

4.13 References

- CANADA, J. R., W. G. SULLIVAN, and J. A. WHITE. *Capital Investment Decision Analysis for Engineering and Management*. 2nd ed. Englewood Cliffs, N.J.: Prentice Hall, Inc., 1996.
- GRANT, E. L., W. G. IRESON, and R. S. LEAVENWORTH. *Principles of Engineering Economy*, 8th ed. New York: John Wiley & Sons, 1989.
- MORRIS, W. T. *Engineering Economic Analysis*. Reston, Va.: Reston Publishing Co., 1976.
- THUESEN, G. J., and W. J. FABRYCKY. *Engineering Economy*, 8th ed. Englewood Cliffs, N.J.: Prentice Hall, Inc., 1993.

4.14 Problems

Unless stated otherwise, discrete compounding of interest and end-of-period cash flows should be assumed in all problem exercises in the remainder of the book. All MARRs are "per year." The number in parentheses at the end of a problem refers to the chapter section(s) most closely related to the problem.

- 4-1.** In your own words, what is the meaning of
- present worth? (4.3)
 - capital recovery amount? (4.5)
 - minimum attractive rate of return? (4.2)
- 4-2.** You are faced with a decision on an investment proposal. Specifically, the estimated additional income from the investment is \$180,000 per year; the investment cost is \$640,000; and the estimated annual expenses are \$44,000, which begin decreasing by \$4,000 per year starting at the end of the third year. Assume an 8-year analysis period, no salvage value, and $MARR = 15\%$ per year. (4.3, 4.6)
- What is the PW of this proposal?
 - What is the IRR of this proposal?
- 4-3.**
- Evaluate machine XYZ on the basis of the PW method when the $MARR$ is 12% per year. Pertinent cost data are as follows: (4.3)

Machine XYZ

Investment cost	\$13,000
Useful life	15 years
Salvage value	\$ 3,000
Annual operating expenses	100
Overhaul cost—end of fifth year	200
Overhaul cost—end of tenth year	550

- Determine the capital recovery amount of machine XYZ by all three formulas presented in the text. (4.5)
- Determine the PW , FW , and AW of the following engineering project when the $MARR$ is 15% per year. (4.3, 4.5)

	<i>Proposal A</i>
Investment cost	\$10,000
Expected life	5 years
Market (salvage) value*	−\$ 1,000
Annual receipts	8,000
Annual expenses	4,000

*A negative salvage value means that there is a net cost to dispose of an asset.

- Determine the IRR of the project. Is it acceptable? (4.6)
 - What is the ERR for this project? Assume $e = 15\%$ per year. (4.7)
- 4-5.** Uncle Wilbur's trout ranch is now for sale for \$40,000. Annual property taxes, maintenance, supplies, and so on are estimated to continue to be \$3,000 per year. Revenues from the ranch are expected to be \$10,000 next year and then to decline by \$500 per year thereafter through the tenth year. If you bought the ranch, you would plan to keep it for only five years and at that time to sell it for the value of the land, which is \$15,000. If your desired annual rate of return is 12% , should you become a trout rancher? Use the PW method. (4.3)
- 4-6.** A company is considering constructing a plant to manufacture a proposed new product. The

land costs \$300,000, the building costs \$600,000, the equipment costs \$250,000, and \$100,000 additional working capital is required. It is expected that the product will result in sales of \$750,000 per year for 10 years, at which time the land can be sold for \$400,000, the building for \$350,000, and the equipment for \$50,000. All of the working capital would be recovered. The annual expenses for labor, materials, and all other items are estimated to total \$475,000. If the company requires a MARR of 25% per year on projects of comparable risk, determine if it should invest in the new product line. Use the *PW* method. (4.3)

4-7.

- class* a. Draw a cash flow diagram for the bond that was described in Example 4-4.
 b. If the bond in Example 4-4 is purchased to yield 5% per 6-month period (rather than $i = 10\%$ per year), the current purchase price would be how much? (4.3)

4-8. How much can be paid for a \$5,000, 10% bond, with interest paid semiannually, if the bond matures 12 years hence? Assume that the purchaser will be satisfied with 8% nominal interest compounded semiannually. (4.3)

4-9. A 20-year bond with a face value of \$5,000 is offered for sale at \$3,800. The nominal rate of interest on the bond is 7%, paid semiannually. This bond is now 8 years old (i.e., the owner has received 16 semiannual interest payments). If the bond is purchased for \$3,800, what effective annual rate of interest would be realized on this investment opportunity? (4.3)

4-10.

a. A company has issued 10-year bonds, with a face value of \$1,000,000, in \$1,000 units. Interest at 8% is paid quarterly. If an investor desires to earn 12% nominal interest (compounded quarterly) on \$10,000 worth of these bonds, what would the selling price have to be?

b. If the company plans to redeem these bonds in total at the end of 10 years and establishes a sinking fund that earns 8%, compounded semiannually, for this purpose, what is the annual cost of interest and redemption? (4.3)

4-11. You bought a \$1,000 bond at par (face value) that paid nominal interest at the rate of 10%,

payable semiannually, and held it for 10 years. You then sold it at a price that resulted in a yield of 8% nominal interest compounded semiannually on your capital. What was the selling price? (4.3)

4-12. A small company bought BMI bonds at their face value on January 1, 1991. These bonds pay interest of 7.25% every six months (14.5% per year). The face value of the bonds is \$100,000, and they mature on December 31, 2006. On January 1, 2001, these bonds were sold for \$110,000. What interest rate (per six months) was earned by the company on the BMI bonds? (4.3)

4-13. Susie Queue has a \$100,000 mortgage on her deluxe townhouse in urban Philadelphia. She makes monthly payments on a 10% nominal interest rate (compounded monthly) loan and has a 30-year mortgage. Home mortgages are presently available at a 7% nominal interest rate on a 30-year loan. Susie has lived in the townhouse for only two years, and she is considering refinancing her mortgage at a 7% nominal interest rate. The mortgage company informs her that the one-time cost to refinance the present mortgage is \$4,500.

How many months must Susie continue to live in her townhouse to make the decision to refinance a good one? Her MARR is the return she can earn on a 30-month certificate of deposit that pays $1/2\%$ per month (6% nominal interest). (4.3, 4.5)

4-14. On January 1, 1997, your brother bought a used car for \$8,200, and he agreed to make a down payment of \$1,500 and repay the balance in 36 equal payments, with the first payment due February 1. The nominal interest rate is 13.8% per year compounded monthly. During the summer your brother made enough money so that he decided to repay the entire balance due on the car as of September 1. How much did he repay on September 1? (4.3)

4-15.

class a. A car can be leased for \$400 per month for 36 months and then purchased for \$10,000 when the last payment is made. If $i = 1\%$ per month, the purchase price today should be how much? (4.3)

b. If the purchase price turned out to be \$22,000, what would this tell you about the dealer? (4.3)

Year	Investment at Beginning of Year	Opportunity Cost of Interest ($i = 15\%$)	Loss in Value of Asset During Year	Capital Recovery Amount	(Pr. 4-18)
1	\$10,000		\$3,000		
2			\$2,000		
3			\$2,000		
4					

Year	Investment at Beginning of Yr.	Opportunity Cost (5% per Yr.)	Loss in Value of Asset During Yr.	Capital Recovery Amount	(Pr. 4-21)
1	\$1,000	\$50	\$(a)	\$250	
2	(b)	(c)	200	240	
3	600	30	200	230	
4	(d)	20	(e)	(f)	

4-16. List the advantages and disadvantages of each of these five basic methods for performing engineering economy studies (*PW*, *AW*, *FW*, *IRR*, *ERR*).

4-17. The Anirup Food Processing Company is presently using an outdated method for filling 25-pound sacks of dry dog food. To compensate for weighing inaccuracies inherent to this packaging method, the process engineer at the plant has estimated that each sack is overfilled by 1/8 pound on the average. A better method of packaging is now available that would eliminate overfilling (and underfilling). The production quota for the plant is 300,000 sacks per year for the next six years, and a pound of dog food costs this plant \$0.15 to produce. The present system has no salvage value and will last another four years, and the new method has an estimated life of four years with a salvage value equal to 10% of its investment cost, I . The present packaging operation expense is \$2,100 per year more to maintain than the new method. If the MARR is 12% per year for this company, what amount, I , could be justified for the purchase of the new packaging method? (4.3)

4-18. Fill in the table at the top of this page when $P = \$10,000$, $S = \$2,000$ (at the end of four years), and $i = 15\%/yr$. Complete the table and show that the equivalent uniform CR amount equals \$3,102.12. (4.5)

4-19.

a. A certain service can be performed satisfactorily by process R , which has a capital in-

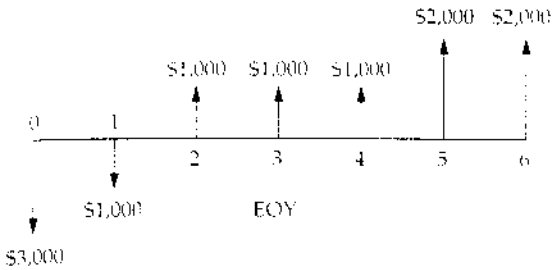
vestment cost of \$8,000, an estimated life of 10 years, no salvage value, and annual net receipts (revenues - expenses) of \$2,400. Assuming a MARR of 18% before income taxes, find the *FW* and *AW* of this process and specify whether you would recommend it. (4.4, 4.5)

b. A compressor that costs \$2,500 to purchase has a 5-year useful life and a salvage value of \$1,000 after five years. At a nominal interest rate of 12%, compounded quarterly, what is the *annual CR* amount of the compressor? (4.5)

4-20. You purchased a building five years ago for \$100,000. Its annual maintenance expense has been \$5,000 per year. At the end of three years, you spent \$9,000 on roof repairs. At the end of five years (now), you sell the building for \$120,000. During the period of ownership, you rented the building for \$10,000 per year paid at the *beginning* of each year. Use the *AW* method to evaluate this investment when your MARR is 12% per year. (4.5)

4-21. Given that the purchase price of a machine is \$1,000 and its market value at the end of year four is \$300, complete the table above (values a through f) using an opportunity cost of 5% per year. Compute the equivalent uniform capital recovery amount, based on information from the completed table. (4.5)

4-22. Based on the following cash flow diagram, answer the following questions (4.3, 4.5, 4.8)



- a. As $i \rightarrow \infty$, the PW equals _____.
- b. The discounted payback period (θ') is _____ years. Let $MARR = 12\%$ per year.
- c. If the cash flow at the end of year six had been $-\$2,000$ instead of $+\$2,000$, $AW (0\%) =$ _____.

4-23. A manufacturing firm has considerable excess capacity in its plant and is seeking ways to utilize it. The firm has been invited to submit a bid to become a subcontractor on a product that is not competitive with the one it produces but that, with the addition of \$75,000 in new equipment, could readily be produced in its plant. The contract would be for five years at an annual output of 20,000 units.

In analyzing probable costs, direct labor is estimated at \$1.00 per unit and new materials at \$0.75 per unit. In addition, it is discovered that in each new unit one pound of scrap material can be used from the present operation, which is now selling for \$0.30 per pound of scrap. The firm has been charging overhead at 150% of prime cost, but it is believed that for this new operation the incremental overhead, above maintenance, taxes, and insurance on the new equipment, would not exceed 60% of the direct labor cost. The firm estimates that the maintenance expenses on this equipment would not exceed \$2,000 per year, and annual taxes and insurance would average 5% of the first cost. (Note: Prime cost = direct labor + direct materials cost.)

While the firm can see no clear use for the equipment beyond the five years of the proposed contract, the owner believes it could be sold for \$3,000 at that time. He estimates that the project will require \$15,000 in working capital, and he wants to earn at least a 20% before-tax annual rate of return on all capital utilized. (4.3, 4.5)

- a. What unit price should be bid?
- b. Suppose that the purchaser of the product wants to sell it at a price that will result in a profit of 20% of the selling price. What should be the selling price?

4-24. To purchase a used automobile, you borrow \$8,000 from Loan Shark Enterprises. They tell you the interest rate being charged is 1% per month for 35 months. They also charge you \$200 for a credit investigation, so you leave with \$7,800 in your pocket. The monthly payment they calculated for you is

$$\frac{8,000(0.01)(35) + \$8,000}{35} = \$308.57/\text{month}$$

If you agree to these terms and sign their contract, what is the actual APR (annual percentage rate) that you are paying? (4.6)

4-25. Suppose that you borrow \$1,000 from the Easy Credit Company with the agreement to repay it over a 5-year period. Their stated interest rate is 9% per year. They show you the following items in determining the monthly payment: (4.6)

Principal	\$1,000
Total interest: 0.09 (5 years) (\$1,000)	\$ 450

They ask you to pay 20% of the *interest* immediately, so you leave with $\$1,000 - \$90 = \$910$ in your pocket. Your monthly payment is calculated as follows:

$$\frac{\$1,000 + \$450}{60} = \$24.17/\text{month}$$

- a. Draw a cash flow diagram of this transaction.
- b. Determine the effective *annual* interest rate.

4-26. An individual approaches the Ajax Loan Company for \$1,000 to be repaid in 24 monthly installments. The agency advertises an interest rate of 1.5% per month. They proceed to calculate a monthly payment in the following manner:

Amount requested	\$1,000
Credit investigation	25
Credit risk insurance	5
Total	\$1,030

$$\text{Interest: } (\$1,030)(24)(0.015) = \$371$$

$$\text{Total owed: } \$1,030 + \$371 = \$1,401$$

$$\text{Payment: } \frac{\$1,401}{24} = \$58.50$$

What effective annual interest rate is the individual paying if this individual leaves Ajax with \$1,000 cash?

- 4-27.** Refer to problem 4-26 and the following “deal” that was actually offered to an engineering student. Your job is to give advice to the student concerning the true effective annual interest rate being charged in the situation below.

An agent of the Ajax Loan Agency offers the individual who agreed to the terms in problem 4-26 a special deal: “If you’re interested in prepaying the loan, I can let you do this. For each prepayment of \$58.50, a month and its corresponding payment will be dropped from the original 24-month loan repayment schedule.”

If the individual has the money to make two payments of \$117 in months one and two, then \$58.50 will still be owed in months 3–22. What is the effective annual interest rate in this situation? (4.6)

- 4-28.** Suppose you are now 20 years old. You decide to save \$ A per year starting on your twenty-first birthday and continuing through your sixtieth birthday. At age 60 you will have saved an accumulated (compounded) amount of \$ F .

A friend of yours waits five years to start her savings plan. Starting on her twenty-sixth birthday, it takes annual payments of \$ $2A$ for her to accumulate \$ F when she becomes 60 years old.

Still another friend delays his savings plan until ten years after you started yours. He finds that it takes \$ $4A$ each year from his thirty-first until his sixtieth birthday to accumulate \$ F .

What effective annual interest rate (i') makes the above three savings plans equivalent? What can you generalize from this problem?

- 4-29.** Your roommate borrowed money from a banker on the condition that he pay 7% of the loan every three months, until a total of 35 payments were made. Then the loan would be considered repaid. What effective annual interest rate did your roommate pay? Solve for the interest rate to the nearest 1/10 percent (use linear interpolation). (4.6)

- 4-30.** A machine that is not equipped with a brake “coasts” 30 seconds after the power is turned off upon completion of each workpiece, thus preventing removal of the work from the machine.

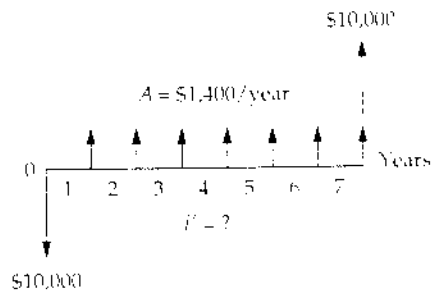
The time per piece, exclusive of this stopping time, is two minutes. The machine is used to produce 40,000 pieces per year. The operator receives \$16.50 per hour, and the machine overhead rate is \$4.00 per hour. How much could the company afford to pay for a brake that would reduce the stopping time to three seconds if it had a life of five years? Assume zero market value, a MARR of 15% per year, and repairs and maintenance on the brake totaling no more than \$250 per year. (4.3)

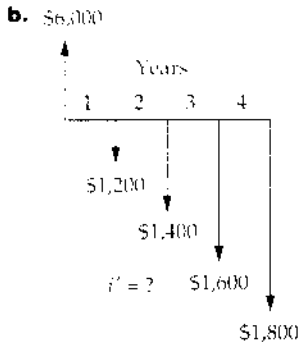
- 4-31.** Your boss has just presented you with the summary (below) of projected costs and annual receipts for a new product line. He asks you to calculate the IRR for this investment opportunity. What would you present to your boss, and how would you explain the results of your analysis? (It is widely known that the boss likes to see graphs of present worth versus interest rate for this type of problem.) The company’s MARR is 10% per year. (4.6)

End of Year	Net Cash Flow
0	–\$450,000
1	– 42,500
2	+ 92,800
3	+ 386,000
4	+ 614,600
5	–\$202,200

- 4-32.** Rework Problem 4-31 with the ERR method. Should the answers to the two problems be the same? Why? Let $\epsilon = \text{MARR}$. (4.7)

- 4-33.** Find the IRR in each of these situations: (4.6)





- c. Calculate the ERR when $\epsilon = 12\%$. (4.7)

4-39.

- a. Monthly amounts of \$200 each are deposited into an account that earns 12% nominal interest, compounded quarterly. After 48 deposits of \$200 each, what is the *FW* of the account? State your assumptions. (4.4)
- b. A "Christmas Plan" requires deposits of \$10 per week for 52 weeks each year. The stated nominal interest rate is 20% compounded weekly. What is the *PW* of the plan (beginning of week one)? (4.3)

- 4-40. Construct the investment balance diagram for problem 4-31. What additional insights into the profitability and liquidity of this new product line do you gain? (4.9)

- 4-41. A \$20,000 ordinary life insurance policy for a 22-year-old female can be obtained for annual premiums of approximately \$250. This type of policy (ordinary life) would pay a death benefit of \$20,000 in exchange for annual premiums of \$250 that are paid during the lifetime of the insured person. If the average life expectancy of a 22-year-old female is 77 years, what interest rate establishes equivalence between cash outflows and inflows for this type of insurance policy? Assume that all premiums are paid on a beginning-of-year basis and that the last premium is paid on the female's 76th birthday. (4.6)

- 4-42. Evaluate the acceptability of the following project with all methods discussed in Chapter 4. Let $MARR = \epsilon = 15\%$ per year, maximum acceptable $\theta = 5$ years, and maximum acceptable $\theta' = 6$ years.

Project: R137-A

Title: Syn-Tree Fabrication

Description: Establish a production facility to manufacture synthetic palm trees for sale to resort areas in Alaska.

Cash Flow Estimates:

Year	Amount (thousands)
0	-\$1,500
1	200
2	400
3	450
4	450
5	600
6	900
7	1,100

- c. You purchased a used car for \$4,200. After you make a \$1,000 down payment on the car, the salesperson looks in her *Interest Calculations Made Simple* handbook and announces: "The monthly payments will be \$160 for the next 24 months and the first payment is due one month from now." (Draw a cash flow diagram.)

- 4-34. Rework part (a) of problem 4-33 by using the ERR method when $\epsilon = 8\%$ per year. (4.7)

- 4-35. Plot the *PW* of part (a) of problem 4-33 as a function of the interest rate. The MARR is equal to 8% per year. (4.3)

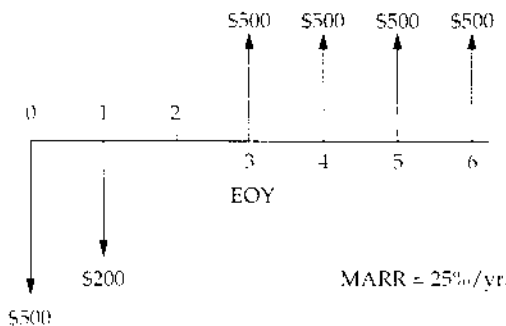
- 4-36. Draw an investment balance diagram for part (a) of problem 4-33 using $i = IRR$ (determined in that problem). (4.9)

- 4-37. A zero-coupon certificate involves payment of a fixed sum of money now with future lump-sum withdrawal of an accumulated amount. Earned interest is not paid out periodically, but instead compounds to become the major component of the accumulated amount paid when the zero-coupon certificate matures. Consider a certain zero-coupon certificate that was issued on March 25, 1993, and matures on January 30, 2010. A person who purchases a certificate for \$13,500 will receive a check for \$54,000 when the certificate matures. What is the annual interest rate (yield) that will be earned on this certificate? (4.3)

- 4-38. A small company purchased now for \$23,000 will lose \$1,200 each year the first four years. An additional \$8,000 invested in the company during the fourth year will result in a profit of \$5,500 each year from the fifth year through the fifteenth year. At the end of 15 years the company can be sold for \$33,000.

- a. Determine the IRR. (4.6)
- b. Calculate the *FW* if $MARR = 12\%$. (4.4)

4-43. With reference to the following cash flow diagram:

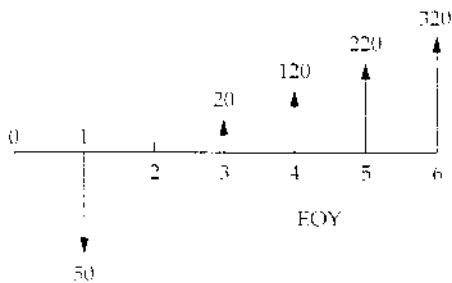


- What is the breakeven life $[\theta']$ of this project? (4.8)
- What is the breakeven interest rate (i')? (4.6)
- Draw the investment balance diagram. (4.9)

4-44. The Going Aircraft Corporation is manually producing a certain subassembly at a direct labor cost of \$100,000 per year. This manual work can be totally automated so that \$80,000 in direct labor and \$20,000 in indirect labor and overhead costs will be saved each year. Annual maintenance for the automated system will be \$10,000, and its market (salvage) value will be \$7,000 at any time in the future. The system's useful life is 5 to 10 years, inclusive.

- If the firm's MARR is 15% per year, develop a graph that shows how much money can be spent on the automated equipment. (*Hint:* Plot the PW of positive cash flows versus the useful life). (4.3)
- When $N = 6$ years and $P = \$344,000$, what is the simple payback period? (4.8)

4-45. Consider this cash flow diagram:



100

- If the MARR is 15% per year, is this project financially profitable? (4.3)
- Calculate the simple payback period, θ . (4.8)
- Calculate the discounted payback period, θ' . (4.8)

4-46. Advanced Manufacturing Technology (AMT) typically exhibits net annual revenues that increase over a fairly long period of time. In the long run an AMT project may be profitable as measured by IRR, but its simple payback period may be unacceptable. Evaluate this AMT project when the company MARR is 15% per year and its maximum allowable payback period is three years: (4.6, 4.8)

Capital investment at time 0	−\$100,000
Net revenues in year k	\$20,000 + \$10,000 · ($k - 1$)
Market (salvage) value	\$10,000
Life	5 years

- The IRR equals _____. Use linear interpolation to determine the IRR.
- The simple payback period equals _____.

4-47. A company has the opportunity to take over a redevelopment project in an industrial area of a city. No immediate investment is required, but it must raze the existing buildings over a four-year period and at the end of the fourth year invest \$2,400,000 for new construction. It will collect all revenues and pay all costs for a period of 10 years, at which time the entire project, and properties thereon, will revert to the city. The net cash flow is estimated to be as follows:

Year End	Net Cash Flow
1	\$ 500,000
2	300,000
3	100,000
4	− 2,400,000
5	150,000
6	200,000
7	250,000
8	300,000
9	350,000
10	400,000