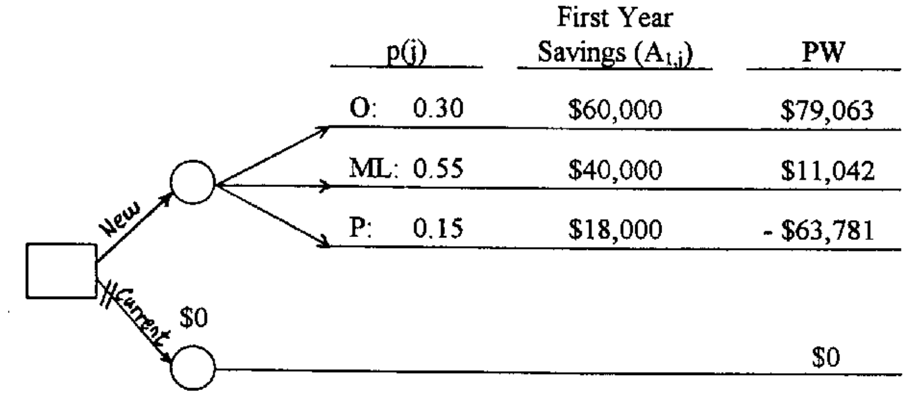
12-23 *continued*



12-24 E(PW) calculation

$$PW(18\%)_{A_{1,j}} = -\$125{,}000 + \frac{A_{1,j}[1-(P/F,18\%,5)(F/P,5\%,5)]}{0.18-0.05}; \; j = O, ML, P$$

$$= -\$125{,}000 + A_{1,j}(3.4010)$$



E(PW) = 0.30 ($79,063) + 0.55 ($11,042) - 0.15 ($63,781)

= $20,225; Yes, new design is preferred to the current design.

Performance Results (j)	Probability p(j)	Decision With Perfect Information		Prior Decision (New)
		Decision	Outcome	
Optimistic	0.30	New	$79,063	$79,063
Most Likely	0.55	New	11,042	11,042
Pessimistic	0.15	Current	0	− 63,781
		Expected Value:	$29,792	$20,225

EVPI = $29,792 − $20,225 = $9,567

The EVPI is the maximum amount that ought to be spent to obtain additional information prior to making a decision.

12-25 Given: MARR = 8% per year; Analysis Period = 8 years

$PW_{\text{New Product}} = -\$1{,}000{,}000(P/F, 8\%, 2)$
$+[0.6(\$200{,}000)+0.4(\$280{,}000)](P/A,8\%,6)\ (P/F,8\%,2)$
$= \$\underline{62{,}165}$

$PW_{\text{Do Nothing}} = \$0$; <u>Select New Product</u>

12-26 E[PW(15%)] = −300^k + 100^k (P/A,15%,N) + 20^k (P/F,15%,N)

$$V[PW(15\%)] = 0 + \frac{(7^k)^2 (P/A,15\%,2N)}{2.15} + (3^k)^2 (P/F,15\%,2N)$$

Pr (IRR ≥ 15%) ≥ 0.90 or Pr(PW ≥ 0 | i = 15%) ≥ 0.90

<u>Step 1</u>: Try N = 4 years, E[PW(15%)] = −300^k + 285.5^k + 11.4^k = −3.1^k

$$V[PW(15\%)] = \frac{(49x10^6)(P/A,15\%,8)}{2.15} + (9x10^6)\,(P/F,15\%,8)$$

$$= (102.27 \text{ x } 10^6) + (2.94 \text{ x } 10^6)$$
$$= 105.21 \text{ x } 10^6 \;\; ; \;\; (\sigma = \$10{,}257)$$

$$Pr\,(PW \geq 0 \mid i = 15\%) = Pr\left[S \geq \frac{0-(-3.1^k)}{10.257^k}\right]$$

$$= Pr\,(S \geq 0.30) \cong 0.38$$

<u>Step 2</u>: Try N = 5 years, E[PW(15%)] = −300 + 335,2 + 9.9 = 45.1^k

$$V[PW(15\%)] = \frac{(49x10^6)(P/A,15\%,10)}{2.15} + (9x10^6)\,(P/F,15\%,10)$$

$$= (114.38 \text{ x } 10^6) + (2.22 \text{ x } 10^6)$$
$$= 116.6 \text{ x } 10^6 \;\; ; \;\; (\sigma = \$10{,}798)$$

$$Pr\,(PW \geq 0 \mid i = 15\%) = Pr\left[S \geq \frac{0-(45.1^k)}{10.798^k}\right]$$

$$= Pr\,(S \geq -4.18) \cong 0.99$$

Hence, N = 5 years is the smallest value permissible.

12-27 Start at $\boxed{2}$: PW(10)%) for BA = -250^k (P/A,10%,5)(0.75)

-150^k (P/A,10%,5)(0.25) – $5{,}500^k$ + $2{,}000^k$ (P/F,10%,5)

= $-5{,}111{,}14^k$

Therefore, select RA

If at $\boxed{2}$ PW(10%) for RA = $-1{,}000^k$ (P/A,10%,5)(0.60)

$-1{,}200^k$ (P/A,10%,5)(0.50) – 25^k = $-4{,}119.06^k$

Bottom branch at $\boxed{1}$: $PW_{BUILD}(10\%)$ = [-200^k(P/A,10%,5)

$-4{,}119.06^k$ (P/F,10%,50}(0.2) – 150^k (P/A,10%,10)(0.6)

-300^k (P/A,10%,10)(0.2) – $10{,}500^k$ + $17{,}00^k$ (P/F,10%,10)

= $-\$5{,}531.33^k$

Top branch at $\boxed{1}$: $PW_{RENT}(10\%)$ = -900^k [1−(P/F,10%,10)(F/P,7%,10)](0.55)

-700^k [10(P/F,10%,1)](0.45) – 25^k

= $-\$6{,}875{,}73^k$

Therefore, choose to <u>build</u>.

Solutions to Spreadsheet Exercises

12-28

	A	B	C	D	E	F
1	MARR =	12%		Useful Life	Probability	
2	Capital Investment =	$ 521,000		14	0.3	
3	Annual Savings =	$ 48,600		15	0.4	
4	Increased Revenue =	$ 31,000		16	0.3	
5						
6						
7	Useful Life	prob (N)	PW	E(PW)	PW^2	p(N)[PW]^2
8	14	0.3	$ 6,602	$ 1,981	4.359E+07	1.308E+07
9	15	0.4	$ 21,145	$ 8,458	4.471E+08	1.788E+08
10	16	0.3	$ 34,129	$ 10,239	1.165E+09	3.494E+08
11	Totals =			$ 20,677		$ 541,360,618
12						
13	E(PW)	$ 20,677				
14	V(PW) =	$ 113,806,908				
15	SD(PW) =	$ 10,668				
16						
17						
18	The revised estimates for useful life have resulted in an increased *E* (PW) and a reduced SD(PW).					

12-29 Left as an individual exercise.

Solutions to Chapter 13 Problems

13-1 NOPAT = (1 – 0.4)($8 million − $4 million − $2 million) = $1.2 million

13-2 $e_a = 0.25 + 1.28(0.084) = 0.1325$ or 13.25%

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13-3 Recommendations differ for Projects A and C

13-4 $R_s = 0.06 + 0.04 = 0.10 = 10\%$

13-5 In this case, $(P/A, i', \infty) = 12$, so $1/i' = 12$ and $i' = 0.0833$. The after-tax return on this stock is 8.33%. With a higher P/E ratio, the implied IRR will drop because investors are more concerned about growth in the price of the common stock and are willing to trade earnings for growth.

13-6 Degrees of dependency between two or more projects range over a continuum from "prerequisite" to "mutually exclusive" as explained in Table 13-2.

In general, complementary projects should be included as part of a given proposal package. However, where the decision regarding complementary projects is sufficiently important to be made by higher levels of management, combinations of projects should be submitted in the form of sets of mutually exclusive alternatives.

13-7 (a) Keep Old:

Capital recovery = ($6,000−$1,000)(NP,15%,3) + $1,800(0.15) = $2,110

Operating Disbursements		720
	Total Annual Cost =	$2,830

Lease:

30 days($30) + 3,000 miles ($0.40) = $2,100

Thus, leasing a truck is better.

(b) The annual cost of having to operate without a truck, $2,000, is less than the minimum cost alternative in (a). Hence, it is better to operate without a truck.

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13-8 (a)

Keep Old

Yr.	BTCF	Depr.	TI	T (t=0.40)	ATCF
0	−\$6,000	−	(−)+\$1,000[1]	(+)−\$400	−\$5,600
1−3	−720	−\$1,000	−1,720	+688	−32
3	+1,800	−	−200[2]	+80	+1,880

Lease

Yr.	BTCF	Depr.	TI	T (t=0.40)	ATCF
1−3	−\$2,100	−	(−)\$2,100	(+)\$840	−\$1,260

(1) Cap. gain if we sell = \$6,000 − \$5,000 = \$1,000
(2) Cap. loss if we sell = [\$5,000 − 3(\$1,000) − \$1,800 = −\$200

PW(Keep Old): −\$5,600 − \$32(P/A,5%,3) + \$1 ,880(P/F,5%,3) = −\$4,063
PW(Lease): −\$1,260(P/A,5%,3) = −\$3,431
Thus leasing is better.

(b) Presumably the extra cost of having to operate without a truck would be tax deductible.

Thus, the extra cost after income taxes would be
\$2,000 − 40%(\$2,000) = \$1 ,200/yr.
PW(without truck) = −\$1 ,200(P/A,5%,3) = −\$3,268

Thus, operating without a truck is still more economical.

13-9 (a) Purchase:

Cash Inflows	=	\$20,000
CR Cost = (\$56,000−\$10,000)(A/P,10%,3) + \$10,000(0.10)	=	\$19,497
	Net AW	\$ 503

Lease:

Cash Inflows	=	\$20,000
Lease Payments (converted to end−of−year)	=	\$24,200
	Net AW	−\$4,200

It is better to purchase the lathe.

(b) If the value of the lathe (as measured by cash inflows) is only \$18,000, the lathe should not be acquired by purchase or lease.

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13-10 Based on the use of equity money of the firm.

Buy

	Yr.	BTCF	Depr.	Taxable Inc.	t=0.40 Income Taxes	ATCF
	0	0				0
	1−20	−$ 100,000	−$100,000	−$200,000	+$ 80,000	−$ 20,000
If (a)	20	− 2,000,000				− 2,000,000
If (b)	20	− 1,500,000		+ 500,000*	− 200,000	− 1,700,000

*Capital gain = $2,000,000 − $1,500,000 = $500,000

Lease

Yr.	BTCF	Depr.	Taxable Inc.	t=0.40 Income Taxes	ATCF
1−20	−$125,000	−−	−$125.000	+$50,000	−$75,000

Annual Worths

Buy and (a) $0 salvage:

−$20,000−$2,000,000(A/F,5%,20) = −$80.400 < −$75.000

Therefore, Lease.

Buy and (b) $500,000 salvage:

−$20,000 − $1,700,000(A/F,5%,20) = −$71.340> −$75,000

Thus leasing is better for case a, but buying is better for case b.

13-11

(1)

	Yr.	BTCF	Depr.	Taxable Income	t = 0.25 Taxes	ATCF
Lease	Beginning Of each Year	−$ 35,000		−$ 35,000	+$ 8,750	−$ 26,250
Purchase	0	−$100,000				−$100,000
	1−5	−$1,000	−$20,000(1)	−$21,000	+$5,250	+ 4,250
	5	0				+0

Depr. = ($100,000−$0)/5 = $20,000

Annual Worths

Lease: (Adjusted to end−of−year) =−$26,250(F/P,1 0%,1) = −$28,875
Purchase: − $100,000(A/P, 1 0%,5) +$4,250 = −$22,130 Thus, purchasing is better if the life is 5 years.

To illustrate the iterative calculations to find the breakeven life, here are the figures for a 3−year life

Purchase	0	−$100,000	−−	−−	−−	−−
Last 3	1−3	−$1,000	−$20,000	−$21,000	+$5,250	+$4,250
Years	3	0	−−	−$40,000(2)	+$10,000	+$10,000

(2) Capital Loss = Book Value − Selling Price

= [$100,000−3($20,000)]−$0 = $40,000

Annual Worths

Lease: (see above) = −$28,875
Purchase, last 3 yrs .= − $100,000(A/P,10%,3) + $4,250 + $10,000(A/F, 1 0%,3)
= −$32,939

Thus, leasing is better if the life is 3 years. It appears that a breakeven life is 4 years (to the nearest whole year).

13-12

	EOY	Capital Investment	Annual Net Cash Income	PW(10%)
A	A1	−500000	90000	53014
	A2	−650,000	110,000	25,906
	A3	−700,000	115,000	6,629
B	B1	−600,000	105,000	45,183
	B2	−675,000	112,000	13,195
C	C1	−800,000	150,000	121,690
	C2	−1,000,000	175,000	75,305

Maximize: PW = $53{,}014X_{A1} + 25{,}906X_{A2} + 6629X_{A3} + 45{,}183X_{B1} + 13{,}195X_{B2} + 121{,}690X_{C1} + 75{,}305X_{C2}$

Subject to: $500{,}000\, X_{A1} + 650{,}000\, X_{A2} + 700000\, X_{A3} + 600{,}000\, X_{B1} + 675{,}000\, X_{B2} + 800{,}000X_{C1} + 1{,}000{,}000X_{C2} \leq 2{,}100{,}000$

$X_{A1} + X_{A2} + X_{A3} \leq 1$

$X_{B1} + X_{B2} \leq 1$

$X_{C1} + X_{C2} \leq 1$

$X_{A1} + X_{A2}\, X_{A3} + X_{B1}\, X_{B2} + X_{C1}\, X_{C2} = 0 \text{ or } 1$

Solution: $X_{A1} = 1$; $X_{B1} = 1$; $X_{C1} = 1$

Objective function value = <u>$219.89</u>

13-13

	Proposal				
MEC	A	B	C	D	Investment
1	0	0	0	0	0
2	1	0	0	0	\$100,000
3	0	0	1	0	\$120,000
4	1	1	0	0	\$120,000
5	1	0	0	1	\$130,000
6	0	1	1	0	\$140,000
7	0	0	1	1	\$150,000*

*MEC #7 is not feasible due to budget limitations

For the objective function coefficients

$PW_A(15\%) = -\$100,000 + \$40,000(P/A, 15\%,3) + \$20,000(P/F, 15\%,3) = \$4,478$

$PW_B(15\%) = -20,000 + \$6,000(P/F, 15\%, 1) + \$10,000(P/A, 15\%,2)(P/F, 15\%, 1)$
$= -\$645$

$PW_C(15\%) = -120,000 + \$25,000(P/F, 15\%, 1) + \$50,000(P/F, 15\%,2)$
$+ 85,000(P/F,15\%,3) = -\$4,729$

Integer L.P. Setup:
Maximize $PW = 4,478X_A - 645X_B - 4,568X_C - 4,729X_D$

Subject to: $X_A + X_C \leq 1$
$X_B + X_D \leq 1$
$100,000X_A + 20,000X_B + 120,000X_C + 30,000X_D \leq 140,000$
$X_A, X_B, X_C, X_D = 0 \text{ or } 1$

Solving yields: $X_A = 1$, $X_B = 0$, $X_C = 0$ and $X_D = 0$
Objective function value = <u>\$4,478</u>

13-14 Maximize PW = $0.12\ X_A + 2.47\ X_B + 1.85\ Xc$

Subject to $4\ X_A + 4.5\ X_B + Xc \leq 5$

$X_A + X_B \leq 1$

$Xc \leq X_A$

$7{,}000\ X_A + 9{,}000\ X_B + 3{,}000\ Xc \leq 10{,}000$

$X_A, X_B, Xc = 0$ or 1

Solving yields: $X_A = 0$, $X_B = 1$, $X_C = 0$

Objective function = $2.47

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13-15 By inspection of the cash flow diagram, it can be seen that the cash inflow exactly equals the cash outflows ($3,000 = 24 × $125). So the APR is 0%.

13-16 **(a)** \$50 = \$2,000(A/P, 1.5%, N). Using Excel,

N = NPER(0.015, 50, −2000) = 61.54 months

(b) The 62^{nd} payment will be:

\$2,000(F/P, 1.5%, 62) − \$50(F/A, 1.5%, 61)(F/P, 1.5%, 1) = \$27.31

Total Interest Paid = \$50 × 61 + \$27.31 − \$2,000 = \$1,077.31

Solutions to Chapter 14 Problems

14-1 Left to student.

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14-2 Noncompensatory Models: Full dimensional
Advantages:

1) Quick and easy to apply to eliminate one or more of the alternatives.
2) All attributes are considered in the analysis.
3) Simple, easy to understand, requires little computation if any.

Disadvantages:
1) Very often does not lead to a final selection.
2) May not eliminate any of the alternatives.
3) Tends to "satisfice" rather than optimize.

Compensatory Models: Single dimensional
Advantages:

1) Trade offs are taken into account in arriving at the final decision.
2) Will almost always arrive at a final choice, and method may be developed to break a tie quantitatively.
3) Numerical answers seem to parallel intuitive choices.
4) All "worths" reduced to a single scale, makes complex problem computationally tractable.

Disadvantages:

1) Weighting is still subjective.
2) Compression to numerical values for qualitative subjective data is often difficult and time consuming, and may not be meaningful;
3) Translation of numerical or subjective values to a single scale may not be plausible for all individuals.

14-3 Left to student.

14-4 Some of the difficulties of developing nonlinear functions or nondimensional scaling of qualitative (subjective) data are as follows:

(a) Dimensionless attributes will contain implicit weighting factors
(b) Dimensionless attributes will not follow same trend with respect to desirability
(c) A non-dimensionalizing procedure could inaccurately rate each attribute in terms of its fractional accomplishment of the highest attainable value.
(d) Higher (lower) values could dominate the solution.

14-5 **(a)** Assume "ideal" means "maximum"

Attribute A for alternatives 2 and 3 is acceptable: $70 \leq A \leq 100$

Attribute B for all alternatives is acceptable: $6 \leq B \leq 10$

Only alternative 2 attribute C is acceptable: $\text{Good} \leq C_2 \leq \text{Excellent}$

Attribute D for all alternatives is accceptable: $6 \leq D \leq 10$

Only <u>alternative 2</u> is acceptable because it is the only one whose attributes <u>all</u> lie in acceptable ranges.

(b) No alternative dominates another.

(c) Alternative 3 has the best value of the top ranked attribute "D".

14-6 **(a)** Dominance

Attribute	Vendor I vs. Vendor II	I vs. III	I vs. Retain	II vs. III	III vs. Retain
Reduction in throughput time	Better	Worse	Better	Worse	Better
Flexibility	Worse	Worse	Better	Equal	Better
Reliability	Better	Better	Better	Equal	Better
Quality	Worse	Worse	Better	Equal	Better
Cost of System	Better	Worse	Worse	Worse	Worse
Dominance?	No	No	No	Yes	No

Vendor II is removed from consideration.

(b) Satisficing

Attribute	"Worst" Acceptable Value	Unacceptable Alternative
Reduction in throughput time	50%	Retain
Flexibility	Good	Retain
Reliability	Good	Retain
Quality	Good	Retain
Cost of System	\$350,000	None

Remove "Retain Existing System" from consideration

(c) Disjunctive Resolution

All alternatives still available ("Retain" already eliminated) pass because all options are acceptable in at least one attribute.

(d) Lexicography

Attribute	Number of times "greater"	Alternative Ranking
Reduction in throughput time	0	III > I > II
Flexibility	2	II = III > I
Reliability	1	I > II = III
Quality	2	II = III > I
Cost of System	4	I > III > II

<u>Select Vendor III</u>

14-7 Left to student.

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14-8 Dominance:

	Paired Comparison		
Attribute	A vs. B	B vs. C	A vs. C
1	better	Worse	worse
2	worse	better	better
3	better *	Worse	worse
4	worse	better	better
5	worse	better	better
Dominance?	no	no	no

No alternatives can be eliminated based on the dominance method.

*Assume that knowing the safety value is better than any unknown value.

Satisficing:

Attribute	Feasible Range	Unacceptable Alternatives
1	\$80,000 - \$100,000	none
2	Fair - Excellent	none
3	Good - Excellent	Alternative A has unknown value *
4	94 - 99%	none
5	Fair - Excellent	none

*if the same assumption is used (as in the dominance model) alternative A would be eliminated using the satisficing model

Lexicography:

Paired comparisons - using given weighting: 5 > 1 > 4 > 3 > 2

Attribute	Ordinal Ranking **	Ranking
1	3	C > A > B
2	0	B > A > C
3	1	C > B > A
4	2	B > A > C
5	4	B > A = C

** 4 is most important rank.

The selection, based on highest ranked attribute (#5), would be Alternative B.
Because all alternatives meet at least one acceptability range, no alternatives are rejected.

Non-dimensional scaling

Attribute	Value	Rating Procedure	Dimensionless Value
1	$100,000	($180,000-Cost)/$80,000	1.0
	$140,000		0.5
	$180,000		0.0
2	Excellent	(Relative rank - 1)/2	1.0
	Good		0.5
	Fair		0.0
3	Excellent	(Relative rank - 1)/2	1.0
	Good		0.5
	Not known		0.0
4	99%	(Reliability % - 94)/(99-94)	1.0
	98%		0.8
	94%		0.0
5	Excellent	(Relative rank - 1)/2	1.0
	Good		0.0

	Non-Dimensional Value		
Attribute	A	B	C
1	0.5	0.0	1.0
2	0.5	1.0	0.0
3	0.0	0.5	1.0
4	0.8	1.0	0.0
5	0.0	1.0	0.0

Additive Weighting (using given weights)

Attribute	Weight	A	B	C
1. Initial Cost	0.25	0.5(0.25)=0.125	0.0(0.25)=0	1.0(0.25)=0.25
2. Maintenance	0.10	0.5(0.10)=0.05	1.0(0.10)=0.1	0.0(0.10)=0.0
3. Safety	0.15	0.0(0.15)=0.00	0.5(0.15)=0.075	1.0(0.15)=0.15
4. Reliability	0.20	0.8(0.20)=0.16	1.0(0.20)=0.2	0.0(0.20)=0.0
5. Prod. Quality	0.30	0.0(0.30)=0.00	1.0(0.30)=0.3	0.0(0.30)=0

Using Additive Weighting Alternative B would be selected.

14-9 **(a)**

Attribute	Relative Rank	Normalized Rank
Social Climate	1.00	1/2.08 = 0.481
Starting Salary	0.50	0.5/2.08 = 0.240
Career Adv.	0.33	0.33/2.08 = 0.159
Weather/Sports	0.25	0.25/2.08 = 0.120
	2.08	1.00

(b)

	Alternatives			
Attribute	Apex (N.Y.)	Sycon (L.A.)	Sigma (GA.)	Mc-Graw-Wesley (AZ.)
Starting Salary	$35,000	$30,000	$34,500	$31,500
Dimensionless Equivalent (DE)	1.0	0.0	0.9	0.3

$$DE = \frac{\text{Worst Outcome - Outcome Being Made Dimensionless}}{\text{Worst Outcome - Best Outcome}}$$

(c)

Attribute	Normalized Weight	Apex	Sycon	Sigma	Mc-Graw Wesley
Social Climate	0.48	1x0.48	1x0.48	0.5x0.48	0x0.48
Starting Salary	0.24	1x0.24	1x0.24	0.9x0.24	0.3x0.25
Career Adv.	0.16	0x0.16	0x0.16	0.6x0.16	1x0.16
Weather/ Sports	0.12	0x0.12	0x0.12	0.33x0.12	0.67x0.12
	Sum	0.72	0.63	0.59	0.31

Using lexicography we conclude that social climate is the most important attribute and Apex is selected. Additive weighting also selects Apex.

14-10 **(a)** Wright dominates Alott – Alott is removed from further consideration.

(b) Only Wright meets the minimum performance levels for all attributes.

(c) All candidates would be retained under disjunctive resolution.

(d) Lexicography – Based on project management skills (most important attribute), Busy is eliminated. Looking next at general attitude, Surley is eliminated. Lastly, looking at years manufacturing experience, Wright would be selected.

Engineering Economy, Fourteenth Edition, by Sullivan, Wicks, and Koelling. ISBN 0-13-614297-4.

14-11 Left to student.

14-12 **(a)** Left to student – no unique answer.

(b) Select a mathematical model similar to additive weighting. Let each judge set his/her own weightings and develop a score for each contestant. Then, sum the three scores for each contestant. The contestant with the highest total score is the winner.

This method will allow each judge to be as subjective about each attribute as he/she desires while making the final selection objective.

14-13 Assume all attributes are of equal importance.

Attribute	Alott	Surley	Busy	Wright
Total years	0.33	0.00	1.00	0.67
Manufacturing years	0.33	1.00	0.00	0.67
Project management skills	1.00	1.00	0.00	1.00
Management years	0.00	0.50	0.50	1.00
General attitude	1.00	0.00	0.50	1.00
Total Score	2.66	2.50	2.00	4.34

Wright would be selected.

14-14

i	W_i	Rank
1	1.0	1
2	?	4
3	0.8	2
4	0.7	? By inspection, $Rank_{i=4}=3$
		10

$$V_j = \sum_{i=1}^{n} W_i X_{ij}$$

$V_2 =$ $2.3 = (1.0)(0.7) + W_2(1.0) + (0.8)(0.5) + (0.7)(1.0)$

$2.3 = W_2 + 0.7 + 0.4 + 0.7$

$W_2 = 0.50$

$V_1 =$ $2.69 = (1.0)(1.0) + (0.5)(0.8) + (0.8)X_{3,1} + (0.7)(0.7)$

$2.69 = 1.0 + 0.4 + 0.8\,X_{3,1} + 0.49$

$$X_{3,1} = \frac{2.69 - 1.0 - 0.4 - 0.49}{0.8} = 1.0$$

V_j normalized = $V_1 = 2.69/2.69 = 1.00$
$V_2 = 2.30/2.69 = 0.86$

By inspection $Rank_{j=1} = 2.0$
$Rank_{j=2} = 1.0$

Filling in blanks,

i	W_i	Rank
1	1.0	1
2	0.5	4
3	0.8	2
4	0.7	3

	Keep Existing Tool	Purchase new machine Tool
Rank	2.0	1.0
X_{1j}	1.0	0.7
Rank	2.0	1.0
X_{2j}	0.8	1.0
Rank	1.0	2.0
X_{3j}	1.0	0.5
Rank	2.0	1.0
X_{4j}	0.7	1.0
V_j	2.69	2.30
V_j norm	1.0	0.86

14-15 Left to student.

14-16 Left to student.

14-17 Left to student.

14-18

	A	B	C	D	E	F	G
1	**Attribute**	**Dr. Molar**	**Dr. Feelgood**	**Dr. Whoops**	**Dr. Pepper**		
2	**Cost**	$ 50	$ 80	$ 20	$ 40		
3	**Anesthesia**	Novocaine	Acupuncture	Hypnosis	Laughing Gas		
4	**Distance**	15	20	5	30		
5	**Office Hours**	40	25	40	40		
6	**Quality**	Excellent	Fair	Poor	Good		
7							
8	*Quality*			*Anesthesia*			
9	Excellent	4		Acupuncture	1		
10	Fair	2		Hypnosis	4		
11	Good	3		Laughing Gas	2		
12	Poor	1		Novocaine	3		
13							
14	**Attribute**	**Dr. Molar**	**Dr. Feelgood**	**Dr. Whoops**	**Dr. Pepper**		
15	Cost	0.50	0.00	1.00	0.67		
16	Anesthesia	0.67	0.00	1.00	0.33		
17	Distance	0.60	0.40	1.00	0.00		
18	Hours	1.00	0.00	1.00	1.00		
19	Quality	1.00	0.33	0.00	0.67		
20	Sum =	3.77	0.73	4.00	2.67		
21				^ best choice			
22							
23							
24	With novocaine rated as the preferred method of anesthesia, Dr. Whoops becomes						
25	the dentist of choice.						